HUMANISING AUTONOMY

WHERE ARE WE GOING?

ustwo
AUTO

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Version **1.1**

FOREWORD

"I've learned that people will forget what you said, people will forget what you did, but people will never forget how you made them feel."

Maya Angelou

Autonomy isn't about technology. It's about freedom, independence and a whole set of experiences that will literally and figuratively move people in new ways. This book is about the mindset that's needed to design the experiences of the future. It's about questions and about people.

While the promise of technology is seductive, applying it in a meaningful and coherent way is the challenge. The customer experience of the future will be real-time, responsive and more emotionally intelligent than ever before. As machines learn, so must we and we need to choreograph this dance. As journeys become fully automated, the experience itself will need to become more human.

Firstly, we need to re-think all the things we take for granted. How do I get in a car with no driver? How do I change direction on the fly? How do I know when I can cross the road? The winning brands and services will be those that care about the thousands of connected human questions like these. The new hows, whys and what ifs. They'll need to take away the stress, save time and money and create new motivations for travel without polluting the world or negatively impacting our wellbeing. Everyone involved in the design process will need empathy as part of their day job to achieve this.

Read on to hear some wonderful conversations from people around the world. From an 85 year great grandmother living in Mexico City to a 7 year old schoolgirl in London, a PhD student in Singapore to a car designer in Delhi and a taxi driver in London, amongst others. As the stories unfold, we'll reveal the hidden experience challenges we're excited about and some golden design principles to make autonomy human.

Lexi Cherniavsky
Client Partner

ustwo **LDN**

Lexi spends most of his day working with Tim and Harsha, the authors, to help automotive clients with their future vision goals - specifically; user-centred challenges and opportunities in automotive and mobility.

WHO ARE WE?

USTWO

ustwo is a global digital business studio launching products, services and companies that make a meaningful impact on the world. Since our foundation in 2004, we've partnered with some of the worlds leading brands and have grown to four studios around the world in New York, Malmö, London and Sydney.

We champion unrivalled user experience design and best in class technical practices, but we recognise that product is so much more than either of these in isolation. For us, the magic happens when these elements come together to form a product that at its core is centred around real human needs.

We form meaningful partnerships with others, but we also recognise the value of going it alone from time to time so that we can learn from a whole range of experiences. We put a large percentage of our profits directly back into these initiatives too, so that we can continue to innovate and learn. We also share these rewards amongst ustwobies as we recognise the value in creating opportunities for our staff and in retaining the best design and engineering talent in the industry.

Our cultural values are centred around enabling the ambitions of 300+ inspiring and talented individuals so that together we can make a difference to the world. We value collaboration, fun, craft, openness and authenticity, and work as 'one team' with our clients.

From ISO 7000-2442
Steering circuit

USTWO AUTO

Our mission is to make journeys more magically connected. We help brands drive change by combining insight and creativity with breakthrough technology. We create experiences that enhance people's lives from the dashboard to the city to the sky. We do this with clients around the world and collaborate with research partners on our own experimental projects.

We're a community of designers, inventors and engineers. We don't make cars but we do have a small collection. We conduct our own research experiments because we're passionate about what we do and want to solve the problems we see around us. We're embedded within ustwo with over 50 of us across our studios globally with specific sector expertise.

Our design methodology is inclusive and from the ground up because we know this creates a better experience for everyone. We have a collaborative way of working and a partnership mindset. This often involves bringing experts together across many disciplines to solve a common problem, whether designers, anthropologists, scientists, engineers, mobility providers, manufacturers, policy makers, city operators or academic and research partners. Clients work with us to help them build new capabilities and sometimes change the status quo.

THE AUTHORS

TIM SMITH

Auto Design Principal

Originally from North Wales, Tim moved to London in 2005 to begin his career as a graphic and user experience designer. Before turning his attention to the challenges and opportunities in the automotive and mobility space, Tim specialised in designing for "human to whatever" interaction as he calls it. Starting his career designing weird and wonderful interactive packaging, he quickly moved on to digital design, where he furthered his interest in Human–Machine Interaction (HMI) working on everything from museum interactives and gestural art installations to smartphones, smart TVs and smart fridges - he even worked on an interface for a cow milking machine.

Nowadays, Tim focusses on studying, exploring and designing for human behaviour in and around the car, including autonomous vehicles, along with transportation services and mobility. Tim also co-wrote ustwo Auto's first book on appropriate design for in-car interactions and has since gone on to write many articles and talked at many events on the subject of user-centred design for automotive and mobility, as well as working with automotive clients on their future products and services.

Tim has a collection of toy cars some 1,100 plus strong, which you might just catch a glimpse of throughout this book...

HARSHA VARDHAN

Auto Interaction Lead

Harsha is an Interaction designer, having previously studied at the Copenhagen Institute of Interaction design (CIID) and the Indian Institute of Technology, Delhi.

His move into digital, from an early focus on engineering physical products, was due to a deep fascination with objects embedded with agency and their impact on the human behaviour. So the segue into robotic vehicles was inevitable. Before ustwo, Harsha briefly worked with Toyota's Kansei division as part of CIID's consultancy wing during 2012. Between 2012 and 2013 he has worked with Service Innovation labs in Berlin, solving for urban mobility issues with two of Germany's largest car manufacturers.

Over the last four years as part of the auto team, he has co-authored automotive thought pieces and books which take a human look at digital experiences - especially focussed on the automobile industry. As a lead for projects, he has worked with major automotive clients such as Ford, JLR and Toyota and academic institutions like University College London and University of Washington.

Harsha secretly prefers motorbikes to cars, with a love of long distance touring.

Tap headings to jump to section

HUMANISING AUTONOMY

Topic: Introduction

16 minute read

SUMMARY

At the beginning of each section, we will summarise here the topic to give the reader a quick understanding of it's relevance or interest.

Everyone is talking about autonomous driving. It's not hard to see why – Autonomous Vehicles (AVs) promise to make a meaningful difference to the world, enabling a new level of mobility, independence and safety for all. Yet discussions continue to focus on topics such as technological feasibility and its impact to our roads, rather than the needs of the user.

Before it's too late, we need to reevaluate our approach to autonomy, asking questions that put humans center stage. We need to be less preoccupied by what can be done and focus on what should be done.

“BS shovelling art school grads.”

Jalopnik reader
in response to our first book

The auto industry’s approach to autonomy is imbalanced – there is too much focus on the discrete technologies that will enable it, with little regard for the powerful human factors involved. As the industry gets profoundly disrupted, we firmly believe that it’s not just automotive insiders who have a valuable contribution to make. What’s important is for car makers and service providers to embrace this moment to rethink the design process to transform the entire customer experience for the better and for everyone. With that in mind, the rewards will go to those who understand people and their mobility needs – and this requires an approach that puts people at its center.

Our first book made industry predictions, suggested user experience (UX) solutions and offered working practices to help with in-car UX problems. And we’ve been pleased to see some of these adopted in current vehicles. In Humanising Autonomy: Where Are We Going? we’re turning our human centred design (HCD) approach to the barriers to adoption facing autonomous vehicles (AVs) and focusing on the new experience challenges and opportunities that come with it. How can the magic of technology combine with a deeper understanding of how we behave to make the actual experience better and truly adopted by all?

A LITTLE BACKGROUND

In 2013, ustwo Auto embarked upon a new and top secret project for a major OEM (Original Equipment Manufacturer or simply the car maker in this case). We were asked to uncover user experience opportunities for improving interactions within the car.

During the project and afterwards whilst researching for a follow-up blog post, we discovered how messy the in-car Human-Machine Interface (HMI) and UX landscape was. It felt awash with ill-considered menus and inappropriately stylised aesthetics.

Something was off. The core (but not the only) reason for this was that the user, the person was absent from the design process and decision making.

So, as you do, we decided to write a book about it. A colourful but short review from a Jalopnik reader can be seen on the previous page. Crude as it is, the reader makes a valid point. We were new to the auto industry at the time (and still are, relatively speaking) but between us, we had over 40 years' UX design experience under our seat belts. The skills required to tackle that secret project were similar to those we've always used here at ustwo, but the in-car context was all new. With our UX design focus, we were able to approach the project with a fresh industry perspective – we looked at the in-car UX and UI landscape, studied what was on the market at the time and highlighted user experience gaps, something quite fresh at the time.

The book culminates with an in-depth user experience analysis, factoring in legislation, technical limitations, design best practice and most importantly; human factors, concluding with a set of design principles on how to design appropriately for the driver. And we've been pleased to see some of these adopted in current vehicles. Bosche, for example, introduced "ultrahaptic" feedback to their gestural interface[1] as suggested in our book, Apple revealed 'Do Not Disturb While Driving'[2] during their own WWDC 2017 conference (a response to National Highway Traffic Safety Administration (NHTSA) 2016 suggestion[3]), which bares a striking resemblance to a 'Car Mode'[4] prototype we built with the University of Washington in 2015, while Alfa, returned to a haptic controller in their Giulia – partly because this is the class standard but you could argue that it's rectifying the "slap a touchscreen on it" approach we discussed in our first book. Were these ideas influenced by our book? Maybe, maybe not, but it shows innovation in action.

What we didn't do in the book, though, was cover how to design for the passenger. With the advent of driverless cars, the driver may soon become the passenger. In this book, the follow up to the first, we face an eerily similar motivation, but within the context of autonomous vehicles. Having tackled various mobility and autonomous vehicle UX projects and researched the landscape over the past few years, the same gap in thinking we saw with in-car UX has presented itself once again; that of not considering the user throughout the design process.

Perhaps the term human is more appropriate here though - the user of the product (the AV) is only one actor in this autonomous play, there are many others outside of the vehicle who also need to be considered, such as the cyclist or pedestrian. We could thus employ some well established and new HCD principles to address this gap.

Are We There Yet? Thoughts on in-car HMI
by ustwo Auto

THE HCD CHALLENGE IN AUTONOMOUS VEHICLES

Everyone is talking about autonomous driving. From automotive manufacturers, to consumer electronic giants, to software engineers and university lecturers, driverless cars are at the forefront of everyone's imagination. There were more autonomous driving concepts at CES 2017[5] than ever before. There is also more money than ever before – in 2016 $1049M was invested across 87 auto tech deals and there was also a record 91% increase in funding[6].

AVs can make a meaningful difference to the world, enabling a new level of mobility, independence and safety for all. This has been covered in reams of white papers and many 1,000s of articles and news stories all over the globe. From questions of technological feasibility to thorny ethical dilemmas, it's been approached from many angles.

But there are aspects that haven't yet been covered – what do people want and need from AVs and how best to design for the many autonomous user experiences – what about those human factors? Even the latest thinking from the US DOT[7] and UK GOV Centre for Connected & Automated Vehicles[8] only cover the driver/passenger and not those around the vehicle, something we address in the book.

We spoke with Wendy Ju, Executive Director of Interaction Design Research at Stanford University and author of *The Design of Implicit Interactions* during her *Ghost Driver* trials, which studied human to AV interactions, about this subject:

"We can now have the machines adapt to our world. Before, there were a lot of people making things happen by catering to the machine. But the current trend is towards using the existing infrastructure that we have for people."

Wendy Ju
Stanford University

According to Wendy, we've finally come to a time when technologists are starting to understand the potential of designing for human behaviour, rather than have the people get to learn how the machine behaves. Unfortunately, this doesn't seem to be happening as much as you might expect in the auto industry.

"I don't think people are thinking about humans in the loop at all right now. Even if we solve autonomous cars, the bigger problem is really humans. Humans are going to mess everything up, and you have to really design for humans using self-driving cars, and how they're going to understand things around them." [9]

Carol Reiley
Founder of Drive.ai

We agree with this sentiment, though we need to design for this mess rather than bend as humans to suit the machines. In fact, this HCD deficit actually plays to our strengths at ustwo. We can approach this problem using a mixture of established design principles as well as some principles from our very own research. The contexts where these can be used and how to apply them for the driverless challenge is something we will discuss in more detail throughout the book.

HOW IS THIS BOOK ANY DIFFERENT? BARRIERS TO ADOPTION

These days, you can barely open your computer or turn on the TV without seeing some new story on autonomous vehicles. In fact, at one point during the writing of this book, we had to ban ourselves from Twitter, we were becoming snowed under with reading material. Only once the first draft was complete did we feel safe to unleash the avalanche of news. Having amassed some 50,000 words of notes from press outlets, white papers, specialist conferences, podcasts and even fledging regulation – we see several topics emerging:

1. Autonomous concepts. What robots are the OEMs and the tech companies dreaming up? Why do the designs look so sci-fi?

2. In the press. Sensationalist headlines demonise or honour the technology.

3. Morality and Ethics. Will AVs have to make decisions that humans simply can't?

4. Liability and Insurance. Inevitably things will go wrong, and when they do, who's to blame?

5. Policy and Regulation. What laws are being put in place to govern the technology on our roads?

6. The City and Society. What knock-on effects will this technology bring to the way people get around and their way of life?

7. The Tech and AI. Deep learning, privacy, hacking – technical feasibility and concerns.

What's the common theme? They all represent barriers to adoption. OEMs and tech companies alike will need to break through these barriers if they're to make the new technology a success. As the rate of car sales are predicted to slow over the next decade[10] in most of the developed world, OEMs are looking to new and innovative revenue streams. Ford state that mobility services are worth $5.4 trillion[11]. When it comes to new mobility options, OEMs are spreading their bets – and AVs are a front runner. Similarly, technology companies – such as Google[12], Bosch[13] and Apple[14] – are turning their expertise in consumer electronics and software development to autonomous tech to make a few quid.

So what does this have to do with those seven topics? Our concern is that they're being approached without the human in mind: that is, without a HCD approach. To illustrate this, let's look at point one – autonomous concepts.

There have been some fantastic concepts, with great forms and great ideas, like those seen on the next page. You will notice how none of them have wing (side) mirrors. The exterior/concept designers can do away with wing mirrors because, well, there's no driver to look into them, opting instead for a smoother more aesthetically pleasing look. So they remove them completely. However, our research tells us that many of the vision impaired community – potential early adopters of AVs – use wing mirrors to orientate themselves around the vehicle. By feeling for the wing mirror, the vision impaired are able to establish which way the car is pointing, which side of the car they are standing and therefore where the door is – it's a physical aid used to enter the vehicle.

So many of these AV designs and concepts that celebrate first time accessibility for the vision impaired, in fact, make it difficult for them to get in at all. The ustwo approach here, after gathering insights like these from user research, speaking to and observing real people from all backgrounds and needs, would be to remove the fully grown wing mirrors to achieve the same aerodynamic and stylistic advantages – like these concepts have – but leave behind something tactile that the vision impaired can rely upon, just like they have already established with their own trusted physical aid.

Sedric, Volkswagen

IDS, Nissan

Eve, NIO

Cody, IDEO

The final frontier then, the last barrier that all parties concerned will need to overcome before the technology becomes truly adopted is...

8. Mobility needs and Human Factors. How do people get around? How do people get from A to B? What is the user experience of acquiring the AV, entering the AV, the journey itself, how the AV interacts with pedestrians, cyclists and manual drivers?

This is the key barrier to adoption and one that has barely been discussed or explored meaningfully. Is autonomous driving technically possible? When will it happen? Is it safe? These are questions that have been asked of the technology time and time again, especially during the last few years. A more important question that has not yet been explored in great detail is:

What do people actually want and need from this technology?

However, the person doesn't care purely about the technology. What they really want is mobility, they want to get from A to B safely and comfortably – the tech simply facilitates and supports that. The big question, therefore, that we are asking is:

What are people's mobility needs and desires and how can Autonomous Vehicles support them?

Furthermore, how will people adopt and use this technology? Beyond getting in and enjoying the ride – there are far more factors, details and nuances to be considered. What are the human factors at play here and how can we design the best end-to-end connected experience? How would the changing faces of cities, preparing themselves for autonomous transport, affect the people and communities that live within them?

HUMAN CENTRED RESEARCH APPROACH

We wanted to ensure that this book was informed by the right approach, asking the right questions – the same approach we think is important for designing for autonomous vehicles.

Firstly, getting familiar with the AV landscape meant a whole range of things:

- Digesting hundreds of news articles and research papers.
- Studying the numerous AV concepts out there.
- Attending lectures in the UK, Europe and the US.
- Visiting AV testing grounds, including Ann Arbor's M City[15], London's GATEway project[16] as well as UK Autodrive[17] in Coventry, UK.
- We even sat in a brand new autonomous vehicle prototype, on a closed track in a secret location, invited by one of our clients.

Most importantly though, are the things we've done that bring us closest to the human side of things. Over the past year, we've:

- Worked on mobility and autonomous vehicle projects with OEMs, service providers and councils.
- Invited the public into ustwo workshops and sketch parties in our studios to get their opinions.
- Visited the homes and work spaces of potential future users, from children to the elderly, the tech optimists and those who could lose their jobs as a result of the technology.

Our own research and exercises like these are where we have truly begun to understand what people's mobility needs are and how AVs can support them.

We filmed many interviews with our study participants throughout the research and writing of this book. You can watch these on our site:

ustwo.com/humanisingautonomy

The moment we asked Yeva if she would enter an AV without her parents

HUMAN AUTONOMY NOT ROBOT AUTONOMY

In recent decades the term "autonomous" has become synonymous with computers and robots and, in more recent years, especially in the tech bubbles of San Francisco, Palo Alto, Cupertino, Shoreditch or Twitter – with driverless cars. Whether it's Advanced Driver Assistance Systems (ADAS) like cruise control that have been around for decades or the more recent Autonomous Vehicles (AV) such as the Google car plodding along around Mountain View, people hear "autonomous" and think "cars".

However, step out of the bubble for a second and we quickly remember that the term autonomous has been around far longer than even the car, never mind the driverless car.

Not wanting to be those guys, but the word "autonomous" actually comes from the Greek auto meaning "self" and nomos meaning "law" and originally applies to humans, not machines.

We use three categories for autonomy… and we make these distinctions in order to foreground what ustwo Auto is all about – human mobility.

Autonomous Technology (AT). Technology, often with Artificial Intelligence (AI) and machine learning capabilities, that can perform tasks without the need for intervention from humans.

Autonomous Vehicle (AV). A form of AT. For example, cars, buses or other means of transport that use AT to provide mobility solutions to people, objects and the city, with no intervention from humans. Note that driverless vehicles are different to autonomous vehicles – some trains are driverless while not fully autonomous. To be classed as a vehicle, an AV must transport people or cargo, with wheels, propellers, huskies and so on.

Autonomy of People (AP). Now that's what we're talking about! We're interested in how autonomous a person is, which is to a great extent dictated by how independently mobile they are. Mobility is a basic human need. AT and AVs can assist with AP. In this current age, AT and AVs can make for a happier AP.

So here's our 'equation':

AT + AV = AP :)

We're concerned with a person's ability, and even right, to make their own decisions and come and go as they please. Not about how clever cars are without human drivers.

The industry is preoccupied with the race to make their machines be as smart but more safe than human drivers. The press and even many research studies support that, and obviously funding helps direct it that way. What's really important though, above all else, is how this technology can enable greater human mobility and hence improve their autonomy. For that, we need to consider everything around the vehicle, from human needs to societal implications – not just the vehicle itself.

DP.01

DESIGN PRINCIPLE UNLOCKED:
01. HUMAN AUTONOMY IS THE GOAL

Ultimately we are creating autonomy for humans, not for the robots. Everything we design is for that human goal – we are not done when the robot is fully autonomous.

So, we have come across our very first design principle. You can expect to see these design principles emerge throughout the book, leading us towards helping people with their mobility needs. We have collected them all in the Human–AV interaction section toward the back of the book.

For this technology to be truly adopted, it must provide greater mobility to people than they had without it. Another way of looking at it is through an egalitarian lens – how many more people can be autonomous with the introduction of this technology when compared to the state of play today. For instance, can it provide greater mobility to people living on the fringes of society due to economic, physical or even social reasons – the vision impaired, the elderly or even the homeless?

You can read on for deeper insights into what all this research taught us. The next chapter will explicitly explore the human impact of this technology – we'll share what autonomy means to the individuals, who all come from different walks of life, that we have interviewed and observed.

With this book, we'd like to invite and open up this debate with the community as we have done with all our previous work. We hope that our research and thinking in this book will help enlighten and encourage OEMs, tier one and two suppliers, local authorities, policy makers and even the users of this tech to consider the human at the heart of all their decision making.

Why is this important? Because 94% of road accidents are as a result of human error. This figure represents over 185,000 injuries and 1,700 deaths per year in the UK[18] and 35,092 deaths in the US alone[19]. In theory, driverless vehicles will help to fix this problem. We want to accelerate the arrival of AVs, designing appropriately for it, so that we can bring the benefits to society. ◆

SOURCES

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AV ART PROJECT

We asked 20 of our favourite artists and designers to create a piece of work that demonstrates their hopes for Autonomous Vehicles. These weird and wonderful creations will feature throughout this book as a way to open our imaginations to what these vehicles might be like. The industry is ripe for change and designers should not be held back by norms informed by outdated legacy technologies such as the internal combustion engine and the controls used to manually drive the car.

On that note, why not have a cloud for a car…

Claudio, The Super Car
by Muxxi
Year: 2099

"Imagine you can drive without worries. Reading your favourite book, watching your favourite TV show or just texting some friends while you get to your destination. That's how I imagine a driverless car. Some comfy place where you enjoy your time and forget about the stress of being stuck in traffic. A very soft and light cloud who takes care of you and our planet."

Artist representation by WE ARE GOODNESS


ustwo

WHAT ARE PEOPLE'S MOBILITY NEEDS?

Topic: People and Autonomous Vehicles (AVs)

78 minute read

SUMMARY

In order to overcome the barriers to adoption, AVs need to be truly accessible to everyone. The way to do this? Observe what people's mobility wants and needs are. A user centred design approach is the key to creating a human approach to autonomy that actually works.

So, for this book we practiced what we preach – we spoke to people from different backgrounds, with different needs and unique opinions about their thoughts and hopes for the forthcoming 'revolution' of transport.

In this section, we ask what autonomy means to you, share the interviews in more detail and introduce the cast of characters whose insights underpin this entire narrative.

"A DRIVERLESS CAR? I DON'T THINK I WOULD... I WOULD PANIC. TO BE HONEST, I DON'T KNOW. BUT IF I HAD NO CHOICE, MAYBE."

Darret, ustwo study participant

INTRODUCTION

First encounters with autonomous vehicles (AVs) are often surreal or even scary experiences. Some people describe their experience as "spooky" or "like being in the future," whereas others default to unprintable exclamations of both fear and wonder. There is probably no better demonstration of a first-time AV experience than that of a 70-year-old woman using Tesla's Autopilot for the first time[1].

Our first experience taking a ride in a new-age Tesla P90D, driving along little lanes amid the Victorian buildings of London in a perfect cyberpunk juxtaposition, was similarly surreal. Our gracious guide was Rick, a Tesla owner of many years, with a penchant for technology and education.

After a couple of Tesla Ludicrous Mode[2] demonstrations, which showed off the car's insane acceleration, Rick pulled into a quieter street with few pedestrians. "Let's try the Autopilot," he said, and with the touch of a few buttons on the massive interface, we were off. Although he had his hands near the wheel, exercising caution, the car essentially drove itself for the next mile, sticking to the speed limits and with great lane discipline. Several brief encounters with pedestrians went perfectly – as they approached crossings the car slowed down to a stop to let them pass, almost respectfully (forgive us for anthropomorphising).

It was a surreal experience – after the initial amazement faded, it felt almost mundane. Only after getting out of the car and thanking Rick as we summoned an Uber did it hit us: we had just experienced the near-future of road transport. Three-tonne robots with varying degrees of autonomy in thought and action, based on underlying machine-level algorithms. And the technological complexity is only the beginning – it's the human, legislative, and social aspects where things really get complicated. The technology may be inching ever closer, but given these other complexities, how near are we really to this future? What sort of basic needs does this future cater to? Is it even necessary? Do we want it?

Granny tries AutoPilot for the first time by CarBuzz, April 14th 2016

FUNDAMENTAL HUMAN NEEDS

Mobility is a fundamental human need. It's enshrined in the basic human right of movement and even in the freedom of expression. As digital natives living in urban climes, we can easily be fooled into thinking that a golden age in mobility is dawning. Many experts have already claimed that driverless cars will be the biggest revolution in mobility since the automobile replaced the horse and cart.

We're living in a techno-optimistic age fuelled by car sharing apps, improved public transport, investment in cycling infrastructure and on-demand services like Uber. Furthermore, what mobility entails and who is entitled to it has changed over time, rightly or wrongly. At a time of disruption, we need to take a fresh look at what technology can make possible for people, for all people.

Is this a 'golden age' for everyone? What do people actually want and need from this revolutionary new form of transport? Is it inclusive enough? Does it cut across technological understanding, socio-economic statuses and so on? Uber locks out many older people who don't use smartphones, just as the first automobiles segregated the rich and the poor.

"The poor live downtown and the rich live in suburbs... transportation technologies play a crucial role in explaining this segregation. Because cars are so expensive, the poor live in cities so that they can use public transportation." [3]

Glaeser, Kahn and Rappaport
Handbook of Regional and Urban Economics: Cities and Geography

Do we want future transportation technologies to continue to segregate? With AVs, cars become public transport – and there is a real inclusive opportunity here. For this technology to be truly adopted it must be accessible to all people, from the technophobes to the tech savvy, from the disadvantaged to the very rich.

These are just some of the questions that prompted us to conduct our own research. We studied academic trials, attended auto shows, watched countless documentaries and read endless articles. But most importantly, we spoke to people – the potential early adopters, the frequent users, even the sceptics. People from different backgrounds, with different needs, different ambitions and unique opinions about their thoughts and hopes for the forthcoming 'revolution' of driverless transport.

"DRIVING FOR ME IS A POSITIVE ACTIVITY... IT KEEPS MY MIND FRESH AND ALERT."

Françoise, ustwo study participant

The insights we unearthed really opened our eyes to the many hidden and poorly-addressed needs that form this human barrier to the adoption of AVs. One such example is that of the relationship between driving and the elderly population. Driving is a complex task that requires a variety of skills, including physical, cognitive, behavioural and sensory-perceptual abilities. Declining health through age may force the elderly to stop driving and surrender their driving licenses (in the UK, driving ability is tested every three years for people over 70).

ustwo study participants
Some of the great people we observed thoughout our research

Studies have shown that giving up driving can have a significant impact on the quality of life for older people. Driving Cessation and Health Outcomes[4] in Older Adults published in the American Geriatric Society reported that driving cessation was associated with declines in general health and physical, social, and cognitive function and with greater risks of admission to long-term care facilities and mortality. A meta-analysis based on their pooled data from five studies examining the association between driving cessation and depression revealed that driving cessation almost doubled the risk of depressive symptoms in older adults. Could improved mobility afforded by AVs thus alleviate some of the strain felt by bodies like the NHS who care for such people?

Mobility is crucial to the older people we spoke to, particularly to Francois and Darret (you can read more from their interviews later). You would imagine then that these driverless cars could truly benefit this population who are no longer able to drive and so have a decreased opportunity for mobility. Is this demographic even being considered in the development of the technology? Would the elderly actually feel comfortable getting into a vehicle without a human driver? What would they miss? What would make them feel more comfortable? Our research highlights a challenge whereby the elderly may not legally be able to drive, yet would be too scared to enter a driverless car. In addition, they could also suffer emotionally and even mentally from the loss of human interaction many isolated people enjoy from the likes of taxi and bus drivers. We've heard stories about cars being considered as 'pets' – an area in which the driverless car could really help.

We also spoke to disabled people and wheelchair users, who told us of their need for discreetness and the independence to do as they please, without relying on others. One London-based wheelchair user in particular told us of his discomfort when buses have to take extended stops for him to board and for the bus to lower and extend a ramp, all the while emitting a "beeping" sound. Hardly discreet. The bus layout even dictates that he must enter from the middle of the bus, where the ramp is fitted, rather than the front of the bus as able-bodied people do; a clear physical segregation. This human need, not for physical accessibility, but for integration, discreetness and independence must be considered in AVs, or a poor user experience will surely result.

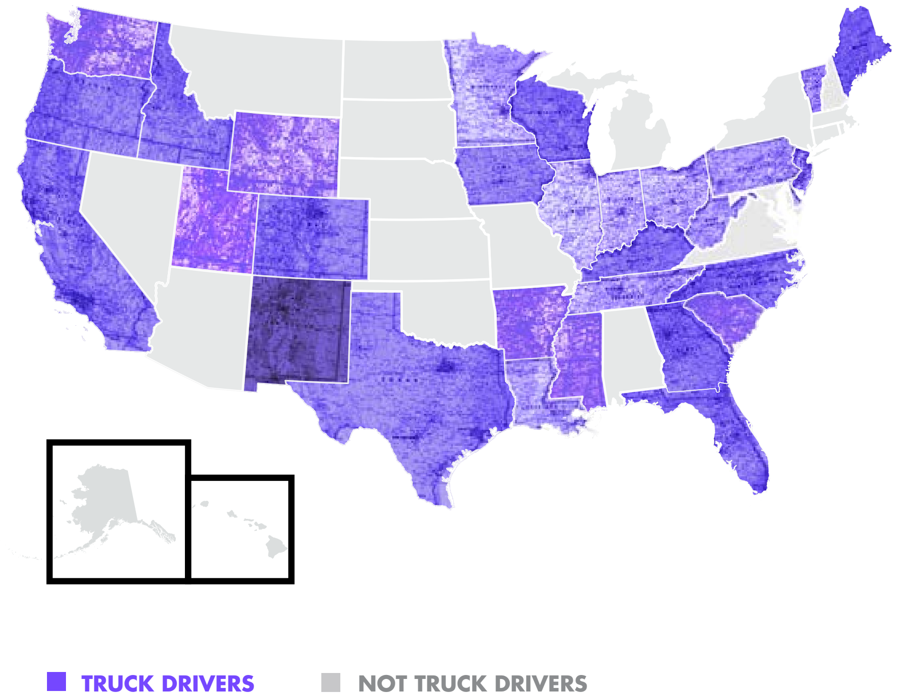
Take this wheelchair ramp for example:

Wheelchair ramp

This accessibility ramp was built after the building had opened. You can imagine that when the first few people climbed the steps to reach the entrance of the building, they thought the job was done. Then a wheelchair user approaches – and can't enter the building. The architect then designs this snaking accessibility ramp to solve the problem. Sure, it functions – the wheelchair user can now enter the building. However, this solution has not taken the need for discreetness or integration into consideration. Much like the bus ramp anecdote told by our London resident, this ramp effectively segregates the wheelchair user from the able-bodied user; able-bodied users would enter from the steps on the right and wheelchair users enter from the ramp on the left. This is both segregating and indiscreet. Our study participants in Singapore and Mumbai talk of similar segregating retrofit solutions for those with disabilities within their transport networks. If the architect had considered these user needs from the beginning, they may have simply designed a ramp rather than a set of steps, which both able-bodied and wheelchair users could use to enter the building together.

"As autonomous vehicle technology improves, it's easy to imagine a world where these vehicles have no need for a human operator. This would leave the following people jobless: 180,000 taxi drivers, 160,000 Uber drivers, 500,000 school bus drivers, and 160,000 transit bus drivers, for a grand total of 1 million jobs (US)." [5]

Joel Lee
Self Driving Cars Endanger Millions of American Jobs (And That's Okay), Make Use Of



Most common job per US state, 2014
Data: NPR
Graphic: ustwo

There are other issues that go beyond the needs of the individual – the social and societal implications of the advent of autonomy. For instance, technological unemployment and its effect of shifting job markets to other fields or in the worst case, the dissolution of labour forces to make way for machine infrastructure. Are societies prepared for what AVs might bring in terms of jobs and also, perhaps more importantly, take away?

Daniel Susskind, from the economics wing of the University of Oxford writes in his probing paper A Model of Technological Unemployment[6] about the well-recognised difficulty of accurately forecasting the future capabilities of machines.

Susskind says that the 'task based' approach of forecasting machine capabilities and its effects on the labour market is flawed, since those tasks are ever-changing as technology progresses. For instance, Autor et al noted in their 2003 paper *The Skill Content of Recent Technological Change: An Empirical Exploration*[7] that the task of driving a car could not be readily automated, but then a type of driverless car appeared just two years later[8]. Autor also noted that order-taking and table-waiting could not be readily automated, but later that year the US restaurants Chili's and Applebee's announced they were installing 100,000 tablets to allow customers to order and pay without a human waiter. We are perennial underestimators of technological progress and its effects – both a sobering and worrisome thought.

The widespread use of driverless vehicles, from cars, taxis and even trucks would not just affect people in driving related jobs – the ripples will be felt in other sectors too, like healthcare and insurance. For instance, insurance costs might increase for driven vehicles without driving aids or autonomous features. Similarly with costs for healthcare – driving per se could be viewed as a dangerous activity and might increase health care premiums (which is already the case for skiing or motorbiking).

The uptake of driverless vehicles is happening in other industries for financial and operational reasons. For example, Suncor Energy Inc last year announced that it would buy autonomous trucks from Komatsu Ltd for its oil-sands operations. Chief financial officer Alister Cowan said its plan is to move to an "autonomous truck strategy, which we should have fully implemented by the end of the decade."[9] He added "That will take 800 people off our site… At an average [total cost] of a few hundred thousand per person, you can see the savings we're going to get from an operations perspective."

Additionally, new, high-skilled technology jobs (software experts) may replace low-skilled driving jobs (bus drivers)[10], says Barrie Kirk, co-founder and executive director of the Canadian Automated Vehicles Centre of Excellence (CAVCOE). Kirk expands that "from an economic point of view, I think it'll all be fairly neutral, but that's no comfort at all to the individuals who will lose their job… I'm a realist: it'll be very challenging to take a 50-year-old bus driver and retrain him or her to be a software developer. There's a tragedy there in the making and there will be social unrest." With that perspective, this decision for movement in jobs has been met with disapproval from the mining unions in Australia's Rio Tinto, who disagree with the economic and social benefits of autonomy as put forward by companies. In their view, the net result would be the loss of high-paying jobs and the introduction of mundane desk jobs for a highly skilled workforce. The ripple effects of autonomous workforces are already being felt beyond everyday traffic on the roads – how long till it affects everyone?

"The facts are workers will suffer significant losses as a result of this… It will be job losses and losses in income." [11]

Brian Fisher
Managing Director,
Australian Mining BAEconomics

Meanwhile, India's transport and highways minister has already responded to this challenge of losing jobs[12] by saying: "We won't allow driverless cars in India. I am very clear on this. We won't allow any technology that takes away jobs." This is a bold but human sentiment, especially in a nation where widespread unemployment exists. But will it affect technological development and can the country continue to stay relevant in terms of vehicular innovation? Won't AVs reduce accident risk and improve safety in a country rife with accidents? Only time will tell.

In order to probe this societal aspect of AVs, we have also spoken to people in driving-related jobs such as driving instructors, Uber drivers, and black cab and taxi drivers whose livelihood is based on both technology and their knowledge of the streets, the people they drive about and the regulations governing them.

Look! No driver!

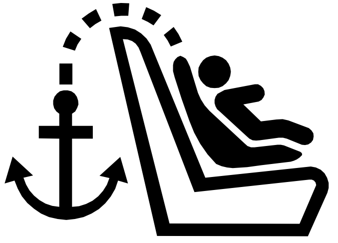
We've asked for their point of view on the nature of their present jobs and how they would change in the near future with an increased adoption of AVs and the changing nature of cities and technological infrastructure around them.

"YOU NEVER KNOW WITH TECHNOLOGY... SOMETHING LIKE THE SMARTPHONE MIGHT COME ALONG FOR CARS AND I WILL NOT BE A DRIVING INSTRUCTOR ANYMORE – THEY WON'T NEED ME."

Ghulam, ustwo study participant

Professional drivers, tech-savvy young professionals, children, the elderly, people with disabilities, driving enthusiasts – these are just some of the people we listened to and explored ideas with in an attempt to break through the insular and singular lens we as digital natives can sometimes be trapped inside. It's this same singular lens that the automotive industry needs to break out of in order to identify the needs, desires and thoughts of real people. And it's real people's thoughts that we will echo and use to direct the conversation throughout our upcoming book.

So what did these people have to say? What follows is a summary from a selection of our user interviews, some of whom we also shadowed, which inform the basis of our approach and thinking throughout the book. We are indebted to these insightful people who generously spent time with us and who were such great sports in our conversations.



ISO 2.07
Child seat upper tether anchor

RICK
41

RICK FISH, 41
CTO IN LONDON

ABOUT RICK

We met Rick a year ago in a Tesla Hackathon he organised for enthusiasts of what the car and company had to offer. He graciously took each team there on a ride in his P90D, showcasing the acceleration and Autopilot. It was a revelation to us and we had to invite him to talk to us again. This time he brought along his Model X to a leafy part of Shoreditch in London and spoke to us from within the car itself. Rick is a technologist, a founder, a father and an optimist about everything technology might bring to people and the environment. He bought one of the first Tesla Roadsters (one of the first 2,500) and has since owned three Tesla vehicles over the years – following the company's and the EV world's transformation.

His insights really helped us get into the mindset of a driving enthusiast, one that has had some real-world experience of the beginnings of semi-autonomous driving and who is not afraid to be in the frontline of exploration and living with technological progress, while being in touch with the reality of living and commuting in a large metropolis with a family.

RICK'S IMPRESSIONS ON USING AUTOPILOT OVER THE YEARS

Being the technology enthusiasts we are, we skipped the formalities and jumped straight into asking about the magic Tesla Autopilot we've heard so much about.

"The car is always scanning and following things around and you kind of trust it really to inform you of dangers, but you should have your hand over the wheel, which is the official stance. But if an event happens in the car like – if a kid spills a drink or something and you are slightly distracted it's nice to know the car is always there and it's got your back, following the lines and making sure it's safe. It frees you up to deal with those incidents. Reduces accidents through distraction."

Rick is gesturing to the front, to the back, to the side – all around the car as he describes his experience with Autopilot. We could almost see the driver becoming the passenger right in front of our eyes, the semi automation in his Tesla freeing his cognitive load to deal with secondary tasks but also completely un-driver related tasks.

“It took away the minutiae of travelling. While [I] drove skiing to the alps with my family, 95% of journey on French motorways was the car driving itself – while we were monitoring the environment and such, the small driver movements were taken care by the car. When you are driving over 12 hours that means you are less tired.”

"I WANT TO BE EXCITED BY IT, TO BE GIVEN SOMETHING I HAVE NEVER THOUGHT ABOUT, HAVE THE CAR DO THINGS THAT OPENS UP OTHER SERVICE CAPABILITIES AND YOU KNOW, EXCITE ME. MORE SO, BY THE TIME MY CHILDREN ARE OF THE AGE THAT THEY CAN DRIVE, I WOULD LIKE TO HAVE THE OPTION THAT THEY DON'T HAVE TO DRIVE – FOR ME AS A PARENT THAT SAFETY FACTOR TO KNOW THAT IF MY KIDS HAVE TO GO OUT, THE CAR HAS THEIR BACK... PROTECTING OF THE FAMILY IS QUITE A GOOD OUTCOME."

RICK'S THOUGHTS ON FULL AUTONOMY COMING INTO VEHICLES

Enough of this semi-autonomy lark! Rick's vehicle is, mechanically at least, capable of full autonomy. If Tesla were to a push a software update over the air and his car was fully autonomous overnight, we wondered how Rick would feel.

"I've always enjoyed it [driving] and I don't think driving should be taken away from me. Full Level 5 autonomy – I see the value of that for a city – it brings forward mobility strategies and opens up a lot of opportunities, but for personal vehicles I would still like the enjoyment of driving, never want the driving experience to be taken away from me."

Our shared excitement for the technology, which clearly shown on our faces, soon turned to a sense of caution when we discussed the potential pitfalls that inevitably follow the giddy highs of the technology.

THERE'S ALWAYS A CHANCE OF REGRESSION, THERE'S A CHANCE YOU WILL BUILD TOO MUCH CON DENCE IN THE VEHICLE – YOU WILL BECOME TOO USED TO AUTONOMY AND THEN COMES A SITUATION OVER TIME THAT WILL SHOCK YOU AND WHERE YOU THINK YOU MIGHT HAVE DEALT A BIT BETTER (YOU NEVER KNOW).

"So if you get to point where I trust the car completely, where I don't touch the steering wheel and the car does something, oversteps a mark and as a family man I came across a scenario where somebody got injured as a result of that – I don't know how I would feel".

Rick then went on to talk about ethics (see Morality and Ethics for an in-depth discussion) and other problems such data privacy, which while he understands has potential for harm, he seems to feel somewhat comfortable with.

"I think it's ok, I can see why people can be uncomfortable with that is that data being used for insurance, how much can be subpoenaed and taken away. From the privacy benefit, Tesla say they anonymise data they store and I am ok with that for the value if offers me… value exchange is key."

NEW OPPORTUNITIES FROM AVS

Tesla's Master Plan Part Deux, of which Rick is very familiar, describes a potential for Tesla owners to allow their cars to be added to a fleet of shared cars for their own financial gain, or to offset their travel costs. We're a little sceptical of such a service, so we were keen to hear Rick's thoughts on the matter.

"Already when my kids leave a pizza box in the car I get upset, so I really don't know how I'd feel about that… So until I test them I don't really know, though I would be pretty upset about that. <laughs >"

"In sharing systems, the vetting of the individual or the trust aspect of seeing that an individual has shared many cars and have good feedback – so you are really moving into the trust aspect of the person you are giving the car too. Only if that's in place it is worth taking that step of sharing the car."

Rick did, however, bring up an interesting point that makes an argument for AV ownership, where most believe the technology will flourish mainly in the car sharing space: "You're earning a revenue stream from your vehicle, that others are using and it's almost, you know, offsetting the original capital cost of the car… to make car ownership an actually more attractive proposition."

And that's not the only opportunity Rick sees with AVs. In an answer to a problem we put forward at the top of this section, Rick imagines many possible new opportunities from this technology.

"I can envisage loads of different services being needed, you know. Again on the technology side there's going to be a huge amount of discovery apps, you know some of these sharing platforms, management of those sharing platforms, legal-type cases. It shifts the emphasis into other types of industries that will either receive the benefits of that or, you know, have to adapt to kind of respond to the sort of changing job market, like in anything, just like when coal-mining etc kind of disappeared, you know – people had to retrain."

Rick sees great potential in the technology, not only for his own mobility needs, the safety of his family and his passion for driving, but also for the societal opportunities it may bring.

WANFY
26

WANFY, 26
POLICY MAKER IN SINGAPORE

ABOUT WANFY

We first met Wanfy (as she is known among friends) three years ago in Cambridge, UK while she was studying Politics, Psychology & Sociology. A highly knowledgeable young woman with a thirst for wanderlust and exploration, Wan is a rockstar - equally comfortable behind vintage cameras, driving and camping across America and debating complex socio-political topics on the fly.

We got back in touch with her after her Masters in Harvard University, while she is currently working for the Ministry of Society and Family development in her native Singapore, where she has spent most of her life. It was an opportunity for us to hear about driverless cars and autonomy from a truly global citizen, with a deep understanding of local affairs in South East Asia.

Wan told us a bit about her love for driving and exploration (which is limited in her home city), her personal viewpoints from her study and work across the world and about her needs and desires for mobility as a young citizen of Singapore. She also comes across as a keen observer of humanity and society in general, which serves her well with her work in policy making.
It is important to note that Wan's views are her own and not representative of the Singaporean Government.

Our conversation was an interesting one, Wan had just finished her work day and spoke to us from her home, which she got to via her usual journey on a commuter bus. So her mind was fresh with an everyday public transport experience - great for us!

WAN'S NEEDS FOR A VEHICLE

Before we began, we were keen to understand if the need for a car in Singapore was becoming as increasingly less feasible than it is in London.

“So I have a driving licence, but I don’t drive in Singapore because it’s really expensive to get a car. The reason being is that we’re a very small state, so taxation on the cars is very expensive. It’s a way to moderate the number of vehicles on the road, so the cost of it is actually moderated by the number of vehicles.”

A somewhat similar situation to London then. Despite these inconveniences, Wan does miss driving.

"YEAH, I WOULD DEFINITELY ASSUME THAT AUTONOMOUS VEHICLES WOULD BE ALREADY SAFE TO USE, BUT THAT'S ME SPEAKING FROM MY SINGAPOREAN HEAD! WHERE WE ARE SO USED TO THIS KIND OF COMFORT AND SAFETY."

“Yeah, I miss driving in the US because it’s really nice to travel there. You know you can see a lot of the state, you have lots of mountains to drive through, and there is the Big Sur in California and it’s absolutely beautiful. Driving in London - not so much! Because it’s quite painful actually haha! Fuel prices are so much higher as well. Yeah so, I mean in Singapore there’s congestion every time, I really don’t see the need to drive at this stage so I don’t miss it that much. It’s a small country - I can get everywhere I need, you know, by bicycle. But there is a Volkswagen Camper though, that I am very tempted to get!”

Mixed emotions then!

WHAT DOES WAN THINK OF AVS?

Wan is very tech savvy and always has an ear to the ground to new technologies and the various others factors that could have an impact on her city, so we were keen to hear her thoughts on AVs.

"Actually, all trains in Singapore are driverless. You know it's funny because, I think when the driverless trains came out it was not reported in the narrative of media at all. So, I think it was not put into the consciousness of people taking the trains… I think people did know that it was not, you know, run by real human beings. I mean there are actually human beings in the control station, still monitoring the vehicles but not, not really piloting the train, so I think there was not much discussion about it being driverless at all. Definitely not! But the experience of it, is great you know."

Wan goes on to tell us how reliable the technology is in Singapore and regails us of us a fascinating incident that got the experts stumped.

"Recently there was a chain of train breakdowns in Singapore and it's very rare and I think the Transport Ministry didn't really know why!"

"There was a huge team, I think of 150 people mobilised to figure out what is wrong with the train system, and why it kept breaking down at certain times only and they managed to find this one train that was emitting this rogue signal and stopping all the other trains in the system. So I think because you could just look at the system and see ok, this is the train causing the problem, and the fact that how we reacted to trains breaking down you know in London, in the US, trains break down, trains catch on fire all the time, it's common… but here you know one train breaks down and everybody goes crazy!"

"My personal opinion is that it's as close to perfect as we could be. I think if there were human beings operating it I think the chances of train breakdowns or train delays are a lot higher."

IEC 60417-5210
Speak, voice activitation

"THEY GO APE-SHIT, THEY THINK THE WORLD'S ENDING! SO I MEAN, APART FROM IT BEING AN INTERESTING REFLECTION OF SINGAPORE SOCIETY AND THE ISSUES THAT WE ARE CONCERNED WITH, IT ALSO SHOWS THAT DRIVERLESS SYSTEMS ARE NOT... ARE NOT PERFECT!"

It's fascinating to hear how trusted the transport network is in Singapore, because of it's reliability, whereas the opposite is true in places like the UK and India. Trust in the system seems to be an important factor to the successful adoption of the technology in Singapore.

WAN PONDERS WHAT IT MEANS TO BE MISSING A DRIVER

Given Wan's optimism and acceptance of autonomous vehicles already, we wanted to know if there was any downsides she could foresee to a driverless car or taxi for example.

"Well, if I were to ever sit in a driverless Uber or Grab or some form of taxi, I think I might miss, you know the occasional 'Hi, how are you?'. You know the occasional surprises that you get from Grab drivers or Uber drivers. There was one that gave me a pen, you know some people give you really great conversations. Ah that's it! You could programme a driverless vehicle to engage in conversation. To be honest some days I just go into either Uber or Grab, and I don't speak to the driver so that's very rude of me but some days you know you just want some down time."

"I would assume that if I ordered it through my phone, I would do so through my phone. I am assuming that but you know I've never sat in a driverless vehicle before I don't know. I don't really know how it works. I always place too much trust in the driver to suggest the route because that's their profession. Sometimes I place trust, too much trust on them because they take the wrong route but you know it's a trade off, right?"

These sentiments speak to some very interesting 'human touches' or human behavioural nuances that can both make and break a taxi service experience. Designing a driverless experience that takes the good and leaves the bad of human driver behaviour would be a great thing to achieve.

"In terms of music you know I would be able to select it on my own. Yeah but I mean these are interesting questions, I hadn't really considered them before."

Some of Wan's work in her job in the Ministry deals with policy making, with the lens of inclusivity. Based on her experiences within and the general lifestyle in Singapore, she has some poignant views on inclusivity within public transport.

WAN'S THOUGHTS ON FREEDOM OF MOVEMENT

Wan's viewpoint is that her city's transport system is inherently inclusive, with provisions for the vision impaired and elderly etc. But there is still a significant impact needed to be made in public consciousness and the stigma associated with disability. Something she thinks will take time.

"I think in many ways it would enable persons with disabilities or people with autism, if they could pick the driverless technology. And know that they're not annoying anyone including the driver. I think that gives them a sense of empowerment. You know there isn't a stigma, they don't have to worry about what the driver is thinking it gives them a lot more choice to travel if they needed to."

"I think within Singapore as well, there is a limited number of vehicles that are equipped to take persons with disabilities, I'm not sure what the current situation with people with autism is. But surely I would assume that I don't see many autistic people on trains or on buses, it means that a lot of them take private transport.

Either through vehicles that, you know, their family owns, or either through taxis for instance. But even when they take a taxi, that's operated by a human being, you know, there could be some form of stigma, there could be a fear that you're irritating someone else who doesn't understand what's going on in your mind. So I think in some ways it could promote inclusivity but the caveat would be that it creates an insular kind of inclusivity right? It creates the inclusivity within the community itself, say the autistic community, but not so much of broader social inclusion, so I think that's problematic.

But just allowing persons with disability or allowing people with autism more choices, more freedom to move, I think that's positive.

Wan brings up a fascinating point. Autistic people often feel insecure around others, fearing those people may get frustrated by their behaviour. Seeking private transport for that reason does not allow them to integrate into society and can therefore make them somewhat isolated. How can a shared driverless bus, for example, accommodate these people and eliminate their insecurities?

IEC 60417-5210
Speak, voice activitation

WAN'S THOUGHTS ON PRIVATE AVS

Wan mentioned the case of a serious accident on Singapore's train lines when people working on the tracks were killed. Young engineers died and resulted, causing public outcry and blame. But Wan still feels optimistic about autonomous transport systems and vehicles for individuals.

"I mean I could definitely see it being legislated, regulated in Singapore but I speak for my own opinion, I don't know what the Ministry of Transport is doing on this front. But we have proper roads, I don't know how it would be piloted if it's ever piloted but I see it, as a positive aspect towards inclusivity in Singapore, mobility for persons with disability, mobility for people who are unable to drive, cos of age or, you know, being visually impaired."

"It would be accepted because it would lead to an inclusive society which is one of our narratives. You know for the next few years, inclusivity for persons with disability or for the elderly, because we face a huge ageing population in the future... that means a lot of people will not be able to drive, so it puts a lot of potential to explore diverse technology for elderly people so on that I think society at large would accept it."

"Whether or not there would be huge questions on things like personal autonomy and safety - I think that there's enough trust in the state to do its proper regulation and this is where it's interesting because if you think about Singapore society, we are a paternalistic society."

It's great to have some opinion on policy and regulation from someone in the industry. We were keen to hear more from Wan on this topic.

WAN'S THOUGHTS ON POLICY FOR AVS

"When the first driverless train came along people just accepted it, actually people welcomed the fact that there were more trains being introduced to the system. Back to driverless cars, yeah I do think society will accept it. I do think it will also come at a huge cost. I think the state will be extra cautious as with many of the things that we do, regulations would have to be put in place."

"I do think the state or the Ministry of Transport will wait and see if there is sufficient precedent in overseas examples, and weigh the pros and cons, and ensure that there's appropriate legislation to govern the use of these vehicles."

"SO I THINK IT'S STILL VERY UP AND COMING AND AN EXCITING SPACE TO EXPLORE OVER THE NEXT FEW YEARS!"

Wanfy's thoughts on inclusivity, especially for autistic people, really opened our eyes to more of the human factors that need to be catered for. It was also enlightening to hear of her interest in the policy making that go into ensuring the safety of such technology.

In Singapore, the public transport network is trusted and already autonomous, therefore Wan trusts autonomous vehicles and looks forward to the day of driverless cars, as long as they are inclusive.

DARRET
74

DARRET, 74
RETIRED TEACHER IN LONDON

ABOUT DARRET

We met Darret in her colourful home at Camberwell in South London. Originally from Jamaica, her initial shyness and hesitation in speaking to us evaporated with a few minutes of playful banter. As someone with serious mobility issues as a result of back problems due to the arthritis she has had since the age of 12, Darret walks with crutches and uses a mobility scooter for short trips to the shops. Her husband, Bill, passed away several years ago, so she now lives alone, but is surrounded by pictures of loved ones and posters of Usain Bolt and the Jamaican track team.

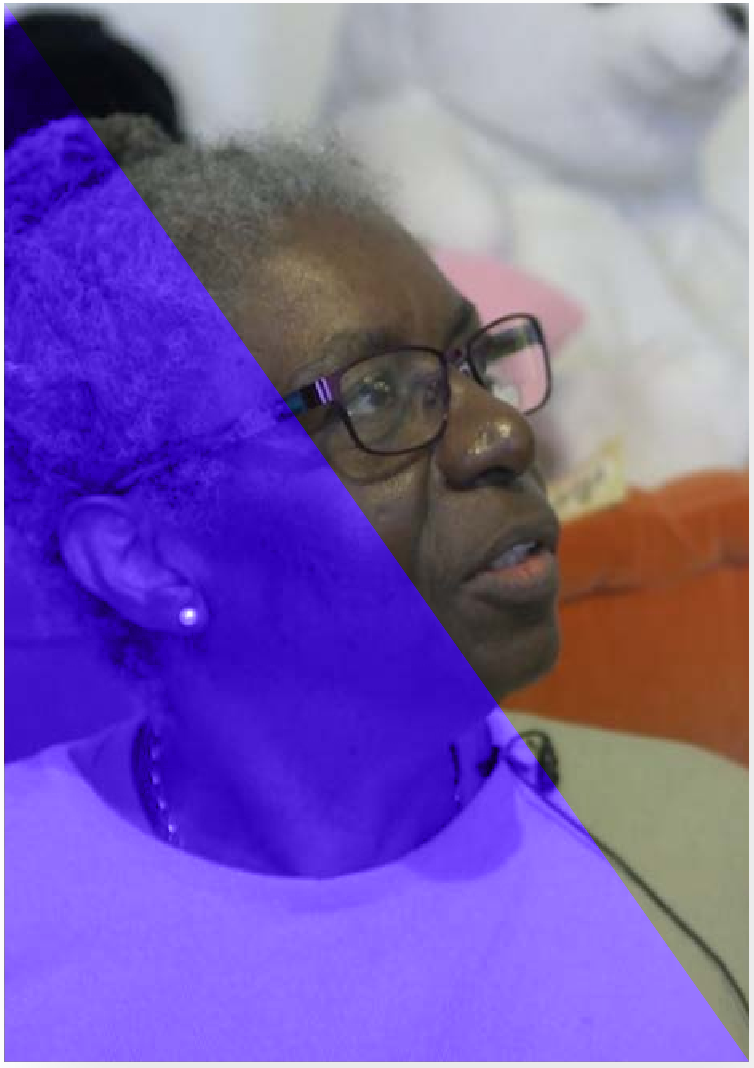
Speaking to Darret helped us understand people's need for both mobility and companionship – even small moments of conversation are important, like speaking to a taxi driver. Companionship is something she values highly and this reminded us that the emotional aspects surrounding mobility experiences should not be forgotten in pursuit of technological progress.

Darret exuded both fragility and independence in the same vein. She's someone who's taken every aspect of life, both good and bad, with a smile and a story to tell, which made for a great conversation.

DARRET'S MOBILITY SCOOTER "BILL"

After the ice had been broken, we were keen to understand Darret's core mobility needs and how she gets around.

"I use crutches, two crutches. For life; without them I can't walk," she said. Darret has had her mobility scooter since 2009. "The Scooter – it helps me when I do small amount of shopping. It helps me because of my back – I've had arthritis since I was 12 years old – it starts hurting. I've also had hip replacements."



Her disability not only affects her mobility but often also has an impact on her day-to-day life, despite her saying otherwise.

“I cannot cook everyday and cook once a month, portion it and put it microwave – again because of my back. I have problems only with mobility. Last year my consultant said I would need crutches for life.”

"I LIKE TO COMMUNICATE WITH PEOPLE. SOMETIMES YOU ARE NOT IN THE BEST OF MOODS AND SOMEONE TALKS TO YOU, IT LIFTS YOU UP... WITHOUT PEOPLE I WOULD PANIC."

In the corner of her living room sat a very colourful mobility scooter which looked to have been decorated and personalised by Darret. Darret spotted our curiosity.

“First one I get it through mobility allowance, but then I was having problems with first one. This one I love it. It is my friend. I don’t have a name for it, but I would call it ‘Bill’ after my husband. Anything I do I name it after him. Everything is just Bill. He was a big part of my life. I will always miss him. I will always remember him.”

“In church even if they don’t see me, they see the scooter and know it’s me.”

"IT (HER MOBILITY SCOOTER) HELPS REALLY. IT MEANS A LOT TO ME BECAUSE EVEN IF I AM IN PAIN, I CAN USE IT. ESPECIALLY WHEN IT'S WINDY AND I AM GOING TO THE CHURCH SOMETIMES. I DON'T FEEL LIKE GOING OUT BUT I CAN SINCE I HAVE THIS. IT IS PART OF MY LIFE. I'VE EVEN DECORATED IT."

Bill
Darret's mobility scooter

It was interesting to hear how she considered it a part of her identity, a part of her life and the freedoms it gave her, similar to how a new driver may take pride in their car for those same reasons.

DARRET'S EXPERIENCE WITH BUSES AND TAXIS

Darret uses her crutches around the house and her scooter for shorter trips in her local area. If she has to go further, to visit her late husband's grave for example, she uses taxis and buses. She was keen to describe her troubles as well as the cherished moments of joy she experiences on public transport.

"Getting into a bus is difficult – for me to get into the bus, the driver puts the bus down, I try to put crutches inside and try to get in. It is painful."

"Buses are sometimes annoying – you never know who is going to be next to you or who is coming to you."

During our time with Darret, her opinion of bus travel changed from negative to positive. Darret described some instances where she had negative interactions with people and yet also some incredibly positive ones. We realised the source of the contradiction – she enjoys those journeys where she has positive interactions with people and dislikes those involving negative human interactions. The people around her matter a lot to Darret and her mobility needs.

"I prefer cabs – you do not have to interact with drivers a lot and they are also very nice and helpful. I have a special card from the council."

Darret uses the London Taxicard which gives London residents with serious mobility impairments or who are severely sight impaired reduced taxi fares, so financially it makes more sense to her.

"I have a good conversation. To be honest I would not like robot drivers, when I see this programme on robots in TV – I like to communicate with people. Sometimes you are not in the best of moods and someone talks to you, it lifts you up. Without people I would panic."

DARRET'S MOBILITY AND COMPANIONSHIP NEEDS

As young professionals working in London, we're used to commuting into work in silence, trying our best not to bother or be bothered by anyone. It was thus eye-opening when Darret spoke of the human interactions she enjoys when travelling around town.

"Sometimes you are going through a difficult time. Maybe you wake up and you're not feeling… that… and especially when my mind reflects back on [her late husband Bill], as I say I miss him, and sometimes my mind does reflect back on him and then that day it's as if I'm a changed, completely changed person because for that day I just vision him and how he would make me feel and so when somebody comes, you know any person will, talk to you… it kinda lift you up."

Darret's mobility needs go hand-in-hand with her need for human interaction and companionship. A driverless car would not be able to support either her mobility need to exit the vehicle safely, nor her need to converse with others.

"I LIKE THE DRIVERS WHO COMMUNICATE. HE HELPED ME OUT WITH STEPS AND MY CRUTCHES. HE TOOK ME RIGHT AT THE PATH I NEED TO GO. NORMALLY WHEN I GO THE CEMETERY I GET VERY EMOTIONAL AND HAVING A GOOD TALK HELPS ME. I APPRECIATE THAT."

DARRET'S REACTIONS TO THE THOUGHT OF DRIVERLESS VEHICLES

We assumed that driverless cars would be welcomed by Darret, who is no longer able to drive herself. We thought that a driverless car would give her that independence she enjoys without having to be bothered by strangers she doesn't like. We quickly found that it wasn't at all that simple.

"A driverless car – I don't think I would… I donna …I donna…. I would panic. To be honest, I don't know. But if I had no choice. Maybe."

"I did not know that thing [London's driverless DLR train network] was driverless. Next time I would not go. <laughs> Just thinking about it makes me panic. But I will try it again and see the front part of the train to see it is actually humanless. <laughs again>"

"When I see this people trying to make this computer things human in the TV to help people with housework. Is it real? I don't know. I say what? I can't have robots coming into my house – I can get a person to do it… Maybe I will not be here, when it really happens. When it's not a human being, I would struggle."

For Darret, there is certainly more to transport than simply getting from A to B.

YEVA
6

YEVA, 6
LIKES UNICORNS IN LONDON

ABOUT YEVA

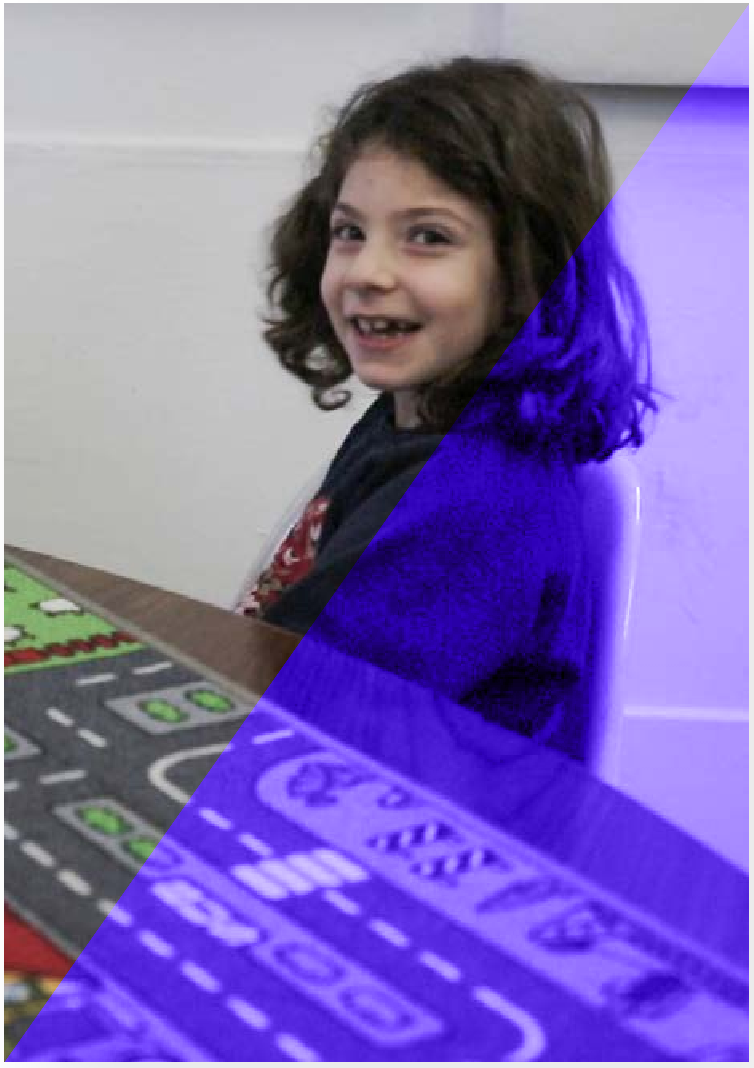
Yeva is an incredibly bright kid whom we expected to have little knowledge of autonomy and the existence of driverless cars. But in fact she knew quite a bit about this new technology, having first caught sight of a driverless car in children's UK TV show, *Newsround*. It was a driverless truck that she saw going around a city and she understands that there is no driver involved.

Yeva blew us away with her knowledge, curiosity, rampant creativity and her keen interest in morality. As she played a little game with the cars we placed out on a mat in front of her, her narratives about the game surprised us. They were imaginative descriptions of a kid's expectation of a machine driver – both good and bad.

YEVA IS NOT A FAN OF AVS

As we were setting up our interview with Yeva, we chatted about what adults are like at driving; Yeva has a lot of faith in adult drivers. We asked her if she would want to drive when she's an adult.

"Unless it was pink and it had lots of things inside like a disco ball and stuff. Maybe it could have like this wardrobe with all the pink clothing so if you spilt some coffee on yourself you could change… or you could be boyish."



We were keen to get her thoughts on cars without adult drivers – driverless cars. “Would you buy one?” we asked her.

“No! Because it would basically be more expensive.”

“I wouldn’t leave (in a driverless car) without them… I would never, ever, ever leave without my parents… I am TOO SCARED.”

"BECAUSE IT'S A DRIVERLESS CAR, YOU'RE NOT DRIVING IT AND I WOULDN'T TRUST IT. I SOMETIMES DON'T EVEN TRUST MY PARENTS! AND THE THIRD THING IS I'D BE SCARED THAT IT WOULD CRASH… AND THEN IF I HAD A KID IN THERE… I WOULD BE VERY, VERY, VERY SCARED. THEY MIGHT DIE."

"UNLESS IT WAS PINK AND IT HAD LOTS OF THINGS INSIDE LIKE A DISCO BALL AND STUFF. MAYBE IT COULD HAVE LIKE THIS WARDROBE WITH ALL THE PINK CLOTHING SO IF YOU SPILT SOME COFFEE ON YOURSELF YOU COULD CHANGE... OR YOU COULD BE BOYISH."

Disco Bus
by Marisa Jensen
Year: 2040

"The driverless car lends itself very naturally as an extension of the home or workplace. Removing responsibility and focus from the driver frees them up to prioritise social, leisurely or productive activities while remaining in a private space. The age of autonomous vehicles often conjures images of quiet, serene privacy pods gently shuttling us from home to office.

But what about the transformation of less private, multi-person vehicles? What are we doing when we're relaxing in larger groups? What happens when social barriers, authority figures and logistical complications (eg intoxication) are removed?

Hedonistic activities could be taken on the road. Some may cringe at the thought of disorderly party animals being further enabled by technology, but pleasure-seekers will always exist, and night owls always need a ride. There are opportunities for driverless revelling to accommodate a relaxed atmosphere as well as create a sustainable, comfortable and safer environment for everyone."

JACUZZI ZONE

- Fully recycled water filtration
- Temperature and bubble control
- Solar powered lighting
- Plants combat air pollution and reduce background noise

CHILL ZONE

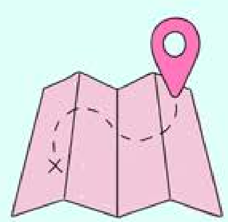
- Spill-proof textiles
- Massage seats
- 'Tap and serve' on-demand cocktails

BOOGIE ZONE

- Sound proof padded walls
- Floor lined with kinetic steppers to power bus
- Disco swing generates ceiling fans

APP INTEGRATION

- Tap on / tap off when entering and exiting the bus
- Head Count: alerts for missing persons + GPS signal
- Stay up to date and edit the itinerary
- Find My Party: track bus location
- Anti 'Ex-Texting' restrictions
- Timed pick-ups and drop-offs
- Alerts for each party member delivered home safely



NAVIGATION

- Party Planner: vote on where to go next
- Algorithm optimises itinerary according to:
  - venue capacity/waiting times
  - venue hours
  - entry fee
  - music / theme / atmosphere
- Sunset / Sunrise Seeker
- Kebab-Finder

MUSIC

- Each zone has it's own sound system
- Que songs collectively via the app
- Match music to mood, genre, or driving tempo
- Live stream sets from venues on the itinerary

YEVA'S REACTIONS TO SEEING A CAR WITH NO DRIVER

It was funny how Yeva's imagination of driverless cars was always from the perspective of an observer, as if she couldn't possibly imagine herself in one. How would she feel then if she saw a car with no driver?

"[I'd be] a bit shocked. If it was driving better than me, I would be even more shocked and I would just look at, stare at it and I might crash."

Even when we asked her who's fault it would be if her car crashed, she still imagined herself as the driver, witnessing a driverless car.

"IF I SAW A CAR NEXT TO ME THAT WAS NOT DRIVING. I WOULD STARE AT IT AND I WOULD CRASH MYSELF, SO THAT WOULD BASICALLY BE MY FAULT."

YEVA AND USTWO PLAY A GAME

We set up a game for Yeva, so that we could get an insight into how she thinks an AV would behave. We asked her to pick a car, imagine it was driverless, and then gave her a route to follow on the cityscape printed on the mat. We pointed to the car she is playing with which is crashing into trees, into buildings and we asked her why.

"Because it's got no driver… woah. It crashed into a lot of trees, it broke the police station and it wasn't in the bus stop and it drove off the city. It went to Italy… hee hee hee."

Her car then sped towards a pedestrian crossing, so we asked her how she thought pedestrians would feel about that.

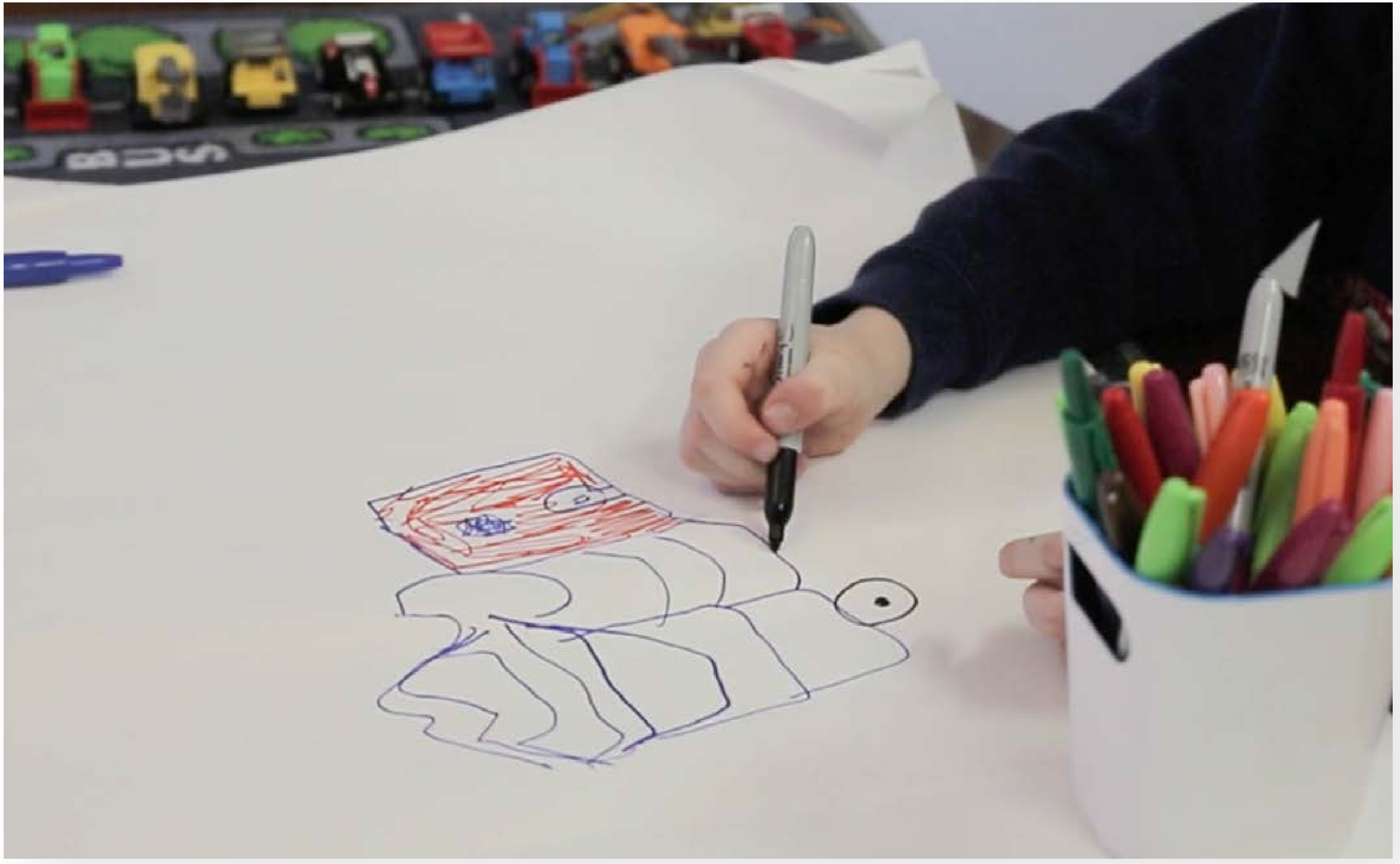
"Um… scared. I think it would just run or stay on the side." However, if the driverless car approached the crossing respectfully, she changed her mind: "I would just walk quickly before the light turned red like we normally do. If I was an old lady I would feel even more scared."

An interesting insight came when we asked her who's fault it would be if the driverless car ran a red light.

"The car's. It would be the car's fault cause there's no one driving. But if my Dad did it and the police saw it, well I'm pretty sure a policeman wouldn't put a six year old into jail. If it was my Dad then, I would probably talk to him." And if Yeva's Dad was asleep in the vehicle when it crashed? "Well, he would blame my Dad but it wasn't my Dad, he was asleep but sleeping is healthy – it's the car's fault!"

Yeva puts blame on the vehicle itself, which is actually a concept theorised by the likes of our friend Wendy Ju at Stanford University and something we discuss further in the Morality and Ethics section. We told you Yeva was bright!

While some OEMs proclaim that children could be among the early adopters of AVs, what we have found with Yeva and other children is that they are actually scared of the technology and would not want to ride in them as they currently understand them, and certainly not without their parents.



Yeva's imaginations of an AV

FRANÇOISE 73

FRANÇOISE, 73
RETIRED CURATOR IN LONDON

ABOUT FRANÇOISE

We met Françoise at her apartment in south London, which has great views over the city. She is 73, originally from France and a former antiques dealer with a shop in central London. A well-read, well-travelled individual, Françoise was a joy to speak to, with her wealth of life experience – her move from France, marriage to an Englishman and a shared love for the great outdoors – especially around Yorkshire. She spoke about her many drives around the moors and dales, which she still adores and misses today.

Françoise seemed very comfortable with technology, with three laptops – one in each room – a smartphone to talk to her family, and a surprisingly quick responder to emails. Technology helped her with her needs for connection and mobility and she seemed thankful for it.

Françoise drives a Nissan hatchback through the UK's Motability scheme[13], which enables her to use her mobility allowance[14] towards leasing a car, but she has to take a qualifying test for her license every three years given her age. She worries about losing her license and her ability to drive and move around. Her reasons were both functional and emotional – and heartwarming to hear.

FRANÇOISE'S NEED TO DRIVE

It means a lot to Françoise to be able to drive and this became abundantly clear almost straight away: "Oh it's really important, yeah. And now I'm 73 we have to take the test every three years... so yeah. It's because of where I live... you see? You have noticed? It's quite a long way from anywhere, and the bus stop – the nearest bus stop is for me too long a walk, you see so I couldn't live without a car."

Françoise seems to have somewhat of a love–hate relationship with the car, as if she enjoys the freedom it gives her, yet isn't too keen on the act of driving itself – at least in the city.

"I like having a car and I like driving but I'm not a fan of driving. I don't like to be dependent on anybody... I just want to do what I want to do when I want to do it!"

"Yes, for me driving is a positive experience. It keeps me alert and you know I couldn't do without it really because of where I live. I mean I am not for driving into towns and things you know but about driving in the the countryside and around here you know. I just couldn't do without it."

"I DON'T LIKE TO BE DEPENDENT ON ANYBODY... I JUST WANT TO DO WHAT I WANT TO DO WHEN I WANT TO DO IT!"

"I would be too isolated, without my car."

"Since I moved down here I'm quite isolated and even walking to the bus stop for me as a disabled person – I have a mobility problem – is you know, a bit of a problem, going to the bus without a car I would be really, uh.... it would be a problem."

"I'm not really interested in driving any distance, but locally I couldn't do without."

Françoise enjoys the freedom driving gives her and it's important to her to have that independence – yet the task of driving seems to be enjoyable only in certain contexts.

Talkie Toaster
Red Dwarf, BBC[15]

HUMAN DRIVERS VS ROBOT DRIVERS

Given our sense that Françoise enjoys the freedom a car gives her and her fluctuating fondness for driving, we were keen to see if driverless cars would be seen as an ideal proposition for her.

"No. No. I don't want to be in the hands of a robot! Ha, ha! It could be my age but I find it spooky. No, I like to be fully in control of my car. It keeps me alert as I said previously."

It's interesting to see how Françoise acknowledges the two as agents in her imagination; she's either interacting with a human driver or a robot driver, applying the same personification to the machine as she would to any human driver.

"I mean, I understand the marvel of the technology you know, ha, ha! I'd rather deal with human beings than machines!"

"It's quite interesting actually because every time I go out, there are some young people that are forever overtaking, sometimes from the wrong side you know. I don't know, would machines do things like that?"

"HUMANS NEED TO BE IN CHARGE OF THE MACHINE."

"I like washing machines and computers and toasters and whatever, you know, but not to drive the car. Driving the car it would be like taking the dog out as well, you know you kind of – to me the car is my friend."

We love this last sentiment. It reminds us of Talkie Toaster, the toaster from the sci-fi series Red Dwarf that has its own mind, constantly, and annoyingly, trying to sell you toast.

Machines with agency could be incredibly annoying.

BUT WHAT IF SHE HAD TO USE A DRIVERLESS CAR?

If Françoise one day failed her driver's license test, which she must pass every three years in order to keep her license, she admits she would be very upset. If the worst comes to the worst, would she consider using driverless cars?

"I'd be very upset. Very, very upset. Yeah… Oh I see! We don't need a licence for driverless car? Ah – that could be a solution. We'll see."

"I don't like doing these things [car sharing]. I want to do what I want to do, when I want to do it!"

Françoise enjoys the freedom driving gives her and it's important to her to have that independence – without the need to rely on anyone else. That said, we got the sense that her fondness for the driving task itself varied significantly depending on the context of the journey; long or short, city or country. It was also interesting to note that her attitude towards driving is that it is somewhat like a gym for the mind, keeping her mentally active and alert. But if one day she was unable to drive herself, then she might just allow that robot to take the wheel… maybe.

SAMUEL, 13
EMILY, 11
JESSICA, 9

SAMUEL, 13, EMILY, 11 & JESSICA, 9
SCHOOL CHILDREN IN LONDON

ABOUT SAMUEL, EMILY & JESSICA

Samuel, Emily and Jessica joined us one March afternoon for a chat about driverless vehicles. They came to us straight from a visit to the Science Museum in London, with their minds already open to and excited about future possibilities.

Although they are all from the same family, it was amazing talking to and playing with three very different personalities. Samuel is the thoughtful and quiet elder brother, Emily, the kind soul, and Jessica is the extremely shy, caretaker of the naughty.

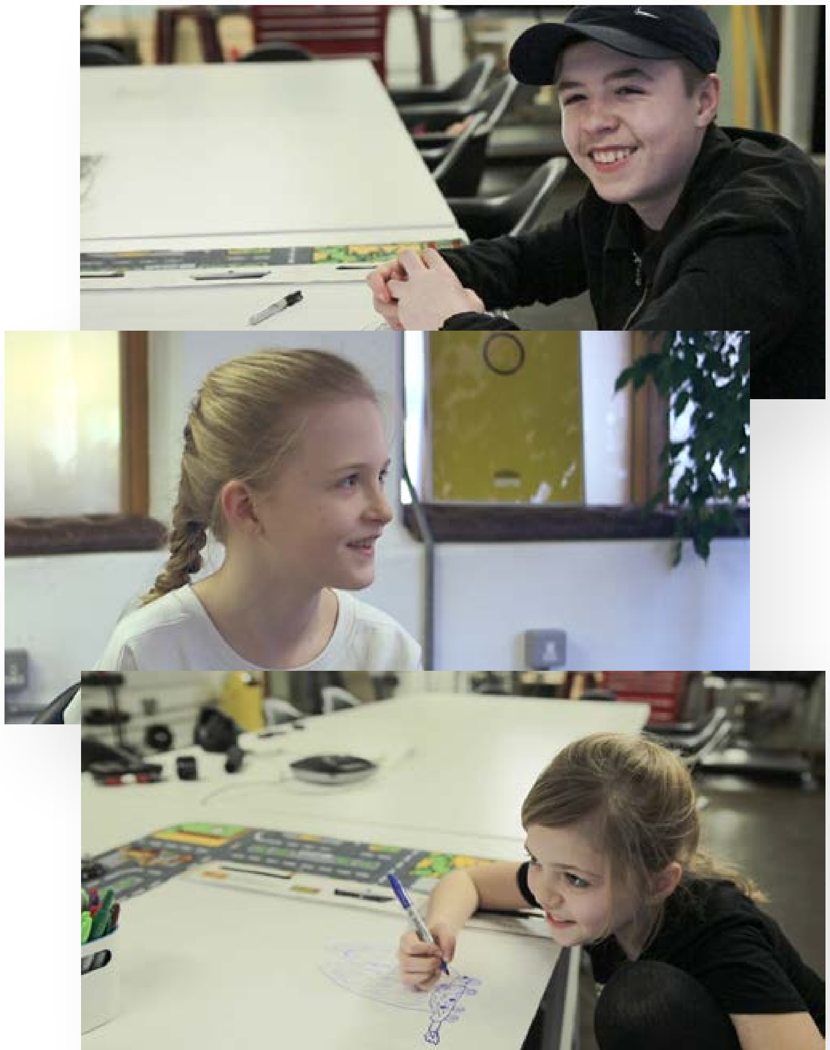
We discovered their likes, dislikes and even managed to bring shy Jessica out of her shell. It was surprising and fun to hear about Emily's love for speed, roller coasters and robots and Sam's cautiousness about them – quite the contrary to the stereotype. Jessica surprised us with her clever drawing skills and creativity – though we did not take too kindly to her calling our sketches 'poop' :D .

THE KIDS WISH TO DRIVE SOMEDAY...

Samuel and Emily were both very keen of the idea that they could someday drive themselves. "Yeah… It would just be cool. So you can go to places and see stuff," said Samuel. He would want to drive a blue Porsche, while Emily would have a pink Mini because she thinks they drive fast and look cool.

… but are less keen on being driven by a robot

Both Samuel and Emily said they would feel a little anxious and scared about riding in an autonomous vehicle. Jessica didn't verbalise it, nor say much during our time, but the expression on her face said it all.



Q: WOULD YOU BE OK WITH YOUR DRIVERLESS MINI EARNING MONEY FOR YOU WHEN YOU WEREN'T USING IT, BY DROPPING OFF PIZZAS OR OTHER PEOPLE'S PARCELS?

"YEAH... COS IT'S DROPPING OFF OTHER PEOPLE'S STUFF FOR THEM..."

Q: DO YOU THINK YOU WILL LIKE THE CAR MORE BECAUSE IT IS DOING A GOOD THING?

YEAH."

Emily

Samuel believed that "we could crash when I was in it." Emily elaborated: "'Cause it might go wrong and then might like go wooooah… everywhere, like into bushes and into trees."

Samuel thinks that a human driver would do a better job than a robot one because "they [take] time to actually can drive and get a test." Emily, likewise, would prefer a human driver: "You always have to have a driver and then if there's no driver it would be scary."

SAMUEL AND EMILY AND USTWO PLAY A GAME

As we did with all of the children we spoke to, we played a game to gain an insight into how they think AVs would behave. We asked them to pick a car, imagine it was driverless, and then follow a route around the cityscape printed on the mat in front of them. We then observed as they acted out how the driverless car behaved along this route.

"I think it would drive like a bit wonky like go all wobbly and down like that and then parking weird and then go out and go wobbly again and then just quickly go and then park there. Cause there's nobody driving it, and then cause normally when you have to have a steering wheel you have to be straight and if you don't really have a wheel it could go wobbly." - Emily

"It [the AV] probably will drive quicker because no one would be driving and it would want to go faster." - Samuel

HOW ABOUT LETTING OTHERS BORROW YOUR CAR?

Parents always encourage their children to share, so we wanted to take that concept of generosity to the extreme and see how the kids would feel about sharing their car with others when they're not using it.

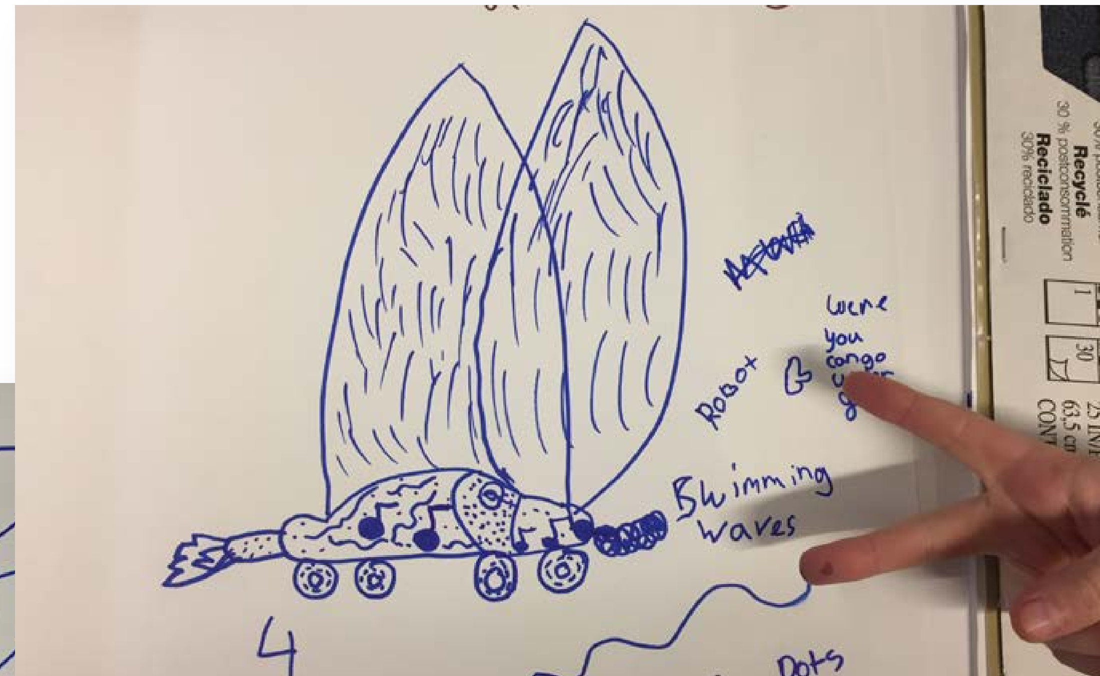
Samuel would want to keep his car hidden away because:

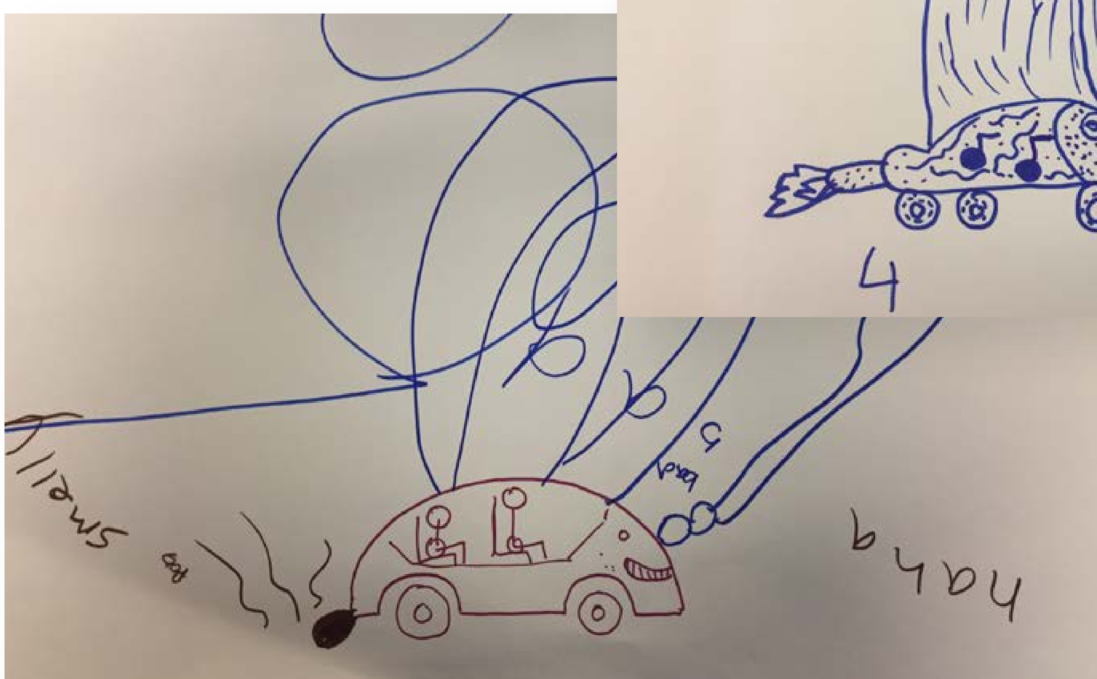
"IF IT WENT OFF, SOMEONE COULD LIKE TAKE IT AND NOT DELIVERING STUFF. I'D BE A BIT WORRIED BECAUSE LIKE YOU DON'T KNOW WHAT WAS ACTUALLY HAPPENING TO THE CAR."

Emily seemed more open to the idea: "'Cause it's dropping off other people's stuff for them instead of them going out and getting it." She went on to say that she would like the car more if it did good for others.

Emily had a childlike innocence and optimism for the technology to do some good for others, suggesting that she would share her car and allow it to go and help others while she was not using it. One day her sense of generosity might need to become the norm in order for this aspect of the sharing economy to work.

Collectively we got a sense of Samuel, Emily and Jessica's innate distrust of a driverless vehicle and a deep trust for human beings despite their many foibles. While you may not have read a lot from Jessica, her facial expressions speak a thousand words – you can view clips from these interviews here.





We asked the children to draw their dream AV as a means to gather insights

NEIL
35

NEIL, 35
DESIGNER IN LONDON

ABOUT NEIL

Neil is a young designer, technologist and service thinker currently running his own practice in London called 'Aye-Aye'. Working in some of the best design consultancies in London, even once being part of the famous BERG studio at the peak of its near futuristic technological pondering.

Neil has a driving license, but as an urbanite choses not to own a vehicle, preferring a bicycle as his mode of transport between his boat home and work around London. Neil comes across as an erudite practitioner and keen observer of human behaviour and our relationship with technology.

It was great having him with us in our London studio for a few hours of conversation. It offered a keen glimpse into his lifestyle and his thinking about the near future.

NEIL LOVES CARS, BUT DOESN'T DRIVE

We were keen to get to the bottom of this contradiction but, really, being like-minded commuters working in London, we already knew the answer: "In London it doesn't make any sense. The last time I had some money to spend on a car it made more sense just to hire one – whenever I wanted. It's quite good fun. I also cycle or take public transport, you know. I'm often on the train at the minute as I'm on a boat at the moment living just outside of London. It would make no sense to drive in. I use public transport all the time – trains, buses, taxis, Ubers, everything."

Neil is, however, keen to balance out his non-car ownership with the reasons with why he loves to drive.

"HOW DO YOU DEAL WITH THE FACT THAT THE AV IS PROBABLY GONNA BREAK? IT'S PROBABLY GOING TO NEED A DIFFERENT KIND OF SERVICING YOU KNOW – IT'S NOT AN MOT, IT'S LIKE A SANITY CHECK!"

"I mean, you know I think that there's a lot of warm, fuzzy, nostalgic feelings about cars – you know as status symbols in the '80s, pretty prevalent things you know. When you get into a car – that's special, for whatever reason, it's kind of like a power-up, you know, it's like putting on a great suit and a good pair of shoes. You feel different. I think cars have that power to extend our physical faculties and I think that's quite intoxicating, Pavlovian."

It's incredibly easy to villainise the car in today's world, especially in a book like this one that speaks of technology that could do away with the deaths, the carbon emissions, and so on that give today's car its bad image. Yes, AVs have the potential to contribute to saving lives and the environment, but we are keen not to forget some of the human factors and desires that come with the car. Neil represents many people who feel the same.

DP.02

The automotive industry has an incredibly unique opportunity to take advantage of this heritage and enthusiasm when creating the AV and that's something that the technology companies like Apple and Google simply don't have.

DESIGN PRINCIPLE UNLOCKED:

02. BUILD ON THE HERITAGE

The automotive industry is one of unique heritage with romantic notions of freedom and travelling to faraway lands. The passion for the automobile is well established and it's heritage is unrivaled. Combining this heritage with the benefits of modern technology would be something we would love.

"If cars become priced out of my... I mean hopefully by then my insurance premiums will be super low, ha, ha... I think likely what I'll miss most is freedom of my kind of civil liberties which is kind of interesting. Cars as I see will have to communicate with each other, to communicate their intent on the road... Which means that the roads will know everything about my car, everything about me and I'll be tracked and, you know, fined and whatever else you know, so it's kind of like, I suppose that Big Brother thing."

"I see that will be a problem for a lot of people and that's probably what I'll miss the most is just the freedom to stick my foot down and be naughty!"

CYCLISTS VS DRIVERS

Given that Neil opts to cycle rather than drive, we were keen to get a cyclist's perspective on sharing the road with driverless cars. London cyclists and drivers have some... tensions between them[16], to put it lightly.

"I think I would feel safer among autonomous vehicles. I think I would feel more comfortable cycling and living around autonomous vehicles."

"I think I don't inherently trust people's behaviour and on a bicycle in London you know people can be quite erratic and second guess everyone and assume they haven't seen you. It's a video game, a giant video game, but um… I would have thought that autonomous vehicles would probably be a lot more predictable. I imagine from other people's perspective they'd be a lot safer."

It's interesting to hear Neil's opinion that AVs will be more predictable and we can see his point. It will be interesting to see if that rings true.

A BRAND'S PERSONALITY IN AVS

Neil goes one step further and starts to unpick potential nuances in this predictability from brand to brand: "If the design of the autonomous system was in line with their current brand principles, OK. I don't know, it's an extreme example, but a Rolls Royce – you assume that it would be smooth, predictable, quiet. You know its driving style would be relatively sedate."

"I would have thought that regardless of the brand, each vehicle would have some parameters like if I wanted to get somewhere in a hurry, I might have to tell the vehicle that I'd like to get there quick or if I wanted to get there comfortably because I wanted to read."

"I'D KIND OF WANNA BE AWARE OF KIND OF WHAT MODE IT WAS IN – I THINK IF IT WAS IN A HURRY, IN A PARTICULARLY AGGRESSIVE MOOD OR WHETHER IT WAS PLAYING IT SAFE."

"I mean obviously brands that have a heritage of safety innovation, let's say Volvo, obviously, and I suppose a lot of the Japanese and French cars have got exemplary safety records, you'd assume they put that much R&D and effort and energy into that part of their car's autonomous behaviour."

"I don't know whether I'd prefer to be in a car that drives safely or one that excites me 'cos you imagine – something like an Audi or BMW, kind of roadster, having a bit more get up and go on the roads – less of an old lady and more of an aggressive driving style. I don't know which would be beneficial. My partner drives like an old lady and it drives me mad but my younger brother drives like a maniac and that's terrifying… So you know somewhere in between would be good!"

Neil is clearly excited by the possibilities of the technology among brands; technology and branding is, after all, part of his craft. His enthusiasm was infectious. As we ponder his thoughts, he's already challenging his own theories:

"You know how do you deal with the fact that it's probably gonna break… it's probably going to need a different kind of servicing you know – it's not an MOT, it's like a sanity check!

"I think that the most exciting thing is how much agency the car surfaces to other road users and to the drivers and the passengers. I think like you could go down the route of it essentially [being] a robot, that you get in."

Neil seems to have far more faith in the ability of the robot driver than that of the human one, much like Rick who we spoke about earlier. Neil has a clear excitement for the technology and its safety benefits, as well as the more innate emotional thrills that come with the car. But it's Neil closing comment that really hit home:

"The best cars are the ones you connect with. Whether they are bangers that you love or some sort of car that really excites you to drive."

At the end of the day, a successful AV user experience will be the one that you connect with emotionally, not just functionally.

DISCO DAVE 45

DAVE, 45
CAB DRIVER IN LONDON

ABOUT DAVE

Dave or 'Disco Dave' as he is known among friends, is a black cab owner and driver, serving the residents of London for over 20 years. He is one of a dying breed - being proficient with 'The Knowledge'[17], an encyclopaedic understanding of London streets for which one has to train for five years at the very least before earning the cabbie badge. Drivers with The Knowledge have the uncanny ability to pick out the best routes for travellers across the city, without having to rely on technological paraphernalia like TomToms or Google Maps but instead on the many moods and complexities present within the city. They essentially have their hands on the pulse of the city, through day and night and many seasons, with tonnes of tacit knowledge gained through patient listening and watching. No wonder that studies have shown that London cabbies possess a larger hippocampus than the average person - which tells us a lot about neuroplastic development of the brain through experience.

With a wealth of experience comes a number of stories to tell and Dave had plenty to share. As a driver he not only has to have functional knowledge but also a deep sense of empathy with society and people's needs and a kind listening ability - which Dave seemed to have in spades. He doesn't just ferry the body from place A to B, but ferries minds, emotions, thoughts - both happy and sad, joyous and alone.

We talked to him from within his cab, meticulously maintained and cared for. It was almost reminiscent of a confession booth on wheels with the facade separating a wise driver from his passengers. We are thankful to Dave for sharing his experiences with us, which made us wonder about the maturity of AI which will be needed to even get close to replacing him - if ever.

DRIVEN CARS VS. DRIVERLESS CARS

The first thought that comes to mind when speaking with a cab driver when it comes to AVs is, how would one feel about their jobs being replaced by a machine? What does Dave know about driverless cars?

"SOMETIMES PEOPLE JUST COME IN AND THEY JUST WANT TO CHAT, THEY WANT TO TELL YOU ABOUT ALL THEIR PROBLEMS... THEY'VE GOT LOTS OF THINGS THEY WANNA GET OFF THEIR CHEST. THEY KNOW THEY'RE NEVER EVER GOING TO SEE YOU AGAIN. IT'S VERY SIMILAR TO LIKE A CONFESSION BOOTH ON WHEELS."

"Oh yeah, I hear about them non-stop really. I know they're actually using them somewhere in the States haven't they? I know they're talking about trucks going across Australia and it's the way I think the way jobs are changing now as well... I mean automation's just totally changing employment. You know it's the same way like in the past, you know - in the industrial revolution everyone was sorta saying this is going to do away with work but it's just people just do different jobs. There's not many people who would do the same work as their grandfather!"

"I can imagine an opposition against it, I mean there's so many drivers, not just taxi drivers but I think delivery drivers, so much of the workforce is made up from driving jobs and when you think how much is delivered now as well, you know, people buy so much stuff on line. There's so many deliveries going on more than ever. Yeah I think there will be a protest - it won't go smoothly. People won't just say ok, I'll get another job doing something else! There would be a bit of friction there. Definitely."

“I still can’t see them in five years. I don’t think everything’s in place when there can actually be driverless cars and no other cars. I can’t see them having driverless cars and people driving cars side by side… especially in a city like London! With little tiny streets that are based around the streets the Romans built they’re hardly changed since two thousand years!”

“I can see it working on the grid system cities and I mean there’s a lot of rumours about you know the bike lanes in London, that’s what the bike lanes are for they’re so wide… they’re designed for, like, driverless vehicles as opposed to cycles. London’s just a bit too busy now for it I think. I just can’t see it working.”

We can’t say we’ve heard that rumour before, but it does make you ponder…

EMOTIONAL NEEDS

Dave spoke about both the emotional and functional needs he serves for his passengers. What became clear in speaking to him was that both of them are completely correlated and cannot be separated from each other. An AV should satisfy both.

“Sometimes people just come in and they just wanna chat, they wanna tell you about all their problems. They’ve got lots of things they wanna get off their chest. They know they’re never ever going to see you again, so they just want to chat.”

“They could probably get on the tube but then they’re not really going to talk to anyone, so they get in the cab and and they know it’s going to take longer, they know it’s going to be more expensive but they’re just going to sit there and they just got things they wanna get off their chest and sometimes they might even want advice. You’re not going get that from like a driverless car!”

"IT'S VERY SIMILAR TO A CONFESSION BOOTH ON WHEELS IN THE FACT THAT PEOPLE COME IN AND THEY TELL YOU ANYTHING AND I MIGHT AS WELL HAVE A CURTAIN GOING ACROSS HERE BECAUSE PEOPLE AREN'T GOING SEE ME AGAIN AND PEOPLE REALLY ONLY JUST SEE MY EYES IN THAT WING MIRROR!"

"That's quite awkward actually, but well you can pick up on people's mood as well, when someone gets in the back of the cab you pick up on how they're feeling or you know if they are a bit down you want to cheer 'em up. Well sometimes you get people get in the back and have a big sigh or sometimes people get in the back and they're in tears you know it's all sorts of things, you know? If they're happy, they wanna share their happiness with you. It's quite hard not to take it on to the next passenger..."

FUNCTIONAL NEEDS

Of course, emotional needs are just half of the journey, there are some real functional needs too. Dave questions how a driverless car could help with some of these.

"Well, obviously you can see if someone wants a hand getting in the cab whether they're elderly or they could just have a lot of luggage, or they could have a young child with them. You know they're going to want a hand to get into the back of the vehicle... Whereas I suppose a driverless car is not going to do that. Who's going to help the old woman in with her shopping bags or, you know, the disabled person in the back of the cab or the mother or the child? Sometimes people get in the car because they, need a hand you know, then sometimes that's the reason people can't drive in the first place! So I think that's a bit of a flaw in that."

THE KNOWLEDGE

We were fascinated by this 'The Knowledge' we've heard so much about. How does this human mental map compare to a digital map we wondered.

Observing Dave
We spent some time in the back of Dave's cab to get to know him

“It felt like a great achievement when I got it. It felt like a huge achievement. London used to be the only place in the world where you sort of have to study so hard to become a cab driver. Most places in the world you go to pick up a cab driver because you can’t do another job. But in London it was sort of like an achievement so then they brought in a two-tier system, where you got mini-cabs and Black Cabs or private hire and Hackney Carriage… they don’t have to do the Knowledge, they just sort of work with Sat Navs.

“We’re trying to stop people from using phones while they drive so if you’re touching a Sat Nav, they do affect the way people drive, without a doubt. People start looking down, looking at the Sat Nav which can be distracting.”

Driver distraction is certainly one benefit of The Knowledge vs. Sat Navs, maintaining focus on the road rather than the screen. We wonder what other benefits there are… perhaps a human understanding of the local area can utilise useful subjective or ‘unstructured data’ rather than just objective ‘structured’ data that bounds the digital maps?

DAVE’S OPINION ON LIABILITY IN AVS

Speaking of distracted driving, and it’s consequences, we wondered what Dave thought about who is to blame should a driverless car get into an accident.

“I’d imagine it’s probably the owner who is liable for accidents. I’d have thought whoever owns the vehicle would be, you know, liable for any issue.” says Dave, but what if the owner wasn’t driving? “That opens up so many cans of worms, I mean - who’s going to start insuring driverless cars? If the driverless cars don’t have any accidents, what are the insurers going to do - they’re not going to make the money out of them are they? It’s just totally going to change everything - so many jobs. Not just the drivers, garages and everything I mean. Who goes out and repairs them - the driverless cars are they in the AA or RAC?”

"WHO WOULD CALL THEM UP IF THEY STOP WORKING, WOULD IT JUST BE ON A COMPUTER? NO MATTER HOW ADVANCED THE TECHNOLOGY IS, PROBABLY EVEN IN 40, 50 YEARS TIME THEY'RE NOT GOING TO BE RUNNING SMOOTHLY, THEY WILL HAVE FAULTS. IF THEY END IN FATALITIES WHO'S SUED THEN? WHOSE FAULT IS IT?"

"Boris Bikes"

"If the vehicle has a fault is it the person who owns the vehicle, is it person who actually manufactured the vehicle, is it who got them serviced? Do they get serviced? That's the thing I mean - what happens if someone goes out and they're sick in it? Who cleans the sick up? Out of an autonomous cab? So the next person orders it… there's a big pile of sick waiting for them. I mean there's nothing to stop that happening, you know? And you want it to turn up in pristine condition but I can imagine they probably won't!"

"People would be doing all sorts of things in them. Especially if there's no cameras, or if the cameras break or they'd probably mask the cameras up, and then get up to what they want in there. The next person won't have the vehicle in the state they want it in I'd imagine."

Dave continues by drawing on a comparison to the bike sharing scheme in London - called 'Barclays bikes' or 'Santander bikes' colloquially - which consists of bikes present in bays which are located around the city.

"I mean I've used Barclays bikes, a few times. And you get one, you think to yourself the brakes aren't working on this one or the crank's feeling a bit sort of creaky or the wheel's slightly buckled, you get it out, get another one out."

"People are meant to report the faults themselves. But people don't - haven't got time to report faults. So they just put it back in, take another one out and that happens all the time. I can imagine they'll probably be doing a similar sort of thing with the Autonomous vehicles… but people don't wanna report faults!"

It's fascinating to hear the opinions of those who work in driving related workforces, not only to understand their concerns for their jobs, that in fact doesn't seem to worry Dave, but to understand their practical opinions around the challenges and feasibility of such technology. Dave's experience with both people and city infrastructure, as well as policy and liability, has unearthed many barriers there are to the adoption of autonomous vehicles, both functional and emotional.

SOCORRO
85

SOCORRO, 85
ARTIST IN MEXICO CITY

ABOUT SOCORRO

Despite being retired for some years, Socorro very much still has a zest for life, this was evident in the way she spoke with us about the things she still wants to achieve in life, or at least spoke to us through our translator, Spanish speaking Daniel of ustwo London.

Socorro lives in Mexico, so we set up a conference call from our London studio to her home in the country's capital to listen to her thoughts on transportation in and around Mexico City. We were particularly keen to hear what she thinks might happen when AVs are introduced into the mix in somewhere quite different to what we are at home with in London and New York. She was remarkably in tune with the technology, more so perhaps than most people we've talked to - she had a keen interest in the bigger picture of driverless cars. What will it do to her city, what will the impact be on crime? Questions it seemed she had pondered even before talking with us.

Conference call, translator - not very conducive to an insightful chat you might think, but Socorro was thankfully very patient and we were able to gain more insights from her thanks to Michelle of ustwo, her granddaughter, shadowing her as she travelled through Mexico City.

Socorro had been driving for over 60 years, but has recently had to give it up.

SOCORRO'S EXPERIENCE DRIVING IN MEXICO CITY

One of the things we were most interested to hear from Socorro was what it was like driving or travelling around Mexico City. We've spoken to people in Mumbai, Singapore, New York - everyone we've spoken to makes us realise how different each city is to London - and to each other.

"Well, I've been using my car in Mexico city for around 60 years. At the beginning it was very different, the city wasn't as chaotic as it is now. I could come and go easily, but now is much more challenging due to heavy traffic and the difficulty to find parking spaces. Crime has also rocketed in recent years. That, together with my age, forced my family to ask me to stop driving. I never thought that I would stop driving. And that's the biggest problem for me now - that I had to stop driving."

"CRIME HAS ALSO ROCKETED IN RECENT YEARS. THAT, TOGETHER WITH MY AGE, FORCED MY FAMILY TO ASK ME TO STOP DRIVING."

WHAT SOCORRO MISSES MOST FROM DRIVING

A similar theme is unearthed by Socorro, that of the independence she enjoyed from the level of mobility driving allows, and how she misses it now that she no longer has it.

"Driving was great as it meant I was independent. I could come and go as I needed, I could organise my time according to my needs and my everyday tasks. That independence gave me security in myself. I've lost that now."

We asked Socorro what made her follow her families wishes to stop driving. "I decided to stop driving because I don't want to cause any problems - the traffic of Mexico City is not for an 85 year old person! But more than anything, I don't want my family to be worried every time I go out." We were later told that carjackings and even kidnapping was a common problem in Mexico City.

"DESPITE MY AGE I'M STILL FULL WITH ENERGY AND WANT TO DO THINGS, BUT NOW I NEED TO DEPEND ON SOMEBODY. A MEMBER OF MY FAMILY HAS TO DRIVE ME AROUND, OR I NEED TO REQUEST AN UBER OR ANY OTHER TAXI SERVICE. I NO LONGER HAVE THE INDEPENDENCE OF GOING WHEREVER I WANT TO GO, AT MY OWN TIME. YOU KNOW, I STILL HAVE STUFF TO DO, THINGS TO SOLVE, AND I STILL HAVE A SOCIAL LIFE, I WANT TO GO OUT AND DO MY THINGS. SO MY BIGGEST PROBLEM IS NOW DEPENDING ON SOMEBODY TO DO THOSE THINGS… IT FEELS TERRIBLE."

"My family drives me around - my children and my husband. But only when they have time. They drive me to my destination, and they drive me back. But is very uncomfortable because I feel like I make them waste their time. You know, they have to work, they have their own stuff to do."

Socorro bucks the stereotype and is somewhat of a techno-optimist, enjoying the mobility it affords her now and looking forward to what it can offer her tomorrow…

SOCORRO'S THOUGHTS ON AUTONOMOUS VEHICLES

"The other option is taxis and Uber. But that means expenses. And at the end of the day I simply don't like it. I want to drive my car myself. That's why technology is important. I wish I will still have some time to enjoy some of the new autonomous technology. I've witnessed so many changes in technology throughout my life! Let's see if I manage to see this one too."

"It's definitely one of the 21st Century marvels! But before I get in one of them I would need to clarify many doubts - especially around security. Because technology moves forward but I haven't managed to fully understand it. But I can also see its advantages. I imagine it will change the public space, and the economy - police officers will no longer need to chase cars in order to raise traffic tickets! And, can you actually insure these autonomous cars? If yes, up to what point? Oh, and will they help improving the quality of the air here in Mexico City? At my age autonomous technology sounds like a good opportunity, but I would like to understand it first."

We can hear a one person tussle going on in Socorros head; yes, AVs have great potential benefits, but at the same time many unknowns too - and who knows what troubles could be lurking in those murky waters.

THE PERCEIVED BENEFITS AND THE PERCEIVED CHALLENGES

It seems Socorro is a good example of the importance of AVs perceived benefits to people, perhaps more important to adoption than it's actual benefits, ie no matter how safe it is in reality, it must be perceived doubly safe for it to be trusted and adopted.

"It's about reassurance. When you are in a car with other people, let's say on the motorway, and something happens, you know we are going to help each other out and solve any problems. But when you're alone in the car, and there's no driver and something happens - how are problems going to be solved? That's why reassurance and security are so important."

"When I imagine myself actually on board, alone, that all my worries arise. If there was a technical fault or a breakdown, how will I react? What will I be able to do? I need reassurance, I need to know there are contingency plans in place to deal with these situations, so that I can feel safe while on board. That's the most important thing for me."

This calls into light the potential appetite for shared AVs, with multiple strangers occupying the vehicle, like a miniature bus or a larger UberPOOL, rather than individual "pods" that first spring to mind when you imagine AVs. How about the benefits of something like that?

"A total marvel! Imagine, being transported around the city without having to face the usual problems of driving. No dealing with traffic - go, stop, go, stop. No struggling to find parking space - doing rounds and rounds trying to find an empty space. No more traffic tickets, as all traffic rules will be uphold by all vehicles. Is something that will definitely be enjoyed by people of all ages."

"I'm going to sit in the back seat and I'll have my "robot chauffeur" on the front. Will there be a way of chatting? Because that would be so interesting! That would be wonderful actually, otherwise it will be too boring. Now, thinking on my end destination - I don't know how it will work. I will somehow "program" the car to take me there, and that's it. It will take me wherever I want. But I would imagine I can't intervene or direct the car once we're on our way. Can I?"

That's a good question! Something we're trying to figure out ourselves! Socorro continues to imagine the possibilities with childlike imagination, though a very well informed one…

"THE FACT THAT WE WOULDN'T NEED TO DRIVE IS WONDERFUL. BECAUSE DRIVING SOMEHOW STRESSES YOU, IT TENSES YOU UP, ESPECIALLY ON THE MOTORWAY. I THINK IT'S SOMETHING THAT CAN IMPROVE OUR QUALITY OF LIFE. AGAIN, THE TECHNOLOGY WOULD NEED TO PROVE IT WORKS, IT WOULD NEED TO BE NORMALISED BEFORE EVERYBODY ADOPTS IT. I THINK MY FRIENDS WILL BE INTERESTED IN IT, AS WE'RE ALL JUST TRYING TO IMPROVE THE WAY WE LIVE."

AVS IMPACT ON MEXICO CITY

Finally, we were very keen to hear how she feel Mexico City will change with the advent of AVs, since she observed such vast changes already in the 60 years she has been driving in the city.

"Well, there will be a reduction of many things. To start with, there will be less cars, no? We would also need less police, less traffic wardens, less people looking after your car, less people cleaning cars - there's so many of them right now!"

All across Mexico it's common to find people working in the streets who will help drivers park, keep an eye on their car so it isn't broken into, and even clean it upon their return.

Mexico City traffic

“There will also be less chaos. Less chaos in parking lots, less chaos created by trying to find a parking space in the street. Normally there is traffic everywhere here in the city, I imagine there will be less of that… Also, I’m supposing autonomous cars will need to keep a specific distance from one another while driving, so there’s going to be less car crashes, less incidents, less tragedies. Because the way of driving will be different, it will be more respectful, these cars will have to respect the traffic laws everywhere. Here in Mexico City, sometimes you may take a forbidden turn if it’s faster, or take an inappropriate lane if there’s no queue. These cars, because they will be truly intelligent, won’t do those things.

"I THINK AUTONOMOUS CARS WILL REDUCE THE FRICTION OF BIG CITIES LIKE MEXICO CITY, THEY'LL BRING SERENITY AND SECURITY TO OUR LIVES."

We couldn’t end on a better note.

DP.03

THERE'S MORE TO TRANSPORT THAN A TO B

Everyone we spoke to had preconceived ideas of what driverless cars were, thanks to existing early autonomous vehicles and, thanks, in part, to science fiction. The concept was not new to anyone, from seven year old Emily to 85-year-old Sorocco, but everyone's interpretation varied, with each person projecting their own hopes and needs onto their understanding of the technology. Some people couldn't grasp how the technology worked, while others worried it would work too well. None of them, nor indeed ourselves, know how this technology will integrate into our lives and or the consequences, be they beneficial or dangerous.

The differing hopes for the technology stem from an infinite amount of personal biases cultivated through our unique experiences and the environments we live in, whether that's London, Mexico City, Singapore or Mumbai. These varying needs will need to be discovered, understood and carefully considered if the technology is to be truly adopted. We will explore some of these needs in this book.

FUNCTIONAL & EMOTIONAL

Some needs were expressed by most of the people we spoke to and these are somewhat easier to understand. One particular and overwhelmingly consistent observation, was that people's mobility needs span far beyond the functional, than that of simply getting from A to B, and include emotional requirements. These emotional needs go hand-in-hand with the functional needs of a journey.

DESIGN PRINCIPLE UNLOCKED:

03. EMOTIONAL AND FUNCTIONAL NEEDS

There's more to a journey than simply the functional need to get from A to B. Any journey includes many human and emotional needs such as comfort and human interaction.

Darret and Françoise, and even 28-year-old Wanfy, for example, enjoy and cherish the human interaction with the driver of their chosen mode of transport; in this case a taxi or an Uber. Darret will even choose to use a taxi when she perhaps need not do, simply to have an uplifting conversation with the driver. People like Darret and Françoise, who are somewhat isolated due to disability, value their mobility so that they can leave their homes and be independent. When the day comes that Françoise is unable to retain her license to drive, AVs could give her back that independence she enjoys in her car. However, there are still some mental wellbeing gaps left by the current understanding of how AVs will work. By removing the driver, a person to interact with, in what is known as the *third place*[18], we risk increasing passengers' sense of isolation, rather than improving it; in a world of AVs, Darret is now not only home alone, but possibly travelling alone too.

At the other end of the spectrum, by talking to people like Dave who owns a London black cab, we can understand the role beyond that of the driver – that of mediator and counsellor. Black cab drivers are also spotters of anti-social behaviour and conversation enablers. In their reactions to emergencies, such as passengers falling sick or a crime being committed, they become authority figures with the power to intervene. These skills are borne out of years of tacit knowledge gleaned while serving a city and meeting its many varied inhabitants, adapting quickly to situations both good and bad. This experience and behaviour is immensely hard to replicate in a robotic vehicle. These secondary roles will be sorely missed in the transition to autonomy, if designers and technologists don't include them.

Mass occupancy shared autonomous vehicles might help in this instance, by providing opportunities for interaction with others. However, our research shows that the relationship with the driver, and the associated "invitations" and "permissions" to engage with them (you have to to negotiate destination and exchange money for example) differ depending on the mode of transport. For example, there are fewer invitations and permissions to engage in a bus or UberPOOL, when compared with a taxi.

Neuroscientist Matthew Lieberman in his book *Social*, stresses the importance of these human interactions, stating that our need to interact with other people is even more fundamental than our need for food and water. His peer, John Cacioppo, elaborates on this point:

"Humans were not designed to be solitary creatures. We evolved to survive in tribes; the need to interact is deeply ingrained in our genetic code. So much so... that the absence of social connection triggers the same, primal alarm bells as hunger, thirst and physical pain." [19]

John Cacioppo,
Director of the University of Chicago's Centre for Cognitive & Social Neuroscience

DP.04

TRUST AND SAFETY

Naturally, one of the most important things to get right in AVs is safety. These vehicles must be incredibly safe, in fact safer, statistically and practically, than manually driven cars on the roads today if they're to be of much use to us. This is something that is clearly on people's minds with the term "safe" being brought up by almost all of our study participants.

While everyone wanted AVs to be safe, their interpretation of the word and therefore the nature of trust in the vehicle or the system changed from person to person. While Samuel, 13, had no trust in the driving capabilities of the vehicle, fearing for his physical safety, sentiments shared by the other children and elderly study participants, the young to middle-aged adults didn't question the physical safety of the vehicle at all. Yeva, 6, sees the driverless car like a malfunctioning robot, running amok around town, striking fear into passengers, fellow motorists, pedestrians, and even Italians! In fact, she thinks that even the sheer amazement experienced by those witnessing a driverless car would cause accidents. Rick, on the other hand, believes that the AV "has your back" and is totally safe. Interestingly, Yeva would not put her children in an AV for fear of their safety, while Rick looks forward to a time where his children don't have to drive and instead can be driven around by much safer autonomous cars.

Despite the confidence demonstrated by Rick and others, the question of who is to blame or liable when things go wrong came up many times, which is rather telling. It seems that most people understand that AVs are not perfect and will indeed fail from time to time. A sense of moral apprehension as to the negative consequences to third parties followed these questions.

On the flip side, the same people who trusted the driving capabilities and physical safety of the vehicle itself, did not trust the safety of their personal information held by the system. This worry never crossed the minds of the young and elderly study participants. Ironically, tech savvy test participants, for example Neil with his Human Machine Interaction agency or Rick with his three Teslas, understood the technology well enough to grasp the fundamental operational necessity for AVs to hold personal information, while at the same time feeling nervous about the security of that data.

All of this boils down to one thing – trust. Trust is one of the core human needs that the autonomous vehicle must establish and defend if the technology is to be adopted at all. This unlocks one of the most essential design principles:

DESIGN PRINCIPLE UNLOCKED:

04. BUILD TRUST IN THE EXPERIENCE

Anxieties in new technology need to be alleviated for their early adoption and continued use. So build trust early and keep it going throughout the lifetime of experience.

CULTURAL DIFFERENCES

It's interesting to see how this question of trust changes from city to city. While our test participants in the UK and India don't have much faith in the transport network, perhaps brought on by the historical experience of failing systems (passengers of UK's Southern Rail and Indian Rail will understand), our test participant in Singapore spoke of great trust in their own transport system. In Singapore all trains are automated, very rarely go wrong and are therefore heavily trusted and heavily used. Mexico City is another story – Sorocco was urged by her family to stop driving there because of the dual threat of robbery and even kidnapping when cars are stationary in traffic. But with no driver on board, passengers in autonomous vehicles in Mexico City could potentially be more vulnerable than ever. Though human needs seem to transcend cultural differences, this city-specific threat could be another barrier to adoption.

THE IMPORTANCE OF UNDERSTANDING PEOPLE

Ethics, liability, policies, implications to cities and society as a whole, questions and concerns about the technology's capabilities, trust, brands, what people do if they're not driving – these are just some of the themes that came up in our user interviews. These themes are congruent with much of the academic and desk research we have been doing, as well as our own real-world experiments.

For the technology to be adopted, it must be trusted, and to do that, all of these human factors – all of these themes and questions – must be taken into consideration. What we want to do is understand each one from the unique perspectives of real people, rather than working on assumptions made in design workshops or in university laboratories. This is an incredibly important step in designing not just for AVs, for mobility, but for everything that is used by humans. The first step in user-centred design is to understand people and their needs for that product or service. In this case, that is people's mobility needs for the autonomous vehicle.

We want to address all of these concerns from a user perspective and a human perspective, applying user-centred design methods and thinking. By doing this we hope to help negate the risk of under-serving the practical, as well as the emotional, human needs of transport and mobility. As we put it in our first book, there is room for beauty and brains.

It's not all doom and gloom. Technology optimists, while nervous of the safety of their data, look forward to the day of autonomous vehicles, not just so they can sleep on the ride, but also so they can get their hands on a new and exciting piece of kit – like a child opening a Nintendo 64 at Christmas[20]. While the elderly and less mobile fear for their physical safety, they will adopt the technology if it means they can remain mobile and independent. The fear of the technology is matched only by the excitement for it, and sometimes the ability it affords to overcome a serious need or problem can outweigh any concerns.

At the end of the day, a successful AV user experience will be the one that you connect with emotionally, not just functionally. How to form that connection is a key challenge we'll attempt to tackle in the upcoming sections. ◆

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Do Whatever You Love To Do
by BLND
Year: 2025

"A self-driven car gives you extra time. Time to spend with yourself, to do what you love most. When you don't have to drive, the car transforms into something else, is a small space but full of possibilities. It becomes your personal space, your bubble, your "me time" place and it just happens to also take you from A to B. So, you can imagine anything you want to customize your brand new personal space. You can grow a garden, build your own library with a very comfy chair to read, your own private cinema, your wood workshop, your own cave, whatever! And since you don't have to watch out for the road you can make very delicate tasks like building a cards tower, modelling planes, and even start your own crystal glass collection."

Artist representation by WE ARE GOODNESS

HOW WILL PEOPLE AND ROBOT CARS TALK?

Topic: Human–AV Interaction

73 minute read

"I THINK THAT THE MOST EXCITING THING IS HOW MUCH AGENCY THE CAR SURFACES TO OTHER ROAD USERS AND TO THE DRIVERS AND THE PASSENGERS... I THINK LIKE YOU COULD GO DOWN THE ROUTE OF IT ESSENTIALLY (BEING) A ROBOT, THAT YOU GET IN."

Neil, ustwo study participant

SUMMARY

Where do our sci-fi fantasies end and AV reality begin? From Herbie to KITT, there are a whole host of pop culture reference that capture our imagination when it comes to robot cars. There are so many questions around how humans will interact with AVs – will they provide passengers with conversation, how personable will they be, will they communicate through speech, graphics or gesture?

This section will look into how self-driving vehicles will interact with its passengers but also how it will deal with a whole host of other complex systems – here we'll also explore how AVs will relate with pedestrians, other AVs and the wider infrastructure.

INTRODUCTION

Robots! AI! Tons of excitement surround them both. They awaken our inner child with dreams of humanoid creatures with minds of their own, objects imbued with HAL-like intelligence evoking fear and fascination. And the reality is that we are moving closer and closer to having social robots and helpful AI or AI-like systems in our everyday lives and not just in manufacturing plants.

This excitement is also buoyed up by a healthy dose of sci-fi flair in popular culture over the last half century, where there have been numerous artistic explorations into robotic entities, both benevolent and malevolent.

Oddly enough, the robots and AI systems closest to reality, those with the ability to make a significant impact, are autonomous vehicles. The promise there is not of humanoid entities, but more of benevolent automatons – in the guise of Herbie, the love bug.

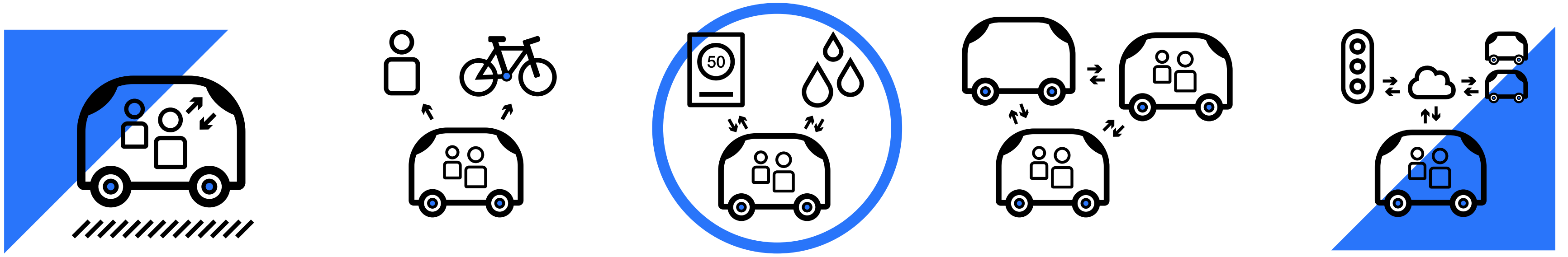
Despite Herbie's cheesy overtones, some real and interesting interactions can be observed in the movies, which also mirror some present-day concepts.

Autonomous vehicles are robots imbued with intelligence and, in many ways, designing interactions for them is significantly more complex, than it is for more generic robots. Generic robot interactions have one outwards face to them – where the robot interacts with the person or environment it is in (as shown here with Paro[1]).

NEIL 35

ParoRobots

Herbie



Inward *Outward* *Middleman* *Each other* *Beyond*

AVs, on the other hand, have multiple faces of interaction, not just one towards an observer or actor. We've drawn them out below to explain the differences and similarities:

1. Inwards: Interactions towards the passengers with the robot looking inwards at its occupants. Here the robot replaces the taxi driver with whom you might interact during journeys, through speech or gesture.

2. Outwards: Interactions with external participants, such as pedestrians, other vehicles, and cyclists. An example of this kind of interaction would be how a taxi driver slows down to allow a pedestrian to cross safely.

3.Middleman: How the robot acts as an interface or the middleman with the outside world for the vehicle's occupants. For example, the decisions the vehicle is taking based on its sensorial observations, fed back to the passenger.

4. Each other: How the robot interacts with other robots of a similar make or other brands of robots, doing things like transferring data and learning from one another.

5. Beyond: How the robot interacts within its cloud infrastructure. For example, it could transmit its learnings about movement in a city to the cloud to enable other vehicle systems to learn. Perhaps it could inform traffic signals to enable smooth, stop-less passage along a planned route.

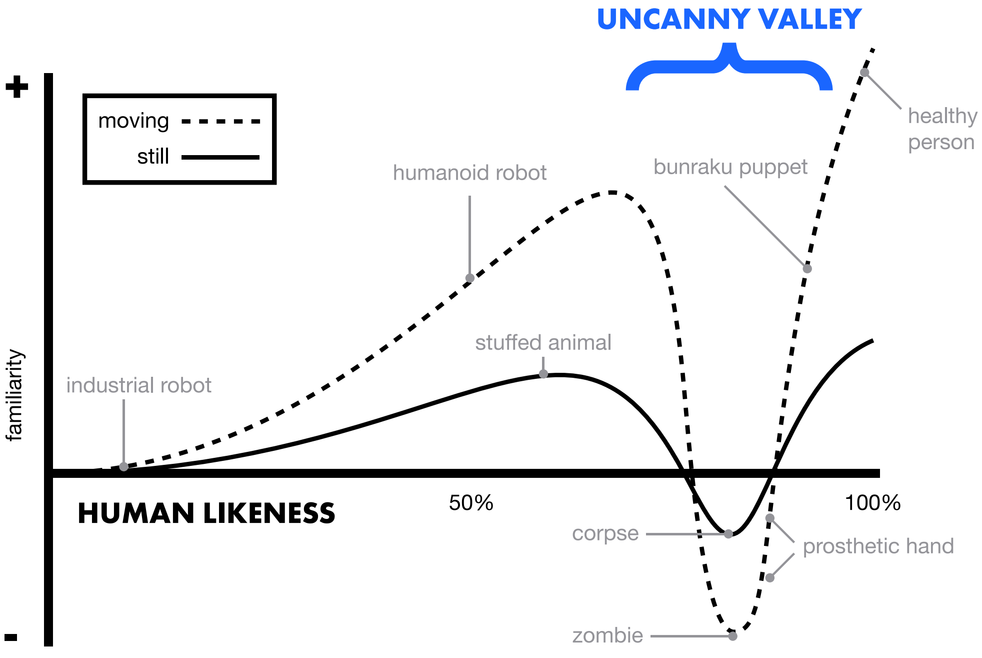
As you can imagine, the levels of complexity in maintaining all of these interactions are profound and must be dealt with very carefully.

In considering these interactions, we have to also bear in mind the "uncanny valley" phenomenon postulated by robotics professor Masahiro Mori in 1970. Mori noted that it is easy for human beings to anthropomorphise robotic movements and assign lifelike qualities to the robots, but there comes a point at which robots reach a huge degree of human likeness and empathy gives way to revulsion. Nowadays, the uncanny valley phenomenon can be applied not only to humanoid or animalistic robots, but also to subtler robotic interactions such as voice, even within services like Alexa and Siri. This has far-reaching implications for the human psyche as it relates to machines in generational, societal, and geographic terms.

Most of the concepts we talked about during our research focused on one, or at most, a few of these faces of interaction. For a holistically designed system, however, we believe that all of them should be considered in unison.

"I HAVE A GOOD CONVERSATION IN TAXIS – TO BE HONEST I WOULD NOT LIKE ROBOT DRIVERS – I LIKE TO COMMUNICATE WITH PEOPLE."

Darret, ustwo study participant



'INWARDS' ROBOT–HUMAN INTERACTION

Interactions towards the passengers with the robot looking inwards at its occupants. Here the robot replaces the taxi driver with whom you might interact during journeys, through speech or gesture.

As we showed in our first book, interacting with a vehicle's digital interface is a complex affair. It is a synchrony of audio, visual, tangible, haptic, and spatial tasks, with different degrees of cognitive load, all of which feed into the complex task of driving itself. Add in just one extra task and disaster can result, for example deaths due to texting while driving (a subject we explored with students from the University of Washington in our concept 'Shift'). Depending on the medium and context, interactions occurring within the car today can be categorised as "hard" or "soft".

Hard interactions can be defined as deliberate manipulative actions performed by the driver. Examples are: changing the drive position using a button, using an infotainment system via a Graphical User Interface (GUI), or inputting location data into the Sat Nav.

Soft interactions can be defined as the actions performed by the machine as non-deliberate inputs provided by the user. Self-cancelling turn signals are an example of a soft interaction – where the machine autocompletes a sequence of actions without any user input. Sensing a driver's heart rate to understand their levels of stress or excitement would be another example of a soft interaction.

The latter type of interaction is now coming to prominence with the advent of embedded interior sensors and the notion of the connected car. Some possibilities have been exploited with contextual information displayed in Heads-Up Displays (HUDs), automatic dimming of interior lighting, and even the experimental tracking of closed eyelids. In our opinion, soft interactions require the greatest amount of care and appropriateness in execution as there is a thin line between assistance and distraction.

We believe that a combination of meaningful hard and soft interactions is key to getting the best out of Human–Machine Interaction (HMI) within a car.

But what about AVs? How will they feed back information "inwards" to the driver and its occupants? Would more information be presented to the passenger since he or she will be freer to consume it, with the vehicle running in semi or full-autonomous mode? Would this take the form of a voice-based interface like HAL 9000, or would it be gestural, visual, or haptic? What could the spectrum of interaction media look like?

Would interactions happen via direct communication with your brain for example? Brain Computer Interfaces (BCIs) fall into the far future spectrum of interfaces. BCIs have been tested to control complex interfaces from industrial machinery to cars[2]. The big issue with BCIs as of now though is the limited range of variables that can be transmitted via the electrodes listening to electrical fluctuations in your brain (up, down left, right). Precise control is missing as can be shown in the various studies and the technology is still very much at its infancy.

Yet, looking into the future, It's feasible that BCIs like Elon Musk's Neuralink[3] venture may reach consumer-facing applications and could help us to externalise and action our internal thoughts. For example, if you feel cold, you could 'will' the heating up of the thermostat. What's still missing is the feedback the vehicle can provide. Another huge step necessary with BCI is the feedback component to show that an action has occurred or that you have made something happen. Tiny motors triggering your scalp or electric signals to gain your attention maybe? Only time will tell.

If BCIs fall in the 'future' end of the spectrum, one could easily see that visual and haptic interfaces fall in the 'now' end of the spectrum. We understand displays and interact with them on a daily basis. The visual spectrum offers a wide range of interactions which we continually employ via our GUIs.

But somewhere in the middle of the spectrum, we can talk about audio or voice based interactions. Voice and speech interactions have captured public consciousness for a long time, with the talking, communicating AI figure being a frequent tope in Sci-fi literature and movies (HAL 9000 to Samantha in *Her*). Only recently, in the last 5 years, are we seeing consumer facing applications of such interfaces, such as Siri or Alexa embedded into devices. We are finally edging beyond singular commands to conversation based voice interfaces. Despite some of it's limitations, we think there is huge potential to be uncovered with voice interfaces which we will now try to explore in this section, deliberately keeping aside BCI or visual interfaces for now.

KITT interior

So when we think about being an occupant in a robotic car with agency, one of the first things that comes to mind is the eponymous KITT from the 1980s TV series Knight Rider.

KITT was a great conversationalist, a personified car looking inside and out, and Michael's perfect companion on the road and beyond. In a way, this fictional series showed us a hypothetical and best-case scenario of both hard and soft human–machine interactions.

KITT:
"AS YOU WISH, MR KNIGHT. BUT, SINCE I SENSE WE ARE IN A SLIGHTLY IRRITABLE MOOD CAUSED BY FATIGUE... MAY I SUGGEST YOU PUT THE CAR IN THE AUTO-CRUISE MODE FOR SAFETY'S SAKE."

MICHAEL:
"NO, YOU MAY NOT. AND THAT'S FINAL. GOODNIGHT."

KITT:
"GOODNIGHT."

Particularly interesting is this interaction between the two, when they first meet in the series (see above).

KITT is anthropomorphised here to sound like a human aide – which is particularly pertinent as he is displaying characteristics that technologists are now getting close to replicating in machines. By delving deeper into the interaction above, we can see how the machine is supposed to interact with the human being.

Please note: the following dissection of this exchange is interesting as an intellectual exercise, but must not be confused with fact. But, as part of a screenplay written by a scriptwriter, the conversation has similarities to how UX designers storyboard the perfect flow in an application to make sense to users.

SEGMENTS OF THE CONVERSATION

1. "As you wish..." Understanding a question or request, in relation to a previous statement or command.

2. "...Mr Knight." Identification of the person spoken to.

3. "But..." Critical analysis of the situation and interjection. Is KITT analysing the driver's performance before this statement?

4. "...since I..." Sense of self.

5. "...sense we are in a slightly irritable mood..." - Sensing the mood of the occupant and downplaying the extent of irritation for non-confrontational communication (known "emotional down regulation" [4] by neurobiologists).

6. "...caused by fatigue..." Sense of context around the mood – historical data, biometric data etc.

7. "...may I suggest..." Speaking like a butler rather than giving Michael an order. Will AI need to behave similarly to gain trust?

8. "...put the car in the auto-cruise..." Referring to the self in an inanimate manner and referring to an action performed by the driver to leave KITT in charge, in this case via a physical button.

9. "...for safety's sake..." Is KITT speaking about the safety of the car (himself) or the driver, or perhaps both? Can a vehicle have a sense of self and also understand its own capabilities and limitations?

10. "And that's final." Taking an order and having the driver supersede the conversation.

11. "Goodnight." Replying in kind to the driver; closure.

AS YOU WISH,[1] MR KNIGHT.[2] BUT,[3] SINCE I[4] SENSE WE ARE IN A SLIGHTLY IRRITABLE MOOD[5] CAUSED BY FATIGUE...[6] MAY I SUGGEST[7] YOU PUT THE CAR IN THE AUTO CRUISE MODE[8] FOR SAFETY'S SAKE.[9]

NO. YOU MAY NOT. AND THAT'S FINAL.[10] GOODNIGHT.

GOODNIGHT.[11]

1 Understanding a question or request, in relation to a previous statement or command.

2 Identification of the person spoken to.

3 Critical analysis of the situation and interjection. Is KITT analysing the driver's performance before this statement?

4 Sense of self.

5 Sensing the mood of the occupant and downplaying the extent of irritation for non-confrontational communication.

6 Sense of context around the mood – historical data, biometric data etc.

7 Speaking like a butler rather than giving Michael an order. Will AI need to behave similarly to gain trust?

8 Referring to the self in an inanimate manner and referring to an action performed by the driver to leave KITT in charge, in this case via a physical button.

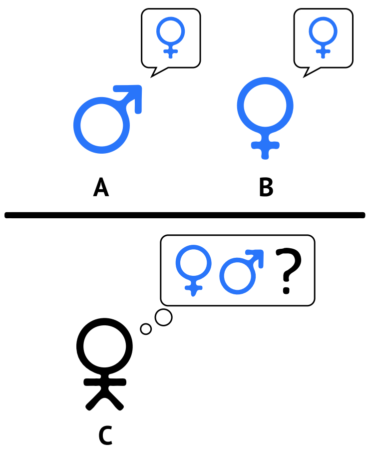
9 Is KITT speaking about the safety of the car (himself) or the driver, or perhaps both? Can a vehicle have a sense of self and also understand its own capabilities. and limitations?

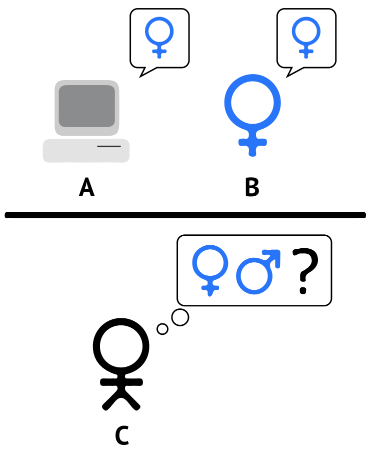
10 Taking an order and having the driver supersede the current conversation.

11 Replying in kind to the driver; closure.

What we see above is a complex interplay between voice interactions, with visual and haptic elements playing a major role in the act of driving itself. And that's without mentioning the sensorial components – how KITT watches and learns from Michael. Voice interactions primarily occur through the car's on-board AI – KITT – with Michael providing the steering and control inputs via the steering wheel and corresponding buttons.

But why the focus on voice interactions? What makes that so seductive for designers and storytellers alike? It's probably because speech is one of the most natural forms of communication, and what makes us quintessentially human. One of the inherent qualities of speech is that it can be used to pass on a massive amount of information in just a few words – there is the actual meaning of the spoken sentence coupled with the information passed through intonation, pacing, and nuance of the spoken word.





"I THINK THAT VOICE IS LIKELY TO BE THE MOST APPROPRIATE INTERACTION METHOD BECAUSE OF ITS BROAD COMMUNICATION BANDWIDTH. HAPTICS AND OLFACTORY ARE PRETTY LIMITED."

Gary Burnett, University of Nottingham

This inherent quality of speech makes voice interaction a true conversational interface, the holy grail for engineers and scientists focusing on interactions with AI. And that's why it has captured the attention of storytellers and filmmakers as they endeavour to add humanity to machine interactions, or comment on the lack thereof.

An example of the hunt for this holy grail is the classic *Turing Test*[5]. The original "Imitation Game" as Alan Turing originally described in Computing Machinery and Intelligence.

Figure 1 Player C, through a series of written questions, attempts to determine which of the other two players is the man, and which is the woman. Player A, the man, tries to trick player C into making the wrong decision, while player B tries to help player C.

Figure 2 The original Imitation Game test, in which player A is replaced with a computer. The computer is now charged with the role of the man, while player B continues to attempt to assist the interrogator.

The idea is that the computer's interface should be indistinguishable to that of the human being used in the comparison.

Another important aspect of speech-based interfaces powered by AI, is accessibility. GUI and, to a certain extent, physical interfaces, have always relied on training and prior understanding for optimal use. Speech interfaces attempt to shortcut this learning curve with the hope that more people are able to interact with machines effectively. For instance, the vision-impaired use speech-based software on the iPhone on a daily basis[6], whereas the ageing populace become reliant on technology, but are encumbered by its growing complexity.

The current state of conversational interfaces is such that there is often an edge of magical realism or even a sense of hilarity to them. We will look at nuances in their design and the difficulties associated with them later.

But before we move on to the next topic, let us leave you with something to mull over. Consider the passage from Knight Rider we dissected earlier on – an example of a perfectly functioning conversational interface – and let's compare it to the interfaces we see today (Google Home, Alexa, Cortana, etc). Here follows some of the differences and difficulties we perceive.

Hilarious Amazon Echo Alexa Fail
Bobby doesn't get what he asks for[7]

UNDERSTANDING CONTEXT / SENSING MOOD: THE CAR LOOKING BACK AT YOU

In segments 1, 3 and 11 of KITT's exchange with Michael, KITT seems to understand the context of the complex conversation and is able to thread together sentences with interjections and appropriate responses. This is quite hard to replicate with present technology and threaded conversations often seem to fail, with further requests and arguments being the norm.

In segment 7, we understand that KITT has the capability to gauge Michael's mood and respond accordingly. This is a critical component in driverless car interiors, and AI co-drivers[8] are now being built with biometric sensors to intercede in dangerous situations and to keep drivers engaged.

A study by Wendy Ju and her colleagues at Stanford University postulated that negative distractions in manual cars, such as texting and tweeting, could be used to create positive distractions in driverless cars by enhancing awareness, and reducing boredom and drowsiness in readiness for a potential handover situation. After all, demanding a passenger takes the wheel is much harder when that person is sleeping.

"These are things that keep you awake... they're actually good." [9]

Wendy Ju
Stanford University

UNDERSTANDING MOOD, INTONATION (PROSODICS) & PROVIDING APPROPRIATE RESPONSES

Segments 2, 5, 7 and 11 seems to indicate KITT's ability to recognise to whom he is speaking, perhaps through some previous voice training, such as that used with Siri. But being able to recognise mood through Michael's intonation and then modulating a helpful response to improve that mood is a much more complex task. Researchers call this "mood up regulation" in voice interfaces. Computationally, this adds a layer of analysis above speech recognition – understanding grammar and threaded conversations. KITT seems to do a fine job of this and that makes him a far cry above Alexa. An important question here is whether people would find the recognition of mood somewhat spooky. How far can we take it before we are in the depths of the uncanny valley?

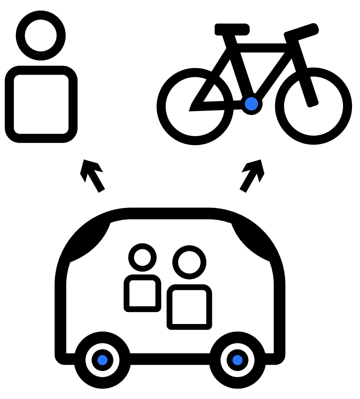
DELAYS, FEEDBACK & THE BRICK WALL OF UNDERSTANDING

A noticeable problem with present day conversational interfaces is the “Sorry, I didn’t get that” reply, or processing delays. Both are brick walls which interrupt conversation and frustrate people. There is also the whole notion of having to address a robot to trigger an interaction: ”Hey, Siri...” for example.

In KITT and Michael’s conversation, KITT provides quick responses and appropriate feedback without inordinate delays or brick-walling Michael. And that’s above the drone of the car’s engine – a howling V8. This requires faster and higher degrees of computation and noise cancellation.

Now let’s leave KITT and Michael alone and move on to the next type of interaction...

'OUTWARDS' ROBOT–HUMAN INTERACTION



Interactions with external participants, such as pedestrians, other vehicles and cyclists. An example of this kind of interaction would be how a taxi driver slows down to allow a pedestrian to cross safely.

Autonomous vehicle interactions are not just about control within the interior space, they also play a part in the greater ecosystem of mobility within cities, highways, and communities. In that regard, their adoption, trustworthiness and widespread use all depend on how these vehicles perform as useful, non-disruptive, safe actors. This makes it very important to study and design their interactive capabilities, inside and out.

"Social robotics" is one area of study that is looking into these capabilities. Social robotics aims to create robots that have a definite place in society, interacting with humans and other agents, while following local norms and regulations, and exhibiting social and emotive qualities.

An example would be Jibo[10] – toted as the world's first family robot – invented by Cynthia Braezel and her team at MIT. Jibo is a smart assistive robot which can detect human emotions, voice fluctuations and commands, and react accordingly. One of many social robots out in the wild right now, it is also one that is terribly easy to anthropomorphise – adorable, some might say. You can make up your own mind by watching the video[11].

Jiro
One of MIT's social robots, Jibo, invented by Cynthia Braezel and her team

These types of robots, living social lives, make use of a basic human tendency – to empathise with objects imbued with behaviour. We tend to see faces in smudges on walls, and attribute human qualities to animals or even machines. Take Boston Robotics' robot, Spot[12], a utilitarian quadruped robot. In their release video[13], a researcher gives Spot a hard kick, to showcase its stability and balance in the face of adverse impacts. The robot reels and stabilises, very much like a mule would. There was an immediate outcry about the video by concerned people and PETA was forced to release a statement:

> *"PETA deals with actual animal abuse every day, so we won't lose sleep over this incident… but while it's far better to kick a four-legged robot than a real dog, most reasonable people find even the idea of such violence inappropriate, as the comments show."* [14]
>
> **PETA**

At the opposite end to empathy is aggression, misunderstanding, and taking advantage of loopholes in how robots function. One example is with HitchBOT[15], a hitchhiking social robot which covered many thousands of miles across three continents, hitchhiking just like a human would. The robot was a social experiment, intended, in part, to test human psychology when confronted with technological novelty. It all came to a sad end when the robot was vandalised and beheaded in one of its trips across the United States. Harrowing to say the least, especially right now when roboticists and ethicists are looking into the ethical treatment of AI-driven robots[16].

"Our well-documented inclination to anthropomorphically relate to animals translates remarkably well to robots. A key characteristic of social robots is that they are specifically designed to elicit these projections. Studies with state-of-the-art technology indicate that humans already interact differently with social robots than they do with other objects. But if we tend to perceive robots as lifelike things, should we be treating them more like devices or like creatures?"

Kate Darling
Research Specialist, MIT

Spot
Spot the robot being kicked by one of its makers – poor thing!

HitchBOT
HitchBOT's website and obituary can be found here

DP.05

So it's clear, that when it comes to driverless cars, outwards interactions need to be carefully crafted to elicit the right amount of anthropomorphic projection and understanding, so that AVs are not feared and treated with respect. A difficult challenge, for sure.

DESIGN PRINCIPLE UNLOCKED:

05. BALANCED ANTHROPOMORPHIC PROJECTION

The anthropomorphic characteristics of an AV's exterior need to consider both the idea of a robotic car as a friend or creature, as well as a tool to make life better, so that it is not feared and treated with respect.

THE IMPORTANCE OF FRAMING – STORIES & ACTIONS TO HELP PEOPLE UNDERSTAND THE CAPABILITIES OF A ROBOT

As the above examples show, it is easy to form complex thoughts around animated objects. Kate Darling, a professor working on human–robot interaction, robot ethics, IP theory and policy at MIT Media Lab, said in her 2015 paper on emotional regulation[17] via "framing" that:

"Our results show that people with a certain type of high trait empathy (empathic concern) hesitate to strike the robots. We also find that high empathic concern and hesitation are more strongly related for robots with stories."

Kate Darling
Research Specialist, MIT

This framing applies to driverless vehicles as well – a label, name or naming convention implying a story or an experience will help ensure that the people interacting with it will:

- trust and accept the technology as a useful tool and actor on the roads and within society

- respect the fast moving heavy box on the street, thus preventing accidents or cases where it is taken advantage of for some inappropriate human benefit

Both the above elements require balanced anthropomorphic projection.

Interestingly, Raymond Loewy called this approach the MAYA principle: "Most Advanced Yet Acceptable." Loewy sought to give his users the most advanced design, but not more advanced than what they were able to accept and embrace.

To understand these two elements, let's take a simple everyday use-case: pedestrians crossing the street at a designated spot. For the purposes of this example, we'll use a zebra crossing in the UK where vehicles have to give way to pedestrians (but don't always).

In the present day, pedestrians generally look left and right to watch out for oncoming traffic, judge speed, and in some cases negotiate with the driver of the vehicle through a glance or a wave, to figure out if they are actually going to stop.

The human driver approaching the crossing slows down as they try to judge if someone near to the crossing is going to use it. If the driver senses hesitation or a receives a questioning look from the pedestrian they will often flash their lights or gesture in some way to signal their intention to let the pedestrian cross the road. At the end of the interaction, there is usually an acknowledgement of the driver's behaviour by the pedestrian with a "thank you" wave, or if the behaviour is untoward, a somewhat ruder reply. Similarly, a pedestrian might run across the road in front of a car, eliciting a rude reaction from a driver, not to mention a skipped heartbeat. This very human set of interactions between the actors showcases both elements above – trust and respect according to a situation.

These small interactions of trust and respect, or the opposite, can also gain weight with time. In the long run, pedestrians' or even a cyclist's trust of driver behaviour in a locality either builds over time or erodes into distrust and over-cautiousness. Statements like: "The traffic in New York is so unruly and people don't follow rules," or "Germans are such considerate drivers," which may not be statistically accurate, but also have an effect.

"I THINK I DON'T INHERENTLY TRUST PEOPLE'S BEHAVIOUR AND ON A BICYCLE IN LONDON, YOU KNOW, PEOPLE CAN BE QUITE ERRATIC AND SECOND GUESS EVERYONE AND ASSUME THEY HAVEN'T SEEN YOU. IT'S A VIDEO GAME, A GIANT VIDEO GAME, BUT UM... I WOULD HAVE THOUGHT THAT AUTONOMOUS VEHICLES WOULD PROBABLY BE A LOT MORE PREDICTABLE. I IMAGINE FROM OTHER PEOPLE'S PERSPECTIVE THEY'D BE A LOT SAFER."

Neil, ustwo study participant

Consider a driverless car interacting with pedestrians at the same crossing. Among the many questions which can be asked are:

- Who initiates the interaction and how? Is it the car or the pedestrian?
- What implicit signals can a car make to illustrate that it is allowing a pedestrian to pass or not?
- With whom does the pedestrian negotiate, when there's no human driver?
- What actions from the car's perspective engender trust both in the moment of the interaction and in the long run?
- How do we cater to people's enhanced trust in the vehicle given the fact that it is supposed to be safer?
- What adverse interactions should the vehicle or pedestrian prepare for? Cases such as the person stepping out onto the road or the car not seeing the pedestrian.
- Most importantly, how can the car leave a positive impression on the pedestrian so that future interactions happen with progressively more trust in the system?

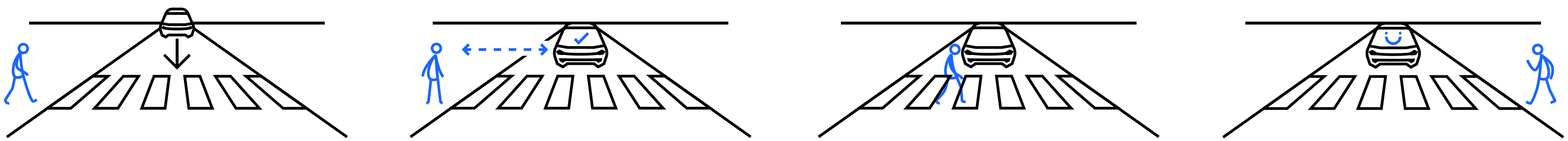
Each of these questions need to be answered with the two elements we discussed earlier – trust and respect for the technology. This is of foremost importance because certain AV experiments have already seen cases where trust is lost in the system – as shown when Uber's AV vehicle jumped a red light[18], the video of which has since gone viral – not good news for trust in it's system.

Another such case is that of Google's AV, Waymo, which was bullied into over-cautiousness when it sensed a fixed-wheel bicycle next to it (you can see the videos online here[19] and here[20]).

Waymo

Fortunately, we have been able to carry out our own studies into human perception of driverless technology to help frame and design the right interaction patterns. Much of this research was backed up by the principles derived from Wendy Ju's book on implicit interactions, along with her *Ghost Rider*[21] report.

Wendy defines implicit interactions as "those that occur without the explicit behest or awareness of the user." For instance, a building doorman who signifies that he understands your approach to the building with subtle facial movements, opening the door ever so slightly as you get nearer, which makes you feel welcome. These are everyday interactions which we rely on – a loving glance, a nod of the head, a friendly gaze, or even a pat on the shoulder. It is what makes us quintessentially human and we recognise them without much cognitive load in the foreground.
A truly interesting addition to our aforementioned 'Soft Interactions'.



1. The pedestrian approaches the crossing

2. The predestrian checks for traffic - looks to engage. Negotiates intentions with the AV

3. The pedestrian crosses the road

4. Negotiation complete. The pedestrian may still want to thank the AV, the AV should reciprocate for a good closure experience

"Overlooking the effect of novelty, people generally adhered to existing interaction patterns with cars unless there was a breakdown in expectations. We found that while erratic behaviour on the part of the car was mentioned as a reason for hesitancy, the decision to cross was still made by most participants."

Wendy Ju
Stanford University

Now let's answer our questions, applying the above criteria.

The Framing Story: Autonomous vehicles should communicate their intent by intentionally imitating elements of human behaviour, with just enough anthropomorphism.

The Implicit Interactions: On approaching the crossing the car behaves like a human driver would, slowing down to signify that it has seen a pedestrian. In studies this has shown to be as effective[22] as visual displays to signify that it has sensed a person in front of the vehicle. On slowing down, the pedestrian looks at the vehicle to engage in a negotiation. If it is a single car on a road, it can respond – perhaps by dipping the lights (as polite drivers do in the UK). This then prompts the pedestrian to cross the road. However, many people will begin crossing in front of the AV without the need for this extra feedback.

DP.06

In most studies and concepts, this is where the story ends. It's a successful and simple solution, yet it does not continue the full story to its conclusion. The interactions might continue – for instance, if the pedestrian waves a "thank you" gesture to the AV, expecting a response, the AV should make some form of acknowledgement.

Humans like to acknowledge and thank a good deed, it's in our nature. This is critical for a 'closure experience' to ensure that the entire experience is well-rounded and satisfying and that a respectful relationship forms with the robot. If the vehicle did not acknowledge the human gesture, then the human won't do it the next time and that respect is thus lost and any relationship breaks down. Acknowledgement is vital for forming and maintaining a respectful relationship between man and robot.

DESIGN PRINCIPLE UNLOCKED:

06. ESTABLISH AND MAINTAIN A HUMAN ROBOT RELATIONSHIP

If a stranger is rude to you, you won't want to interact with them again. The same applies to a robot. The AV must acknowledge and reciprocate human manners and behaviours. For example, when a person waves to thank an AV for letting them cross the road, the AV must display acknowledgement of the gesture back to the human.

Such repeated interactions can engender trust and, just as importantly, respect, in the system. There are other cases where similar framing and design of implicit interactions can apply, such as when a pedestrian just walks out into the road (not at a crossing). Here the implicit interactions can become more explicit and communicative – sounding the horn, for instance – enabling people to respect the fast-moving heavy box.

Applying these interactions onto what is known as the *Implicit Interaction Framework*[23] we can see an interplay of system behaviours. These behaviours are based on the conditions the robot encounters in the crossing scenario.

THE IMPLICIT INTERACTION FRAMEWORK

The implicit interaction framework allows us to analyse and track our solutions to situations based on two parameters: "attentional demand" and "initiative". The axis of the framework have the following terms being used:

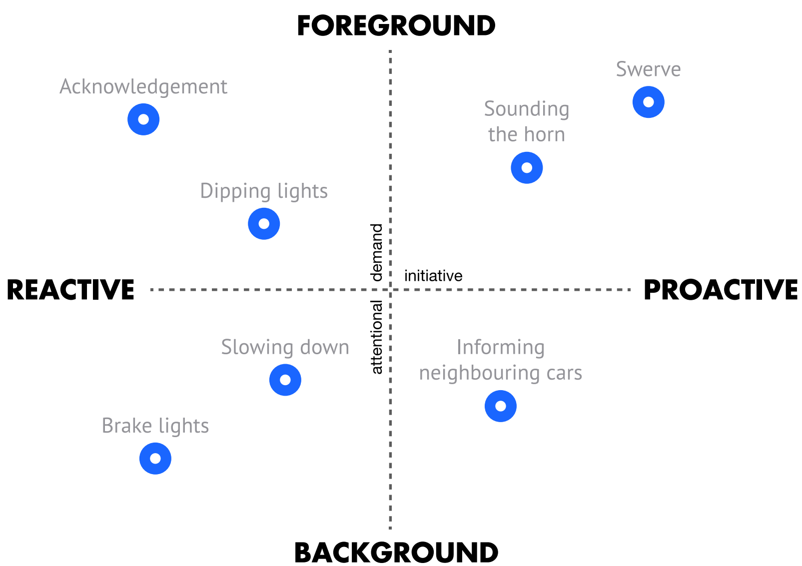
Foreground - refers to interactions that have an active impact on the the human being interacting with the machine. More 'attentional demand'. For instance, sounding the horn to get attention a foreground interaction.

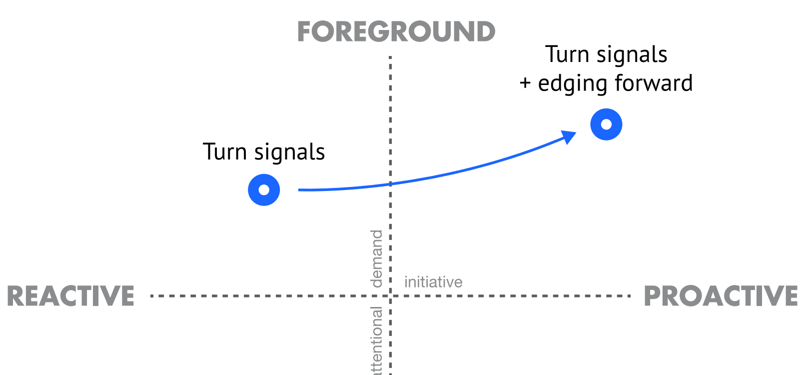
Background - refers to interactions that have a passive impact. For instance - slowing down to let a pedestrian pass. Less 'attentional demand' but effective communication nevertheless.

Reactive - refers to machine feedback to a human input. For instance, brake lights turning on as a sign to slow down. Less initiative but reactive to braking.

Proactive - refers to the machine taking initiative in communicating with the human being. For instance, swerving early to avoid a possible accident.

In our case with AVs it also serves as a tool to devise and test new interaction solutions if certain quadrants have not been explored further. For example, sounding the horn as you see a pedestrian in the road scores high on the initiative and attentional demand, and is thus a proactive and foreground-oriented activity.



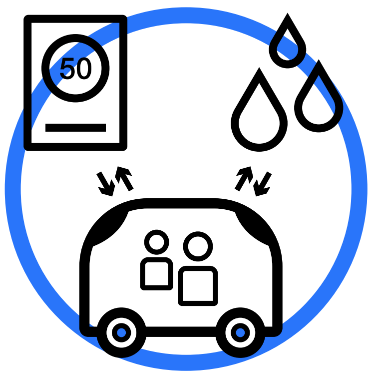


In comparison, slowing down is a background activity because it requires less attentional demand from the pedestrian.

Another interesting case was found by Google's Waymo – that of joining an intersection. Early iterations of the vehicle found itself pinned down by traffic on perpendicular roads, with the car being an obedient rule-follower, flashing its indicators (turn signals) in the direction of the turn and not being aggressive. Repeated situations demanded a change in response. The engineers then allowed the vehicle to imitate human drivers – gently edging forward onto the road, giving implicit indications to the flowing traffic to slow down and allow the car to join. This is something Courtney Hohne, a spokeswoman for Google, calls "smoothing out" the relationship between the car's software and humans.

In this case, the reactive and foreground interaction of using the indicators and waiting at the intersection gets an additional proactive interaction of edging the vehicle forward. The engineers moved the interaction to the right to achieve optimum output, that of joining the intersection, and added a bit of humanity and anthropomorphism to boot! This is a fascinating story and one that will be repeated throughout this book – robots imitating human behaviour just enough for people to identify with and relate to them.

'MIDDLEMAN' ROBOT–HUMAN INTERACTION



How the robot acts as an interface or the Middleman with the outside world for the vehicle's occupants. For example, the decisions the vehicle is taking based on its sensorial observations, fed back to the passenger.

This set of interactions with the autonomous vehicle demonstrate how new technology affords us different lenses through which we perceive our presence in the physical space. For example, maps drastically altered our worldview as they became more and more accurate over the centuries. Today, our connected smartphones add contextual layers with features such as GPS and social media, fundamentally altering our perception of place and time, for both good and bad. In both cases, the technological elements basically relate our presence in the physical or social domain to either an abstract graphical entity such as a map, or to our digital services.

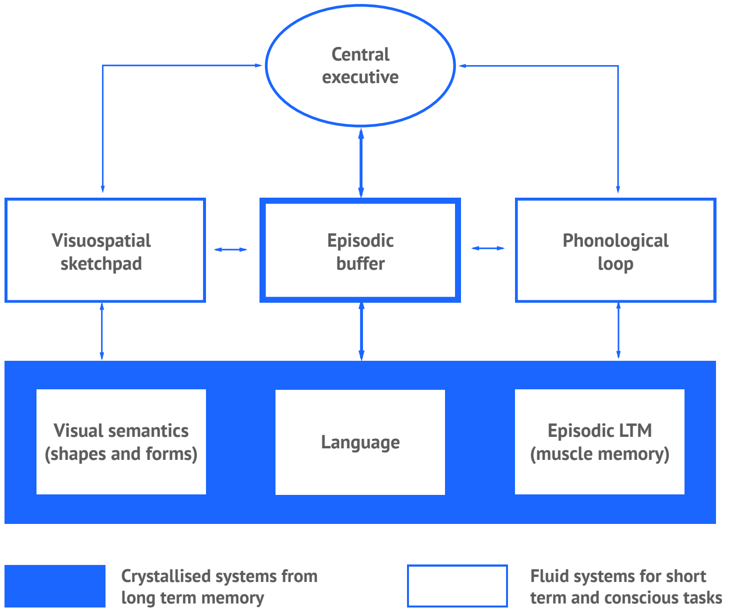
Vehicles have a means of doing this as well. In the early days it was purely about the control of the vehicle on the road, feeling the bumps and vibrations in relation to the speed and revs through your interface – the steering wheel. With the advent of computing within automobiles, especially with connected devices (the smartphone or the car itself), we have started seeing our presence in new ways. For example, despite our frustrations with mapping applications, the chances of getting lost are minimal in most of the developed world. The pulsing blue dot we take for granted is the device plotting our location in relation to the world with a gamut of satellites and algorithms dancing to a delicate technological tune. Truly beautiful and the stuff of science fiction just 25 years ago.

This is the perfect segue into thinking about autonomous vehicles, which have to relate what the robot is looking at to the occupants, along with its worldview, decision-making and its intentions on the road. Middleman interactions also become critical when we consider the two forms of driverless vehicle usage – the near-term semi-autonomous vehicle (Society of Automotive Engineers (SAE) Level 2 or 3) and the long term fully-autonomous vehicle (SAE Level 4 or 5).

Why critical? Firstly, with semi-autonomous vehicles, the unique 'handover' or 'takeover' phase from autonomous to manual driving makes it incredibly difficult to get Middleman interactions right. In cognitive terms this is called a mode shift, which in this instance can be a dangerous activity. It is very similar in condition to texting while driving[24], one of the leading causes of accidents on the road.

Handover typically refers to the staged period during which the AV transfers all controls to the driver, so that the vehicle can be driven manually, whereas takeover tends to refer to the specific length of time in which the driver has regained manual control of the vehicle and automated systems have been deactivated. Conditions that may impact performance include the number and type of critical incidents, traffic density, feedback, distraction, and fatigue according to Merat & de Waard in their paper Human Factors Implications of Vehicle Automation[25].

Imagine a scenario where you are reading a newspaper or texting in your car, which is negotiating traffic itself, when you come to a street where roadworks have introduced deviations in traffic flow. This might be where the vehicle can no longer handle the task and so you need to regain control of the vehicle (the handover) while dropping your secondary activity and then understanding the situation – in this case negotiating the deviation signs put up by the roadworks (the takeover). Without understanding what the vehicle has seen, how the vehicle has already responded, and its last intentions, the risk of an accident increases greatly. This is the exact problem Google deems too complex to solve[26] and is thus instead focusing on full autonomy, without the need for the handover.



Episodic Buffer
Baddeley (2000)

Delphi's cross-country autonomous trip

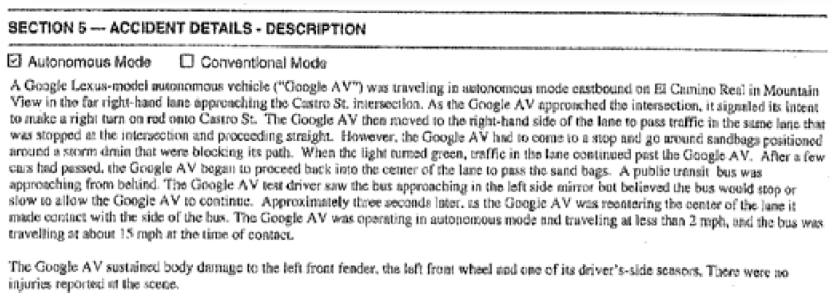
What's happening here is conflict with mode shifting between task one (reading and analysis) to task two (driving and analysis), which places a lot of stress on cognitive load. This results in an an overload of the episodic buffer[27] in the brain.

The episodic buffer is part of the working memory model put forward by Baddeley in 2000. It is highly dependant on context, the driver's age, physiological state, mental state, and the task he or she might be undertaking before the mode shift. In simulator experiments taking place at 70 mph, Merat & de Waard found that 35-40 seconds were required for the human driver to achieve stabilised lateral control of the vehicle, irrespective of whether handover from the AV had been planned or was in response to a critical event.

This mode shifting is already proving to be an issue in driverless experiments being run around the world. One of the primary problems the cars seem to face is in recognising and reacting to unexpected deviations on the road while in fully-autonomous mode, ie obstacles caused by roadworks or accidents.

Delphi's cross-country autonomous trip is one example. Its prototype was packed with technology including four short-range radars, three vision-based cameras, six LIDARs (similar to radar), a localisation system, intelligence software algorithms, and a full range of advanced drive assistance systems. Despite all this paraphernalia, the on-board drivers had to intervene and take over driving for a 50-mile stretch when unmarked lanes and heavy roadworks proved too unpredictable for the vehicle.

This type of recognition error has also caused Middleman difficulties for Google's prototype car, which got into a misunderstanding, and consequently a collision, with a bus in California during 2016.


SECTION 5 — ACCIDENT DETAILS - DESCRIPTION

☑ Autonomous Mode ☐ Conventional Mode

A Google Lexus-model autonomous vehicle ("Google AV") was traveling in autonomous mode eastbound on El Camino Real in Mountain View in the far right-hand lane approaching the Castro St. intersection. As the Google AV approached the intersection, it signaled its intent to make a right turn on red onto Castro St. The Google AV then moved to the right-hand side of the lane to pass traffic in the same lane that was stopped at the intersection and proceeding straight. However, the Google AV had to come to a stop and go around sandbags positioned around a storm drain that were blocking its path. When the light turned green, traffic in the lane continued past the Google AV. After a few cars had passed, the Google AV began to proceed back into the center of the lane to pass the sand bags. A public transit bus was approaching from behind. The Google AV test driver saw the bus approaching in the left side mirror but believed the bus would stop or slow to allow the Google AV to continue. Approximately three seconds later, as the Google AV was reentering the center of the lane it made contact with the side of the bus. The Google AV was operating in autonomous mode and traveling at less than 2 mph, and the bus was travelling at about 15 mph at the time of contact.

The Google AV sustained body damage to the left front fender, the left front wheel and one of its driver's-side sensors. There were no injuries reported at the scene.

Google AV accident report DMV[28]

Google's autonomous car, a Lexus SUV, was driving itself down El Camino Real in Mountain View. It moved to the far right lane to make a right turn onto Castro Street, but stopped when it detected sandbags sitting around a storm drain blocking its path. Getting out of that scenario involved backing up at 2 mph, which then caused an altercation with a passing bus:

"After a few cars had passed, the Google AV began to proceed back into the center of the lane to pass the sand bags. A public transit bus was approaching from behind. The Google AV test driver saw the bus approaching in the left side mirror but believed the bus would stop or slow to allow the Google AV to continue. Approximately three seconds later, as the Google AV was reentering the center of the lane it made contact with the side of the bus."

Google AV accident report

The post-accident analysis suggests that the human driver could have taken over, but the decision to hand over controls and then achieve takeover needed a faster understanding of the situation. Could the car have related things better about its decision or indecision prior to the stop? It's a good question, but let's not go into a post-rationalist loop just yet.

The complexity in Middleman interactions during handover and takeover has prompted a few pioneers in autonomous vehicle development to take an alternative approach – completely skipping levels 2 and 3 of autonomy to get to level 4 or 5.

Skipping those levels introduces the other great need for well-crafted Middleman interactions – people gaining trust in new technology – as our design principle ***04. BUILD TRUST IN THE EXPERIENCE*** recommends, irrespective of whether we consider semi or fully-autonomous vehicles. In our own early research, and in other studies, we find that despite age differences and reliance in technology, there is a fundamental fear and distrust of autonomous systems. According to a Deloitte study[29], trust appears to be the biggest roadblock to selling the notion of self-driving cars in every country surveyed. South Korea ranks the highest with 81% of people expressing safety concerns about fully-autonomous vehicles. China has the lowest figures, with 62%, but that still represents a large majority of consumers. The US falls roughly in the middle, where nearly three-quarters of consumers (74%) believe that fully-autonomous vehicles will not be safe. For the other countries in the study the percentage of consumers who believe fully-autonomous vehicle will not be safe are: Japan at 79%, Germany at 72%, and India at 64%. This is certainly a sentiment we have seen echoed by our own study participants.

"I WOULD FIND IT RATHER WEIRD GETTING INTO A CAR WITHOUT A DRIVER – IT WOULD BE SPOOKY."

Françoise, ustwo study participant

The first-use and honeymoon period of adoption will be incredibly critical – people will need to quickly see the benefits to both themselves and the world around them. The vehicle will need to act as an interface, and a safe, protective bubble from the world, both physically and mentally – knowing where you are in relation to your journey and why the vehicle is behaving the way it is are vitally important. Mitigating anxieties about the road and what is happening in relation to the outside world will be critical in triggering quick adoption.

This is a notion many car companies are working towards. One example comes from Brian Lathrop, who runs the UX group at Volkswagen's Electronics Research Laboratory (ERL) in California, with his "3+1" principle:

"There are three things an autonomous car has to get right, plus one: Above all, we need to know what mode a car is in, whether it's driving itself or not. The second principle Lathrop calls the Coffee Spilling Principle: We need to know what something is going to do, before it's actually done. Third, and perhaps most vital in fostering trust, is that we need to know what the car is seeing. And finally, we need perfectly clear transitions when a car takes control, or when we take control from a car." [22]

Cliff Kuang
Co.Design

These principles played a chief role in the design of interactions and feedback within Volkswagen's *Jack* prototype[30], a modified Audi A7.

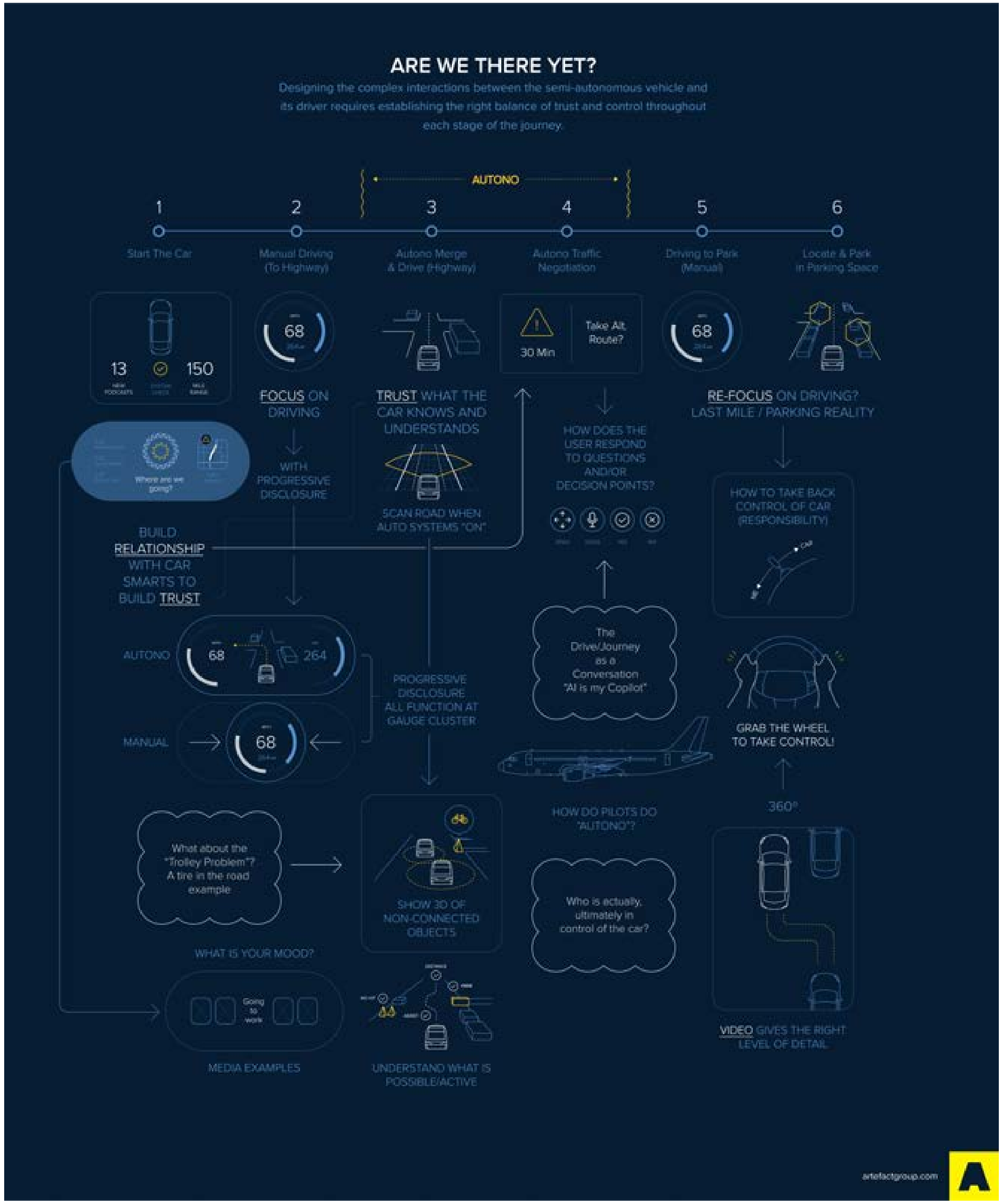
If you watch the video of the Jack prototype, you can spot some great Middleman interactions, including the handover distance and time before the driver cedes control – a prime example of an anxiety mitigation tactic in action.

Another great example of Middleman interactions has been explored by Artefact studio in their rather fascinating study for Hyundai[31]. Their design for trust once again explores how the vehicle relates the environment to the driver in the most human way possible, looking at the near future of semi-autonomous vehicles where drivers might need to take control of the vehicle.

“To establish user understanding of the system and its capabilities the interface must communicate clearly and transparently – by revealing what the car sees, what the system is currently doing, what it intends to do in response to environmental conditions and why.”

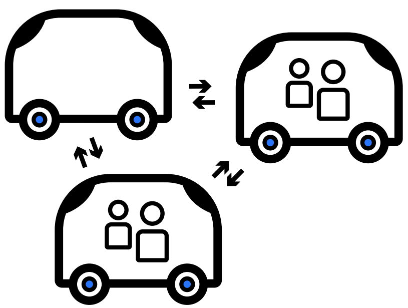
Artefact

We completely agree with this sentiment and believe transparency and communication are critical to building trust – a prime example of an anxiety mitigation strategy – at least for the near term with semi-autonomous vehicles. We have explored these strategies as a key principle in our approach to designing interactions around AVs further on.



Interactions for semi-autonomous vehicles
Artefact for Hyundai

'EACH OTHER' ROBOT–HUMAN INTERACTION



How the robot interacts with other robots of a similar make or other brands of robots, doing things like transferring data and learning from one another.

Communication is one of the cornerstones of human existence. Nonverbal and verbal communication gave us human beings the advantage in terms of cultural transmission and learning – a defining part of our evolution as a species. Building better communication systems helps build society and enhance relationships. A breakdown of communication causes the opposite – the collapsing of relationships and enhancement of strife. We can see that from our study participants such as Darret or Wanfy who require social interactions for their mental wellbeing.

In his wonderful book *Traffic*, Tom Vanderbilt describes interesting phenomena surrounding the breakdown of communication with drivers in automobiles. One such case is how vehicles become a driver's personal armour, becoming a deaf-mute extension of the self, affording us a place to be ourselves and also insulate us. This insulation is the issue. We are not able to communicate our intent or thinking with other members in traffic – with each other. Hence drivers may become more rude or aggressive towards other drivers, more so than if they met the same person on the street.

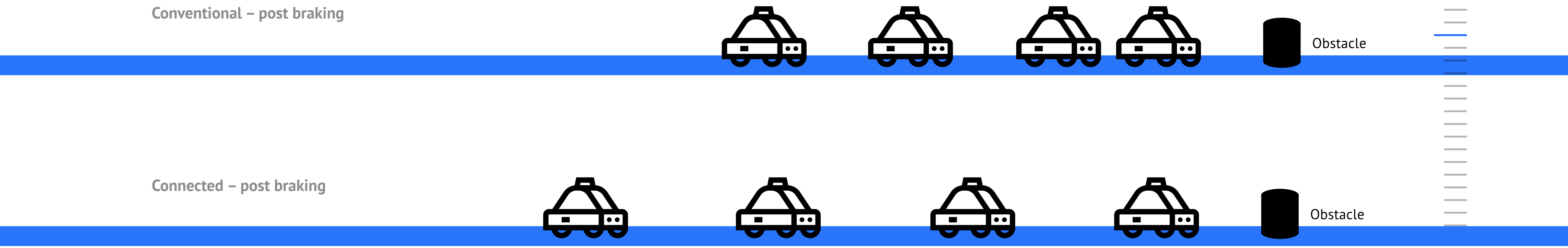
In cars, our complex language systems are reduced to a set of gestures, signals and semaphores which hark back to our primitive ancestors. We are subject to the "fundamental attribution error" where we attribute the actions of other drivers and actors to who they are, reducing people and vehicles to stereotypes. This perpetuates accidents, misunderstandings, and good old road rage.

"Traffic is riddled with 'asymmetries' in communication... You can see but you can't be heard... In a very precise way, you are made dumb. You can shout as much as you want but nobody's going to hear you." [32]

Jack Katz
Professor of Sociology, University of California

This sets us up then to discuss why interactions enabling communication between each other with the aid of robotic machines such as driverless vehicles has been a huge challenge for roboticists and manufacturers alike. Better systems improve the likelihood of:

- communication of intent and thus inherent improvement of safety for both driverless and human-driven vehicles
- learning, collaboration and transference of accumulated data and knowledge among machines or robots



Communication between vehicles is a well-known goal for manufacturers and technologists – the advent of the "connected car" – irrespective of autonomy. Connecting the vehicle and its sensor arrays to central servers and the world wide web is seen as a massive boon and opportunity for a group of vehicles to access each other's data and influence each other on the road.

A classic case of connected vehicles improving safety is illustrated by the following example.

Consider three cars travelling behind each other, maintaining a decent gap between them. The first car experiences an obstacle, causing a sudden-braking scenario. In the first case, with a line of conventional vehicles, the speed at which the third car notes the brake lights of the second and reacts to the first car will be slow. This will cause either a closing of the distance between them or, in the worst scenario, a tailgate collision.

With connected cars communicating with each other, as soon as the obstacle is noticed, the transfer of the knowledge of braking between the first and third car can be much quicker – fractions of a second. Thus the probability of collision is reduced.

In essence, this opens up communication channels and transfer of both foreground and background information, as discussed in the implicit interactions concept earlier. Foreground information can be defined as the information or data received in the immediate vicinity or actionable area around the vehicle (in the three car scenario, it's the sudden braking). Background information is thus every piece of information sensed or received beyond the immediate vicinity of the vehicle, eg traffic information being shared from neighbouring streets along a particular route being shared between cars (similar in function to that of community-based traffic and navigation app Waze).

The connected or knowledge-sharing car can affect both vehicles with human drivers and also those that are driverless. What truly separates driverless vehicles (semi or fully-autonomous) will be the second likelihood – the collective capability to learn from and react to information received in or around the car, both in real-time and over time. It's a mouthful, but we can break it down into layman's terms by analysing how AI systems are made to learn.

TENNIS & MACHINE LEARNING METHODS

Consider how a child learns to play tennis for the first time. The most important thing to understand is that the ball has to be struck with the racket in the right manner to produce the desired effect – sending it over the net.

A child without a coach could, with a lot of trial and error, figure out a method to hit the ball with enough velocity and force, to be rewarded with the satisfaction of sending it over the net and possibly admiration or praise from an adult. Their technique might not be perfect, but by rote repetition the goal and reward is achieved.

A second method could be that of imitation and replication – watching another child play the same stroke and trying to imitate their actions. The child could learn faster than by rote repetition, and by watching better and better tennis players, his or her own technique could become further refined.

The third, and perhaps the most effective method, is supervised training or coaching. A seasoned veteran of the game displays the correct method of racket grip, stance, and ball play technique, and through further repetition and practice, the right mental models are built – perfecting a stroke over time.

The thing to consider here is that learning to play a good tennis stroke requires a combination of the three methods we listed. Each one has its own benefits and flaws. The supervised coaching method can be flawed by replicating the inherent problems in the coach's own technique. Imitation of different styles might cause cognitive dissonance between understanding how each individual plays. And rote learning can be a very slow process.

Learning how to play tennis can be considered analogous to how robots and AI are being built to learn new skills, with a few significant differences.

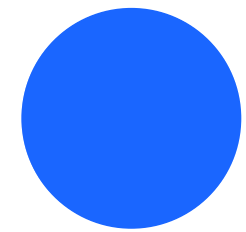
There are some distinct advantages that machines have over human processing. Chief among them are that they are excellent data parsers and processors, working at large scales in processing power, memory, and reproducibility. Reproducibility manifests itself in a machine's capability to do the same activity over and over, without getting tired. It also relies heavily on statistical knowledge with fewer internal biases and irrationality. Of course, this relies on the quality of the data being collected – human biases in data aggregation algorithms and training can expose even a machine to biases. An example of this is the classic case of XBox's Kinect having trouble picking up dark skinned people[33] in its earlier versions.

But data aggregation and parsing is not learning and does not bring about knowledge and wisdom to make key decisions. This is because decision-making capability is both a function of the processing power of the human brain and of our understanding of context and intention, which, despite advancement in sensor technology, is still far away for machines. Thus, continuous learning and improvement remains an enormous challenge for the researchers developing AI.

A technique which marries together a machine's advantages with human intervention is that of "deep learning" using algorithms or neural networks to aid machine learning. In essence, this is equivalent to coaching a machine to learn with data and information input over time. Coaching is used as a broad term here, as it might mean learning from one expert, like an autonomous vehicle learning from a driving instructor, or learning from a number of coaches, like a machine learning from drivers in a city and then sharing that data with other machines (between each other). For example, AVs could learn to navigate London through the combined expertise of the city's one million drivers, along with the data sensed by the vehicles themselves.

Tesla collects millions of miles of road and driving behaviour data with its vehicles, which are infused with sensors and are being driven actively around the world. This is termed as "fleet learning". Tesla uses the data to construct in-depth models of cities for its vehicles, with traffic signs and generic traffic behaviour. The AV learns to perceive a city and its people – turning sensory data into perception – with AVs being a trojan horse for information.

To understand the difference between sensing and perception, consider a sensor – which could be a camera or simply your eyes – spotting a circular object ahead of you. The sensor perceives this as a circle, but it could be a number of different things including a sphere, a cone, or a cylinder. Turning this sense into perception requires a prior understanding of the number of things of which the circle could be part. This could be based on historical data – you've seen this object a 100 times before, or 900 people have identified this to be part of a cylindrical object – or based on other sensory data, such as shape of the shadow it throws on the ground. Thus, the human being or machine can forecast what the object is, based on prior understanding of the situation.



Sense: an object?

Perception: cone, sphere or cylinder?

Tesla has outlined this approach of learning and forecasting, with a wonderful example in a blog post[34], which talks about a similar phenomenon involving the use of radar sensors and fleet learning to understand the world.

Radar has a tendency to produce false alarms based on its detection capabilities, which sometimes amplify the size of metallic dish-shaped objects, like soda cans. The AV car has to avoid such false alarms and Tesla describes its three-step approach to solving this problem (see right):

This coached training approach is a great way for machines to achieve an understanding of the world around them when there is already a data pool to fall back on. This is not the same as understanding the world in isolation, like learning a tennis stroke only through experimentation and practice. When there is no existing data, chaos could ensue – for example, driving a Tesla from Germany to India and then engaging Autopilot.

This is where "reinforcement learning" comes in, where the machine explores the boundaries of the task through constant experimentation – gaining confidence and achieving rewards. In a similar way to the self-taught tennis stroke, the technique allows the machine to gain new knowledge through trial and error. Thankfully, trial and error does not mean crash and burn, or endangering human life. It is in the subtleties of interaction and personalisation, where a robot tunes its behaviour to adapt to human needs.

Google and Fanuc, the well-known robotics company, are already experimenting with industrial robots with reinforcement learning properties. The robots also share data with each other via a server, collaboratively teaching each other to further reduce the time taken to achieve a goal. The aim of these projects is to reduce learning time for tasks undertaken in industry when one job lot changes to another. For instance, assembling a door of one shape and size during hour one, and then assembling a different type of door during hour two. The physics and mechanics of the door remain the same but the learning time for new components and their placement changes.

"The first part of solving that problem is having a more detailed point cloud. Software 8.0 unlocks access to six times as many radar objects with the same hardware with a lot more information per object.

"The second part consists of assembling those radar snapshots, which take place every tenth of a second, into a 3D 'picture' of the world. It is hard to tell from a single frame whether an object is moving or stationary or to distinguish spurious reflections. By comparing several contiguous frames against vehicle velocity and expected path, the car can tell if something is real and assess the probability of collision.

"The third part is a lot more difficult. When the car is approaching an overhead highway road sign positioned on a rise in the road or a bridge where the road dips underneath, this often looks like a collision course. The navigation data and height accuracy of the GPS are not enough to know whether the car will pass under the object or not. By the time the car is close and the road pitch changes, it is too late to brake.

"This is where fleet learning comes in handy. Initially, the vehicle fleet will take no action except to note the position of road signs, bridges and other stationary objects, mapping the world according to radar. The car computer will then silently compare when it would have braked to the driver action and upload that to the Tesla database. If several cars drive safely past a given radar object, whether Autopilot is turned on or off, then that object is added to the geocoded whitelist."

Tesla software 8.0 report
September 2016

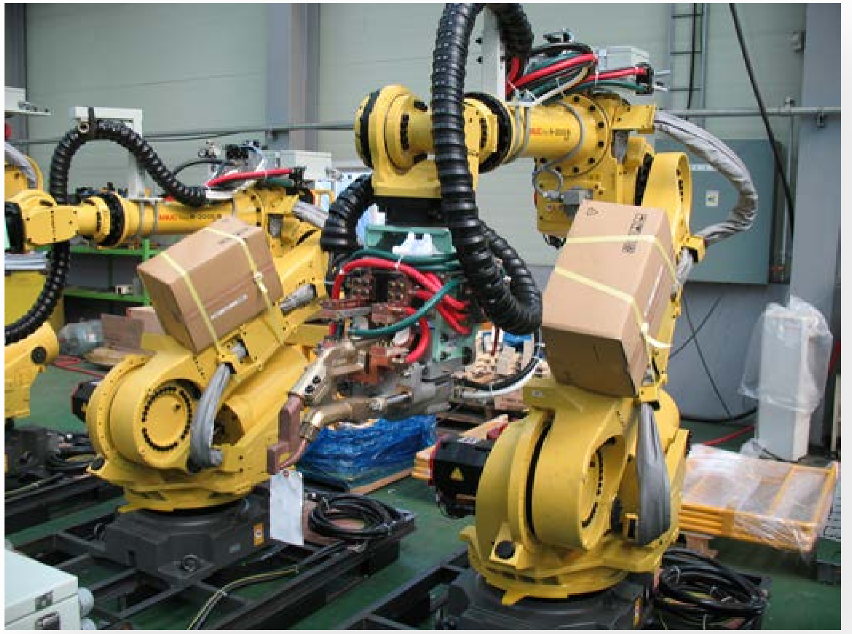
Frankfurt

Chandi Chowk

"Perhaps one of the simplest ways for robots to teach each other is to pool information about their successes and failures in the world. Humans and animals acquire many skills by direct trial-and-error learning. During this kind of 'model-free' learning – so called because there is no explicit model of the environment formed – they explore variations on their existing behavior and then reinforce and exploit the variations that give bigger rewards. In combination with deep neural networks, model-free algorithms have recently proved to be surprisingly effective and have been key to successes with the Atari video game system and playing Go. Having multiple robots allows us to experiment with sharing experiences to speed up this kind of direct learning in the real world." [35]

Google's Brain team

Google's own experiments have shown that a combination of learning methods is the way to go, in order to transmit human intuition of handling objects and scenarios to robots, by coaching or training them, and also by allowing them to share knowledge and collaborate via experimentation.



FANUC R-2000iB

"In all three of the experiments... the ability to communicate and exchange their experiences allows the robots to learn more quickly and effectively. This becomes particularly important when we combine robotic learning with deep learning, as is the case in all of the experiments discussed... We've seen before that deep learning works best when provided with ample training data. For example, the popular ImageNet benchmark uses over 1.5 million labeled examples. While such a quantity of data is not impossible for a single robot to gather over a few years, it is much more efficient to gather the same volume of experience from multiple robots over the course of a few weeks. Besides faster learning times, this approach might benefit from the greater diversity of experience: a real-world deployment might involve multiple robots in different places and different settings, sharing heterogeneous, varied experiences to build a single highly generalizable representation."

Google's Brain team

WHAT DOES REINFORCEMENT + DEEP LEARNING + TALKING VEHICLES MEAN FOR THE HUMAN?

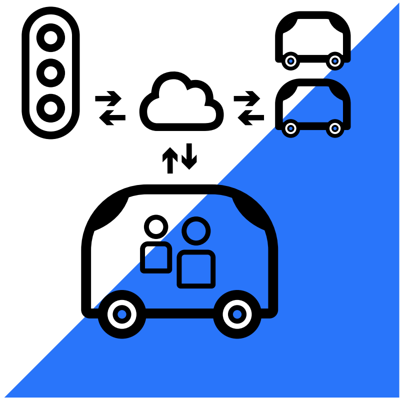
A long heading indeed, but what does it mean for us as people using autonomous vehicles? What advantages do deep and reinforcement learning, and the combination of the two, have when interacting with these automatons?

The primary advantage of deep learning is that it enables us to extract deep and complex patterns that are impossible for humans to find, which then allow us to make use of the massive amount of vehicle data being collected. In essence, this means that AVs can keep us safe when traversing complex city and nationwide infrastructure while following the best patterns set up by a number of human drivers. It creates the ability to adapt to any situation, learning the best reactions to unique situations – light, dark, rain, snow, pedestrians, bikes, etc. This is vastly different than previous radar tracking systems, which were programmed to keep a specific distance and are much more brittle. The best of our driving habits imbibed by a machine – perhaps AI might be the perfect commuter!

The next task is to fine-tune the actions and reactions of the vehicle to the actual person within, who expects a certain behaviour from the ‘driver’ of an AV. Let’s take cornering speeds as an example. While a vehicle might understand the average cornering speed at any junction and act accordingly, it could be adjusted for someone who is accustomed to lower speeds which they perceive as safer. The reinforcement reward here could be decreased stress levels being detected in the passenger, influencing how the vehicle performs and thus garnering increased safety and trust over time.

Talking to “each other” thus enables the vehicles to communicate knowledge and work towards a norm for those passengers who need a relaxed driving style in order to feel comfortable. Similarly, a vehicle could prime itself for passengers in a hurry, but within safe limits. Communication between vehicles could enable fleets to perform optimally for people with varying needs, both personal human needs and needs from the context of their journey, requiring any specific driving style, which, in the most optimistic scenario, entirely stymies road rage. Or would it perhaps engender other forms of emotional outbursts in people who might not feel in control? Only time will tell.

'BEYOND' ROBOT–HUMAN INTERACTION



How the robot interacts within its cloud infrastructure. For example, it could transmit its learnings about movement in a city to the cloud to enable other vehicle systems to learn. Perhaps it could inform traffic signals to enable smooth, stop-less passage along a planned route.

"I like to think
(it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over by
machines of loving grace"

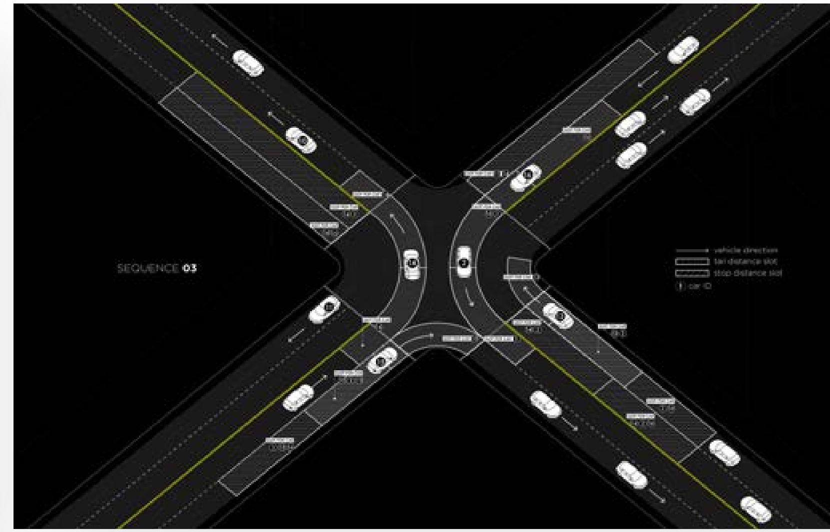
Richard Brautigan
All Watched Over by Machines of Loving Grace, 1967

"Beyond" interactions are about the bigger picture, beyond singular machines, to systems or communities of machines learning from each other and growing over time. In turn, these systems give rise to services or as Brautigan imagines, a "cybernetic ecology" enabling people and societies to be more efficient and creative with their time.

A well-known example of such a system is car-sharing – a set of services enabled by an ecology of personal smartphones, connected vehicles, machine learning, and extensive mapping by GPS satellite systems. These services then enable on-demand micro-mobility for city dwellers and beyond on a massive level. Autonomous vehicles too will find themselves in a similar ecology of systems, in which they will either thrive or perish, which we will try to understand here.

Systems like these are predicated on effective interactions between machines of various capabilities and purposes, like smartphones and GPS satellites, or even a certain garbage disposal unit and a protocol robot in a spaceship. Of course, here I am speaking about one of our personal favourite robotic interactions from the film of the same name, in which the robot WALL-E teaches another to be more human and wave to say goodbye – a trait it has learned by watching endless runs of Hello, Dolly!

The reason we bring up WALL-E is because not all robotic interactions we see today are this obvious and human. Interaction between hardware objects such as phones and satellites are invisible and not easily understood by a layman, even though they are the groundwork for movements such as the Internet of Things (IoT) and pervasive computing. There is another layer of interaction that is even less well understood – that between software objects like the ones invisibly manipulating your Twitter or Facebook feed based on your browsing behaviour.



WALL-E
Robot WALL-E teaches another robot to be "more human"

Light Traffic
MIT Senseable City Lab

Understanding these interactions is critical for the trust in and adoption of a smart, interconnected city, a vision at which many legislators and manufacturers are aiming. Despite sounding like a bingo card of buzzwords it is a worthy dream for cities – cleaner, safer, greener – and sets the stage for a future of highly efficient autonomous vehicles moving people and goods around.

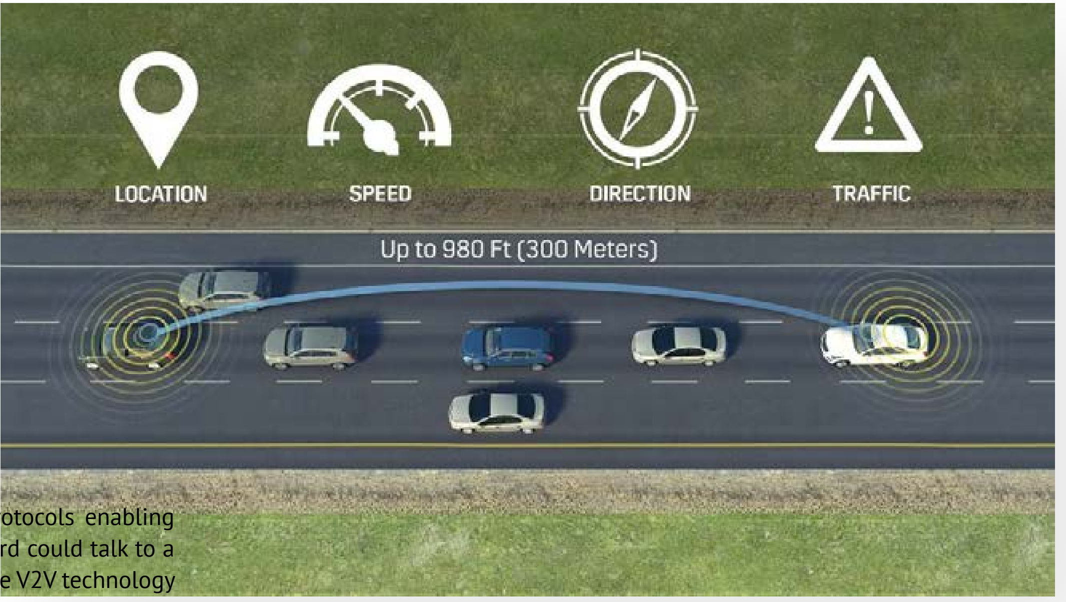
Imagine a future city where there isn't a need to stop at traffic signals and no problems with parking. A self-organised arterial network of movement with little to no stops – always in motion, with no clots. The vehicles talk to each other and the infrastructure around them – the traffic lights and parking zones (if they still exist), the traffic monitors, and even the people around them through conduits like smartphones. A complex synchrony of robotic agents and actors, communicating beyond just their immediate kin and living in harmony.

This utopian system is mathematically and theoretically possible through the right systemic interactions. One such example is the provocative vision put forward by MIT's Senseable City Lab in their Light Traffic piece, where cars travel seamlessly through a slot-based intersection.

The proposed slot-based intersection replaces traditional traffic lights, thereby significantly reducing queues and delays. Sensor-laden vehicles pass through the intersection by communicating and remaining at a safe distance from each other, rather than grinding to a halt at traffic lights. As the paper explains[36]:

> *"The model provides a performance breakthrough: all safety requirements being equal, traffic efficiency is doubled with respect to current state-of-the-art traffic lights. With today's traffic volumes, queues would vanish and travel delays would be cut to almost zero."*
>
> **MIT Senseable City Lab**

What a lovely concept, with the different actors or robotic elements in the model communicating harmoniously! It is a seductive image of the future – who wouldn't want to see traffic move that smoothly? Manufacturers and cities alike are now looking at different protocols for communications between the various players on the road using technology in order to achieve such a vision.



Cadillac V2V
Cadillac's V2V solution uses Dedicated Short-Range Communications (DSRC) and GPS, and can handle 1,000 messages per second from vehicles up to nearly 1,000 feet away[37]

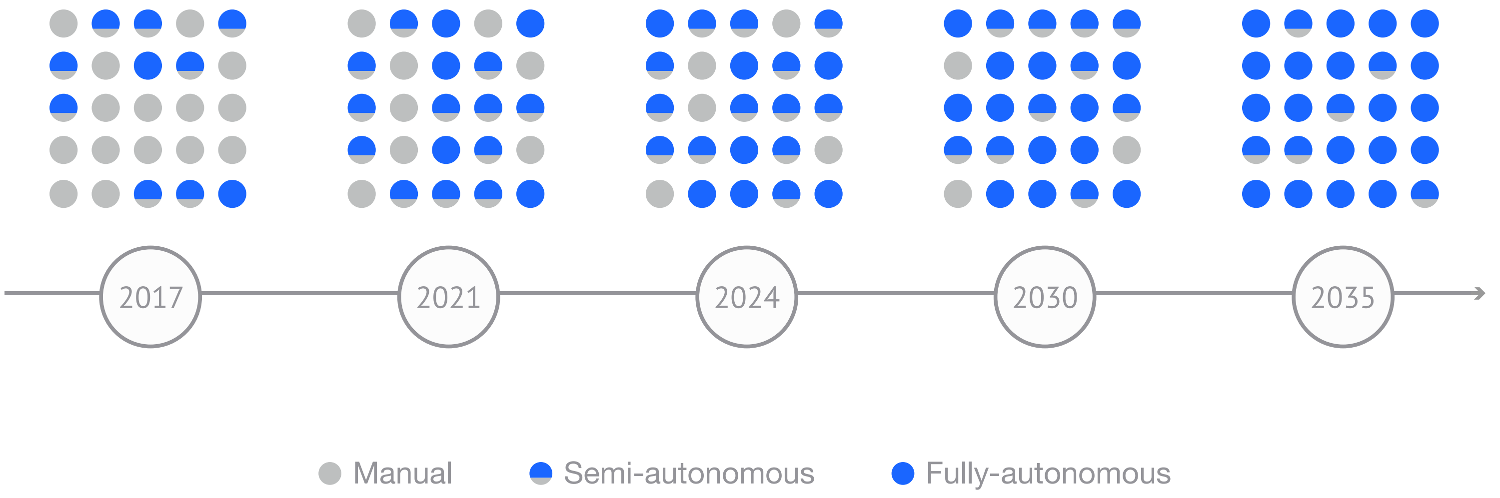
Some such protocols are:

V2V: "vehicle-to-vehicle communication", along with all the protocols enabling conversation between different platforms and brands. Thus, a Ford could talk to a Volvo without missing a beat. Cadillac's CTS sedans in the US have V2V technology as standard.

Cadillac's V2V solution uses Dedicated Short-Range Communications (DSRC) and GPS, and can handle 1,000 messages per second from vehicles up to nearly 1,000 feet away. For example, when a car approaches an urban intersection, the technology scans the vicinity for other vehicles and tracks their positions, directions and speeds, warning the driver of potential hazards that might otherwise be invisible.

V2I or V2X: "vehicle-to-infrastructure communication". The vehicles talk to infrastructure elements around them, like a car talking to traffic lights.

These systems are fantastic pieces of kit, but we feel that visions like these pose problems when you bring human and robotic actors into the mix. Both of these actors will have decision-making capabilities of their own and issues resulting from those, the clash of which may well need to be solved.



We will refer to the MIT concept in order to analyse and understand these issues:

1. Autonomous vehicles
2. Driven vehicles of different kinds
3. Traffic lights
4. Pedestrians with various mindsets and capabilities

Issues arise because of complexities in understanding the time, space, and context around these actors.

In terms of space, it is important to understand what an intersection actually looks like (they're not perfectly perpendicular and straight for example) and who are the actors in play. One of the most important exclusions in MIT's model are the human elements – pedestrians, cyclists, drivers of non-autonomous vehicles, and even the passengers in fully-autonomous vehicles.

Ideally, roads and streets should be egalitarian systems, not just focused on efficiency and movement, but on easing and improving city life. The space offered for interactions could change from country to country, city to town, town to village, with varying infrastructure. Space thus sets the stage for interactions.

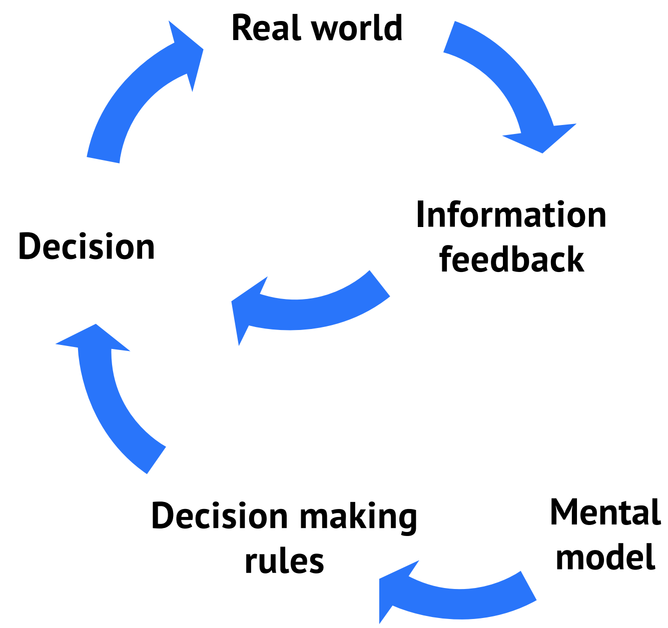
Time again has different connotations. Imagine all the technical evolution which needs to happen in parallel to make the MIT vision a reality. There will be a long tail for the adoption of new technologies due to differing socio-economic and market factors. Thus driverless cars will mingle with driven cars – at least for the foreseeable future.

Vehicles roaming the streets will have differing capabilities – both with respect to autonomy and sensing – a reality that already exists. A bus might have different algorithms or sensors to that of a car, or a motorbike, or a bicycle, for that matter. Different release cycles of the same vehicles might have varying capabilities, not to mention different brands. Countries, states and cities might have different evolutionary cycles and adoption rates. Diversity can be beautiful and interesting – as well as a massive challenge.

What about the poor human beings embedded in the experience? "Poor" because of all the mental models we need to build or biases that need to be rewritten, in order to understand, and eventually trust, a new system and its many actors.

SINGLE LOOP LEARNING MODEL

Our mental models help define the rules by which we make decisions in the real world. A single loop learning model is described in this sketch.



Talk of mental models brings up another interesting point from earlier about hardware and software objects. These models are narratives we construct about the way systems function. Sometimes these narratives are objective – based on well-learned stories and explanations (why we have day and night) – but other narratives can be flimsy and fictional (how email works). One of our prime tasks as designers and technologists is to make sure the right narrative or mental model forms in people's minds.

Returning to our model of the intersection: do we understand how the current system of traffic lights work? What makes the lights turn green, red or amber? It's safe to assume that it is some sort of human-designed algorithm running in the background and all we see are its effects in action as the lights change colour. We choose to obey traffic lights based on an implied sense of control from an authoritative body. What happens when we cede control of this choice? Would you expect a vehicle to obey the lights? Do you know of the safeguards put in place for you by the manufacturer and the authoritative agency?

Similar questions are posed for the pedestrians interacting with the traffic. What if a pedestrian walks out into the road on a green light? Would a hyper-connected vehicle or traffic light, which might be focused on efficiency and flow, identify the human mistake in time? Time thus offers us a way to think about the different actors in a play, happening in space.

Audi is testing its Traffic Light Information (TLI)[39] system within vehicles in Nevada.

"When the traffic light ahead turns red, if your car has Audi Traffic Light Information, an indicator shows up in the instrument panel: a traffic light icon and a countdown timer with the predicted time to green. If your Audi has a head-up display, the traffic light and timer appear there, too.

Audi instrumented volunteer drivers to determine stress levels. Stress can be high, including at traffic lights. Knowing how long you have until green – almost two minutes at a long red in Las Vegas (the above shows 109 seconds) – means you could do something useful. Audi suggests it's enough time to remove your jacket if you're warm, or turn to the back seat to check on the well-being of your baby. You might also fish the phone out of your backpack and plug it in to charge if it's running low on charge.

In the real world, TLI also means you have enough time to check your texts and send a reply or two. Technically, that's a violation even in a stopped car because you're not paying attention. But as long as you glance up at the instrument panel every 10 seconds, and maybe check the rear view mirror to make sure you're not blocking an ambulance, you know generally how much time you've got left until green."

Audi

Trafic Light Information (TLI) system
Audi

SERVICE DESIGN FOR ROBOTS

One discipline that deals with multiple touchpoints and services is "service design", the principles of which we can apply here to help resolve the questions around time, space and context. Service designers work with multiple partners and collaborators to design a system and help construct the right narratives or mental models in people's minds.

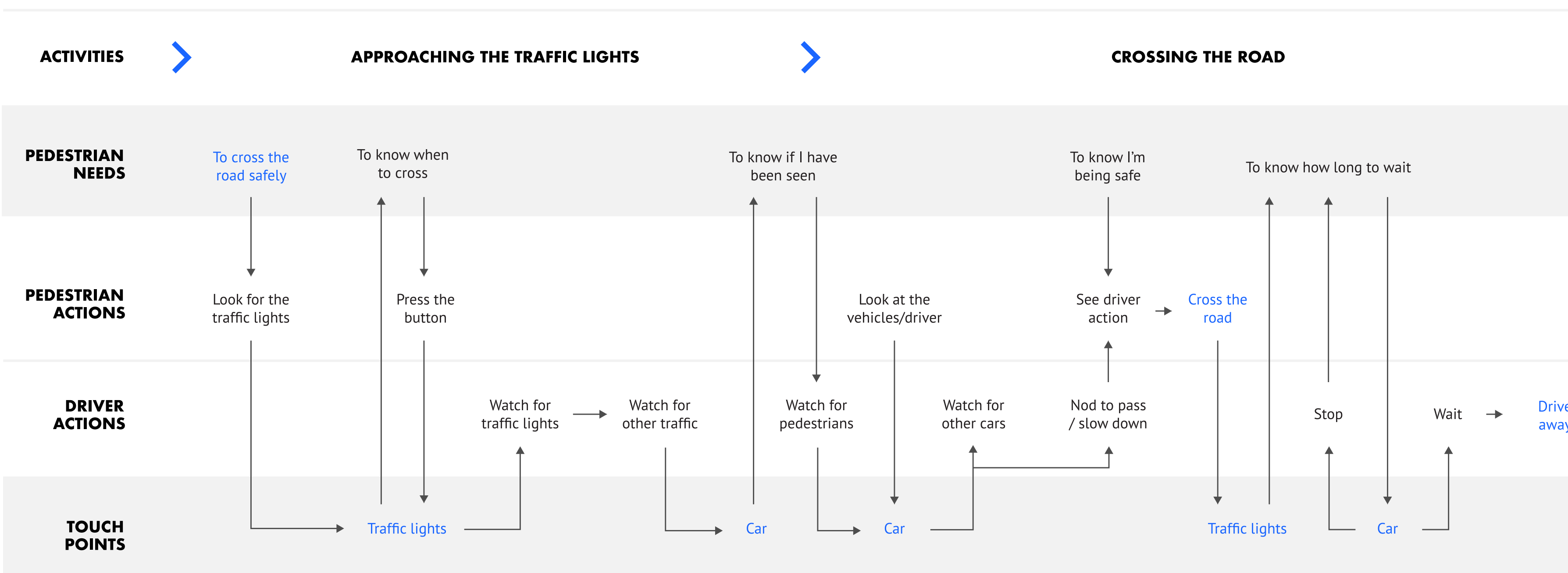
"All our ideas and concepts are only internal pictures."

Ludwig Boltzmann

Consider the intersection again, this time with pedestrians and the drivers of multiple cars taken into account. We can examine a tiny sliver of the many possible interactions at this intersection, namely:

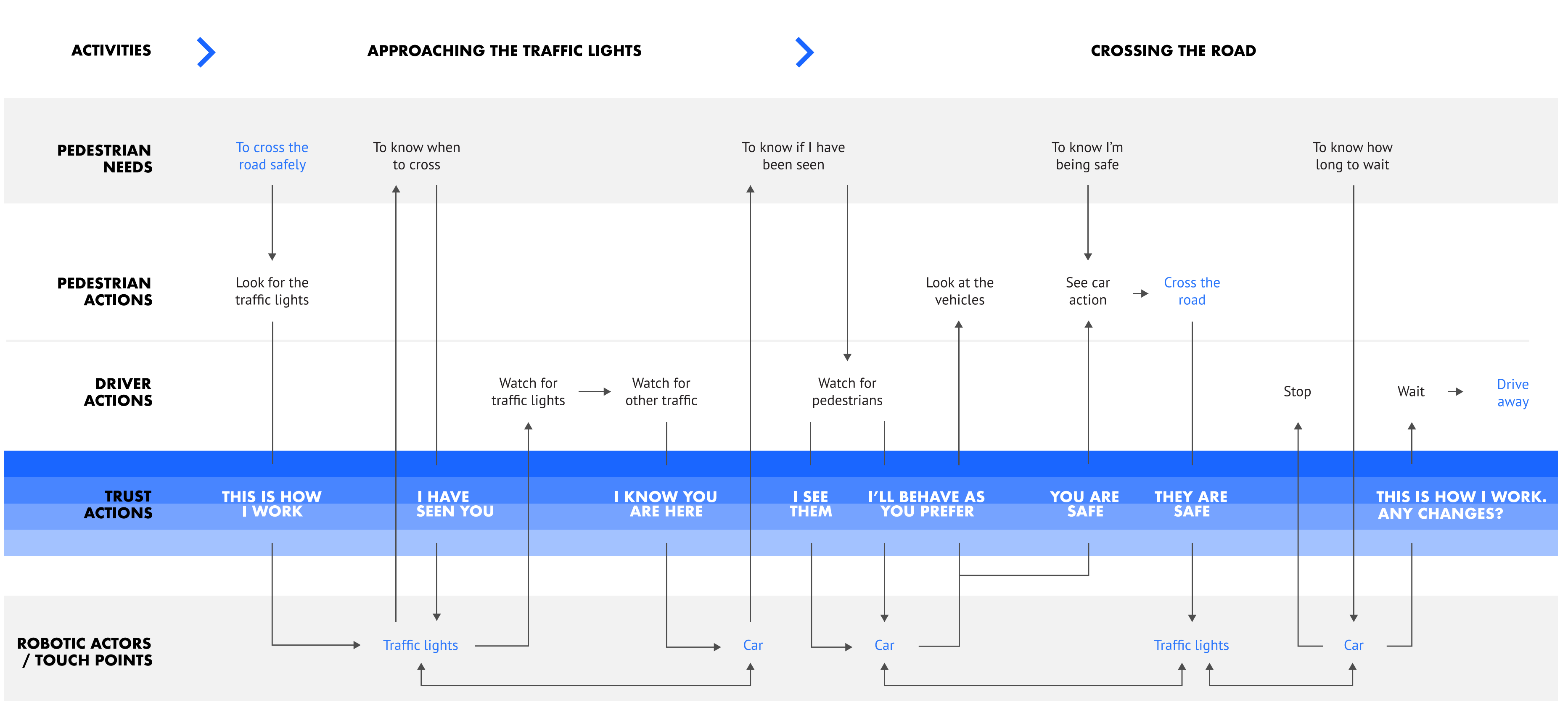
- approaching the lights (pedestrians and cars)
- crossing the intersection or road (pedestrians and cars)

Let's take the scene as it exists in the present day and apply it to a simple service blueprint, typically drawn out to consider the activities, needs, actions of actors, and the different touchpoints they use. We'll end up with something like this:



As you follow the arrows, you can see the "simple" action of crossing the road and negotiating with the oncoming traffic is actually highly complex, born out of many needs and actions. We see how the first need: "I want to cross the road" leads to the final actions of crossing and heading off from the intersection, assisted by the traffic lights and car touch points, which are used as tools for signalling. You can see how complex the actions of a driver are – negotiating with both pedestrians and traffic.

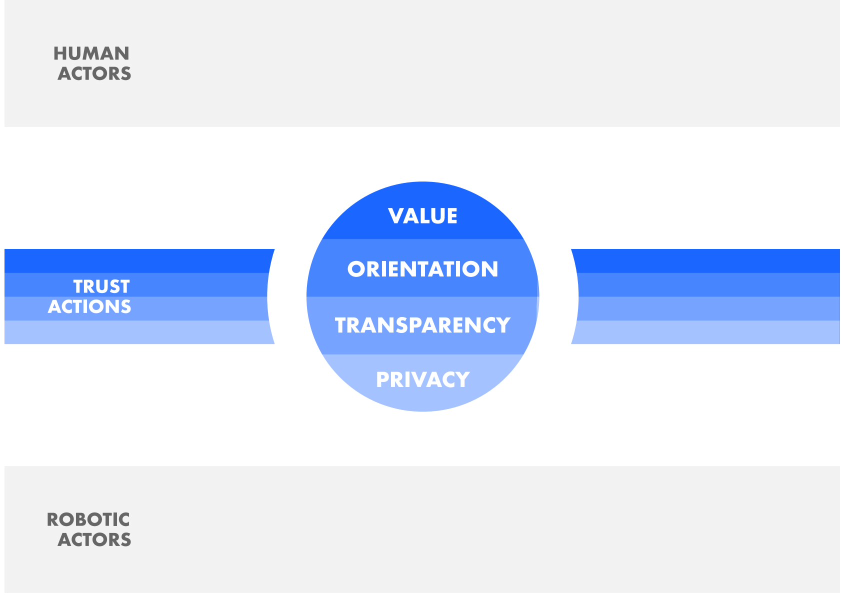
Imagine the anxieties going through drivers' heads at each of those junctures when safety questions are asked. The same service blueprint can be then drawn out for a future scenario, where the car's driver becomes the passenger and we can then see how touchpoints such as traffic lights and cars become robotic actors with the ability to make decisions and act on behalf of their wards – the pedestrians and passengers in the AVs.



This future scenario is built upon advancements in the Internet of Things, where an individual's preferences or needs are taken into account before the system or product itself can act – deep personalisation and prediction. Traffic lights are connected entities, identifying the pedestrians, their anxieties and the probability they will conduct an action, communicating the traffic lights' own actions and behaviours to vehicles and a central hub. Similarly, AVs themselves have the ability to sense the anxieties and needs of their passengers, and to communicate them visibly (to pedestrians) and invisibly (to the traffic lights and perhaps a central hub of operations).

These elements form part of a future Intelligent Transport System (ITS)[40] – a system being put together by manufacturers and cities today.

As you can see in our service design for robots, we have introduced a new layer in between the human actors and the new robotic actors – the crucial 'trust' layer. This layer is built upon service design principles, enabling people interacting with systems with agency to build mental models about the actions of the systems, their inner workings, the reasons why they act the way they do, and the safeguards in place to protect their human users.



The trust layer in our above example has the following questions or statements that the future robotic actors need to ask or convey to their human users. These statements guide the users of the system through the experience, helping them learn, interact, and create the right narrative in their brains for future use.

For instance, the vehicle and the traffic lights have the action of explaining: "This is how I work" to their users. They need to let the pedestrians and other road users know that they have seen them in order to give them confidence about their safety, whether it is crossing the street or stopping for another car. They also need to receive feedback about the way they function, allowing people to tailor their experiences, manually or automatically, during further interactions.

A DEEP DIVE INTO THE TRUST LAYER

The statements within the trust layer can be broadly expanded into four primary thoughts that the robotic service should be designed with:

"Orientation and learning" is all about showing humans how the system functions, just before they interact with it. Orientation is a method of anxiety mitigation, where questions about a system are answered beforehand to increase comfort. In this case it is about the traffic lights informing passengers and pedestrians about its actions – how it communicates. It is also a potential way to inform people about how autonomy and autonomous systems could help increase the safety and efficiency of an intersection, not forgetting the improved experience.

"Transparency and visibility" are concerned with the "inwards", "outwards" and "beyond" interactions we dealt with earlier. It is about informing both pedestrian and passenger about the actions of the system and what it is going to do next. In this case, it is as simple as conveying the fact that the traffic light has seen the pedestrian and told the car of the pedestrian's position, thus alleviating any passenger anxiety.

"I WOULD HAVE THOUGHT THAT REGARDLESS OF THE BRAND, EACH VEHICLE WOULD HAVE SOME PARAMETERS LIKE IF I WANTED TO GET SOMEWHERE IN A HURRY, I MIGHT HAVE TO TELL THE VEHICLE THAT I'D LIKE TO GET THERE QUICK... I'D KIND OF WANNA BE AWARE OF KIND OF WHAT MODE IT WAS IN—I THINK IF IT WAS IN A HURRY, IN A PARTICULARLY AGGRESSIVE MOOD OR WHETHER IT WAS PLAYING IT SAFE."

Neil, ustwo study participant

"Value and benefit" is a tough one. It is a massive design challenge, wherein the value of a system's actions in increasing efficiency or safety is conveyed clearly to its participants. For instance, how will a traffic light tell passengers and pedestrians who are waiting for the signal to change why it is being so slow? Or from a passenger's perspective, how it's slow but steady speed is reducing traffic congestion in the city as a whole? There are huge considerations to be made in conveying immediate value (cost and time) versus long-term value (climate change and pollution).

"I'D BE VERY UPSET (IF SHE LOST HER LICENSE). VERY, VERY UPSET. YEAH... OH I SEE! WE DON'T NEED A LICENCE FOR DRIVERLESS CAR? AH—THAT COULD BE A SOLUTION. WE'LL SEE."

Françoise, ustwo study participant

"Privacy and Safeguards" – last but not least, a hugely important aspect of a system's transparency is its method of dealing with privacy. How does a system respect the passenger's or pedestrian's privacy, while catering to an individual's personalised requirements? If, for instance, a safety-conscious passenger is in the vehicle, can it behave more conservatively on approaching an intersection, to put them at ease? Can traffic lights recognise that you have impaired mobility (using crutches or carrying many bags) and keep the pedestrian crossing open for a little bit longer than usual? Would a person be comfortable with the decisions being taken by this system, once its benefits were made are clear?

"I THINK IT'S OK, I CAN SEE WHY PEOPLE CAN BE UNCOMFORTABLE WITH THAT IS THAT DATA BEING USED FOR INSURANCE, HOW MUCH CAN BE SUBPOENAED AND TAKEN AWAY. FROM THE PRIVACY BENEFIT, TESLA SAY THEY ANONYMISE DATA THEY STORE AND I AM OK WITH THAT FOR THE VALUE IF OFFERS ME... VALUE EXCHANGE IS KEY."

Rick, ustwo study participant

DESIGNING A LEARNING FRAMEWORK

The cars of the future will need to think, feel and then do. They will be powered by a brain. Right now, that brain is at nursery taking in elementary shapes and patterns. It's learning to learn. As it journeys through primary and secondary education, synapses will fire, connections will be made. Confidence will grow, there will be exams, competitions, stresses and failures. Only the best will graduate.

But the best learning happens on the job, not in training. And in this case the job is not a static thing but one fraught with change and with danger. Much has been written about the science, so let's focus on the interesting human and societal questions instead.

WHO DECIDES WHEN AN AV HAS 'GRADUATED'?

There will need to be a final exam, with a practical and a written element. The questions for this exam need to be defined on a local, nationwide and global level. They need to be publicly available so everyone can read the questions and results. A common syllabus will help standardise the playing field. Or perhaps, if multiple education systems take shape at once, the competition will drive faster learning. In this case, integration will be everything.

After graduation, the car will need to continue to show progress or it might have to go back to school. Rather than an annual MOT, it should be taking advanced classes in its sleep and demonstrate it's amazing capacity to learn.

MIGHT YOU PAY MORE FOR A BRAIN WITH A HIGHER DEGREE?

The objective should be to make safety as mundane a benefit as possible. This sounds counterintuitive, given the aim of autonomy. When you choose a dishwasher, you compare things like efficiency, form, size, speed. You never wonder about the possibility of the machine catching fire. That's why the idea of a higher degree, shouldn't be about enhanced safety. It's either safe or it's not. 1 million training miles or 100 million means nothing to the public.

The notion of the higher degree is simply more like looking at a CV and seeing that you speak three languages. Capability and capacity for learning will be important when comparing (autonomous) apples with apples. And once you start work, the idea of where you received your education becomes irrelevant anyway.

WHAT ARE THE IMPLICATIONS OF LEARNING FOR THE CUSTOMER?

This is the really interesting challenge. Will there be AVs with learner plates? How should an AV communicate what it's good or bad at? How should improved intelligence feel? How should an AV communicate its new capabilities? Look mummy I can fly :)

There are thousands of questions like this. The aim should be to create a sense of control and minimise the friction. We have to know what to expect. That means communicating the rules, operations and capabilities. Customer on-boarding and first time training will be crucial. Forget the 1000 page manuals. This needs to be way more interactive than that. Moreover, we have to understand the rules of the game, in order to accept that the rules of the game will change. Right now we can chose to ignore our sat navs as we think we might know better. But in the future, we might need to go with the flow and trust the system to move us in the best way possible, for the collective good.

Improved intelligence shouldn't feel like anything at all. Like a person, a truly smart car is defined by its actions. So the journey should just get better.

WILL LEARNING BE ONE FOR ALL OR ALL FOR ONE?

It costs billions to train the brain. It costs more to operate it. So why would anyone share those precious algorithms and level the playing field? Would open source autonomy be dangerous and open to corruption? Could it introduce error? Or would it accelerate intelligence and demand? Which will lead to greater success?

At the very least, if we all want to go to this party, we need to dance to the same beat.

CLOSING THOUGHTS

These questions and statements also reflect Don Norman's thoughts on mental models as set out in his 1987 essay, *Some Observations On Mental Models*[41] where he talks about three aspects that the right model should cater to: belief systems of people, observability/referencing, and finally, predictive power, which helps people anticipate. The essay is well worth a read for the curious designer.

We feel that these primary thoughts have the potential to open up a deeper conversation about complex systems communicating with each other, including people and their behaviours. **This might be particularly important because, as we started to speculate from our research, to our study participants there's a difference between a "driverless car" and a "robot driven car". Essentially the same thing, but some people trusted the former or latter more so depending on the person.** An onboard avatar, digital or otherwise, for example, may be something to consider. More study is required here. Consequently, we'll be covering these themes in more detail later on when we approach other topics in this book, such as morality, inclusivity and liability.

But for now, here is another extract of Brautigan's poetry, to leave you in a thoughtful – and hopefully optimistic – mood about the future. There are a number of issues we must consider, with the human beings and the robots which form the ecosystem, an ecosystem, which if built well, has the capability to change the face of the world as we know it. ◆

"I like to think
(and the sooner the better!)
of a cybernetic meadow
where mammals and computers
live together in mutually
programming harmony
like pure water
touching clear sky."

Richard Brautigan
All Watched Over by Machines of Loving Grace, 1967

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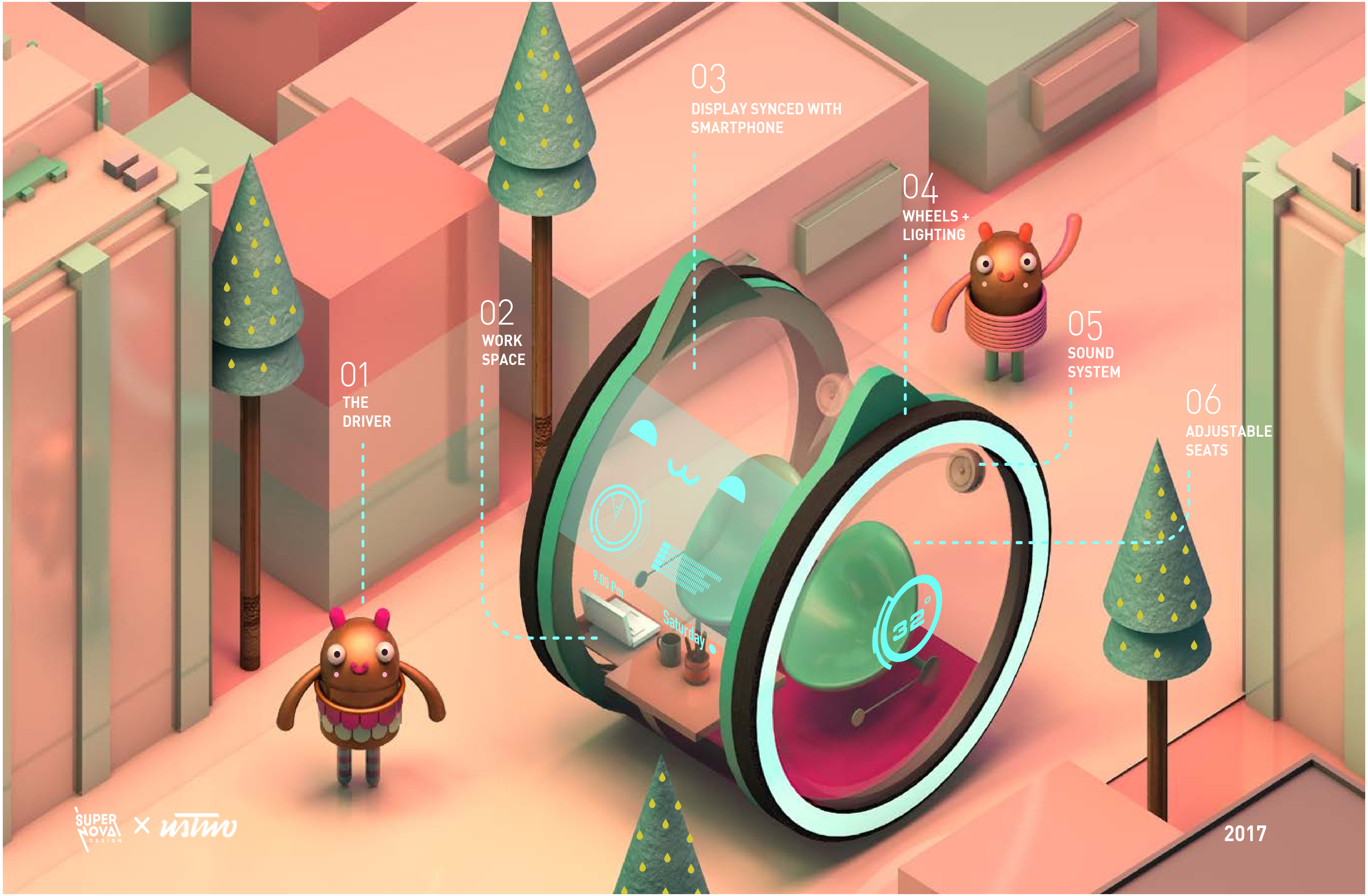
FELIX
by SuperNova
Year: 2030

"FELIX is your personal transportation pod, allowing you to have a moment of tranquility in the chaos of daily life. Inspired by a hamster ball and the more notional idea of a 'personal bubble', FELIX explores the idea of being in the eye of the storm. There are unavoidable realities of over population, traffic congestion, and nervousness around the idea of self-driving cars. This concept takes these issues into account and creates an experience where your daily commute becomes an opportunity to gather your thoughts and prep on your way to work or unwind and relax on your way home. In an increasingly reactive world, its hard to take time out to self reflect and psychologically prepare one's mind and body for the day ahead. FELIX's AI is integrated with your smartphone and is aware of what you have been though or what activities lie ahead. It supports you by creating an appropriate ambiance by using audio and lighting so you are better prepared to handle your day-to-day."


01
THE
DRIVER
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WORK
SPACE
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DISPLAY SYNCED WITH
SMARTPHONE
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WHEELS +
LIGHTING
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06
ADJUSTABLE
SEATS
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Saturday
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SUPER NOVA DESIGN
2017

HOW DID CARS BECOME ROBOTS?

Topic: Past, Present and Future of AVs

68 minute read

Joe Simpson
Founder of In-car UX
Research Lead, Car Design Research

CDR × ustwo

SUMMARY

In many ways driver assistance technologies, from cruise control to automatic parking, act as precursors to autonomous driving but there is still a lot to learn with their shortcomings – in particular, the disjointed integration of these technology with both the user and the vehicle.

This section is a contribution from Joe, a Research Lead at Car Design Research – we collaborate with experts such as CDR to increase our expertise on specialist projects. In it, he will take a closer look at the the driver assistance technologies in some of today's cars – whilst keeping our autonomous future in mind.

INTRODUCTION

It's not the destination but how you get there, that truly matters. So goes an old adage. The auto industry loves to play off this idea, as it tries to sell people on an ever-more connected, feature-filled in-car journey experience. But could this old industry phrase apply as we move towards autonomous cars, too?

Autonomy will represent a paradigm shift – potentially both in how cars are used and also how they are designed, inside and out. Many predict that their adoption will be gradual. And while brands like Google/Waymo and Ford have publically stated that they intend to skip intermediary stages and launch only a fully-autonomous-capable, Level 4 car when the technology is ready[1], many car brands (OEMs) are poised to pursue a gradual, feed-in approach to autonomy. From the customer's perspective, this appears to have already begun – with many ADAS (Advanced Driver Assistance Systems) beginning to influence, or take control of certain aspects of the way the car drives.

Across the car industry, there is a commonly held view that it is not the fundamentals of underlying technology which will prove to be roadblocks in the way to full autonomy, but customer acceptance.

To gain a better understanding of how the automotive industry might do that, and what issues could arise as we move towards this autonomous future, in this chapter, we explore the current status quo – looking at the driver assistance technologies, in some of today's cars. In many ways they act as a prelude to autonomous cars.

What can today teach us about tomorrow, and what questions does it raise?

BACKGROUND — THE HUMAN FACTOR

Adding in new technologies has proved a challenge throughout the history of the car. In the early days of the automobile, the new technology that cars represented was greeted with significant suspicion by the public.

Ford Model T

Before 1900, cars were preceded by a man, bearing a red flag, walking along the road in front of the vehicle to warn unsuspecting pedestrians of its impending passing. The fact that this limited the early car's speed in populated areas to around 5 miles per hour – barely faster than walking – is one of automotive history's more amusing ironies.

In the early 1900s, uptake of cars continued to stutter, despite the arrival on the scene of one Henry Ford and his new mass production process. One of the factors holding back the adoption of cars was that they were difficult to operate. Among the models available, there was no set "pattern" for how they were made to go forward, go faster, slow down and turn. Brakes and clutches were sometimes hand-operated. Foot-operated pedals were set out in different orders, or had different functions from car to car. There was even the need for manual labour to simply move off — the user had to physically crank the car's engine into life.

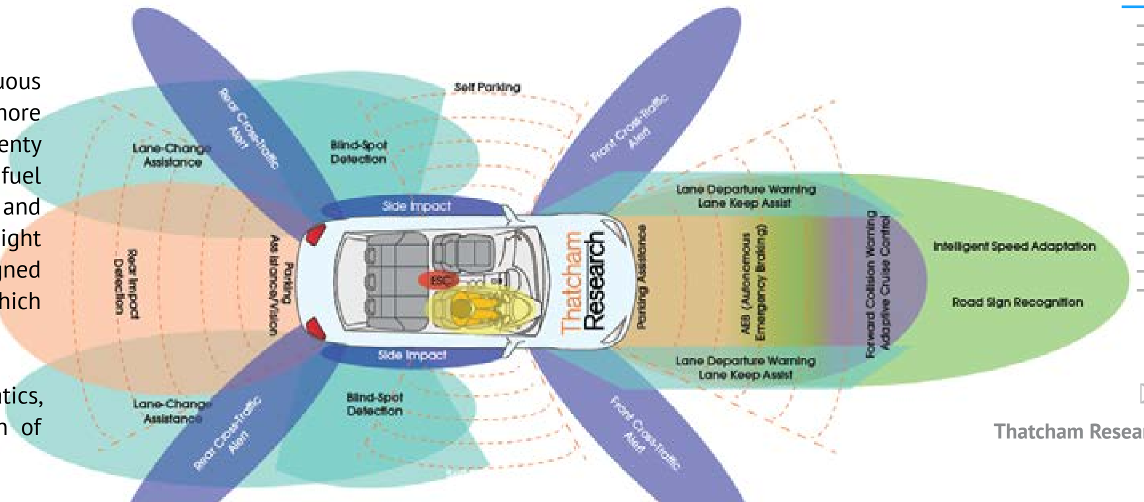
Among many challenges for the car in its early years, these control and operation variances were a significant barrier to adoption of cars and the general expansion of the car industry.

Of course, road networks, oil production, refuelling infrastructure and mass production techniques were key reasons for the car's eventual success. Just as electric vehicle charging networks, battery capacity and software engineering is likely to be for the vehicles of tomorrow. But when it came to the design of the vehicle itself, it was the adoption of a standardised pattern for the control layout — clutch-brake-accelerator — and the invention of the electric starter motor, that really sped up adoption among people.

TECHNOLOGY AND CARS — A TUMULTUOUS RELATIONSHIP

This history may offer insight to the car's future. Cars have a tumultuous relationship with new technologies. While cars have become significantly more usable — particularly with regard to reliability and safety over the past twenty years — thanks to the introduction of new technologies such as electronic fuel injection, the seat belt, crumple zones, ABS, airbags, electronic stability control and GPS satellite navigation, many of these technologies have succeeded out-of-sight of the humans behind the wheel, their intervention either barely felt or designed to work only in a should-the-worst-happen scenario. Regardless, the way in which such technologies function is not well understood by the user.

Yet when it comes to newer technologies — both on-board telematics, communication and the ADAS, we see a much less successful integration of technology, vehicle and user.



Thatcham Research

At the broadest level, many of the technologies available in modern cars do not appear to have been developed with a particular user-centred approach. They exist because the technology has become available to perform a specific function. These are then developed into features — marketable aspects of the car, intended to appeal to the user via some previously unseen added value — enhancing the driver and occupant's comfort, driving capabilities, safety, reducing workload, or simply providing a novelty compared to what has gone before. Much of this approach is rooted in the model year change, which GM's Alfred P Sloan pioneered in the 1920s — where new colours, materials and features were introduced year-on-year, to provide a reason for a customer to upgrade to a newer model car.

Hardware costs — particularly for technologies such as sensors, cameras and in-car screens which are needed to run driving assistance systems, have dropped, meaning there is more widespread availability of new driver assistance and advanced safety systems. They are no longer the prerogative of expensive, premium brand cars. Family cars now have them, too.

All of which should be making cars better, safer, less-taxing to drive and to sit in, and could mean that they have fresh, unique appeal compared to cars of just a decade before. Yet customer uptake has been slow. On-board and safety technologies are rising up the "reason to buy" criteria for many car buyers, but in many cases they still fall behind price, brand, reliability, exterior design, fuel economy.

Why is this? A deeper exploration of the purpose, operational behaviour and customer benefit provided by these individual systems could provide us with some clues, so ustwo and CDR have been spending some time together in many of the most recently launched cars to gain a better understanding of them.

TODAY'S DRIVING ASSISTANCE TECHNOLOGIES

Specify any new car today, and you are unlikely to get far before coming across some form of driver assistance or support system. The SAE definition of ADAS covers some features that have become taken for granted by a proportion of car buyers – acoustic parking sensors, backup cameras, auto headlamps and wipers, tyre pressure monitor systems. Some – such as the tyre pressure monitor – are being made mandatory equipment in certain markets, such are their perceived safety benefits.

Yet within the context of autonomous cars, there are a few, more complex ADAS technologies which are more important to explore. These technologies form the building blocks of certain operations for cars operating autonomously (and thus give clues to future behaviour patterns). Importantly, one or more of these technologies are being put together by certain OEMs and presented as giving the car semi-autonomous driving capabilities.

Here we detail five of the most important ADAS technologies, and how they are implemented in vehicles today.

ACOUSTIC PARKING SENSORS / PARK ASSIST

A parking assist system – with ultrasonic parking sensors, is perhaps the most common standard fitment and rudimentary driver support system to be found in modern cars.

Purpose: Acoustic parking sensors aim to prevent the driver hitting static objects around the car (typically another car or a wall) during low-speed parking manoeuvres.

How they work: Although OEMs implement acoustic parking solutions in slightly different ways, the way they operate and communicate with the driver is relatively consistent across cars. A series of sensors, typically mounted in the rear / front bumper of the car, uses an ultrasonic system to assess how far the vehicle is from other static and slow-moving objects, during low speed manoeuvring. As the vehicle approaches the object, an audible beeping sound is emitted in the cabin.

Park distance control (Mini Countryman)

In some cases this is accompanied by a visual representation of the car on a screen. As the vehicle gets closer to the object, the frequency of the beeps increase, until – at a predetermined distance point (usually when the vehicle is around six inches from the object) – the acoustic warning in the cabin changes to one continuous tone – signalling the driver should stop.

Some OEMs (BMW, VW Group) augment sound with a display which graphically shows the car in space relative to objects. Increasingly, acoustic parking systems are supplemented by a back-up or 360-view camera, (back-up cameras are mandatory equipment in the United States from 2018 for vehicles under 10,000 lb).

Benefit: The popularity of acoustic parking systems stems from their provision of a tangible usefulness for the driver. They prevent many low speed parking accidents – bumps and scrapes that would result in cosmetic or physical damage to the vehicle that is expensive to repair.

More pertinently, they work in a specific context, which many drivers struggle with – low speed parking manoeuvres. Parking a vehicle in a confined space requires concentration, spatial awareness and good vehicle control. Combine these factors with growing vehicle dimensions and worsening visibility and increasingly constrained parking spaces in many urban environments, and parking sensors give drivers genuine support in an area they perceive to need it, aiding their confidence.

Notably, the relatively consistent implementation and manifestation of acoustic parking system (almost all systems work via the "progressively more rapid beeps") means that over time, drivers have come to understand the pattern by which these systems work. They do not need to re-learn a new set of behavioural conventions each time they swap vehicles – something that was discussed in ustwo Auto's first book.

ADVANCED PARKING ASSISTANT

Sometimes referred to as automatic parking, Intelligent Parking Assist System (IPAS), advanced parking guidance, "Park Pilot", etc).

Recent years have seen many OEMs introduce more advanced parking assistant systems which go further than the simple, acoustic / sensor set-up discussed above. For many drivers, advanced parking assistants will offer their first partly-autonomous vehicle experience. The specifics of advanced parking capabilities and operation varies by OEM and even by specification within a given model range. In general, these systems will identify a parallel or perpendicular parking bay and then steer the vehicle into the space with the driver only operating brake, accelerator and controlling reverse/forwards direction selection through the gear shifter.

Park Pilot (from MkVII Golf)

Purpose: Advanced parking assistants take over some of the driver's role – primarily steering – during manoeuvring. This allows less-proficient or confident drivers to park in spaces that they would perhaps not otherwise have felt able to park in unaided. It augments their abilities.

How they work: The capabilities of different systems, and how they are operated, varies by OEM. The parallel park function that many OEMs offer was developed by INRIA in the 1990s, and first seen in conceptual form on the 1992 Volkswagen Future Concept. Advanced parking systems were first seen in production in the 2003 Toyota Prius – then in Toyota's luxury subsidiary, Lexus, with the 2006 LS – which added the ability to perpendicular park.

A driver activates the system, typically by pressing a marked button on the instrument panel, or via a menu within the cluster information display. Once active, the system will scan for a space big enough to accommodate the car, and once this is found, an acoustic chime usually alerts the driver a space has been identified. On coming to a halt, the information display in the cluster, or on the centre screen, provides a series of step-by-step instructions to the driver. This typically involves selecting reverse, letting go of the steering wheel but then applying first accelerator and then brake as the car steers itself back into the identified space.

The system uses a combination of the acoustic parking sensors, on-board cameras, time-of-flight data and the electric power steering system (EPAS) to understand how it must manoeuvre itself and its position in space.

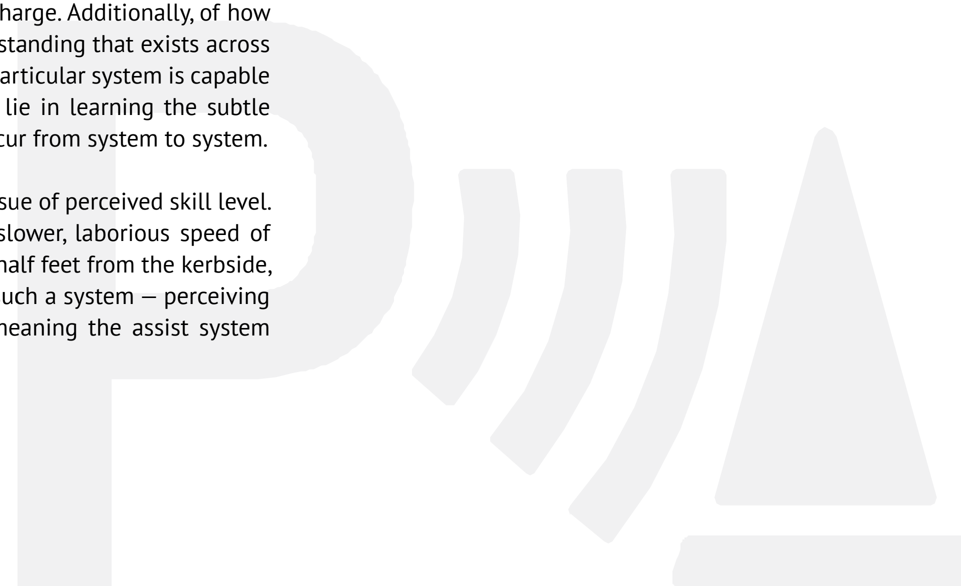
Benefit: Advanced parking assistant systems go a step further than acoustic parking sensors, allowing drivers to access parking spaces they might otherwise consider beyond their personal abilities to park the vehicle within. Marketing of such systems has, in Europe, focused on this quality.

Yet the real benefit is less tangible – it is the inherent "wow" of sitting in the car, removing your hands from the steering wheel and watching as it whirls around, as if by magic, controlled by some invisible force. At one level, it taps into a childhood memory about what the future car might be like, of Herbie the car that could drive itself. A car turning a steering wheel by itself – especially when it is being done in such an obvious, extreme manner as parking manoeuvres require, never fails to elicit a little yelp of disbelief from passengers when seen for the first time. It is perhaps an early sign of the potential magic, and opportunity that lies with the fully autonomous car.

Challenge: At the same time, these systems' semi-autonomous qualities (where in most cases drivers must retain some control — typical of the accelerator and brake, and be watchful of the system making a mistake or missing an object) is illustrative of the user-centred challenges which may be involved as we progress towards, but before we arrive at Level 4 and Level 5 autonomy.

Specifically, advanced parking systems illustrate the potential for confusion about which roles are held by driver and car — of who is in charge. Additionally, of how to design for the varied levels of knowledge and understanding that exists across different drivers (vehicle occupants) about just what a particular system is capable of. And of the ultimate usability — the problems that lie in learning the subtle differentiation — and behavioural differences — that occur from system to system.

Finally, for confident, experienced drivers, there is the issue of perceived skill level. When the self-parking function necessitates a much slower, laborious speed of manoeuvre, and the car ends up positioned one-and-a-half feet from the kerbside, some drivers may question the ultimate usefulness of such a system — perceiving that they can better execute the task, than the car, meaning the assist system doesn't get used.



ISO 7000-2582
Parking aid

ADAPTIVE CRUISE CONTROL

Sometimes referred to as radar cruise control, intelligent cruise control, Distronic, ACC, etc.

Cruise control has been a standard fit feature on many models for several decades. In recent years it has been supplemented — in some cases replaced — by a cruise control system which reads and adapts to the traffic context around it. Generally known as adaptive cruise control — sometimes as radar cruise control or intelligent cruise control, these systems don't just maintain a constant set speed, predetermined by the driver, instead aiming to maintain the driver's intended speed, but also monitoring traffic ahead (usually via a radar), and then adapting the vehicle's speed to ensure a safe distance is maintained to the vehicle in front.

Adaptive cruise control dispaly (from MKVII Golf)

Purpose: Adaptive cruise control is designed to be a more useful support for drivers on the crowded highways that exist in many countries today. The sheer number and varying speed of vehicles can make cruise control almost redundant in congested areas, because it's impossible to maintain a set speed for long periods of time.

Adaptive cruise control means that, instead of the driver having to constantly brake and accelerate based on traffic conditions, switching cruise control in and out, the car will do this for them. There's an added safety bonus, because the car always maintains a safe distance to the car in front. Additionally, many systems are able to bring the car to a complete stop, should traffic in front come to a halt — even if the driver is failing to pay attention.

An additional benefit — recent research has illustrated[2] — is that adaptive cruise control is able to even out traffic flow and eliminate the bunching and queues that occurs when drivers over-react to the car in front applying the brakes.

How they work: Mitsubishi introduced the precursor to adaptive cruise control, on its Debonair in 1992, then in 1995 on the Diamante with a laser-based system which could influence and trim the throttle. But it was Mercedes, in 1999, with its Distronic system (a name that it still uses today), which provided the first radar-based system which was allowed to intervene and apply the brakes.

While laser systems are still available, most system today work via a radar, hidden (or not so well hidden) in the front fascia, which determines distance to the car in front, sends messages to the ECU which can then apply accelerator or brake accordingly.

In the cockpit, the driver tends to activate adaptive cruise control in much the same way that he or she would regular cruise control — a steering-wheel based control or column stalk is used to first activate the system, and then set a speed. The critical difference between adaptive and non-adaptive cruise systems in the cockpit, is that drivers are usually able to adjust the preferred distance they want to maintain from the car in front, with many systems featuring an instrument-cluster displayed tell-tale to show the driver this distance (represented by a series of stripes in the road) and also to show when the system can see a car in front.

Benefit: Adding contextual awareness to the cruise control system brings back its original usefulness — which was to reduce drive workload in highway driving situations, and not mandate a continuous position on the foot pedals.

But by adding in the ability to brake the car, adaptive cruise control introduces an important safety benefit, reducing the likelihood of the car with adaptive cruise running into the car in front, if the driver's concentration lapses. Perhaps the most interesting benefit, in the context of an autonomous future, is the research illustrating the adaptive cruise control alone has the potential to even-out traffic bunching — in effect, the car (the technology) does a better job than many drivers, creating a benefit for everyone on the road.

Challenge: Using adaptive cruise systems in a number of cars illustrates three key challenges. Potentially, the simplest to overcome is the system's activation. As with other ADAS systems, the way adaptive cruise is activated, differs from car to car — with separate switches, stalk-mounted systems and steering wheel buttons all used. The provision to adjust the gap to the car in front adds an extra switch into the mix, which given the already complex nature of many car interface designs is arguably undesirable.

The bigger challenges centre around the differing functions and abilities of systems from car to car. And the way they react to very dynamic traffic situations. Specifically, some cars are able to brake to a stop, whereas some hand back control to the driver, disengaging below a certain speed threshold. Some will brake the car, unless the car in front emergency brakes — at which point they sound an alert and ask the driver to take over (hard) braking. And some systems are able to resume once the car in front sets off from rest, while some need the driver to reactivate the system. For drivers only utilising one car, this might not seem like an issue — they simply learn how their specific system works. But as more cars gain this particular assist system, having differing functional attributes becomes more problematic. It raises the risk of confusion about vehicle capability, when a driver moves to another car.

And as mobility systems and car-sharing systems increase the likelihood of a person driving more than one type of car, more frequently, a level of understanding and confidence in the system's capability would likely drive greater utilisation — with the benefits outlined above.

A much more nuanced issue, is the system's ability to discriminate in dynamic traffic situations. A good example, presents itself when driving on a three-lane highway. If you're driving along in the inside lane (keeping left in the UK/Japan/Australia, right in the US/Europe), you'll often come across slower moving vehicles driving in the middle lane. Instead of undertaking the car, moving out to pass it (as highway rules suggest) creates an unnecessary intervention of braking by most adaptive cruise systems. As you move from lane one, through two (behind the car to be passed) and into three, the radar picks up the car in the middle lane and applied the brakes — often at the exact point you don't want it to. The system needs extra "intelligence" — which could come from vehicle-to-vehicle communications — to understand that the trajectory of the manoeuvre won't put the two vehicles into contact. Unfortunately, on crowded highway networks, these kind of false interventions are all too common with today's adaptive cruise systems — meaning that progress can become jerky, or a driver can feel like they're going "backwards" in traffic as other drivers "cut and thrust" in and out. In the context of autonomy, it's an example of how simply knowing where roads, infrastructure and other vehicles are may not be enough — systems will need both finely tuning, and the ability to learn in order for progress to feel natural and ultimately, like human driving.

ISO 7000-2580
Adaptive cruise control

LANE ASSISTANCE SYSTEMS

Referred to generally either as lane departure warning and lane keeping assist – Lane Assist by Audi and Volkswagen, Active Lane Keeping Assist by Mercedes, Lane Departure Warning by BMW or Lane Keeping System by Ford.

Lane assist systems track the white lines on roads with multiple lanes or edge markings, and if a driver begins to deviate outside the boundaries of the lane without indication, either sound a warning or sensory intervention, and "active" systems help to steer the car back on course. Often abbreviated by OEMs to LKA, Lane Keeping Assist is in many way a development of the more rudimentary lane departure warning systems which began to appear over a decade ago, but didn't apply intervening steering input. Today, most LKA systems add resistance into the steering or apply a small amount of counter-steering to try and keep the car in the correct lane.

Selecting Lane Keep Assist (LKA) in the Toyota C-HR

Purpose: Lane assist systems prevent unintended diversion out of a lane, particularly in a highway driving scenario. Such excursions, which are one of the most significant causes of highway driving accidents, help in the event that the driver becomes distracted or – more likely – falls asleep at the wheel.

How they work: The first of this type of system debuted on the Mercedes Actros truck in 2000, with Nissan launching the first passenger vehicle system in 2001 on the Japanese market Cima. Infiniti brought the first lane departure warning type system to market in the US in 2004, Citroen did in Europe with the C5, and Lexus were the first with an "active" system which counter-steered to help, in 2006.

In most systems, a camera situated behind the rear view mirror at the top of the windscreen, monitors the white lines of the road, and if a wheel at the front begins to stray across the white line, intervenes.

In Lane departure systems, various way of notifying the driver have been used – a warning chime, sending a vibration or pulse through the steering, or a pulse/vibration through part of the seat. With the 'active' lane-keeping assist systems, these warnings are replaced or supplemented by steering input, which is made possible through the electric power steering system. On many systems today, an instrument cluster tell-tale warning light is used in addition – green when the system is on and the car driving between the white lines, turning to orange or red if the driver strays across them.

Benefit: The systems are primarily designed to prevent accidents and overcome issues generally created by driver fatigue. In the context of highway driving and speeds seen there, LKA systems ultimate have the potential to significantly reduce death or injury caused by collision.

Challenge: Lane keep assist is one of the ADAS for which it is easiest to see the benefits. Helped by the fact that the systems tend to exist in a simple on/off state activated by a singular button, their ability to do their job isn't hindered by a driver's ability to activate them via an overly complex process, as might be an issue with some adaptive cruise control systems.

The challenge with LKA, is to get drivers to leave the system active in the first place (most cars provide a button on the auxiliary panel to turn the system on or off – most cars we drive have the system set by default to off). Why would drivers not use it? Because for all its relatively simple manifestation through interface, active lane keep assist systems can feel quite un-natural in day-to-day driving, because they can feel like they're creating a fight between driver and car – tugging or buzzing at the steering wheel in a way which can be quite unnerving and feel very unnatural.

That happens because most drivers, even if infrequently, will change lanes without indicating. Or cut a corner – straying across the white line – to smooth out the curve of a tighter bend. In these occasions, having the system intervene is annoying and often unexpected. Some of the more aggressive systems (a Land Rover Discovery Sport we recently drove, for instance) quite forcefully jabbed in a dose of counter-steering – presumably the intention being to wake you up if you've nodded off, or to make sure you're very aware you were straying. As with adaptive cruise control, it's building a level of subtlety into the system and tuning it to understand the nuanced behaviour that occurs out on the road – so that it can discriminate between a deliberate manoeuvre and one that is unintended because of tiredness or distraction, that feels hard. Only when LKA feels like it has the intelligence to know this, are more drivers perhaps likely to leave what is ultimately a very useful system, switched on more of the time.

TRAFFIC JAM / PILOT ASSIST SYSTEMS

More commonly known as Autopliot, Drive Pilot, traffic jam assist, pilot assist.

Full "pilot assistance" systems are able to both accelerate and brake the car, but steer it too – in effect marrying together adaptive cruise control and a sort of "lane keeping assist plus" system, to create an experience which, in some circumstances, make the car feel like it is driving itself.

Tesla's Autopilot is the best known – and, at the time of writing, most advanced – of the systems that customers can currently buy, offering Level 2 stage autonomy, although later in 2017 Audi will begin to sell the 4th generation (D5 internal code) A8, which will progress to level 3, going beyond the capabilities of what we describe below.

Pilot assist display (from Volvo XC60)

Purpose: The purpose of these systems is for the car to reduce workload for the driver. While all Level 2 systems implicitly mean that the driver must be sat in the seat and monitor steering, braking and acceleration, the best systems can successfully create the impression (at least for short periods of time) that the car can drive itself.

How they work: Most pilot systems combine several technologies already described – for instance, the camera used for monitoring lane markings, the one for identifying speed limits, additional camera systems for identifying people and vehicles, radar for measuring distance to other vehicles, and the acoustic sensors as a short range distance measurement functions. Using the ECU and the electric power steering system (EPAS) the car is then able to drive along the road within the boundaries of the lane, steering to follow direction changes and adhere to speed limits as well as respond to the behaviour and position of other vehicles.

Benefit: Step from a Volvo (Pilot Assist), to a Mercedes (equipped with Drive Pilot) to a Tesla (equipped with Autopilot) and the experience is subtly different. In many ways, one of the inherent issues is that it's difficult to describe the true benefit, because no two systems are the same. The benefits, to a certain degree are merely a combination of those offered by LKA and adaptive Cruise Control. But as the Level 3 A8 arrives, and to an extent as we describe Tesla's Autopilot which is the most advanced of the Level 2 systems, the benefit is that the driver can to a certain degree, switch off from driving input duties. Tesla robustly defends Autopilot's ability to make driving safer – citing just one death in over a million Autopilot driven miles, compared to an industry average of more than twice that.

Yet in many ways, the benefit is being able to 'see' what autonomy might be like in the future, with your own eyes – in gaining belief in the car's ability to do the job the driver normally does, to begin to gain trust in the system and then imagine the possibilities of what you can do with the time, normally spent driving the car, as you move from place to place.

Challenge: The primary challenge this creates is the one that Waymo's John Krafcik identifies as the reason for the company going straight to Level 4. As driving "feels" at least partly autonomous, people switch off, they become disengaged from the process of driving — and fail to monitor the system. The sad death of Tesla driver Joshua Brown, in Florida, is perhaps at least in some part an example of what happens in extremis. Brown's Model S crashed into the side of truck turning across his path. The Tesla, running in Autopilot mode, failed to see the side of the white truck against the bright sky, and Brown for some reason didn't respond.

Related to this, is what we see in many other Tesla videos that can be found via a quick YouTube search. People are aware the systems have limitations, but push them further than their intended use, operating pilot assist systems on roads or situation when they shouldn't.

Our own experience in cars with these systems bears this out. Use a pilot/driver assist system in heavy, slow-moving traffic on a highway and you become quickly convinced of the car's capabilities. Later, at higher speed you begin to believe it can cope with tighter turns, only then to discover that the steering system is unable to make very quick, sharper turns and you have to intervene — quickly — to avoid running off the road at high speed.

Other situations are similar — roadwork zones challenge these systems, because of the inconsistent, or scrubbed-out white line markings. And yet speed-limited roadworks are the kind of place you'd like to use these systems, they seem genuinely useful here because they reduce what can be a significant driver load. And yet in Volvo's and Mercedes' systems, we've found that we've had to take avoiding action with the systems engaged, because the system got confused — or it has repeatedly disengaged in these zones, but the means by which the system displays whether it is operating or not via the instrument cluster, is sufficiently subtle that you don't notice it has switched out. And it's only when you realise that the car has stopped steering itself when the car wanders unintentionally out of its lane, that the car provides any meaningful feedback for you to intervene.

LEARNING FROM TODAY'S DRIVER ASSISTANCE SYSTEMS

Many of these systems provide a clear safety benefit or take workload off the driver in a way which, when used over time, has clear benefits. Yet quite often, these qualities are not clearly and easily apparent for the first time user, or when the car is static in a show room. Their perceived benefit is much harder to discern and thus these systems are either not selected as options, or used less than they might be where fitted as standard. There are a series of learnings from these current ADAS systems, which designers should be mindful of as they develop first semi and then fully-autonomous cars, which we'll outline below.

USER EXPERIENCED

Many drivers today have learned in, and spent much of their driving lives using older and more basic cars, which didn't possess these newer, additional assist systems. Therefore, exposure to, and experience of, these new systems is limited. And so there is a basic lack of understanding about what they actually do.

Parking sensors or auto headlights might be relatively simple concepts to understand – and have become so ubiquitous that the customer understands their operation and value. But with the more complex, safety-orientated ADAS systems, before we begin to discuss how the user activates, understands and adjusts it to their personal preferences through a car's interface, we must ask the same questions they do – namely: 'Just what is this? What does it do?. The aforementioned Tesla Autopilot accident in Florida, is perhaps a key example of what can happen when users don't understand the limitations of a system.

The challenge for the designer and researcher is that many consumers are unlikely to express their questions and concerns about these systems in as blunt terms as these, be that in research sessions or in a dealership environment.

LACK OF PERCEIVED VALUE = LIMITED ADOPTION (SALES)

Many of these ADAS systems are only offered as optional extras – rather than standard equipment. Optional equipment is something the customer needs to see and be able to perceive its value of. Otherwise they will eschew its selection. Popular new car options include satellite navigation, metallic paint, bigger wheels, leather or heated seats. All of these have a direct, aesthetic or functional value that is easy to perceive and can be utilised or experienced on almost any journey, or even when the car is stood still.

With more advanced ADAS systems such as steering pilot, its much more difficult to perceive the value of. It is harder for the customer to see – or understand – what the value of this might be to them. It is not directly visible, aesthetically on the car. Today it is often not even manifested via a physical button. How it works, and what it does is almost impossible to demonstrate without a test drive – and fewer car buyers now test drive vehicles prior to purchase[3]. Additionally, with such a vast array of models from many OEM brands, and such a wide selection of options available on each car, many dealers will not have a demonstration vehicle which is equipped with this requisite, optional equipment. Surely, it will be easier to 'sell' or demonstrate the value of full autonomy.

FITTED AS STANDARD DOES NOT MEAN USED

Simply because a system is fitted, does not mean it is activated and being used. As we move towards a scenario where more people use (more, different) vehicles rather than simply owning one, there is a potential compound effect, where fewer people understand the ADAS systems in their cars, and therefore they are less often used/active.

We can see a precedent in even relatively well-known driver assistance systems, such as cruise control. Found in many mid-level and premium cars today and available on some cars for several generations now, its use saturation in many markets remains limited.

On congested roads, even fast flowing European highways, cruise control usage remains limited because of the contextual conditions we discussed earlier in the section about adaptive cruise control. This raises the question, what the default for ADAS and semi-autonomous systems be? On? Or Off? Currently this varies by car, and is often dependent on an initial set-up. But toggling systems on and off can be hard (selections are often buried deep within menus, or on an auxiliary button panel that's hard to see while driving).

SETTING PATTERNS OF OPERATION: BEHAVIOUR

A distinctive driving experience and user experience is one of the foundations of car brand differentiation. Over the years, many OEMs have developed a distinct approach to vehicle dynamics, on-board technology and interior layouts. When done well, customers get used to the way a car feels, and so when driving a competitor product, it feels slightly alien and — often — just less good.

Car brands are fiercely protective of this character, and the development of a distinctive, unique approach to design. But as we move towards autonomy, is there a need for a fundamentally different approach?

There is the lack of a basic, easily relatable explanation of what many existing systems do and don't do ("So the car drives itself but I still have to steer?"). Use of these systems isn't taught when learning to drive, so there is no "baseline" of learning from which the user can build their own experience.

Even long-time assist systems like cruise control are set and then adjusted in a different way from car brand to car brand. They can be on a stalk, on the wheel, on a button. Setting a specific speed introduces greater variation of operational logic (push the stalk down to set, pull it towards you to set, press the "se"' butto etc).

This raises the question – for first ADAS, and then for autonomous functions to be widely adopted – do we need to consider "design patterns" — consistent approaches to layout and operation of these systems (rather like the clutch, brake, accelerator foot pedal box layout), in order that more customers understand and can easily use them?

Currently, the implementation of cruise control and many new ADAS systems represent the opposite of a good design pattern — they introduce confusion and ambiguity and the user needs to learn multiple modes and methods. That creates greater cognitive load. And therefore ultimately, the systems may just get ignored.

Cruise control is the canary in the coal mine for cars with some level of apparently autonomy (Level 2 or Level 3). If the industry takes the implementation approach with autonomy that it has with cruise control, the customer experience will be diverse and potentially confusing. We might reasonably expect to see autonomous functions simply not being used.

More worryingly — if similarly named systems have different capabilities (cruise control, cruise control with brake and adaptive cruise control all behave differently) — confusion about both capability and expected behaviour of the car may occur. At best, this will undermine driver confidence. At worst, it risks ADAS causing, rather than helping to prevent accidents.

AUTONOMOUS VEHICLES — A BRIEF HISTORY

Many of these systems provide a clear safety benefit or take workload off the The path to autonomy begins far outside of the automotive sphere. The first experience of autonomous travel began with the humble elevator. In their early years of existence, elevators had an operator. Gradually, people became familiar with what an elevator did, and operators were phased out for a button you pressed to "autonomously" be taken to the floor required. Will the elevator's transition to autonomy prove to be precedent for cars? In years to come, will a car operated by a person feel like an anachronism, or the ultimate luxury?

IN THE BEGINNING

Other transport has long had some autonomous qualities. Many ships feature something called *auto-helm* which steers a set course, while the more well-known aeroplane *auto-pilot* was first seen in 1931. The first fully auto-pilot flight took place in 1947 and today any passenger plane capable of carrying more than 20 people must have some form of autopilot.

Near our studio in London, you can jump onboard a driverless-train – the Docklands Light Railway (DLR), where the best seat in the house is right at the front, allowing you to see out in a way that's simply not possible in a typical train (as our study participant Darret discovered). In fact, many light rail, underground and airport-based trains function without a driver and — rather like the in-coming SAE grades for levels of automation in cars, the International Association of Public Transport has its own five-level system for the grading of automation of trains.

PRTs (Personal Rapid Transit) pods, have begun appearing in dedicated locations such as London Heathrow's Terminal 5 and Masdar City. Fully driverless, running on dedicated roadways (but not rails), PRTs have not taken off in the way predicted, but are the closest to what current vision projects the fully autonomous cars of tomorrow will be like.

THE FIRST 'AUTONOMOUS' CAR CONCEPTS

Much autonomous vehicle development has grown out of space programmes, academic institutions and — particularly in the US — the military. DARPA (Defence Advanced Research Project Agency) is part of the US Department of Defence, and its *Challenge* programmes which ran through the 2000s began the modern race towards autonomous vehicles that we are in the midst of today.

Focusing in on cars and commercial vehicles illuminates some interesting lessons from the past. We might think of autonomous cars as a very modern construct, but the first driverless car was developed by GM in 1958. Developed throughout the late '50s and further into the '60s, when it began press demos on an integrated roadway with embedded sensors, there was an expectation that such vehicles would be on public sale by 1975. Perhaps those predicting the public availability of Level 4 or Level 5 autonomous cars within a couple of years would do well to consider this history.

However, the Americans weren't the only ones to work on rudimentary and experimental autonomy. The UK Transport Research Laboratory tested vehicles controlled by wires in the roadway during the 1960s, while it was the Japanese — Tsukuba University — who were the first to test a vehicle that tracked via the white lines on the road, in 1977.

CAMERA BECOMES KING

Much of the work conducted during the '70s, '80s and '90s was led by academic research groups, funded by governments and generally collaborative. One common change in approach was a switch from wires/road based sensors, or white-line follower systems to the use of camera-based systems. The two most significant projects — Stanford University/DARPA in the US, and the Mercedes-Benz VaMoRos (and its descendents) in Europe, both used camera-based systems. Beginning development in the late '70s and early '80s they were developed over the following decades, eventually paving the way to two of the most significant milestones of autonomous vehicle history.

1835

1947

1960

1987

1987

The 1995 Mercedes S-Class used learning from the VaMoRos van. It was developed with Bundewehr University and in 1995 travelled from Munich to Copenhagen with barely any human intervention. It not only recognised lane markings, but also knew its own position and "saw" other vehicles. In many ways it was a template for future autonomous projects. But it also gave Mercedes leadership, which helped them be first to market with adaptive cruise control or *Distronic* as the company calls it.

THE DARPA CHALLENGE

Public interest was first piqued by the other significant project of this time – the DARPA challenge. Begun in 2004, 15 cars competed for a prize of one million US dollars to complete a course over 200km long in the American desert. That year, no vehicles completed. But the challenge came back in 2005, with a larger prize of $2M and this time, four entrants completed the course – with the winner a VW Touareg, nicknamed *Stanley* and developed by a team from Stanford, whose works stemmed from the Cart programme begun in the 1970s.

DARPA upped the ante, because in 2007, it changed the challenge from one which kept to safe, far-from civilisation locations, to an "Urban challenge." It was a closed course, but simulated the realities of city life and roadways, with other vehicles, pedestrians and intersections. Tartan Racing – a joint GM and Carnegie Mellon University team, won.

GOOGLE CHANGES GEAR

If DARPA was the catalyst, then Google really caused the shift to top gear for autonomous vehicle development. The Mountain View tech giant began its exploration of “driverless” cars in 2009 (with a second generation Toyota Prius). Why was Google doing this, people wondered? The project was a perfect bed-fellow for the firm’s long-established Maps programme, and the establishing artificial intelligence work. But it’s easy in hindsight to see how significant this move from Google was. It was the first significant evidence of a technology firm moving into automotive territory, something which today feels increasingly normal. And, eight years on, it seems likely to provide Google with a very significant advantage over most legacy firms – simply because it has racked up so many autonomous miles, and been able to learn and refine both hardware and software alike.

Google begun with the Prius, but shifted to the Lexus RX SUVs in 2012, vehicles it still uses today – alongside its own, self-styled pod-like Google car. This was first unveiled in 2014 and has undergone a couple of iterations to become the vehicle used for on-road testing (and some user testing) today. Notably, Google’s own car has no steering wheel or pedals, and currently the company says it has no plans to become a fully-integrated producer of cars.

BIG AUTO RESPONDS

However, the auto industry – often criticised for its inertia and slow response – has responded with gusto. Notably, there has been an attempt to stay true to brand ethos, particularly from the German OEMs. Audi “raced” a TT it had developed with Stanford University up the Pikes Peak hill climb race, a location where it had for some years been competing and setting records. Mercedes unveiled the new S-Class in 2013 by illustrating its near-autonomous capability – the car driving itself onto stage at the Frankfurt auto show with CEO Dieter Zetsche in the back, who stepped out and announced that it was only legislation and public appetite stopping driverless cars becoming a reality from his firm.

Not to be outdone, BMW – whose “Ultimate Driving Machine” strap line looks most problematic in the context of vehicles that don’t need driving, “autonomously drifted” a 2-Series around a race track as part of CES 2014.

By 2014, autonomous cars were firmly in the public eye, and some of the most significant moves were just around the corner – in 2014 Tesla began equipping its Model S with the hardware which would enable Autopilot which it later “activated”via an Over-The-Air (OTA) software release in 2015.

At this point, the autonomous car as a concept begins to feel normal – with several OEMS presenting concepts with some form of autonomous capability. But while concept cars are often viewed by those outside of the industry as flights of (frustrating) fancy, with autonomous in the mix, they deserve closer exploration.

2004

2012

2013

2014

2015

DARPA Grand Challenge

Google Toyota Prius test AV

Audi TT test AV

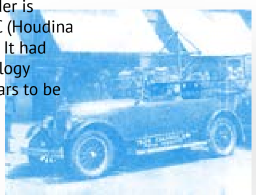
Google's test AV

Tesla Model S

130 BC
Prince Husain purchases a Magic Capet

1478
Da Vinci invents self-propelled cart, which is considered to be the ancestor of modern automobile

1926
Linrrican Wonder is created by HRC (Houdina Radio Control). It had remote technology enabling the cars to be driverless



1939
Norman Bel Gedde's Futurama exhibit at the World's Fair includes driverless cars roaming the streets, using duo technology

1940
The book *Magic Motorways,* argues that humans are the real problem for safety on the road

1941
RCA (Radio Corporation of America) creates Laboratories for R&D purposes, much like how OEMs have done in recent years

1945
Ralph Teetor, a blind inventer creates modern cruise control out of frustration from how his lawyer drove

1953
RCA creates miniature driveless car that is guided by wires, only to recreate a full sized version on a public highway in Nebraska five years later

1958
RCA builds prototypes for ADAS in GM Firebirds

1958
Chrysler Corporation imperial is released and incorporated Teetor's cruise control system

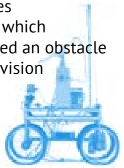
1960
UK Government agency, Transport and Road Research Laboratory focused on in-vehicle self-driving technology

1965
The first commercial flight with passengers landed with an autolanding system

1971
Bendix created the first comupterised ABS, which is considered to be the early evolution of autonomous vehicles

1977
Tsukuba Mechanical Engineering Lab creates an autonomous vehicle, tracking white street markers and drove at 30km an hour

1979
SAIL (Stanford University Aritificial Intelligence Laboratory) creates autonomous cart, which successfully crossed an obstacle filled room using vision



1986
The PROMETHEUS project launched by Daimler-Benz AG

1986
DARPA releases ALV (Autonomous Land Vehicle), it used LIDAR technology which is used today

1987
The automated metro system, DLR, opens in London

1995
Dickmans & the Mercedes-Benz team successfully drive an autonomous car over 1,678km

1995
Carnegie Mellon University's NevLav 5 completes 3,100 miles cross country journey from Pittsburgh to LA. Though it was semi-autonomous

1996
University of Parma launch Argo. It successfully traveled 1,200 miles over 6 days on public motorways

1997
NAHSC (National Automated Highway System Consortium) demonstrate AVs at Demo '97 on i-15 in San Diego, California

1999
Holland's ParkShuttle became operational using magnetic cables burried in the road beneath.

2003
Tesla is founded.
Elon Musk joins in
the following year

2004
DARPA Grand Challenge
1 - No team came close
to the finsihing line of
150 miles. Closest was
Carnegie Mellon's
Humvee 7.32 miles

2007
DARPA Grand Challenge
3 - Set in urban
environment, vehicles
had to obey traffic
regulations. Carnegie
Mellon took the prize

2010
University of Parma's
autonomous vehicle
successfully drove from
Italy to China

2010
ULTra (rapid transit)
launches at London's
Heathrow Airport

2012
Amazon announces
Prime Air, automated
drone delivery system

2014
New OEM startups are
founded: Faraday Future
in California and Nio
in Shanghai

2015
LIDAR unit is now
under $100

2016
Stanford's Wendy Ju
conducts Ghost Driver
project to observe how
pedestrians react to
driverless cars

2016
Tesla claims that their
Autopilot is twice as safe
as human druvers

2017
GATEway, a UK
government funded
research project
launches. It aims to
overcome challanges
of implementing AVs
in an urban
environment

2028
Fully automated vehicle
by ustwo launches.
It wins AV of the year for
its excellent inclusive
design :)

2004
Mars Spirit Rover lands
on Mars. It cruised on
the surface driverlessly
for 7.78 km

2005
DARPA Grand Challenge
2 - 5 entries completed
the course. Stanford's
SAIL came 1st, and
Carnegie Mellon came
2nd and 3rd

2010
Google reveals a fleet
of automated Toyota
Prius have logged
140,000 miles

2010
Audi's Shelley
autonomously climbs
Pikes Peak, Colorado's
iconic mountain

2010
Automated personal
rapid transit is
implemented in Masdar
city in Abu Dhabi

2013
Google posts a Youtube
video of autonomous car
being used by blind man

2015
Apple's automotive
project, Titan is reported

2015
Carnegie Mellon and Uber
annouce a research pact

2016
US DOT publishes
Federal Automated
Vehicles Policy

2017
VW group announce
Sedric, a fully automated
concept van

Waymo

Mercedes-Benz F 015

Volvo Concept 26

CONCEPT CAR VISIONS OF THE AUTONOMOUS CAR TODAY

From a design point of view, the diversity of what has been shown is intriguing. Concept cars tend to function as static pieces of sculpture – perhaps able to drive onto a stage at a motor show with the help of a couple of 12-volt batteries, but often little more.

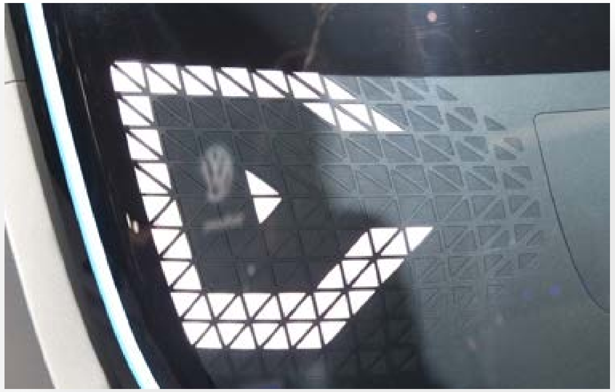
Yet the autonomous concept has been different. From Google/Waymo's first bespoke car, to the Mercedes F015 and Volvo's Concept 26, the focus has been on providing a vision of what the human experience on-board might be like, and understanding how user, vehicle and the environment it is moving through interact with one another.

This has meant that concepts like the Mercedes F 015 – which in a previous era, would never have left the auto show stand – have been used on the real-world streets of Las Vegas and San Francisco for demonstrations and publicity. Google/Waymo's own autonomous car grew into a fleet of test vehicles. While looking like nothing else on the road, Google used it as part of its testing fleet – alongside Lexus RX SUVs – eventually letting the car loose on its own, with a member of the public inside to drive through the streets of Austin, Texas.

What can these concept cars of the past few years tell us about how car and technology brands are thinking, as we look to the fully autonomous vehicles of tomorrow? Despite the disparate characters and design approaches employed, there are several common themes.

HUMANISING THE MACHINE

While autonomy brings much focus of attention to the inside of the car, many concepts have taken the opportunity to rethink aspects of the exterior design, in a way that humanises the car. Most people already read vehicles in anthropological way. The front of a car is referred to by car designers as the "down road graphic" – or DRG, but more commonly people refer to this as a car's face. And it really is a face – made up of eyes (headlamps), nose (upper grille) and mouth (lower grille).



Toyota I-Concept

Volkswagen Sedric

BMW iNext

Beyond a face which we analogise to a human being or animal, we read a car's character in different ways, depending on how it is designed. One of the reasons that the Mini is seen as friendly and approachable is its very human face, with round lamps set above the main grille openings. Proportionally it is quite human. In contrast, recent Audis, with their single frame grilles, have merged nose and mouth, and the lamps – with their LED-based running lights and headlamps, they have lost the round projector that makes the headlamp look like it contains a human pupil. Instead the square LED blocks gives them an entirely more mechanoid, robotic and aggressively high-tech look.

Some autonomous concepts have been notably more "human" than this though; or even animal-like in their character. Waymo's car may be derided as a naïve piece of vehicle styling by designers, but in some ways this is to miss the point. The appearance is deliberately cute, approachable and friendly. The lamp graphics have the projector positioned low within the oblong, and the laser sensor is rendered in black – sticking out, turning it into a real, physical "nose". The face is slightly doe-eyed, reminiscent of a koala, or panda – animals we tend to view as cuddly and non-aggressive. Google wasn't playing lowest denominator car design, it was deliberately making a friendly vehicle that we immediately associated with a cuddly toy, rather than a scary robot.

The automotive OEMs have subsequently gone further. Rather than physically fixed lamp/grille elements, Toyota (with i-Concept) and Volkswagen's Sedric use a digital front fascia, onto which is rendered a traditional style face with lamps, logo etc. But the lamps become true eyes, with promotional videos showing the car "winking" – it is alive – a living being that's on your side, and in both cases then welcoming you on board in person. The i-Concept's "Hello" greeting displayed on its door skin was one of the stand-out images in the car world, in 2017.

Furthermore BMW's iNext features a skin of reptile-like scales which stretch and move around as the wheels turn, and then link exterior and interior design as they come into the cabin. These form a means of communicating dangers and hazards occurring that the car is detecting outside to the occupants inside. The scales stand on end and reveal a red "danger" layer below when the car spots a cyclist hidden from view behind a parked van, and on a collision-course with the car.

Duel

Humanising the machine is even creeping into current cars. The approach employed by Mini is worthy of note. The light ring that now surrounds each car's centre screen, acts as a light-based communication method in the cabin. It's most notable mode is when the stop-start cuts in at the traffic lights. The ring pulses green, and dies down to the outer edges (at 8 and 4 o'clock on the dial). Then, while the engine is shut off, these green sections gently fade up and down – the car seeming to "breath" to show it's still alive, yet at rest – in the same manner as a Mac's gently beating white light does when it is in sleep mode.

It might seem ironic that as the car gradually becomes more autonomous and reliant on artificial intelligence, designers are seeking to give vehicles human qualities. But it is far from surprising in another sense. With Apple used as a constant design reference over the past 15 years, automotive and user experience designers working at car brands know the value of humanising the machine, as a way of creating an emotional connection with consumers.

Fundamental to this trend, is the need to make autonomous cars feel approachable and safe from a user perspective. Older readers may recall 'Duel' – Stephen Spielberg's 1970s film in which terrified motorist Dennis Weaver is stalked by a mysterious tanker trunk and its mostly unseen driver.

For some users, this vision of the omnipresent, driverless machine is closely equated to what the autonomous car might be. Autonomous cars may eventually provide great benefit in safety and convenience, but for many people today, that is outweighed by the prospect of them being terrifically scary, unpredictable robots. Endowing autonomous cars with human characteristics, mimicking behaviours, mannerisms, movements and communication methods is therefore a powerful tool in taking away much of that user fear. Though it could also increase it if done in the wrong way!

Humanising the machine is a key part of the designer's toolkit for the autonomous future, particularly if we consider the most likely initial implementation of autonomous vehicles is as a taxi or small bus – which needs to serve many people, rather than being owned by an individual.

EXTERIOR COMMUNICATION

Many recent concepts share another trend — they adopt a different approach to exterior communication. This in itself is a development of the humanising design point above. On the roads today, cars communicate behaviour and intention through internationally mandated, and standardised means. Essentially turn signals, headlamps and stop lamps/brake lights. However, what even non-drivers may realise is that drivers have developed a secondary series of communications methods, which vary by country, but — particularly in cities — are critical to all types of vehicles and pedestrians getting along. As drivers we read car "body language" and give oddly behaving vehicles a wide berth. We know the road conventions dictate that, if we arrive at an intersection after another car which is already waiting, we wait in turn for that other car to perform its manoeuvre first. And a flash of the lights — in countries like the UK — means "you go ahead" (it has other meanings in other countries).

Yet perhaps the most important secondary means of communication is eye contact. Pedestrians and cyclists — both consciously and subconsciously — gauge the intent of a vehicle, and whether it is planning to slow down and give way to them, by making eye contact with its driver. This typically occurs at a zebra crossing — a crossing that is not traffic-light signalled, but where a vehicle should give way if pedestrians are waiting to cross. Yet pedestrians rarely wait for a vehicle to fully stop before stepping out — they use eye contact with the driver, and observation of the vehicle's body language, to begin crossing as the car approaches, because they know it plans to stop. We discuss this, and challenges like it, in detail throughout the book.

A CHANGE IN SIZE, AND FORMAT

Many people ask — as they have with battery electric cars — whether autonomous technology could lead to big changes in the way that cars will look. And contemplating many of the concepts we've seen in recent years, it would seem that yes, autonomy could lead to very different-looking cars. Different looking from an aesthetic point of view, but not necessarily better designed or more beautiful-looking.

Today, autonomous concepts tend to seek to show how four occupants can share a space, and conduct new activities in the car, permitted by its autonomous nature. They are turning cars into a room on wheels — and in the conceptual world presented by the automotive brands, this means that the people onboard are engaging in a lot screen time, or facing each other as if in a meeting.

However, the practicalities of having four humans facing each other within a vehicle space we recognise as like today's car is challenging. The road-going cars of today are carefully designed around a package, with the best cars providing just enough room for each occupant. Because the position of this occupant is known — and fixed — the best designers are able to design an appealing form around the cabin.

In our future autonomous car, if these occupants have seats which are able to move around significantly — to turn in on themselves, or even turn around through 180 degrees, then the "packaging" constraints of the car change. If it's a vehicle that people aren't in for long — and need to quickly and easily be able to get in and out of — then the designer's job becomes all the more difficult. We end up with a box on wheels, with a tall roof — a car equivalent to the London taxi cab — because its cabin has the volume needed to accommodate four people sat facing one another

These packaging realities are the reason why so many recent, autonomous car concepts have been large, mono-volume forms. The BMW iNext, Mercedes F 015, Toyota i-Concept, Yanfeng XiM17, Audi Aicon and Renault Symbioz all have similar silhouettes.

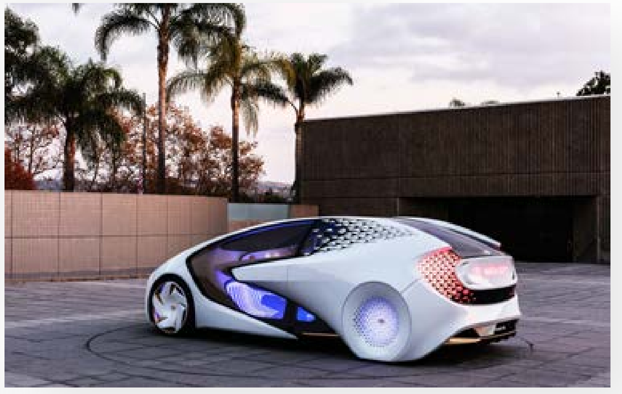
Volkswagen's Sedric concept takes this to an extreme — it truly is a mono-volume — a high, squared off, one-box shape. Sedric wasn't presented as a car for people to buy and own though, so its form and aesthetic positioning is, superficially much closer to the personal rapid transit (PRT) pods, seen in places like Heathrow Airport. As a solution for the future taxi — or taxi-replacement — this approach makes a lot more sense than a car of today. On an aesthetic level, it doesn't read like a car of today — it is clearly something different, new. And on a practical level, the high roofline and sliding, central door opening makes ingress and egress far easier than many cars of today.

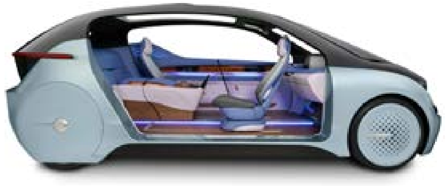
Within the context of a shared, or summoned vehicle in the city, such an approach has much to commend it. But as a car to own, or desire and aspire to — or to convey the values we know a brand to have? The mono-volume format is one which, historically in the automotive industry, was used by the MPV or people-carrier vehicle. While concepts like the Lancia MegaGamma and the production Renault Espace were revolutionary and highly space-efficient, this is a style currently very much out of favour with consumers. Moreover, it seems to be causing brands and car designers considerable levels of discomfort. Many of the autonomous concepts have sat uncomfortably within the brands they come from, in the way they represent the brands character, values and history. Additionally, the sheer scale needed to accommodate four people, in four comfortable seats that can turn and move around within the space, dictates that the vehicle be physically very large — the F015 concept stretches beyond five meters in length, it is larger than Mercedes' own S-Class limousine and would be too big for any European parking space. Perhaps, given autonomous cars wouldn't necessarily need to be conventionally parked for hours of the day, that's the point? Yet again, the approach raises many more questions than it answers.

The automotive industry remains unusual — and distinct from the technology sector — in the relationships many customers develop with their cars, and the quality they provide as an "avatar".

Today, auto manufacturers spend billions on researching and testing what consumers will deem acceptable, and want to be seen in. While this leads to a slow, evolutionary design approach that is bemoaned by many outside the industry, there is a reason that the Tesla Model S looks like it does – a conservative, sober, generic but neat sedan-cum-fastback. And that by being so normal, it has been a success in the market. Meanwhile Nissan's Leaf, and BMW's i3 – much more daring and innovative designs in many ways – have been sales flops. Future autonomous car designers may do well to dwell on this point – looking as futuristic as possible may not be the best way to bring customers on board.

While exterior designs are undergoing radical changes, the heart and soul of change in today's autonomous concept car does lie in its interior. Several, similar trends have begun to emerge within recent concepts.





BMW iNext

Mercedes-Benz F 015

Toyota I-Concept

Yangfeng XiM17

Audi Aicon

THE FOLD-AWAY STEERING WHEEL

Many brands are exploring the concept of transition – where car and driver hand control of driving duty between each other. Two distinct approaches have emerged to this challenge – one which telescopes the wheel in, towards the instrument panel – pulling it away from the driver, whose seat is often, simultaneously moved backwards. The other, more extreme approach sees the wheel fully retracted – folding up, or being subsumed by the dashboard.

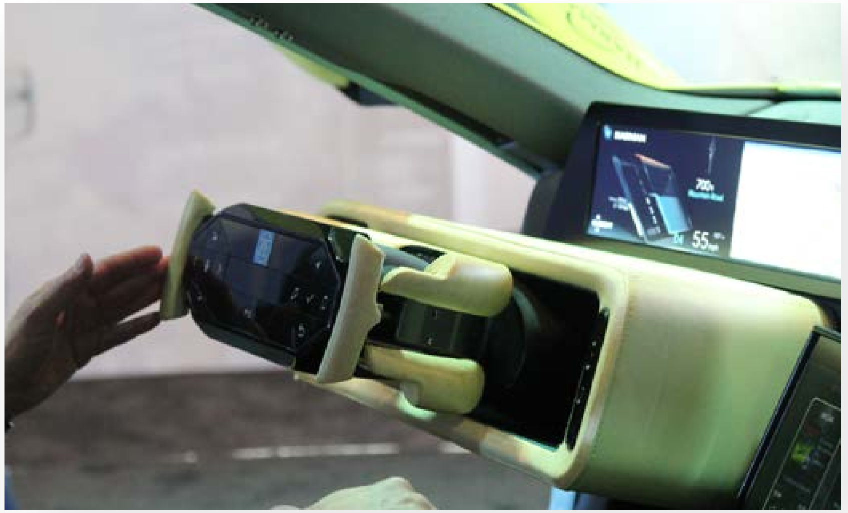
Volvo's Concept 26 telescopes the wheel away, at which point the driver can select two seat positions – relax (reclined and rearwards), or creative (upright, but rearwards, for reading or interacting with the large passenger-side screen).

Rinspeed's Etos concept presents a square steering wheel, which when autonomous mode is selected, splits in two at the rim and folds inwards through 90 degrees – thus allowing the folded wheel unit to be pulled in and sit flush with the dashboard.

Perhaps the most elegant solution to the steering wheel "pulling in" to the dashboard can be seen on Volkswagen's ID concepts. The steering wheel has been redesigned so that the main centre point joins with the lower section of the rim. In driver-operated situations, the wheel is set up normally. But when an autonomous driving period presents itself, the user must lay their hand on the centre of the wheel to accept autonomous mode, and their hand remains there as the wheel gently telescopes into the dash. The steering wheel rim then becomes a flush surround to the main information screen.

What's particularly impressive is the simple interface logic and immediately "gettable" nature of the user modes. It also wraps two solutions into one. Rather than needing to press a button to switch between two modes, and then confirm that, yes, you really do want to switch modes and haven't hit it accidentally, the five seconds it takes for the wheel to shuttle in or out, during which time the hand must remain on the wheel, both activates the mode and confirms intention.

And while its steering wheel the steering wheel design is somewhat different to the steering wheels of today, VW stops short of transforming the round steering wheel into a pair of joysticks, magically appearing from the dashboard. This, more gameified approach is taken by the Nissan's IDS, Peugeot's Instinct, Chrysler's Portal and BMW's iNext.

Volvo Concept 26

Rinspeed Etos

Volkswagen I.D.

Jaguar Land Rover Saye

CHANGING THE POINT OF FOCUS

Beyond steering wheels, many autonomous concepts unsurprisingly take the opportunity to reformat the car's interior layout – with two points of focus, currently – seats and screens.

Seats have seen less innovation than we might expect – largely because many of the concepts presented have been designed to function in both autonomous and driver-operated modes, and with the possibility of a crash still a reality, seat swing (inwards or outboard from the forward direction of travel) is limited to around fifteen degrees away from straight ahead. This is the angle at which, OEMs say, they can still retain good protection of seat occupants in a crash. Clearly, a passenger turned 180 degrees is possible too, as a rear facing passenger is in most ways better protected than one facing forwards in a typical crash.

Nissan's IDS and Yanfeng's XiM17 concept both take advantage of the ability to turn all four seats slightly in-board in autonomous mode – to allow better inter-passenger conversation, or every user in the car to focus on a large screen – perhaps so they can all jointly take part in a video conference call.

Nissan IDS

Yangeng XiM17

But in other ways, this way of thinking is unusual. As many OEMs and suppliers – Yanfeng included – now believe that, with the advent of autonomy, one of the most significant changes in car design will be the repositioning of occupants' in-car screen-based focus, away from the centrally mounted screen on the dashboard today, to ones that are in the door units, or mounted on a central, flat table in the centre of the cabin.

Rinspeed's Tesla-based XchangE, and Volkswagen's Sedric both feature large, TV-like screens that users can watch. This is an interesting approach, given the expected rise in travel sickness induced by autonomous vehicle occupants no longer focusing on the outside. Sedric tries to overcome this by using a transparent display screen.

Other notable takes on the screen's possible relocation feature in the Mercedes F 015, where, in fully-autonomous mode, each of the four passengers gets an interface in the door panel. And in Mercedes' autonomous Future Truck and its US sibling from Freightliner, the interface is like a large tablet, which docks into the truck's dash but can be removed for the driver to use when the vehicle is running autonomously and their seat position is moved back and twisted to the side.

In-car screens represent perhaps the biggest challenge and opportunity for legacy OEMs in an autonomous context. Current user behaviour suggests an ever-growing desire for connectivity in the car. Many of these concepts have been presented as giving the user the opportunity to turn wasted commute time into something productive or simply spend time online. Volvo's concept 26 features a huge screen, which appears on the passenger side of the instrument panel, rolling out through the axis of the dashboard. Yet by granting the user their apparent wish for more screens and more connectivity, legacy OEMs move out of their own core realm of competency, and surely risk handing over the onboard vehicle experience to one of the technology brands?

Perhaps this is why so many autonomous concepts — from Mercedes' first *DICE* demonstrator, through to Toyota's i-Concept at CES 2017, propose extensive augmented reality projections — using the windscreen and windows as a projection surface, which keeps users looking beyond the world of screens and engaged with the outside world they are moving through (and which is an experience unique to being in a car or vehicle) while augmenting it with information harvested from the digital realm.

MOVING FORWARD

Looking at where the industry stands today, it is important to remember that there is not an autonomous car that the customer can buy. Yet Tesla's Model S and X – with their Autopilot systems already offer a solution which some drivers believe means the car can drive itself. This is part of the significant challenge we face, on the road to fully-autonomous cars. The Tesla Autopilot systems represents Level 2 autonomy. The SAE defines Level 2 as partial automation – where the steering, acceleration and braking are executed by the car. Crucially however, monitoring of the driving environment and execution of other driving tasks (eg indication) must be performed by the driver. Late in 2017, Audi will unveil its new A8 model – set to be the first Level 3 capable car.

Like a Level 2 car, it will be able to steer, accelerate and brake based on conditions, but crucially it also conducts all aspects of driving tasks, in certain contexts. The driver's role is to act as fall-back – responding to a request from the car to take over, or intervene.

We have seen in this chapter, just how many questions this raises. Will the user understand the systems capabilities? Will they remain attentive – or will they switch off and become over-trusting of the car? Will these systems truly reduce accidents and deaths. Do they provide a genuinely better driver or rider experience?

The picture is far from black and white. It is all too easy to be overly sceptical (fully-autonomous cars must be decades away) or overly enthusiastic (autonomous cars are just around the corner) about the future. Everyone has seen the social media circulated pictures of people reading books at the wheel of Teslas in the United States, anecdotally illustrating some of the issues. Just as they have seen various OEM and tech company demos of ADAS-equipped cars avoiding catastrophes that humans failed to spot.

Our own anecdotal experience bears this out. Over the past few years, we've driven dozens of ADAS-equipped cars. The picture is messy – the experience of being at the wheel of a car as it seamlessly steers, accelerates and brakes its own way along mile after mile of the M1, is quite magical. Having to apply your hands to the steering wheel every 10 seconds to tell the car you're still paying attention, feels ridiculous. As does emergency braking intervention slamming the brakes on as you try to weave around parked cars on narrow urban roads which causes you to switch off a potentially useful safety system.

In general, our field research found that today's ADAS or partly autonomous functions most positively contribute to the user's experience when they can do the following:

Enhance confidence: allowing the driver to do things they would otherwise not be prepared to attempt.

Augment, not replace skills: allowing the driver to feel like they are "in-charge" and providing a soft, sometimes invisible layer of intervention to optimise their skills and prevent the worst from happening.

Behave holistically: when the systems work in tandem, and appear to relate to one another, as opposed to functioning independently, the user experience is significantly improved.

Speak in human terms: acronyms, unknown dashboard warning lights and confusing icons undermine confidence, and create confusion among users. Support and assistance needs to be presented in a human way, in terms that people understand. If they don't value and likely use of systems reduces, significantly.

Generate engagement: until fully-autonomous Level 4/5 cars arrive, the need to keep drivers and riders engaged in the process of piloting the car will be the most significant challenge. Driver Assistance systems of today create a huge paradox – by taking over many functions or providing a very obvious safety net, they provide the opportunity for drivers to switch off, becoming less rather than more engaged and thus less likely to spot, or react to a situation where they need to intervene.

Recognise that driving is nuanced, humanised and not absolute: driving is a nuanced process that, analysed in one way is terrifically "human" — vehicles behave and react in differing, often organic ways dependent on a number of contextual factors. Until driver assist systems and autonomous cars are able to mimic this highly nuanced behavior, the experience will continue to feel unnatural; to feel that on a good day a good driver will do a better job without current systems engaged.

From these observations, we take away three key points — challenges for designers exploring the next levels of autonomous vehicles..

The current, additive process — with a gradual movement towards vehicles doing more of the required driving tasks, feature by feature – feels flawed. Cars feel like they are stuck in an age, which is analogous to a feature phone. More and more technology is added, but it rarely works in concert and much of it feels limited — an unsatisfactory half-way house, on the way to a giant step change.

The additive approach described above represents a missed opportunity — to have augmented, before autonomous, driving. This concept, first laid out by author and journalist Alex Roy[4], feels like an obvious opportunity for the industry to take advantage of during the transition period to full autonomy. At its basic level, it would function rather like a modern airliner — with its protection laws. The pilot (driver) is still in charge, but the plane systems work together, with the ultimate aim of making sure that there isn't a crash — even in the event of user input error. The aim would be to make the driver be the best they can be — to support and protect, to enhance their skills, to let them remain in control, but with a protective safety net of systems working to mitigate and ultimately prevent the thousands of accidents caused by human error.

Our experience shows that many current ADAS feel too timid and disjointed in their application — even bailing out or throwing back control to the driver at just the point where they least expect it, or need the system to help most. And they rarely work in concert with one another.

Finally, we need to look at the way technology is adopted, in a holistic way, which we discuss in more detail in the Holistic Problem Solving section. Today, we don't educate or test new drivers about how to make the most of new assistive technologies. They are implemented in a confusing, quite varied manner. And the advantages they offer are not understood or known — poorly communicated through their design implementation in the car, marketing messages and communication/dealer channels. We need to explore how this could change.

It may not be fair to say that the implementation of today's ADAS systems suggests that we have a Herculean challenge as we move toward the autonomous car. But there is much to learn from past mistakes, and current issues, as we develop the future.

Just as the first automobiles struggled to gain traction and replace the horse-drawn cart, today, the autonomous car is a confusing, sometimes off-putting concept. Yet a holistic, human approach to design and technology in autonomous cars could – rather like the infrastructure, design-patterns and key innovations that drove adoption of the modern mass produced car in the early 20th century – help autonomous cars to become a reality more quickly, and fulfill the great, revolutionary potential they have.

You can see ustwo's own AV concept, designed with a user-centred approach, adopting the themes in this section as well as the research and user interview insights unearthed throughout this book, in the Putting Theory Into Practise section. ◆

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ASUV: Autonomous Sport Utility Vehicle
by Scott Park
Year: 2030

"Most concept autonomous cars are super slick and Silicon Valley looking. In other words, they're designed to function in a city. And a temperate one at that. I might live in a city, but I live in a Canadian city. Where we have winters. And frost heave. And all the things that long, cold winters do to roads. And that doesn't even take into account driving in the snow. How would a self-driving car handle less-than-perfect road conditions?

Autonomous cars sound great for the long-haul driving we often do here (Canadians measure distance in hours it takes to drive, not by the actual distance), but how would it decide what route to take? Google maps and GPS tend to pick the most efficient route. But a human might take the most pleasant route, purposely going off-track, just to see something nice or interesting.

I would want a self-driving car that could handle my day to day city needs, but also handle the winter (the last thing I would want is my car to tell me I can't get to work because it's too afraid to drive in the snow). But I also want one that can handle camping trips, and cottage roads. A car that knows what to do when it runs out of asphalt, or has to haul camping gear on its roof.

The answer to those needs for many people (myself included) is an SUV. Multipurpose, flexible and reliable. So I decided to imagine how a self-driving SUV might improve the formula, and add functionality to autonomous idea."

ASUV

AUTONOMOUS SPORT UTILITY VEHICLE

AKA: THE SELF DRIVING CAR FOR WHEN YOU ACTUALLY LEAVE THE CITY

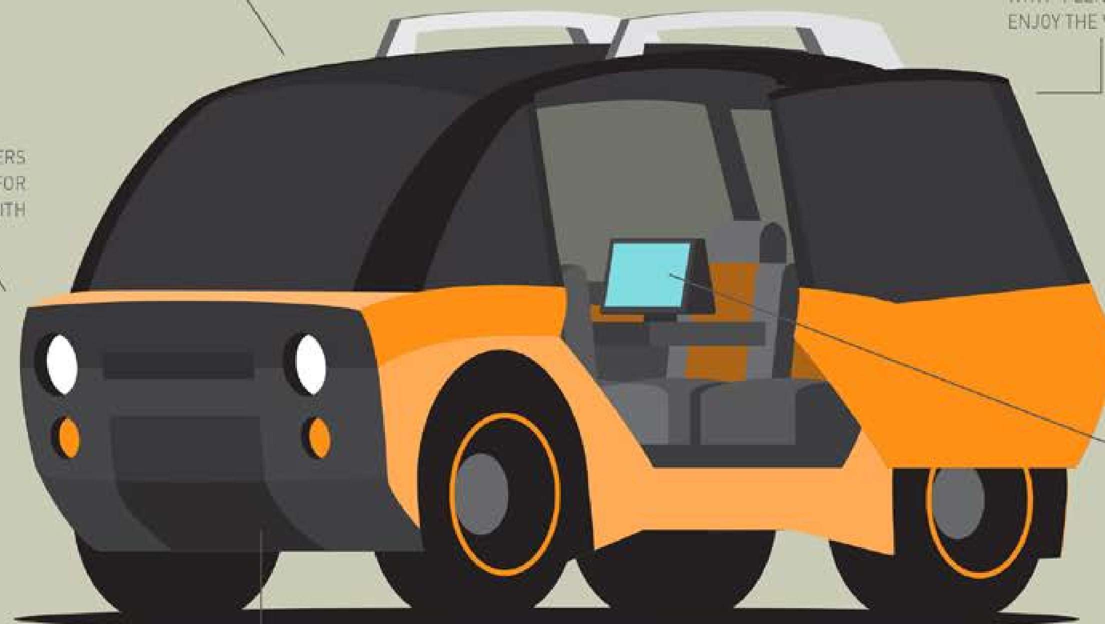
SPARK | ustwo AUTO

THE CAR MIGHT DRIVE US TO THE CAMPSITE OR SKI-HILL, BUT WE STILL NEED TO HAUL THE GEAR WITH US.

SOLAR PANELS ON ROOF, FOR CAMPSIDE CHARGING

GIANT CABIN. PERFECT FOR CROSS COUNTRY ROADTRIPS WITH PLENTY OF GLASS TO ENJOY THE VIEW.

ELECTRIC POWERTRAIN POWERS ALL 4 WHEELS, AND ALLOWS FOR LOW CENTRE OF GRAVITY WITH LOTS OF TORQUE



INTEGRATED ENTERTAINMENT CENTRE, WITH WIFI. BECAUSE EVEN MAJESTIC MOUNTAINS GET BORING AFTER HOUR 7.

ADJUSTABLE RIDE HEIGHT AND BIG TIRES FOR BACK COUNTRY TRAILS, ROCKY INCLINES AND YOUR BASIC CANADIAN WINTER.

WHEELBASE PUSHED TO EDGES FOR MAXIMUM CABIN SPACE, AND MINIMUM OVERHANG.

BECAUSE NOT EVERY ROAD IS ACTUALLY A ROAD, UNDERBODY SENSORS READ AND EVALUATE ROUGH TERRAIN, LIKE GRAVEL ROADS, TRAILS AND SNOW COVERED ROADS.

NAV SYSTEM

NAV SYSTEM COMES WITH 3 SETTINGS: STANDARD GPS, *SCENIC* MODE AND *WANDERLUST* MODE, WHICH CHOOSES A RANDOM ROUTE & DESTINATION, BASED ON USER GENERATED SUGGESTIONS.

WHAT IMPACT WILL AUTONOMY HAVE ON OUR CITIES?

Topic: City and Society

22 minute read

Tom Harle
Strategy Principal

ustwo **LDN**

SUMMARY

From interstate highways and congested city centers, the 'big plans' of our past have left us with noisy, dirty, dangerous places to live – further away from the things that matter to us most. That is the landscape into which we must consider the future of cars and of autonomy.

In this section, we argue that with the introduction of autonomy into our cities, we have an opportunity to approach things differently. We need to stay away from large scale, clumsy planning. We need to use human needs, wants and behaviours as a starting point to create sustainable change. And this means starting with small, but scalable, plans.

INTRODUCTION

"Forget the damned motor car, and build the cities for lovers and friends."

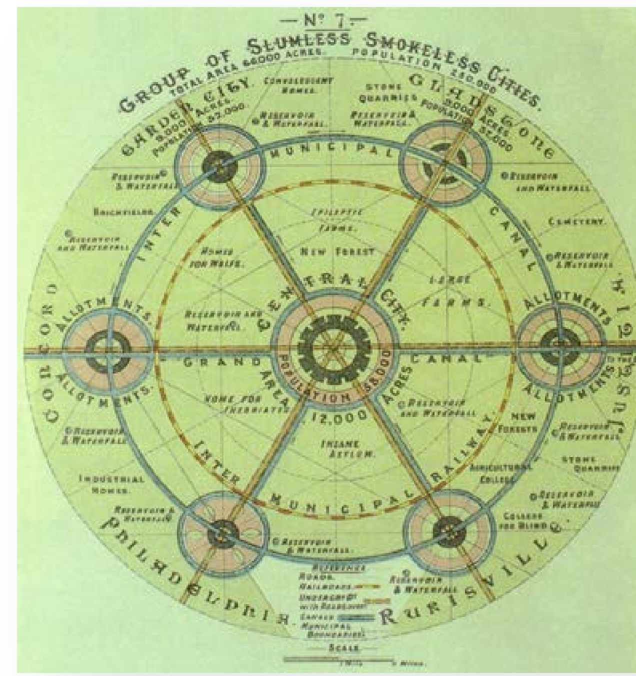
Lewis Mumford, 1979

Few could argue that the motor vehicle defined the 20th century. Sprawling metropolises, mass distribution, long-distance personal travel, and so-called "big box" retail, all developed from the increasing ease of movement afforded by cars, trucks and buses.

The story of the car's, or the internal combustion engine's role in economic development – both at personal and societal levels – is too rich to tell in just one chapter. But as this book examines the future of mobility from the perspective of autonomy, and as this chapter seeks to evaluate autonomy's impact on "city and society", it is worth noting a few significant moments in history, so that we can examine what changes may take place over the coming years.

We think that the story of cars and trucks is specifically different to that of other transport modes. For example, during the industrial revolution, trains (and canals before them) changed much of the world and their effects are still being felt today. Canal and rail travel has evolved, and both still enable the transport of goods and people on increasingly unprecedented scales. But fundamentally, despite changes in size and propulsion, these planned networks have continued to function in much the same way since they were first imagined. They took years to conceive and build, and they contribute to systems that were planned based on perceived economic need.

Even in the first half of the 20th century, cars were challenging this model. In the UK, metropolitan railway had helped suburban "garden cities" flourish, but the drastic contraction of more rural railways was challenging the economic viability of smaller towns and villages. Long before the mass construction of motorways (freeways), cars and trucks were filling the gaps left by the removal of slower, less direct and less reliable trains.



Garden City Concept

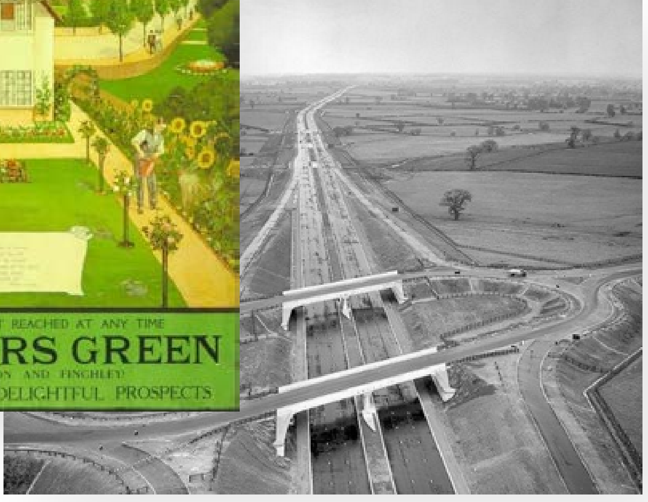


Image courtesy Orange County Archive

Golders Green poster 1908

The M1 just before it opened in 1959

Unlike trains and canals, the autonomy (on a personal level) afforded by cars has meant that there hasn't always needed to be a planned system in place before the benefits could be realised. When people wanted to go somewhere, for the most part, they could drive there. Ages-old infrastructure for walking and for horses was easy to use and upgrade for cars. But people didn't just use their cars to make up the emerging shortfalls in the rail network. Crucially, the majority of people chose to stay in their cars, rather than adopt a "mixed mode" approach where they may have driven to a railway or bus hub, to continue their journey through public transport.

So by the 1960s, major infrastructure for these increasingly popular motor vehicles was the talk of politicians and town planners across the world, with huge schemes such as US President Eisenhower's Interstate system, the Parisian Périphérique, and London's Ringways being inspired by the efforts of Germany and Italy in previous decades.

Today, these freeways have come to define not just our built environment, but enable whole new ways to work and live. Where public attractions and holiday destinations used to cluster around railways, now shopping malls, cinemas, stadiums and theme parks are within easy reach of a freeway intersection. Downtown industrial zones alongside railways have been replaced by out-of-town office and business parks. And parking spaces for all of those visiting cars have pushed the places we want to go further apart from each other, necessitating more, and bigger roads and intersections, and more time in our cars.

The trucks that can travel on our freeways have enabled us to enjoy lower prices at discount supermarkets, by bringing larger quantities in from further afield. And our inner cities have become cleaner without the smoke of industry, as factories relocate globally, and the products can still be transported back to us efficiently by ship and truck.

In the internet age, swarms of vans bypass the need even for the supermarkets, as products can be shipped individually from warehouses straight to our houses and workplaces, giving us even lower prices. In many ways, the pioneering, freeway-laden vision of the post-war planners has enabled our modern, convenient lifestyle.

But not all of those schemes from the 1960s were built. In Manhattan, whole neighbourhoods were saved from demolition, when a protest movement fought for "little plans" [1] that focused on social hubs and diverse local community needs. They opposed the grand plans being drawn up for highways through Greenwich Village and along the East River. In arguing against grand, single-use boulevards, Jane Jacobs presented a case for the diverse neighbourhood street scene, with people out on the pavements visiting a whole range of local businesses. She called for a preservation of "strips of chaos that have a weird wisdom of their own" [2]. These strips, she said, would be anathema to the big plans being put before her community. These big plans were inherently boring "because of the fact that big plans are the product of too few minds".

"Big plans, in theory, are justified as being gifts to the future. Planning is foresight; the future is what it is all about. Yet big plans, in which everything has been foreseen as far as possible, stifle alternative possibilities and new departures. To plan for the future, and at the same time stifle fresh possibilities, is a contradiction in terms." [3]

Jane Jacobs

Jane Jacobs

While Jane Jacobs campaigned in Manhattan, a similar story was unfolding in London, where eventually only a few parts of the planned Ringways were realised. Some of London's best-known neighbourhoods are very lucky to still exist, thanks to the efforts of protest groups, who successfully brought the plight of residents under the new A40 Westway flyover to national attention. Similar schemes around London were soon paused and later cancelled, as public resistance and costs escalated[4].

In Paris, the Périphérique has also been blamed for strangling the city's economic and social development[5], effectively creating a stifling and isolating concrete belt between the core administrative area and the neighbouring towns and suburbs.

So, we've developed a complex relationship with cars. As soon as their benefits began to be felt, we started to push back. In the UK, in 2016, 252.6 billion miles were travelled in cars and taxis, up from 38.6 billion miles when the first stretch of the M1 motorway was opened in 1959[6] and the national economy has, for the most part, flourished and diversified, as people have been able to work further from home, and to sell their wares even further afield.

Indeed, before the world wide web, the car allowed personal freedom in work, study, leisure and living more than any other technology (and maybe it's done more besides). Many of the economic and political gains of the past century could probably be linked to the rise of the automobile.

And it's not fair to suggest that roads were entirely scaled back after initial growth in the 1950s and 1960s. In fact, it's more accurate to say that despite numerous and vociferous protests, highways have become ubiquitous in most developed countries. But the efforts of later campaigners like "Swampy" at the UK's Newbury bypass project in 1996 did start to have an impact; newer road plans have found it increasingly hard to gain approval. In an increasing number of cases, roads are even being scaled back or reconfigured to enable local communities more opportunity to flourish[7].

Image courtesy Pratt Centre
Community-generated proposal to unlock space taken up by the Sheridan Expressway in The Bronx, with riverfront parks, affordable housing and commercial space

It's become difficult to argue against the evidence for "induced demand"; that new roads bring more traffic, not less. Rather than easing congestion, people who previously avoided the area start to use the new road alongside everyone else. And it's becoming harder to make a case for new roads on the basis of new jobs or businesses as well. In fact, a study of a highway "de-elevation" scheme in San Francisco showed that downgrading the road and integrating it better with surrounding businesses and residents actually increased economic activity, revitalising local jobs while also reducing the amount of traffic[8].

In London, the vast high-speed roundabouts at the Elephant and Castle area, built in 1959 for a future "where the car would be king" [9], have been made into more manageable two-way streets and junctions, with space for cyclists and pedestrians. It has calmed traffic and created space for new small businesses and public art, as well as opening up the beautiful Faraday memorial sculpture for the first time (it was previously inaccessible in the middle of the roundabout).

In the Bronx, just north of Manhattan, one 1950s freeway scheme that did go ahead is being downgraded to a pedestrian-first boulevard, re-linking the local community to waterside parklands that have been cut off, just like in Paris, for over 60 years[10].

And apart from the isolation of communities and spaces, there have been other notable downsides in the face of this democratisation and decentralisation. The World Health Organization estimates that around 1.3 million people are killed every year as a result of road traffic accidents. Nearly half of those killed aren't in cars – they've been sharing the road space, or walking alongside. They're classed as "vulnerable road users" – pedestrians, cyclists, or motorcyclists. Millions of people have died just trying to get where they wanted to go, because of cars[11].

And while our cities may be clearer of industrial pollution, a study at King's College London found that in 2010, as many as 9,500 early deaths in the city could be attributed to airborne particles and nitrogen dioxide, largely a by-product of diesel engines[12].

Diesel engines which have enjoyed preferential treatment (in tax and fuel subsidies) by successive UK governments, until recent scandals at auto manufacturers wiped billions of dollars from share values, consumer confidence and future revenue plans. What was once a trust in efficient design has become an existential misalignment between our hopes and dreams as drivers, and the now more unavoidable truth of what we probably knew all along: cars, as we currently know them, kill.

Although the vast freeway networks aren't quite as vast as they may have been, subtler effects still proliferate. The big plans of our past have left us with noisy, dirty, dangerous places to live – further away from the things that matter to us most. That is the landscape into which we must consider the future of cars and of autonomy. Despite the many negatives, we are largely where we wanted to be as a society, and cars have taken us there. Where do we want to go next?

CITY AND SOCIETY: THE OPPORTUNITY

At ustwo, our mission is to deliver products and services that make a meaningful difference. Often that involves working with our clients to figure out what “next” should look like for them, as well as being ready for what the landscape will look like after “next”. As we describe in Prototyping and User Testing, in-depth qualitative research is one way to gain the insight needed to be able to guide these discussions and product stories.

One of the most rewarding parts of user research is discovering complicated behaviours and workarounds that people have developed for themselves, to solve problems that look, to the outside observer (or product designer) like they could be eminently solvable with a much simpler solution.

For example, on our GoPark project with Ford, it was estimated that 30% of London traffic could have been caused by people looking for parking spaces. When we travelled with people as they parked, we observed complex rituals of slow driving, craning necks, un-jargoning of parking signs, pulling in, pulling out again, and scrambles for coins, all before a successful “park” could be completed. When you list the steps we all go through just to park, you understand why it can feel so stressful.

What other workarounds do we accept in our daily mobility? What's the mental load we take on, unquestioningly? For Londoners, travelling to a town whose transport network lacks a single, seamless payment solution like TFL's Oyster card certainly seems like a step back in time to the Dark Ages. But even the Oyster card has turned out to be a transitory step towards an even simpler solution using contactless cards, phones and watches.

So when thinking about autonomy, part of the story will undoubtedly come from a deep understanding of where we are now as a society, and the way we solve the problems we perceive.

THE SILENT MACHINE

Apart from the challenges of road safety and air pollution, society is asking other questions. How can everyone have an affordable and healthy home? How can we plan for a dignified later life? How can we better integrate our communities? How can we encourage sustainable business growth? How can we present ourselves best to the rest of the world? How can we give the generations of tomorrow their best opportunities?

The answer to most of those questions starts with access. If people can access services, they can benefit from them. We can leave the design of the services themselves for another day. But in an urban environment, when we think about access we often use words like mobility – not just in terms of how people move around a space, but also the social mobility granted through access to education, culture and employment.

Cities themselves are mobility systems, giant machines to serve the needs of the people who live and work in them. They whirr and clackle along with trains, subways, buses, boats and trams, and more private taxis, motorbikes and personal cars. Around the machine people walk and cycle, inserting themselves into the flow like ants, checking every space for the best way through.

Even though the car has enabled us to travel across most of the globe on four wheels, if we wanted to, one has to wonder: why did we put everything so far apart in the first place? With physically closer communities, we could create microcosms of society that would each foster a core set of businesses to serve their needs, as Jane Jacobs saw threatened in downtown New York. Because we don't have the time or money or political will to come together and envision a better public network, we've created a self-fulfilling ideology that we need more private cars to go to more places, which are further and further away. We only walk for the "last mile", we can't cycle as much as we'd like to.

We're dreamers at ustwo, and we're excited that the conversation about autonomy has also turned out to be a conversation about energy. To curb our air and noise pollution problems, we need quieter, zero-emission vehicles to replace the internal combustion engine. There is a young love affair brewing: a flirtation between between cars powered completely by electricity, which seem to be finally growing up, and the "new on the scene" autonomy technologies. Love isn't easy, but we hope this will blossom into a happy and successful marriage.

As we move through this chapter, let's dream that in the background there is a culture of micro-generation of energy, engaging individuals and communities to proactively monitor and respond to their energy usage. And that on a UK-wide level, we've had the difficult discussions about our energy mix and created a distributed grid of tidal, wind and solar, supported by batteries and smart meters. If we're going to challenge 120 years of automotive evolution, we may as well do the same with energy.

When the "cycle superhighways" were first hastily introduced in London, the blue paint that started to snake around london was seen as sloppy design and was often unsafe, giving neither cyclist or motor vehicle the space that they needed to co-exist[13]. Seven years on, more permanent construction projects have followed, and parts of the city have been completely transformed. Where once noisy four-lane carriageways "flowed", with pedestrians and cyclists choking on the edges, now peaceful, equally assigned spaces allow pedestrians, cyclists and vehicles to move together at a more human scale.

In an autonomous future, every pavement could in effect be a subway platform, with vehicles darting between locations to take their passengers from point to point, before setting off to pick up the next person.

The nightmare in this scenario would be an extension of the "Prius pack" we see outside nightclubs and other events, where drivers jostle for space while they wait for their clients. But just as the cycle superhighways have transformed the urban realm in London, we should see the arrival of shared vehicles as an opportunity.

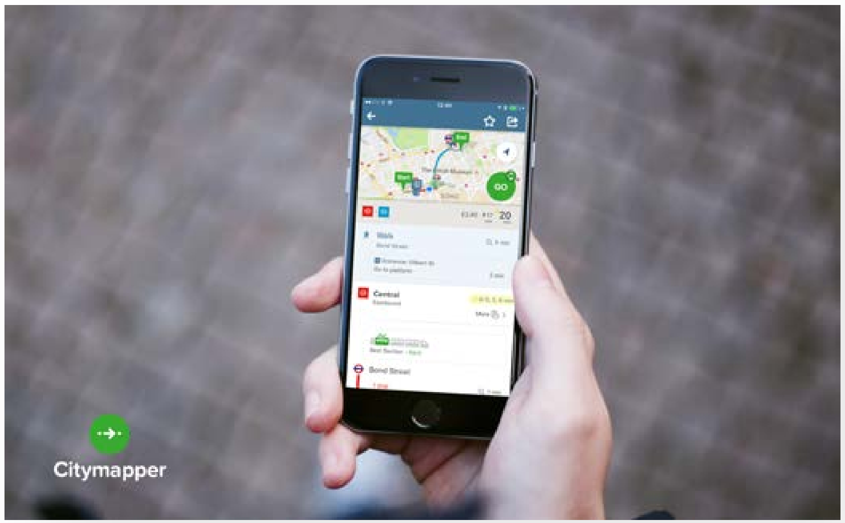
First, let's reclaim the parking spaces that will be surplus to requirements, and give more space back to nature, or to local businesses who want to open out onto the street. Every day could be market day, as self-regulating AV "pods" move smoothly through defined lanes.

Secondly, human drivers who are still on the roads should find their streets less daunting as well. Assistive technologies will help their vehicles follow the speed of surrounding autonomous vehicles. Road markings, signage and junctions will need to be made clearer to help our robot friends to understand, but actually this simplification would help us all. As we've found with most technology at ustwo, making a space more inclusive for one user group actually opens it up and improves it for everyone.

We worry about later life because we've isolated our elderly, and made it difficult for them to independently get where they need to go. Things are so far away that the costs are prohibitive. We worry about housing, because despite the decentralisation the car has allowed, property prices in cities are far higher than those in surrounding areas. Village businesses struggle to attract customers to their noisy shopfronts on narrow pavements, as people thunder by on their way to a supermarket. All of these problems could be alleviated with safe and regulated shared transportation.

City streets will be quieter and calmer. Pavement conversations will no longer be interrupted by revving engines and noisy gear changes. The constant drone that people have learned to block out will give way to a lighter wave-like sound of tyres and asphalt, as autonomous "pods" cruise by at a more constant speed. The streets will proclaim: "We're not just for drivers any more; come and enjoy us!"

A 100-year reboot of Fritz Lang's *Metropolis* would hopefully show us proles not trudging through dark tunnels of smoke and pistons, but free to move at surface level to wherever we need to be that day. Instead of standing and sweating in cramped spaces, we'll read, socialise and meditate. The planned machine-system of the 20th century will finally give way to a calmly spontaneous, openly inclusive urban realm.



Citymapper app

CHALLENGING OUR MENTAL MAPS

In most European cities (and European-style cities elsewhere) there are distinct regions and neighbourhoods. There's the plucky neighbourhood on the edge of the centre where young artists and entrepreneurs set up and interact. There's the downtown business district where packaged sandwiches and news stands litter the pavements. There are the inner suburbs where tree-lined streets branch off busy ribbon roads and roaring buses pull out from between parked cars. Further still, wider roads and roundabouts divide up playing fields and low-lying estates. There are countless other typologies as well: the identikit suburban high-street, the out-of-town strip mall, the leafy commuter suburb.

Depending on who we are, or who we hope to be, a lot of our identity comes from where in this mix of neighbourhood personalities we choose to spend our time. In this final segment we'll ask whether these ideas of city and space are still helpful as autonomous transportation emerges.

When we think about what we love about an app like Citymapper, it's often difficult to see past the magic we felt when we first used it. In a way, all the hard work that goes on behind the scenes, to plumb all the the data together, to map station platforms and entrances, and to calculate walking and changeover times, is superseded by the sheer joy of seeing options you'd never before considered, neatly laid out and rationalised to help you choose. And it's in real-time! It solves the mental challenge we used to give ourselves every time we considered starting a journey in unfamiliar circumstances.

Essentially, it's become the go-to partner for residents in any city it's available. When it launched in London, Time Out proclaimed: "It's so slick, oil is jealous!" [14]

It's not much of a leap of the imagination for a Citymapper release of the future where autonomous ride-hail services are at the top of the list. Why walk all the way to the subway, when a ride could be summoned right to your feet? With companies like Uber and Lyft already (very) publicly testing autonomous software, it's probably a leap they're betting on as well.

There is an understandable worry about the potential rise in unemployment that this could bring. Not just for Uber drivers, but anyone whose employment relates to driving. "Increasingly capable systems", as Susskind and Susskind put it in their book *The Future of the Professions: How Technology Will Transform the Work of Human Experts*, will render the work of whole professions largely obsolete – first by standardising the craft, then systemising it, therefore enabling it to be opened up more widely and cheaply, and without the need for the individual craftsperson in the first place.

Manual skills like driving could be the next crafts to be standardised and systemised. Much of driving already is: we have highway codes, white lines, road signs and traffic lights, and laws that govern how people should behave in different situations. As soon as a system can be shown to safely operate normally within those parameters, and to also have a safe way of dealing with extreme and unpredicted events, the role of human drivers will be mostly negated.

Through the 20th century, the idea of local employment, a job for life, and the village high street crumbled. People found they could move more freely and further in search of better career options or cheaper goods. And as they could, they increasingly had to, as the stores and industries they left behind became less viable. In the 21st century, the jobs of moving those people and goods around are also under threat. So what can we do?

Perhaps we need to rethink how we see our towns and cities. An app like Citymapper is great for taking us to the places we think we want to be, and planning the steps we need to take to get there. But if all of our street environments became more pleasant spaces to be, why should we be constrained by traditional transport infrastructure – couldn't every place become a nice place to be and therefore couldn't we go anywhere?

We see shared and driverless vehicles as vehicles for change in the places we live and work. Around major cities, our public transport infrastructure tends to point into the middle. But if public transport could go anywhere, we could herald a renaissance in the suburban and rural high street. Forgotten neighbourhoods, whose disenfranchised residents have to move themselves great distances to access the services they need today, could find themselves easily plugged into a whole network tomorrow. And the support could come to them, too.

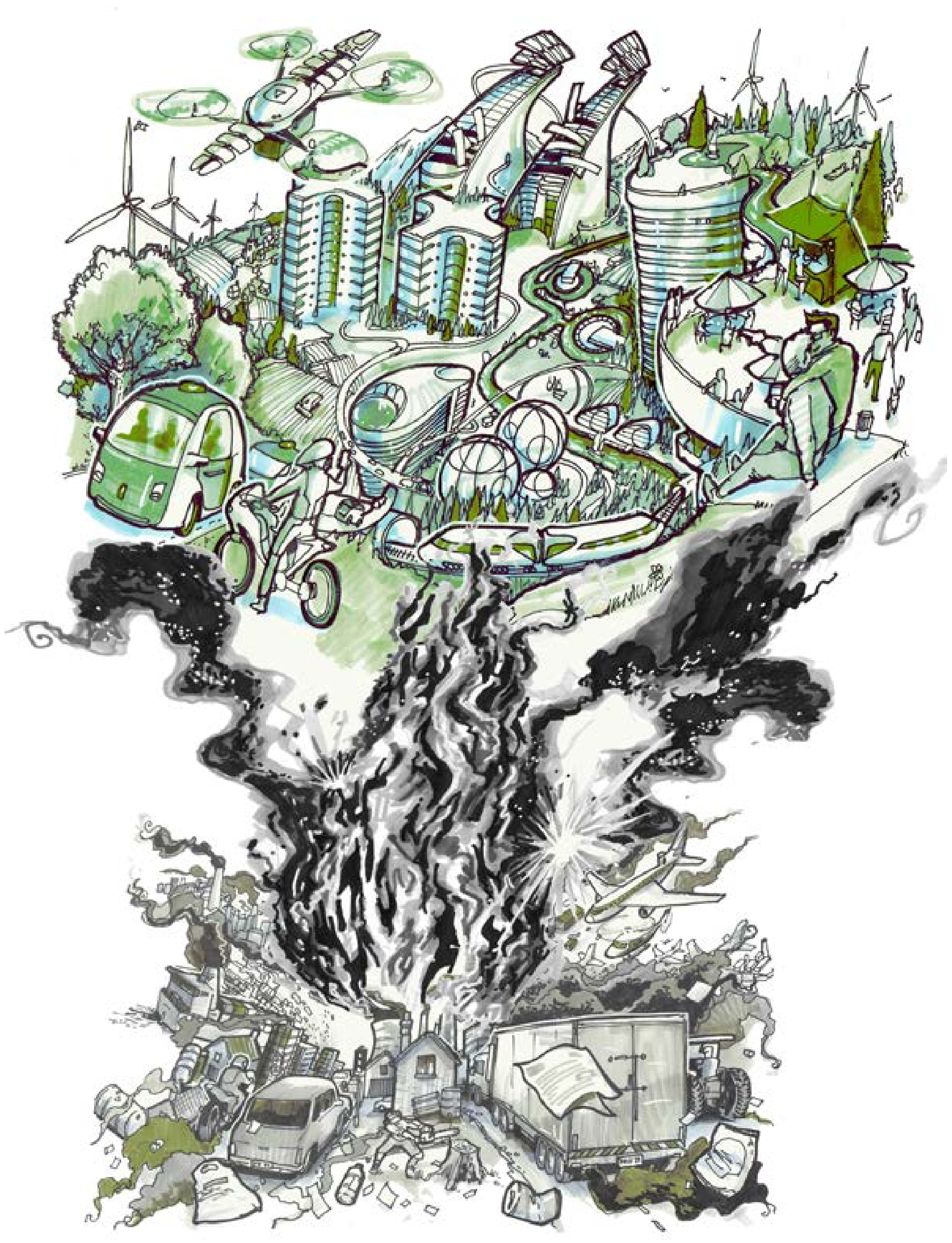
How could this unfold, practically? When autonomy heralds so many changes, how might we help people challenge their own ideas of what a place is, and what it could be? We thought about whether a smartphone application was a good first touchpoint, and it probably isn't. After all, we may not even still be glued to our smartphones by the time these possibilities emerge. And putting everything on a tiny screen is, well, boring.

Nevertheless, "the smartphone app" is a great space in which to construct the idea of a challenger to the utility and directness of an app like Citymapper. On our "Adventures" floor, where new startups have space to grow and imagine, Sally coined the term "Shittymapper" – essentially, it could be an app that takes you to places you didn't think you wanted to go.

What if, instead of selecting a destination, a person could select a task:

- "Today I want to meet friends and discover somewhere new," or "Today I need an inspiring meeting space for five, with wifi and great snacks."
- "Today I need milk, eggs and fabric softener."

Today we'd use our own mental models to decide the best way to solve those needs – but Citymapper has shown us the power of doing the hard work on behalf of the user. If, as well as showing the solution, we could take them there autonomously as well, there's evidence to suggest that this would catch on pretty quickly. It's the real-time-and-place Amazon for our suburban environment, the Uber, for, well, Uber.



In the first instance we may ask "but where will people go?", because the vacuum of talent and space that our cities have created in the spaces around them will be difficult to fill quickly. But it's a chicken that will create the demand for more eggs.

Our suburban and rural spaces will behave like phoenixes, rising from the ashes of an age where cars promised to take us to better places but destroyed everything on the way. In *Harry Potter*, students are asked: "Which came first, the phoenix or the flame?" The answer is: "The circle has no beginning."

And if it has no beginning, then it's surely already circling. We must stop focusing on big plans, and use the understanding we have today of human needs, wants and behaviours to get started. Let's make little plans. Our jobs, as dreamers and doers, town councils, business leaders, and simply as people, is to imagine what we can do now to realise this future. ◆

City Phoenix
Duncan Hill

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yapyap car
by Kristina Gordon *ustwo*
Year: anytime

“Relaxing in soft moss and watching the clouds float by.”

HOW CAN WE DESIGN AUTONOMY FOR ALL?

Topic: Inclusivity and Wellbeing

48 minute read

"WHAT I MISS THE MOST FROM DRIVING IS, AS I SAID BEFORE, MY INDEPENDENCE. DESPITE MY AGE I'M STILL FULL WITH ENERGY AND WANT TO DO THINGS, BUT NOW I NEED TO DEPEND ON SOMEONE... I NO LONGER HAVE THE INDEPENDENCE OF GOING WHEREVER I WANT TO GO, AT MY OWN TIME. YOU KNOW, I STILL HAVE STUFF TO DO, THINGS TO SOLVE, AND I STILL HAVE A SOCIAL LIFE, I WANT TO GO OUT AND DO MY THINGS. SO MY BIGGEST PROBLEM NOW IS DEPENDING ON SOMEBODY TO DO THOSE THINGS."

Socorro, ustwo study participant

SUMMARY

Accessibility design in systems such as in transport is still generally an afterthought. There's an inclination to retrofit features to improve accessibility, but this contributes to the segregation of the disabled from the able-bodied.

We fervently believe that automated systems – and autonomous vehicles – should be designed from the ground up to be fully inclusive. By looking at the full spectrum of disability, age, and gender, we can actually see the world and its problems through fresh eyes. We can see beyond the skills and activities we take for granted – and beyond our own biases.

INTRODUCTION

We live in an extraordinarily normalised world. We work, play and sleep using products or services that cater either to the "mean" or to a human being belonging within the 95th percentile of the population. Business economics mean that it's prudent to design tables and chairs to fit the average height and leg length of the people living in the area. Our laptops and phones are designed to the mean sizes of people's palms and their viewing angles. The seats in our cars, and the size of the steering wheel and doors are designed to fit the majority of the population where the vehicle is sold.

In terms of digital design, governmental websites[1] cater to what the average person can read and understand. Manufacturing plants and nuclear research facilities have benefited from the normalisation of controls and switches, making them operable by most trained personnel. Even the blue of Facebook – and Google's brand colours – is supposed to be the colour most people like and associate with "friendliness".

MANY, MOST, UNIFORM

Means, averages, and percentiles were born of a need, an industrial and democratic need. In the age when we moved away from handcrafting to mass production it became vital to understand what "most" people would use – both to reduce production costs and to cater to general comfort of use. Industrial designers and engineers are now taught how to design with ergonomics in mind.

"Ergonomics is a science-based discipline that brings together knowledge from other subjects such as anatomy and physiology, psychology, engineering, and statistics to ensure that designs complement the strengths and abilities of people and minimise the effects of their limitations."[2]

International Ergonomics Association

Great research endeavours began in the 1950s to figure out the full range of human anatomical differences and associated cognitive and functional limits, and how they could be applied within industries and workplaces. This was a massive boon to safety and usability, both for users of ergonomically designed equipment and the impacted masses, like factory and office workers, technicians at research facilities, and even soldiers.

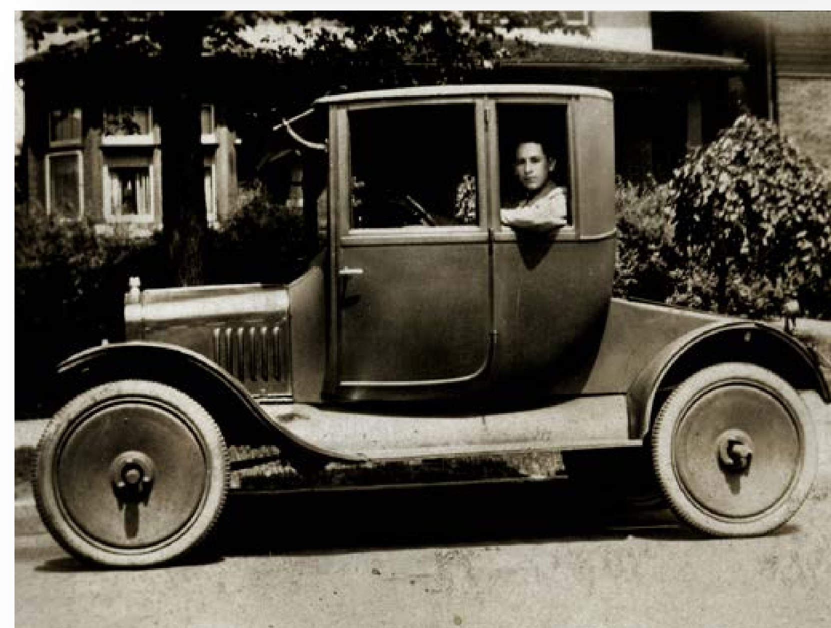
In vehicle design, ergonomics had come a long way since the early days of the Ford Model T[3], which was notoriously difficult to drive. The standardisation of ergonomic criteria – especially safety and comfort – meant that we could come to expect vehicles to meet a minimum standard of operability.

Errors and accidents were thus reduced, while productivity, efficiency, and user health increased across the board. By using a scientific approach to understand human limitations and capacities[4], high quality products and services were produced that could be used safely by many people.

But "many" does not mean "all". With the focus on developing products and services with ergonomics and percentiles in mind, some people were being left out. People with disabilities, elderly people, pregnant mothers, and even children, were being left out of design and manufacturing considerations.

It was only much later on that the movement for introducing "accessibility" and equal opportunities within ergonomic considerations began. Disability discrimination acts were passed internationally in the early 1990s, setting out legal frameworks for buildings, job opportunities, health, and wellbeing for people with disabilities. In the UK, it was as late as 2004 that these standards were enforced in architecture and civil engineering.

Within software design, the World Wide Web Consortium (W3C)[5] released its Web Content Accessibility Guidelines in 1999. This was a milestone in the history of the internet, enabling everyone to benefit from the services the web could provide.



Ford Model T

Ford Model T Coupe

DIGNITY, FREEDOM, MOBILITY AND BIASES

But does "accessibility" mean that discrimination and prejudice are reduced? Does "equal opportunity" take into consideration the mental barriers people have in place when they think about disabilities? Is accessibility just a plaster on a cut, rather than a way to heal the wound?

A potent thought can be found in Building for Equality: Disability and the Built Environment[6] released by UK House of Commons:

"The aspirations that disabled people hold are no different to those of any of us: to work, to spend time with family and friends, and to do the things that we enjoy and that give our lives meaning... Yet disabled people are still finding their lives needlessly restricted."

UK House of Commons

To explain, let us consider the design of buildings and accessibility ramps (a subject we have raised previously). In India, the law[7] states that:

"The appropriate Governments and the local authorities shall, within the limits of their economic capacity and development, provide for:
1. ramps in public buildings
2. adaptation of toilets for wheelchair users."

Indian Ministry of Law and Justice

A good guideline for sure, but does it consider the underlying causes of discrimination – such as perception and labelling? Labelling a toilet as wheelchair-friendly or adding ramps just highlights something designed purely for a specific segment of people. There is also the issue of living with dignity. Labelling is a huge barrier here. What if the design was "inclusive" instead? Inclusive design principles rely on a ground-up approach. By looking at the needs of "all", a better design can be found for the many. And this also provides the opportunity to innovate.

With inclusivity in mind, ramps instead of stairs could become the norm or buildings could be designed with elevators from the get-go, rather than retrofitting wheelchair lifts as an afterthought as described in the People and Autonomous Vehicles (AVs) section.

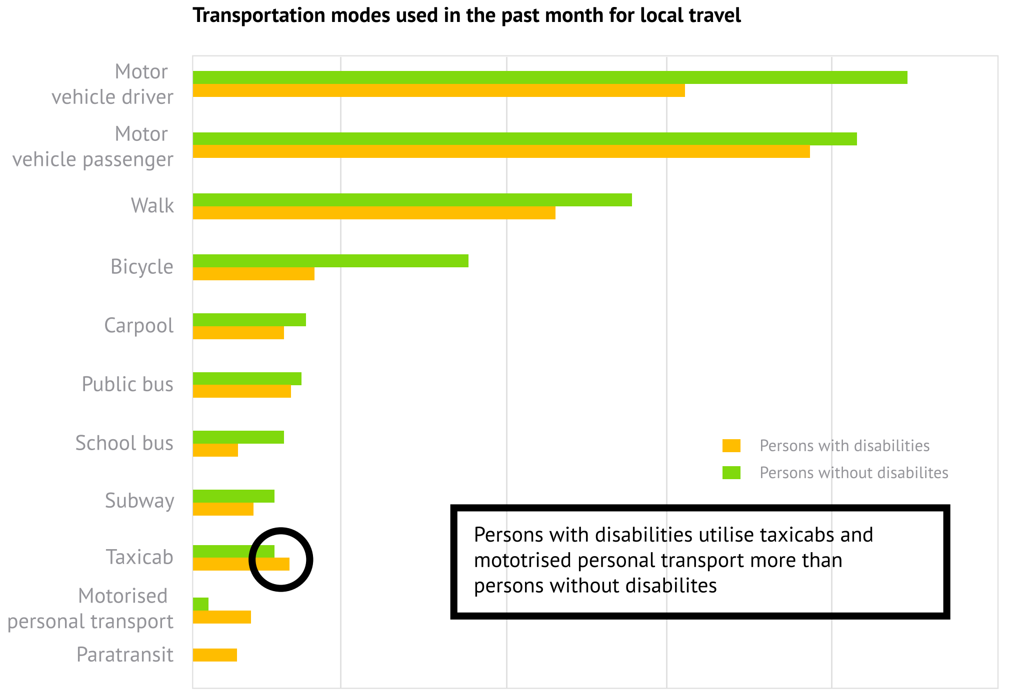
All the toilets could be designed to be friendly to all, without the need for specific labelling. Accessibility and inclusion also applies to transportation design. Accessibility standards in most of the developing and developed world affect public transport systems – both the vehicles themselves and the support infrastructure around them. Some ubiquitous elements include tactile surfaces on the floors and edges of pavement, enabling people to understand where they are in relation to traffic. Others, like in London buses, include the lowering of suspension and extending of a ramp for wheelchair users or parents with buggies to get on board. Transport for London (TfL) even publishes its guidelines for all to see.

But despite these advances, there is still a lack of inclusive design. Why build an extendable ramp, when the bus could be designed to include easy ingress and egress for passengers of all capabilities. There's an inclination to retrofit features to improve accessibility, but this makes people stand out, segregating the disabled from the able-bodied. Accessibility should not be at the cost of dignity.

There is a reason why many of the elderly or vision-impaired people we spoke to use their own vehicles or taxis, in spite of the associated costs and the ready availability of buses. It is about dignity and freedom.

This is also reflected in statistical studies made by US Department of Transportation (USDOT) among others, in which mention is made of taxicabs and motorised personal transportation being used more by people with disabilities than people without[8]. The freedom of movement is a civil and human right without which serious loneliness, economic disparity, and loss in quality of life might result.

Tilting Sink by Gwenole Gasnier and Véronique Huygh
A sink designed for everyone[9]



US DOT, Bureau of Transportation statistics

"GETTING INTO A BUS IS DIFFICULT – FOR ME TO GET INTO THE BUS, THE DRIVER PUTS THE BUS DOWN, I TRY TO PUT CRUTCHES INSIDE AND TRY TO GET IN. IT IS PAINFUL... I PREFER CABS – YOU DO NOT HAVE TO INTERACT WITH DRIVERS A LOT AND THEY ARE ALSO VERY NICE AND HELPFUL. I HAVE A SPECIAL CARD FROM THE COUNCIL."

Darret, ustwo study participant

There is also a huge market for retrofitted vehicles – large cars and minivans. The class of vehicles shown below represent the current best option for wheelchair users, but as you can see, they are not particularly discreet.

Imagine having to deal with a retrofitted vehicle on a daily basis. Imagine going to the shops, to restaurants, to the movies, or even just commuting to work each day. You'll probably need assistance to use the ramp, and it takes time to get into and out of the vehicle. You'll also need a considerable amount of room to manoeuvre and position the vehicle. And that's only if you can afford the vehicle in the first place – this is not a cheap option.

We also see cases where wheelchair users have to fight in court to get priority over child buggies being used in buses. Doug Paulley, a disability campaigner, claimed victory in a bid for wheelchair users to have priority over buggies on buses[10] – something which present UK accessibility rules do not cater to. He was unable to board a bus because the driver could not persuade a mother with a buggy to give up her place in the space designated for buggies and wheelchairs.

"This is important – a significant cultural change."

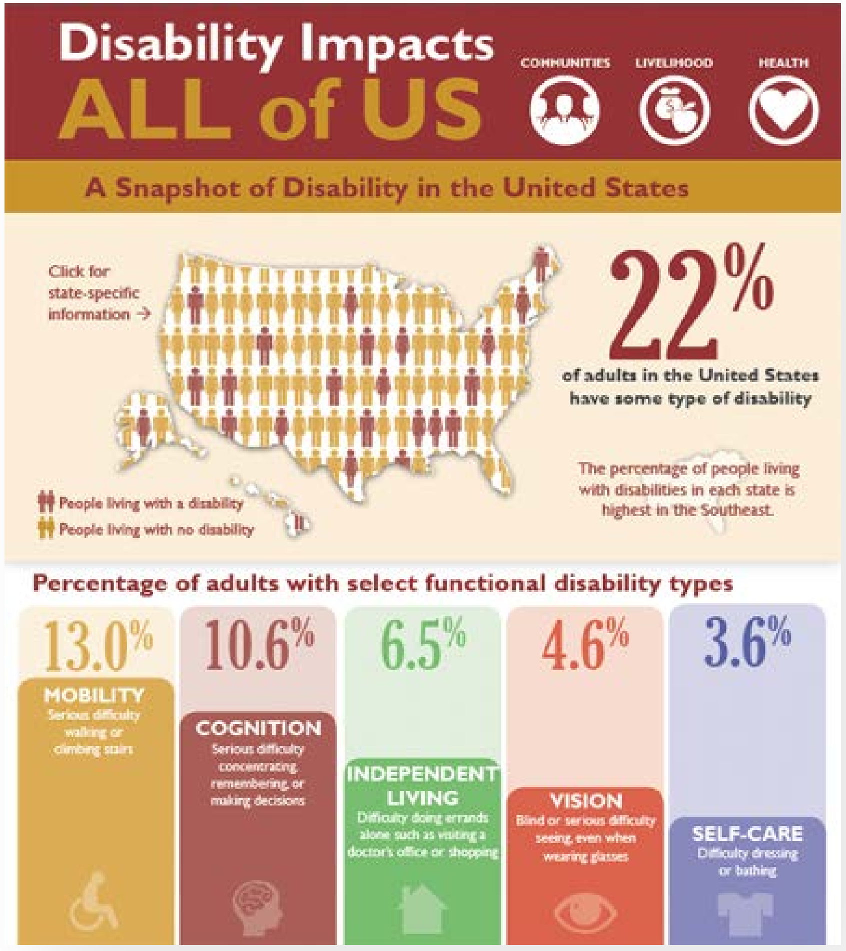
Doug Paulley
Disability Campaigner

The cultural change Paulley speaks about is that of empowerment and dignity, which current accessibility guidelines and general attitudes do not consider. We really need to understand how inclusive design can alleviate this problem – the number of people living on the fringes of society, whether they be disabled, elderly, or otherwise segregated, is not insignificant.

The WHO[11] defines disability as "...an umbrella term, covering impairments, activity limitations, and participation restrictions... Disability is thus not just a health problem. It is a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in which he or she lives. Overcoming the difficulties faced by people with disabilities requires interventions to remove environmental and social barriers."

By this definition it is estimated that one in five people in the US[12] and the UK[13] have some form of disability, with approximately one in ten of the population having mobility issues.

A wheelchair-enabled car[15]



That's more than 50 million people in the US and 10 million in the UK who are disabled. The spectrum of disabilities as defined by the International Classification of Functioning, Disability and Health (ICF) is:

- Mobility and dexterity issues
- Cognitive difficulties
- Sensory impairment
- Mental health issues
- Social difficulties

It is important to note that just a singular disability can have a significant impact on other aspects of a person's life. An example of this is how the inability to be mobile can affect a person's mental health. ustwo study participant Darret suffers from isolation-based depression due to her severe arthritis which impedes her mobility. As a result, she really values her taxi service and mobility scooter which give her back the ability to move around – something which abled-bodied people can easily take for granted.

Similarly, two people with the same type of disability can be affected in very different ways. Some disabilities may be hidden or not easy to see[14].

It's a similar story for age and ageing. More than a 100 million people in the US are over 50 years of age and one fifth of the UK's population is over 65. Mobility is a big – no, huge – issue for this group.

Yet, accessibility design in transport systems is still generally just an afterthought. This is something that needs to be tackled institutionally, both within government and within the manufacturing industry. We fervently believe that automated systems – and autonomous vehicles – can be designed from the ground up to be fully inclusive.

Centers for Disease Control and Prevention

1 in 5

In the UK, more than 12 million people have a disability. 1 in 5 of the population.

33%

Only 1 in 3 disabilities are obvious. Your customers' access needs may not be apparent.

50%

Half of UK will be over 50 by the year 2020. Older age means a greater incidence of disability.

£249 billion

The value of the purple pound is £249 billion, equivalent to the GDP input of the UK financial services sector.

THE OTHER SIDE OF TECHNOLOGICAL NEUTRALITY = TECHNOLOGICAL DIVERSITY

"The future is already here — it's just not very evenly distributed."

William Gibson

There is another aspect to inclusivity which is worth speaking before we move on. It's about inclusion and diversity – considering cultural effects, adoption among communities, and the even spread of technology around the world. It is about allowing people of different ages, genders, and nationalities equal access to technology. What works in Europe, should work in Africa; what works in Korea, should work in India. A grandmother in Mexico City should have similar access to technology as a young man drafting policies in Singapore.

In the increasingly connected world we live in, it is often easy to disappear into echo chambers[16] of thought and online interaction. It's easy to live within the comfort of our own biases and these biases can colour the technology we build and design.

Take voice interfaces, for example. There's a lot of talk about them (pun intended) being the next big platform, even being the primary interface in vehicles[17] (and not just AVs), but there are many cases where the software fails to recognise or make sense of certain accents and languages[18].

What's needed here is extensive training of the speech recognition algorithm with the most diverse sample set possible, in order to pick out variances in language and speech patterns. The less diverse the sample set is, the less inclusive the software will be.

What about cameras? Are they simply objective pieces of hardware or are they also biased by software constraints? Unfortunately, the latter appears to be true, as noted by by researcher and activist Joy Buolamwini, whose "Algorithmic Justice league" fights bias in machine learning and intelligent systems.

Open Inclusion Ltd

In her poignant TED speech[19], she demonstrates how a facial detection algorithm fails to pick up her dark-skinned features, while a human does so easily. This is a phenomenon she has termed the "coded gaze" – a camera bias built by the people who developed the algorithm.

"One way to deal with the challenges of illumination is by training a facial detection system on a set of diverse images with a variety of lighting conditions."

Joy Buolamwini

This highlights the massive mindset change that's required in the technology community. This change needs to bleed into all the sensors and big data processing systems which will be used in autonomous vehicles.

Another issue is that of reach – it is easy for technologies like autonomous vehicles to bypass entire countries, especially where there is little network or internet connectivity. And these are generally countries where driverless cars could make the biggest impact, reducing accidents and increasing safety.

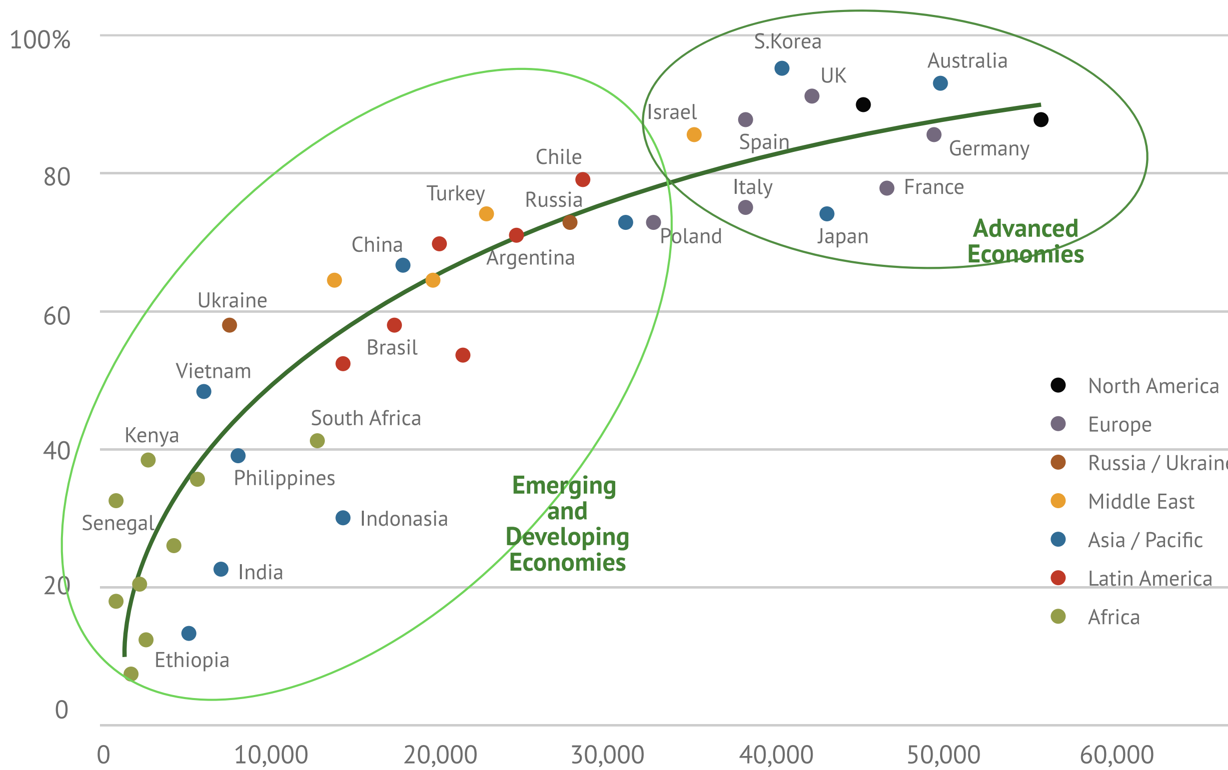
Despite great progress in adoption, the internet is still not evenly distributed across the world. Although at least 60% of people in large developing economies have access, the majority of internet users are found in the wealthier countries.

"As more people come online, we need corporations, governments and civil society to work together to develop better broadband policies, and new business models for equitable access." [20]

Mozilla Foundation

The strong relationship between per capita income and internet access

Adults who use the internet at least occasionally or report owning a smartphone



2015 GDP per capita (PPP, current international $)

Source: Spring 2015 Global attitudes survey, Q70 and Q72. Data for GDP per capita (PPP) from IMF World Economic Outlook database, October

PEW RESEARCH CENTER

The strong relationship between per capita income and internet access[22]
Pew Research Center

One of the first driverless car tests in India, described below, clearly demonstrates the differences in reach and groundwork required to make technology evenly distributed:

"When John's test car, a tiny white Nano hatchback, recently weaved its way through thin Sunday morning traffic in Bangalore at just 25 miles per hour, it still made frequent, jerky stops. As the car pulled up the required four meters short of the vehicle in front, irate drivers honked incessantly and yelled out abuse. A cow meandering into its path triggered another halt, as did the flinging of a massive banana stem out onto the road by a shop owner. As a limbless beggar wheeled his crude platform close, the car's engine stopped abruptly." [21]

Saritha Rai
Bloomberg Technology

We've only spoken of a few examples that highlight the importance of inclusivity and inclusion, but there are many more. We believe that inclusivity and inclusion should form the mindset with which we develop technology and interactions. It is society's moral prerogative – that of its creators, technologists and pioneers – to make sure no one is left behind and everyone is lifted up by its advantages.

This cultural change towards inclusivity and inclusion is severely missing in the automotive industry – most commercial vehicle design is born of a couture or engineering mindset and is also marketed in that way. If you scour the brochures and websites of car manufacturers, you'll notice the significant absence of elderly or disabled people.

Even concept vehicles in major shows like CES are marketed in a similar vein, with the focus on futurism with fantastic angles, sleek design, and slick technological interfaces. Accessibility and inclusivity do not appear to sell, despite the evidence pointing to the huge number of people[23] who might benefit.

But what are the advantages of a change in mindset? Isn't it just more expensive to consider people on the fringes who have varied mobility needs, or design for countries where connectivity is non-existent? Isn't that segment of the market incredibly small? We think there's a massive advantage in tackling technology this way, through a lens of morality, dignity and freedom, and, most importantly, innovation. This mindset can also be applied to the development of autonomous vehicles.

TED speech, she demonstrates how a facial detection algorithm fails to pick up her dark-skinned features, while a human does so easily. This is a phenomenon she has termed the "coded gaze" – a camera bias built by the people who developed the algorithm.

BMW Vision Next 100

Renault Symbioz

Mercedes-Benz F 015

INNOVATION AND ADOPTION AT THE FRINGES – AFFECTING "ALL" WITH TIME

"Mr Watson – come here – I want to see you."

Alexander Graham Bell
March 10th 1876

When Alexander Graham Bell uttered those famous words 150 years ago, the first to be spoken through a telephone, little did he know his innovation would spark a communication revolution. But his attempts to create his "acoustic telegraph" or "vibraphone" were not born out of a desire to help the majority.

Bell, a teacher and educator, worked with the deaf community and was a lifelong proponent for the integration of the hearing impaired into mainstream society. His experiments with electrically transmitted sound, as a way to invent tools for the deaf, ultimately led to the birth of the telephone.

This is a prime case of an innovation for people at the fringes of society going mainstream, and it's not the only one. Protocols for email communication, the keyboard, and even the gramophone were originally intended for use by people living with disabilities (in respective order: a deaf wife, a blind lover, and books for the blind). There is a common thread here. Inclusive design is both a search to solve the needs of the underrepresented and a huge opportunity for innovation. By looking at the full spectrum of disability, age, and gender, we can actually see the world and its problems through fresh eyes. We can see beyond the skills and activities we take for granted – and beyond our own biases.

There is another reason why inclusivity has an advantage – early adoption. Technology allows us to amplify, extend or substitute our abilities and is similarly used by people who need these properties. Apple's iPhone is the smartphone of choice for the vision-impaired due to its high accessibility standards.

Unsurprisingly, blind people are among the early adopters of the voice interface Siri[24]. Voice interfaces allow blind people to carry out many high-level tasks that others might take for granted – setting an alarm, for instance. This has already prompted many of the world's leading technology firms to look to inclusivity for inspiration when creating products for all. Microsoft's inclusivity team[25] is one example, helping create products which range from word processors with extremely high accessibility standards to gaming controls for disabled people.

There are beautiful stories of the motion-sensing Kinect giving people previously unable to play video games the freedom to enjoy them, because there is no physical controller involved.

Alexander Graham Bell with Helen Keller, 1873

“For the first time, I was able to play something with my son and not spend any time with him being frustrated on not being to do anything or have a character get stuck on the screen. He had fun with all the games and actually did well with them. The joy in his eyes as he was able to complete the tasks and move around in the menus is something I’ll never forget.” [26]

John Yan
Senior Hardware Editor at Gaming Nexus
Father of a child with autism

A similar line of thought has been applied to autonomous vehicles, the most famous instance being Google’s driverless car – which is both a commercial exploration and an altruistic attempt to provide the means of mobility for everyone, everywhere. Google’s AV gained tremendous popularity and accolades after technologist Steve Mahan reviewed it, having been one of the first people outside Google’s team to ride in it. Steve is also vision-impaired, having lost his sight at the age of 37.

Inclusive gaming
John Yan, senior hardware editor at Gaming Nexus and father of a child with autism

Waymo
Steve Mahan

Mark Riccobono
National Federation of the Blind president Mark Riccobono preparing to drive the car developed by the organisation's Blind Driver Challenge in 2011

"It is like driving with a very good driver... If you close your eyes when you're riding with somebody, you get a sense of whether this is a good driver or whether they're not. These self-driving cars drive like a very good driver... This is a hope of independence. These cars will change the life prospects of people such as myself. I want very much to become a member of the driving public again."

Steve Mahan

Mahan's optimism is shared by many and similar explorations have been carried out by other manufacturers, such as Ford[27]. Another study carried out by OptimusRide[28], a self-driving technology startup, along with the Perkins School for the Blind in Cambridge, Massachusetts, US, speaks about how the vision-impaired community is taking an active role in shaping technology, and even legislation, which has the power to further their own lives[29].

"Autonomous vehicles will be transformative for people who are blind," says Dave Power, Perkins's president and CEO, "For the first time, they will be able to get to school, work, and community activities independently, regardless of distance. There is tremendous enthusiasm about it, both here and nationally, among the blind."

Dave Power
Perkins's president and CEO

The American Council for the Blind is another organisation which is following the progress of legislation and manufacturing. It is doing so in order to make sure that this technology is incorporated into car design and is working to steer clear of laws that would prohibit the blind from one day sitting in the driver's seat. A noble quest indeed, given the empowering nature of driverless technology.

"Transportation is probably one of the top three barriers that people who are blind face – being able to get anywhere and do it independently... We think that when [autonomous vehicles] are at a point when they can be deployed safely for everyone, there should be a way – there has to be a way – for blind people to use them as well." [30]

Kim Charlson
American Council for the Blind

We have found similar sentiments through our research – especially among elderly people. In the UK, people over 70 years of age have to take a test every three years to certify their ability to drive. This can be a harrowing affair according to the people we spoke to, because of the possibility that they might lose their ability to drive and move around, something they find crucial to their daily lives.

Françoise is at first concerned, but then optimistic when she figures out that a licence might not be necessary for a driverless vehicle. This is something we refer to in our section on a "Rider's Licence". Françoise and Darret might have the freedom to move around with the advent of driverless vehicles. They might be the early adopters of the technology and it is our responsibility to take their needs into consideration when developing autonomous technology. However, they both demonstrate a fear of the technology, something that will need to be addressed if they are to adopt the technology at all. This is especially true given the steady increase in the ageing population around the world[31] – we can even consider that we are developing transport solutions for ourselves given the 15-20 years (or much more) it might take for the proliferation of AV tech to happen.

But the freedom of movement is just one of the many advantages we can offer with driverless vehicles.

SOCIALITY, INDEPENDENCE AND EMPOWERMENT

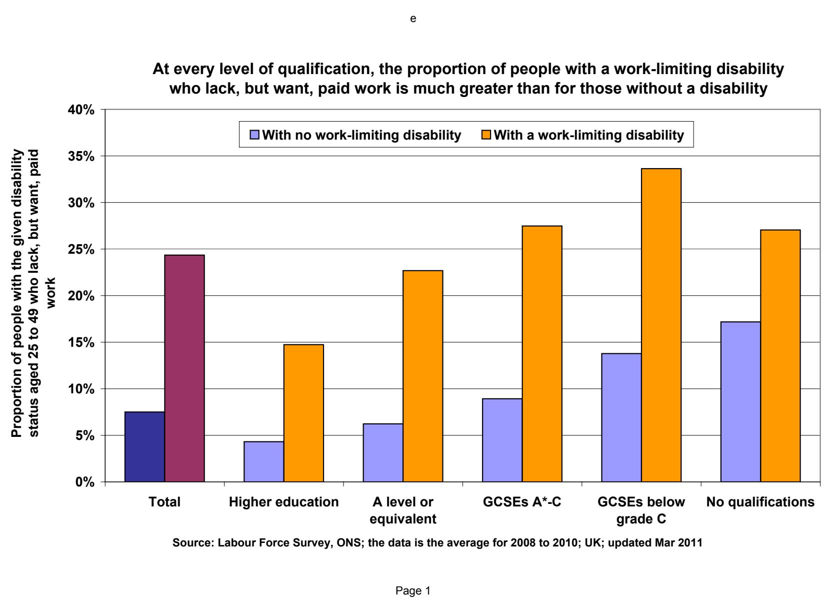
"I WOULD BE TOO ISOLATED, WITHOUT MY CAR."

Françoise, ustwo study participant

Imagine living a life where every one of your movements is an event. Climbing down stairs, walking to the door, going down the driveway, getting into a taxi, getting to a bus stop, getting into the bus, talking to people, looking for help, afraid and frustrated of being judged or being asked questions.

This is what people with disability face according to our research. Being blind makes navigating roads and stations an arduous affair; having a wheelchair or even age-related arthritis severely impacts where you can move – even a simple curb can be defeating. Imagine invisible disabilities like claustrophobia or agoraphobia. It is very difficult for the able bodied to even imagine these difficulties, it takes a special effort.

There are physical and emotional limitations too. The constant stress, fear, frustration and judgement faced by disabled people can inhibit their integration into society and sap their confidence. We heard many stories of isolation-based depression, with medication and behavioural therapy being undertaken by the elderly and vision-impaired. This all impacts their chances of being employed, reduces social wellbeing, and increases the likelihood of depression[32].



Poverty.org

We've uncovered some big transportation problems which can be resolved not just by a product – the driverless car – but also by services around it. For instance, automakers already understand the "last mile problem" of personal or shared transportation. It's the last part of the journey from when you park your vehicle and get to your front door. We see another issue occurring when dealing with the less mobile – "the first mile problem". It is the whole aspect of getting to the vehicle and entering it. Simple tasks like finding a door, how it operates, or even access heights can stymie elderly or vision-impaired users and needs to be sensitively dealt with.

Another case is that of the driver's presence. The current paradigm in taxis with drivers, human beings with whom people can interact or ask for help, might give way to having no driver. There are obvious issues like that of wheelchair access – who will help the person get in? The less obvious issues are mental and emotional. The positive companionship the driver provides which is positive, will be lost, along with the less positive curiosity or nosiness of the driver. It's worth noting that with these challenges also come opportunities. For example, some people with autism prefer not to ride in taxis, as they feel that their behaviour or communication skills are a burden to the driver[33]. People with autism then may opt for a driverless vehicle or "pod" (a single person vehicle) – how can we best serve that need?

The advent of driverless vehicles essentially means the birth of a whole other form of transport, which we believe, if empathetically designed, can have a huge positive impact on the physical and mental mobility of people left out by current modes of transportation.

There is also an economic reason that makes this a relevant goal. By attracting the one in five people who have been left behind to engage with new forms of mobility, in the UK alone there is a potential to unlock nearly £212 billion from UK households with a disabled person[34], known colloquially as the "purple pound". In 2014, the UK Minister for Disabled People, Mark Harper, said:

"We want businesses up and down our high streets to realise they're excluding more than 12 million customers and their families if they fail to cater for disabled people. That's the equivalent to the populations of London, Birmingham, Leeds, Sheffield, Cardiff and Manchester combined... It's not just about fairness, it makes good business sense to be accessible." [35]

Mark Harper
UK Minister for Disabled People

Worldwide the economic case is even bigger, with an estimated market potential of one trillion dollars[36], with 550 billion dollars in the US alone. A staggering potential for future mobility solutions – not counting the millions of potential early adopters.

Going forward, we look at the design of autonomy and the services around them from our point of view, specifically with inclusivity in mind.

INCLUSIVITY AND WELLBEING: THE OPPORTUNITY

Building on our feeling that AVs could drastically alter the transportation industry, we believe that the early adopters will be people who truly "need" the intervention of this technology – people at the fringes due to disability, age or even gender. Looking at the current scope of mobility solutions, it's a fair assumption to think about both mobility services and products aiding people. Let's take on-demand taxi services like Uber and Lyft as an example, which consist of both taxis (the product and service) and the digital touchpoints that enable their use (smartphone apps, backend infrastructure etc). These services have opened up new possibilities for mobility among people with mobility issues or disabilities, allowing them to call upon hundreds of drivers in a city to cater to their needs. A tool which did not exist just a few short years ago.

Let's consider a scenario with an on-demand taxi service five to ten years from now, designed with autonomous vehicles and inclusivity in mind. We can use this scenario as a baseline for a few thought experiments going forward.

THOUGHT EXPERIMENT 1: OUTSIDE-IN AND INSIDE-OUT DESIGN

Is there an advantage to designing an AV with say, vision-impaired people in mind? Or perhaps a person with crutches? We think so – we think constraints can be beautiful and offer an opportunity to innovate.

An approach we like to use when working with constraints is something we call "inside-out and outside-in". For instance, consider the case of designing an AV-sharing service for blind people. The users of this service or product are primarily vision-impaired (inside-out), but as an inclusive system, it will have to work favourably for everyone who uses it, vision-impaired people and those with perfect vision alike (outside-in).

So let's look at the interaction channels available to us. If we considered only the sighted, we could go down a rabbit hole of just using visual channels. For instance, screens or printed material might be considered the primary interaction medium – like signs on buses showing the bus number and signposts stating the locations the bus serves and the timetable. In our on-demand taxi service scenario, the position of the vehicle is signified on a smartphone screen for the user to track and the licence plate to recognise the vehicle itself.

But if one considers this situation from a vision-impaired person's perspective, we have to think outside of the visual box and consider multiple channels of communication. Critically, we need to understand the spectrum of blindness or better yet – gain a visual understanding, from the complete to the situational.

INSIDE-OUT

Firstly, is blindness the complete lack of visual understanding? Not really. In our research we discovered that there is a broad spectrum and many different kinds of visual impairment. There is no singular definition of visual impairment and it can range from low vision to being legally blind. A legally blind person can have a range of impairments with light and movement perception. The percentage of blind people who live in complete darkness is minimal. Some blind people can recognise a lit or dark room and also the change in states. They can also recognise movement of light or have peripheral vision.

The spectrum of users can be considered as:

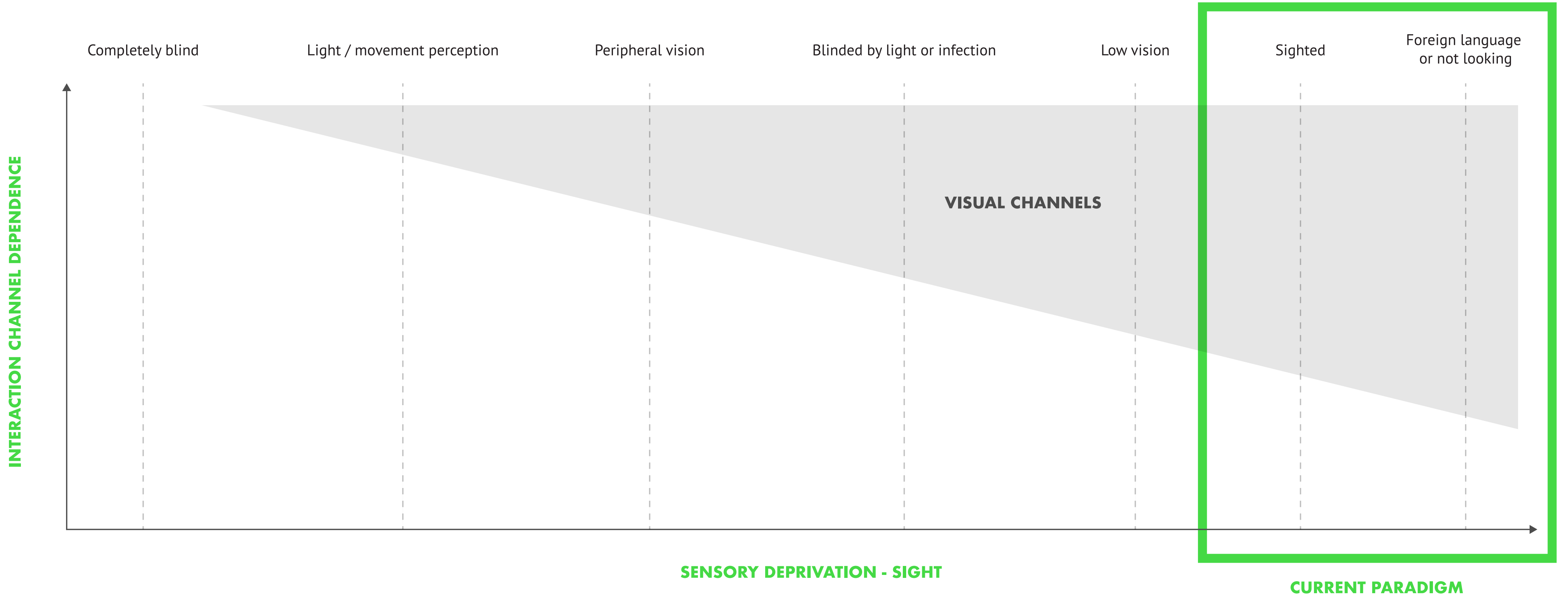
Completely blind > partially sighted > light/movement perception > low vision > sighted

OUTSIDE-IN

We also need to bear in mind that blindness or visual understanding can sometimes be temporary or situational. Someone might be blinded by a strong light, or through loss of correctional glasses, an infection, or just because they're not looking. A case of situational loss of visual understanding can also be because of language – for instance, an English speaker trying to navigate the Tokyo underground. It's a maze of signs in a complex system, many of which are undecipherable to non-Japanese speakers – for all intents and purposes leaving them with a disability of sorts.

So, by thinking some more, we can add a few more points into the spectrum of visual understanding to make it more complete and inclusive:

Completely blind > light/movement perception > peripheral vision > blinded by light or infection > low vision > sighted > foreign Language > not looking


Completely blind
Light / movement perception
Peripheral vision
Blinded by light or infection
Low vision
Sighted
Foreign language or not looking
VISUAL CHANNELS
INTERACTION CHANNEL DEPENDENCE
SENSORY DEPRIVATION - SIGHT
CURRENT PARADIGM

In the current paradigm, without thinking about the spectrum on sensory deprivation, it is easy as designers and technologists to focus on visual channels – often the lowest hanging fruit or primary consideration for design in our visually rich world. If we then consider the myriad interaction channels which can be used to communicate with people of various abilities, you notice that the common channels which might be accessible by all are the auditory channel and in some cases, the haptic channel. The visual channel is thus relegated in priority.

We are then presented with a plethora of options to play with, despite starting with a constraint of "blindness". The pallette of interactions has the capability to be incredibly rich and multisensory.

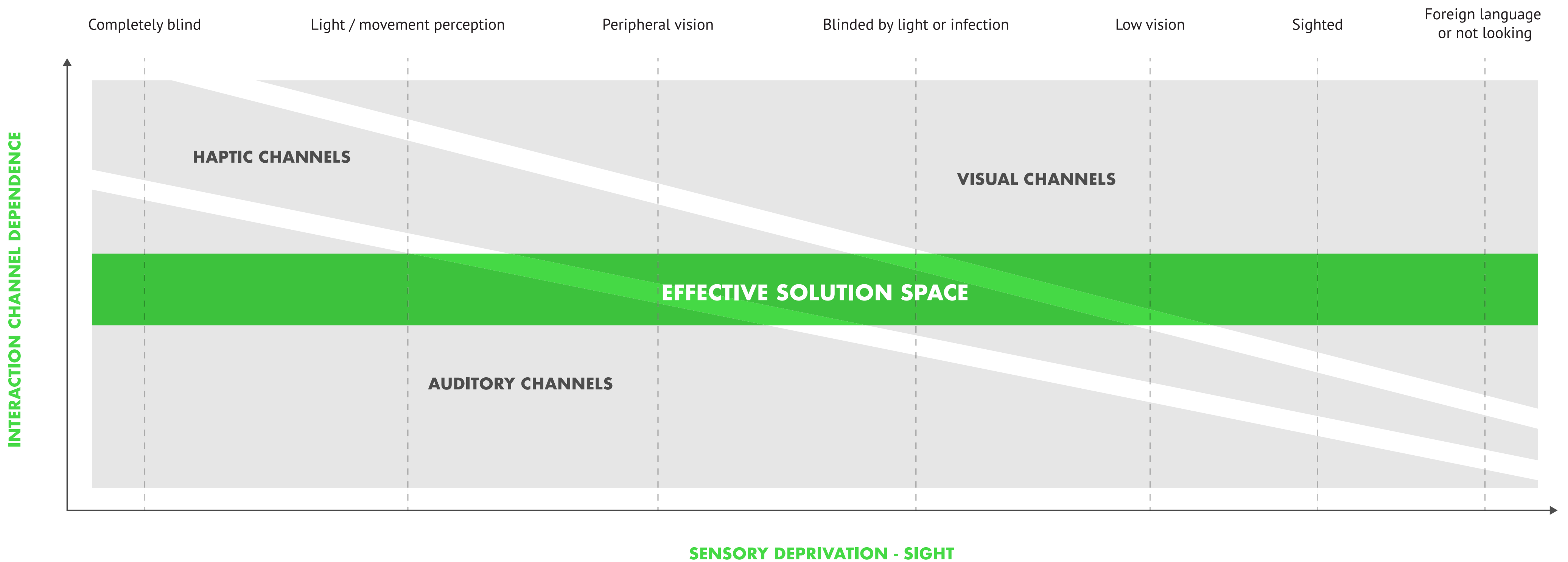
Going back to our example of signage on a bus, thinking about auditory channels could prompt interactions by means of a verbal announcement of the approaching bus at the station, with the locations it is heading to, voiced to the waiting public.

In the case of AVs as an on-demand taxi service, we find the 'first mile' problem rears its head for vision-impaired users too – how do they locate the vehicle on a street? With services like Uber, users rely on a visual medium – a map on a smartphone or the licence plate number. There is a point where the driver does call the prospective passenger, but in our research we find this is not a failsafe.

Thinking with inclusivity in mind, we can, for example, think about turn-by-turn directions for locating the vehicle or perhaps reaching a pre-ordained pickup point. The turn-by-turn directions could be delivered via auditory channels – a smartphone application or even via a phone call. Open and accessible to all.

Thus, the effective solution space for design ideas should traverse the entire spectrum of users and levels of sensory deprivation. Turn-by-turn navigation for example, delivered both by audio and visual means, fits into this space.

But navigation and wayfinding is a difficult technical challenge, given the inaccuracies with GPS pinpointing, making a user's position variable by 5m on average to even 50m around their device. But it is not insurmountable in the near future


Completely blind
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HAPTIC CHANNELS
VISUAL CHANNELS
EFFECTIVE SOLUTION SPACE
AUDITORY CHANNELS
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SENSORY DEPRIVATION - SIGHT

But navigation and wayfinding is a difficult technical challenge, given the inaccuracies with GPS pinpointing, making a user's position variable by 5m on average to even 50m around their device. But it is not insurmountable in the near future

> *"In this lab, with over one thousand participants in one hundred countries, the measured mean accuracy, remarkably, came to 4.9 meters."* [37]
>
> **Frank van Diggelen, Per Enge**

An attempt to make this sort of wayfinding accessible and inclusive is a project – turned open standard – called Wayfindr[38], conceived by Umesh Pandya within an ustwo self-initiated research project and incubated at ustwo in collaboration with the Royal Society for Blind Children (RSBC)[39] and TfL (Transport for London)[40] and funded by Google's innovation fund.

Wayfindr began as an exercise to help vision-impaired people (VI) navigate London's maze-like underground system. In the current paradigm it is quite difficult for blind people to be independent while finding their tube line. They have to rely on their prior knowledge of the area or use TfL's brilliant assistance program, where an employee guides the VI person to their desired location. But that's not very empowering or discreet. In Wayfindr's trials at Pimlico and Euston tube stations, the team installed bluetooth low energy (BLE) beacons at key areas of the station, each triggering a position announcement in the trial user's companion app on their smartphone which triangulates itself based on nearby beacons. The announcement contained carefully crafted audio cues and voice-based directions to the next beacon and the next, finally helping the VI person to their platform or destination.

This was a truly creative application of technology, and gained a lot of acceptance with vision-impaired people, thanks to its discreetness and ability to empower. In fact, the research conducted by Wayfindr into audio-based wayfinding gave rise to their open standard, which has been adopted by the International Telecommunication Union (ITU), the United Nations' specialised agency for information and communication technologies as of 2016.

The beauty of this wayfinding solution is that the principles for navigation go way beyond the vision-impaired community. This can be used equally well for the sighted, new to a certain location, or travellers to a new country who cannot speak the language. It is equally empowering for everyone. A truly "effective solution space".

Wayfindr

THOUGHT EXPERIMENT 2: FUNCTIONAL AND EMOTIONAL EMPATHY

There is an interesting finding in this Wayfindr study, with regards to the perception of safety – undoubtedly of paramount importance to vision-impaired people:

> *"During our trials and in other work by other researchers* **vision impaired people reported that they are willing to walk further provided that the longer route is considered safer and easier to manage**. *For example, instead of crossing a hotel lobby where there are a lot of people waiting with luggage they might prefer to walk all the way round the lobby rather than face obstacles and the potential danger of collision and/or loss of orientation. This makes their journey less stressful and enhances confidence. Thus the shortest or quickest route may not be appropriate for some vision-impaired people."* [41]
>
> **Wayfindr open standard**

THE SAFEST, NOT THE FASTEST OR SHORTEST ROUTE

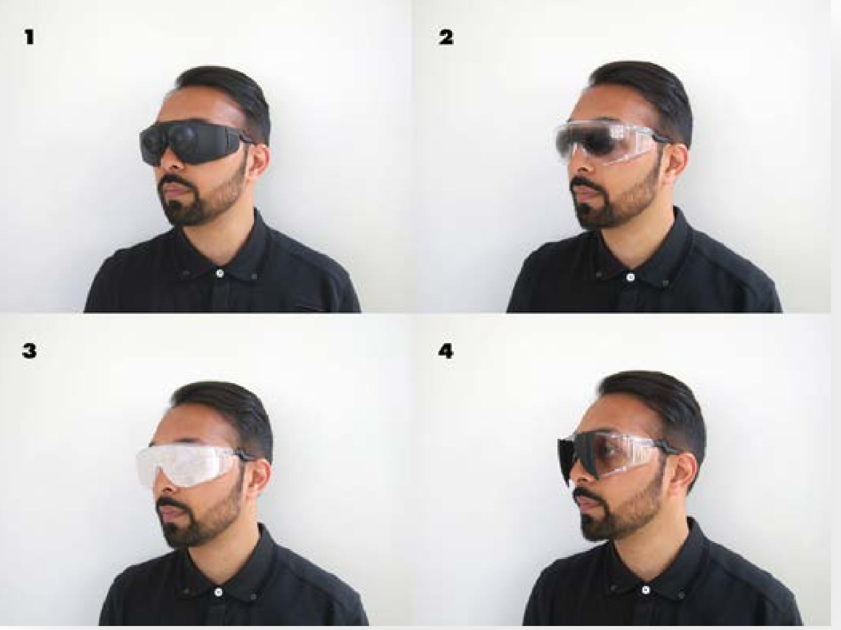
Safety is not primarily a functional consideration, it is also emotional. It overrides the former in this case due to the risk of potential danger. It is an anxiety, and a very human one at that. This is critical when thinking about technological solutions to complex and inclusive transportation issues, like the design of autonomous services and products.

We believe these twin issues of functional and emotional should be tackled together.

So, going back to the spectrum of visual understanding we can look at how design ideas could work from both those perspectives.

In practice, uncovering functional needs can be a case of observing and asking the right questions while spending time with the people you are trying to understand. But understanding emotional needs is a much tougher affair, which relies deeply on empathising with conditions, lives, and circumstances very much different from ourselves.

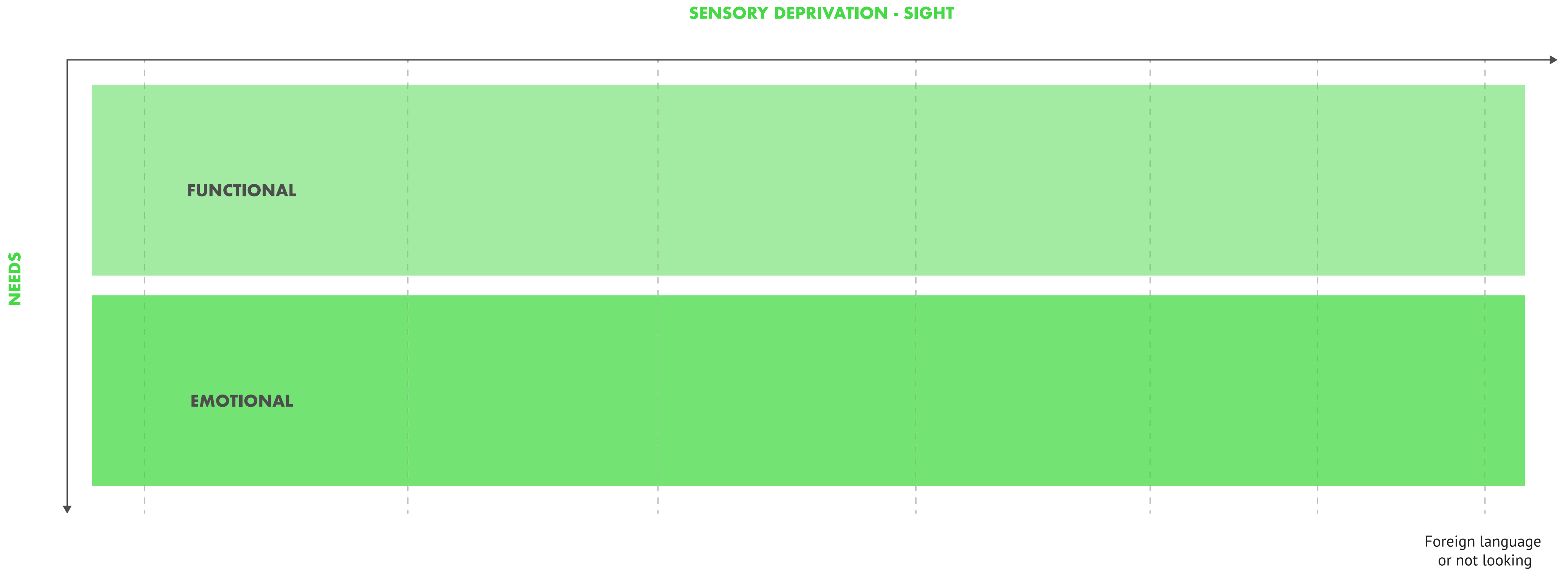
It is about forming bonds, having deep conversations and living a part of their lives as they do. It is about using a wheelchair or a white cane and understanding the anxieties that come from having to navigate a curb. It's about spending time living with deaf or vision-impaired people, seeing the tools they use, trying them out for yourself. There are tools out there that can simulate certain visual deprivation conditions, such as SimSpecs and the low vision simulation kit, which can help you experience a tiny slice of the issues faced by people with vision impairment.



"1: Total loss of peripheral vision (tunnel vision) common in sight conditions such as glaucoma, retinitis pigmentosa, also a possible side effect of stroke or brain injury. 2: Loss of central vision common in congenital sight conditions (such as Leber's hereditary optic neuropathy) and also age-related macular degeneration (very common in older people). 3: Light perception only. 4: Hemianopia (loss of half the visual field in each eye) common after a stroke of brain injury."

Wayfindr open standard

Wayfindr


SENSORY DEPRIVATION - SIGHT
NEEDS
FUNCTIONAL
EMOTIONAL
Foreign language or not looking

Pat Moore as a young designer in her geriatric getup

It is also possible to temporarily experience life as a senior citizen, with tools such as the GERT geriatric simulation suit. The first form of GERT suit was invented by renowned industrial designer and inclusivity specialist, Pat Moore[42]. From 1979 to 1982, while in her 30s, Moore spent quite a bit of time dressed in her elderly disguise, testing different aspects of New York, from shopping to infrastructural and architectural artefacts, to pavements and buildings, gaining considerable insight into inclusive design. She observed how people treated her too, by varying her clothing from that of a wealthy dowager to a bag-lady.

Moore's attempt was both brave and poignant, and opened people's eyes to a set of problems faced only by the ageing populace. Her disguise took four hours to apply, using techniques such as tapeing her fingers and covering them with cotton gloves, to duplicate the effect of arthritis. To simulate deafness, she plugged her ears. To approximate poor eyesight, she applied Vaseline under contact lense. She attached splints to her knees, and even went as far as to use a prosthetic hump for her back.

Since then, there has been a movement to further understanding these issues, leading to the invention of the GERT suit as it exists today in multiple design and research establishments.

"If you can imagine a 25-year-old man wearing this suit, it's funny, but it really gives them the perspective of what it's like to be pregnant and getting into a car."

Katie Allison

Josh Halliday tries out an age simulation suit Designed to help healthcare professionals experience and empathise with conditions associated with elderly people

These techniques have also been employed in the automotive Industry, such as the "empathy belly" [43] used by Katie Allison's ergonomics team at Ford. The suit mimics the physiology of women in the third trimester of pregnancy, and is used by her team for empathy-training new recruits and helps designers create interiors that work for pregnant women[44]. We've used similar techniques, along with many interviews, to inform our research over the last couple of years, which will be brought to light by these thought experiments.

Coming back to our case of the on-demand taxi service five to ten years from now, we found that the prime needs for elderly and vision-impaired passengers concerned **contextual information**, **understanding the technology**, and most importantly the **driver or lack thereof**.

"I LIKE TO COMMUNICATE WITH PEOPLE. SOMETIMES YOU ARE NOT IN THE BEST OF MOODS AND SOMEONE TALKS TO YOU, IT LIFTS YOU UP... WITHOUT PEOPLE I WOULD PANIC."

Darret, ustwo study participant

By contextual information we mean basic questions such as:

- *Where am I?*
- *Am I going the right way?*
- *Where will I need to get off?*
- *How many minutes do I have to be on this thing?*

Whereas an understanding of technology could mean basic questions such as:

- *Is this vehicle safe enough?*
- *Am I doing the right thing?*
- *How do I get the vehicle to stop?*

In terms of the driver, the questions might include:

- *Can I trust him/her to go the right way?*
- *I just need some company – can I speak to him/her?*
- *Will he/she doesn't judge me?*

When posed by young sighted people, these basic questions can be resolved through visual channels – an app, a screen, a sign. But they can leave other people paralysed when visual stimulus is missing or technology is opaque and difficult to understand. To cater to these people as well, we need inclusivity.

Take, for example, interactions in the auditory channel – the common denominator for most people. As described earlier, **speech or voice interfaces** are making major headway into becoming the primary form of interactions within the in-car space. The advantage speech has is in the breadth of information it can deliver, information that is both functional and emotional. This twin benefit can squarely target the needs originating from not having a driver in an AV. Present day taxi drivers act as both authority and sympathetic figures. As authority figures, they hold domain over the route, type of ride, cleanliness, and keep an eye out for anti-social behaviour. As sympathetic figures, they gauge the emotional and mental states of their passengers, answer questions, or just engage in casual dialogue – providing a sense of company and support for passengers.

"PEOPLE SAY ALL KINDS OF THINGS TO ME, SOMETIMES I FEEL LIKE A THERAPIST – MAYBE IT IS BECAUSE THEY WILL NEVER SEE ME AGAIN AND THEY CAN SAY WHAT THEY WANT... IT'S LIKE A CONFESSION BOOTH ON WHEELS."

Dave, ustwo study participant

Let's look beyond the functional elements of conversation. We already have systems like Siri and Alexa which can perform adequately in that respect – waking you up at set times, giving you the weather report, latest news reports, and even telling basic jokes. The emotional elements of conversation are more interesting. How could an AV behave as a sympathetic and empathetic entity? This is a subject researchers call "emotion regulation" or "emotional responsiveness" and is achieved by varying the tonal quality and information presented by voice interactions. This regulation is based on both sensing a passenger's emotional state via their physiological characteristics – their voice or perhaps facial gestures – and then providing the right response to "regulate" a situation.

For example, "emotional down-regulation" could be used when passengers might be facing an upsetting or frustrating situation – for instance, a delay in travel. Here the AV could sense the frustration and then down-regulate through voice

"SORRY ABOUT THE DELAY, [1] THERE IS AN INCIDENT UP AHEAD. [2] WE SHOULD BE MOVING IN TWO MINUTES." [3]

The sentence has four parts aiding the down-regulation:

1. Recognising the frustration and playing back
2. Explaining the situation, providing context
3. Resolution of the situation and future steps
4. Tonal variation

A soothing voice and the right set of words can make you calmer or even put you to sleep. Similarly, a clear, loud voice and words that grab attention can be used to signify critical situations.

- For instance, in the sound design for aircraft cockpits the design guidelines are to use a multitude of audio signals only when:

- A visual display needs attention. Directionality of sound plays a role in identifying the source. For example, a loud beep from the display that requires attention.

- The condition needs an immediate response. Usually a mix of short audio icons and speech. For example, "whoop, whoop" (attention) and "pull-up, pull-up" (message).

- Ambient light conditions may conceal a visual display of importance.

A real-world example for an authoritative and clear instructional interaction can once again be found in Wayfindr's open standard:

"**Audio instruction example 1:**
"Turn left and take the escalator down to the platforms. The down escalator is the one on the left."

The instruction comprises the following elements:

Verb (ie turn), directional delimiter (ie left), verb (ie take), environmental feature is the pathway (ie the escalator), directional delimiter (ie down), directional delimiter (ie to), environmental feature is the area/segment (ie the platforms), directional delimiter (ie the down), environmental feature is the pathway (ie escalator), state-of-being verb (ie is), directional delimiter (ie the one on the left)." [45]

Wayfindr open standard

DP.07

But by considering audio interactions will people will be left out of the interaction loop? What if you have a hearing impairment, whether permanent or temporary, such as when listening to loud music over headphones? Here's where the principle of "graceful degradation" comes in, where we can make use of our multisensory pallette of interaction channels to reduce anxieties and convey key information.

DESIGN PRINCIPLE UNLOCKED:
07. DEGRADE GRACEFULLY FOR THE SENSES

There should always be reasonable fallbacks for interactions, without overtly relying on any one interaction channel. For example, audio interactions for vision-impaired people should have visual counterparts for people who cannot hear or understand auditory information.

Graceful degradation is a concept once used in development terminology for software that works over multiple device types and ages. But in our case it takes into consideration inabilities and also performance issues with primary modes of interaction. For instance, what if there is a hardware failure in our shared AV, rendering audio interactions mute? In that case, falling back to a visual medium might be useful.

A great example of this can be found in train stations of today such as Victoria Station in London.

What we see there is a mature handling of accessibility issues, where quite a few interaction channels are used. To explain this with a tangible example, we can use the example of the yellow line on the edge of platforms, which separates the train line and the people standing on the platform.

Visual: screens, banners, signs, drawn lines and pamphlets. This includes the yellow line with the words "mind the gap" – an iconic fixture in all London stations – helping people orient themselves in a safe place on the platform.

Audio: announcements tied to screens and sound cues at key places. Along with the yellow line and the words displayed at the edge of platforms, there is an audio announcement helping people remember and orient themselves away from the edge of the platforms. There is also a steward monitoring people on the platform, helping out when people stray across the yellow line. Listen to an audio clip here.

Haptic: railings, tactile flooring for cane usage and Braille on some signs. (It is interesting to note here that Braille is an EU-mandated necessity, but actually used by a relatively low number of people, less than 1% in the UK, for example. Audio instructions and digital reading tools have begun to supersede its use.) At the yellow line, we can see the two types of tactile flooring leading to the platform edge.

So, there is a channel to fall back to for everyone, including assistive staff at every node of travel. One can argue that the human intervention by staff could be the one which caters most to emotional needs – something that should perhaps never be automated.

We have found that using this method of thought within the vehicle is essential in solving the emotional needs of passengers and is key to the adoption of driverless technology. Working with elderly and vision-impaired people can thus pave the way for emotional interfaces through other channels like voice, rather than relying purely on visual cues.

London Victoria Station

THOUGHT EXPERIMENT 1 AND 2: WHAT DOES IT MEAN FOR DESIGN?

Taking a step back, we can combine the two thought experiments into a tool for inclusive design, which can be used effectively in AVs.

Inclusivity allows for three-dimensional thinking and can help create a diverse and rich pallette of interactions considering a wide spectrum of users, their need types, and the right interaction channels.

They can provide the groundwork for:

- Considered haptics and voice interfaces
- Appropriate first and last mile resolution
- Considered interactions within the vehicle without the driver
- Isolation and sociality within AVs

Before we move, we would be remiss if we did not mention a few other aspects of inclusivity – aspects for policy makers and technologists to consider.

POLICY AND REGULATION

We have established that mobility is critical to wellbeing. The loss of mobility can be debilitating[46], so it is no wonder that progress in AV technology has been closely followed by people who have been sidelined by disability or age – especially if they have experienced freedom of movement at some point in their lives.

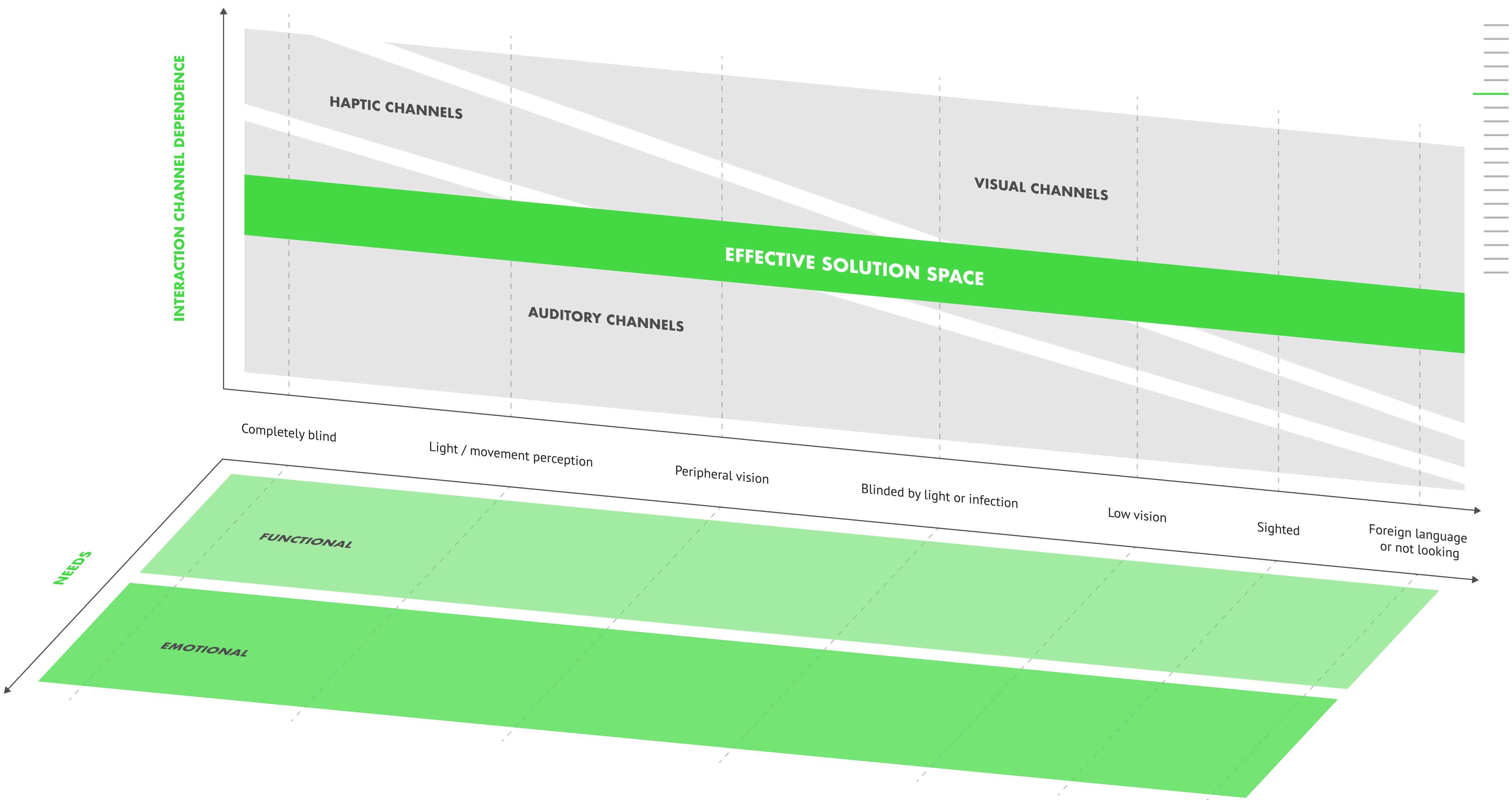
However, a big part of the adoption of AV technology is not just dependent on its development, but on the policy makers and regulators who make sure that it reaches the people who really need it. An aspect of this is licensing.

If AVs have the potential to change people's lives by giving them the freedom to move and work, we should actively move towards removing or minimising the barrier of driving licences.

This would be part of an ethical approach to give people the right to live an independent and full life, once primary safety concerns have been addressed. It's an approach which should be considered right from the get-go, and not tacked on later as an afterthought.

"A disabled person, due to, for example, societal barriers and individual impairments may not currently be able to drive a car and achieve the functioning that is independent travel. Autonomous car technology is part of a conversion factor; a resource that could, if technical, regulatory and legal systems permit, give disabled people the actual ability to attain this functioning."[47]

Bradshaw-Martin & Easton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NEEDS
FUNCTIONAL
EMOTIONAL

This has been echoed by some of our interviewees, in particular, Françoise, who fears losing her licence and the loss of easy mobility:

"YES, FOR ME DRIVING IS A POSITIVE EXPERIENCE. IT KEEPS ME ALERT AND YOU KNOW I COULDN'T DO WITHOUT IT REALLY BECAUSE OF WHERE I LIVE."

On losing her licence:

"I'D BE VERY UPSET. VERY, VERY UPSET. YEAH... OH I SEE! WE DON'T NEED A LICENCE FOR DRIVERLESS CAR? AH — THAT COULD BE A SOLUTION. WE'LL SEE."

Françoise, ustwo study participant

We'd like to share a poignant story in which policy makers have paved the way for people with disabilities. In late 2016, Sam Schmidt, a former IndyCar racer, received the first licence restricted to an autonomous vehicle in the US. An accident had left him paralysed from the waist down and he lost the ability to drive, and consequently his driver's licence.

"I can't even begin to explain just how much this provisional driver's licence, and the mobility and independence it represents, mean to me." [48]

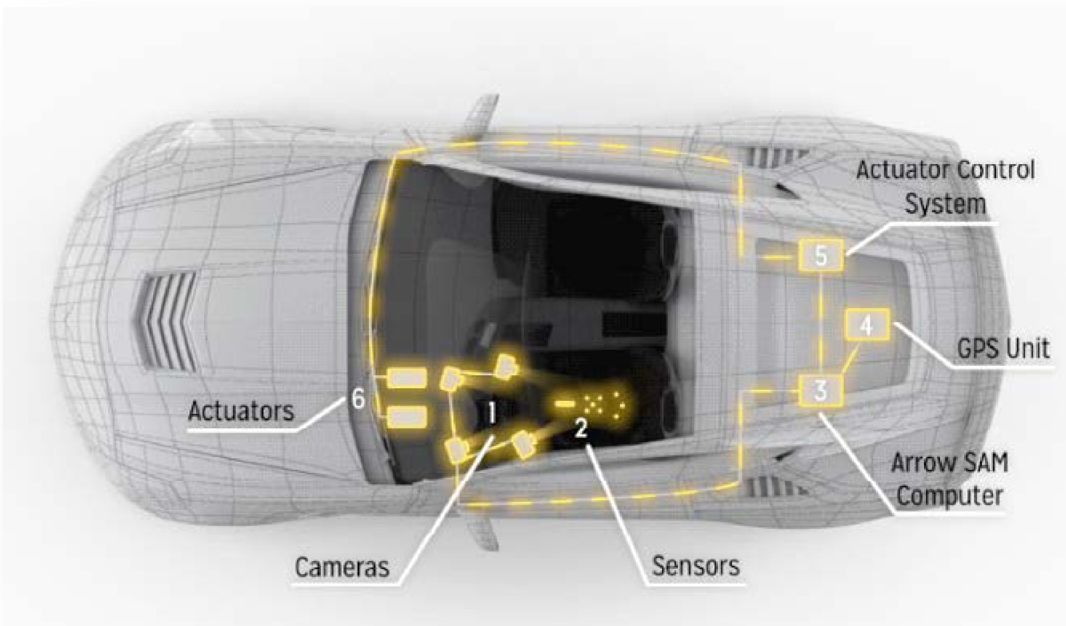
Sam Schmidt
Former IndyCar Racer

The new licence allows him to drive on Nevada roads in his specially modified Corvette, which requires no hands on its steering wheel or feet on its pedals. His car isn't fully autonomous; it uses four cameras to monitor his head and transmit his movements to the tyres and the team behind his car, Arrow Electronics[49], is working to improve its autonomous capabilities.

"Arrow Electronics created a semi-autonomous vehicle in a short period of time that not only breaks the current definitions of autonomy, but also delivers a technology that has the potential to bring freedom to those who have physical disabilities. We were proud to collaborate with Arrow to pioneer a way for Sam Schmidt and the SAM Car to drive legally and safely on Nevada highways. This testing will help to improve their technology and bring them closer to providing increased mobility to the disabled community." [50]

Jude Hurin
Nevada DMV

This is a perfect example of technological and policy progress, moving hand-in-hand to empower people.



SAM
A semi-autonomous vehicle by Arrow electronics, USA, 2016

AutoX webcams

Comma's Neo hardware system
Not pretty,
but it does the job

HACKING PROGRESS – AUTONOMY FOR ALL

Autonomous vehicle development thus far – in both hardware and software terms – has been in the hands of individual companies or large governmental bodies. It relies on certain technical know-how with a high knowledge and financial barrier, which keeps it in the purview of the developed world. This could seriously hamper the spread of AVs, especially in regions around the world where such barriers could be insurmountable – an inclusivity problem again.

But consider the development and use of early mobile phone handsets, which saw an immense boom when amateur and professional technologists worked out how to "hack" the system, learning how to build, use, and manipulate systems so that people could make the technology fit the needs and desires of a regional economy. This also gives rise to the "leapfrogging" [51] phenomenon, where the appearance of new technology short-circuits progress. For example, mobile handsets removed the need to have cumbersome and highly regulated landlines in countries like India and China. Another example is the explosive proliferation of electric vehicles in China[52], which it sorely needs to curb high volumes of local demand, while dealing with growing environmental pollution.

This mindset has already prompted companies like Comma.ai[53] and AutoX[54] to work towards democratising autonomy. For instance, Comma is building open source software and hardware tools[55] called "Open Pilot" [56] and "Neo" [57] which help reduce the knowledge barrier for people and help them autonomise their own existing vehicles.

"On certain roads, the comma Neo with openpilot is capable of completely driving, as a handful of YouTube videos will show. But before you take your eyes off the road, remember that it is not superhuman yet. Without your supervision, all self driving systems today are more likely to crash than your average human. But this won't be the case forever. Our mission is to build the world's first superhuman driving agent."

Comma.ai

AutoX's novel approach to bring the price points of autonomous hardware/software down was created in a similar vein. Sensors are a significant cost of hardware, so AutoX disrupts this approach by creating an open source camera-based tool for sensors. AutoX is also creating full-stack AI software solution for self-driving vehicles to achieve Level 5/6 full autonomy. It's basically a grid of webcams on top of a car to help it sense the environment – how cool is that?

"We invented a camera-first self-driving solution that amounts to only a tiny fraction of the cost of traditional LIDAR-based approaches. We believe that autonomous driving should not be a luxury, and we are making it universally available to every citizen." [58]

Professor X (Jianxiong Xiao[58])
AutoX

We believe this is just the beginning of democratisation and reach. We could very well see potential hacks of these open source tools and software quite soon, powering previously driven vehicles into the driverless future.

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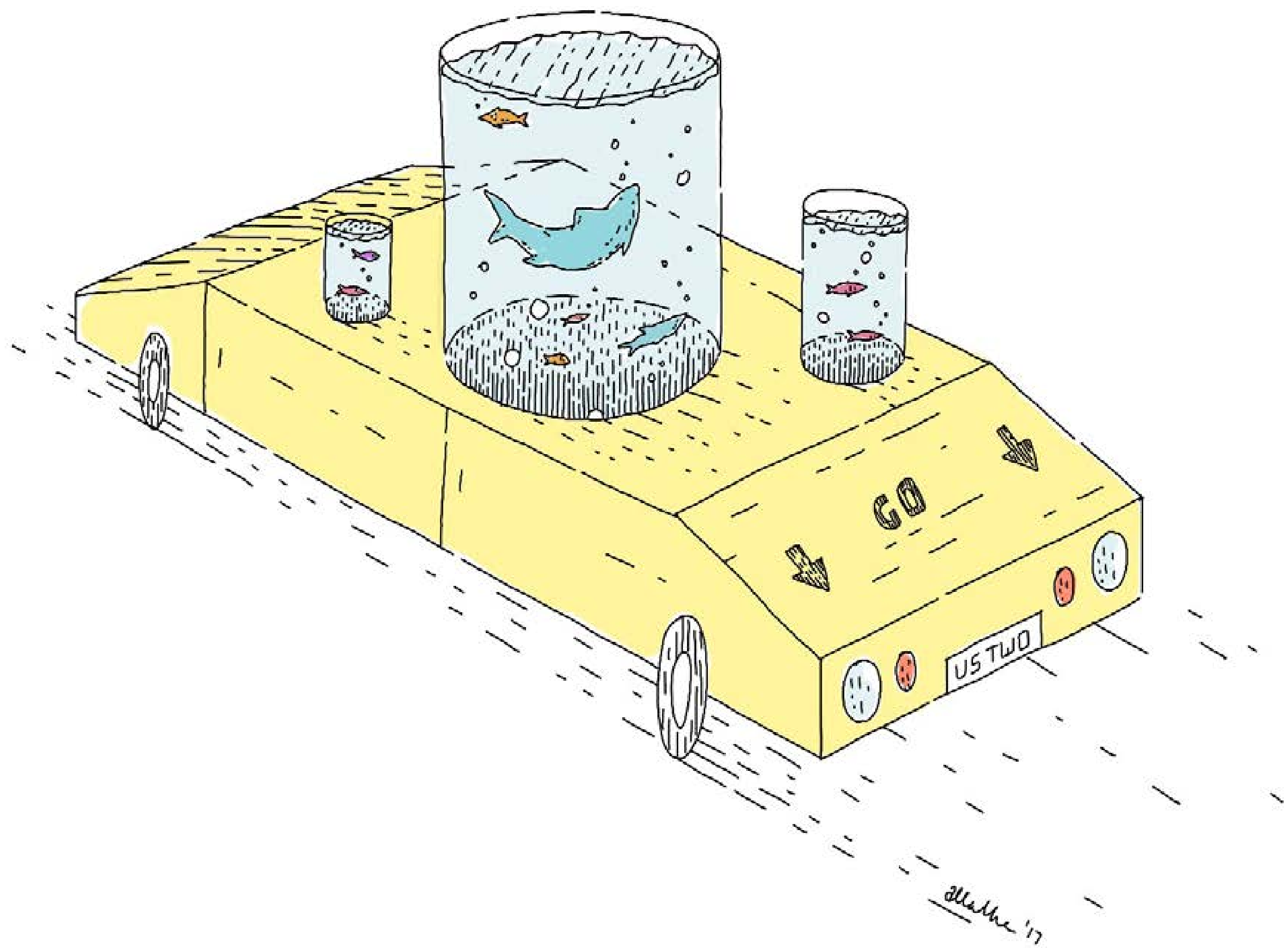
Self-Driving Tank
by Alex Mathers
Year: 2026

"This concept of fish in a driverless fish tank on wheels, emphasises the fact that - because passengers no longer need to drive - the cars may become more popular as a means to show the world what is inside them, much like the 'pope-mobile' - rather than the more conventional mode in which passengers use cars to peer out at the world."



DOES THE ROBOT HAVE A MORAL COMPASS?

Topic: Morality and Ethics

50 minute read

"IF YOU GET TO THE POINT WHERE I TRUST THE CAR COMPLETELY, WHERE I DON'T TOUCH THE STEERING WHEEL AND THE CAR DOES SOMETHING, OVERSTEPS A MARK AND AS A FAMILY MAN I CAME ACROSS A SCENARIO WHERE SOMEBODY GOT INJURED AS A RESULT OF THAT — I DON'T KNOW HOW I WOULD FEEL."

Rick, ustwo study participant

SUMMARY

The idea of machines that take over responsibility for human lives prompts unavoidable ethical questions. Namely, should robots be making ethical decisions that have consequences for the safety of people?

Questions like these remain a huge barrier to AV adoption, and have been widely debated by sceptics and futurarist alike. In this section, we cross reference established moral approaches with user-centred thinking.

INTRODUCTION

In 2015 in the UK, 186,000 people were injured on the roads, and 1,732 of those died [1]. Believe it or not, despite the increase in traffic over the past few decades, this statistic represents the second lowest number of annual road fatalities on record. One reason for the steadying decline of road accidents is the proliferation of improved advanced in-car safety systems, such as Advanced Driver Assistance Systems (ADAS). Given that 94% of all road accidents are caused by drivers, you can see why this is [2].

These numbers provide a pretty compelling argument for the need for autonomous vehicles, regardless of whether we want them or not. However, when we contemplate that machines, in this case the driverless car, are increasingly taking over responsibility for human lives, questions of ethics arise. Should robots be making ethical decisions that have consequences for the safety of people? When we design these systems, computing code inevitably has to align with moral code.

An autonomous vehicle is, after all, a robot on wheels – think Tesla rather than R2-D2 or K9. The word "robot" can conjure up dystopian images of Terminators travelling in time to take over the world, or robot armies invading from Mars. However, as the technology moves from science fiction into science fact, we're understanding more and more that robots can be helpful and sometimes even necessary.

It seems fitting then to start with the hypothetical ground already covered by science fiction. This medium has the benefit of not being bound by reality or technical feasibility, but can instead suggest scenarios in which we can exercise new concepts and thinking. Isaac Asimov's Three Laws of Robotics is a great vehicle (excuse the pun) in which to stress-test the concept of ethics for robot cars.

RICK 41

These laws will be familiar to many, but here's a quick reminder for us forgetful fleshy humans:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2. A robot must obey orders given to it by human beings except where such orders would conflict with the first law.

3. A robot must protect its own existence as long as such protection does not conflict with the first or second law.

Now, let's take those three rules and replace the word "robot" with "driverless car".

1. A driverless car may not injure a human being or, through inaction, allow a human being to come to harm.

The first half of that law is very simple. The car simply must not collide with another vehicle containing or convoying passengers (cars, vans, motorbikes etc), cyclists, or pedestrians. The second half gets a little more complicated. For example, if the driverless car is on a direct collision course with a pedestrian, and is travelling too fast to stop, it must not stay true to that course, because it's inaction would kill the pedestrian. Therefore, the driverless car must turn to avoid the pedestrian.

Phew, problem averted, life saved. Uh oh! The evasive manoeuvre that saved the pedestrian's life has put the car on a collision course with a second pedestrian. Unfortunately, saving the first pedestrian's life has meant injury or death for the second pedestrian. So, AVs can have problems obeying the first law. Let's see how they fare with the second...

2. A driverless car must obey orders given it by human beings except where such orders would conflict with the first law.

In Asimov's original law, the assumption is that you're giving the robot orders through some form of verbal or gestural communication. This is something that will also be available inside, or indeed outside, the AV (as discussed in our Human AV Interaction section). This is what we are calling "commanding" the car, as opposed to driving it. Passengers will also occasionally take the wheel, and begin actually driving the car. In this context, turning the steering wheel (which nowadays has no mechanical connection to the wheels and is all electric/computerised) is also an order given to the robot of which it must obey, according to the rule, unless it harms others.

If the occupant of the vehicle verbally asks the car to make a detour to get some food, the assumption would be that if this puts a pedestrian in danger, the vehicle would either not take the action and provide the appropriate feedback, or wait a few moments until it is safe to do so.

If the occupant of the vehicle commanded the wheel to make a detour to get some food, the assumption again would be that if this puts a pedestrian in danger, the vehicle would simply render the driver's physical inputs redundant and remain true to its safe course, leaving one frustrated and hungry driver. However, what if the driver wants to avoid a pedestrian that the AV simply hasn't spotted, and to do that the driver attempts to steer off the road into a wall? This action would be considered dangerous to the driver by the AV, and it would not be allowed. The pedestrian would be killed with the driver arguably left feeling to blame or indeed liable. This issue of liability is discussed in detail later.

Currently, when the robot faces a situation it does not know how to handle, it passes control over to the passenger, forcing them into the role of the driver. This is how Tesla's Autopilot works. But what if the driver also doesn't know how to handle a situation, and ultimately either option results in a fatality?

“Echoing many other experts, Madeleine Elish, a research analyst at Data and Society Research Institute, says she was concerned that Tesla is ‘engaging in an unethical research practice by shifting the risk from developer to the user.’”

Kelsey Houston-Edwards
Nova Next[3]

It’s like a wingman having your back, until the proverbial brown stuff really hits the fan, and then running off, leaving you to deal with a tricky situation – alone.

This second law seems to hold up pretty well for AVs, providing the AV never makes a mistake, and we don’t think there’s any technology out there that has never malfunctioned. Mistakes do happen, but how frequent they are, could make all the difference.

How about the third and final law?

3. A driverless car must protect its own existence as long as such protection does not conflict with the first or second law.

This is where robot ethics in the context of AVs gets an extra nuance. A robotic car is unique among robots in that a person can get inside the robot. In this case, “human” can refer to both the person on the street and the passengers within the robot car.

Let’s imagine a scenario. An AV is delivering a package, with no one on board. A human driven car is speeding towards it head-on, and so the AV takes evasive action to protect its own existence. The AV continues its journey, but further down the road that same speeding car approaches from the side. To move out of the way here would mean opening up a direct collision course with a group of pedestrians on the AVs other side. According to this third law, the AV should remain where it is, sacrificing its own existence, so that it does not break the first law.

Ignoring, for now, the fact that no one can predict the outcome of the collision and its consequences to the pedestrians, and assuming that everyone is safe, this is all fine and dandy. Now, what happens when we bring in that nuance unique to robotic vehicles and put a passenger inside the robot?

Further, does “protect its own existence” include the passenger within? A man books and enters an AV taxi so that he can go to the ustwo studio to play Monument Valley 3. A pedestrian jumps out in front of the AV. The car can’t stop in time to avoid hitting the pedestrian because it’s travelling too fast, but an evasive manoeuvre means risking the passenger’s life. The vehicle must choose between the pedestrian or the passenger. How can a robot make such an ethical decision?

HUMAN REACTION VERSUS ROBOT DECISION

When a human is at the wheel and faced with a situation in which another driver or pedestrian is at risk from their actions, the human mind can't contemplate all possible outcomes, process the consequences of each, and make an informed decision as to what action they should take. This would simply take far too long for the human brain. But a robot is capable of doing just that in a fraction of a second. People panic and they react. These reactions are innate, somewhat random, without prejudice, and happen in the blink of an eye. Sure, training and practice can lessen that randomness, with the driver doing the right thing as second nature kicks in, but when a person jumps out in front of their car, the driver will either slam on the brakes, risking the safety of the drivers behind, or swerve to avoid, risking their own lives and possibly others. This isn't always a conscious decision, it can be an innate human reaction, one that can seem illogical in hindsight.

Autonomous vehicles, on the other hand, are capable of processing thousands of inputs and decisions a second. With their multiple cameras, LIDAR (Light Detection and Ranging), image recognition, processing power and algorithms, AVs can not only understand their surroundings, but also know what their surroundings will be ahead of time. AVs will be able to predict, with some accuracy, what is going to happen and how best to negotiate that future event right now. Robots do not react, they decide, because they can process thousands of decisions a second.

This is where the problem scenarios illustrated above become of ethical concern. If there's no other option, the machine will have no choice but to harm someone either through a decisive action or indeed decisive inaction – breaking all three of Asimov's laws of robotics. This is what is known as the "trolley problem".

THE TROLLEY PROBLEM

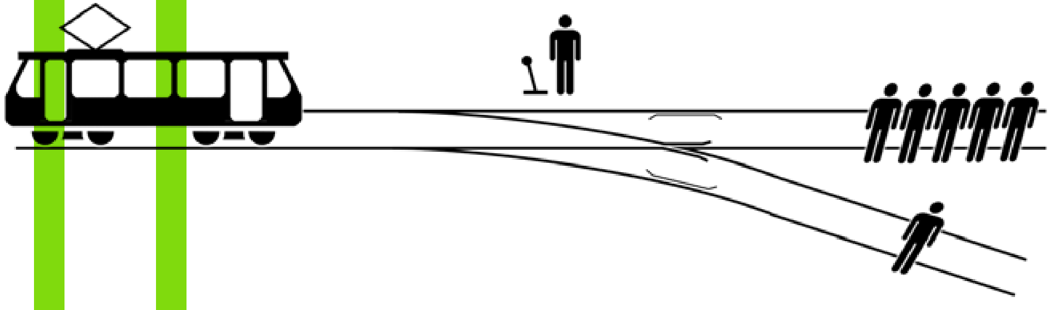
The trolley problem is an illustration of ethical decision making. A "this or that" scenario whereby both options result in death, both with associated subjective values. The metaphor for this scenario is usually a train or trolley on a track. The trolley is on a collision course with two workers. You can change the track's points, so that the trolley moves to the alternate piece of track, but that would result in killing a third person instead. The ethical dilemma here is that you have the option to either let the trolley kill two people, or you can save those two people, but risk the life of another. Do you take action to save two and kill one, or do you choose not to get involved, leaving two dead and one survivor? People almost always choose to do nothing.

The trolley problem is what makes Asimov's three laws hard to obey with the unique characteristics of the robot vehicle – its fundamental functions of both containing people and travelling at (dangerous) speed – characteristics not present in the imagined humanoid robot of Asimov's novels.

In all three laws, the driverless car would have to choose which pedestrians to save and which to, effectively, kill. This decision gets even more complex when you consider how many people are involved. Should the car stay on course, killing two, to save three?

Now throw in who these people are into the mix. Would the AV choose to save a younger person over an older person? Or avoid a collision with a pregnant woman, killing the passenger inside the vehicle? What about criminals versus doctors? Those are utilitarian questions, but how about personal ones? Does the AV avoid family members, harming a stranger instead?

This is not something that can be easily addressed by Asimov's three laws of robotics. In fact, should robots even be making such ethical decisions at all, ones that have fatal consequences to human lives? The robot is simply meant to serve, not harm. The Terminator was intentionally killing people, and it seems that the poor AVs may be forced into doing so.



The trolley problem

So, let's say the rare situation arises where the vehicle must choose one life over another, how does it do this? The way we see it, there are four main possible options (none of which we're endorsing, by the way):

1. MINIMISE LIVES LOST – THE UTILITARIAN APPROACH

The concept here is quite simple: the AV will protect the largest number of lives above all else, even if this means sacrificing the passenger. These sorts of ethical questions have been around forever, and never more so than in situations such as war. When it comes to prioritising casualties to attend to in emergencies, armies, and indeed individuals, have had to face these dilemmas. This is known as battlefield triage. It's interesting to hear that in battlefield triage, all lives are considered equal; the elderly, children, men, women – each individual is a person equal to the rest. For that reason, the key motivation is to minimise the overall number of lives lost, rather than decide who to save, because who are they to decide?

"All humans have an equal basic moral status. They possess the same fundamental rights, and the comparable interests of each person should count the same in calculations that determine social policy. Neither supposed racial differences, nor skin color, sex, sexual orientation, ethnicity, intelligence, nor any other differences among humans negate their fundamental equal worth and dignity. These platitudes are virtually universally affirmed."

Richard J Arneson [4]

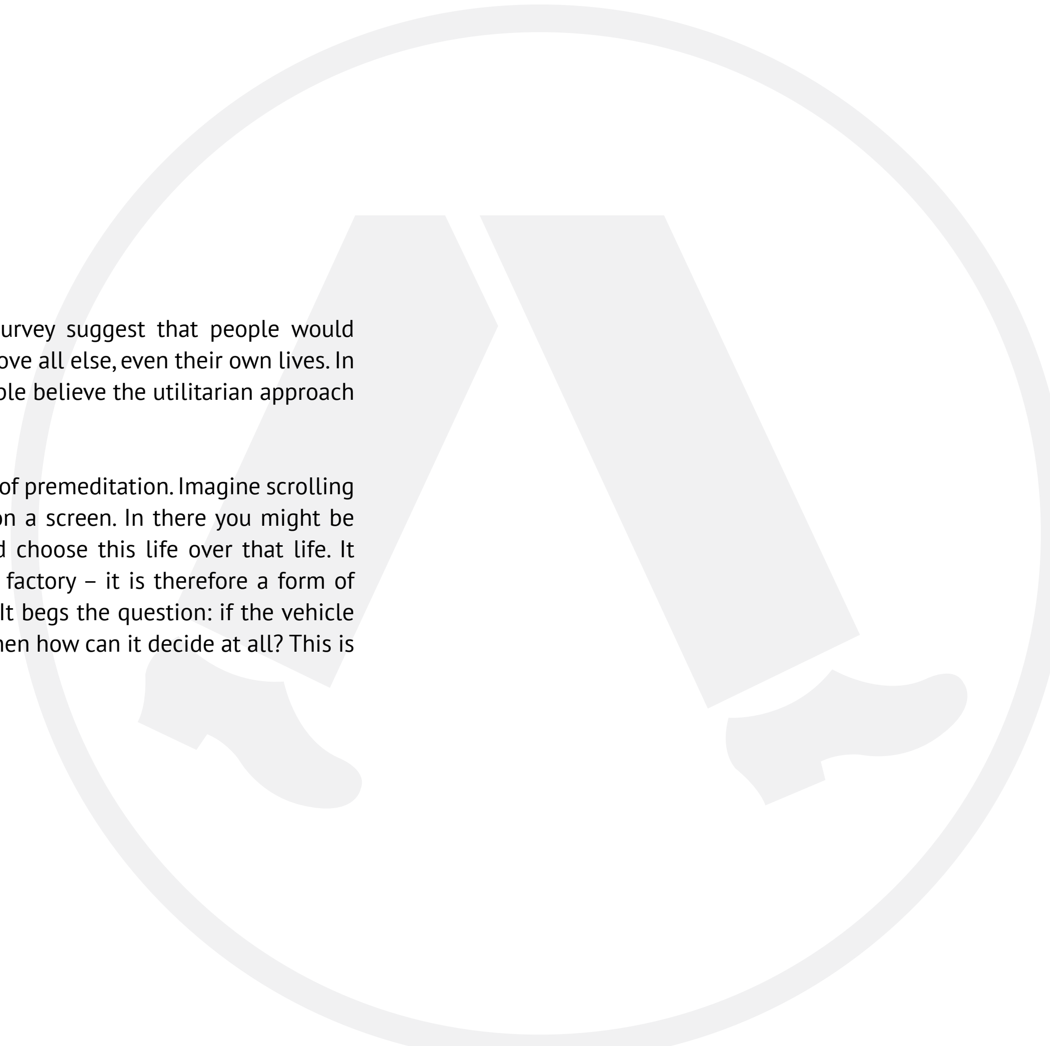
2. PREDETERMINED BASED ON HUMAN TRAITS – THE VALUE APPROACH

This one is a little more controversial. Here, the vehicle is able to make a choice based on who the parties concerned are. For example, you might assume that the AV would choose to save a pregnant woman over an elderly woman, the assumption being that the woman is younger and carrying a child, a second human being. Whereas the elderly woman is older and has a shorter time left to live. However, the elderly woman may be a doctor and go on to save a dozen lives. Doing the maths, in this outcome perhaps 13 people would lose their lives, but two would be saved. With sensors and biometric records in the cloud, it is possible to know who these involved people are, but we cannot predict what those individuals will go on to do and that is why every person is given an equal moral value as described by Arneson above. Who are we as humans to decide the fates of others, never mind robots? As an aside, making this more complex is the fact that humans may be deciding the topline rules by which the robots operate, ie, the buck stops with us whatever.

Well, perhaps it's subjective on a person-by-person basis, and if we all collectively have a say, there may be an answer to be found in the average result, much like a voting system. This is precisely what MIT seeks to experiment with in its crowdsourcing *Moral Machines* project. In this experiment, MIT poses a series of this-or-that trolley problem scenarios, asking visitors to the site to choose which option the AV should take. Should the AV avoid two pedestrians, killing the two passengers, or remain on course, killing the two pedestrians, keeping the two onboard safe? It is a crowdsourced way to gain a consensus of human moral decision-making, in this specific context (and it is specific).

The current results of the Moral Machines survey suggest that people would choose to minimise the number of lives lost above all else, even their own lives. In other words, the general consensus is that people believe the utilitarian approach to be the most moral.

This does, however, pose another problem: that of premeditation. Imagine scrolling through the moral code of the AV algorithm on a screen. In there you might be able to see, written down, that the car should choose this life over that life. It is set in stone before the car even leaves the factory – it is therefore a form of premeditation which seems inherently wrong. It begs the question: if the vehicle can't decide based on code it has been given, then how can it decide at all? This is something we discuss shortly.



Australian pedestrian crossing sign

Auto UI conference, Ann Arbor 2017
Tim at presenting during an AV and ethics workshop

3. RANDOM SELECTION – THE RANDOMISED APPROACH

This concept was discussed at great length at the Auto UI conference we attended in Ann Arbor in November 2016. We used this firing squad analogy to help explain the concept:

A firing squad, in which a number of people are wielding weapons (the executioners), all aim at the offender's heart. Only one of the executioners' weapons is loaded with live ammunition, the others firing blanks. The reason for this is twofold. First, because it anonymises the individual firing the fatal shot, passing responsibility for the death over to the state. Second, because the uncertainty helps the executioners with their moral compasses, the odds being against the individual having killed the person, which is known as 'diffused responsibility'.

We can apply this to AVs. The passengers of the vehicle may feel somewhat responsible if their vehicle's algorithmic code was written to choose a certain approach over another, for example, injuring two teenagers rather than one elderly man (the value approach). If the AV's decision was randomised, the passengers may feel less responsible, because they did not subscribe to a particular decision-making process when they entered the vehicle.

4. PROTECT THE PASSENGER – THE PASSENGER FIRST APPROACH

The problem with the utilitarian, value, and randomised approaches lies in our nature as humans to think one way but behave in another, creating a human barrier to adoption. It's easy when you're sitting on your sofa at home to say that you believe that the fewest lives lost is the right decision, but when the life of someone you know, or your own life, is put at risk, behaviours inevitably change.

Imagine that a car company rolls out an AV in which the moral algorithm has been written based on the research of MIT, using, for example, the utilitarian approach. Would you feel safe getting into a vehicle knowing it would sacrifice your life to save others? Would you get in it at all?

In fact, research suggests that while people believe that the utilitarian approach is the most moral, they would prefer to board a vehicle using the passenger first algorithm:

> *"We found that participants in six Amazon Mechanical Turk studies approved of utilitarian AVs (that is, AVs that sacrifice their passengers for the greater good) and would like others to buy them, but they would themselves prefer to ride in AVs that protect their passengers at all costs."*
>
> Bonnefon, Shariff and Rahwan[5]

This would be of concern for the manufacturers, which might be why Mercedes-Benz has already declared its standpoint – that the passenger's safety is paramount[6]. According to the company's manager of driverless car safety, Christoph von Hugo, by adopting the passenger first approach, a Mercedes-Benz AV would protect its passengers no matter what – and they mean, no matter what! This might prove very tempting to consumers, and may even be a factor in overall adoption of the technology. After all, in theory, the longer it takes to adopt this technology, the more lives are lost at the wheels of manually-driven cars.

At the 2016 Paris Auto Show, Hugo described the rationale behind Mercedes-Benz's bold decision, becoming one of the first OEMs to break cover on the thorny issue:

"If you know you can save at least one person, at least save that one. Save the one in the car... If all you know for sure is that one death can be prevented, then that's your first priority... You could sacrifice the car. You could, but then the people you've saved initially, you don't know what happens to them after that in situations that are often very complex, so you save the ones you know you can save."

Christoph von Hugo
Head of Active Safety, Mercedes-Benz Passenger Cars

This harks back to a point we made earlier. Yes, you could avoid a collision with a pedestrian no matter what, but the knock-on effects, which are infinite and unpredictable, could be equally as life-threatening as the initial collision, potentially sacrificing the life of the passengers for nothing.

Interestingly, when asked how many miles Mercedes-Benz AV algorithms are drawn upon, Hugo replied: "It's not about miles, it's about situations, and there are an infinite number of them." [6]

While that does seem to be a compelling argument, this is only looking at half the picture, that of the accident itself. What about the emotional consequences of that accident and the actions taken? In a manually-driven car, within a trolley problem situation, the driver would not have decided what to do, but would have reacted to the situation, without prejudice. In an AV, the passenger would be left with the cold decision made by the machine. The AV passenger may then feel like they were a part of the AV's mercilessly fatal actions, where the AV appeared to be staying true to its course, as if taking no reactive action at all. Who knows what psychological ramifications that comes with? We will attempt to answer this question later.

MORALITY PYRAMID IN AVS

It is our opinion that, while incredibly important, these fatalistic trolley problems overshadow other equally important, yet more common human problems. Here's why we think this way:

Robots should simply not be allowed to make ethical decisions. The only way to comply with ethics is to ensure that the robot fundamentally isn't choosing the value of one life over others. If you're cynical about this concept, check out these EU directives for robots.

The technology will advance so much that these instances will be incredibly rare. In fact, we'd go as far as saying that we think that this technology should not be considered road-safe until a certain level of confidence is reached whereby the technology decreases the risk of danger significantly to that caused by human drivers, as suggested in Tesla's Master Plan Part Deux[7].

Just as we have become inured to thousands of fatalities now, we may well become inured to the new trade off: a few deaths at robot hands for many saved. However, in the transition, the type of accident will change eg a car thinking that the side of a truck is the sky. Initially people will need to adjust because this sounds like an unreasonable grounds for an accident because it's a kind of accident that would not have happened before.

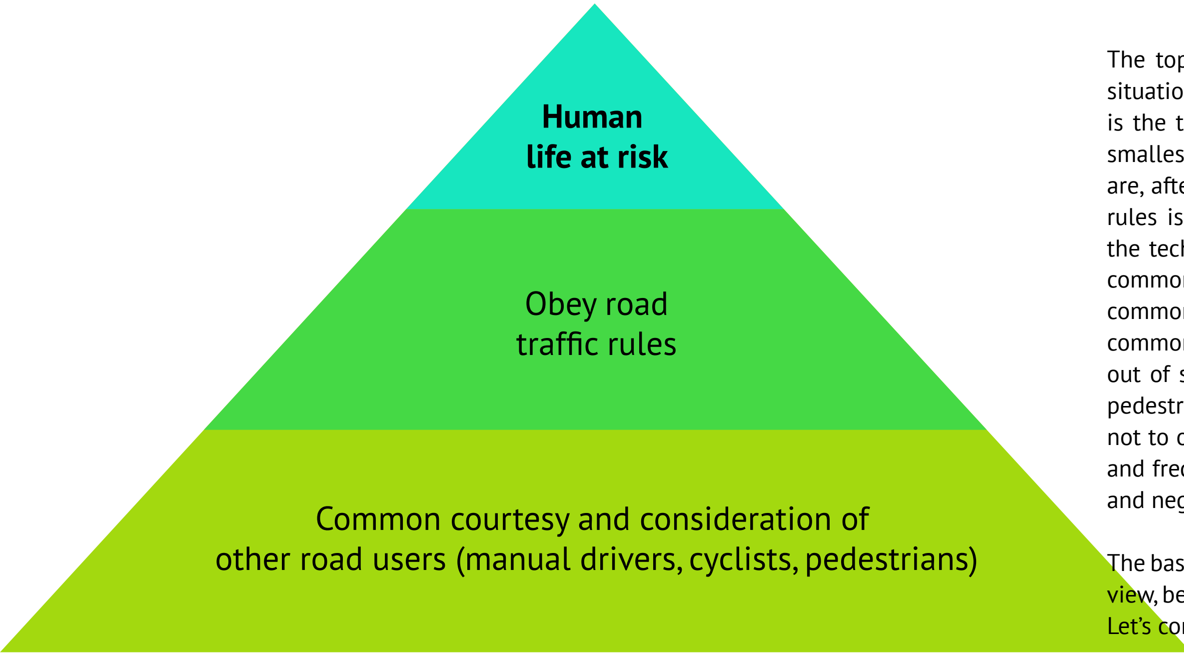
In our interview with Paul Jennings at the University of Warwick, he agreed with the latter sentiment:

"WITH THE ADVANCEMENT OF THE TECHNOLOGY, THE SHARPENING OF THE ALGORITHMS AND THE MILES AND MILES OF DRIVING DATA WE COLLECT, THE SCENARIOS PRESENTED BY THE TROLLEY PROBLEM WILL BECOME INCREDIBLY RARE. WE NEED TO CONSIDER THE MUCH LARGER CATEGORY OF DAY-TO-DAY MORAL DECISIONS; THE TROLLEY PROBLEM IS A DISTRACTION."

Paul Jennings, Warwick Manufacturing Group

A "morality pyramid" for this very topic was discussed (though not illustrated) by Kieran Laird, principal associate in the public law and regulation team at Gowling WLG, in The Moral Algorithm, which was co-authored with UKAutodrive[8].

We have illustrated the concept here:



The top of the pyramid represents the number one priority, that of preventing situations that risk human lives, the likes of which are discussed above. While it is the top priority, it will also be the rarest of all instances and hence it is the smallest part. Secondary to that is the following of road traffic rules. These rules are, after all, put in place for the safe and fair use of public roads. Obeying the rules is a legal and safety requirement, though this may change and evolve as the technology proliferates on our roads. These everyday decisions are far more common than those at the top of the pyramid. The third priority, but by far the most common, is the observation of established human social norms and exhibiting common courtesy on the road. Things like letting people out at a junction, staying out of someone's blind spot, thanking those that let you go ahead, stopping for pedestrians crossing the road, and so on. The unwritten rules that we observe so as not to offend other drivers, cyclists, or pedestrians. These instances are numerous and frequent, and have a huge impact on our driving experience, in both positive and negative ways.

The base of the pyramid is by far the most important from a user experience point of view, because it covers situations that occur multiple times within a given journey. Let's consider a trolley-like conundrum, but without the fatal consequences.

An AV is idling in traffic, when suddenly the cars ahead start to move forward. However, the car directly in front does not move on, because the human driver is too busy checking their emails to notice the traffic has eased. The AV can do nothing but wait patiently, and meanwhile its passenger is becoming increasingly impatient. How do you solve these sorts of problems? Should the vehicle do what a human would do and sound the horn? According to the UK Highway Code, Rule 112[10] to be exact, the horn should not be used when stationary.

These kinds of questions don't just concern the academics or philosophers, they're a very real concern for the users of the technology too – the consumers themselves.

MORALITY AND ETHICS: THE OPPORTUNITY

We have discussed the problems surrounding the thorny topic of morality and ethics for autonomous vehicles. These are very real and very human concerns that create barriers to adoption. We must overcome these barriers through good user experience design – designing for human factors, so that the technology can be adopted as quickly as possible, preventing future lives lost at the wheel of the manual driver.

Here we suggest our points of view and potential design solutions to each of these problems.

OPPORTUNITY 1: THE TROLLEY PROBLEM

Giving a robot the choice of one life over another is fundamentally inhuman. As discussed earlier, it's inappropriate for humans to do this, let alone robots, which is why agencies like the military use the utilitarian approach in triage situations. When presented with this problem, the consensus of the general public is also that the utilitarian approach is the only morally acceptable one.

For this reason, the AV robot must be developed in such a way that the question of which person to save never arises. The robot never has to make this decision, because it would never be posed with the dilemma in the first place. From a machine code point of view, keeping the machine logic (ie the pre-written piece of code, rather than what is derived from more organic machine learning) separate to this issue seems like the most sensible strategy, and one which would prevent possible issues around premeditation. Imagine some logic or pre-written code that stipulates one life's priority over another – the question of premeditation would certainly arise.

This strategy will bypass any machine ethics question. Instead, the largest number of lives will be protected, even if that means the passenger is sacrificed. This is somewhat contradictory to Mercedes-Benz's approach, which aims to protect the passenger at all costs. However, reading into that further, you can see that it stems from the same motivation – to save the most number of lives. Mercedes-Benz believes that the passenger is the only person whose safety they can guarantee, because external situations are infinite, with unforeseeable consequences to others. Saving that one life is more certain and therefore one more life saved than a potential zero. This too, is the utilitarian approach. The utilitarian approach also solves the problem of premeditation – being one without discrimination, on a human level.

So, we believe that the utilitarian approach is the way forward. However, this does present some new challenges that must be overcome.

In order to follow the utilitarian approach, the AV will need to understand the value of its cargo, be it human or non-human. For example, if to avoid a pedestrian it must drive into a building, the AV will need to know what it is carrying. If it is an inanimate object such as a pizza, or perhaps even an animate object such as an animal, then it can safely avoid that pedestrian.

However, if the AV is carrying people, it will need to know how many, so that it can make its utilitarian cost-benefit decision, ie save two passengers or save one pedestrian. An extra complexity, and an uncomfortable one, is the consideration of pregnant women, either inside or outside the vehicle. Does a pregnant woman count as two people? What if she's carrying twins? What if she's less than 24 weeks pregnant (the UK legal limit for abortion)? These are concerns far beyond our expertise.

In order to make such decisions, the AV will also need to understand its own resilience, ie how much damage it can take without risking injury to its passengers. If the AV is carrying a person, it has to be sure that the safety of this passenger is guaranteed in the evasive manoeuvre. This is where considerations such as age and fragility come into play. An injury to one person could mean death to another.

This brings into question the cost-benefit and risk element, whereby injuring one person is "safer" than the certain death of another. Of course, the injured person may die as a result of their injury, but this risk is lower than certain death of the pedestrian. Here one might consider a tweak to the utilitarian model, whereby the likelihood of death from an incident is factored into a decision, omitting any personal information about those people involved. It might be the case that both parties involved on opposite tracks of the trolley problem have a possibility of survival, one greater than the other, say person A has a 70% survival chance whereas person B only 50%. If we develop this thinking further, what happens when the odds are equal? Still, the same utilitarian approach could apply here, rather than using technology to judge each person's fragility based on things like age and hospital records, perhaps fragility should not be taken into consideration at all. People should be protected from injury, not just death.

The utilitarian algorithm then will need to be carefully written to factor in all of these mathematical conditions.

As the Mercedes-Benz example highlights, there is an awkward opportunity for ambiguity here. The utilitarian algorithm will need to be balanced between standardisation and flexibility, so that innovation can happen in a way that doesn't allow for ambiguity in the rules.

The algorithm will need to learn from the experience of the entire fleet of AVs tackling all of the infinite scenarios Mercedes-Benz spoke about. In a way, our increased usage of the technology will form a kind of unofficial alpha test that will improve the technology over time, but this needs to be done responsibly, which we believe Madeleine Elish was alluding to when she spoke of Tesla's Autopilot already being in use on public roads. The responsible way, while still being flexible enough to innovate, would be to have all parties agree on a way forward and to commit to the same moral utilitarian algorithm, a kind of "Moral Code of Conduct".

OPPORTUNITY 2: THE MORAL CODE OF CONDUCT

Imagine that brand X has a moral code aligned to the utilitarian approach, in which the most lives saved might be those outside of the vehicle, whereas the Mercedes-Benz version saves its passenger's lives at all costs. Both are following a slightly different version of the utilitarian approach. Here, you have a conflict of interest between the two vehicles, and people will be confused about how the technology operates and how they should interact with it, thus putting people in harm's way. Furthermore, any AVs using the Mercedes-Benz code, that protects the passenger at all costs, are more likely to be used than AVs with the truer utilitarian moral code, which are safer for the majority. This human barrier to adoption, by which people would choose to use a passenger first approach (safety for the passenger first) over a utilitarian approach (safety of the majority), is discussed later in the Liability and Insurance section.

A single unified "rule book" would be more easily understood, trusted and adopted by people. A potential solution to this would be that of a sort of "Moral Code of Conduct" as we're calling it, where the term "code" has a dual meaning – the programming language and the set of rules by which AVs must abide. This will need to be region-specific, as attitudes change from country to country, continent to continent, country to city, etc.

Brands could still differentiate their offering in other ways, through user experience (discussed in detail in Brand & Service Experience), but the ethical basis (or lack thereof) should be identical from manufacturer to manufacturer. This is similar to how commercial airlines all operate under the same governance of air traffic control.

So who should take charge and regulate this moral code of conduct? The UK government? The US Department of Transportation (USDOT)? Jeremy Clarkson? Research[10] from academics in France and the US suggests that such a governance may actually be detrimental to the adoption of the technology:

"Regulators will be faced with two difficulties: First, most people seem to disapprove of a regulation that would enforce utilitarian AVs. Second – and a more serious problem – our results suggest that such regulation could substantially delay the adoption of AVs, which means that the lives saved by making AVs utilitarian may be outnumbered by the deaths caused by delaying the adoption of AVs altogether. Thus, car-makers and regulators alike should be considering solutions to these obstacles."

Bonnefon, Shariff and Rahwan

While this research suggests that this sort of enforcement could actually slow the adoption of the technology, we believe that it is necessary, and indeed a prerequisite, for the technology to be adopted at all. Without it, you'll find people simply won't adopt the 'for the greater good' technology, favouring the AV that protects only themselves. It's easy for us to say, but this should be done as quickly as is possible to minimise that risk posed by Jean-François Bonnefon, Azim Shariff and Iyad Rahwan.

So how can we mitigate this friction? The Moral Code of Conduct could be written collaboratively by all the major stakeholders, including the OEMs, the government, and legislative bodies, but more importantly, by the people, facilitated and fueled by research studies such as MIT's Moral Machines. In this way, the image of "Big Brother" could be softened and the code would feel more like the voice of the people, engendering greater trust and hopefully, faster adoption. The beginnings of such a project have been alluded to by USDOT and the UK government, but we have yet to see how this will be carried out in practice. BMW has recently invited Intel (including recently acquired MobilEye), Delphi and others to hop onto their platform for AVs[11]. This is a very good sign, we hope they meaningfully consider the sorts of human factors we have been discussing.

As serious and challenging as these moral dilemmas may be, for the technology to be accepted and adopted, such incidents will need to be rare, and we are confident this will be the case. Incidents like these will be seen as the technology's gaps in understanding due to the infinite number of possible scenarios. The industry will learn from these mistakes and improve the technology as a result, making such dilemmas iteratively rarer as adoption increases, much like we have seen over the decades in the commercial aviation industry.

Therefore, attention should be placed on avoiding getting into these dilemmas in the first place.

OPPORTUNITY 3: AVOIDING THE ETHICAL DILEMMA

“The two, the car and the road, are both essential to the realization of automatic safety.”

Norman Bel Geddes

Where autonomous vehicles mingle with manually driven cars, cyclists, or pedestrians, a number of pre-emptive measures could be put in place to prevent the trolley problem from ever occurring. All technologies must meet certain safety criteria before they are allowed into the public domain. Unfortunately for us road users, the technology in this case is moving quicker than the regulators USDOT and the National Highway Traffic Safety Administration (NHTSA) can keep up with, and they have only recently started to draft the beginnings of safety standard measures[12].

We believe that the frequency of such ethical dilemmas can be dramatically reduced, not only by adopting the moral code of conduct discussed earlier, but also by putting preventative measures into place that stop these dilemmas occurring at all, especially during the advent and early adoption phase of the technology. Here are just a few preventative measures that could increase the safe and increased adoption of AVs on public roads:

AV-ONLY LANES

Similar to bus and taxi lanes in London, AVs could benefit from their own lane. Unlike buses though, the AVs would have to remain in this lane for the safety of other drivers. This segregation has some issues, such as the potential for bullying and other bad driver behaviours, as well as restricting the AV’s capabilities to learn from its surroundings, but it could be a way to soft launch the technology into the environment. Interestingly, given that many hypothesise that AVs will serve mostly in car-sharing fleets rather than car ownership, AVs could take advantage of the pre-existing bus, taxi and car pool lanes. So, from an infrastructure point of view it would be that one step closer to a full roll-out, at least in city centres.

As it happens, Britain’s first foray into AVs, back in the 1960s, worked on a similar premise. The Transport and Road Research Laboratory modified a Citroën DS19 to follow cables buried in the road, which they installed and tested on the M4, under the outside lane between Slough and Reading – where they still lie today.

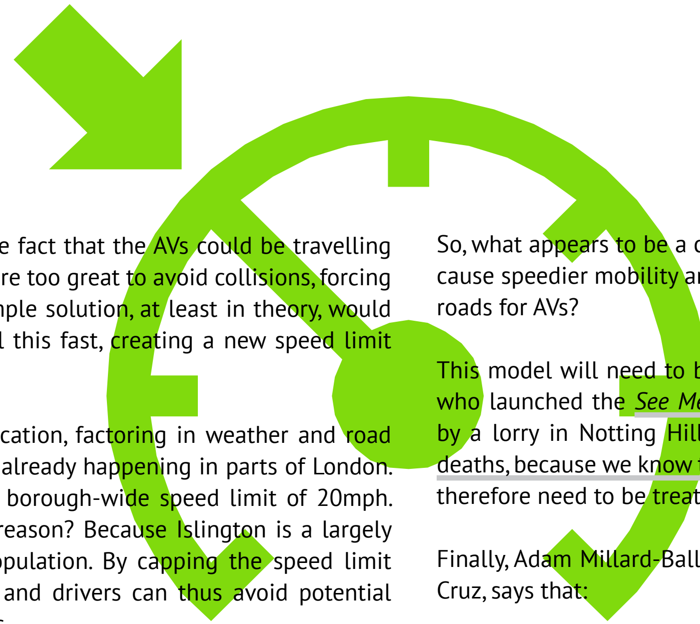
TRAFFIC TYPE RESTRICTIONS

Rather than segregating AVs physically, “breaking them in” slowly from one traffic condition to the next might be a neat way for them to both learn from, and integrate with, other humans, drivers, and pedestrians. A bit like starting off in the shallow pool before you get to the deep end. This is the way in which Tesla’s Autopilot works, which is intended only to be used on highways rather than in urban environments[13], although there isn’t anything stopping the driver from doing so.

Currently, autonomous driving should only really be used on highways – environments with fewer obstacles and pedestrians – which are arguably less complex than city environments. Once confidence levels rise, AVs could be allowed to move up to the next level of traffic complexity, such as highways in extreme weather conditions. From there, they could move into suburbs, then into town centres, and so on – the levels being dependent on how complex the environments are from an AV perspective.

This should be a regulated, phased release strategy, with the launch of each phase widely publicised to make people aware of new AV presence in any given environment. Much like a learner driver brandishes a recently passed plate, the AVs could feature a similar icon, which could be removed once a certain confidence level is met. This does, however, leave them temporarily open to bullying or being taken advantage of, which we discuss later in this section. The AV will thus slowly be able to integrate with all forms of traffic and the humans involved; passengers, drivers and pedestrians will also start to learn from them and know what to expect.

SPEED LIMITATION



Many of the trolley problems arise from the fact that the AVs could be travelling at speeds at which the stopping distances are too great to avoid collisions, forcing potentially fatal evasive manoeuvres. A simple solution, at least in theory, would be to ensure that AVs simply do not travel this fast, creating a new speed limit specifically for them.

This limit could vary from road type to location, factoring in weather and road conditions. On a human driver level, this is already happening in parts of London. The Islington area of north London has a borough-wide speed limit of 20mph. No vehicle can travel over this limit. The reason? Because Islington is a largely residential area with a majority family population. By capping the speed limit at 20mph, stopping distances are shorter and drivers can thus avoid potential collisions, reducing road injuries and deaths.

When the speed limit was implemented, the then Mayor of London, Boris Johnson, said: "This doesn't necessarily have a huge impact on average speeds or journey times through these locations, but does have an impact on injury rates."

Potentially then, by lowering the speed limit to enable safe stopping distances in populated areas (opening up on highways with little pedestrian presence), AVs could still get you to where you want to get to on time – with added safety benefits. In fact, a Transport for London (TfL) experiment[14] showed that stopping all together could get commuters to work quicker! The encouraged social norm at London Underground stations is to stand on the right side of escalators, so that people in a rush or up for a bit of exercise can walk on the left. In the 2016 six-month experiment at Holborn station, TfL enforced that all people stand, on both the right and the left hand side of the escalator. Although results were somewhat mixed, station capacity was increased by up to 30% and congestion was "notably lessened" thanks to the escalators being able to carry an average of 151 passengers rather than the usual 115.

So, what appears to be a counterproductive move – reducing speed – can actually cause speedier mobility and improved safety. Could this concept be applied to our roads for AVs?

This model will need to be calculated on a vehicle-by-vehicle basis. Kate Cairns, who launched the *See Me, Save Me*[15] campaign after her sister Eilidh was killed by a lorry in Notting Hill, said: "Reducing the speed of trucks will not prevent deaths, because we know that a lorry can kill at 2mph." [16] Passenger vehicles might therefore need to be treated differently to haulage vehicles.

Finally, Adam Millard-Ball, in a new study from the University of California, Santa Cruz, says that:

"Because autonomous vehicles will be risk-averse... pedestrians will be able to behave with impunity, and autonomous vehicles may facilitate a shift toward pedestrian-oriented urban neighborhoods."

Adam Millard-Ball

Perhaps this makes the trolley problem even less likely to occur.

ISO 7000-2047
Cruise Control

DP.08

OPPORTUNITY 4: ADOPT OUR FLAWS, BEND OUR LAWS

While the trolley problem poses the largest risk and the most challenging ethical dilemma, it will also be the rarest. As shown in the Morality Pyramid for AVs, the most common of all ethical concerns are those encountered daily – the very human challenges of common courtesy and the observation of social norms.

Let's use our earlier example to see what design principles we can unearth. Once again, imagine an AV is idling in traffic, when suddenly the cars ahead start to move. The car directly in front does not move on, because the human driver behind the wheel does not notice the traffic has eased. The AV can do nothing but wait patiently. According to the UK Highway Code, it is unsafe to sound the vehicle's horn to get the driver to move on, because that might act as a false and dangerous instruction to others around (more on that later). Effectively, the passenger is stuck limbo, with all control left in the hands of the inattentive manual driver, causing frustration and the late arrival to an important meeting.

When we design at ustwo, we use conventional UX patterns to supplement our work because they are already understood by users, we leverage pre-existing human behaviours and take advantage of those in our designs, and we contribute code and design guidelines to the community via GitHub and the like to help establish these norms.

DESIGN PRINCIPLE UNLOCKED:

08. ACT HUMAN, BE ROBOT

Utilise both human and machine advantages by instilling the beneficial nuance of human behaviour while exploiting technological benefits ie quick response times of machines.

So how should the AV handle this situation, that of being stuck behind an unobservant driver? Well, despite what the Highway Code says, the AV could act like a human – honk the horn. However, the robot has the benefit of an acute awareness of its surroundings, as well as being devoid of emotions that lead us humans to do stupid things. All that's needed is a simple "pip" of the horn, rather than an aggressive, drawn-out "hooooooonk." This polite "pip" could additionally have three design characteristics that could mitigate the safety risk highlighted by the Highway Code:

"Ahem": The emitted sound could be horn-like, but differentiated to appear separate and new. Currently, the cars pip of a horn is the driver's equivalent of the person's "ahem" when trying to get attention. The sound the AV makes in this situation could be an AV equivalent.

Situational awareness: Given the AV's increased sense of situational awareness, the sound could be emitted only when it is safe to do so. This is something Google has started trialing, with Google cars which are "polite, considerate, and only honk when it makes driving safer for everyone." [17]

Direct communication: This couldn't happen presently, but technically speaking it is feasible that the AV could talk directly to the inattentive driver in front. For example, if bluetooth could be used for vehicle-to-vehicle communications, on a restricted, temporary, yet open authorisation, the AV's audio signal could play through the manual car's internal speakers, or even the driver's smartphone. There is strong potential for vehicle-to-pedestrian communication here too. If a vehicle needs to get the attention of a single individual pedestrian safely, without alarming others around it, this could be done via their smartphone or wearable device.

How does this "act human" design principle work for other ethical social norm scenarios? A pre-existing example is that of Google's Waymo project.

Google has been testing its AV for some years now. One of its early and persistent problems, is that other cars have human drivers in them. Unpredictable, impatient, selfish people commanding the vehicles, which poor Waymo finds hard to understand. So when the Waymo rolled to a stop at a junction, as it should, stopping within the correct and legally prescribed distance from the road markings, it would wait, and wait, and wait… None of the human drivers would let it in, because it was too timid and thus it became stuck. Much like our earlier example, this would prove increasingly frustrating for any passenger, or indeed someone waiting for a parcel to be delivered by the Waymo.

What should Waymo do? Act human. Google learned from this scenario and tweaked the "personality" of the car, so that it edged ever so slightly forward at the junction, rather than waiting patiently. To human drivers, this is a recognised behaviour, universally understood. The result – drivers slowed to let Waymo out, allowing it to continue its journey alongside its fellow motorists, having gotten to know us humans that little bit more. It's funny that to be successful, the robot must display human flaws, including being a little creative with our rules.

This principle should only be applied up to a point, hence the addition "be robot". After all, humans are responsible for the majority of road accidents and the whole point of AVs is to mitigate that. So AVs should behave more like humans, but marry the benefits with their own robot strengths, such as its increased situational awareness, decision-making capacity, and the ability to act without detrimental emotional baggage.

There is opportunity here for frustration to creep in. If an AV slows to allow a manual driver to merge into the lane, this could irritate a time-poor passenger.

CAUTION YOUR BLAST

DP.09

OPPORTUNITY 5: STICKS AND STONES

Google's Waymo has faced many other similar human problems at intersections. Take for instance this case in which a cyclist met with Google's car and began to test how the AV operates, taking advantage of the good nature of its algorithm. Road Bike Review forum user Oxtox spoke of his liaison with Waymo:

"It apparently detected my presence... and stayed stationary for several seconds. It finally began to proceed, but as it did, I rolled forward an inch while still standing. The car immediately stopped... I continued to stand, it continued to stay stopped. Then as it began to move again, I had to rock the bike to maintain balance. It stopped abruptly. We repeated this little dance for about two full minutes and the car never made it past the middle of the intersection. The two guys inside were laughing and punching stuff into a laptop."

Oxtox
Road Bike Review forum[18]

DESIGN PRINCIPLE UNLOCKED:
09. RESPECT FOR THE FAST METAL BOX

The AV does not need to be submissive to the actors it shares the road with, it just needs to convey an understanding of the situation. We feel that AVs need to be treated with the same respect as a person would treat any other vehicle or machine so that it can safely integrate with society.

As this new technology is rolled out onto our roads, people will inevitably want to test it, even if just for fun. As the technology becomes more commonplace and less of a novelty, this fun will wear off. However, people may still want to take advantage of it in other ways, for example to get ahead and thus to work quicker. Although AVs may display human-like behaviours for the sake of better integration with human traffic, they will still need to put safety first. People will know this and take advantage of it. However, a balance should be met, whereby the AV's intentions, and that of its passengers, are respected just as much as those of a human driver.

The AV must command respect to remain viable. If manual drivers and cyclists take advantage of the robot's safety features, its inherent benefits could actually prove dangerous to the passenger of the AV. Research suggests[19] that manual drivers may drive more erratically around AVs due to their lack of respect for the technology, knowing that they can take advantage. This not only has safety consequences to the passenger of the AV, but to other manual drivers and cyclists too. Our study participant, young Yeva even suggests drivers may be distracted by the very sight of a driverless car.

The lack of respect we're seeing for pilot AVs such as Waymo is one thing, but we doubt that the same attitude would be displayed to commercial, passenger-carrying vehicles – they are after all, carrying live people. However, bullying seems almost inevitable for AVs carrying non-human loads. How can we mitigate this problem?

Segregation and discrimination have long been part and parcel of human bullying. For that reason, one mitigation strategy could be to incorporate ambiguity as to who or what is driving the car. Volvo is doing just this with its AV XC90 vehicle, coming to London in 2018, called Drive Me[20] which has no obvious markings to single it out as autonomous:

> *"From the outside you won't see that it's a self-driving car... just to be on the safe side they will all be unmarked cars. I'm pretty sure that people will challenge them if they are marked by doing really harsh braking in front of a self-driving car or putting themselves in the way."*
>
> **Erik Coelingh**
> Senior Technical Leader, Volvo Cars[19]

Erik Coelingh, senior technical leader at Volvo Cars, believes that the visual similarity to other cars is key to ensuring that the XC90 is not discriminated against. However, this vehicle will have a person behind the wheel, which helps. In the future, if there is obviously no one behind the wheel, how do you mitigate against bullying there? You could black out the windows so that you can't see whether there's a driver or not, but there may be other non-visual tell-tale signs that give it away – like how the AV behaves.

Anthropomorphisation is an approach that could work. As discussed earlier, anthropomorphising objects, and indeed machines, can trigger the profound human response of familiarity and connection. A car that appeals cute and animal-like, like Google's test AVs that look like koalas (to us, at least), will be perceived as such, embodying that persona. This may make drivers and cyclists respond differently. Empathetic people (known in this context as "high trait empathy") will be kind, but others will be more sceptical and may still treat it poorly regardless, just like the HitchBot[21] example in the Human–AV Interaction section.

"I'D BE A BIT SHOCKED. IF IT THE AV WAS DRIVING BETTER THAN ME, I WOULD BE EVEN MORE SHOCKED AND I WOULD JUST LOOK AT, STARE AT IT AND I MIGHT CRASH."

Yeva, ustwo study participant

A more appropriate design of personality might work better. Imagine the Google koala car next to an autonomous Humvee – you'd respect the Humvee. That thing could do you some serious harm if you mess with it, it is military hardware after all. This idea is something that our study participant Neil takes one step further:

"THE BIGGER YOU ARE THE MORE ROAD PRESENCE YOU HAVE, THE MORE IT KIND OF INFORMS YOUR SOCIAL STATUS AND GIVES YOU KIND OF... YOU CAN DO WHAT YOU WANT. IF YOU'RE IN A BIG CAR ON THE ROAD, IT'S KIND OF LIKE AN ARTIFICIAL KIND OF POWER-UP, I SUPPOSE, FOR PEOPLE, SO I THINK IF CARS ALL DRIVE THEMSELVES AND THEY'RE ALL RELATIVELY DEMOCRATIC IN THE WAY THAT THEY'RE DEPLOYED, IT KIND OF CHANGES THE BALANCE OF POWER."

Neil, ustwo study participant

Waymo

Neil is an avid cyclist, commuting in and out of London everyday, so he knows how dangerous it can be to share the road with cars. As a cyclist, he looks forward to this hypothesis of a democratic nullification of status, in which all vehicles can be trusted, either through the shedding of any anthropomorphised sense of vehicle personality:

This embodiment of personality is not new to autonomy – car exterior designers are all about personality and proportions of the vehicle – something we learned more and more about when we attended Ian Callum's DandAD lecture on his experience over the decades at Jaguar Land Rover in 2017.

So, when designing the exterior of AVs, designers may want to continue this "personality design" attribute, but with a new approach. AVs should look friendly, but also command respect from the humans around them.

"CYCLISTS AND PEDESTRIANS, PRESUMABLY, BECOME MUCH MORE IMPORTANT, YOU KNOW, AN AUTONOMOUS VEHICLE COULDN'T POSSIBLY HIT ONE, SO THAT WOULD BE INTERESTING FROM A SOCIETAL LEVEL. IT'S KIND OF LIKE THE CAR IS LESS ABOUT STATUS AND IT'S JUST ANOTHER FORM OF TRANSPORT — I COULD SEE THAT HAPPENING. THE BALANCE OF POWER COULD BE REALLY INTERESTING, AS A CYCLIST, YOU NORMALLY HAVE A CLOSE CALL EVERY COUPLE OF DAYS DON'T YOU... I WOULD FEEL SAFER AMONGST AUTONOMOUS VEHICLES."

Neil, ustwo study participant

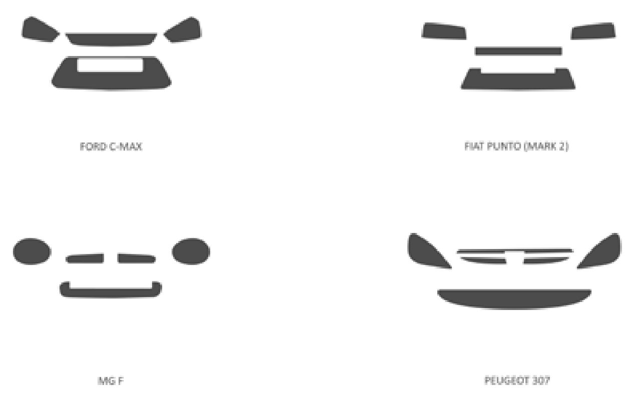


Illustration by Kyle Bean – thanks Kyle!

As an aside, remembering the utilitarian approach from before, would an AV prioritise a cyclist without a helmet over one with? Would it effectively reward the bad habit of the helmetless cyclist?

OPPORTUNITY 6: WHEN THINGS GO WRONG

No matter how safe any mode of transport, things do go wrong occasionally and this will certainly be the case with AVs. We discuss later in the Liability and Insurance section how insurance might mitigate concern and cover damages when a passenger comes to physical harm, but what about when the passenger's vehicle causes harm to others, leaving the passenger in an emotionally unstable condition?

Earlier we highlighted how their Mercedes-Benz's position on protecting the passenger above all else is problematic, or at least somewhat incomplete. Mercedes-Benz's answer to the trolley problem is simple – you can only guarantee the passenger's safety and no-one else's. This is an interesting notion, but this means that consideration for the passenger ends at the point of impact. What about the survivor's emotional safety?

Let's imagine you are the passenger of an AV and you're accompanied by a friend. An extremely rare circumstance has arisen in which the vehicle has only two options – avoid a pedestrian who has walked into the road thereby killing both passengers, or remain true to its course and kill the pedestrian. Given the utilitarian moral code it is operating under, the AV will do the latter and kill the pedestrian. Hit and run laws would require the vehicle to stop as soon as it could afterwards, but a life will still have been lost.

This is the part of the story where most thinkers in this space end the debate. But let's play out how this is observed and felt by the passengers after the incident. To the passengers, the vehicle would either appear to have:

- developed a fault, resulting in a terrible mistake
- **mercilessly killed someone, to save them**

The latter case comes with some extreme emotional ramifications. Not only would the passengers have experienced a traumatic incident, but they may also feel responsible. After all, they have entered into a tacit agreement by using the AV that the robot would do such a thing in such rare circumstances. They may feel selfish in allowing the incident to happen. These instances will be extremely rare, but the emotional damage caused to passengers will be considerable. This is a somewhat new concern for AVs, at least in the public domain – it does not seem to be the case with autonomous trains, for example.

Given that the passenger is commanding the vehicle, they may even feel as responsible as if they were actually driving it. We know that professional drivers, such as train drivers on the London Underground, suffer from severe emotional trauma when their vehicle kills someone. With trains they are often travelling too fast to stop, the driver powerless to prevent the death, but they feel responsible nevertheless. This is the trolley problem, but from the post-incident, passenger perspective. Further to this, the AV will need to inform the passenger of its decision making process and the rationale behind it, justifying its actions. This will also need to be documented, like a black box, for legal and insurance purposes.

TfL train drivers who have encountered "passenger under" suicide incidents are entitled to free therapy to help with their post-traumatic stress. In 2015, TfL paid £145,000[22] for such treatment. We believe that passengers of autonomous cars involved in similar incidents will likely need similar help to treat the emotional trauma they will experience. The OEMs or service providers responsible for the AVs should either offer this as part of the service or consider it when costing such services, which could include insurance policies.

While we believe, like Paul Jennings, that fatal accidents will be rare, they will happen, and when they do, who's to blame? Even more importantly, what should happen in the event of an accident, when there is no driver? We discuss these themes and more in the next section on Liability and Insurance… which is not as boring as it sounds!

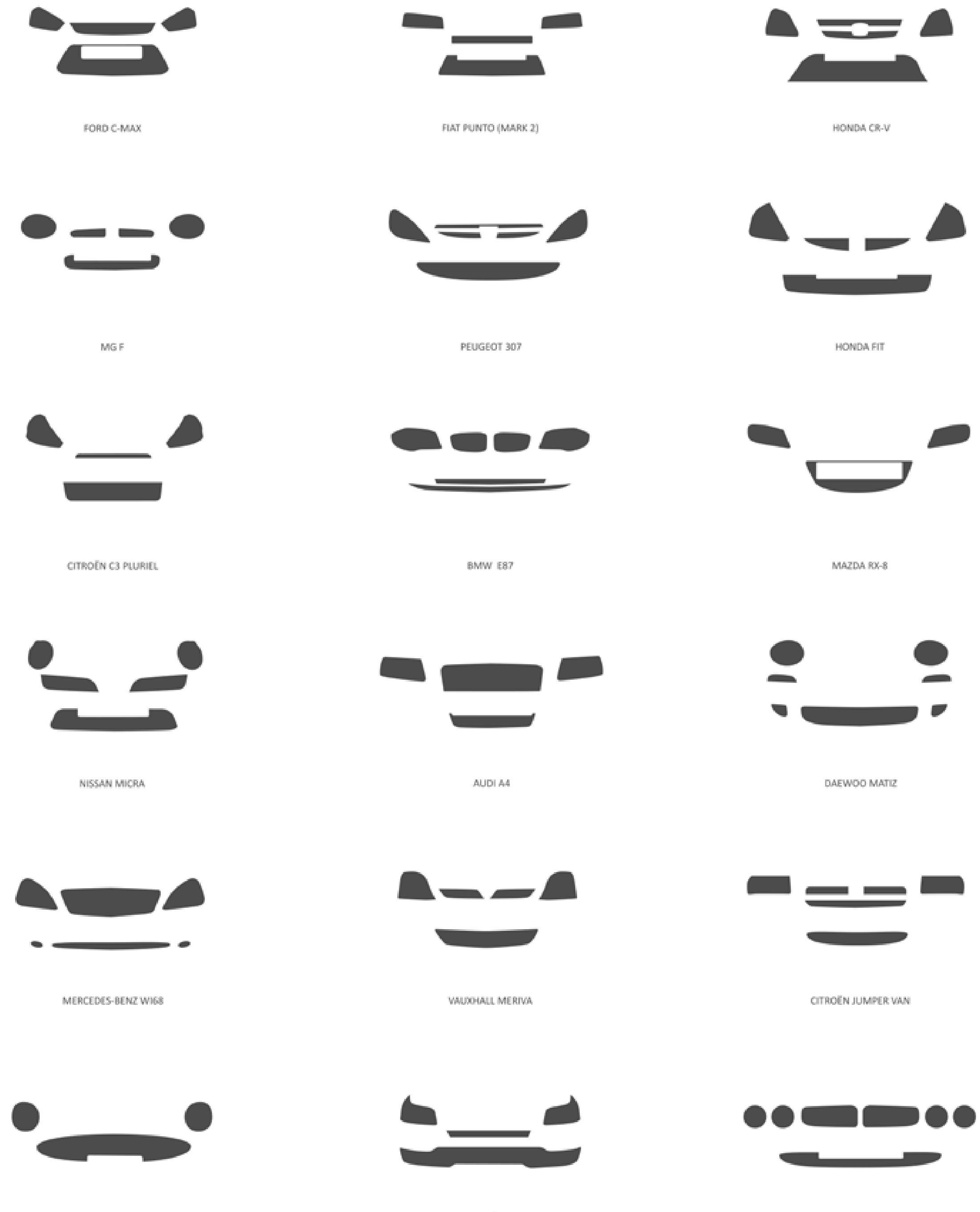


Illustration by Kyle Bean

SOURCES

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The Survivor
by Pete Fowler
Year: not that far in the future

"A vehicle that gives you comfort and safety during the approaching apocalypse with a very economical fuel consumption.

Everything you need is inside so you don't need to step out into the Mad Max style environment."


ustwo
AUTO

CAN THE ROBOT CAR BE HELD RESPONSIBLE?

Topic: Liability and Insurance

51 minute read

"AUTONOMOUS CARS COULD HAVE FAULTS WHICH END IN FATALITIES BUT WHO GETS SUED THEN? WHOSE FAULT IS IT THEN? IF THE VEHICLE HAS A FAULT IS IT THE PERSON WHO OWNS THE VEHICLE? IS IT THE PERSON WHO ACTUALLY MANUFACTURED THE VEHICLE? IS IT... WHO IS IT?!"

Dave, ustwo study participant

SUMMARY

Who is accountable for an autonomous vehicle accident? These considerations already shape the research and development of autonomous vehicles – with many OEMs accepting liability this early on to remove the barrier to adoption that ambiguous responsibility for accidents creates.

However, the fundamental question of who is to blame in such an incident remains unanswered. Is it the driver, the car maker, mother nature or the AV itself?

We discuss why policy makers and car makers, insurers and consumers all need to write the rules together, with a human centred approach.

INTRODUCTION

As human beings, when something goes wrong it's in our nature to find the fault and place blame. This is because we want to fix what's broken so that the issue doesn't recur and we want those responsible to be held accountable. When an accident occurs involving an Autonomous Vehicle (AV), with no one behind the wheel, you can see how pointing the finger might be like shooting in the dark.

To get to the bottom of the issue, it might help us to step back a little and understand how blame is placed today in accidents involving manually driven cars.

Conventionally, there are three main parties[1] on the chopping block for an accident on the road:

1. The driver(s): either one or many.

2. The OEM: who have ultimate responsibility for the failings[1] of the entire car, even if the fault occurred with a part manufactured by a third party (ie a tier-one or tier-two supplier). Crucially, this potentially includes software.

3. Mother Nature: sometimes she'll throw a hurricane your way and the consequences aren't anyone's fault. This also includes failings of the city.

But when it comes to AVs, you could argue that the driver should be struck from the list. However, in this context, the term "driver" is somewhat ambiguous. Let's take a look at what the term can mean in the context of AVs.

Driver as the driver. Let's start with the obvious one. Eyes on the road, hands on the wheel, feet on the pedals. The person driving the car in old-school mode, despite its autonomous capabilities.

Driver as the occupant of the driving seat. You might think this is an obvious one: the driver is the person driving the vehicle, in the driving seat. However, with varying levels of autonomy, it's hard to know when the person in the driving seat is driving or merely "commanding" the vehicle. Even on today's highways, Tesla's Autopilot can do all of the work for you, while you recline in the driver's seat. (That said, the occupant of the driving seat must be alert at all times, with their hands on the wheel.)

Driver as the passenger. If the first definition was full-on old-school manual driving and the last the vague middle ground, then this one is the definition of full-autonomy – eyes on smartphone, hands on burger, feet in foot spa. Owned or shared car, it doesn't matter, the passenger is not paying attention to the road – or anything outside the car.

Driver as the owner (within the car). Driving or reclining, eyes on the road, or eyes on Facebook, the owner of the vehicle could be the main user of the vehicle, riding it to and from work everyday. In an accident, as both passenger and owner of the vehicle, could he or she be held accountable for the vehicle's actions? In their paper Pathway to Driverless Cars[2] the UK Department for Transport (UK DfT) suggests an amendment to the Road Traffic Act, making the 'registered keeper' liable for insurance purposes, rather than the current 'user' meaning the driver. This might seem unfair, but when you consider that when a dog attacks another person, the human owner, regardless of their involvement will be held accountable and punished by law as a result – this too could be the case for AV ownership. This could create another potential barrier to adoption, as discussed earlier in the Morality & Ethics section. Not only are people nervous about getting into an AV that might risk their lives to save others, but they may also be nervous about owning an AV whose potentially fatal errors would fall under their responsibility, just as ustwo study participants Dave and Yeva expressed. Admittedly, a dog can't be taken to court, but a car manufacturer can…

Driver as the owner (away from the car). What if the owner of the car isn't using it when it causes a collision? For example, a 'landlord' of a fleet of cars or indeed a service company such as Uber or in use cases covered by third party insurance. If the AV is not maintained as prescribed by the manufacturer, the responsibility may then fall into the lap of the owner, who could be thousands of miles away when the accident occurred. This would mean the vehicle would need to constantly update the owner on its status and condition, making him or her aware of any degrading functionality or problems.

The first two definitions place responsibility clearly in the driver's camp – if they get into a crash, it's likely to be their fault in some way. Even in the second definition, despite the occupant of the driving seat not necessarily making the driving error, they would still be held responsible as they should be alert at all times to correct the vehicle's mistake, as described by the US Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA) and UK Department for Transport (DfT). This is particularly alarming when it comes to the "handover", where the AV can no longer handle a situation and shifts responsibility over to the human, instantly changing their role from passenger to driver, all at 70 miles an hour.

It's those latter definitions, when there is no human driver – level 5 autonomy – where things get ambiguous. Just when you might think that there is no single person at fault, other than the car itself. Interestingly, researchers from Stanford and Brown Universities add that fourth party to the list of those responsible in their experiments:

1. The driver(s)
2. The OEM
3. Mother Nature
4. **The AV itself**

How can you place blame on an inanimate object? Well, it is an inanimate object that 'thinks'.

In their experiments, published in their paper From Trolley to Autonomous Vehicle: Perceptions of Responsibility and Moral Norms in Traffic Accidents with Self-Driving Cars [3], Stanford University (including Wendy Ju) and Brown University put the car forward as potentially liable for an accident, because it is effectively acting as an agent (defined as a person or thing that takes an active role or produces a specified effect), making its own practical and ethical decisions (though we challenge this in the Morality & Ethics section) – both human-like attributes. Given that AVs may also have some form of additional anthropomorphism – like Google's driverless koala-like vehicle – you can see why people might point their finger at the grill of the driverless car.

While people may naturally blame the car itself, in the same way a dog handler is blamed for any harm their dog causes to another human, it may well be that the owner is really blamed for the vehicle's actions. However, the same research suggests that people would place more blame on the OEM of the vehicle, rather than its direct owner. This would suggest that the public do not currently consider AVs as agents and therefore to blame – and remember that this same public would also be on the jury.

We find it interesting that while the adults in studies like those above put less blame on an autonomous car than a driven one, implying they trust the ability of a driverless car more than a human-driven one, all the children we interviewed believe that robot cars will malfunction and cause havoc.

In the case of an incident between a car and a pedestrian, most people already place less blame on a driverless car than a driven one [3]. Whether people will blame the car itself or not, ultimately it's who is held accountable that matters, and a car cannot be taken to court. As Santa Clara University details in their fascinating paper, The Coming Collision Between Autonomous Vehicles and the Liability System [4], ultimately it's the manufacturers who will be held accountable.

"Even though an autonomous vehicle may be safer overall than a conventional vehicle, it will shift the responsibility for accidents, and hence liability, from drivers to manufacturers. The shift will push the manufacturer away from the socially-optimal outcome – to develop the autonomous vehicle."

The Coming Collision Between Autonomous Vehicles and the Liability System, Marchant & Lindor, Santa Clara Law Review

The OEMs will be fully aware of this. In fact Mercedes-Benz, Volvo, and Google have already announced that they will accept liability when their vehicles cause an incident in autonomous mode (note the emphasis on autonomous mode here – they still intend their vehicles to be driven). To a degree, this flies in the face of policy makers, such as the suggested amendments to the UK's Road Traffic Act which place liability on the AV's owner (rather than the driver, as now). It might seem counterproductive to even announce such a position to the press and general public, as any discussion of AVs going wrong is often met with trepidation. But the reason that these OEMs have accepted this liability early on is to remove the barrier to adoption that ambiguous responsibility for accidents creates.

This can be seen in the case of Volvo, whose CEO Håkan Samuelsson plans to loan 100 XC90 SUVs designed to drive in full autonomous mode to local families in Gothenburg on a trial basis. To clarify the ambiguity before the trial, Volvo has stated that it will take the rap for autonomous accidents. A follow-up pilot on parts of the London M4 will commence in 2018.

Mercedes-Benz, the self-proclaimed "first car brand in the world" and keen to become the first true AV brand, has recently made announcements intended to side-step two potential barriers to adoption. The first is who the car will protect in a trolley problem-like situation? Their answer? The passengers. After all, who would want to own or ride in a vehicle that sacrifices their safety over others (discussed in more detail in the Morality & Ethics section)? The second barrier removed is that of liability in a collision, which of course has further insurance ramifications. In this case, Mercedes-Benz will take full responsibility. Controversial or not, it's evident Mercedes-Benz is thinking of the customer first, removing moral and legal ambiguity, and thus making the road to adoption that much smoother.

So, we've ruled out the driver (as a passenger) and the owner as liable for fully-autonomous accidents, and of course Mother Nature is off the table. Thus it seems that the finger can well and truly be pointed at the OEM, and as discussed above, they are beginning to accept that. The problem the industry now faces is a reluctance to innovate as a result of potentially overwhelming liability claims. In the aforementioned paper, researchers at Santa Clara University predict that by negating driver liability in road accidents, the automotive industry may face an influx of liability claims, with which will come significant financial baggage. This poses another threat to the adoption of AVs: if the OEMs face mounting liability, they could become increasingly nervous to innovate and thereby slow the adoption of the technology. As we saw earlier with the moral barriers to adoption, the longer the take-up of the technology, the more lives are lost at the wheel of the manually driven car.

What sort of cases could be brought against the OEMs? The US liability system punishes what is known as "sins of commission[5]" whereby blame can be placed even when a once non-existent solution goes wrong. Imagine cars before airbags were introduced. In a collision, where the driver injured his or her head on the steering wheel, blame would probably be placed on the driver who collided with the rear of the vehicle and not the OEM. Now imagine the same accident a year later, but now the car is fitted with a steering wheel airbag. If that airbag fails to deploy, and the driver is injured as a result, the OEM would now be held liable for its faulty safety feature. This is a sin of commission, which is easier to argue than the absence of an airbag altogether (a "sin of omission"). This is precisely what happened to General Motors when it was sued $18.5 million when passenger-side airbags failed to deploy in a collision with an 18-wheeler, severely injuring the passenger, despite the fact that the safety feature was not an NHTSA requirement at the time, according to the same Santa Clara Law review. We wonder whether this feature was used to promote and help sell the car and, if so, does that factor into who is liable for the incident?

The UK DfT believes that, using minor amendments to fault, negligence, and product laws, the issues surrounding liabilities for AVs can be accommodated without the need for a whole new liability scheme:

"We are not currently proposing any significant change in our rules on liability in road traffic accidents to reflect the introduction of automated cars. We still think a fault-based approach combined with existing product liability law, rather than a new strict liability regime, is the best approach for our legal system. We think that the existing common law on negligence should largely be able to adapt to this new technology."

Department for Transport[2]

BETRAYAL AVERSION

Think, for a moment, about vaccines, where the sensationalist media dramatised and even demonised the technology when things went wrong. For a vaccine to work it requires majority adoption. Yes, occasionally individuals face adverse reactions to vaccines, which can even be fatal. While unfortunate, these instances are isolated cases – where every one death represents thousands of lives saved by that very same solution. Much like vaccines, for AVs to be truly successful in reducing the number of lives lost on the roads, the AV with the utilitarian algorithm (see the Morality & Ethics section) must be adopted by the majority, certainly within cities. Tesla's fatal Florida crash on May 7th 2016, in which Joshua Brown sadly lost his life, occurred after 130 million miles of Autopilot use globally. This compares very favourably to the average 94 million miles of driving per fatal car crash in the United States (on highways only), and is likely to further improve.

Despite impressive safety records and the high potential numbers of lives saved, both vaccines and AVs face a similar barrier to adoption as a result of media headlines. "Betrayal aversion" is a concept whereby individuals have a fear of adopting or using a certain technology (or vaccine) because of the dramatised harm they have previously witnessed, for example in the media, even if the net effect of the innovation is improved safety. A good example of this is a fear of flying. Despite the odds of being involved in a plane crash being only one in 11 million, and that getting to your destination by plane is far safer than by any other mode of transport, fear of flying is very real to many people. By comparison, the chances of being involved in a car or traffic accident are one in 5,000.

DEATHS PER 1BN PASSENGERS MILES

Figures: 2000 - 2009, US
Data: Northwestern University

Flying is the safest mode of transport in the world, yet crashes are heavily reported in the media when they occur, precisely because they are so incredibly rare and therefore prone to being over-dramatised, potentially causing isolated cases of fear.

Betrayal aversion is already happening in the AV industry and needs to be addressed. Not that the issue here is revenue, but just as an illustration, in 1978 (the most recent figures we could find) it was forecast that the commercial aviation industry lost $1.6 billion revenue and suffered a 9% reduction in air travel due to betrayal aversion. One can only assume that that has increased along with the popularity of the transport – a significant chunk of which is actively invested in helping people overcome those fears.

LIABILITY AND INSURANCE: THE OPPORTUNITY

"Without certainty of how claims will be handled, there is a risk of customer confusion, which could reduce the sale and use of automated vehicles."

Department for Transport

As we can see, when it comes to barriers to AV adoption in regards to liability and insurance, there are two opposing sides, the industry and the consumer. To ensure the widespread adoption of AVs, future drivers-come-passengers and the industry alike will need to adopt human-centred design thinking and behaviours in order to overcome these barriers.

Here we explain our points of view and some potential design solutions to each of the problems, tackled from both the user and industry perspective.

OPPORTUNITY 1: WHO IS LIABLE?

A consideration most people go through when they're buying something is their responsibility for it. Admittedly, this decision-making factor at the point of purchase can vary in significance. If you buy a pen, it is your responsibility to look after it, but, what if you lose it? A pen never hurt anyone, so you'd just buy or borrow another pen. But what about a weapon? That's a different story, with an awful lot of responsibility, a lack of which could come with some pretty serious consequences and therefore weapon sales are restricted and controlled.

Those are two extremes, of course, one harmless, the other potentially lethal (though they do say the pen is mightier than the sword). How about something in the middle ground, like a car? Cars can be incredibly dangerous if misused and accordingly a licence is required to drive one. People tend to buy cars they feel they can control – nothing too powerful. What about a dog, as per our previous example? A dog is its own being, which can be trained, but also acts with agency beyond our control. However, a dog is arguably a lot less dangerous than a car.

In all of these examples, you make a trade-off when you commit to the responsibility of the item you are buying. It's a trade-off between the control you have over it and how potentially dangerous it is when out of your control – if it's very dangerous, you'll want a high level of control, but with low danger, lesser control is acceptable. Thus, people are comfortable buying a car that they feel more in control of – the high danger reading is mitigated. And because insurance covers them if they do lose control, the perceived danger reading is further reduced.

But what happens when an AV is purchased (or leased, or even borrowed)? The consumer may – and they do according to our own study – feel that they have no control over what is, conventionally, a highly dangerous object. We may be well versed in the safety factors of AVs, but those more familiar with a manually driven car are all too aware of its ability to cause damage, injury and death.

Much like if your dog harms another, your car could too – when you're not controlling it, or even when you're not in the same city as it (imagine a car-sharing scenario). People will not only want to avoid hurting people, but they will also not want to be held liable, and this will make many consumers reluctant to consider acquiring or using an AV in the first place.

"IF NO ONE WAS DRIVING? UM IT WOULD BE THE CAR'S FAULT COS THERE'S NO ONE DRIVING... BUT IF MY DAD DID IT AND THE POLICE SAW IT, THEN I WOULD... WELL... I'M PRETTY SURE A POLICEMAN WOULDN'T PUT A SIX YEAR OLD INTO JAIL, UM IF IT WAS MY DAD THEN... I WOULD PROBABLY TALK TO HIM."

Yeva, ustwo study participant

The UK government has not yet been able to issue clear guidance on this problem and is seeking advice from us all, in much the same way as we suggested should be the case in the Moral Code of Conduct we spoke about earlier.

“When more advanced automated systems are approved and available, which allow the driver to be out-of-the-loop and divert their attention away from driving and actively monitoring for parts of the journey, we will aim to expand on this and provide fuller advice for drivers of automated cars and other road users... We are seeking views on whether to change Rule 160 of the Highway Code which states ‘drive with both hands on the wheel where possible’, to clarify the position for those using in-the-loop motorway assist and remote control or automated parking.”

Department for Transport[2]

This guidance will need to become clearer as we approach the general release of these vehicles for the adoption of the technology to happen. So how do we go about that? We have already established that when it comes to who is liable for an accident in autonomous mode, the OEM takes the blame (unless adverse weather conditions come into play). This is indeed what OEMs and regulators alike are starting to confirm as discussed earlier. It is then the responsibility of these stakeholders to begin communicating this intent, as soon as possible.

Of course it is not quite as straightforward as that. Car manufacturers will want to know exactly what happened in the accident, using a sort of on-board black box to see whether the vehicle was indeed in autonomous mode and whether it was its own autonomy that caused the problem, before they accept responsibility.

In fact, Volvo has already begun negotiating with insurance companies to draw out agreements as to who is responsible in certain situations. “If there is a crash and the car is in self-driving mode, even if the driver is reading a newspaper, then we – Volvo – are responsible” said Erik Coelingh, senior technical leader at Volvo, speaking to The Observer

As things stand currently, the person in the passenger seat would be liable, autonomous mode or not. However, Coelingh is discussing the future of autonomy at level 5 (full autonomy). Coelingh continues:

“The principle is easy. If we can find out the root cause of the problem and it’s a third party, then they are responsible... or if the driver hacked the car or misused the technology then you as the driver or the passenger in the car will be held responsible. But if there is a software bug or whatever that causes a crash then we will be held responsible.”

Erik Coelingh
Senior Technical Leader, Volvo

So there is some ambiguity to the bold claim that OEMs will take the rap. If the user invalidates the warranty, or uses the AV outside of its understood terms, then the user will be liable. These terms will need to be clearly communicated to the owner or user of the vehicle at the point of purchase or use, so that it is clearly understood where the individual’s responsibilities lie. These “small print” details often sting us within insurance claims, but they do raise some very serious safety concerns.

DP.10

OPPORTUNITY 2: T&CS AND INSURANCE POLICIES

While it is true that AV technology is moving faster than the policy makers can keep up with, governments are keen to ensure that use of such vehicles continues relatively unhindered by their policies and intend to maintain liability and insurance standards throughout:

"Our policy objectives are to ensure that the use of vehicles continues to be covered by insurance, and that insurance claims continue to be handled quickly. So, instead of making wholesale changes that would affect every driver in the country, we are proposing to make a set of smaller changes that would only apply to those buying automated vehicles."

Department for Transport

Among the UK DfT's proposed set of "smaller changes" is one that aims to distinguish what (or when) an autonomous vehicle is indeed autonomous:

"To develop a system to classify an automated vehicle so that manufacturers, insurers and consumers know which vehicles this particular insurance requirement applies to."

In other words, all parties, including the user, must know exactly what is covered by autonomy and what the autonomous aspect is responsible for. The user must know when responsibility lies with them and when it lies with the vehicle. This could be achieved through an itemised list of the AV's capabilities, so that the user has a full understanding of when it is autonomous and when it is not, as suggested in The Coming Collision Between Autonomous Vehicles and the Liability System. Taking control of the vehicle when it is no longer safe to operate autonomously – the handover – has its own safety and liability problems, as discussed earlier.

The UK government has not yet been able to issue clear guidance on this problem and is seeking advice from us all, in much the same way as we suggested should be the case in the Moral Code of Conduct we spoke about earlier.

DESIGN PRINCIPLE UNLOCKED:

10. COMMUNICATE CAPABILITIES

The user must understand the capabilities and failings of the AV so that they can either operate it appropriately, ride in fully-autonomous mode safely, or know when it is safe to enter autonomous mode.

This list of capabilities may well be long, but it is necessary for an understanding of responsibility and for operational expectations, and therefore safety. In fact, it is this gap between understanding when the car is responsible and when the user is responsible that killed Tesla Autopilot user Joshua Brown. The use of such a list may sound familiar – in fact, it's what many companies, from Apple to Zoopla, use to cover themselves from liability, in the form of reams and reams of words (sometimes as many as 30,000, according to a Fairer Finance survey [6]) known as terms and conditions. Hardly anyone reads them – according to that same survey, a whopping 73% of people admit to not reading all the fine print. Of those who do, only 17% say they understand it. Personally, we don't believe it is anywhere near this low – if 73% admit they don't read them, there are probably plenty more who won't admit that they don't. After you're done not reading, you click a button, thereby accepting those terms and probably a number of other responsibilities. This is known in legal terms as "the assumption of risk".

You might think: tough, the user has accepted the conditions, in a legally binding contract, so some or all of the faults in the AV can be pinned on the owner. Even if that might be the case from a legal perspective, the UK DfT's proposed amendments to the Road Traffic Act will mean that the owner can still reclaim their costs of liability from the OEM (as is the case now), rendering the OEM ultimately liable. Further, this defence does not often hold up in a court of law, at least in the US:

"The assumption of risk defense provides that a product user who knowingly accepts the risks of a potentially hazardous product assumes some or all of the responsibility for any harm that may befall them from use of the product. Such a defense requires that the product user understand and willingly assume the risks. Thus, for such a defense to apply to autonomous vehicles, the manufacturer would have to fully disclose the potential risks of the vehicle, including the likely failure modes and some approximate sense of their probability. Such a defense would be stronger if the driver of an autonomous vehicle signed a written waiver accepting the risk of the vehicle. Even in these circumstances, however, courts often refuse to recognize the defense."

Santa Clara Law Review[4]

When does the assumption of risk happen when buying or hailing an AV? At the dealership? On the roadside? Online? As the car continues to learn and adapt to its surroundings, and the surroundings to it (eg changing infrastructure), more holes will appear in its experiential understanding. These failings would also need to be communicated to the user. This could result in a perpetual stream of notifications from your car – not a good user experience. The car will also need to communicate when it has a problem through wear and tear that will void the OEM's liability. This will force the owner to maintain the vehicle regularly to avoid being held responsible in case of an accident. Problems like these illustrate why it is generally thought that these vehicles will be largely fleet-managed, rather than consumer-owned.

DP.11

What about when simply taking a ride to work, in a car-sharing scenario, which the majority of use-cases are expected to be? It's not very convenient to have to read a 200-page document on the ins-and-outs of the vehicle's capabilities while you try to get to a meeting on time. Perhaps registering with what we're calling a "Right to Travel Pass" will circumvent this, proving pre-acceptance to certain terms and conditions. Such a pass would contain your personal and payment details to allow you to travel anywhere using any mode of transport, much like London's Oyster card, but far more ubiquitous and perhaps farther reaching (like the ustwo x Garmin project we discuss later in the Branding & Service Experience section).

Ethically speaking, the users of an AV should be made aware of the vehicle's failings and where responsibilities lie. The problem is that this is simply too large an amount of information which we know that consumers won't be able – or have the time – to digest. If we're talking about removing this barrier to adoption, then the simple solution would be that the AV manufacturer or the service provider guarantees that they protect their passengers when things go wrong, not just from a safety perspective, but also from a legal one. If liability never falls on the driver or passenger then people will be much happier to adopt the technology. With the passenger and driver taken out of the liability equation, people will be able to rely on the use of the technology, thus removing this particular barrier to adoption. If incidents are so rare, then perhaps this is a price worth paying for the OEMs.

If an AV should fall into disrepair, the usual laws of neglect in product liability would apply, which would also cause concern for the user, so perhaps even in this instance the OEM could shoulder the responsibility. A way to mitigate the associated cost would be to simply not allow autonomous mode be used if a fault voids the OEM's liability guarantee, meaning that the user will need to drive it manually. (But imagine a future where AVs are self-healing and drive themselves to a garage for repair, while their owners are safely asleep in bed.)

There still remains the problem of how to provide up-to-date information about the car to ensure peace-of-mind, set operational expectations, and ultimately engender trust in the user. How do you provide so much vital information in a way that the user will digest, and maintain that understanding and operational expectation as the vehicle experiences and adapts to the real world? Currently, when Tesla release a new Over-The-Air (OTA) update to their vehicles, often including changes to autonomous features, they come with 'release notes', just like those you see when you update an app on your smartphone. Of course, no one reads these either.

A clever strategy will be needed to convey the information to the user and to maximise the chances of them understanding everything that is required. Here are just five of ustwo's design pointers that could help achieve this aim:

DESIGN PRINCIPLE UNLOCKED:

11. REMOVE ALL LIABILITY FROM THE USER

Liability in case of an accident in AVs is ambiguous and confused. For users to truly adopt the technology, OEMs or service providers should accept liability in 100% of cases, removing that confusion.

1. Information should be clear and concise... and as short as possible
The fewer the number of words, the quicker the read, and therefore, the more likely the user will consume all the information. Be ruthless; scrap any information that is not useful or legally or ethically imperative. Only vital content should be included.

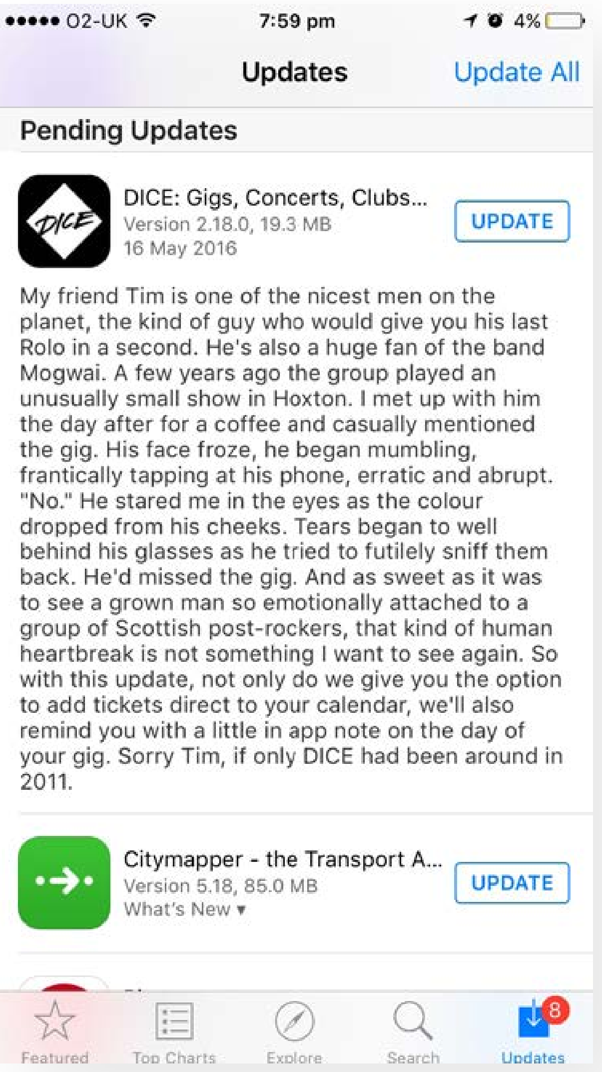
2. Prioritise; drip-feed over time
Prioritise the order of delivery of information. The most vital information should be communicated first. Information could be delivered over time, with a notification or piece of information pre-empting the associated feature as it is used for the first time. This is a design principle we identified in our first book, called 'design in time'.

3. Speak with a native tongue
Obviously people understand information more easily and more quickly if it is in their native tongue. This is particularly relevant in the case of AVs which can cross borders and carry multiple occupants, sometimes strangers of different backgrounds.

4. Make them visual or interactive
Sometimes information is best displayed visually rather than textually. An icon or picture can often communicate a thousand words. Interacting with this information has reinforcement learning benefits too.

5. Fun information is learned information
Making the information fun, humorous, or engaging will provide an extra incentive for the user to invest their attention, much like the aviation industry does to coax passengers into watching their safety demonstration videos. Here is an excerpt from one of our own product's release notes, for our ticketing app Dice:

Tim does love Mogwai. This is all taken very much from the user's perspective, but the industry will also want to provide certain information (terms to which users have to agree), to cover their own liability in case of accidents. This industry perspective has its own motivations and its own challenges, such as the "sin of omission".



Dice update
Written with love

OPPORTUNITY 3: ON-BOARDING

When it comes to liability, it helps to talk about the two opposing forces that come into play. As described earlier, the US legal system operates on sins of commission more so than sins of omission. Let's briefly describe these two concepts:

Sin of commision. A sin of commission is usually a "thing" at fault. If a part in the AV fails, causing an accident, then the OEM will be held liable for the failure of the commissioned part, even if the part was manufactured by a tier-one or tier-two supplier – and this includes software (though the OEM may subsequently seek damages from the supplier). Our earlier example of a failed airbag illustrates this concept well. This can sometimes be negated by applying the standard laws of negligence on those responsible for the upkeep of the vehicle, be it a company or an individual.

Sin of omission. This sin is often harder to prove, and therefore prosecute, as it involves something being left out. Imagine a time before airbags were invented – it would be hard to fault an OEM for omitting to include an airbag before we could even imagine such a feature. However, a sin of omission could include the lack of something that legally should be commissioned, such as an airbag today, or even warnings or instructions. This is far more serious, described here under US products liability law as a defect:

"[a defect is] when the foreseeable risks of harm posed by the product could have been reduced or avoided by the provision of reasonable instructions or warnings... and the omission of the instructions or warnings renders the product not reasonably safe."

US products liability law [7]

This is where OEMs could face huge liability cases if they do not provide adequate and "reasonable" warnings. This is why any fault, or a situation an AV cannot handle, or a scenario that it or its fleet siblings has not encountered must be properly communicated to the user. This is where well-considered and appropriate communication needs to be employed, as outlined in the Terms & Conditions subsection above.

Current terms and conditions, manuals, instruction books, and the like are simply not read by users, especially in the automotive industry:

"The percentage of car owners that actually read their owner's manual is depressingly small."

Karl Brauer
Analyst, Kelley Blue Book [8]

Fiat Chrysler Automobile's (FCA) Uconnect system
The latest Uconnect system provides "effortless accessibility" to vehicle information

This is one reason why the “assumption of risk” argument, which these systems support, is often not upheld in a court of law. This system of vital information delivery is simply not working. Along with other manufacturers, Fiat Chrysler Automobiles (FCA) has moved the owner’s manual for its 2017 Chrysler Pacifica into its new onboard Uconnect infotainment system. This makes it more interactive (digitally speaking), much like we suggested in our design pointers earlier.

“Switching to an electronic version, especially one that can be contextually referenced while using features like in the new Pacifica system, might finally teach owners about their vehicle’s full capabilities.”

Karl Brauer
Analyst, Kelley Blue Book

The problem we see here is that this information is arguably less visible than the physical owner’s manual (even if that is hidden away in the glovebox). This format, the centre console of the vehicle, is far less comfortable, convenient, reliable or even conducive to reading than a good old-fashioned book. And what if the car’s battery is dead? Well, the AV wouldn’t start at all. For these reasons, even fewer people may end up reading this information.

RIDERS LICENSE

When people hop into an AV they need to be "onboarded" as to how the system operates and what happens when the system fails. Once the terms and conditions have been written, we believe that a whole new strategy – we're calling it Gradual Release Information Distribution (GRID) – should be designed to onboard them, maximising the knowledge sharing between the AV and the user.

The GRID strategy could take the form of a "Rider's Licence". Similar to a driver's licence, a rider's licence would operate on a tiered "experience points" system that grants greater access to the AV's features or situations as the user gains exposure to them. In this way, the GRID strategy would hand-hold their onboarding experience so that they would be confident on how the system operates when they hop into the AV.

This strategy is akin to the Compulsory Basic Training[9] (CBT) module that all prospective motorcyclists in the UK have to go through. The CBT was introduced in 1990 as a means of giving riders a basic knowledge of the road, and the limitations and capabilities of a 125cc (or smaller) motorcycle, primarily to reduce the number of accidents caused by provisional or novice riders. The scheme has five parts to it:

- **Element A:** Introduction and eyesight test
- **Element B:** Learning the controls of the motorcycle
- **Element C:** Off-road riding
- **Element D:** Road briefing and safety talk
- **Element E:** Practical on-road riding

The introduction of the CBT has been heralded as a great improvement on the streets. People are more attuned to on-road behaviour and accident rates have fallen – between 1991 and 1996, the accident rate for 17 to 19-year-olds fell by 57% and by 20% for 20 to 29-year-olds.

The proposed Rider's Licence could have a similar format to that of a CBT. Currently, with manually driven cars, the primary purposes of a licence are to prove that:

- you have learned and understand the driving requirements
- you have the skills and capability to operate the vehicle

Fully autonomous vehicles do away with the need for the second point, but point one is still very much relevant. In the UK, after you pass the driving test, you have the option to acquire a 'Pass Plus' licence that gives you greater experience and confidence on dual carriageways. A similar tiered licence mechanic could be applied to the Rider's Licence, whereby a user must first experience residential or urban environments before becoming eligible to move to the next tier that enables them to travel on dual carriageways.

Like FCA's digitised owner's manual, our GRID strategy would mean that users acquire the right knowledge at the right time through a contextual and gradual release of information, culminating in a full understanding of the legal, ethical and liability considerations of the technology. This wouldn't need to take months or even weeks – it could happen over one large journey, or several over the course of one week. In this way it would be quicker, fully automated – and cheaper – than acquiring a driver's licence today.

Compulsory Basic Training (CBT)
Motorcyclist test

"I WOULDN'T LEAVE (IN A DRIVERLESS CAR) WITHOUT THEM... I WOULD NEVER, EVER, EVER LEAVE WITHOUT MY PARENTS... I AM TOO SCARED."

Yeva, ustwo study participant

"YOU ALWAYS HAVE TO HAVE A DRIVER AND THEN IF THERE'S NO DRIVER IT WOULD BE SCARY."

Emily, ustwo study participant

This does pose a problem for one of the proposed demographics that would benefit from this technology: children. It might be that children could not hold such a licence and therefore would not be able to use AVs on their own unless accompanied by a licence-holding adult. However, this potential problem is superseded by a human one – according to our user research, children would not be comfortable travelling in an AV without their parents anyway.

So, once people are fully onboarded and understand the AV's capabilities and failings, when things do go wrong, it's truly the OEM or service provider that takes responsibility. As discussed earlier, if the OEMs are the sole party responsible in any road accident, they will face all of the legal claims. With too much liability comes too much cost and this could prove detrimental to the development and progress of the technology.

OPPORTUNITY 4: TOO MUCH LIABILITY TO INNOVATE

As described above, when it comes to parties liable in an AV accident (rare as they may be), only the OEMs are on the chopping block. With such a large number of claims heading towards the auto industry, OEMs could be held back. It will be difficult for the industry to innovate and progress if much of its time and money is spent fighting and compensating claims.

As we mentioned earlier, the pharmaceutical industry faced similar problems with the manufacture of vaccines. The industry once faced an influx of liability cases, so much so that the cost of the payouts was hindering innovation of the technology. For this very reason, in the US The Public Readiness and Emergency Preparedness Act of 2005 was passed, a federal pre-emption law designed to protect the vaccine manufacturers, which imposed a cap on the value amount of liability claims, so that they could continue to do their good work. Incidentally, this cap contributes to the lower cost of vaccines, as the cost of overwhelming liability claims is tempered and therefore that cost is not passed onto the consumer.

We can assume that the OEMs creating AVs will be subject to similar problems in the future and consequently, similar protective pre-emption laws should be put into place. This will greatly benefit the user as it will significantly reduce the cost of using AVs – and affordability is one of the key drivers for the adoption of the technology. The UK DfT has already suggested[2] that car makers and insurance providers should collaborate on insurance products to protect all parties.

OEMs and service providers may want to lobby the US government to extend The Public Readiness and Emergency Preparedness Act to cover AV manufacture, or perhaps pass a new act specifically for AVs, seeking support from the likes of the Federal Motor Vehicle Safety Standards (FMVSS) and the United States Department Of Transport (USDOT). When it comes to lobbying governments to incorporate new policies or standards, this is something in which ustwo has some experience.

Wayfindr was co-created by ustwo, lead by Umesh Pandya, and young vision-impaired adults from the Royal Society for Blind Children[10] (RSBC), and was funded by Google.org. Further to what was discussed in the Inclusivity and wellbeing section, we identified that the growing indoor positioning and navigation market could hold the key to independent travel for people living with sight loss. Wayfindr facilitated the creation of an Open International Standard for Audio Navigation.

When this standard is applied to indoor navigation services, vision-impaired people are no longer held back by their sight loss, and the barriers to employment, to meeting friends and family, and community engagement are removed. In addition to the social benefits, there is also a clear economic benefit for cities through an increase in the number of independently mobile citizens who can easily access their cities' services.

The open standard that we created with the Google.org funding was submitted to and accepted by the International Telecommunications Union (ITU), the United Nations' specialised agency for information and communication technologies (ITU-T F.921).

Wayfindr

OPPORTUNITY 5: PEOPLE WON'T BUY A DEATH TRAP

In an earlier chapter, we suggested that a utilitarian model is the most morally acceptable one, where the vehicle will do what it needs to protect the maximum number of lives possible. However, research shows that people will be reluctant to own or ride in vehicles operating on such a code, despite wanting others to do so. This comes as no surprise:

> *"This is the classic signature of a social dilemma, in which everyone has a temptation to freeride instead of adopting the behavior that would lead to the best global outcome. One typical solution in this case is for regulators to enforce the behavior leading to the best global outcome. Indeed, there are many similar societal examples involving trade-off of harm by people and governments. For example, some citizens object to regulations that require children to be immunized before starting school. In this case, the parental decision-makers choose to minimize the perceived risk of harm to their child while increasing the risk to others."*

The Social Dilemma of Autonomous Vehicles[11]

As with compulsory vaccination, people want others to adopt the AV solution for the greater good – using utilitarian-model vehicles – but personally would prefer to ride in the vehicle that protects their own lives (or those of family members riding in the vehicle) above all else. This is unfortunate but understandable. However, this moral code is simply not compatible with the ethical and regulatory ecosystem we discussed earlier, and therefore we still believe these vehicles must be utilitarian. But if no one wants to own or ride in one of these utilitarian vehicles, then the technology simply won't be adopted – there will be no demand for the product.

Not only that, but as our study participant Rick pointed out, we need enough people to adopt these vehicles, for the vehicles to learn to be fully autonomous:

> "I THINK THERE HAS TO BE A HAPPY MEDIUM THERE OF THE RISK TAKERS WHO ARE WILLING TO KIND OF HELP THE CAPABILITIES EVOLVE... AND THE INNOVATION TO HAPPEN... TO THOSE WHO JUST YOU KNOW... WANNA JUST CLOSE THE DOORS AND PRETEND IT'S NEVER GOING TO HAPPEN."

Rick, ustwo study participant

Earlier we established the importance of communicating gaps in the AV's situational awareness, or circumstances outside of its operational capabilities, but how do we mitigate people's concerns enough for them to want to use a utilitarian AV? First of all, if the enforcement is there, then they will simply have no choice – we need to make it the only option.

People already subconsciously accept the risk of travelling, so this is not new to AVs. For example, we don't make a cost-benefit analysis each time we use a car – we just do it. We trust and rely on the car so much, that we simply don't consider that we might come to harm.

Aeroplanes fly high up in the sky, huge heavy metal tubes hurtling at unnatural speeds – autonomously for the most part. Yet there are over one million people in planes at any given time, hence the nickname "city in the sky". Most people trust the technology unequivocally.

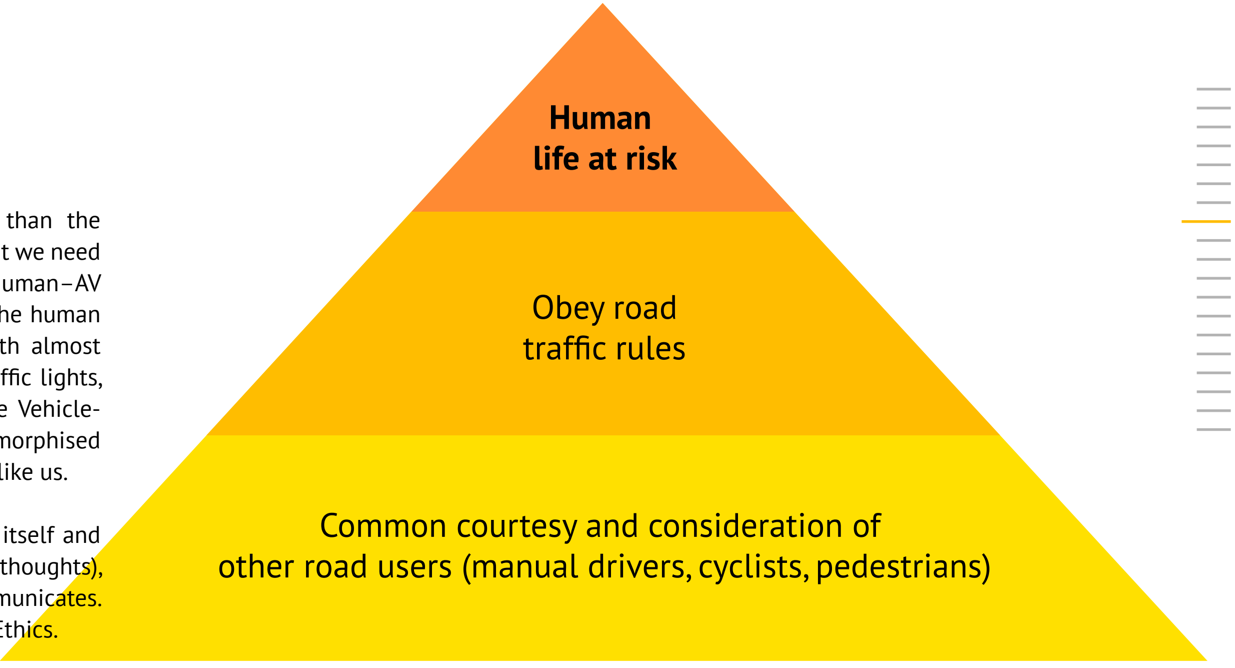
The reason most people trust commercial air travel so much is that they have little reason to doubt it anymore. It is the safest mode of transport in the world, so most people board planes without question. When commercial aviation was first introduced, there were initial concerns and doubts, much like we're seeing today with AVs. The first person to fly as a passenger was Leon Delagrange, who took off from a meadow[12] outside Paris with French pilot Henri Farman in 1908. Six years later, commercial aviation began with the first scheduled flight leaving from Florida to cross Tampa Bay, a $5, 18-mile trip that took 23 minutes rather than two hours by boat. But adoption of the technology after this successful flight was slow due to public fear.

The fact of the matter is that AVs will have to be as safe, and perceived to be safer than other modes of public transport for the technology to be adopted. All of our study participants, from 7-year-old Jessica to 74-year-old Darret, have little faith in the technology right now, because of the perceived risk and their lack of experience with it. The technology has had little time to prove its safety credentials, much like aeroplanes in the early days of the commercial aviation industry. Over time, the technology will need to establish this trust until it does not come into question at all.

OPPORTUNITY 6:
AN AV SHOULD SPEAK ONLY FOR ITSELF

We have come to understand that there's far more to autonomy than the autonomous vehicle itself. In our very first design principle we stated that we need to address human autonomy and mobility needs above all else. In the Human–AV Interaction section, we explained how the vehicle is just one actor in the human mobility ecosystem, with the ability to communicate and interact with almost everything around it, from other cars, autonomous or otherwise, to traffic lights, email accounts, and people. And that communication can be invisible Vehicle-to-Vehicle (V2V) cloud-based information sharing or visible anthropomorphised human-like driving styles where the vehicle even acts with agency, just like us.

Given the AV's animal-like – or even human-like – quality to think for itself and communicate with others, including people, through computations (or thoughts), the AV has a responsibility to be mindful of what and how it communicates. This brings to mind the Morality Pyramid we discussed in Morality and Ethics.



At the uppermost, smallest part of the pyramid are those incredibly rare, yet potentially fatal trolley problem incidents, the this-life-or-that-life scenarios. At the lowest, largest part of the pyramid, are the less consequential but frequent moments of common courtesy and driving etiquette that the AV needs to follow. This includes how the vehicle integrates with society and its communications and interactions with others.

Just like with the trolley problem, OEMs may be liable for the frustrations of or even injury to others should the AV make inappropriate or unsafe communications or interactions. One such example is that of an AV stuck in traffic behind a manual driver, who has not noticed the traffic light turning green, giving the AV no choice but to wait patiently, while the AV passenger becomes increasingly frustrated. Our proposed solution here is to deploy the design principle ***08. Act human, be robot*** whereby the AV should act as a human would by honking the horn, while taking advantage of that unique robot trait of increased situational awareness and sounding the horn in such a way that does not cause confusion or harm to others.

Perhaps a better example might be that of an AV interacting with a pedestrian who is attempting to cross the road at a non-designated crossing place, known as "jaywalking" in the US and as "the norm" here in the UK, where it is legal to do so.

A specific dance between driver and pedestrian occurs. When the pedestrian is looking to cross the road in front of a car, they will engage with the driver, often by looking for eye contact. The driver may then slow down (an "implicit" communication), reciprocate by offering a nod, a wave, or maybe flash the car's headlights (an "explicit" communication), thereby giving the pedestrian permission to cross the road. What is happening here is threefold:

1. The pedestrian requests to negotiate with the driver: **the eye contact**.
2. The driver acknowledges this request: **the act of slowing down**.
3. The driver gives permission to the pedestrian: **the nod, the wave, or the flashing of lights**.

Mercedes-Benz F 015
Crosswalk projection

The awkward thing with driverless cars is that there is no driver – no eye contact, and certainly no nodding or waving. What can be done in this instance is to again have the machine ***08. BE ROBOT, ACT HUMAN***. Let's take it step by step.

Step 1: the request can't be made without a driver – there is no eye contact to be had. Where does the pedestrian look to negotiate with the car? Volkswagen's Electronics Research Laboratory (ERL) discovered that people may still look to where the driver would normally be (the driver's seat), but as long as Step 2, the act of slowing down commences, the lack of a driver does not confuse them. The slowing down of the vehicle appears to give many pedestrians enough permission and confirmation to cross. For some people, however, this implicit communication does not bring with it enough confirmation for them to be confident about crossing – they need the explicit communication of a nod, wave, or flashing of lights.

DP.12

With a driverless car, all that it has in its repertoire for Step 3 is the flashing of its lights. The problem here is that flashing lights is somewhat indirect, and could easily communicate the permission to cross to a third party, when it might not be safe for them to do so. An AV flash of the lights "broadcasts" an explicit communication meant for one person to any number of people within sight.

Thus, a more tailored solution might be required. Mercedes-Benz has debuted a solution for this very problem with their new F 015 Luxury in Motion[13] concept, which rather cunningly projects a crossing onto the road for pedestrians to walk across.

Ingenious, but will it actually work on real streets for multiple people? Its success will depend on how safe it is, and the problem here is similar to that of flashing lights as a way of communication. A projected crossing is safe to specific pedestrians and offers a physical location where they can cross the road, but the crossing is created from the perspective of only one vehicle. What about other cars in other lanes? Here, the AV is telling pedestrians it is safe to cross the entire road, but this may not be the case. There may be a manually-driven car speeding towards the pedestrian in the next lane – the AV's nifty projected crossing could put the pedestrian directly on a collision course with another car.

DESIGN PRINCIPLE UNLOCKED:

12. THE AV SHOULD NOT ASSUME TOO MUCH

Prediction or assumption of human driving behavior and intention is a complex task. One that should not be relied upon in designing systems - so the AV should only speak for itself and it's intentions, not others.

The AV may well be able to speak to other AVs, the traffic lights, and the city, but it won't be able to predict all eventualities and certainly not the action of manually-driven cars. For that reason, the AV must only speak for itself, and not for others.

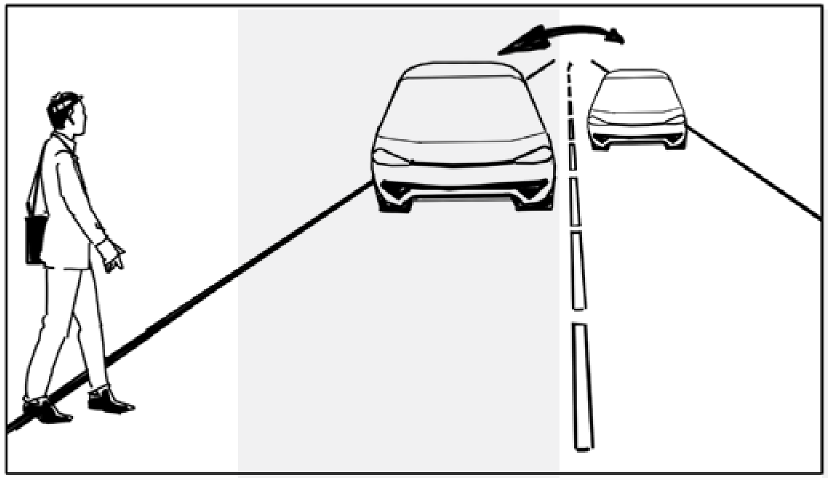
So, how could we tackle this problem? Firstly you can ensure that the communication coming from the AV is explicit in regards to that vehicle – designed in such a way that the pedestrian understands that the AV is giving permission to cross in front of it and only it, and warns the pedestrian to be careful beyond that point. There is some scope for a bit of magic beyond this. For example, if a pedestrian wants to cross a road with two lanes, both occupied by AVs, the two AVs could talk to each other and give permission to the pedestrian to cross the entire width of the road. Using Mercedes-Benz's solution, one AV could project a crossing onto the road for its lane with the other AV completing the crossing for its half of the road, they could even emit the same sound that crossings do currently as a familiar cue. Both AVs would still only talk for themselves, but would also be working together as a team. Working together, AVs can create temporary and dynamic infrastructures to help pedestrians cross more safely, perhaps doing away with permanent fixtures such as zebra crossings altogether.

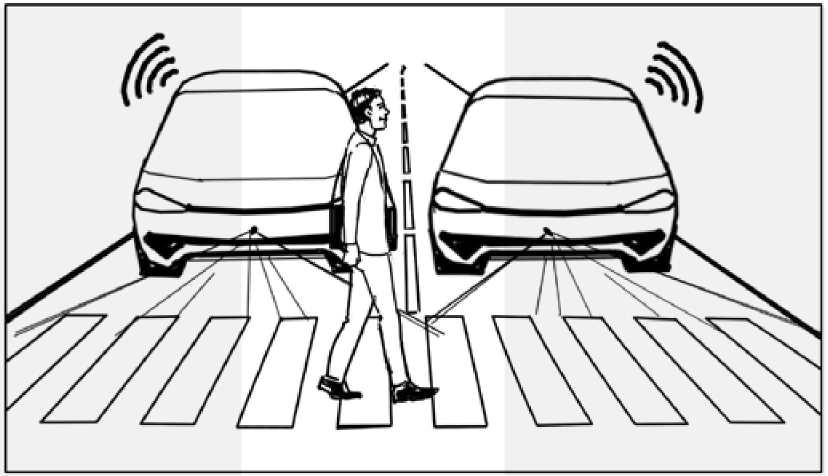
Of course, and as Wendy Ju pointed out when we spoke with her during her Ghost Driver trials, the relationship between AV and pedestrian will vary from place to place. Further, AVs can only recognise certain things from a pedestrian, like that they're stood at the side of the road, but it'll be hard for them to understand the intentions of the pedestrian, for example that they want to cross the road.

Will people subconsciously start exaggerating their movements to communicate that they want to cross to the AV so that they can cross, much like you see smartwatch wearers today exaggerating their arm movements to check the watch face, ensuring it activates at a glance? Only time will tell.

"NEGOTIATING WITH A DRIVERLESS CAR IS LIKE NEGOTIATING WITH A TWO-YEAR-OLD, BECAUSE A TWO-YEAR-OLD IS REALLY LIMITED WITH WHAT THEY'RE ABLE TO DO, THEY KIND OF ARE DICTATORS - IF YOU CAN'T DO WHAT THEY WANT, THAT IS THE END OF THE INTERACTION. IT'S LIKE THAT WITH THE CAR, THERE'S NOT MUCH OPPORTUNITY TO NEGOTIATE."

Wendy Ju, Stanford University





AVs can talk to each other and act as a team to benefit a pedestraian, for example. Here, the two AVs, who occupy the entire road width, can guarantee the pedestrian's safe crossing.

OPPORTUNITY 7: COST

When it comes to the question of car insurance, many people speculate that costs will be far cheaper for autonomous vehicle owners because of how well behaved and safe they will be, thus qualifying for all the "good driver" [14] discounts. However, we have speculated that this might not be the case, as OEMs are likely to face more liability claims as the finger is no longer pointed at the driver and as a result, this expense could be offset by passing the cost on to the insurance policy holder.

As discussed earlier, OEMs like Volvo are already in talks with insurers about this situation, while the UK Government's Centre for Connected & Autonomous Vehicles recommend OEMs follow suit in preparing for such an eventuality:

"While we are not mandating any particular model of insurance product we would anticipate that in practice manufacturers will make arrangements with insurers to develop insurance products that share the economic risk to support the sales of their automated vehicles. In the absence of a risk sharing arrangement between the manufacturer and the insurer, the insurer would be entitled to claim the product liability damages paid out from the manufacturer. Insurance products will therefore be developed and be available to consumers when they purchase an automated vehicle." [2]

Pathway To Driverless Cars, UK DfT

We went as far as saying that the confusion as to whom is liable in an AV road accident should be removed, with the liability being taken away from the individual in order for the technology to be adopted. We named this our design principle ***11. REMOVE ALL LIABILITY FROM THE USER***. This increases costs for OEMs and we argue that this could be offset by the decrease in accidents that the technology promises.

One solution would be to impose a cap on liability claims and payouts[4], much like how the vaccine industry benefitted when the US government passed The Public Readiness and Emergency Preparedness Act of 2005, a federal pre-emption law which imposed a cap on the value amount of liability claims. This cap contributes to the lower cost of vaccines, as the cost of overwhelming liability claims is tempered and therefore not passed on to the consumer. Could AV manufacturers be added to such an act or could new regulation be imposed to protect the AV manufacturers and keep consumer insurance costs low?

Or perhaps, in a world where manually-driven cars and vastly safer AVs share the roads, the higher costs of insurance could be placed upon the driver of the manual cars. At a connected car conference hosted by the Society of Motor Manufacturers and Traders[15] (SMMT), Gus Park, managing director of the UK's largest car insurance provider, Direct Line, said that human driving "may increasingly become a luxury pursuit," meaning that insurance premiums will be higher for driven cars and lower for AVs[16].

CALL TO ACTION

The question of liability in the case of driverless vehicles is one that seems to be full of paradoxes. Who is to blame when there is no driver? Who is responsible for the AV's safety? Why did the AV make this choice instead of that one? What if the car has learned from its owner's bad habits, and it is those habits that are to blame? The UK House of Lords Science and Technology Committee began to take evidence on liability and insurance for driverless cars in November 2016. The committee asked, among other things: "Is it clear who is legally accountable for a vehicle that 'thinks' for itself?"

The questions are endless and at times sound more like riddles than solvable problems. To decipher these riddles, we need all the stakeholders and relevant parties to come together to define some ground rules. Policy makers and car makers, insurers and consumers – all need to write the rules together, with a human-centred approach. We're pleased to see the likes of the House of Lords are already inviting such collaboration and debate, which we plan to get involved in.

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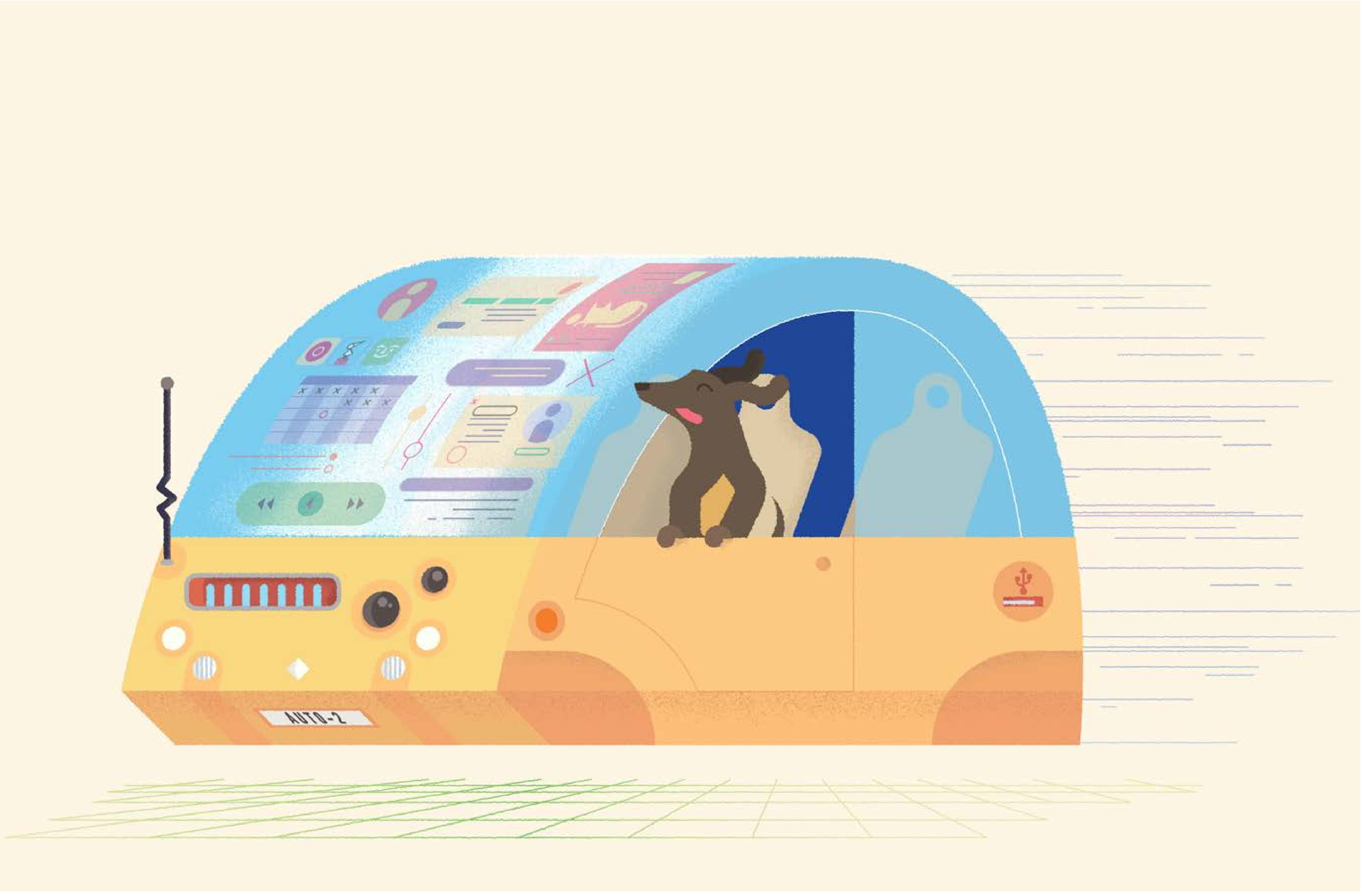
HUD Car
by Simon Child
Year: 2057

"Where we're going we don't need roads... or passengers for that matter. My vision for Autonomous Vehicles will allow vehicles to carry out simple tasks on their own.

Either picking you up from the train station or even taking itself to the local garage to be serviced, full autonomy will help integrate the family vehicle into an intrinsic part of your day-to-day life.

With a full Head-Up Display taking over the windscreen, you can sit back, relax and enjoy funny cat videos on the move."


AUTO-2

HOW ARE LAW MAKERS REACTING TO INNOVATION?

Topic: Policy and Regulation

20 minute read

"ANOTHER SIDE OF THAT REASSURANCE IS LICENSES AND PERMISSIONS. I WOULD IMAGINE AVS WILL IMPLICATE CHANGES ON OUR LEGISLATION. AND ONLY ONCE ALL THESE ELEMENTS HAVE BEEN FINALISED, ONLY THEN I WILL FEEL 100% SAFE ON BOARD OF AN AUTONOMOUS CAR."

Socorro, ustwo study participant

SUMMARY

Autonomous technology is moving so fast it makes it hard for regulators to keep up, especially when it comes to our roads. As a result, we are seeing policy makers on both sides of the pond reach out to experts across the industries to create new regulatory frameworks that are increasingly collaborative and agile.

In this chapter we argue the importance of flexible policies like this – that allow innovation into a real-world environment allowing us to get real-world data, from which we can learn, and improve the safety and security for everyone. We also take a look at the SAE's levels of autonomy from a human perspective.

INTRODUCTION

Autonomous vehicles have the potential to improve the efficiencies of our roads, reducing traffic congestion and improving fleet management. These benefits are already being considered by governments, and in the UK, revisions to the Highway Code are being put in place to allow for this. Here is one such example:

"The Highway Code defines and describes how the stopping distance of a typical vehicle is a combination of 'thinking distance' and 'braking distance'. By employing a system which can brake simultaneously with the vehicle in front, such as in a platoon, the thinking distance is reduced if not removed completely. As such, there is an opportunity to reduce the separation distance required between these vehicles, and hence to maximise the efficiency gains through reduced aerodynamic drag." [1]

In theory, policies and regulations protect us from harm by restricting the level of danger that we may put ourselves into at the wheel of these fast-moving metal boxes. These "restrictions" are sometimes met with "tutts" or even scoffs, as they begin to feel dated when driving technology drastically outpaces them. That can certainly be said for AVs – the policy makers themselves are even holding their hands up and asking for help. Just recently the UK Department for Transport (DfT) invited everyone from town planners to tech industry professionals to submit their opinions, while in the US, the Department of Transportation (USDOT) says that the National Highway Traffic Safety Administration (NHTSA) "intends to revise and refine the document [NHTSA's Federal Automated Vehicles Policy] within one year, and periodically thereafter, to reflect such public input, experience, and innovation, and will address significant comments received in the next revision of this document." [2]

SOCORRO 85

It's great to hear that a form of iterative, agile[3] approach is being taken to help write the correct regulation for this technology. As we've stated throughout this book, no one is sure how this technology will integrate into our roads and societies, so it seems wise to "feel as we go". Though perhaps this should be done with controlled risk, akin to Tesla's approach in which it is already "testing" autonomy features in their commercial vehicles on public roads, improving the technology as they learn.

Just like the algorithms of autonomy, regulations will need to undergo iterations as we learn to adopt the technology, just as the UK government has already woven into its policy-making approach:

"By taking a step-by-step approach, and regulating in waves of reform, we will be able to learn important lessons from real-life experiences of driving of increasingly automated vehicles. We can then apply these lessons when considering what further changes will be required and are appropriate to allow the safe use of technology that is yet to be developed."[1]

UK GOV Centre for Connected & Autonomous Vehicles

Balancing effective regulation, with the flexibility to allow autonomous cars to be tested and to learn, is vital. The machine-learning algorithms of autonomy need real, practical, in-the-field experience to increase AVs' intelligence and therefore safety. When things go wrong, the makers must understand how they went wrong. Did the car make the right decision? If not, why not? This can then be corrected, either through formal logic or the car's own machine-learning. That's easy to say of course – a mistake could be fatal – but there are "for the greater good" arguments that can be made (see Morality and Ethics for a more in-depth discussion on this).

As we've discussed before, largely in Liability and Insurance, regulators like the DfT or USDOT have made a smart move by inviting various stakeholders to participate, like car makers, city boroughs and the tech industry – we at ustwo have even been involved.

Apple also wrote to the NHTSA[4] suggesting potential changes to the laws around AVs. It's great to see that in the UK and US, law makers and technologists have started having these conversations, and other nations are following suit – but not all.

POLICIES SHOULD ENABLE INNOVATION

Complexities in the structure of such legislation can slow things down. For example, US DOT and the NHTSA are trying to mend the "patchwork" of state-based regulation into a coherent countrywide policy. For example, Californian policy limits Google's plans for a steering wheel-less cockpit, but then US DOT's 15-point guidelines[5] somewhat relax those limits. Federal law can then supersede both – confusing at the very least.

Policies can also create strange dichotomies. The Heathrow "pod" that shuttles travellers around its Terminal 4 airport, is autonomous but has to follow a track. Technically speaking, it doesn't need to, but regulations state that the airport is allowed to use train transportation, but do not yet factor in autonomous vehicles (ignoring those flying ones, of course). This is an example of how policy can hinder innovation, but we're seeing some good signs that the regulators understand this problem and are trying to do the right thing for technological advancements.

Unfortunately, tides have recently started to turn. At the time of writing, TfL has decided to effectively ban Uber from London's roads due to "lack of corporate responsibility" [6].

Uber had this to say:

"Uber operates in more than 600 cities around the world, including more than 40 towns and cities here in the UK. This ban would show the world that, far from being open, London is closed to innovative companies who bring choice to consumers." [7]

Uber statement

While the Mayor of London Sadiq Khan said:

"I fully support TfL's decision – it would be wrong if TfL continued to licence Uber if there is any way that this could pose a threat to Londoners' safety and security." [8]

Sadiq Khan
Mayor of London

Allowing innovation into a real-world environment allows us to get real-world data, from which we can learn, and improve the safety and security for everyone, while offering greater choice. In fact, as Sebastian Thrun, the Stanford roboticist who heads their self-driving project, says "the data can make better rules" [9] – our policies could be even better thanks to such innovation.

Not everyone believes this though. In India, Nitin Gadkari, India's transport minister, has formally and assertively banned AVs operating in the country through fear of a negative impact on the jobs market, despite a bold move towards electric vehicle transformation by 2030.

"We won't allow driverless cars in India. I am very clear on this." [10]

Nitin Gadkari
India's transport minister

In response, Harsha, the co-author of this book and a native from India, would like to invite a conversation with the transport minister in the following open letter.

POLICY AND REGULATION:
THE OPPORTUNITY

"Without certainty of how claims will be handled, there is a risk of customer confusion, which could reduce the sale and use of automated vehicles."

Department for Transport

As we can see, when it comes to barriers to AV adoption in regards to liability and insurance, there are two opposing sides, the industry and the consumer. To ensure the widespread adoption of AVs, future drivers-come-passengers and the industry alike will need to adopt human-centred design thinking and behaviours in order to overcome these barriers.

Here we explain our points of view and some potential design solutions to each of the problems, tackled from both the user and industry perspective.

AN OPEN LETTER TO THE UNION MINISTER FOR TRANSPORT IN INDIA ABOUT DRIVERLESS VEHICLES

Mr Nitin Gadkari
Union Cabinet Minister,
Ministry of Road Transport and Highways,
“Transport Bhawan” 1, Sansad Marg,
New Delhi - 110001, India

Dear Sir,

Subject: The future of driverless vehicles in India.

A few weeks ago a story in the *Hindustan Times* really hit me. It was an interview in which you categorically stated that driverless vehicles will not be allowed in India, due to the risk they pose to jobs. It put me in two minds – one where I agree with your sentiment that jobs should not be lost, but, more importantly, a second long-term view where I believe you are mistaken in your sentiment. Not allowing for a driverless future will, in my opinion, seriously limit our country’s progress.

Please allow me to pose a short argument for this second long-term view. Both professionally as a designer working with this technology, and personally, as a concerned citizen with family and countrymen and women living amidst the chaos that is our roads.

Over the last few years I have lost some family and have seen my friends hurt on our roads. Terrible driving behaviour, road infrastructure, and maintenance were to blame on each occasion. In the same few years I have had the privilege of living and working around the world, which has helped me see the stark contrast and just how far behind we as a country are in terms of road safety.

Just in terms of road accidents, in 2015 Delhi as a city alone had 1,582 fatalities compared to 1,730 in the entire United Kingdom. Looking at similarly populated cities – London had 136 fatalities compared to nearly seven times more in Bangalore (714). A terrible contrast. Not to mention the untold suffering faced by the families involved. You yourself have a target to reduce accidents in India by 50% by 2020[11]. But going by current trends, it is a very tall order.

Even though the accident statistics are relatively lower in countries like the UK or Germany, those countries are looking to reduce them even further[12] by reducing human error which is estimated to cause more than 90%[13] of road accidents. This is among the prime arguments for the research into driverless vehicles in the industry and among countries around the world.

Improved safety by reducing or completely removing human error that result in accidents. Improved safety and peace of mind also attained by intelligent systems that assist and aid people behind the wheel, to help them make sense of the chaos and become better drivers. Jobs are an important factor but shouldn't the safety of people and improving the quality of their lives be the primary motivation for our nation? How many potential jobs are equal to the loss of a loved one?

Driverless research is not just about the vehicle alone, it is also about the software and the communication technologies that power the intelligence driving these autonomous vehicles. We as a nation speak in glowing terms about our software engineering capabilities, but we will be left behind if a carte blanche ban on driverless vehicles reduces investment into the technology due to the lack of potential growth. It is tantamount to shooting ourselves in the foot.

We have our very own designers at Tata Elxsi[14] running autonomous vehicle tests in their facilities, saying: "If it can work in India, it can work anywhere in the world," despite initial failures due to the great number of constraints the algorithm behind the vehicle has to deal with. They see that constraints can be beautiful and India can prove a valuable testing ground for the rest of the world, while at the same time keeping up with, and even having the ambition to lead, the rest of the world.

Investing in this technology is also about complementing the vehicle, by building better and smarter infrastructure for autonomous vehicles to operate in, further reducing accidents, and improving the quality of travel for people. There is also air pollution and a growing reliance on petroleum, which is a major bane[15] in our country, which can be reduced by encouraging electric vehicles and their supporting infrastructure. Vehicular development will drive infrastructure development and vice versa.

This is not to say nothing is being done at the moment – we are already seeing a growing impetus towards better roads and highways, as presented in your list of achievements. This is much needed for our nation, but isn't it also a time to ride this wave and prepare this new infrastructure for safer, cleaner, and greener vehicles? It is not just about looking at the needs of the present, but looking at the arc of the technology and our growing population's many needs and desires.

Coming back to jobs and the reason for your entire argument – the development required for driverless cars has the added advantage of creating far more jobs than exist at present. Infrastructure development, vehicle manufacturing, software development, supply chain management, vehicle trainers, insurance, maintenance, and support, to name but a few – all might see a quantum leap in demand both within commercial and non-commercial sectors. This passenger economy has the potential to reach seven trillion US dollars by 2050, according to studies[16]. This is still a speculation, but we have seen this before with the IT revolution[17] over the last 25 years, where technological and economic growth has shifted the labour market giving rise to new and better opportunities – without necessarily seeing a loss in jobs.

As a country, India picked up the scent of the information technology revolution at the right moment. It was aided by the will to create a successful growth ecosystem – the will of prominent policy-makers, planners, and technologists – and in turn, was embraced by people.

I believe we are on the cusp of another revolution, that of mobility and its related services.

This is already being embraced by the teaming masses in the cities using homegrown car sharing services and relying more on public transportation services like the efficient metro networks. Our people have proven time and again that there is an innate desire for change and to experience development in all its forms. We want to see safer, healthier, greener streets that are fit for moving around in and that will improve the quality of our lives.

In my humble opinion, driverless technologies and their development are an important part of this mobility revolution which should not be shunned through short sightedness but must be embraced. If not for ourselves, then for the sake of our children and their children in turn, who will taste the fruits of our labour and vision.

Yours Sincerely,

Harsha Vardhan

HUMAN LEVELS OF AUTONOMY

While we're glad to hear that governments are looking to collaborate on policies and regulations, we're not sure that all of the right stakeholders are contributing. This book was partially written to address the human side of the debate. We're seeing more road laws and technical requirements being met, but the human needs? Not so much.

Remember our very first design principle: ***01. HUMAN AUTONOMY IS THE GOAL***? Now, cars have always offered semi-autonomy, and therefore have always been semi-autonomous. Since the very first car, designed in 1808 by François Isaac de Rivaz (an internal combustion engine fueled by hydrogen) and Carl Benz's 1886 gasoline-powered car (patent number 37435, claimed by some to be the "birth certificate of the automobile" [18]), these vehicles have automated human walking. In fact, you could say that the automobile automated the horse and cart.

Ever since then, cars have become more and more automated – from the internal combustion engine (ICE) to the indicators, and from power steering to park assist and Autopilot. Cars have always been semi-autonomous, so why is it such a huge trend today? Perhaps it is because we're edging ever nearer to that holy grail of full autonomy?

In the article, *Top Misconceptions of Autonomous Cars and Self-driving Vehicles*[19] website *Driverless Car Market Watch* states that this trajectory of semi-autonomous development after semi-autonomous development is misunderstood to be the evolutionary path towards tomorrow's full autonomy – there's a missing link. They say that technologies such as advanced driver-assistance systems (ADAS) simply cannot evolve in a way that can handle all of the infinite situations.

However, this comes from a very technical perspective, questioning the abilities of the technology, and is perhaps born out of the SAE's five levels of autonomy[20]. But autonomy is for the people, not for the technology, as per our design principle – and not just for the driver, at that. It's not that we agree or disagree with this statement, we just think it's somewhat moot. The technology perspective is just one side of autonomy, one that both the journalist above and SAE is looking into. When it comes to autonomy in cars, it should not be about what the technology can do and how well it can do it, but about the needs of people, both inside the vehicle and outside in the environment.

With this in mind, we propose a new, more appropriate, more human and more inclusive way of looking at these levels of autonomy.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene.	System	System	Human driver	Some driving modes
4	High Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.	System	System	System	Some driving modes
5	Full Automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.	System	System	System	Some driving modes

SAE's level of autonomy

Let's look at what the SAE says and add a few human elements.

"The SAE report's six levels of driving automation span from no automation to full automation. A key distinction is between Level 2, where the human driver performs part of the dynamic driving task, and Level 3, where the automated driving system performs the entire dynamic driving task.

"These levels are descriptive rather than normative and technical rather than legal. They imply no particular order of market introduction. Elements indicate minimum rather than maximum system capabilities for each level. A particular vehicle may have multiple driving automation features such that it could operate at different levels depending upon the feature(s) that are engaged.

"System refers to the driver assistance system, combination of driver assistance systems, or automated driving system. Excluded are warning and momentary intervention systems, which do not automate any part of the dynamic driving task on a sustained basis and therefore do not change the human driver's role in performing the dynamic driving task."

It is important to note that these levels are elegant in their construction, with very little ambiguity, but the act of driving and the system are rendered with only technical and mechanical consideration.

As an addendum, we can attempt to modivfy these levels by adding fundamental human needs uncovered in our research to that spectrum – as a driver/passenger, pedestrian, cyclist, or other driver interacting with the vehicle.

Let's look closely at the narrative definition for each level.

LEVEL 0: NO AUTOMATION

Narrative definition. The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.

Driver/passenger needs. The driver needs to be able to control the vehicle's every movement with minimal distraction, while obeying the rules of the road.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the driver and interact with them if needed.

LEVEL 1: DRIVER ASSISTANCE

Narrative definition. The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.

Driver/passenger needs. While the system is operating the steering of the vehicle, the driver needs to be able to ascertain the vehicle's every movement with minimal distraction and take over control with ease – while obeying the rules of the road.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the human driver if needed.

LEVEL 2: PARTIAL AUTOMATION

Narrative definition. The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.

Driver/passenger needs. Prior to the drive, the driver should be cognisant of the capabilities of the autonomous vehicle, including all the alerts. While the system is operating the vehicle, the driver needs to be able to ascertain the vehicle's every movement with minimal distraction and take over control with ease. The driver also needs to be reminded or cognitively engaged to an optimum level – since their supervision is required continuously to make sure the vehicle obeys the rules of the road.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the human driver if needed.

LEVEL 3: CONDITIONAL AUTOMATION

Narrative definition. The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene.

Driver/passenger needs. Prior to the drive, the driver should be cognisant of the capabilities of the autonomous vehicle, including all the alerts. While the system is operating the vehicle, the driver needs to understand what the vehicle is doing and even going to do. The driver should also be able to understand and analyse the situation presented to them, in case they need to take over. The driver should feel free to take up the role of the passenger with minimum anxiety – to do whatever they need do.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the vehicle or driver in case it is needed. Other drivers should know when the vehicle is in autonomous mode, so as to know they might not be able to quickly communicate to a human counterpart.

LEVEL 4: HIGH AUTOMATION

Narrative definition. The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.

Driver/passenger needs. Prior to the drive, the driver should be cognisant of the capabilities of the autonomous vehicle, including all the alerts. While the system is operating the vehicle, the driver needs to understand what the vehicle is doing and even going to do. The vehicle in turn should understand when the driver is in position to take over control if needed or the driver in turn should actively control or be able to secede complete control. The driver should feel free to take up the role of the passenger with minimum anxiety – to do whatever they need do.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whomever is in control of the vehicle, and should be able to interact with the vehicle in case it is needed. The vehicle in turn should use the norms and customs of the culture to convey its intentions to other road users so that other drivers and pedestrians are at ease.

LEVEL 5: FULL AUTOMATION

Narrative definition. The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.

Passenger needs. While the system is operating the vehicle, the passenger needs to be able to accept and trust the vehicle. They need to feel reassured and informed by the system about its capabilities, so as to take up the role of a passenger with ease. For instance they need to understand how they can make the vehicle stop or move when they need it to.

Pedestrian, cyclist and other driver needs. The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system in control of the vehicle and should be able to interact with the vehicle in case it is needed. The vehicle in turn should use the norms and customs of the culture to convey its intentions, to other road users so that other drivers and pedestrians are at ease.

WHY AMEND THESE LEVELS?

Why do we do this? Because just like we should write the policies and regulations that keep us safe on our roads together, with many minds from different backgrounds forming a more holistic and robust opinion, we must also consider the whole environment in the same holistic manner. This will ensure that all road users, from drivers to passengers, cyclists and pedestrians remain safe during the advent of autonomous vehicle proliferation.

We believe this is just the beginning of a thought process – a process where human needs are ingrained into technical criteria. We look forward to hearing your thoughts as well. ◆

SAE level	Name	Narrative Definition	Driver/Passenger Needs	Pedestrian, Cyclist and Other Driver Needs
Human driver monitors the driving environment				
0	No Automation	The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.	The driver needs to be able to control the vehicle's every movement with minimal distraction, while obeying the rules of the road.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the driver and interact with them if needed.
1	Driver Assistance	The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	While the system is operating the steering of the vehicle, the driver needs to be able to ascertain the vehicle's every movement with minimal distraction and take over control with ease – while obeying the rules of the road.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the human driver if needed.
2	Partial Automation	The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	Prior to the drive, the driver should know all capabilities of the autonomous vehicle. While the system is operating, the driver needs to be able to ascertain the vehicle's every movement with minimal distraction and take over control with ease. The driver also needs to be reminded or cognitively engaged to an optimum level – since their supervision is required continuously to make sure the vehicle obeys the rules of the road.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the human driver if needed.
Automated driving system ("system") monitors the driving environment				
3	Conditional Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene.	Prior to the drive, the driver should know all capabilities of the autonomous vehicle. While the system is operating, the driver needs to understand what the vehicle is doing and even going to do. The driver should also be able to understand and analyse the situation presented to them, in case they need to take over. The driver should feel free to take up the role of the passenger with minimum anxiety.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whoever is in control of the vehicle, and should be able to interact with the vehicle or driver in case it is needed. Other drivers should know when the vehicle is autonomous, so as to know they might not be able to quickly communicate to a human counterpart.
4	High Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.	Prior to the drive, the driver should know all capabilities of the autonomous vehicle. While the system is operating, the driver needs to understand what the vehicle is doing and even going to do. The vehicle in turn should know when the driver is able to take over control or the driver in turn should actively control or be able to secede. The driver should feel free to take up the role of the passenger with minimum anxiety.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system or the driver, irrespective of whomever is in control of the vehicle, and should be able to interact with the vehicle in case it is needed. The vehicle in turn should use the norms and customs of the culture to convey its intentions to other road users so that they are at ease.
5	Full Automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.	While the system is operating the vehicle, the passenger needs to be able to accept and trust the vehicle. They need to feel reassured and informed by the system about its capabilities, so as to take up the role of a passenger with ease. For instance they need to understand how they can make the vehicle stop or move when they need it to.	The pedestrian, cyclist and other drivers should be able to ascertain the intentions of the system in control of the vehicle and should be able to interact with the vehicle in case it is needed. The vehicle in turn should use the norms and customs of the culture to convey its intentions, to other road users so that they are at ease.

Our interpretation of SAE's level of autonomy

SOURCES

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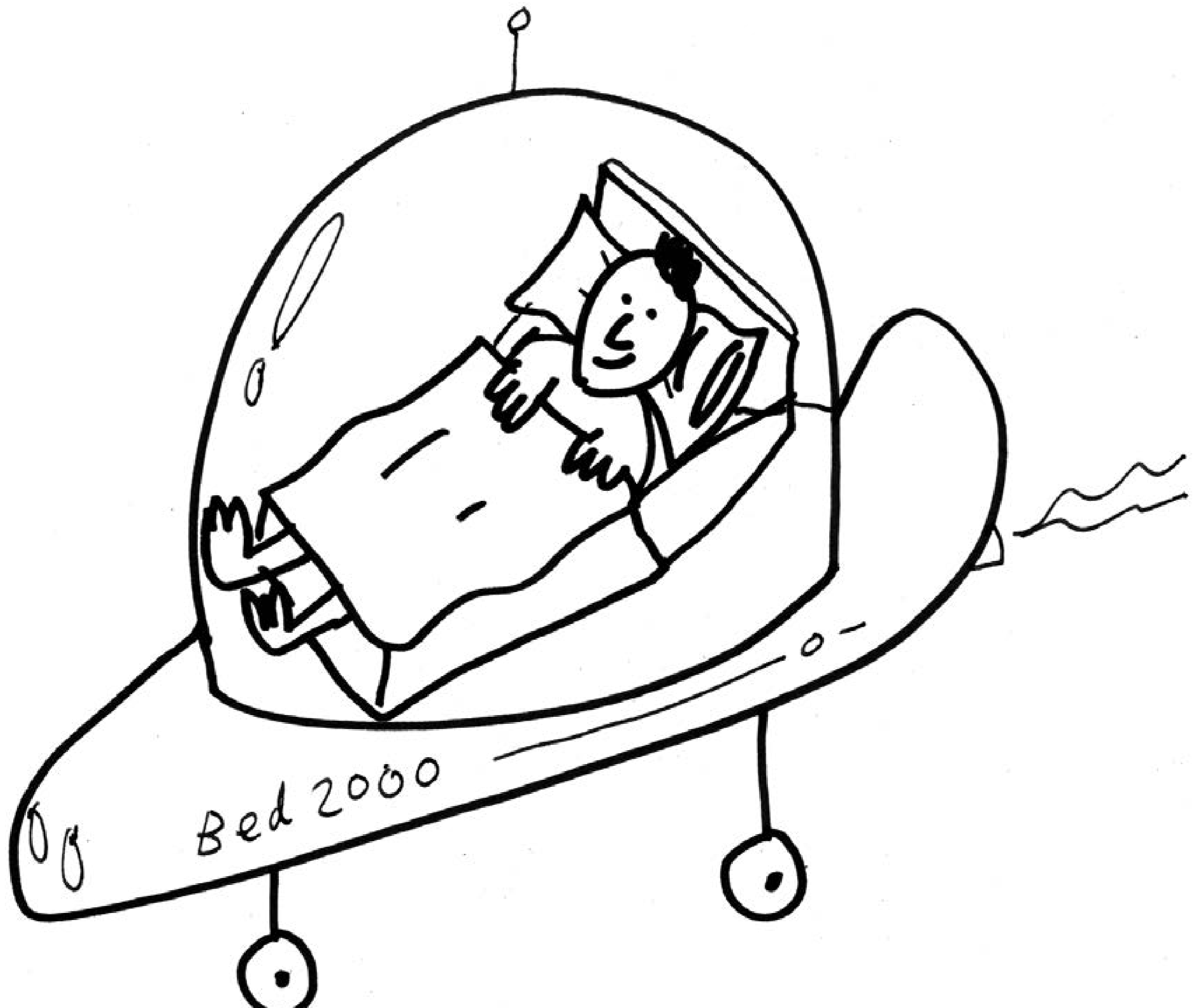
Bed 2000
by Jon Burgerman
Year: unkown

“Driverless cars will be able to deliver people to their desired destination even whilst they sleep.”

Ideal driverless car



WHICH BRANDS WILL SUCCEED IN AN AUTONOMOUS FUTURE?

Topic: Branding and Service Experience

32 minute read

"I THINK I WOULD PROBABLY BE MORE CONSCIOUS OF PERHAPS THE BRAND, THEIR ASSOCIATION WITH SAFETY, ASSOCIATION WITH THAT KIND OF CAR'S BEHAVIOUR. EACH CAR MANUFACTURER WILL HAVE A DIFFERENT DRIVING STYLE, A DIFFERENT BEHAVIOUR ON THE ROAD."

Neil, ustwo study participant

SUMMARY

When it comes to consumers experiencing an AV brand, it'll most likely be as part of a car-sharing scheme, rather than an ownership one – meaning brand loyalty will similarly shift from the cars themselves to services they provide.

In this section we delve into how brands can overcome their current perspective, which existing brands are best setup to adapt their offering and which automotive brands should worry about other things.

INTRODUCTION

The very first true brand is believed to be a soap product known as Sunlight Soap. Sunlight completely changed how soap was sold in the 1800s. Before Sunlight, soap was sold in piles of shavings or clumps. The new Sunlight Soap was formed into weighted blocks. The first of its kind, Sunlight Soap promised consistency and stipulated quality, thus establishing fair value for money. This was the first product to fulfil that essential branding virtue – trust, a guarantee of consistency and quality. For any brand to be successful it must establish that same trusted guarantee; trust is, after all, a core design principle.

A brand today is what a brand does and how it behaves. But what does this mean in the context of AV brands in the city of tomorrow? Automobile marketing and branding may need to completely change how the product is sold, much like Sunlight Soap did. Can a brand that has been synonymous with the freedom of driving be as loved within an automated experience? As the car becomes our everyday thinking, travel companion it presents as many opportunities for experience design as it does challenges.

Existing car makers need to shift from from being original equipment makers (OEMs) to original experience makers. This won't be easy. But it will be necessary to compete and claim a more direct relationship with customers and the places they move in.

The winning brands will be those which combine the traditional brand properties and the physical design of the vehicle with emotional intelligence and deep insight into how we behave. The increase in agency for the vehicle increases its responsibility to understand its passengers at a far deeper level. The brand will be the service and the service will be the experience. What the AV ***does*** and how it makes us ***feel*** will be key. Will it give me priority drop-off on my way home? Can I watch my kids travel in to school? Does it make me feel safe and in control? Have I made the right choice?

EXTRA SOAPINESS

BRANDS OPERATING WITHIN A SYSTEM

Decisions driving consumer choice within the autonomous vehicle market will be broader than ever, creating an even richer experience for the commuter and enthusiast alike. Consumers will assess not only power, safety and aesthetics, but also how well the vehicle integrates within the driver's wider digital ecosystem, or how regularly new services become available. And what about designing AV experiences for those who crave driving? AVs won't be for everyone, and not all brands are ripe for autonomy. In the distant (distant) future, as AVs take over the streets, we must still make space for the original driving experience too.

Now let's take a closer look at some of these challenges and opportunities in AV branding and service design.

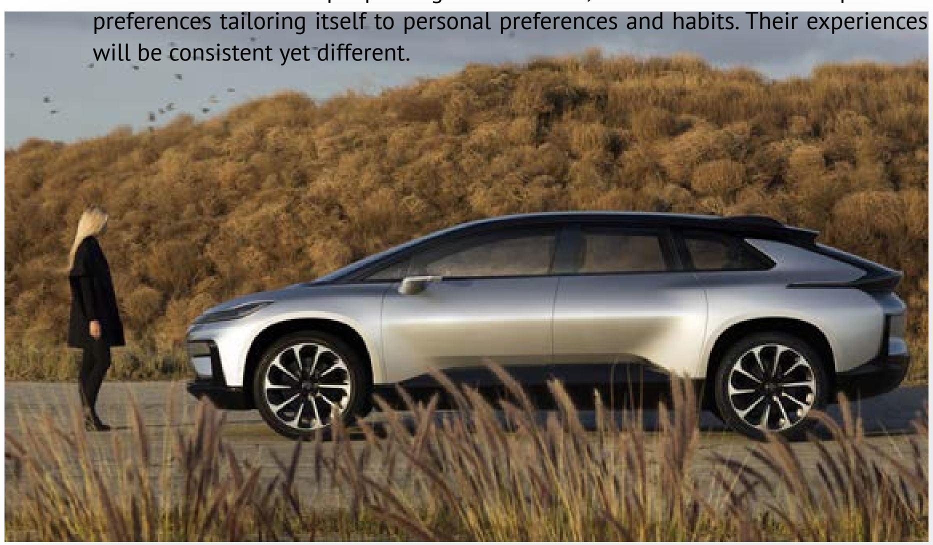
In the first instance, the majority of AV purchases are likely to come from fleet companies and delivery services, or through government public transport schemes. Our first encounters are likely to be things like fast food delivery, or airport shuttles. When designing for these early encounters, it's important to create the right impression to build trust. If I trust my pizza to come on time without a driver, then why not my shopping? Or maybe I'll even take an AV to work.

The first time we might have choice as a consumer to pick an AV over another mode of transport, will most likely be as part of a car-sharing or shuttle scheme. Here, the decision will be driven less by the exterior design and more by the service offering and experience of the journey itself.

Earlier we discussed the need for all AVs to follow the same moral code (and therefore share programmatic code) in order for them to cohabit safely and ensure widespread adoption. With standardisation comes an increased need for differentiation. This is a subject that IBM's Institute for Business Value describe in *Automotive 2025: Industry without Borders*[1].

Sunlight Soap
The world's first branded product

But how do brands operating within a system differentiate themselves? One of the ways to do this is through personalisation. This is something that startup Faraday Future promises in its FF91 model[2] due for release, hopefully, in 2018. Their idea is that while different people might use the car, the machine will learn personal preferences tailoring itself to personal preferences and habits. Their experiences will be consistent yet different.



Faraday Future
FF91

DESIGNING THE SERVICE WITH THE PRODUCT IN MIND

Generation X consumers tend to consider their car a part of their identity. The brand, the model, the colour, the engine – all accessories carefully picked out to coordinate with their vehicular "outfit", which communicates their identity. Nowadays, this is becoming less and less prevalent, with Generation Z individuals opting for consumer electronics as their preferred form of self-expression. It's interesting to note here that this generation tends to be less brand loyal, but still values high quality experiences[3].

In many cases the physical "brand" is becoming invisible – for most of us, the actual car you get when you order an Uber is incidental. It therefore follows that AVs may be designed with a more practical focus, rather than the more "couture" approach used with conventional cars.

The same vehicular ambiguity, coupled with service provider visibility, applies to almost all other forms of transport. Who did you fly with last? United Airlines. What plane was it? Um... Which train did you use last? Virgin Trains. What model of train was it? Erm... The car and motorbike are the last vestiges of vehicular brand awareness, perhaps because they are attainable.

It's the brand as a service that you remember. The ease of booking, the price, the conversation you had with the driver on the way, the cleanliness of the vehicle, the choice of route they made, and the way they drove. Uber as a brand is fairly invisible – after all, all they own is the app and service framework – the rest of the service is somewhat out of their control, as it's individual drivers with their own cars that provide the experience.

Compare that to when you get in a black cab. The brand is more intrinsically associated with the physical product. You are stepping into a London classic, with its spacious inward-facing seating, iconic black brand colour, and quintessential London cabbie with "The Knowledge"[4] – a brand asset in itself.

"I'VE HAD A GIRL, AND SHE WANTS TO GO TO THE SHARD. SHE SAYS, LIKE: 'I JUST GOT OUT OF AN UBER,' A BIT FRUSTRATED. SHE WAS TELLING ME THAT ALL HE THE UBER DRIVER WANTED TO KNOW WAS THE POSTCODE, AND SHE WAS SAYING: "YOU CAN SEE THE SHARD THERE LOOK – THE SHARD! IT'S STICKING UP IN THE AIR… YOU CAN SEE IT!" THEY DIDN'T KNOW THE POSTCODE SO HE COULDN'T TAKE HER THERE."

Dave, ustwo study participant

In the future, ideally the physical product and the service will be designed in sync to create a harmony between form and behaviour. Even if car makers continue to sell to service providers, they'd do well to collaborate rather than retrofitting the product into the service.

NOT ALL BRANDS ARE ON-BRAND

This won't be the first piece you've read on autonomy that quotes design guru Don Norman, nor will it likely be the last. Norman famously wrote in his book *Design for Future Things*:

"Driving an automated car is very much like riding a horse."

Don Norman

The horse has its own mind and operates within the interests of its own safety (though, unlike Asimov's robot, it probably doesn't care about its rider), and it'll get you to where you want it to with some level of autonomy. Applying our brand qualities from above, you'd want the riding experience of this horse to be safe, convenient, and comfortable.

During the course of writing this book, we have spoken to many of the major OEMs to understand their opinions on AVs and their plans for their customers. What we discovered was that not all of them even want to offer such a service, while other brands simply won't be able to offer fully-autonomous vehicles, because their brand values are not conducive to an autonomous experience, like those of Norman's horse. Take Lamborghini, for example – its brand values really do not mirror those associated with autonomous driving:

"Aggressive, Challenging, Extreme."

Lamborghini brand values[5]

If we look at Norman's analogy, would you ride a horse that was described as aggressive, challenging and extreme? It sounds awful – like riding a raging bull, which incidentally is Lambo's mascot.

For Lamborghini, this technology may be beyond its current commercial offering capabilities, and this may not be of any great concern – after all, we're talking about an enthusiast's car here, one which attracts the very rich petrol head or the fashion conscious. In fact, when we spoke with Nicola Porciani, head of connected car at Lamborghini at the London TexhXLR8 conference in 2017, he compared the brand to the likes of premium fashion brand Gucci, rather than tech firms like Google. As he sees it, Lamborghini customers buy their vehicles for their driving performance and as a couture fashion accessory, not for a vehicle that gets them from A to B.

Lamborghini

With the advent of AVs, Lamborghini's strategy might be to play up its unique manually-driven car brand features, perhaps even portraying driving one as a nostalgic pastime or an extreme sport. Nicola himself told us that Over-The-Air (OTA) updates or Downloadable Content (DLC) is where they see their connected car experience going in the future, with customers able to download "track day packs" that prime the car ready for the race track, or "power-ups" as Nicola called them.

Manually-driven cars may even end up being banned from many roads, just like Oslo banned private cars from its city centre in 2015 (which was later converted to a city-wide parking-ban[6]).

Other brands that are less interested in offering fully autonomous vehicles, at least for now, include Porsche and Mazda, who both say that they will be continuing to focus on the driver (in the traditional sense), and not the passenger of the future.

Porsche is focusing on what it calls "sport mobility", hinting at the kinds of technologies used in AVs, but not yet committing to developing an AV per se:

"The sportscar of the future will blend the history and values of the Porsche brand with innovative technologies, while at the same time ensuring sustainability. In achieving this, topics such as electromobility, digitalisation and connectivity will play an important role. Embracing these topics will allow us to shape the exclusive and sporty mobility of tomorrow."

Porsche Strategy 2025[7]

While Mazda is clear in its intent and wants to "celebrate driving":

"Mazda's Brand Essence is 'Celebrate Driving'. 'Celebrate Driving' delivered by Mazda is not just about driving performance. Choosing a Mazda prizes the owner with confidence and pride. Driving a Mazda leading up to urge to take on new challenges. Not just our products but every encounter with Mazda evokes the emotion of motion and makes customers' hearts beat with excitement. All of these are contained in our brand essence of 'Celebrate Driving'."

Mazda Corporate Vision[8]

Count it: the word "driving" used five times there. If brands like these are declaring themselves out of the race, then who is still in the running?

WHICH BRAND WILL WIN?

We spoke with a member of the design team at Bentley's Crewe HQ who shared a very interesting parallel between the Bentley brand and AVs.

He said that Bentley is the first autonomous car brand. Bentleys are meant to be driven, but not by the owner – most of them have a chauffeur. That's why there is so much attention to comfort. It wouldn't be a huge leap to suggest that Bentley might have an easy ride into the AV space, offering a high-end car-sharing experience. But it will be a careful balance to ensure a sense of exclusivity is maintained.

In fact, Bentley's CEO, Wolfgang Dürheimer, has already stated claim to their plans at the 2016 Automotive News World Congress in Detroit:

"I believe there is a big future for more diverse and sophisticated concierge-style services that will enhance the lives of our customers. We are also investigating a global Bentley customer network – a 'club' where ownership does not relate to a single vehicle, but rather it entitles you to a luxury mobility solution in selected cities around the world."

Wolfgang Dürheimer
CEO, Bentley

Here Dürheimer reaffirms our opinion that some brands live more in the experience rather than in the ownership of the vehicle itself. And in Bentley's case, physical styling will be an important brand element in its AV vision, both inside and out. Bentley's brand values include "uncompromising luxury" and "outstanding performance" – values a user would want to associate with their AV experience.

Another brand value people want from AV technology is safety. Volvo has recently announced that it wants its vehicles to be "death-proof"[9] by 2020. It'll do this by improving accident avoidance technology, eventually culminating in driverless vehicles. When it comes to brand values for vehicles, safety has to be one of the most compelling, and it's one that Volvo has written into its brand values since its very beginnings in 1927. Claiming your vehicles to be death proof is an incredibly strong brand proposition – one that is ethically commendable while being very persuasive to boot. At the time of writing, Volvo's XC90 has not had a single fatal accident in the past seven years[10]. The brand is very much associated with these impressive safety credentials and this may serve Volvo well as it enters the race to dominate the AV market.

"With the development of full autonomy, we are going to push the limits of automotive safety."

Erik Coelingh
Safety Engineer, Volvo – speaking to CNN

Despite the rays of light described above, the auto industry in general has a bad reputation. If the auto industry as a whole was a single brand, its brand values might be: dangerous, dirty, expensive, corrupt, and clunky. These are not conducive to the adoption of driverless cars.

~~DANGEROUS~~	SAFE
~~DIRTY~~	CLEAN
~~EXPENSIVE~~	CHEAP
~~CORRUPT~~	OPEN
~~CLUNKY~~	INNOVATIVE

Of course, almost all of today's car brands were crafted around a now-antiquated piece of technology. Their messaging was designed to persuade exchanges of hard cash for cold steel. Their stories begin with the internal combustion engine and end with the emissions baggage that brings. Think of any car brand and "safe", "clean", "cheap", "open" and "innovative" are not words you generally come up with. Except maybe for one…

NEW KIDZ ON THE BLOCK

In Tesla's original Master Plan[11], Elon Musk put forward a ten-year roadmap for how Tesla's products would be launched and what each product would offer. In short, the Master Plan states four key products and their order of launch:

1. Create a low volume car, which would necessarily be expensive
2. Use that money to develop a medium volume car at a lower price
3. Use that money to create an affordable, high volume car
4. Provide solar power.

Musk here is using a fresh new brand, with a clean slate, putting forward a step-by-step product plan. By building from the ground up, Tesla is able to create a product without legacy – bespoke for its intent. Conventional OEMs, on the other hand, have to retrofit their brands to suit new consumer attitudes. The first Tesla model, the Roadster, was designed specifically with sustainable energy in mind. Musk goes into huge mathematical detail as to how the running and even production of the vehicle is not only sustainable, but can actually create more energy than it uses. And with that, Musk is building a brand whose values are tailored specifically for the current climate and consumer attitudes. Unlike older car brands, Tesla does not have any of those old auto industry brand values we listed earlier. It does not have to carry that baggage and so can position itself exactly as it likes.

Tesla isn't the only new kid on the block. Faraday Future[12] debuted its high-performance electric car, the FF 91[2], at CES in 2017, while Nio[13] (formerly NextEV), a startup based in China, develops high-performance electric and autonomous vehicles, including "the world's fastest" electric car, the EP9[14], which holds the lap record at the Nürburgring of 06:45.900.

Nio
EP9

We were fortunate enough to meet with some of the designers, including the branding team, who conceived Nio's new Eve vision concept, first demonstrated at SXSW in Texas in 2017. The outward expression of the Nio Eve brand appears to be more about experience than "product" (perhaps because it speaks for itself). According to Nio's website, it stands for:

"How people use these products, and their entire ownership experience. We want you to feel positive again about owning a car... We want to redefine what premium service means for a car company."

Nio website[15]

The new players stand for something different. Tesla's Elon Musk purposefully distances himself from the industry. His relentless and public pursuit of innovation is building his brand, which is reinforced by Musk's halo as a space pioneer. It is a brand with a clear purpose.

Could non-automotive brands, playing in the AV space, enjoy an easier ride without the chains of the auto industry to weigh them down?

Nio
Eve

Hear the word "Google" and you immediately think technology, search, fun logo, maps… just downright clever. You don't think: automotive industry, dangerous, dirty, expensive, or clunky. But Google is making a car and it may even be one of the best-known, most respected AV producer right now. Google does carry some baggage of its own, however – that 21st century baggage of data privacy and security.

Waymo

"I CAN SEE WHY PEOPLE ARE UNCOMFORTABLE WITH THAT. YOU KNOW, IS THAT DATA BEING USED AGAINST ME AROUND INSURANCE EVENTS OR IN THE EVENT OF AN ACCIDENT? HOW MUCH OF THAT DATA CAN BE SUBPOENAED AND TAKEN AWAY? I GUESS THERE'S STILL SOME CHALLENGES…"

Rick, ustwo study participant

People are becoming increasingly aware of the dangers of data sharing and the internet, and Google is at the very heart of that concern. Perhaps this is why Google has rebadged its AV project under a new brand, Waymo[16].

Much like Tesla, Waymo will be distancing itself from the industry in which it belongs, in an attempt to leave behind the negative connotations. And what a cute little brand that is. One you'd trust, that surely wouldn't do anything naughty with your data…

Whether as a producer of the AVs themselves, or as the service provider, brands will need to be trusted, with the brand perception matching what the user expects from the technology and service. Without this, AV technology will have a hard time finding public trust.

BRANDING AND SERVICE EXPERIENCE: THE OPPORTUNITY

"THE BEST CARS ARE THE ONES YOU CONNECT WITH, WHETHER THEY ARE BANGERS THAT YOU LOVE OR SOME SORT OF CAR THAT REALLY EXCITES YOU."

Neil, ustwo study participant

In a completely autonomous world, car makers will not be able to rely on the usual automotive tropes attached to driving style and "emotion in motion". So what are some of the ways in which they can differentiate themselves?

Putting aside the obvious factors, such as cost and eco credentials, we see four areas in which brands can excel over others or offer something unique:

1. In-car communication
2. Personalisation as you go
3. Ecosystem integration
4. Service models (money, money, money)

Let's take a look at these each individually, through the lens of a driverless vehicle.

OPPORTUNITY 1: IN-CAR COMMUNICATION

One thing missing from the Uber brand experience is the ride itself. How the brand communicates to its users and how the users can communicate and interact with that brand opens up huge opportunities. One tangible manifestation of this would be to personify the brand within the vehicle and elsewhere in their customers' lifestyles, like Apple's Siri or Bentley's robot butler.

"They [automotive manufacturers] should see it [in-car UI] as a major opportunity to bring moments of joy and delight to customers. These are systems that allow us to physically interact with their brand."

Geoff Teehan
Product Design Director, Facebook

As discussed in Human–AV Interaction, a good conversational interface might well be the interaction method of choice in AVs. Whether it's through screen interactions, or by having a verbal conversation with an Alexa-like robot UI, this interaction should be friendly, trusted and is an opportunity for brand expression. Sound design is already a key component in car design. Welcome to the new age of brand conversation.

These "robot butlers" already exist in science fiction, such as the KITT example we spoke about earlier. KITT has the right personality for its audience – Michael Knight. You might say that Michael identified with KITT's personality (think brand values) and so they got on famously. In a future world where Michael might have to hail an AV to fight crime, he may opt for the KITT brand or, indeed, the KITT brand might opt for him.

Bentley's robot butler could be seen as akin to Bruce Wayne's Alfred, a loyal, faithful, long-standing servant who understands Bruce's most intimate personal information (for example, he's Batman and hates bats, yet dresses like a giant bat). Rolls Royce has *Eleanor*, which very much reminds us of Samantha from the 2013 film *Her*[17], a charming, playful, and intelligent young PA-come-companion, played by Scarlett Johansson, with whom the protagonist falls in love. So that's two car brands who already have their own science fiction-like personified personal assistants.

So on that note, let's play *MATCH THE AV BRAND TO THE SCI-FI BUTLER!*

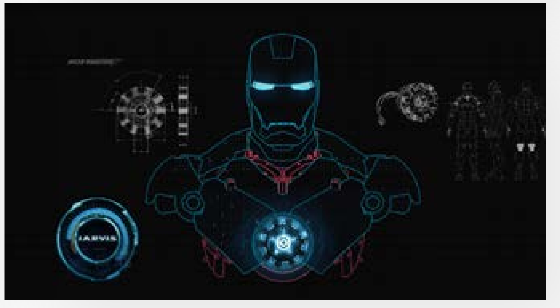
UBER X JOHNNY CAB

Johny Cab's robotic driver is a perfect accompaniment for an everyday Uber. Talkative and always smiling - happy to take you anywhere.

PORSCHE X KITT

KITT seems a perfect foil for the perfect driver's car. Less subservient than Johnny cab's AI - more empathetic and always ready to lend a hand for the driving task and adventure at hand.

BMW X JARVIS



Sophisticated vehicles need sophisticated butlers and Jarvis is as cool, calm and savvy as an AI can get. With the knowledge, technical skills and the ability to be hyper connected to the world,Jarvis is perfect for a BMW.

But don't make the interfaces too friendly, as Gary Burnett at the University of Nottingham told us when we interviewed him for this book:

"PEOPLE RESPOND BETTER TO AN IN-CAR SPOKEN INTERFACE WHEN IT APPEARS TO BE MORE LIKE A BUTLER THAT HELPS THEM DO WHAT THEY WANT TO DO LIKE NAVIGATION, READ THE NEWS OR CHECK THE WEATHER, RATHER THAN A COMPANION – SOMETHING TO HAVE A CHAT WITH."

Gary Burnett, University of Nottingham

There is, however, some early ethnographic research into Amazon Alexa that suggests a balance needs to be struck between butler and companion.

As the brands inevitably continue to play "me too", there is a risk that AV service providers will find it difficult to offer something unique. What might happen is that the playing field levels out and users start to suffer from brand fatigue, not caring which they use. Brands will need to do their best to offer something new.

Emerging technologies are like the latest trends, they fall out of fashion and consumers find uniqueness by adopting alternatives – often retro or nostalgic options. One obvious example is the vinyl culture and a more recent one is the mobile phone market. Motorola and Nokia were the leading mobile phone makers until the iPhone came out. Then Apple, and shortly thereafter, Google, became the forerunners, threatening Nokia's buoyancy. That lasted some years, but now people are adopting that old technology again, with Nokia re-releasing its classic, nostalgic, 3310[18].

In that vein, some brands may want to offer "old-school" human-driven cars. Many of the people we interviewed spoke about how much they enjoy speaking with the driver when getting a taxi, for example:

"IF I WERE TO EVER SIT IN A DRIVERLESS UBER OR GRAB OR SOME FORM OF TAXI, I THINK I MIGHT MISS, YOU KNOW THE OCCASIONAL: 'HI, HOW ARE YOU?'. YOU KNOW THE OCCASIONAL SURPRISES THAT YOU GET FROM GRAB DRIVERS OR UBER DRIVERS. THERE WAS ONE THAT GAVE ME A PEN, YOU KNOW SOME PEOPLE GIVE YOU REALLY GREAT CONVERSATIONS. AH THAT'S IT! YOU COULD PROGRAMME A DRIVERLESS VEHICLE TO ENGAGE IN CONVERSATION."

Wanfy, ustwo study participant

Another possible commercial benefit of a human-driven car could be the ability to break the law. We've spoken previously how autonomous vehicles will probably keep to the right side of the law. Human-driven cars, on the other hand, can break the rules, with drivers performing misdemeanours to gain an advantage on the road.

"WHAT I'LL MISS THE MOST ABOUT DRIVING IS JUST THE FREEDOM TO STICK MY FOOT DOWN AND BE NAUGHTY!"

Neil, ustwo study participant

Alternatively, brands may want to combine offerings, taking advantage of the unique pocket of time that comes with travelling. BMW has already partnered with Microsoft Office 365[19], perhaps hoping to one day provide the ultimate on-the-move meeting space. Maybe office workers of the future will just ride around all day in circles, occasionally switching cars, but not actually going anywhere. A dystopian future such as this could actually cause more congestion rather than less, one of the technology's supposed advantages. What if Uber partnered with a fitness chain and held classes or personal training sessions in vehicles on the way to work? Maximising time is an emerging human trend that brands may need to partner up on in order to take full advantage. We talk more on this in *What Will People Do in AVs?* Time is a commodity.

OPPORTUNITY 2: PERSONALISATION AS YOU GO

When you're jumping in and out of different AVs, a consistent and personal experience will be vital for a successful brand. As Manuela Papadopol, director of business development and communications at Elektrobit Automotive puts it:

"This will be where the brand differentiation will happen for the car makers. The personalized experience will be far greater in a self-driving car than it is today."

Manuela Papadopol
Elektrobit Automotive[20]

This certainly applies to owned cars, but imagine the pure magic of this in a hired or shared car. What if when you jump from one car to another, the new car is playing the song you were just listening to and automatically configuring its interior to your liking? How can you achieve this consistency and personalisation when riding in multiple different AVs?

We collaborated with Garmin to explore this challenge. The idea evolved around having some kind of "passenger ID" which learns your habits, behaviours and preferences over time and creates a more seamless and personal experience.

So upon booking an AV, for example, the interior can be configured to the person's liking. This could be anything from the more functional qualities such as seat position, temperature, destination, and payment, to more personal things such as driving style preference (leisurely or determined), mood-based entertainment options, and even facilities for meditation or work.

In the future, a wearable may not even be required, with all the passenger's details saved in the cloud and the vehicle accessing that information via face recognition. And with learnings from the passenger's other lifestyle behaviours outside their journey, the journey itself could be greatly improved. For example, if the wearable device indicates that the passenger has run from their office to the vehicle, it might suggest that they are late for an appointment – with this insight, the vehicle could choose optimal urgency over optimal comfort.

The purpose for Garmin in this concept is to demonstrate the role it can play in enabling personal mobility. The idea raises the question around of who should own the profile? And shouldn't the technological means of enabling it be accessible to all?

We've spoken about the interior experience and then zoomed out a little to consider how the car might connect with other devices, but we can zoom out even further to consider the whole user's lifestyle…

Garmin x ustwo
Using wearables to make an in-car experience personal

Jaguar x ustwo
Jaguar remote for Apple Watch

OPPORTUNITY 3: ECOSYSTEM INTEGRATION

Some companies considering service design for a shared AV experience are looking at it from a product-first perspective, in which the story begins when the user hails an AV and ends when they exit the vehicle:

1. User hails AV
2. User locates AV
3. User enters AV
4. User rides AV to destination
5. User leaves AV

Thinking about this a little more holistically, we can see there's more to this story:

1. User needs to get from A to B
2. User opts for AV option over others
3. User hails AV
4. User locates AV
5. User enters AV
6. User rides AV to destination
7. User leaves AV
8. User finishes journey to B
9. User fulfills new needs at B
10. User repeats journey over time

A good experience will consider all of these steps, but this is just the basic framework. We need to look at this in more human terms:

- How do we create the right first impression?
- How do we create familiarity and make it easy to get started?
- How do we learn from the everyday journeys to improve the experience?
- How do we understand what to do when things going wrong?

To create brand loyalty, these, and the many thousands of connected questions, will need to be considered as part of the design process. Or it will be all too easy to hop into a competitor's AV.

It doesn't take a huge leap of imagination to see how an AV service brand can integrate into other aspects of people's lives, far beyond basic mobility needs. Bentley has presented a concept for a holographic Jeeves, an in-car butler.

In-car butler
Bentley

When speaking with Bentley, we understood that as it has a far more intimate relationship with its customer base than many other OEMs. Their customers trust Bentley with very intimate personal data. In fact, Bentley CEO Wolfgang Dürheimer has already hinted at this: "I believe there is a big future for more diverse and sophisticated concierge-style services that will enhance the lives of our customers."

It wouldn't be the first time something like this has been achieved. Take Apple, for example. When people first bought Apple's new MP3 player, the iPod, back in 2001, no one expected to find themselves sucked into the "Apple ecosystem". Thanks to the humble iPod, many of us are now fully committed and perhaps even somewhat reliant on this ecosystem.

Back then, to use the iPod, it was best to have iTunes, Apple's accompanying music management/library software which Mac and PC users installed from a disc. And, as it was easier to use iTunes if you had a Mac, over time, many PC users became Mac users. Mac laptops then did away with disc drives, so now we download or stream our music from iTunes rather than listen to CDs and rent movies from iTunes rather than watch DVDs. Now all our precious "owned" music, which once had lived on an actual physical CDs (subsequently flogged at car boot sales), are in our iCloud accounts. Then the iPhone came out, which was a phone, an iPod, a camera and a computer all in one.

All of a sudden we need to register, agree to Apple's terms and conditions and login to listen to music, watch movies, work, make phone calls, and take photos, all because we bought an iPod years ago. Apple has effectively become our invisible personal assistant, somewhat personified through Siri. What's next? Maybe Apple CarPlay is the bridge between today's Apple ecosystem and the future – Apple's rumoured AV concept Project Titan[21] perhaps?

The same thing is happening in the auto industry with Tesla. What started off as an $80,000+ high performance sports vehicle, sales of which funded a mid-range vehicle, which in turn funded an affordable high volume vehicle, is now fixing its solar panels to your roof, and supplying a Tesla Powerwall battery in your living room, so that you can fuel your electric Tesla, your home and the grid. In just ten years, Tesla has gone from nothing, to an automotive manufacturer making your car, to an energy supplier providing energy for your home. Tesla is now, according to its Master Plan Part Deux[22], planning to use both of these technologies to enter the public transport sector, with AVs, mass transit vehicles, and a fleet operation.

Integration into people's lives will be a key differentiator in this space, the depth and breadth of which could be far more significant than even the Apple and Tesla examples. You can read more about our holistic design thinking in Holistic Problem Solving.

Solar roof charges yout Electric Vehicle
Tesla

OPPORTUNITY 4: MONEY MONEY MONEY

Parallels can be drawn between the AV and aviation industries. It might be that AV brands could start to differentiate themselves by offering different product standards and cost levels, akin to economy and first class plane travel.

This is a very easy extrapolation to make, but AVs could present a whole new take on this concept, far beyond offering luxury interiors and champagne on demand. Earlier we spoke of the importance of a base level Moral Code of Conduct, whereby all AVs should adhere to a standardised ethical code, embodied in the algorithm or the AV "brain". Brands would still have the opportunity to build on top of that in terms of the AV's driving personality as well as the way in which it communicates.

People may be able to pay for a superior service, perhaps one that has priority over other autonomous vehicles on the road. If all vehicles in the network are accountable and controlled through a service algorithm, cars in that network can be de-prioritised in order to give a clear route to a vehicle that has priority – a priority that has been paid for by the user, getting them where they want to go, faster.

However, this is scarily close to the issues we've been seeing with net-neutrality. In a world where wealthier individuals could purchase better and more convenient routes from brands and services, what are the options left for those who can't? Even though we're still years away from this potential service "offering" becoming a reality, it could easily become a much larger problem. Whatever happens, choices like these should extend only to those services built on top of the Moral Code of Conduct, which should form a sacred foundation.

Many in the industry believe that AVs will be cheaper to produce thanks to the removal of certain driving mechanics and that AV ride services will also be cheaper thanks to the removal of a paid driver. The scenario above illustrates just one contradiction to that. There are other reasons that could suggest that this ideal of cheaper hardware and cheaper travel is a fallacy.

A cost-benefit analysis on safety design features is unique for AVs compared with other cars. The reason for this is that of the three parties held liable in current traffic accidents – driver, brand, and Mother Nature – only the brand is left to blame in an AV world. Therefore, choosing a less safe, cheaper option in terms of mechanical parts is no longer possible. OEMs simply won't want to risk the liability, the sin of commision (see Liability and insurance), when choosing an inferior safety option for the sake of cost savings. Manufacturers are more likely to choose the safer option, and in many cases that is likely to be the more costly option. And that cost will be passed on to the customer.

Further, there is a risk that liability claims will go up, now that the driver is removed from the liability equation. And those costs will be mitigated through the unit price of each vehicle, which in turn could be offset by the cost to hire the vehicle. On the flip side, the price of charging an EV or AV could drop to zero. This is because it takes time, unlike filling up a petrol tank. People will want something to do while they're charging. Malls are already offering free charging (like free parking) because they know that the car occupants will spend much more money in the mall while waiting for the AV to charge.

There are practical considerations too, not least refueling or charging. An important part of a brand is to be consistent and friendly. The shared autonomous vehicle will somehow need to be kept clean, its interior free of rubbish, and, most of all, kept safe. The brand will need to pay for this kind of maintenance, potentially more often than once a day. Again, this cost will likely be incorporated into the overall cost of the AV service.

A potential solution to these problems, and one we would love to get involved with, is to encourage acts of passenger-community altruism. It could be as simple as picking up a piece of rubbish, taking your newspaper with you, or even looking out for one another to prevent anti-social behaviour. A system that incentivises people who want to offer micro-maintaining interactions, like micro-transactions for the maintenance world.

As our energy needs increase and we put more demand on space and infrastructure, we may all need to become more socially responsible, much like we have become more environmentally responsible over the last few decades, which has perhaps even created the demand for electric and autonomous vehicles, in turn creating the new sharing economy in order to be as efficient with our resources as we can. That sharing, that extra social interaction, may soon create a demand for greater social responsibility. In the same way that popular health food brands of today have traded on their "healthy alternative" branding, AV brands of the future might win big if they position themselves as the "socially responsible alternative".

Therefore, cost may not be the defining factor in people's mobility decision making. Many people may choose cheaper options than AVs, opting for public transport. Some brands may want to offer the bare minimum, other brands may want to offer unique or superior services at a higher cost, while whole new and affordable mobility brands may surface that serve a need not met by the potentially prohibitive cost of AV travel. Autonomous bikes perhaps[23]?

The name of image
Credit the photoman

OPPORTUNITY 5: GETTING READY FOR THE NEW WORLD

The brand is the personality, the ambassador of the product or service, and will need to be trusted to be accepted. Further, for a brand to succeed over the rest, it'll need to be appreciated by the user to encourage repeat engagement.

In the case of AVs, you accept a brand when you hop on board. To continue to use that service over others, the user will need to know, understand, and like the brand, throughout the experience.

Some brands may need to create new spin-off brands, not immediately associated with the parent brand, like Google's Waymo. Over the past few years, ustwo have been supporting Ford with just such a task.

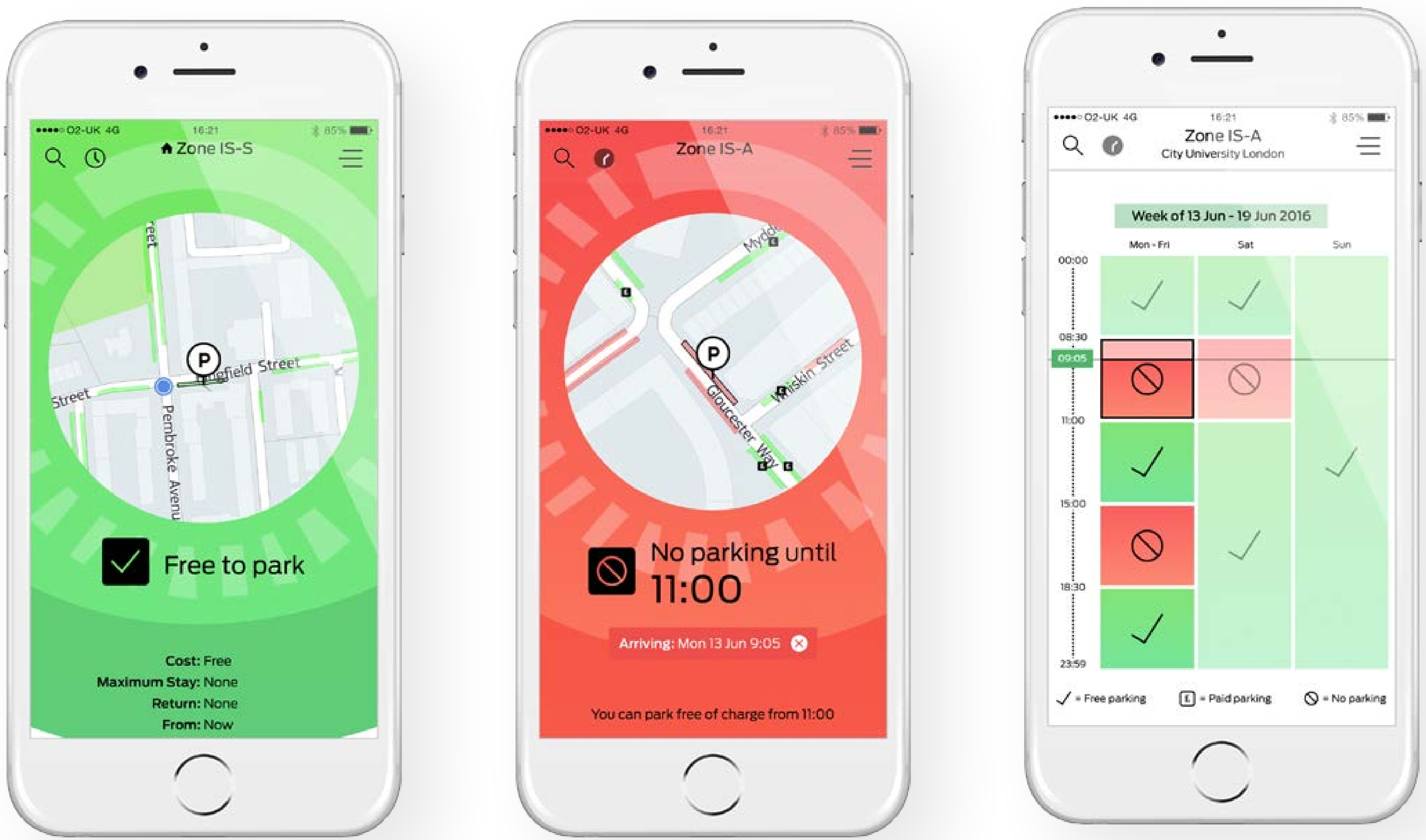
At the 2015 Consumer Electronics Show (CES), the then Ford president and CEO Mark Fields announced that the Ford Motor Company would be engaging in 25 mobility experiments to help drive their new smart mobility vision:

"We are driving innovation in every part of our business to be both a product and mobility company – and, ultimately, to change the way the world moves just as our founder Henry Ford did 111 years ago."

Mark Fields
Former CEO, Ford Motor Company

Ford is no longer just about selling cars – it's about offering a variety of mobility solutions, in, around, and completely separate to the car. ustwo have been involved in a number of these experiments, helping Ford develop new sub-brands with the "Go..." moniker.

GoDrive is a car-sharing service, while GoPark helps solve parking problems, initially in London. Up to 30% of the traffic in London is made up of people looking for parking spaces. Drivers find it hard to find a space and when they do, find it even harder to understand the archaic parking rules. GoPark does away with these two issues by first suggesting the location of the most likely available parking bays, using a pool of data sources, and secondly by providing a simple "yes" or "no" – can the driver park in that spot, based on their permit type?



GoPark
Ford x ustwo
collaboration

At ustwo, we always place the user at the heart of the design process, which is known as User-Centred Design (UCD). We apply this even to branding. Imagine designing a logo without even understanding what the brand's customers would want and expect from the brand, from the logo. Sadly this happens all too often.

Before we even began with the brand, we worked on understanding and designing for the user's need for the product. When designing the user experience of GoPark, we observed drivers as they looked for parking spaces (we were sat in the back seat). We were not only able to design the user experience of the app around them, but the whole end-to-end customer experience and service design. Once we had the service design and the product design (the app) we were then able to appropriately design the branding, to ensure it was informed by the UCD product it represents.

As with the Greyhound example, this experience and service design forms a part of the brand, and as these come from a UCD approach, we can ensure that the brand itself also has the user at heart – a powerful way to engage our audience.

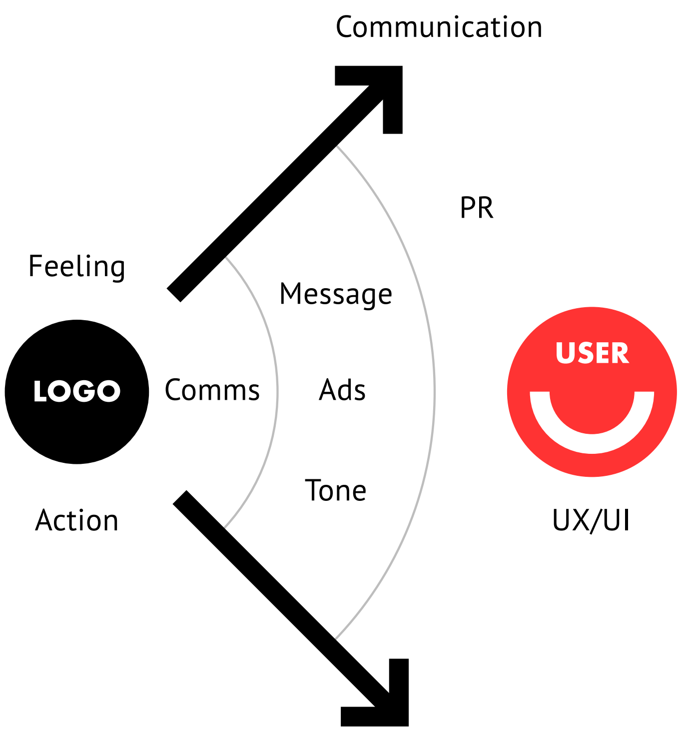
By partnering with Imagination on the GoPark brand identity, we were able to create a brand with the appropriate values that the user would associate with such a service, creating familiarity and trust. The Ford name was omitted as a new, tech-savvy and friendly brand was created, with a contextual, real-time and simple app that provided the user with a hassle-free and trusted experience.

Ford was thus able to shed its auto industry baggage, creating an entirely new brand that supported its business goals in entering a new mobility market. GoPark is an early experiment that's part of a wider vision which includes plans for autonomous vehicles. Ford may want to continue this strategy as it moves towards this goal.

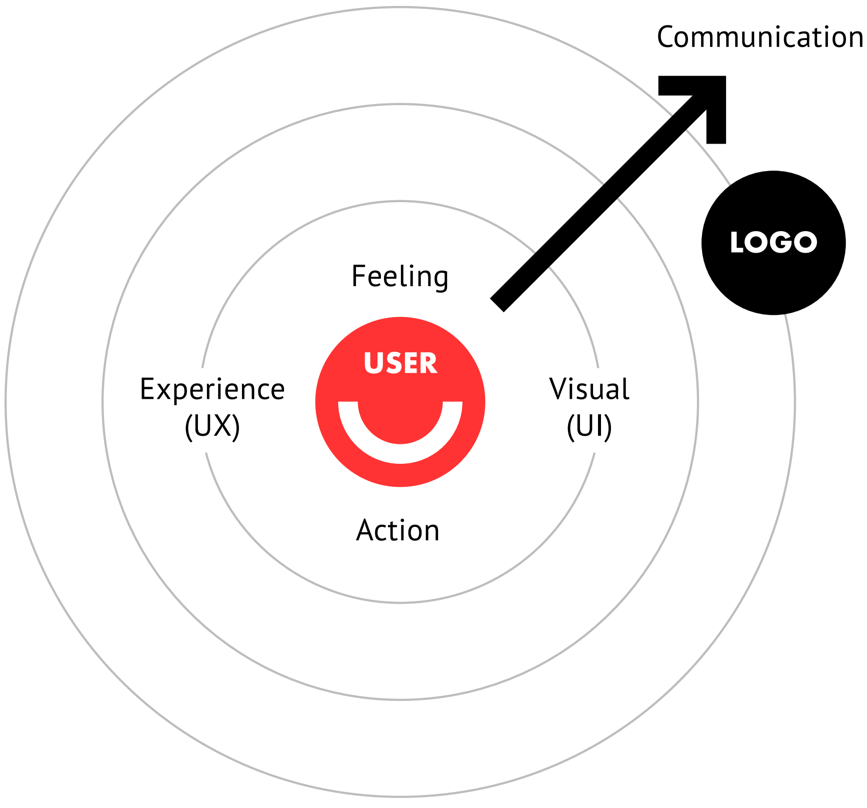
"Our priority is in making the first Ford autonomous vehicle accessible to the masses and truly enhancing customers' lives."

Mark Fields
Former CEO, Ford Motor Company

Fields' ambition is a great one. Many OEMs will be rushing to get their AV out to market first, but Ford wants to do it in the right way, ensuring the technology benefits people. By doing so, Ford might miss out on the first-to-market advantage and so will need to find another way to beat the competition. This is where a classic brand design virtue comes into play, that of defining the correct unique selling point (USP).



TRADITIONAL MODEL



USTWO MODEL

THE EXPERIENCE IS THE BRAND

In the future, they say it'll be easier to get around and cheaper too. Everything will be connected and the city will be a place of parks and peace – all choreographed by a hyper-intelligent mobility network.

Catch a driverless car, hop on a drone, travel at the speed of sound underground and touch in and out with a blink of an eye. It's a seductive vision. True or not, what's important for brands is to really understand what matters to people and to break down their silos in pursuit of a common purpose – to create a remarkable experience end-to-end. That's what we really care about[24]. Brands have a business advantage by being human. Those thinking about their next 300-page user manual will not survive.

In the years to come, if our movement needs won't be served by individual products, but a series of interconnected services, whose job is it to care about the end-to-end experience? We can learn from today's experience glitches to design a better future.

EXTRA SOAPINESS

Micro but Many

SOURCES

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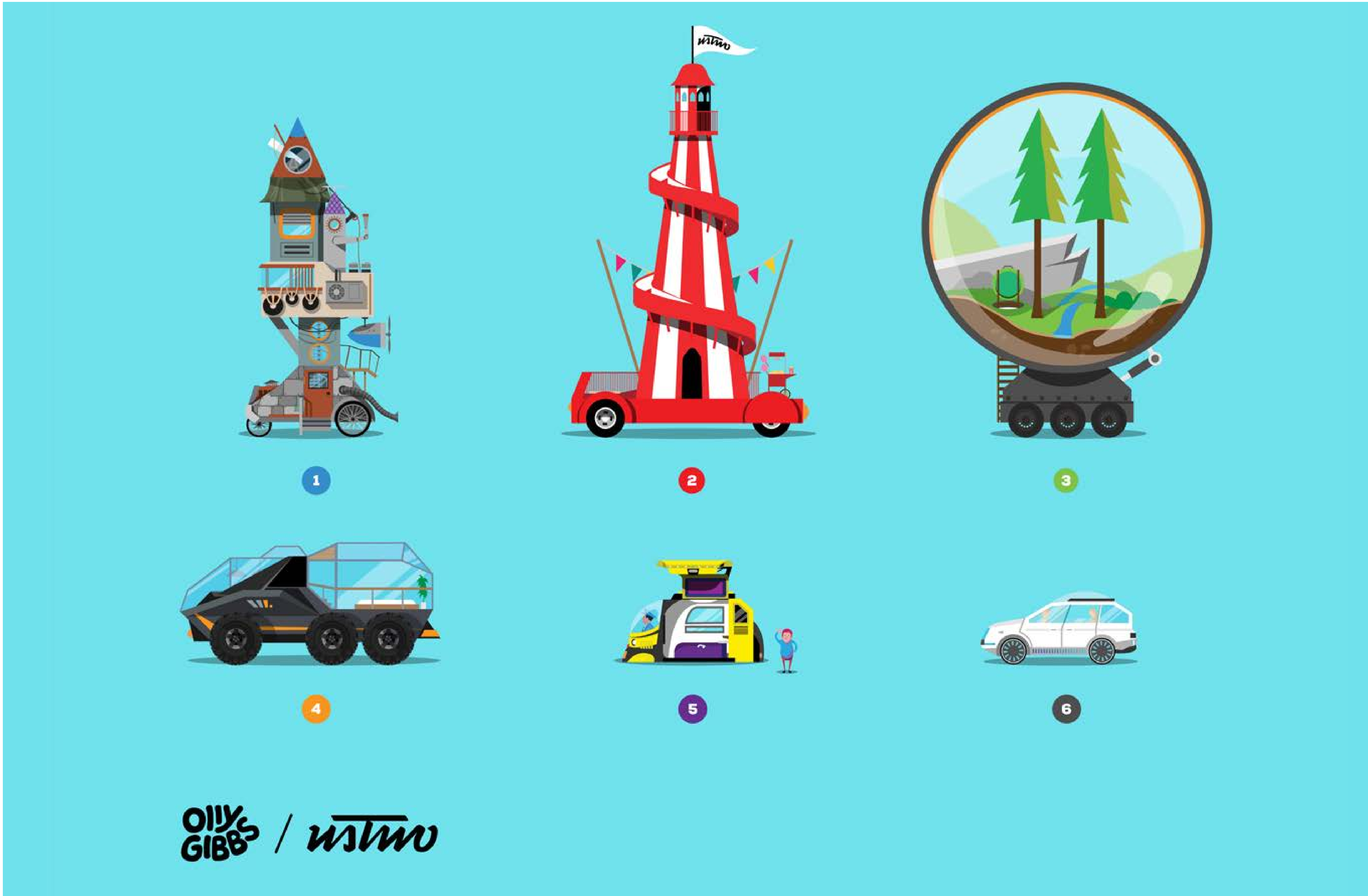
23. https://www.youtube.com/watch?v=LSZPNwZex9s
24. https://ustwo.com/auto

Pure Imagination
by Olly Gibbs
Year: 2025 - 2366

"1. The Higgledy Piggledy / A base driverless machine you can adapt and make your own - hugely customiseable. This example uses scrap parts including a room for a telescope for stargazing. 2. The Helter Skelter / What better way to use your time than using this slide instead of driving? Comes with popcorn machine. 3. The Geo Dome / A fully self-sufficient nature reserve conserved in a glass dome. This has an artificial sun and regulatory systems with filtering for clean, breathable air. Perfect for relaxation from the concrete jungle. 4. The Swank Mobile / Made from high quality materials this oozes wealth. Imagine a speedboat on wheels with a hot tub in the back and lounging area in the front for entertaining. This has one-way glass for privacy. 5. The Taxi / This driverless car is the future of taxis. Combining elements from famous film cars such as Johnny Cab from Total Recall and the gull wing doors of the Delorean from Back To The Future. Perfect for long journeys this has a bed, tv and games console. 6. The Driverless Car / A more down-to-earth driverless car similar to what we're used to in vehicle design. This simply has basic but high quality leather seating with a table in the center. Stay classy."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Olly Gibbs / ustwo

IF WE'RE NOT DRIVING, WHAT ARE WE DOING?

Topic: What Will People Do in AVs?

88 minute read

"PEOPLE WITH AUTISM COULD PICK A DRIVERLESS VEHICLE AND KNOW THAT THEY'RE NOT ANNOYING ANYONE, THE DRIVER... I THINK IT COULD BE EMPOWERING FOR THEM. YOU KNOW, THERE ISN'T A STIGMA, THEY DON'T HAVE TO WORRY ABOUT WHAT THE DRIVER IS THINKING, IT COULD GIVE THEM A LOT MORE CHOICE TO TRAVEL WITHIN SINGAPORE."

Wanfy, ustwo study participant

SUMMARY

The reality is that what we can do in semi-autonomous vehicles, isn't that different to what we can do in driven cars. However, fully autonomous cars are another ball game – offering passengers freedom to eat, sleep, drink, read, pray, watch TV and even have sex.

Currently brands seem focused on on-the-go entertainment as the answer to all this free time. However, we argue that the spoils of the autonomous revolution will go to manufacturers who look beyond in-car Jacuzzis, to create AV interiors that meet the needs of real people, in real scenarios.

INTRODUCTION

The term autonomous vehicle, or driverless car, is becoming increasingly more muddled. Some people think Tesla's cars are autonomous, but really, they're not. Before we begin to answer that human challenge, first we must understand what we mean by autonomous vehicles. As discussed in the Policy and Regulation section, we propose a human approach to the SAE's more technical perspective of five levels of autonomy.

Autonomy in cars today exist only partially – we only have semi-autonomous vehicles – but these vehicles are increasingly becoming more autonomous, the robot car taking over more and more of the driving tasks from the human driver. Eventually, fully-autonomous vehicles will be on the road. In fact, Tesla's new models already have fully-autonomous capabilities from a hardware perspective, they're just not there yet on the software side.

Before we begin with full hands-off-the-wheel, eyes-off-the-road, sleeping-in-the-back-seat-autonomy, let's talk a little about the semi-autonomy that precedes it.

WANFY
26

WHAT WILL PEOPLE DO IN SEMI-AUTONOMOUS VEHICLES?

Well as it turns out, not a lot more than what we do in any car now. Let us explain…

The term "semi-autonomy" is an ambiguous one. One could argue that the introduction of the automobile was the introduction of the first autonomous horse and cart, taking over many of the "driving" tasks from the horse, the walking and pulling – the locomotion – replacing them with the engine. Something Don Norman might argue.

A similar parallel can be drawn with a fully-autonomous vehicle today. As it happens, the cars we drive today have been semi-autonomous for decades, or indeed, since their invention. Ever since Chrysler introduced cruise control (named even then as "Autopilot") in their 1958 Imperial[1], cars on the road have had some level of autonomy, whether that be cruise control, power steering, park assist, or any other form ADAS, many of which our good friend Joe Simpson at Car Design Research (CDR) discussed a little more in Past, Present and Future of AVs, earlier in this book.

But we already know about all these – we get them; with some magic, they replicate the mechanics that we as drivers would action, but with computer-like precision, taking the mundane task away from us humans. In fact, Norman Bel Geddes, in his pioneering 1940 book Magic Motorways, predicted that such advanced driver assistance systems would exist:

"These cars of 1960 and the highways on which they drive will have in them devices which will correct the faults of human beings as drivers. They will prevent the driver from committing errors. They will prevent his turning out into traffic except when he should. They will aid him in passing through intersections without slowing down or causing anyone else to do so and without endangering himself or others."

Norman Bel Geddes

Mad Men, AMC

In the series Mad Men, the episode set in 1962 described the then Cadillac Coupe de Ville's automatic headlight sensor, which dims headlights on a car's approach. An example of early ADAS systems, which were very obvious in appearance.

However, more recent semi-autonomous features seem far more mysterious and somewhat intelligent – semi-autonomy of the artificial intelligence kind. Tesla's Autopilot is probably the most recognised example of this today. Tesla's Autopilot takes Chrysler's 1958 cruise control and ramps it up to eleven. Tesla's Autopilot automates:

- Speed to match traffic conditions
- Keeping within a lane
- Changing lanes when required
- Transitioning from one freeway to another
- Exiting freeways when the destination is near
- Self-parking when near a parking spot
- Summoning to and from the driver's garage
- Auto-steering for complex roads
- Recharging
- Many more safety features

But it can't do everything, and as Tesla declares, while Autopilot is capable from a hardware perspective of full autonomy, it is still not clever enough to tackle all the human and environmental complexities required for full autonomy from a software point of view.

When you hear "Autopilot" the image of an aeroplane comes to mind, where the pilots are free to wander off for a toilet break. Tesla's Autopilot is not this. It's very name does not help, as it confuses our understanding of it, creating a chasm between human expectation from technological capability.

This became somewhat of a reality in the fatal Tesla crash in May 2016; the driver's understanding was that Autopilot was just that, that it could handle any situation and drive with full autonomy.

That is not the case, and as a result the vehicle, despite multiple warnings from the car, collided with an articulated lorry when the onboard cameras failed to spot it amidst bright sunlight, with devastating consequences. This illustrates the necessity of our design principle ***10. COMMUNICATE CAPABILITIES***. Ensuring that the user is fully aware of what the machine is and isn't capable of is important not only for the safety of the passenger, but also for comfort.

Tesla's Autopilot, and others like it, aren't yet good enough, intelligent enough, to do everything the driver does, which is why even the most sophisticated cars only offer semi-autonomy, including the recently released Tesla Model 3[2]. Even the yet to be released 4th-generation Audi A8, the first SAE Level 3 vehicle, is only just semi-autonomous. The technology is only capable of automating some of the journey – often the driver will have to regain control. Regaining control at 70mph when the mind is elsewhere, like in a gripping book, is no mean feat. Herein lies the most complex, most challenging, and perhaps most debated of human problems when it comes to semi autonomous vehicles – the handover and the takeover.

THE HANDOVER AND TAKEOVER

"Before the cars of the future can become our pilots, they need to prove themselves as our co-pilots."

Jon Brownlee
Co.Design

Until full-autonomy, people are going to spend lots of time acting as "co-pilot", taking cruise control to the next level – with this comes a whole new set of experiences. As discussed in Human–AV interaction, the "handover" typically refers to the staged period during which the AV transfers all controls to the driver, so that the vehicle can be driven manually, whereas "takeover" tends to refer to the specific length of time when the driver has regained manual control of the vehicle and automated systems have been deactivated.

It becomes clear how much of a human problem this is when you consider all the variables of the driving scenario and how hard we would find it to take them all in, in a way that meant we felt in control of the situation... again, at around 70mph. Also, how do you know when the car wants to handover and how does the car know that the passenger is ready to takeover, effectively transitioning from passenger to driver? Some of the key user experience challenges that come with this are:

Mode change:
- *How does the user know it is safe to engage autonomous mode?*
- *How does the user know it is safe to takeover?*
- *How does the car know it is safe to allow the user to takeover?*
- *How does the user takeover?*

Mode awareness:
- *How does the user know autonomous mode is successfully engaged?*
- *How does the user know the capabilities and failings of autonomous mode?*
- *How does the user know they are in control?*
- *How does the user know if or when autonomous mode will expire?*

Many companies and universities are tackling these issues, including ourselves (which you can read more about later in this section). One of our favourite, and relatively early, examples of an experiment that attempts to solve the mode awareness question: "How does the user know autonomous mode is successfully engaged?" is Audi's retracting wheel concept, inspired by Don Norman's horse analogy, which is being developed by Volkswagen's Electronics Research Laboratory (ERL) (Audi belongs to the VW Group). First, the Audi A7 concept, codenamed Jack, informs the user through iconography on an extra screen in the centre console, that autonomous mode will be available in X minutes.

This reassurance helps to instill trust in the machine, one of the key design principles we believe vital for the adoption of the technology – everything should instill trust in the machine, and maintain it indefinitely.

Once the countdown has ended, and the car is in an area deemed safe for autonomous mode, two buttons on the steering wheel glow – the driver presses the buttons to activate autonomous mode. The idea here is that both buttons have to pressed together to avoid accidental activation, inspired by missile launching systems[3].

At this point, autonomous mode is activated, but how does the user know this has been successful – what is the feedback? Well this is the clever bit...

Step 1: Lights on the dashboard turn from orange to blue. That's it. Incredibly simple, doesn't sound all that clever at first, but keep on reading... ISO standards for in-car displays, lights and buttons, dictate that the colour orange should be reserved for intimidatory or "get ready" type information, much like on a traffic light, while blue typically means operations are normal or just "on".

Notice that red and green weren't chosen. Red and green denote information of "go" and "stop", "right" and "wrong"; Audi wanted a new symbology. Given that we need to instill trust in the machine, symbology can be used for a dual purpose:

1. Providing information: For example, the fuel level low icon.
2. Evoking emotion: For example, red is danger, blue is calm.

This is something the concept Audi A7 is already utilising. Before the car takes over, representative lights on the dashboard glow orange – a sign of cautionary preparation. When the car takes control, they turn to a blue, confirming the action, and also evoking the emotion of calmness – you can trust the car is safe. The colours were carefully chosen for this dual purpose[3].

Step 2: Now this is the really clever bit. Remember Don Norman's analogy, comparing horse riding to autonomous vehicle riding?

"Driving an automated car is very much like riding a horse... You can ride a horse with tight reins or loose reins. Loose reins means the horse is in control – but even when you're in control, the horse is still doing the low-level guidance, stepping safely to avoid holes and obstacles."

Don Norman

It seems this is the metaphor that the UX group at Volkswagen's ERL have used to handover the controls (reigns) to the car (horse).

After the lights on the dashboard turn blue, the steering wheel then recedes towards the dashboard and away from the driver, literally taking the control out of the driver's hands. The steering wheel proceeds to twitch and turn to accomodate for bends in the road. There is nothing more innately understandable that the car is in control than watching the steering wheel being taken away from you and taking over the steering. This leads us to question if the pedals, wing (side) mirrors and so on should act like this as well.

The handover / takeover problem is not a technical one – the technology is pretty capable already – it's a human one and it presents a significant design challenge. This demonstrates the need for design considerations and user experience problem-solving, which will only become more and more vital as cars become more and more autonomous.

One final anecdote from FastCo's fascinating demonstration is from the supervising engineer, who was monitoring the demonstration from a laptop in the backseat of the Audi, who said during the demonstration:

"The first three minutes you're thinking: 'This is crazy, this is the future!' Then you get bored."

ERL Supervising Engineer[3]

As FastCo's Cliff Kuang remarked at the time, boring is good, boring is not scared, boring is trust in the machine and that it is doing what it should. Boring though is not an ideal experience, and could cause inattention and fatigue, when the driver is still supposed to be paying attention regardless. Drivers need to be kept alert so that they can take over when the semi-autonomous vehicle can't handle a situation.

"Driving is a really boring activity, and they [drivers] are trying to keep themselves mentally occupied... So the car should be doing things to keep the driver engaged, just in case it finds itself in a situation that it can't manage."

Wendy Ju
Stanford University[4]

How do you keep drivers alert as to avoid a situation like the Tesla crash? This is something we have explored with students from University College London (UCL), which you can read more about later in this section. As Norman Bel Geddes put it, people will do what people will do, including losing attention, getting bored, or even falling asleep. The vehicle can't do much about that.

So, if we can't guarantee that a passenger will be ready to takeover, to become the driver, then are there ways for the car to detect if and when the passenger is ready and only relinquish control back to them once it is completely safe to do so?

Faurecia has been working on just this concept with its Active WellnessTM 2.0 seat[5]. Faurecia's seat, a smart seat, is designed for comfort and safety in an autonomous age, according to Philippe Aumont, automotive seating chief technology officer at the company:

"Our aim is to ensure optimal comfort and safety at all times through merging biometric data, predictive analysis and the connected vehicle into an integrated technology for well-being."

Philippe Aumont
Automotive Seating CTO, Faurecia[5]

The position and configuration of the seat informs the vehicle whether the passenger is in the driving position or not, while sensors within the seat itself provide the vehicle with a number of data points, such details of the passengers physical position, which in turn are compared to a checklist of accessibility criteria to determine whether the person is in a fit state to drive.

Ergonomically speaking, this sounds very promising, but it doesn't tackle the more difficult of human problems, that of cognition, awareness, and mood – all of which can dramatically affect the passenger's ability to drive. While biometric data and facial expression detection can help glean such information, these are still very surface-level, detecting certain physical cues – reading someone's mind and knowing they are mentally ready for takeover is not yet possible.

From the examples above, you can see what a complex and problematic human challenge this handover scenario is. In fact, Google and Ford, and just at the time of writing, Volvo, have taken the bold move to skip semi-autonomy altogether, claiming that this human problem is just too difficult to solve, not only from the perspective of the demands placed on the shoulders of the person, but also in questions of company liability and government legislation.

Volvo's president and CEO, Håkan Samuelsson, said:

"In this mode [Level 3] the car is in charge of the driving, yet the driver must still be prepared to take over in case of emergency, which could be a matter of a few seconds. Volvo considers this Level 3 driving mode unsafe and will thus skip this level of autonomous driving."

Håkan Samuelsson
President and Chief Executive, Volvo[6]

While Google Waymo's CEO John Krafcik said:

"Level 3 may turn out to be a myth... Perhaps it's just not worth doing."

John Krafcik
CEO, Waymo[7]

Although Delphi states that: "If every car on the road featured Level 2 capabilities, fatal automobile collisions would drop by 80%" [8], automakers have found that there are very few safety benefits when stepping from SAE Level 2 to Level 3, both of which fall under semi-autonomy. Therefore, the likes of Google and Ford believe that SAE Level 3 – semi-autonomy – is just not worth doing. Waymo chief executive officer John Krafcik even believes that Level 3 might be a myth, although Audi will be releasing its 4th generation Audi A8, which offers Level 3 semi-autonomy, later in 2017. Google, Ford and Volvo are opting instead to skip straight to Level 4 – full autonomy – potentially opening up new markets while the other players remain busy with semi-autonomous pursuits.

So, as it turns out, to answer that first question again: "What will people do in semi-autonomous vehicles?" the answer is a lot more than what we do in any car now. To remain safe behind the wheel, the very purpose of autonomous driving, people have to be alert and pay attention at all times. Semi-autonomous vehicles, as demonstrated above, seem to have as many human user experience (UX) challenges as they promise to solve, and may have minimal benefits to safety until we reach full autonomy. This is not to say that semi-autonomy is without benefits. Our user Rick summed up one such benefit well:

"IT (HIS TESLA'S AUTOPILOT) TOOK AWAY THE MINUTIAE OF TRAVELLING. WHILE I DROVE SKIING TO THE ALPS WITH MY FAMILY, 95% OF JOURNEY ON FRENCH MOTORWAYS WAS THE CAR DRIVING ITSELF – WHILE WE WERE MONITORING THE ENVIRONMENT AND SUCH, THE SMALL DRIVER MOVEMENTS WERE TAKEN CARE BY THE CAR. WHEN YOU ARE DRIVING OVER 12 HOURS THAT MEANS YOU ARE LESS TIRED."

Rick, ustwo study participant

However, as Google puts it on its Waymo website: "The full potential of self-driving technology will only be delivered when a vehicle can drive itself from place to place at the push of a button, without any human intervention." We're talking full-autonomy.

WHAT WILL PEOPLE DO IN FULLY-AUTONOMOUS VEHICLES?

What will people do in a fully-autonomous vehicle is, on the surface, a far less complex question and one that often comes to people's minds first – if you're not driving, then what are you doing? Even Norman Bel Geddes in his book *Magic Motorways* ponders a similar question. As he pointed out, humans will want to do human things, even while driving:

"Human beings, even when at the wheel, are prone to talk, wave to their friends, make love, day-dream, listen to the radio, stare at striking billboards, light cigarettes, take chances. They would not be very human if they abandoned these practices even while driving."

Norman Bel Geddes

Bel Geddes sentiment above speaks of the human perspective, what humans need from technology, and this is precisely what we believe is somewhat missing from current thinking and is what we are focusing on in this book.

IT'S NOT WHAT CAN, IT'S WHAT SHOULD

"The user experience can evolve dramatically inside the car, I don't think that's going to be road blocked by any regulation."

Danny Shapiro
Senior Director of Automotive at NVIDIA Corp.[9]

That's nice to hear – designing with regulatory restrictions can be frustrating, as any designer in the auto industry will know all too well. But do the regulators agree with that sentiment? Like NHTSA for example:

"I think that's part of the excitement... All this stuff is going to change. We, of course, put safety at the top of it. But all those things are another competitive space. How do you give control of it? How do you use it?"

Mark Rosekind
Outgoing Head of the NHTSA[10]

It seems they do! The interior of the vehicle then can be approached with somewhat of a clean slate, dropping any legacy features that could hold back the experience, as can the exterior of the vehicle – something we illustrate with the AV Art Project you see throughout this book.

One or two of the things listed by Bel Geddes earlier are being shown off today by manufacturers with their visions of the future at technology shows like CES. One such activity is listening to the radio, or as we can project into today's technological offerings, being entertained, whether that be through audio, visual, or interactive means.

Many of the concepts we've seen in the past year or so from the likes of Panasonic and Mercedes-Benz, provide the driver-come-passenger with a multitude of entertainment options.

It's not just entertainment that these OEMs imagine you'll be doing in an AV, but those other things you do in other modes of driverless transport like trains and planes.

Audi's Long Distance Lounge (LDL) concept[11] is the ultimate rest and relaxation environment on wheels. Enzo Rothfuss, head of interior design at Audi AG even opts to avoid the term "car" and instead calls the vehicle a "moving object" in which you can not only rest, but also work as you travel across the country.

Yangfeng's XiM 17[12] concept has a mode for all three; entertainment, relaxing, and working, bringing in the third activity you might do when on a train or plane journey, with configurable interiors for each. Because all we want to do as people is watch TV, sleep, and work, right?

You can read more about the various concepts we're seeing today in Past, Present and Future of AVs.

"The next generation of gearheads won't obsess over horsepower and torque; they'll focus on things like radar range, communication latency, and pixel resolution."

Tom Vanderbilt
Wired[13]

Panasonic

Mercedes-Benz

We hope not! You may be picking up a sense of cynicism reading this, that's not because we don't think passengers will be afforded an array of entertainment options – in fact we propose certain entertainment solutions of our own later in this section – we just feel that there's far more potential here, there are far more meaningful needs than simply being entertained or otherwise distracted.

When we attended the Automotive Interiors Expo and Autonomous Vehicle Technology World Expo in Stuttgart in 2016 and 2017 respectively, we found that most people were talking about the same three options in regards to what people will do in autonomous vehicles: 1) be entertained, 2) do work, and 3) relax or sleep. You could suggest that this thinking is an assumption informed by similar transport offerings, like those presented by train and plane travel.

In fact, Volvo's new Concept 26 (named after the average time Americans spend per day driving to work), shown off at the 2015 LA Auto Show, has three distinct modes, as if designed around this observation: "drive" that lets the user drive, "create" that lets the user be entertained or work, and "relax" that lets the user relax or sleep.

Volvo Concept 26

The industry assumption that the driver-cum-passenger will either want to be entertained, do work or relax, (mis)informed by the likes of other driverless transport, then informs their concepts, which are all starting to look the same. Multimedia displays and augmented reality windshields provide the entertainment and work requirements, while the retractable steering wheels and super comfy seats provide rest and relaxation.

These solutions seem to still revolve around that fundamentally misleading question of "what can we do with the technology?" taking answers from what is known from current public transport. But what people require from a specific journey varies from vehicle to vehicle (car to train to plane) and also from person to person.

What do people actually want? What do people actually need from their journey? To get to the bottom of the problem, we need to look to users for the answer, not the industry.

OBSERVE, RATHER THAN ASK

"If I had asked people what they wanted, they would have said faster horses."

Not said by Henry Ford

A recent survey published by the Auto Service Center did just that. The survey asked 2,000 people to list the activities they would primarily do during their driverless car commute. The top ten responses were:

1. Read a book
2. Catch up with friends
3. Get work done outside of the office
4. Watch a television show
5. Watch a movie
6. Eat
7. Play video games
8. Sleep
9. Have sex
10. Pray

This list does seem to support the industry point of view, with the majority of the answers falling into one of the three categories: 1) be entertained, 2) do work, and 3) relax or sleep. Indeed, many of these, if not all of them, are common in air travel. Even response number nine is a necessity if you want to join the Mile High Club, and airports all over the world have installed multi-faith prayer rooms to facilitate response number ten.

The problem with this survey, and the assumptions made in events like those examples given earlier, is that the insights are based on personal assumption and experiential bias rather than observation of real human behaviour. The respondents to this survey would not and could not have had the entire context in mind when answering these questions. For example, if the respondents knew that the average time they would spend in these vehicles is likely to be around 15 minutes would they give these same answers?

Even if they were all American commuters, who spend on average 26 minutes driving to work[14], hence Volvo's Concept 26, how much book reading would you do in 26 minutes? How much work? You certainly couldn't watch a movie in that time. What sex act could be resolved in 26 minutes? (More on that later.) As an aside, Volvo's Concept 26 uses a little "contextual empathy", a term coined in our first book, whereby the tachometer in autonomous mode is replaced with a timer, informing the user when the autonomous mode will end, giving them the information they need to make a decision as to what to do with that time. If the user does not take over the wheel by the time the autonomous session expires, the car will pull over – pretty neat. How this will work in practice, for example on a bridge or highway, is yet to be seen.

We also spoke with Dan Phillips from the Royal College of Art (RCA), who is project manager of the UK's AV research project GATEway. At the Driverless Futures: Utopia or Dystopia[15] exhibition at the London Transport Museum, curated by the RCA, Dan and his colleagues asked visiting school children to draw what they would like from an AV, much like we did with some of our study participants.

"WE GOT 500 MEANINGFUL RESPONSES AND ABOUT 1,000 ADDITIONAL SCRIBBLES. WE WENT THROUGH ALL OF THEM AND WE IDENTIFIED WHAT PEOPLE'S NEEDS ARE AND WHAT THEY WANTED TO DO IN THESE VEHICLES... THE TOP TWO WERE SLEEPING AND EATING."

Dan Phillips, Project Manager, GATEway Project

Similar results then, but this approach is somewhat better than the cold survey example described earlier, and one that we use too. Observing the user's imagination unfold, spending time with them and asking questions gets you a little closer to what they may actually expect and need from such a technology.

However, there's nothing better than the real thing. There's a difference between asking people in the comfort of their own home and watching them in an actual autonomous vehicle. If you want to find out what people will do, or what people will want to do, in AVs you need to observe what they actually do, in context, over time. Merely asking them will provide subjective presumptions, not truth.

DESIGN PRINCIPLE UNLOCKED:

13. DON'T ASK, OBSERVE

People say one thing but do another – this disparity is human nature. In user testing or mining for insights, it's more accurate to observe what people do, rather than ask what they would do.

So to answer this question: "what will people do in AVs if they're not driving?" we will need to observe what people do in this context. This presents a barrier to adoption. When designing the vehicle itself and its interior, both physically, digitally, and from a service design point of view, getting this wrong will make for an inappropriate user experience and therefore poor adoption – the brand which gets this right is destined to win in this space. To understand the human need here, OEMs will need to trial their vehicles, with real users, in real scenarios (or as closely as is safely possible), to help guide their design direction. We discuss the importance of this, and how to achieve it, in greater detail in Prototyping and user testing.

HUMAN NEEDS

Referring again to the survey results, the top ten things people think they will do in an AV, the majority of the list falls under three main categories: 1) be entertained, 2) do work, and 3) relax or sleep. However, there are perhaps a few answers that don't quite fit, and these three represent very human needs: **Eat, have sex, pray.** We'll talk about one or two of these later.

What we see here is the beginning of very real and innate human needs, needs that users seem to feel is important in the context of AV riding, something that otherwise may not have been spotted if the people themselves were not consulted with or observed when designing the AV experience. From our own research projects over the past couple of years, we're seeing some further human needs that need to be addressed if the technology is to be adopted. Before we can begin to start thinking about how to show the latest movie, play a favourite album, or provide calendar syncing functionalities, there are very real and very deep human needs that first need to be addressed.

Many issues stem from the gap left by the driver beyond driving related tasks. Imagine getting into a taxi and there's no driver there. How do you confirm you're in the right taxi? How do you know the taxi is going to the right place and the right way? What if the car screeches to a halt? With no driver "effing and blinding" at the dog that ran into the road, you wouldn't know why it made such sudden braking and this lack of context could cause stress and even fear. There are numerous situations in which all of us rely on the driver, whether that's ourselves, our partner or a stranger, for a number of needs. One of the more serious situations is that anxiety and anxieties left unmitigated could get worse in what is known as the anxiety "snowball effect".

Some of these issues apply to all transport, but some are very unique and new to driverless cars, because of their smaller form factor and perceived risks on roads. This is where drawing parallels and forming assumptions based on these pre-existing transport modes proves inappropriate and begins to breaks down.

Currently, OEMs and tier one and two suppliers are asking what can we do. But the real question, the very question we're asking throughout this entire book is:

"What are people's mobility needs and desires and how can AVs support that?"

In this context, what do people need in order to be comfortable and confident riding in an AV and therefore adopt this technology? Not only that, but how can this technology integrate into and improve their lives and wellbeing?

THE THIRD PLACE AND THE MISSING SECOND PLACE

"I personally think what we know today as cars will change drastically. They will be automotive, you'll be expecting a completely different interior, and it's a march not only of mobility and technology, but mobility and third living spaces."

Frank Rinderknecht
CEO, Rinspeed[16]

Speaking of human needs, it's great to see that these are being considered by some manufacturers at least. In speaking with The Verge, Rinspeed CEO Frank Rinderknecht touches on a human need for what is know as the third place, which informed much of Rinspeed's Oasis AV concept[17], shown off at CES 2017. A concept popularised by Ray Oldenburg in his 1989 book The Great Good Place, the third place refers to another space separate from home (the first place) and work (the second place) which Oldenburg argues is important for civil society, democracy, civic engagement, and establishing feelings of a sense of place, all of which represent very important individual and group human needs.

Third places today are usually places like pubs, supermarkets, coffee shops, or libraries. Even bus routes have a third place quality to them, especially to those who board the same bus at the same time each day, seeing people they recognise or even form friendships with. To qualify as a third place, the space must have a number of characteristics, which are often summarised as follows.

Third Space 1: A levelling place
A space in which a person's societal status is unimportant or anonymous. Everyone is accepted equally, no matter their wealth or class.

Third Space 2: Neutral ground
A space in which you can come and go as you please, with no pressures to be there.

Third Space 3: A low profile
A space in which the personality is not overly grandiose and makes anyone feel welcome, no matter their background or lifestyle.

Third Space 4: Conversation is the main activity
A space whereby conversation is the main, but not only, activity – usually light-hearted and casual.

Third Space 5: The mood is playful
A space in which the atmosphere and mood is not serious or threatening, but playful and light-hearted.

Third Space 6: Accessible and accommodating
A space that is readily available, easily accessible and accommodates the needs of its occupants.

Third Space 7: Regulars
A space which occupants include regulars. Regulars, like in a pub, help set the tone and mood of the space. They're a familiar face that help newcomers feel welcome.

Third Space 8: A home away from home
A space in which they feel somewhat "at home" and feel a sense of belonging and a part of the space.

Rinspeed is not the only manufacturer considering the vehicle as a third place. In fact Fiat Chrysler, with its first-ever AV concept, a family minivan named Portal[18] showcased at CES 2017, has explicitly aimed its future concepts at the third space… space. However, as The Verge rightly point out in their CES 2017 rundown, the autonomous vehicle may have a difficult time fulfilling many of the characteristics Oldenburg stipulates as important for the third place.

If the AV is to be considered a third place, with its human and societal benefits, automakers will need to address each of the characteristics. In recent years, many people the internet industry has observed third places existing in the virtual world. Online communities, including chat rooms and forums, or multiplayer game lobbies, demonstrate the same characteristics defined by Oldenburg for traditional third spaces. Might the OEMs be able to combine the virtual third space, defined by the in-car digital systems as well as the connected and shared car service design, with the physical third space characteristics of the vehicle itself?

The last three characteristics, points six to eight, will be incredibly difficult to pull off in AVs. Further to that, the first three points will require an inclusive system, one which everyone can use, as we discussed in detail in People Autonomous Vehicles.

Our own study participants have expressed interest in third spaces too. Darret, for example enjoys a bus ride for its third place benefits. This is especially true for retired people, or those with reduced mobility, whose second place (work) no longer exists, leaving only two or as few as one of the three spaces required for mental wellbeing.

This problem exists not just for people who no longer work, but also people who work remotely or from home. More and more of us work from home, but with that comes a sense of isolation. By doing that, you combine the first place (home) with the second place (work) and without a third place, a person can become incredibly isolated and depressed. For this reason, more and more people are now working from a third place, increasing their number of "places" and diversifying their social interactions, which as we stated in People and Autonomous Vehicles, is as important as our need for water or food.

Coffee shops have noticed and taken advantage of this trend, offering free wifi to enable people to work from their establishments, paying for gallons of coffee and fueling the explosion in coffee shops all over the world. Hyundai's bonkers 2017 Mobility Vision concept[19] does this in a way that smashes all three spaces into one, the car acting as a literal extension to your home, that detaches itself and drives off when you need to get away.

Hyundai describes the concept as "blur[ring] the line between mobility and living and working space, integrating the car into the daily lives of users." While the execution is as mad as a bottle of chips, this could also greatly increase this probably of isolation-based depression by combining all three places into one, starving us of that social interaction our minds need to stay healthy – you may never see another human being ever again!

Before we move on to the ustwo point of view, we'll end on a great sentiment shared with us by Dan Phillips, project manager of the GATEway project, when we spoke with him at the project's London studio:

Hyundai Mobility Vision concept
Panasonic

"I THINK WE NEED TO SPEND LESS TIME CONSUMING AND MORE TIME BEING CARING AND CREATIVE. IF YOU CAN DEVELOP ECONOMY AROUND CARE, CREATIVITY AND CRAFT – AS SAID BY PETER JACKSON, A PROFESSOR OF SUSTAINABILITY – THAT'S WHAT THE FUTURE NEEDS TO BE."

Dan Phillips, Project Manager, GATEway Project

WHAT WILL PEOPLE DO IN AVS?:
THE OPPORTUNITY

"Have nothing in your house that you do not know to be useful, or believe to be beautiful."

William Morris

Or…

"If there is a market for cars with Jacuzzis, someone is going to build them."

Frank M Rinderknecht
CEO, Rinspeed[20]

It could go either way! We certainly hope for the former. In this section we give our point of view and suggest potential design solutions to each of the problems that could pose as barriers to adoption. Firstly, in brief for semi-autonomous vehicles, followed by fully-autonomous vehicles.

AV OPPORTUNITY 1: LET ME ENTERTAIN YOU

Travel in cars, whether for long or short distances, can be either be a welcome experience or a chore. While travelling to work on cold mornings can be an arduous affair, the travel back can be a relatively soothing one during which you might take the time to unwind after a tough day. In the worst case scenario, you might even have a day with a bad case of motion sickness or have to deal with children who are sick – motion sickness affects nearly 80% of people[26] at some time or another in their lives. This is further aggravated by our use of digital devices while travelling, furthering the chances of getting sick, prompting some people to predict that digital motion sickness will be the occupational disease of the 21st century.[27]

Of course, this is all an assumption, but the point to be acknowledged is that our mental and emotional needs might vary throughout the day, through the seasons or over the years – take a moment to think about what you did on this morning's commute to work, for example.

So "entertainment" as a blanket term can be a bit of a misnomer. The role of the vehicle and the entertainment that can be had within can vary depending on the type of passenger and the mindset they might be in on that occasion. This is even more so in AVs which have a greater mental void time to be filled with the removal of the cognitive load involved in driving. We will all be either involved or not-so-involved passengers in a journey. AVs can be a shared space as well – with people you know, or total strangers, akin to public transport.

So, the deeper question is: do we even have to fill this mental void? Can the time be used for other purposes – to soothe a person after a tough day, listen to a podcast, learn a new language, or even meditate for a few minutes? Besides, people will probably turn to their phones for entertainment like they do today. The avenues for AV entertainment can then be broken down and reassembled into what we can call "fulfillment" or even "recovery". Can we use this to recreate the positivity that Françoise or Rick experience while driving?

"DRIVING FOR ME IS A POSITIVE ACTIVITY, IT KEEPS ME ALERT."

Françoise, ustwo study participant

One method we can use to build positive experiences, is to use the concept of the “third space” which we spoke about previously. We could take up some of the aspects which make up such a space to see how an AV could affect it.

Third Space 1: A levelling place

Where good conversations can be had, sometimes with regulars, perhaps building positive relationships with good company.

Living in a city, especially in a large one with a multitude of people and environments, can be quite stressful and, ironically, quite lonely[28]. Studies have shown that the incidence of mental illness rises in city environments[29] when compared to rural ones. This is also symptomatic of growing smartphone use, where people have the tendency to disappear into their virtual worlds either to escape or to commune with others online. Think of the number of people on their phones in a bus, train, or tube. Interaction and conversation barriers are high.

> *“Technology promises to let us do anything from anywhere with anyone. But it also drains us as we try to do everything everywhere. We begin to feel overwhelmed and depleted by the lives technology makes possible. We may be free to work from anywhere, but we are also prone to being lonely everywhere. In a surprising twist, relentless connection leads to a new solitude. We turn to new technology to fill the void, but as technology ramps up, our emotional lives ramp down.”*
>
> **Sherry Turkle**[30]

Cities could also be among the first places to see the use of AVs, especially given the specialist vehicles which might be needed from delivery to emergencies, to taxis and shared cars. Looking at the shared-car space, which is a growing segment, we can see a potential for creating a third space environment where the interaction barrier might be reduced between people. This can be especially true given the proximity of people with one another in a shared vehicle and will depend a lot on the seating layout as well.

Conversation or interaction currently happens in a shared car by two means – with the driver or with fellow passengers. With a lack of driver in AVs appearing to be a possibility, there is potential for a technological mediation which can break down interaction barriers. The AI behind the vehicle or service can act as a friendly intermediary between people with the use of certain basic human conversational techniques coupled with some technological advantages, some of which are listed below.

Introductions. The ability to recognise people and provide introductions, to people already on board or to people who are getting on board. The human equivalent would be a friend providing introductions during a dinner.

Identify. The ability to identify regulars and greet them accordingly, which may serve as an addition to the introduction. The human equivalent would be the local barman who recognises regulars.

Common ground. The ability to find common ground between people – their shared interests, likes and dislikes.

Matchmaking. Synchronising journeys and providing alternatives so as to make like-minded people meet or to allow interrupted conversations to continue (a conversation which ended in one journey could be picked up in another).

There are, however, some huge design challenges in making this work without making things creepy between people or stepping on huge privacy issues. It’s a worthwhile topic for further study.

Third Space 2: A neutral ground

Where you can maintain a low profile, perhaps allowing people to spend some time to recover.

The previous point about conversations in the third space that is the AV is based on the assumption that people will be open to interaction. But what if people just want to switch off?

The space within the AV in this situation can in this particular instance be used for rejuvenation or even introspection. This has been explored to a certain extent by manufacturers like Faurecia.

Their Active Wellness™ 2.0 concept seat[31] is equipped with sensors to identify the mental and physical state of the passenger and see if they are in a state of stress. The seat then provides appropriate feedback to enable them to reach a nominal state – personalised actions and therapies that include adjusting the seat position, a five-programme massage capability, seat ventilation, and changes in ambient lighting or the audio environment.

Faurecia's Active Wellness™ 2.0 concept.

A rather interesting concept, but with an innate assumption that changes in the physical environment could impact stress levels. There might also be mental and emotional needs that might be unmet from this form of feedback.

This was raised by some of our interviewees, especially Darret, who thrives on interaction with the driver of the vehicle to both reduce stress and also as a source of company, without necessarily having to deal with people on public transport. It is all about having a safe, non-judgemental area to air your mind. As Dave mentioned, his cab sometimes acted as a "confession booth on wheels".

This concept of a neutral ground can be taken much further with the therapeutic values of conversation being assisted by AI (remembering that conversations can be visual or verbal, depending on the passenger's needs).

An early example of this in operation were the ELIZA experiments by Joseph Weizenbaum[32] in MIT's AI lab during the '60s. ELIZA was a relatively primitive chatbot whose responses were based on pattern matching and substitution, giving the illusion of intelligent conversation. Despite starting with an early premise of proving the superficiality of conversing with computers, Weizenbaum was surprised by the extent of the humanity people attributed to ELIZA, which sometimes lead to addictive and prolonged conversations.

This anthropomorphism of chatbots has now reached a stage where techniques in cognitive behavioural therapy are being used in their programming. An example of such a bot is Woebot, built as a Stanford project. This is a chatbot running on Facebook's messenger platform and is so far the only such therapeutic device that has peer reviewed clinical data to back up its effectiveness.

"It's kind of funny... If people get the sense that it's safe then they'll disclose anything. Their desire to reach somebody overrides those privacy concerns because they're much more intangible and ephemeral."

Steven Chan
American Psychiatric Association[33]

Despite its many limitations, and the fact that a human therapist is what is ultimately most effective, there is a space for AI tools that can actually provide a forum or a safe space for people to just talk to someone, while on the move. A space that can very well be seen in an AV, providing if designed well – a pure, non-judgemental space for conversation.

Third Space 3: The mood is playful

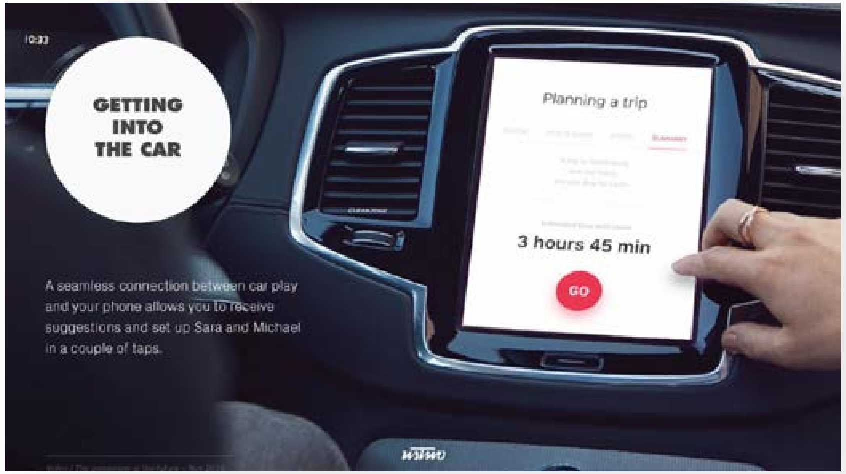
The space is accommodating, perhaps providing an ability to construct unique brand experiences.

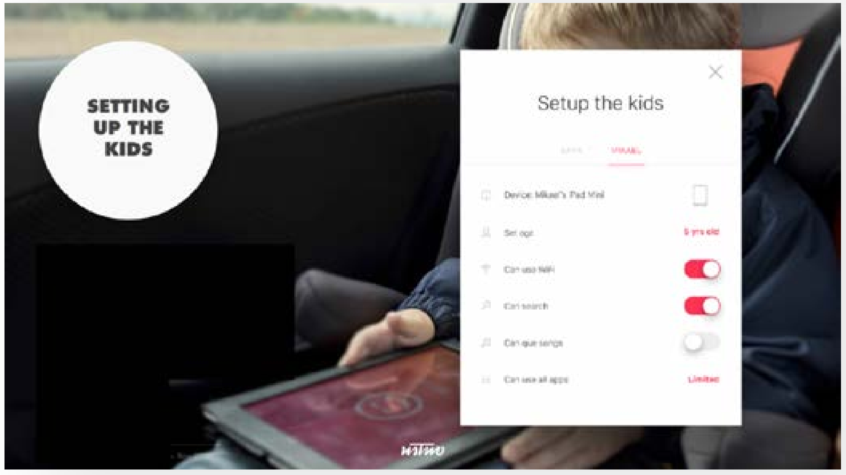
One thing missing from the experiences offered by taxi or ride sharing services (eg Uber) is the ride itself. As discussed earlier, there's not much to the Uber brand once you're riding in the back of a Prius. Something brands will want to consider is the brand visibility and offering during the ride, inside the vehicle itself. Here is an opportunity for brands to offer something unique to the consumer, which could help them establish a corner of the market.

Volvo are doing remarkable work in the field of semi-autonomy anf their *human-made* proposition sets out what's important to them. It's exciting to imagine what a Volvo family car of the future might offer.

With this in mind, here's a small concept we developed with them to help demonstrate how the interior of the car could bring the family together.

We believe that people will still be using personal screens in 2025 and beyond, when AV technology will appear on the roads (or so people predict). We can use this ubiquity to our advantage.





In this concept, we turn the interior of the car into an entertainment environment, the personal devices acting as a remote or controller. The child, through security settings, will have access to various pieces of technology throughout the vehicle, from internal speakers to chair configurations, to external cameras and the like. With each user holding their own device, each with various permissions, the family can play a game together, the vehicle facilitating a unique style of gaming. The potential ideas are plenty, but as an example, one of the games we developed was a new take on the familiar "count the yellow cars" or "first person to spot a blue car" game. Players have access to the various external cameras required for the AV to operate, using their device as a means to navigate the various camera perspectives – tap on the yellow cars to increase your score and beat your family's scores. Alternatively, using augmented reality and transparent OLED screen technology installed into the windows, tap that blue car you see outside before your sister does. This latter iteration could also help mitigate the predicted rise in motion sickness described earlier. Motion sickness is caused by a mismatch between your inner ear sensing movement[34] and your eyes not seeing that movement, ie when looking at a tablet in the moving car. By moving the game onto the car's windows, and incorporating the real world into the gaming, the inner-ear and eyes' perception finally match, thus preventing motion sickness.

This is a very simple proof of concept, but it demonstrates a way in which a brand like Volvo could enhance its position as a family car.

Our concept for in-car family entertainment

AV OPPORTUNITY 2: MISSING THE HUMAN DRIVER

When fully-autonomous vehicles come, we can then transition to that human-centric term “driverless car”. Once we’re free of having to operate the vehicle, or pay attention to the unfolding situations of the road, technology can truly begin to help make us, as humans, more autonomous. When we say “begin” we really do mean that this is just the start, the potential still yet to be realised, with the opportunities matched only by the many challenges.

Take, for example, a London black cab or a taxi in New York – a transport method in which one would expect the presence of a driver. The automobile is, after all, the last vestige of the manually-driven vehicle, with trains, planes, and metros all being mostly or completely autonomous these days.

The complexities of the road make it that much more alarming for those not used to thinking about autonomous vehicles – and that’s all of us, by the way. Our study participant Dave remarked that Londoners don’t mind that the DLR (Docklands Light Railway) is driverless for one simple reason:

"THINGS LIKE THE DLR, PEOPLE DON'T MIND GETTING ON IT BECAUSE IT'S ON A RAIL."

Dave, ustwo study participant

The implication being that the rail makes it somewhat simpler and thus safer. On the other hand, another study participant, Darret, was alarmed to hear that the DLR was driverless – she had no idea.

"IS IT DRIVERLESS?! OH, I WON'T GO BACK ON IT THEN!"

Darret, ustwo study participant

These other vehicles travel on tracks, whether physical ones like the train or digital ones like an aeroplane’s flight path, greatly reducing the complexity. Further, for the most part, trains and planes have that entire stretch of “track” all to themselves, which is clearly not the case in our cities with their congested roads.

That said, AVs will be far safer than a driven taxi, as we pointed out in Morality and ethics. So why would people fear them? Well, it’s quite simple. The perceived risk of danger is, apparently, far greater than if a driver were on board, despite the fact that it will be statistically far safer. That *percieved* risk of danger is of huge consideration when tackling people’s trust of the technology.

So, even without incident, as the passengers board the AV, their stress levels will already be higher than normal, at least for some people (the significance of which is yet unknown) and at least in the early days of the technology appearing on our roads (or perhaps indefinitely as we see with people’s fear of flying today, over 100 years since the first commercial flight).

The children we interviewed also believed that the cars would be unsafe without a human driver. However, we’re quite confident that, over time, with the technology proving itself and gaining trust from the public, AVs could one day not be observed like an unsafe drunk driver. To get there though, many of the things that the presence of a driver brings to the experience must be replaced by the service and user experience of an AV journey.

DP.14

Given that passengers may already have increased stress levels getting in the vehicle, any new cause of stress could increase those levels exponentially. This can be seen on planes today with people with a fear of flying. They are already stressed when boarding the plane, then the myriad of odd noises, the unfamiliar environment, followed by the takeoff itself, the levelling out, not to mention turbulence, can bombard the traveller with sources of stress which all build on one another. With that in mind, we come to a new design principle.

DESIGN PRINCIPLE UNLOCKED:

14. MITIGATE CONCERN EARLY

While the technology is earning trust, people will feel concern using AVs. Continued sources of stress from the all-new experience of a driverless can cause stress levels to rise. Concerns left unmitigated may result in panic.

Let's take an example. You're taking a taxi from work to home, with a taxi driver leading the way. You look out of the window and see familiar landmarks, each one making you more confident that you're on your way home. Those milestones are your stress mitigators. Now imagine you're getting into that same taxi, but this time from your home to a location you've never been to before. You look out of the window and you don't recognise anything. You look to a map on your phone, but the journey is taking longer than expected, and you begin to get nervous.

Questions like "Am I going to be late?" or "Are we going the right way?" start going through your head. Finally you ask the driver, who explains that congestion is causing the delay, but that you are indeed going the right way and the delay should only be as much as ten minutes. You feel better. Now imagine that same scenario, but without the driver. If the AV is taking you to an unknown destination and it is taking longer than expected, what stress mitigators are in place to help you feel better? Not to mention the more practical questions like: "How much longer is this going to take?"

Let's try another example. You're riding a manually-driven taxi to meet your friends at the beach for the weekend. You're travelling at 50mph down the motorway when, all of a sudden, the car screeches to a halt and the driver presses firmly on the horn, preceded by some cursing and colourful language. It transpires that the evasive manoeuvre was taken to avoid running over a dog that ran out in front of the taxi. Now again, imagine that same scenario, but you're in an AV and there is no driver. The vehicle will likely perform the same evasive manoeuvre, but the stress mitigators are missing. Will the machine sound the horn? Maybe (see Liability and insurance for more on that). There definitely won't be any cursing or colourful language… maybe (see Branding and service experience for more on that). You're left to wonder what just happened, and your stress goes unmitigated and unpacified. The "perfect" machine is missing that imperfect but important human behaviour

There is potential for frustration here too. The passenger is more likely to make human/lifestyle requests that distract from the original plan of getting them home. For example, they may choose to pop in to the McDonald's drive-thru they spot on the side of the road and command the AV to do that. However, if this action means hurting a pedestrian or colliding with another vehicle, the AV will simply not do it (as discussed in Morality and ethics), and by the time the feedback has been provided, if any, the opportunity has gone, leaving a frustrated and hungry passenger. Now, that situation would of course play out the same with a human driver behind the wheel, but the frustration here will be directed at a machine. Far from an ideal experience.

What's missing from these scenarios is orientation, contextual empathy, and feedback.

1. Orientation. Where is the user in space and time? A fundamental human need is to understand our place, whether that be how long into a journey we are (ie 15 of 20 minutes) or where we are in the city (ie Athenaeum Road, just down the road from our house).

2. Contextual empathy. Provide information about certain contexts of any given situation. In the example above, the information of stopping suddenly is not enough – the user wants to know why. The context is that the car had to avoid squashing the dog. Without that context, we panic.

3. Feedback. Communicating to the user that the AV has acknowledged both of the above, as well as inputs and interactions from the user. In the previous scenarios, all three points – orientation, contextual empathy and feedback – are potentially absent. In the driver examples, the driver's cursing was the feedback, and contained both the orientation and contextual empathy within its content.

So with that in mind, to fill the gap left by removing the driver, in this case the feedback of the cursing, designers of the AV experience may want to ensure that appropriate feedback is given at all times. How can an AV do that? Well, as discussed in previous sections, namely Human–AV interaction, using the multitude of onboard sensors to understand context as best it can, the AV can verbally and visually provide feedback at two important intervals:

Proactive. The feedback here could be in providing orientation information such as status updates at intervals along a journey, ie "three minutes to destination". These will need to be well-designed and well-considered as to not overstimulate, annoy, or be ignored.

Reactive. After an event, such as the screeching to a halt example above, the reactive feedback could carry the contextual empathy information, explaining the reason for the sudden stop.

Here we can apply our design principle ***08. ACT HUMAN, BE ROBOT***.

Without bearing these parameters in mind and by not designing for these needs, AVs could cause more stress in our lives, perhaps even on a societal level, than they could actually alleviate.

ISO 7000-0085
Hazard warning

AV OPPORTUNITY 3: SEX

"Every form of transportation has played a part in American courtship and romance. Pedestrian locomotion, horses, boats, trains, bicycles, streetcars, automobiles, buses, and airplanes have brought lovers together, or sped them to the Elysian fields for idyllic pleasures."

David L Lewis[36]

SEX

Ever since the horse and cart transported us from place to place, people have been having sex on the road. Intercourse in the well-cushioned, spacious, unencumbered, enclosed cart of the pre 1900s automobile was comfortable and exciting. Ford Historian David L Lewis, in his 1980 paper Sex and the Automobile: From Rumble Seats to Rockin' Vans, covers this early 1900s history of sex in automobiles.

When the automobile came along, it offered a sanctuary for romantic forays from the otherwise mood-killing supervision of overbearing parents or annoying curiosity of siblings. However, the form factor of the automobile, the successor to the horse and cart, made this practice somewhat more difficult. Before the 1920s, most cars were effectively convertibles, or at least they had no roofs. "High rise" seats made any act of passion easily observable by any member of the public. Even the bucket seats, now individual – one for each person, as opposed to the bench of the cart – acted like chastity belts, separating one another and limiting opportunities for wandering hands. Rumour has it that Henry Ford even designed the seats in the Model T to be just 38 inches in length simply to discourage sex. This proved to be unsuccessful[36].

Come the 1920s, though, and the automobile becomes well-suited as a place to go for the act of sex. Now largely enclosed, their roofs obscure obscene views and protect naked couples from the elements. Seats are larger and more comfortable, and some are even detachable and somewhat modular, meaning love-makers could clear the decks for a romp in the back (far cheaper than visiting a motel). The car is in fact credited with making America more sexually liberated by increasing the radius in which sexual partners could meet, from the mere five-mile radius of the horse and cart, to the 50-plus mile radius of the automobile. According to Lewis:

"Sociologists noticed that increased mobility provided by the motorcar would lead to more cross-breeding and eventually improve the American Species.

David L Lewis[36]

Improving the American species?! While that sounds incredibly bold, we can see his point. Could this be applied to mobility of the future, and on a global scale, for the human species as a whole? Could the increased mobility provided by AVs, such as planes and cars, in the future lead to greater reproductive opportunities and therefore a genetically enriched human species?

AV + MOBILITY = SUPERHUMANS?

Though far-fetched, perhaps the AV is more than just the "biggest revolution in mobility since the automobile replaced the horse and cart" [37]. Not cars, but sex in cars, according to Lewis, was even responsible for the very existence of drive-in restaurants, theatres and "by the hour" motel rooms in the 1920s and 30s.

Of course, it wasn't long before popular culture, from music to advertising, began sexualising the car, perhaps due to the mobile love-making it afforded, or simply because "sex sells". It has long been understood that car designers even sexualise their vehicles in a sort of kinky form of anthropomorphism. Long, curved, phallic-shaped vehicles give the stigma of "over-compensating" to their drivers, while other cars have been designed with the female form in mind. Mechanophilia, in which people feel sexual attraction to machines, such as automobiles, is an actual condition, but we'll leave it here – we're talking about sex in AVs, not sex with AVs.

Today, the sexual need for the automobile, as a refuge to have sex, is less of a necessity. Young adults have plenty more places to go to if they want some extra privacy. Sex in cars today has more to do with excitement and voyeurism than it does with privacy.

SEX IN AVS

One might argue that a commercial plane is an AV and in which case members of the Mile High Club have been having sex in AVs for decades. There's no such established club for autonomous cars... yet. When mingling at a conference or an event, the question of what people will do in autonomous cars always comes up. Sex never comes up of course, we're all too serious and professional to even acknowledge that sex exists at such events. However, at the pub or at a friend's house, when others hear that we work on the design of autonomous vehicle experiences, conversation almost always turns to sex.

"IMAGINE, ON A NIGHT OUT, YOU MEET SOMEONE AND TAKE AN UBER HOME WITH THEM – WITH NO DRIVER, YOU COULD HAVE SEX IN THE CAR WITHOUT BOTHERING TO 'GO BACK TO MY PLACE'."

Drunk party friend

The scenario so colourfully painted here supposes that the car could then drop off both individuals (or more – who knows!) at their respective homes, post-sex, both feeling safe in the knowledge that their home address will remain private and that they won't have to endure the awkward moment of waking up next to each other the morning after. Another great example of the time saved through the lifestyle integration principle discussed earlier. Maybe people will get into AVs purely for this reason, not to go anywhere, just to have sex while the car rolls around the block, dropping you off back home when the deed is done. "Would you like a five-minute lap (a "quickie") or a 45-minute lap (sex of epic complexities)?" Sex was, after all, the ninth highest response on the Auto Service Center survey on what people think they'll do in AVs. We wonder how many taxi drivers have had to endure impatient couples in the back of their cabs on a Saturday night?

In 2016 Uber had to even pose a no-sex rule in the first ever guidelines aimed at passengers[38].

Maybe it's because movies like Crash[39] popularised the idea. Or perhaps the famous scene in Titanic[40] in which DiCaprio and Winslet's characters have sex in a car romanticised it. They went fully multi-modal though, having sex in a car – on a boat. According to studies, the second most popular sexual fantasy for women is to have sex in an usual place, which very much includes the car[41]. However, the same study also indicates that people often prefer sexual fantasies to remain just that, and would not necessarily want to act them out in real life.

Nevertheless, people regale us of the times they've enjoyed a spot of giving or receiving "road head" (when the driver of the car receives oral sex) and extrapolate the possibilities even further in the understanding that they won't have to concentrate on the road anymore, the car taking over the driving act while the people can carry on with the sex act.

Full sex in a car though is not as simple as it sounds and sex while driving is clearly a no-no, and of course falls under reckless driving laws[42] (though we're sure it still happens). Sex in a stationary vehicle is another matter. Some of you may have had experience with this idea and having spoken to many people about it, it's evident that sex in a car is actually incredibly uncomfortable and somewhat difficult, ergonomically speaking (and let's not talk about sticky leather seats). In fact, Bustle sights just two possible positions for having decent sex in the car:

1. Backseat "spoon": Fairly self-explanatory. Both parties lie on their side, one behind (big spoon) the other (little spoon) on the back seat of the car. This is the only way both will be able to fit comfortably in the back seat and has the added bonus of people outside not being able to see you. At least, in today's cars...

2. Passenger seat "cowgirl": In this position, one person (the horse) sits in the passenger seat as normal while the other (the cowgirl) straddles the first as if riding a horse. Reclining the passenger seat gives more space and the lack of a steering wheel means the "cowgirl" won't be honking the horn every other second.

Is sex in cars illegal though? The short answer is no. The longer answer is: that depends. As far as our research is concerned, we couldn't find anything that specifically says that sex in a car is illegal, moving or otherwise. Jezebel[43] failed to find any such laws in 2008 either, but they did discover that some US states prohibit all kinds of sex other than penis to vagina, whether committed in a car or not. In fact there are 13 states that will prosecute those found performing oral sex anywhere[44]. Further to that, if people are caught having sex in a car, in some parts of the world people risk being accused of a crime through assumption that they may be engaging in prostitution or other forms of illegal sexual activity[45], rather than the sex itself.

One killjoy in this matter is that sex in a public space is illegal, which also of course increases the risk of being seen (or caught). However, when it comes to cars, this law can be somewhat grey, or a shade thereof. A highway is a public space, so having sex on the tarmac of the A406 is definitely illegal. Having sex in your own car, on the A406 – is that illegal? What about sex in a shared AV?

In the future this could be considered a form of public transport – does that count as a public space? Is sex in a shared AV therefore illegal? The state of Chicago and others do classify the car on non-private land as a public space, and therefore in Chicago, sex in a car is illegal. Whether police officers take the offence seriously and actually enforce the law is another question.

However, unless you're on private land, if people can see you having sex, through the car windows, you are guilty of public indecency. Beyond that embarrassment, and the legal ramifications, what if children could see – a definite issue, and in the US could mean you would be registered as a sex offender.

So sex in cars isn't illegal but you are at risk of being found guilty of another sexually related crime if:

- The public are offended by seeing the act, known as public indecency
- Children see you, potentially putting you on the sex offenders' register
- Police see you and assume you are engaging in prostitution

In the future, people may see their AV as an extension of their home, much like some of the concepts described earlier in this section. In a way, the AV could be a strange middle-ground between home and public space, or dynamically shift between the two. Ignoring for a moment that there are windows people can see into, the notion of this mobile cocoon on public roads, may or may not equate to the feeling of privacy (ignoring that cameras are everywhere, perhaps even in the car). Perhaps, like on planes, sex in an AV will be considered risky, and appeal in that way. Rather like the Mile High Club on planes, perhaps we will have the "**Last Mile Club**" in autonomous cars.

Our perspective? Have consensual sex in an AV by all means, just don't get caught. There's one simple way to solve this problem – control the opacity of the windows. Brands need not market this as an anti-voyeur feature, but as a general privacy feature. Although if you see a stream of AVs driving by, only one of which has turned off "transparent mode", you might have your suspicions...

When all is said and done, sex in cars today is actually incredibly rare, with people only choosing the car as a place to have sex four times in their entire lifetime (or so they say[46]). Maybe because it's so incredibly uncomfortable. So, for people to have sex in the car, autonomous vehicle makers may want to consider more comfortable and ergonomic opportunities within its interior, while offering the privacy required for shy love makers or the cloak that hides them from ambiguous laws. Do car makers care, though? Probably not. When asked by journalists at Inverse, Tesla and Delphi declined to comment, while a Google spokesperson said that Google "has no official position[47]". Might we suggest backseat spoon or passenger seat cowgirl?

"THE LAST MILE CLUB"

But perhaps they should care. As you free the hands of the passenger, and remove the third-wheel that is the taxi or Uber driver, AVs may bring with them a resurgence in sex in the car that peaked in the 1960s, thanks to a change in culture and young adults leaving home younger[36]. If AV makers want to take advantage of this possible new corner of the market (don't forget that sex has been used to sell cars for decades), then perhaps they should take inspiration from the very beginnings of road history, that of the cart (minus the horse), specifically with regards to the interior – detachable seats, comfortable, and obscured interior etc.

Don Norman once said that riding a driverless car should be like riding a horse – loosen the reigns and the horse will find its own way home, taking you home with it. When it comes to sex, you could therefore have intercourse in the cart while the horse, oblivious to all but the way it was going, takes you back home. With AVs, we could get that horse and cart sex experience back again!

AV OPPORTUNITY 4: SAFETY ISSUES

Safety of course is one of AVs' major benefits. It is predicted that human error is the cause of more than 90%[48] of today's road accidents. Removing that error with machine control or aids seems like a no-brainer and is something that the industry is striving towards. However, one aspect of safety that has largely remained unexplored is that of personal safety from others, ie from robbery or carjacking.

These days you see a lot of smashed car windows, trails of broken glass leading to thieves who have smashed and grabbed valuable pieces of kit to sell on the black market. With AV concepts showing off huge HD screens and other forms of high-tech gadgetry, could AVs take us back to the days of highway robbery? These vehicles might well come fitted with bulletproof strengthened glass, but when threatened by an attacker a passenger may still volunteer access to the vehicle.

There are far more concerning scenarios than theft, however. Having spoken to 85-year-old Socorro who lives in Mexico City, we discovered that in her city, cars waiting in traffic are a prime target for carjacking and kidnapping.

IT WAS VERY DIFFERENT, THE CITY WASN'T AS CHAOTIC AS IT IS NOW. I COULD COME AND GO EASILY, BUT NOW IT IS MUCH MORE CHALLENGING DUE TO HEAVY TRAFFIC AND THE DIFFICULTY IN FINDING PARKING SPACES. CRIME HAS ALSO ROCKETED IN THE LAST YEARS. THAT, TOGETHER WITH MY AGE, FORCED MY FAMILY TO ASK ME TO STOP DRIVING."

Socorro, ustwo study participant

In fact, as we write this, The US Department of State published a travel warning to people travelling through parts of Mexico[49] – including Mexico City – for "violent crimes, including homicide, kidnapping, carjacking, and robbery". If you imagine an AV taxi situation, a method used by the elderly who can no longer drive, then these people could be even more vulnerable to these crimes as a result of the advancing technology.

This challenge demonstrates why we need to understand human needs for all social groups and cultural differences with regards to feeling safe on the road. For AV technology to be adopted in places like Mexico City, OEMs will need to consider and design for safety, not just from accidents, but also from outside forces, such as criminals.

SEMI-AV OPPORTUNITY 1: TO DRIVE OR NOT TO DRIVE?

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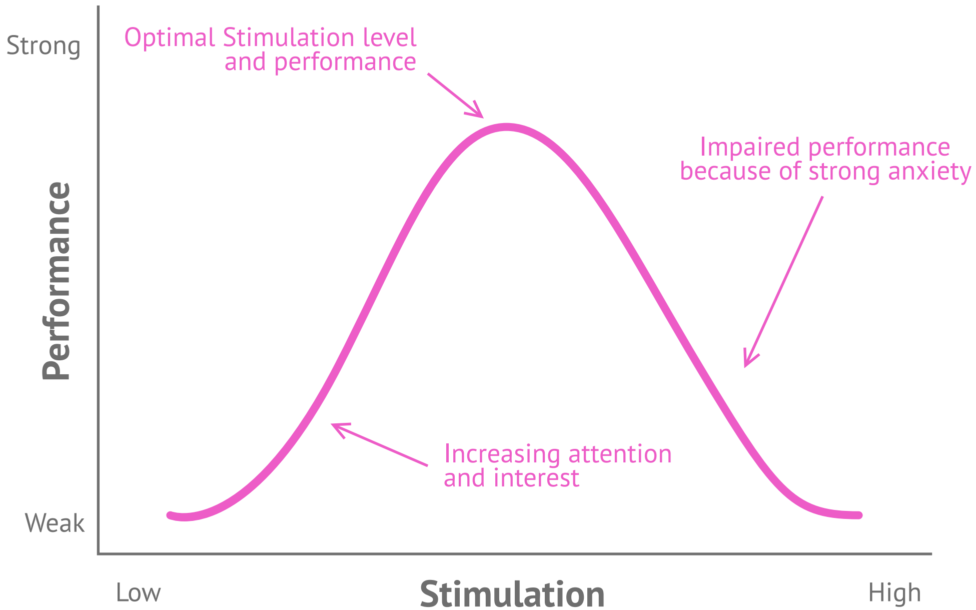
University College London

Each year, ustwo Auto sets a brief and mentors a group of masters students through their Human-Centred Interaction Design (HCID) courses. In the previous two years we worked with University of Washington in Seattle's students, first helping with an innovative solution to the problems associated with texting while driving[21], and last year with a fascinating exploration into community connected motorbike solutions for the unique problems that context presents over automobile driving. This year we wrote a brief for the HCID master students at UCL on the handover and takeover and asked them to explore human tolerances for such a cognitive mode shift and to try to understand how people will feel once fully-autonomous mode kicks in. We mentored them through the year and here they present their studies and findings. Collaborating on research projects like these mean that we can continue to develop our understanding of the complex relationship between people and the AV machine.

A "goldilocks" zone of cognitive load from situational awareness is key for the fastest takeover response in SAVs. Too much or too little can result in a slower response.

With current SAVs, the biggest problems seem to derive from the human drivers not having a well formed mental model of how the autonomous system works. Drivers that don't build a good enough understanding of the system can either end up trusting it too much, or not enough. As AV design and production move through levels 3 and 4 of autonomy, more control over the vehicle will be in the hands of the autonomous system. With this change, it's going to be more important that the AV system has a well formed "mental" model of how human drivers work. The communication and transfer of control between the human and computer systems would greatly benefit from a better understanding of human SAV use. To make an impact on this increasingly important field of study, I looked for new ways to understand the way drivers use semi-autonomous vehicles.

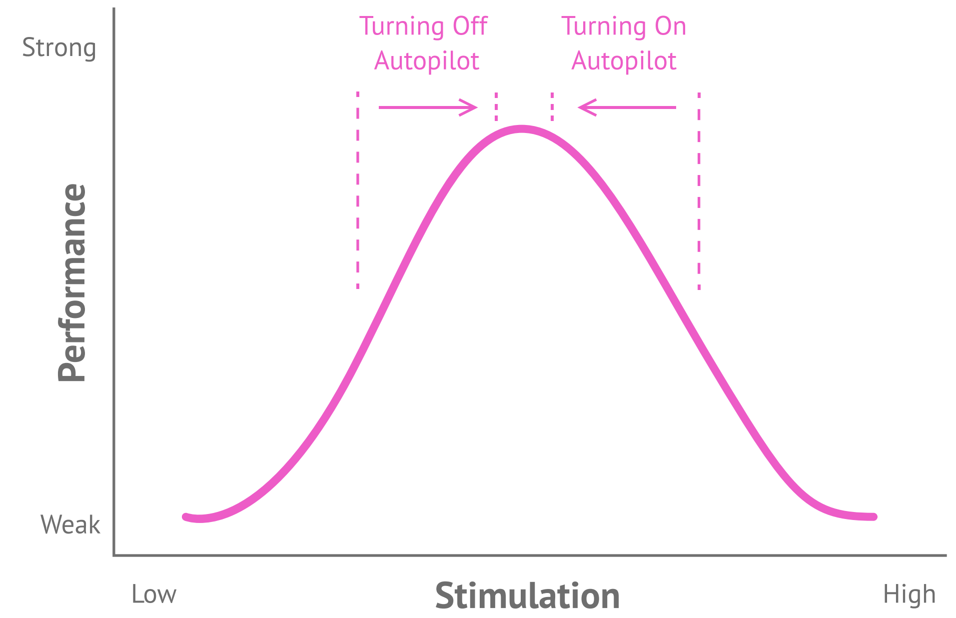


One of the more intriguing areas of research in this field is the Yerkes-Dodson Law. This well-established psychological law was first observed in 1908 with mice using mild electrocutions. Robert Yerkes and John Dodson found that when trying to learn and navigate a complex maze, mice performed best when they were stimulated just the right amount. A lack of stimulation or having too much would hurt the mice's performance. This began a slew of related research that found this same effect of a Goldilocks zone of stimulation levels in human performance. You can see this in the graph provided. We learned that humans perform complex tasks best when they are stimulated or aroused, but at the right amount. This means that when people are understimulated, bored and apathetic they don't give a task enough attention or effort, and hinder their performance. On the opposite end of the spectrum when people are overstimulated, swamped and overwhelmed, they cannot focus on the correct actions, over think and perform worse at the task as well. When stimulated the right amount, humans have the motivation to perform well, without overthinking a problem. This research has been used to understand the behaviour and performance of a humans doing a lot of different tasks.

Research on how this applies to driver behaviour and performance in vehicles has been done, but has yet to be applied to SAVs. This gap of knowledge is what I aimed my research to tackle.

THE HYPOTHESIS

To start solving this problem, I designed and ran a study that would put participants through simulated runs with a SAV. These runs were designed to change the stimulation levels of participants by changing the workload and expectation of workload. These expectations were changed by altering the frequency of traffic lights that participants would see during each run. The workload itself was changed by occasionally having participants watch a video while driving, and testing their memory of it after each run. Both of these factors were meant to change participants' placement on the stimulation axis of the Yerkes-Dodson curve.



Test setup

THE APPROACH

With these changes occurring, I measured the reaction time participants had to red lights, and their use of Autopilot. It was fully expected that with an increased workload and expected workload, participants would react to red lights slower, but my main interest was if participants would change their use of Autopilot. This was because I wanted to see if participants would change their behaviour according to the Yerkes-Dodson curve. My hypothesis was that participants would react to the different stimulation levels by turning on or off Autopilot according to whether they felt overstimulated or understimulated. If evidence for this behaviour was found, it could mean that drivers regulate their position on the Yerkes-Dodson curve by turning on Autopilot to lessen their workload (or stimulation) or turn off Autopilot to increase their workload (or stimulation).

THE RESULTS

The results showed that there was some evidence for drivers adjusting their behaviour according to the Yerkes-Dodson Law. In terms of reaction time, drivers performed significantly worse when their workload was highest (frequent traffic lights and a video distraction). This result showed a clear benchmark for drivers being overwhelmed with stimulation.

Autopilot usage was where the starkest effect of the factors was found. When given the video, participants overwhelmingly used more Autopilot. This was the clearest insight found from my study. The fact that participants wanted to use Autopilot more when they were distracted meant that they used Autopilot to decrease a workload that was too big (the blue side of the second graph). On the other end this could also be seen as participants using Autopilot less when they weren't given a distraction, or source of stimulation. That would mean participants were using driving as a source of stimulation to bring them to the centre of the Yerkes-Dodson curve (the orange side of the second graph) – to entertain themselves as they got bored.

Overall, I found some evidence for my hypothesis, but looking to the future it is obvious that more research needs to be done. This study was just the first swing at a better understanding how drivers decide to use Autopilot. Due to a lack of resources, I did not get to test on a larger and more diverse selection of participants. That being said, if an auto company with greater resources were to use this blueprint and run a more comprehensive version of this test, the results could be very insightful for the future of SAVs.

Designers of SAV systems could benefit from understanding the stimulation levels and attentiveness of drivers. Systems could be designed knowing that drivers can be dangerously distracted without realising. If drivers are distracted or stimulated by something such as a phone call or another passenger, the vehicle could ask to take control. Features like this could help reduce the risk of an accident by removing opportunities for drivers to accidentally lower their situational awareness.

If the goal of SAV designers is to have drivers be more attentive to the road, this may mean encouraging drivers to drive themselves when they show signs of being bored or under stimulated. This could make drivers less likely to seek forms of stimulation outside of the task of driving, which increase the risk of an accident.

As for the bigger picture, this theory could be applied to a greater strategy for the transitions to greater vehicle autonomy. Having systems in place that will detect the human driver's psychological state could help the relationship between the driving system and the human driver be more understanding.
This could in turn raise public trust in AVs, and ease each customer who transitions to one. This would have a snowball effect, making the roads safer, and increasing trust in vehicle autonomy even more.

In conclusion, research on driver behaviour in SAVs is both necessary and forthcoming. People will adjust their behaviour and use of their vehicles according the environment inside and out of the car. Understanding that past models for human behaviour and performance can be used could help accelerate research and design processes. With my research, I aimed to fill a gap in the understanding of how and when drivers choose to use Autopilot. Hopefully this will help future SAV system designs become safer and more effective. A better understanding of how humans interact with SAVs would not only have the potential to save lives, but also make the expected transition to fully-autonomous vehicles easier.

SEMI-AV OPPORTUNITY 2: THE EFFECT OF PROCEDURE, TASK TYPE AND DURATION ON DRIVER PERFORMANCE

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There is a surprising correlation between the duration of autonomous travel in an SAV and response to taking over control. A "stepwise approach", ie pedals first, followed by steering is more effective than all at once.

There are a few obstacles still to be overcome before fully-autonomous vehicles become part of mainstream road traffic on our roads. While designers continue to work to overcome these, vehicle manufacturers are continuing to roll out increasingly autonomous functionalities. We are now in a position where we have semi-autonomous vehicles on public roads. Of course, the issue that arises with this is how to re-engage drivers when the vehicles reach the limits of their capabilities. At this point, the cars must handover control of the driving task to the driver, who must disengage from whatever they were doing and be able to fully re-engage with driving both safely and quickly.

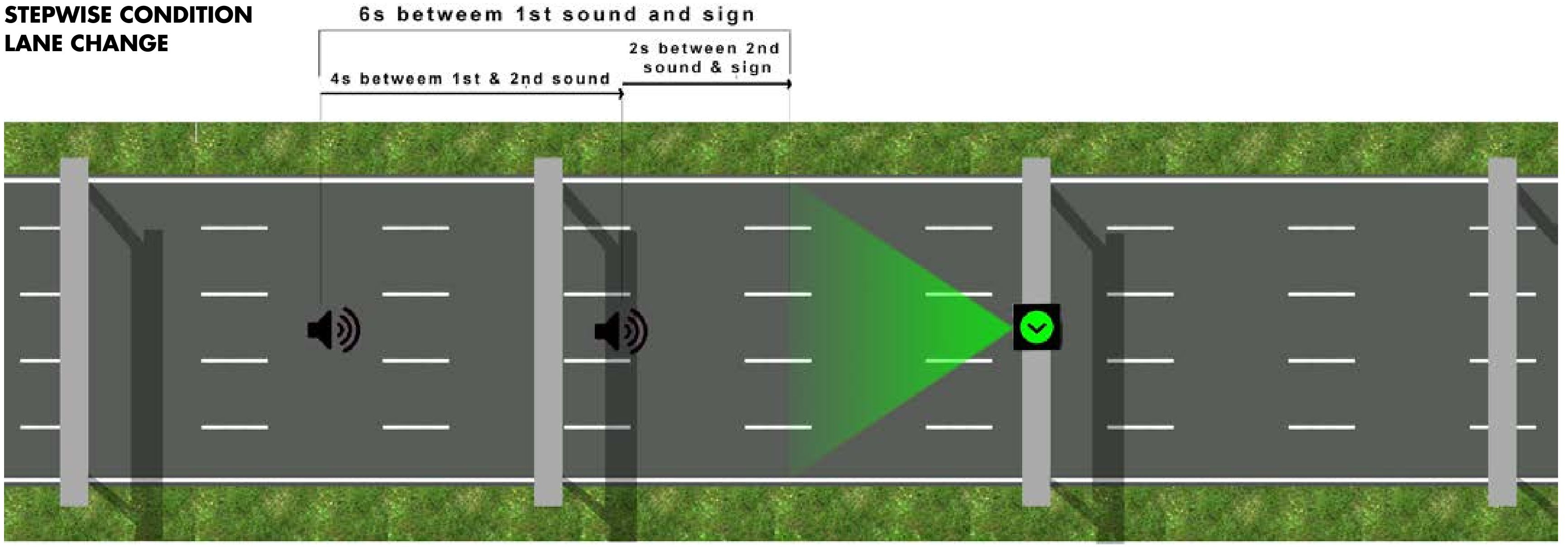
It's this trade-off between safely (ie having situational awareness) and quickly re-engaging that poses a problem for the design on handovers in SAVs. Some have proposed the use of pre-alerts (Van der Heiden et al, 2017[22]) and informational alerts (Koo et al[23] and Walch et al, 2015) which allow drivers to increase their awareness of the driving circumstance. However, these need to be implemented well before the handover occurs to be effective and there isn't always the time. On the other hand, there has been a focus on designing a quicker handover through the use of multiple-modality alerts (Politis et al 2015[24] & 2017[25]). While these effectively convey urgency and improve the speed at which handover occurs, the driver has no clue as to the circumstance in which the handover was needed.

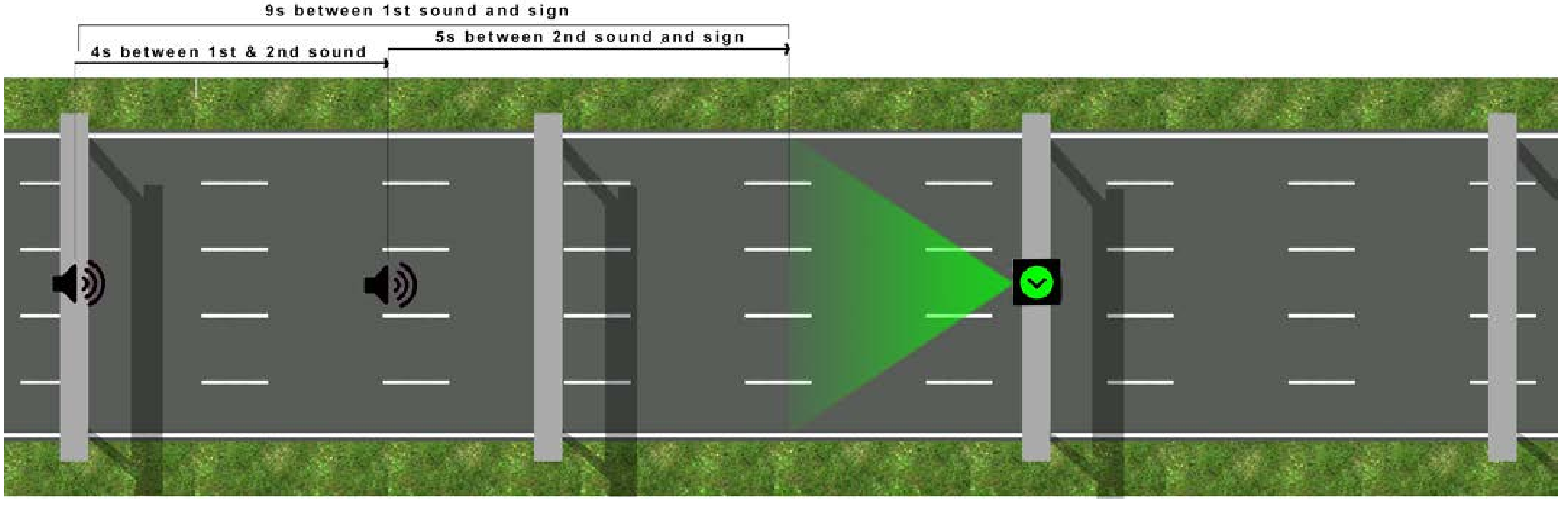
Research has looked at solving this problem through the improvement of handover alerts – but what if we changed the design of the handover procedure instead? This eliminates the problem of needing pre-alerts or increasing time taken to handover (as seen with informational alerts) while still encouraging situational awareness. Furthermore, this could tackle issues that have not been considered as part of this design process – issues encountered following handover such as difficulty re-adjusting to steering. Currently, the handover procedure is immediate; the control of the vehicle is handed over all at once. What if we were to use a stepwise handover instead? Meaning the handover of control is gradual, beginning with the steering, followed by the pedals. This could allow quicker re-adjustment and more situational awareness due to reduced cognitive load at time of handover.

THE STUDY

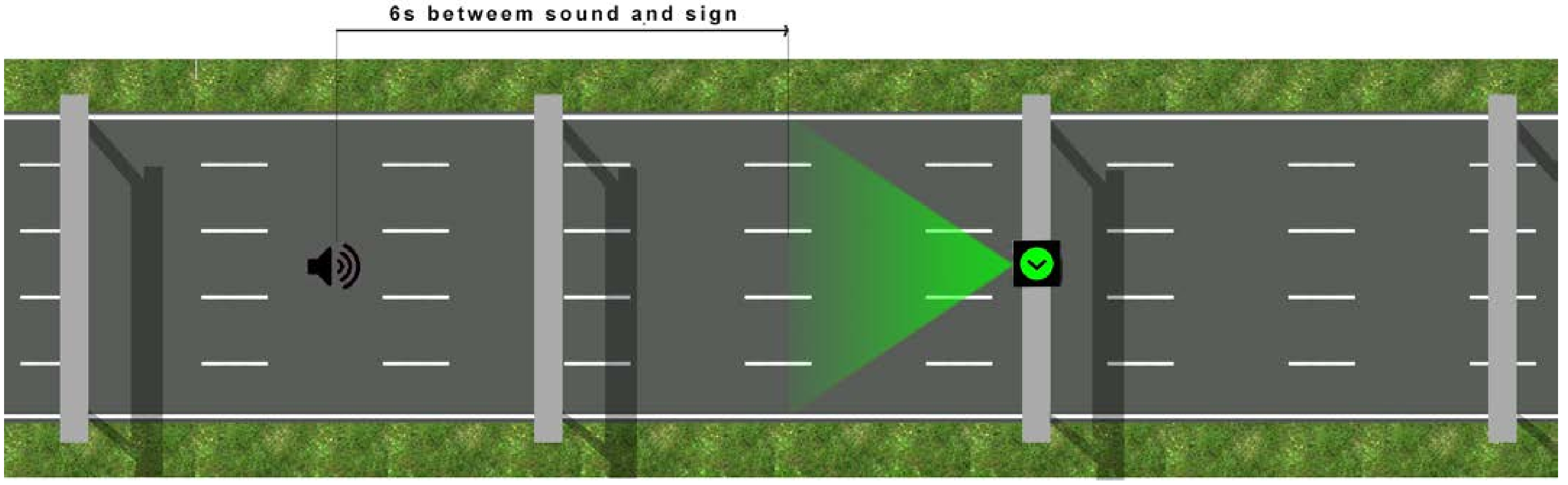
A lab study was conducted using a driving simulator designed to simulate semi-autonomous driving. Thirty-seven participants sat in a simulated autonomous car which failed at some point during the task; participants were then handed over control of the vehicle either in an immediate or stepwise fashion. They then had to respond to a critical task; either a brake sign or a lane change sign. The length of time spent in autonomous mode (one or three minutes), and the time between handover and critical task (six or nine seconds) were also manipulated.

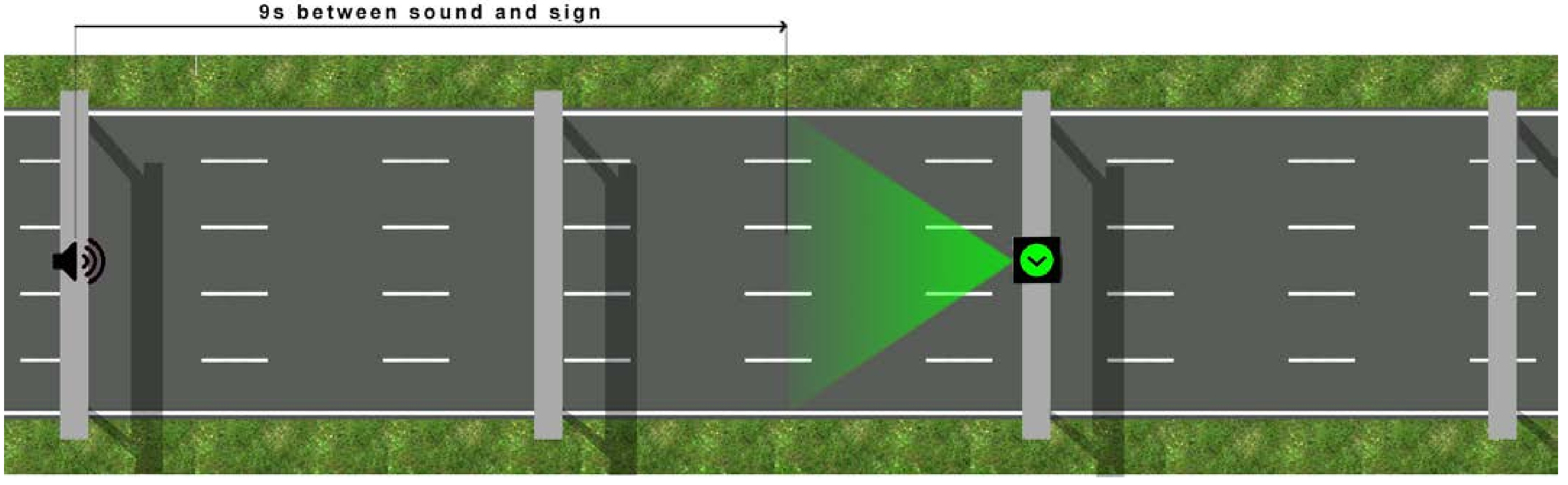
STEPWISE CONDITION LANE CHANGE





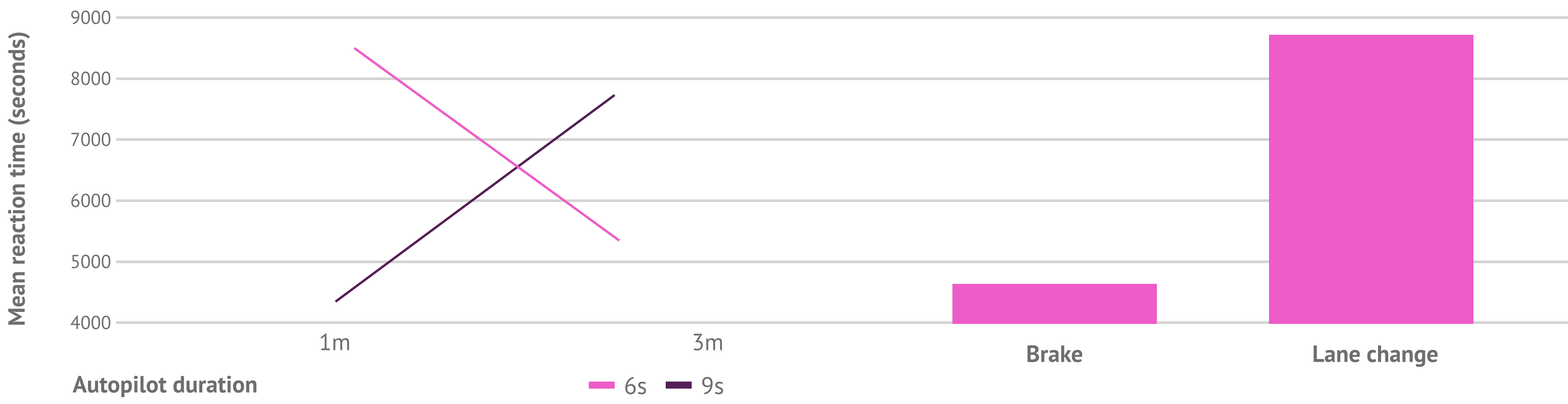
IMMEDIATE CONDITION
LANE CHANGE





Interaction between handover task time and Autopilot duration for lane change data

Mean reaction time for brake and lane change tasks



RESULTS

The results showed no difference in reaction time between stepwise and immediate handover procedures. Interestingly, participants reacted faster to the brake task than for the lane change task.

The most surprising finding, however, was the difference in the effect of autonomous driving duration on reaction time between the tasks, where participants were asked to brake versus when they were asked to change lanes. During the brake test, longer durations in autonomous mode before handover resulted in slower reaction times. The same effect was found in the lane change trials but only where there was a nine-second delay between handover and task, in six second trials the effect was reversed.

It is thought that this difference is due to shorter autonomous durations providing less opportunity to be engaged in secondary tasks and therefore maintaining the situational awareness needed to brake at shorter notice. However, longer autonomous durations may provide drivers with the time to process a change in driving circumstance, namely speed, and its resulting change in steering sensitivity, thus allowing faster reaction times. The duration of autonomy essentially seems to have a different effect on the driver's ability to quickly react to braking tasks and lane change tasks.

WHAT THIS MEANS

While I may have dismissed pre-alerts and informational alerts prior to this lab study, the findings provide support for another use for these types of alerts. Keeping drivers "in the loop" during autonomous driving has been proposed before (Cunningham and Regan, 2015) and referenced in the UK's Department for Transport's policies. I encourage building on this idea and testing the effectiveness of informational alerts throughout the driving process. Providing alerts about changes in speed and direction throughout the journey would maintain a level of situational awareness which would mean there would be no need for this information to be presented at handover, thus faster handovers, implementing multimodal alerts, could be designed.

SEMI-AV OPPORTUNITY 3: HOW WELL WOULD PEOPLE TRUST FULL END-TO-END NAVIGATION IN AUTONOMOUS VEHICLES?

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Trust in AV navigation might be deeply correlated to the physicality and openness in the design (eg. larger windows for visual confirmation) and the feedback it provides to passengers during the drive.

Autonomous vehicles are the subject of broad and current interest, with a multitude of studies finding novel ways to reach higher levels of vehicle autonomy. The intricacies involved in "driving" a semi-autonomous vehicle offer a wide range of research areas into high-functioning vehicles that are able to handle difficult situations on the road. A great deal of this research explores the specifics of designing an optimised vehicle that can drive its owner safely. While the functional aspects are essential, what should also be considered is how well the AV is received by the people who will be riding in it.

The aim of my study was to investigate these human perspectives as effects of relinquishing control of navigation in AVs. One possible analogy for doing so is relying on taxis or Ubers to get to places. These transport services help represent various levels of automation. Specifically, taxis in London provide an interesting frame of reference to which to compare, owing to the drivers' possession of "The Knowledge" of London. This knowledge of the streets of London allows the black cab drivers to rely solely on their memory and experience rather than a satellite navigation system. This corresponds to a low level of automation. On the other hand, Uber drivers rely on the navigation provided to them by the Uber app. This corresponds to a higher level of automation, especially considering the pre-programming of source and destination addresses.

Familiarity is another important property that was addressed. Familiarity with locations affects how people behave with the driver's navigation. For example, when do people choose to check their maps? When do they tend to notice their surroundings? This study aimed to identify these tendencies. Therefore, an observation of twelve Uber and taxi journeys was conducted where two key factors of navigation were investigated: level of automation and familiarity of location. These observations revealed several behaviour patterns. These include a disinclination towards interacting with drivers, a tendency to use phones for entertainment and distraction, using maps for unfamiliar locations, and noticing points of interest.

The universal opinion on the matter of driver–passenger interaction was that people preferred not to have to communicate with the driver. Some of them chose to use their phones more often because of this aversion to communication. Despite the journeys being short (10-15 minutes each), participants took to using their phones as a way of entertaining themselves on the journey. Most of the time spent on their phones was used for checking emails and social apps. However, they still retained a certain level of awareness of their surroundings, since they were able to recount some of the landmarks they noticed. This could be because of how often the vehicles were stopping – mostly due to traffic. Frequent changes in motion caused participants to look up from their phones and get a sense of their location.

Navigation habits in passengers are harder to capture, especially since participants were using their phones for most of the duration of the journeys. As participants glanced up intermittently in between texting or emailing, they noted landmarks along the route that helped them identify their whereabouts. Most of the landmarks they recounted were of personal value (eg specific restaurants and shops) because they had been there before or the location had been pointed out to them by someone they know.

Overall, participants expressed trusting attitudes towards the Uber drivers' as well as the taxi drivers' navigation, though noting increased confidence in the taxi drivers especially, with whom they were very impressed. Participants did, however, specify situations in which they would choose one over the other. They felt more comfortable using taxis for the well-known destinations and Ubers for arbitrary addresses. The destination pre-programming feature contributed to this preference, indicating that people were more inclined to trust satellite navigation over human drivers for the less known locations.

Test setup

A second phase of the study introduced imaginary navigation scenarios with AVs, which were supplemented by videos of Tesla vehicles. Participants were presented with hypothetical navigation scenarios in AVs to steer their imaginations towards navigation-related vehicle tasks rather than highly-specific driving tasks. These scenarios included hypothetical forms of navigation feedback. For example, participants were asked how they would feel if the car decided to change routes, and the only feedback it provided was visual (ie displayed on the map).

This phase revealed initial distrust towards the AV's capabilities for full navigation. However, they did express preferences for utilisation of the hypothetical AV's navigation for specific situations like motorways or faraway destinations. Finally, participants indicated their preferred type of navigation feedback: audio feedback with an extra user-approval component.

CONCLUSION – IMPLICATIONS FOR DESIGN OF AVS

My study was designed to identify human behaviours and attitudes towards a specific function of AVs – navigation. One of the most effective methods to gauge human behaviour in automobiles is in-the-wild ethnographic studies, rather than using simulators. This is especially relevant in the navigation context, where passengers would have to depend on the AV's navigation technology. Therefore, using drivers to represent AV navigation would help to uncover subjective measures like trust, confidence and comfort. Two forms of this driver-based study were chosen: Ubers and London taxis. These two forms were chosen because they each represent different levels of an automated process, which is helpful for determining satisfaction with these levels of automation.

Observations of twelve Uber and London taxi rides identified behaviours that passengers resort to when someone else oversaw the navigation. I call them passive navigation habits. The observations revealed passenger behaviours and attitudes that emerged from being driven by someone else. These behaviours were a balance of attention and entertainment, which were reflected in the overall trust they had in both Ubers and taxis. For instance, the inclination to be distracted or entertained on a non-demanding car ride suggests the importance of stimulation in autonomous vehicles when the navigation task is automated. On the other hand, sufficient attention is also necessary, which was mirrored by participants, who kept aware of their surroundings despite seemingly being engaged by their phones. One design aspect that would improve attention, as identified from observations, is the ergonomics of the vehicle. Large windows and sitting in the front can affect how well and how often people choose to be aware.

As people become more exposed and accustomed to AVs over time, trust in their abilities will grow. However, there are dangers associated with over-trusting an autonomous system to a point where users are unaware of mistakes made by the vehicle. Participants in this study seem to realise this concern.

WAY MORE THAN DRIVING

It was a pleasure working with Sinan, Manesha, Latefa and their professor Duncan Brumby on this project and we wish them the best of luck in their future endeavours. We're sure we'll be hearing more from them.

Traditional cars must all be designed for one specific application: driving. Remove the need for this function and the possibilities suddenly open up. Want to study on the way to school? Sure. Want to Have a sit down meal? Covered. Want to have sex with your partner on the way home from a date? Great!

The future car can accommodate and repurpose itself for all of these situations – we're seeing the rise of the contextual vehicle. This is analogous in technology with the implementation of field programmable gate arrays (FPGAs), processors that can change their hardware on the fly to accommodate different needs. Need more graphical performance? Got it. More machine learning power? Done. These have begun a new wave of contextual computing and are replacing the inefficiencies of application specific chips (ASICs). Cars will move on from being application specific, and the possibilities will be endless, making them capable of being personal, adaptable. It can help find that sweet spot of a great experience for every person out there.

On that note, we will leave you with this thought:

> *"But for the consumer to accept a self-driving car, it has to feel natural. The sweet spot is there, but it's going to take a lot of effort and resources to find where that spot is."*

Chris Schreiner
Strategy Analytics[50]

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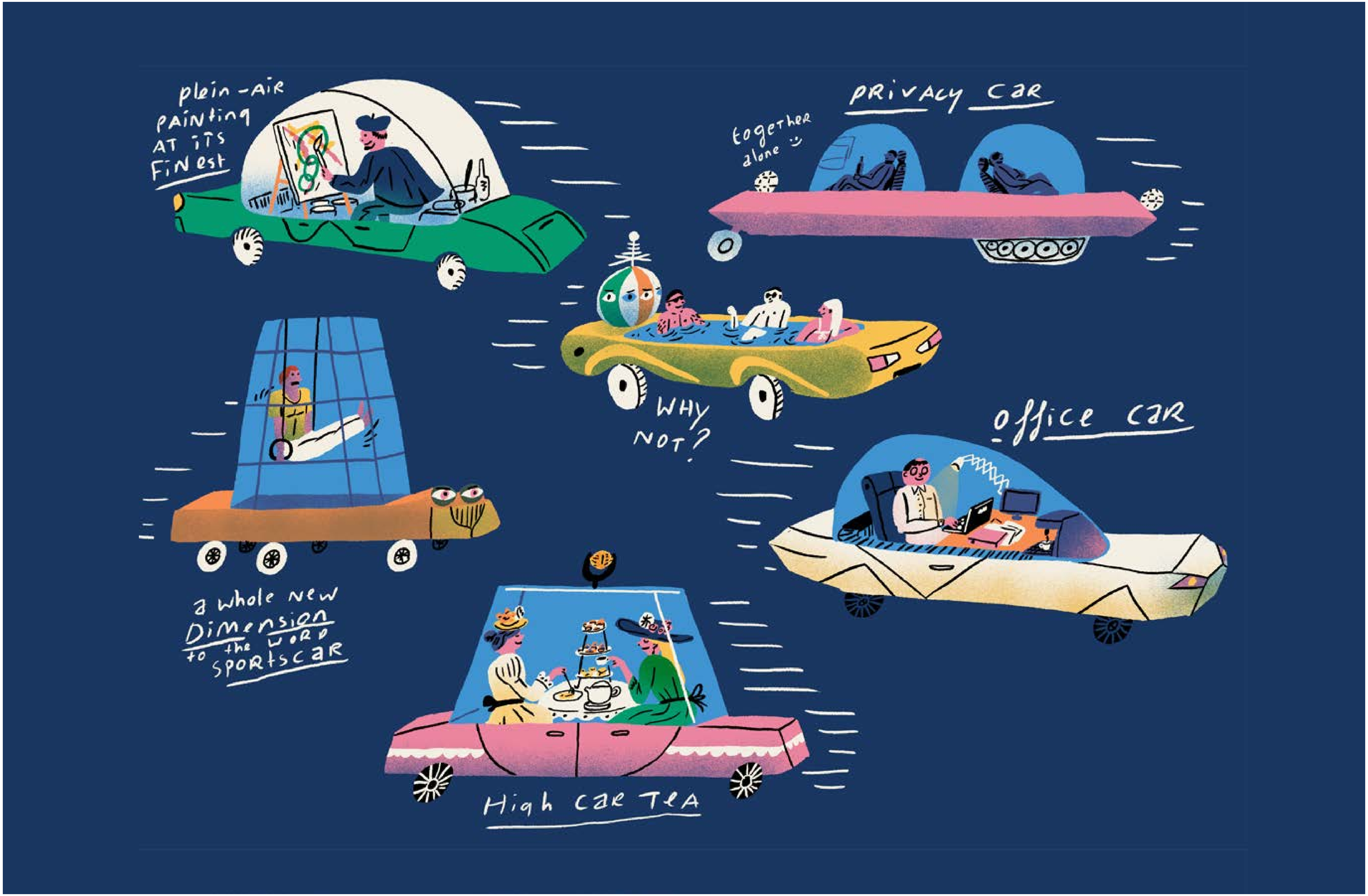
No more wasting time with driving
by Aart-Jan Venema
Year: 2027

"The concept is pretty simple. As opposed from what might seem obvious for driverless vehicles (very uniform, neutral) it would be fun to have cars more personal, and actually functional."

Artist representation by WE ARE GOODNESS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WHY NOT?
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HOW DO WE TEST THE UNTESTABLE?

Topic: Prototyping and User Testing

36 minute read

Rob Penny
Senior Designer

Michelle Constante
Product Lead

ustwo **LDN**

SUMMARY

With AVs we need to take the opportunity to design with the user, rather than for them. Currently, scientific testing is standard in the automotive industry – and that's great because we need to know that our cars are safe. However, it can't stop there. We need to augment these technical tests of the vehicle, with testing performed by users – such as potential AV passengers or owners.

In this section our authors, Rob and Michelle, share a step-by-step approach to user testing for AV projects. And if – like most of us – you don't have a driverless car to hand, we show how you can get equally valuable results with virtual solutions.

INTRODUCTION

"If a picture is worth 1000 words, a prototype is worth 1000 meetings."

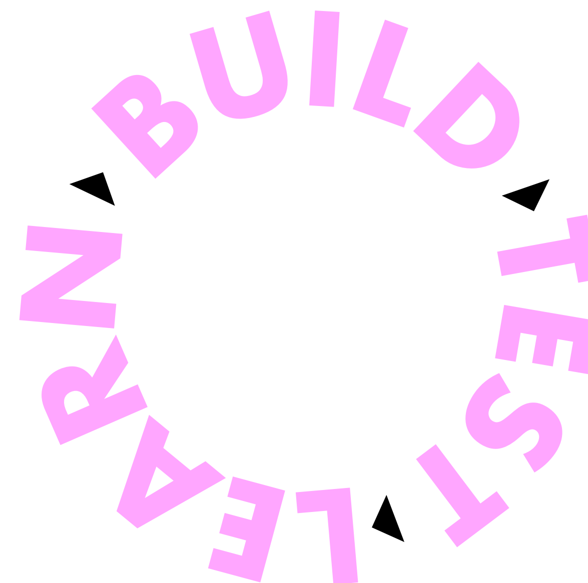
Tom & David Kelley
Founders, IDEO

Great products are *useful, usable and beautiful*. Achieving this holy trinity of design requires the creativity to bring new ideas to life, but in equal measure, it requires ruthless reduction. Reduction to the core features makes a product useful. Reduction of choices and cognitive load makes a product usable. And reduction in complexity and noise makes a product beautiful.

Autonomous vehicles are complex ecosystems of technology, which will give rise to infinite new possibilities for the people that will use them. This is a recipe for complicated and unpleasant experiences with lengthy lead times. So what can we do to chip away the unnecessary, to reduce these experiences down to their useful, usable and beautiful core? The answer starts in 1940s Japan.

Toyota had a problem. They wanted the efficiency of the Ford production line, but with the flexibility to build multiple vehicle variants. Over the next three decades, they developed the Toyota Production System. The core principle was reduction of "Muda" or waste. Waste of materials, time and inventory. This lead to operations in their plants becoming more efficient, more lean, which allowed them to move faster and adapt more easily.

The Toyota Production System caught on in a big way in the automotive industry. But it wasn't until a book called *The Machine That Changed The World* was published in 1990 that the term lean was coined and the methods were adopted by other industries. In 2003, Mary and Tom Poppendieck applied Lean to software development. The context of use had changed completely, but the guiding principle remained the same: eliminate waste. And the number one most wasteful exercise was identified as building the wrong product or feature.



The second principle of lean software is "amplify learning", and this is where the concept of user involvement appears. The idea is that if we build quickly and test with users, you will learn where the waste is, and therefore eliminate it early. The tech industry has taken these principles and run with them. We've adapted and refined the concepts to serve us better here at ustwo as well.

So now that cars are no longer just cars, now that they are complex digital products with a vast array of potential features and interactions, and therefore hold vast potential for waste, it feels like the right time to repay the auto industry with our updated set of tools that we borrowed from them years ago. And at the very heart of this new way of working is the user. Build fast, test with users, learn and iterate.

In some ways, the automotive industry is very user-focused. Upfront large ethnographic studies aim to understand people and culture. Ergonomic product testing is used to ensure comfort and safety. All this work does relate to people, but it's scientific, it views people as numbers, almost as an engineering challenge. We also hear a lot about autonomous vehicle testing in the news, but there is an important distinction to be made here. These tests are aimed to test and train the vehicles themselves. The person in the front seat is testing the vehicle rather than being tested themselves.

What's needed is co-creation, creating not just for users, but with them.

Think about your phone for a moment. It's a piece of hardware made up of glass, aluminium and silicon. It has buttons and sensors. It has software that brings it to life, that makes it something useful, essential. The operating system with its inputs and outputs, the apps that get you from A to B, that play music and keep you updated. None of this has been created in a vacuum. Every feature and every function will have been validated with users throughout the design process.

Now go back and read the last paragraph again, but replace "your phone" with "an AV".

Just as we would never build a smartphone app without user input throughout, we should never build AV software or services without user feedback either.

Over the years we've worked on many auto projects, always with the principle of user involvement at the core, and more recently we've been applying the same methods to AV projects. For example, in one of our projects, we've given people with disabilities a taste of the future in which they have the freedom to travel alone. In the process we found that the experience can bring so much more than independence, that the car could be their tireless tour guide, bringing to life the world around them.

We've also learnt that a shared driving experience can lead to a sense of shared responsibility, that autonomous vehicles can make transport more personal, not less, that they can even bring people together and create a sense of community. We wouldn't have learned any of this without user testing.

But here's the interesting thing. While we've been lucky enough to test out AVs for ourselves, we've never used one for user testing. That's not to say we wouldn't love to, it's that so far we haven't needed to. When you break a problem down you can often test its constituent parts in isolation. This means you can use simple, fast and affordable methods early in the design process. Sometimes this means getting creative, as a team at Stanford did when they set out to test pedestrian responses to AVs. In a study called *Ghost Driver*[1] they dressed a regular car up to look like an AV and created a "car seat costume" to disguise the driver. This allowed them to test early, fast and cheaply while gleaning similar results as they would from the use of a real AV.

And it's not just at the beginning of the design process where users should be involved. The electrification of vehicles and everything within them, combined with over-the-air updates means that vehicles can be completely transformed much like a smartphone after a software update. Manufacturers will need to stop thinking in terms of a single "big bang" release, and more in terms of iterative updates, all the time led by real users. Now for the first time in automotive history, it's possible to implement a test-and-learn way of working throughout the product development process and beyond.

Ford and Virginia Tech's take on the Stanford Ghost Rider test[2]
Photo courtesy Ford Motor Company

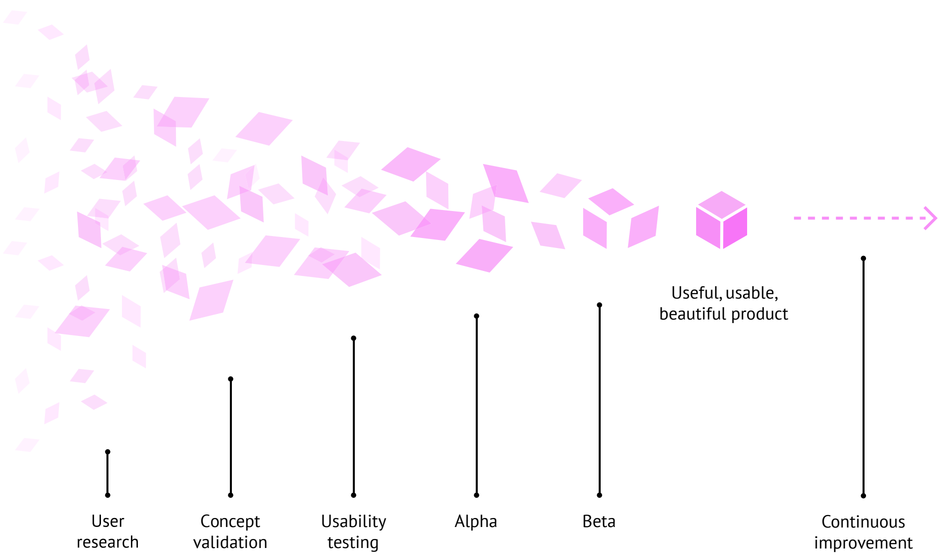
PROTOTYPING AND USER TESTING: THE OPPORTUNITY

"The 1:10:100 ratio - it will cost a company £1 to fix a problem in design phase, £10 to fix it during development, and £100 to fix it once it has gone live."

Leah Buley
Former Forrester analyst

The digital product design process can be applied to the creation of AVs. You start with a set of assumptions about how the product and service will add value to your customer's lives and then set about validating those assumptions by involving your audience at every step.

OPPORTUNITY 1: APPLYING A SOFTWARE DEVELOPMENT PROCESS TO AVS



Let's go back to our definition of great products. They are useful, usable and beautiful. A useful product is something that solves real user needs and is therefore something people will actually use. Upfront interviews and concept validation will ensure this. Usability testing will make sure there's no unnecessary complexity and that the product is intuitive and easy to use. Weaved within the upfront research and usability testing we gather feedback to craft products to be beautiful, enjoyable and delightful. The Alpha and Beta phases will help us refine every aspect of the product.

Take the example of a voice interface (voice UI) for an autonomous vehicle. This is an interesting example as it's relatively unexplored and therefore has many unknowns. It's also something we have experience with at ustwo.

Imagine you're in charge of a team that's been tasked with integrating the voice UI as the primary interface for a new fully-autonomous car. This is the first time that a fast-moving, context-aware robot has communicated primarily through the use of spoken language, so there are great opportunities, as there are risks.

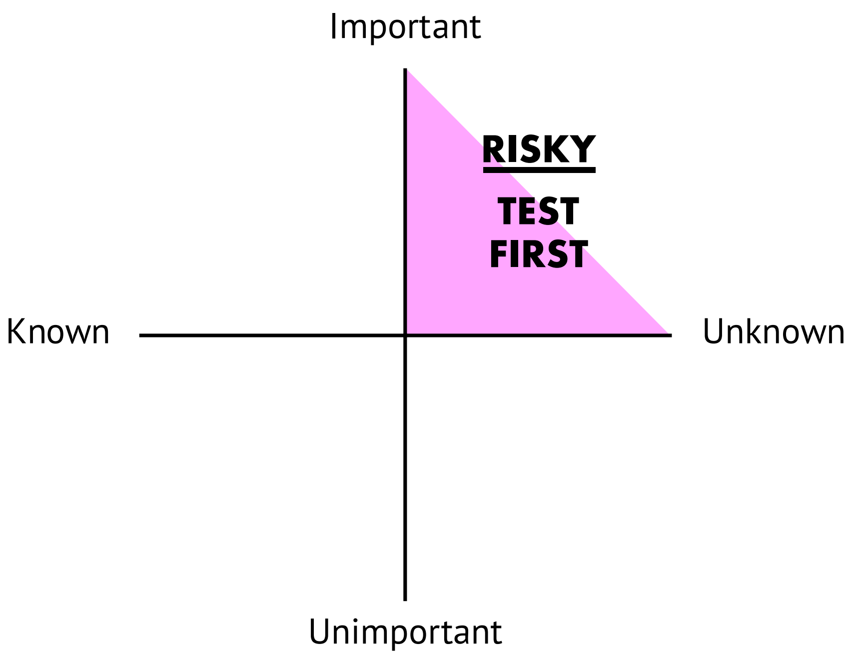
Where should you start? Well, until you truly understand your users all you have is a long list of assumptions. This might sound terrible, but actually it provides a great starting point. The way to get to this list of assumptions is by asking questions about your users.

- *What will people use the voice UI for?*
- *Will it always understand the intention of a user?*
- *How should it refer to itself?*
- *How will deaf users communicate with it?*
- *When should it proactively talk?*

Now try answer these questions as well as you can. This might feel uncomfortable as you really don't know the answers, but that's the point here, to start with a series of assumptions that we can test and validate later. Some examples:

- *The primary uses will be for navigation, climate control and entertainment*
- *The UI won't always understand commands and users will get stuck*
- *Passengers will want it to refer to itself as a separate entity to the car*
- *Deaf users will need a visual interface option*
- *Passengers will want it to proactively notify them of actions the vehicle has taken*

You'll find you come up with a lot of questions and assumptions so it's important to prioritise them. The best way to do this is to think about which of these you know the least about, and which are the most important for the success or failure of the product. These are your riskiest assumptions and should be tackled first.



Now it's time to start testing with real users. You might think that user-testing autonomous vehicle technology is going to be expensive and time-consuming, but it needn't be either. Here, the concept of fidelity is important. A low-fidelity prototype has limited functionality and is used to explore high-level concepts. A high-fidelity prototype is detailed and functional and is used for in-depth research. Generally in the early stages of testing fidelity can be low, and it increases as the design process moves on.

1. USER RESEARCH

The first step should always be talk to your users. Interviews are best for exploring existing behaviours, rather than asking a user what they think they would want or would do. For example, one of our assumptions might be that users will prefer a personified voice interface. In the interview, you could ask about their phone assistant and listen carefully to the words they use to describe it. Do they say "it's useful" or "she's helpful"?

Let's say we have another assumption that voice UIs are most useful for lengthy tasks due to the speed of talking compared with typing. Ask what they use their phone assistant for and maybe we'll find out that people mainly use them for setting timers and alarms. We've just moved a step towards disproving one of our assumptions and that's totally fine. We were never trying to confirm they were all right, we were trying to learn something.

Interviews like these should work in conjunction with desk research, and as with all the testing methods discussed here, recruitment of the right users is key. Recruitment itself can be complex and time-consuming, but it needs to be right if you want meaningful insights. That's why there's a business need for specialised agencies to offer these services.

Here are some tips we've learned while recruiting users for our projects:

- Attitudes and behaviours are more important than demographics
- Use high-level personas to pull out the required behaviours of your audience segments
- Collaborate with the recruitment agency to write the screener questions, which should be based around your interview script
- If you require niche users make sure you get the right recruitment partner as different agencies have different specialisms

User interviews ustwo's Tom Harle running a card-sorting exercise in Shanghai

2. CONCEPT VALIDATION

In our interviews, users have given us a lot of insights and this has helped us come up with some initial concepts. The next stage is to see how they react to these concepts.

One of our biggest questions is what the voice UI will be used for compared with other input methods such as a touchscreen. From our interviews, we have learned that users say they prefer to complete quick and simple tasks with voice. So we can build on this and other learnings and assumptions to form a testing hypothesis which might look something like this:

We believe that when an AV passenger has the option of a touchscreen and voice UI, both with the same functionality, and is given a series of tasks, that they will choose to complete the one-step tasks with their voice, and the multi-step tasks with the touchscreen.

This gives us a solid starting point for our test. Now we need to create the test itself. First up let's think of some single step tasks to give our users: stop the vehicle, turn the temperature up. And some multi-step tasks: give the destination address, confirm the correct one and set off. As for the test setup itself, we're still in the early stages of the design process, so fidelity can be low. This means we don't need a real driverless car driving down a public road with working voice recognition software. What we need is for the user to feel that the situation is sufficiently realistic that they will act as they would in the real scenario.

We'll need a touchscreen with a UI, so let's mock up a few rough screens and load them onto a tablet. There will be a limited set of commands in our test so our voice UI can simply be a set of pre-recorded responses played through the speakers. For the car itself, let's avoid dealing with moving vehicles and use a regular car with the driving controls covered up.

Now we need some users. One misconception that often puts people off user testing is that you need a large number of participants to achieve accurate results. But we find that five well-screened people are usually enough.

After three or four you're spotting a trend and after five it's fairly well confirmed. Think about who your target user is. If this is an existing brand then you probably already know your user well. In this case finding people to test with should be achievable through your current networks. If this is a new brand then the user type may be one of your assumptions to test, and you might want to purposefully recruit a range of different users.

On the day of the test make your participants feel comfortable. Tell them this is a prototype driverless car and that some things will work and some won't. It's likely that the touchscreen will be more familiar to them than a voice UI, so give them a number of tasks to try on each: turn the temperature up and down, turn the heated seats on and off. Make sure that your prototype is very forgiving here – each command they give should elicit a confirmation of success so that they consider each option equally functional. Now that they're familiar with both input methods give them a scenario that involves a series of tasks of varying complexity. For example:

You're about to set off on a journey to your home address but you need to go via your work address. But first, it's a cold morning so you'll want to warm the car up.

After a couple of similar scenarios, the user will be settled into what they're most comfortable with and you can finish the test by giving a brief interview to understand their thought processes.

This type of testing is incredibly rewarding. After second-guessing behaviours in the days leading up to it, you now have solid user insights, which can be taken into account for the next round of design and testing.

3. USABILITY TESTING

While concept validation is great for testing the usefulness of different ideas, usability testing looks at one feature and how easy it is to use.

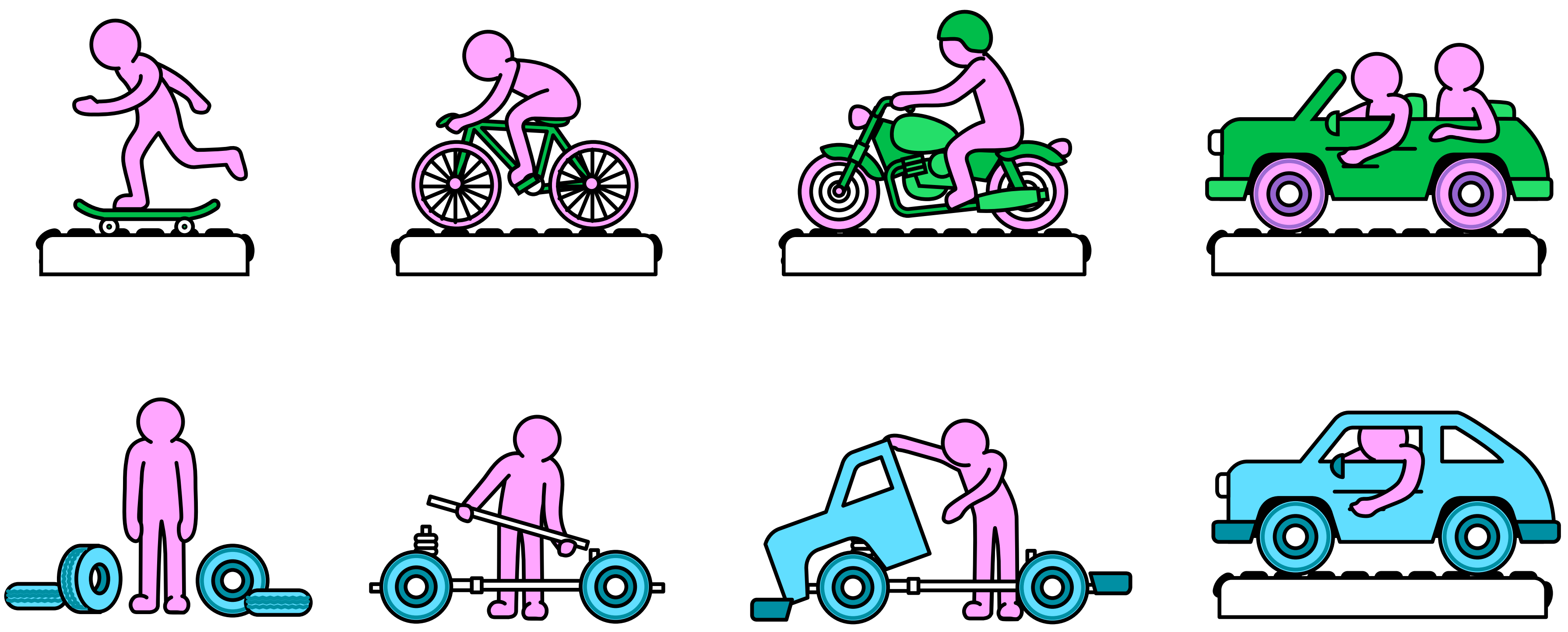
Take the example of mid-journey navigation. You know from concept validation that this is an essential feature and that people want simplicity over control when it comes to voice UIs. So you're in the process of creating an elegantly simple solution, but you'll need some users to test out what aspects of your implementation will work and which won't.

At this point, it makes sense to test with a "Wizard-of-Oz" prototype to cut down on development work. The user will believe that certain aspects of the software are working, but in reality, there is a "Wizard" working behind the scenes to give the impression of functioning software. For example, here we might have a working autonomous car to test with, but no working voice software yet. The wizard could be sitting in the back seat on their laptop listening to the voice commands of the user while manually giving commands to the car. A similar method was used by Nottingham University and Jaguar Land Rover in their study of the cognitive demand of voice UIs while driving[3]. In their test the user believed they were speaking with a voice assistant, but in fact they were speaking with a person mimicking a computer generated voice.

We'll want to be more specific about our users and the tasks they will complete. We might want to test that elderly people can stop the car mid-journey, and what language they would use to do so. At ustwo, we've found that testing users with lower ability levels will ensure a more inclusive product for everyone.

In 2016 we had a tour of Mcity[4] at the University of Michigan where we explored their mock city and road infrastructures. As our scenario involves controlling a moving vehicle, a facility like Mcity would be an ideal test environment, especially if combined with an autonomous car. If you don't have access to either of these, then a drive-in automotive simulator like the one at WMG at Warwick University[5] would work too. It's worth noting that while a number of these amazing facilities exist around the world, they are predominantly used for testing the vehicle itself, and rarely for user testing. We think there is great potential for them to offer these services.

Usability testing
One of our "Wizard-of-Oz" testing setups



Minimum Viable Product
Get going as quickly as possible, improving as you learn

With the track test, or the virtual one, you have your elderly user inside the car. Let them know that they will be controlling the car with their voice and that you'll give them a series of tasks to complete. Always try to give the outcome of the task rather than the task itself. Say: "After a few minutes please bring the vehicle to a stationary position," rather than: "After a few minutes please tell the vehicle to stop." You want to leave the process as open as possible. In the second version, it's likely the participant will say: "vehicle, stop" because that's essentially what you told them to do, and in this particular test that would lead to biased results. Tell the participant to ignore the technician in the back seat and the video camera filming and to relax and enjoy the ride. When they voice their command, the wizard in the back seat will relay that command to the vehicle itself. Over time build up the complexity of tasks and interaction with the UI. Maybe in this example, the next step would be that the participant needs to imagine they need the toilet while on their trip.

In our experience, this kind of testing is very convincing. But we always make sure we don't lie to our participants, and that we explain the nature of the test afterward. In this example, you wouldn't tell them that you are testing working voice control software. You would tell them you're conducting tests as part of the design of voice control software. And after your exit interview with them, you would tell them exactly how the test was run. Usually, people are very understanding of the methods we need to use to gain genuine insights, and the fact that they are having the opportunity to shape such groundbreaking products is always their biggest takeaway.

If you gave all participants the same instructions and asked the same questions, then synthesising the results should be easy. For example, perhaps four out five people asked to stop at the next service station, while only one told the UI simply that they needed the toilet.

Usability testing is also where you start to think about preferences for the aesthetic of a product (the last point of useful, usable and beautiful). This is an interesting one for voice UIs as beauty is normally associated with visual attractiveness, but it is important here too. If we were only to consider usefulness and usability then we could end up with something that works perfectly and is easy to use, but has an incredibly irritating voice. Using the right voice, and the right tone, will actually help to build trust between users and the voice UI. This unconventional beauty could also be the perfect opportunity to communicate your brand.

Mcity
Mock building facades line the streets of Mcity's urban downtown area. University of Michigan

4. ALPHA

Alpha testing involves building working software fast, testing with a controlled group of users and iterating regularly. Alpha software is often unstable, so its usage in vehicles could be potentially dangerous. Having said that, banks probably thought that releasing an Alpha product would be crazy until Monzo came along and did it[6]. We believe that car makers could do the same. Start very small and establish a two-way relationship with your users. Give them something new and exciting with the understanding that it might not always work, and that their feedback will help build a better product. You'll be surprised how many people will want to help. This is actually a great way of creating and nurturing a loyal user base.

So how might this look in the world of AVs? For the self-driving algorithms themselves, you could adopt a similar approach to that of Waymo's early rider programme[7] in Phoenix. They offered a limited number of people ongoing access to their fleet of autonomous minivans, with a safety driver at the wheel, and in return the participants give feedback on the service.

> *"Rather than offering people one or two rides, the goal of this program is to give participants access to our fleet every day, at any time."*

John Krafcik
CEO, Waymo

As for our voice UI example, the majority of functionality can be implemented without the need for an autonomous vehicle. With navigation for example, you can use many of the same commands – take me to work, I need to pee, how long until we get there? – in a manually-driven car, the only difference being that the driver will need to follow directions and do the actual driving.

Waymo
One of the first families to alpha test for Waymo

You might want to start with internal testers at the beginning, like employees. Fit their cars with the relevant technology and means of regularly updating. Tell them to use it every time they drive, in the same way they would in a driverless car, and remove any UI elements that won't be there in the final product. For example, if our final solution won't have a screen then don't show journey information such as arrival time on the navigation screen. Only show directions. This will force your testers to act as they would with the final product. They'll need to ask: "When will I arrive?"

As well as regular feedback sessions you can now start collecting valuable usage data. Which commands are most used? When are they used? Which ones are never used? Which ones aren't recognised? Your team can constantly monitor and action each update to the software, building, reducing and refining the features.

With an alpha, you can't always test every feature slated for the full release. Sometimes this might come down to time or sometimes a feature simply requires scale.

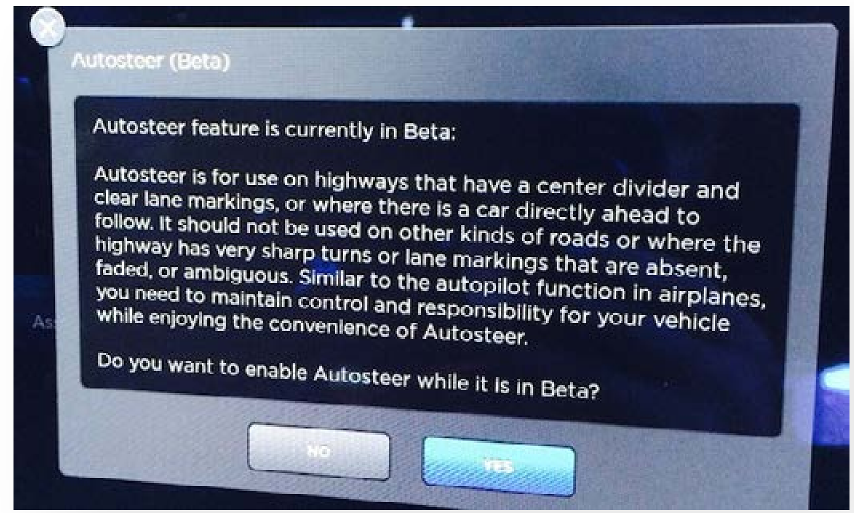
5. BETA

The alpha phase was about building as fast as possible and testing with a controlled group of users. The design and code will be scrappy and much of it will be thrown away. A beta is an early version of the production software and can be open to the public. It allows you to test usage of the real product at scale and make final tweaks before shipping the full release.

The idea of public beta testing with autonomous vehicles can be controversial. One user of Tesla's beta Autopilot software had a fatal crash in 2016 when the system did not recognise a tractor trailer blocking the road. On the other hand, the National Highway Traffic Safety Administration found that the crash rate of Tesla vehicles dropped by almost 40%[8] after Autosteer installation. We're not going to comment on the ethical pros and cons here, only to say that clearly appropriate safety measures should be put in place when testing hardware or software that controls the vehicle itself.

So how would you go about beta testing your software? Your vehicle will need the ability to receive regular updates. And you will need a willing group of people who are happy to deal with some bugs if it means they get access to new functionality. If you're launching a new vehicle, it could be with the proviso that certain aspects are in Beta, or if you have an existing vehicle then your users could opt in. This kind of testing is common with smartphone apps. For example, anyone can sign up to the Google Maps Beta on Android.

Once you have your beta users, it will run in a similar way to the alpha. Collect usage data and feedback, implement changes and repeat. At this point, you're at the narrow end of the funnel. You will have validated and refined your product at multiple stages so any changes now should be small tweaks rather than drastic overhauls.



Tesla update
Tesla Autosteer
Beta warning

Like carving a stone, you started with a nebulous shape, chipped away big chunks and gradually reshaped the entire piece, finally touching up the details. In an almost anti-climax you're ready to release. No "big bang" launch fraught with risks and questions, it should be a smooth transition from beta to useful, usable and beautiful production software.

OPPORTUNITY 2: TESTING WITH VIRTUAL REALITY

You're standing at the side of a quiet country road on a sunny afternoon. You hear a faint humming to your right and turn to see a small black vehicle approaching. As it pulls up, a message appears on the window inviting you over. As you step forward a camera scans your face and in a shimmer of light, the exterior turns from black to green and the door slides open, revealing a single large seat inside. You climb in and as the door closes a voice surrounds you, asking where you would like to go. You give the address of a restaurant in the city and the vehicle smoothly pulls away.

A few minutes into the journey you're travelling fast. Looking through the windscreen you see the landscape changing, as is the weather. Run-down shacks replace the country cottages and dark clouds gather above. With a loud clap of thunder, the rain starts falling. The glass is covered in streaks of water which makes it hard to see out. You spot a "Wipers" button on the glass and press it.

You're in the city now, huge tower blocks cutting out what's left of the of the daylight. Red and white lights zip past in both directions. There's a sudden screech of tyres to your right and you whip your head around to see the car next to you veering out of control. As it spins into your lane it catches the kerb, flips and lands upside-down in front of you. Your vehicle comes to a sudden stop.

After a moment, with the blinking of indicator lights, your car slowly pulls around the upturned vehicle and continues on its route to the restaurant.

Now let's come back to reality. In this scenario there are a number of interesting interactions which could be tested: the sound of the taxi approaching and how long it takes the user to react, their response to the colour change of the vehicle, whether they're happy with the rainy windscreen or if they'd rather see where they're going, and finally their reaction to the seemingly selfish act of their vehicle after the crash.

Using traditional methods this would be very challenging to test. Besides the obvious difficulty of driving a test subject through a busy city in an autonomous vehicle, there are other factors at play here, such as changing the weather on cue and staging a car crash.

This is where Virtual Reality (VR) can help us out. It's early days for user testing with VR and very little has been written about it, but we believe there is huge potential in this method. Let's take a look at some of the benefits of using VR for testing, in the context of our hypothetical scenario.

IMMERSION

There's a reason it's called virtual *reality*. It feels real, even if we know it's not. VR allows you to see, hear and move as you would in the real world and this leads to an unparalleled feeling of realism. It's testament to the power of this immersion that VR is being used for the treatment of post-traumatic stress disorder in soldiers[9].

At the beginning of our scenario, we want to test the user's response to the sound of the approaching vehicle. For this they need the ability to look around naturally, coupled with true-to-life spatial audio. Both these things come as standard with modern game engines such as *Unity* when paired with a VR headset like the HTC Vive. While the rest of the test scenario is hypothetical, the vehicle sound test is something that we have built[10].

Teague
Teague have run AV traffic tests using a stationary prototype (top) and a far more immersive VR environment (bottom).
© Photo by TEAGUE

SCALE AND COMPLEXITY

In our story, the user travels long distances, through vast landscapes surrounded by many vehicles. This kind of scale is hard to replicate in real-world controlled environments. Test facilities such as Mcity are essential proving grounds for autonomous vehicles, and can be used for a number of testing situations, but are limited by their size. In VR you can ride forever.

As well as big things there are smaller things that can be complex to prototype physically. The vehicle itself changing colour, the facial recognition and the door opening automatically are all much simpler to build in a game engine than they would in real life.

As well as physical scale and complexity, VR also allows for a large number of test variables. In our test, we could replace facial recognition with a number pad in one test and voice authentication in another with relative ease.

ENVIRONMENT

Once you've decided to use VR as your testing method, it allows you to focus your test on exactly what you want to learn. You are no longer bound by the constraints of geographical location, weather, day of the week or time of day. For example, we want to know how a user reacts when it goes from clear weather in a rural environment, to rain in an urban environment, so we can easily write that into our test.

There is a theme emerging here: VR allows for complete control over the testing environment. And that includes on-the-fly changes by the person conducting the test. Cue traffic jam, lightning storm, vehicle breakdown. To a certain extent, this control is possible with a more traditional simulator, where the user sits in a mocked-up interior with screens around them. But what this setup doesn't allow for is a change in the user's interaction mode with the vehicle.

In our scenario the user starts off standing outside on a sunny day, a small AV approaches, stops and the user climbs inside.

Using traditional methods this would be costly and complicated to simulate, or more likely it would need to be broken down into multiple steps, each tested separately. With VR it is a little tricky, but totally doable.

It requires the virtual layer (that you see though the headset) to be overlaid on the built environment (that you touch) and they must be closely aligned. One of the most successful applications of this method are The Void[11] VR experiences, which allow visitors to interact physically with virtual worlds.

To achieve this effect in our scenario we would build a simple prototype vehicle with a seat inside. We would use depth cameras and motion trackers, such as Kinect and Leap Motion, to track the physical environment to ensure it is aligned with the virtual one. This will also allow us to track the user's hands and accurately render them in VR so that they can interact with interfaces more naturally than with controllers.

As the visual stimulus is coming from the headset, the prototype is purely there for touch which allows us to do the absolute minimum physically and use relatively low-fidelity props. As the user sees and hears the car approaching from the distance it's really in front of them all the time, and an old sofa and large piece of wood magically become the luxury interior of a future taxi.

The Void
Visitors explore virtual worlds at The Void

SAFETY

We're used to testing concepts in a safe and controlled environment, and when you're trialing a new mobile app that's generally not a problem. But a road full of fast-moving vehicles is not a safe and controlled place, and if you can't test some of the more dangerous and unpredictable aspects of AVs then there will be a critical gap in your knowledge.

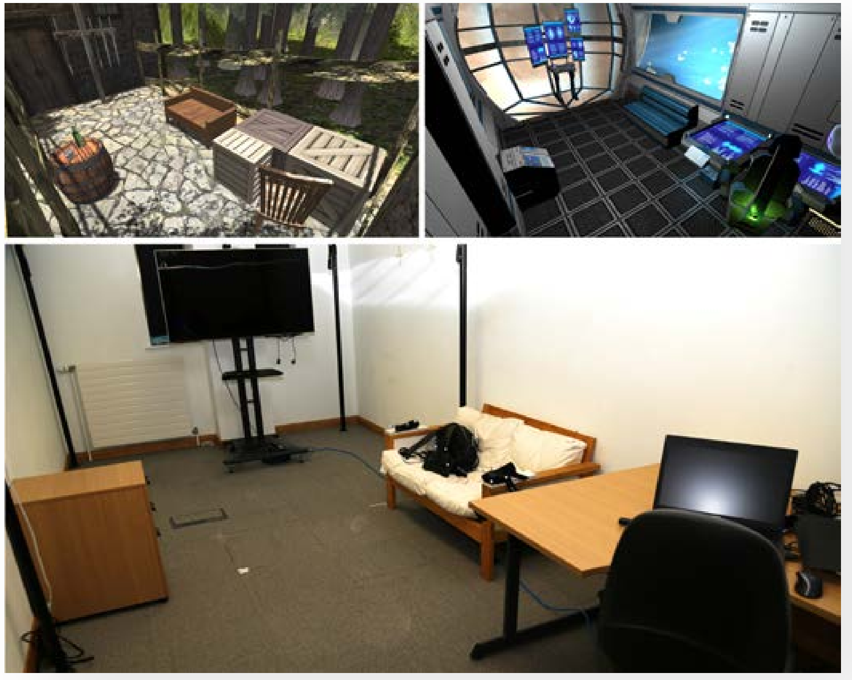
At ustwo, when someone tries VR for the first time, we get them to walk the plank[12]. Once they've nervously teetered their way along a virtual plank of wood, hundreds of metres above the ground, almost no one can bring themselves to step off it. They're not in any real danger, but that feeling of danger is very real. In our scenario the user witnesses a car crash at close proximity. This would evoke visceral emotions, which would be hard to reproduce with other testing methods. Only once the user is feeling these emotions can we see a realistic response. Do they command their vehicle to stop? Do they reach for the door handle to jump out? Or do they sit there in shock and let the taxi drive them away? These kinds of questions are important for car makers to answer, as they will affect the way their vehicles should behave. You might discover that users are in a state of mild shock and decide that on detecting a crash the vehicle should call the emergency services.

Our example here is a clearly dangerous situation, but with AVs pretty much any situation where the vehicle is driving itself will be too dangerous to test in the real world. The complete safety of VR gives a compelling reason to use it in these situations.

COST

Imagine for a moment that you are going to test our hypothetical scenario in the real world. You'd need a safe, working prototype vehicle, a large piece of private land, some pretty elaborate sets and the workforce to support it: the designers, developers, builders, drivers, managers, and health and safety experts. You'd have to transport your participants to the test site, and each test would take a substantial amount of time to set up. The costs associated with this would be enormous.

Now imagine the setup you'd need for VR. A medium-sized room, VR equipment and PC, basic props, and a small team of designers and developers. Not only would this be dramatically cheaper for this test, but it could be used again and again for completely different tests, with the cost falling even further. We imagine that soon car makers will have dedicated VR spaces that could be used for internal testing and visualisation as well as for user testing.



In his paper Substitutional Reality[13], Adalberto Simeone describes how multiple virtual environments (top) can be based on one physical environment (bottom).

Substitutional reality
Adalberto L. Simeone, Eduardo Velloso, and Hans Gellersen. DOI

SECRECY

The auto industry is famously secretive, rarely giving members of the public a look at upcoming vehicles. Cars are even disguised with camouflage to break the form of the vehicle when real-world testing is required. With VR, car companies can test situations which they wouldn't have felt comfortable doing before, simulating public situations.

WHEN NOT TO USE VR

For every situation where VR provides a great testing solution, there is one where it doesn't. Social interactions are still rudimentary in VR, and if a user needs to believe that a certain aspect of a test is actually real then it's a definite no-go. For example, they might have been invited to test a new autonomous bus knowing that the bus itself is a prototype but believing that the people getting on and off the bus are genuine commuters, to test the interactions between them. In VR while things can feel real, you know that nothing actually is.

And then there are technical issues. As Teague Labs explain[14] in a piece around prototyping car UX in VR, a current problem is replicating how your eyes see the real world. In VR everything is always in focus, so looking at some things nearby can be hard. For example a head-up display in front of a moving landscape would look unnatural and be hard to read.

Then there's the disconnect between movement in VR and lack of movement in the real world, for example when a vehicle accelerates but the user is sitting still. This can diminish the illusion and even cause a feeling of sickness.

AUGMENTED REALITY (AR)

VR isn't the only player here. Augmented reality is a big one to watch. AR visually blends a virtual layer into the real world. Even though it's in its infancy compared with VR, there is every reason to believe that in the near future we will be able to don a pair of glasses and the virtual world will become indistinguishable from the real one. Every big tech company is betting on AR, as are a number of high-profile start-ups.

AR allows you to be flexible with where you place your virtual object in the real world. For example, if you want to understand how users would feel about owning a new vehicle concept, you could go to users homes and walk around the virtual car, parked right in their driveway. In fact, one Tesla enthusiast has done just that. He couldn't wait for his Model 3 to arrive, so he created an AR Kit[15] app to bring it just that bit closer to reality. We've even had a play with this ourselves, placing a floating car in the middle of our office using a Hololens.

ustwo Auto AR
An ustwo experiment using Microsoft Hololens

Later in the development process, when decisions have been made and prototypes have been built, AR can act as a useful tool for working out details. For example, if a prototype exterior has been built then you could use AR to test different seating configurations with users. They could walk around the real car, open different doors and look inside at virtual seating options. This is particularly pertinent for AVs where we expect to see much more variation in vehicle design in the future.

We mentioned that social interactions are a weak spot for VR. Right now they are pretty awkward while wearing an AR visor too, but as these devices become less intrusive and more commonplace, like wearing a pair of glasses, it will feel quite natural to have a shared AR experience with others. Let's say you want to see how warehouse workers organise themselves when a delivery drone lands in the loading bay. You could go to an actual warehouse and arrange for employees to wear AR glasses as they go about their daily activities, but whenever a drone comes in they must work together to "unload" it. Testing this kind of interaction would simply not be possible with traditional methods or with VR.

Right now there are two main AR technologies that we use at ustwo, both of which could act as a viable testing tool in some situations: Microsoft Hololens and Apple AR Kit. While the technology and interaction mode of each is different, the end result is essentially the same: virtual objects integrated with the real world. As with VR, little has been written about the use of AR for user testing, but we believe the potential for car makers is huge. What's compelling about AR is that it combines the best of both testing in the real world and VR. When planning your test you can choose which elements should be real and which should be virtual. It also overcomes some of the pitfalls of VR. This gives rise to some fascinating opportunities.

VR + AR =

It's early days for VR and AR, and the pace of change right now is unprecedented. Over the next few years we expect to see advances in resolution, field of view, head and hand tracking, and render quality to name but a few. What this means is that the technology is becoming much more realistic, powerful and comfortable, and we believe it will increasingly become a go-to testing method for autonomous vehicles.

Maximum value can be delivered with the minimum of resources when users inform key decisions throughout the product design process. Ideas validated and new sources of value discovered. Interfaces tested to be intuitive and usable. Designs crafted to delight users. Useful, usable, beautiful.

All this can be achieved through carefully designed test plans and prototypes built with the newest emerging technologies or simply with the most ingenious hacks.

A shift is needed, away from rigid and lengthy product cycles and big bang releases, to a phased and iterative approach. An alpha phase with quick and iterative builds. A beta launch that enables the mass usage of a product, and the acquisition of high volumes of data. All this before the final product release. And it doesn't need to stop there – continuous improvement and updates based on cumulative usage data and user feedback, throughout the whole lifecycle of a product. **Build, measure, learn**.

These are some of the key principles that have allowed digital products to become such a meaningful and essential part of our lives. And the origin of many of these principles goes back to the manufacturing processes of the early automotive industry. From Kanban to Muda, we've learned from the auto industry and improved our design methodologies. Now it's our turn to give back and continue transforming the future together.

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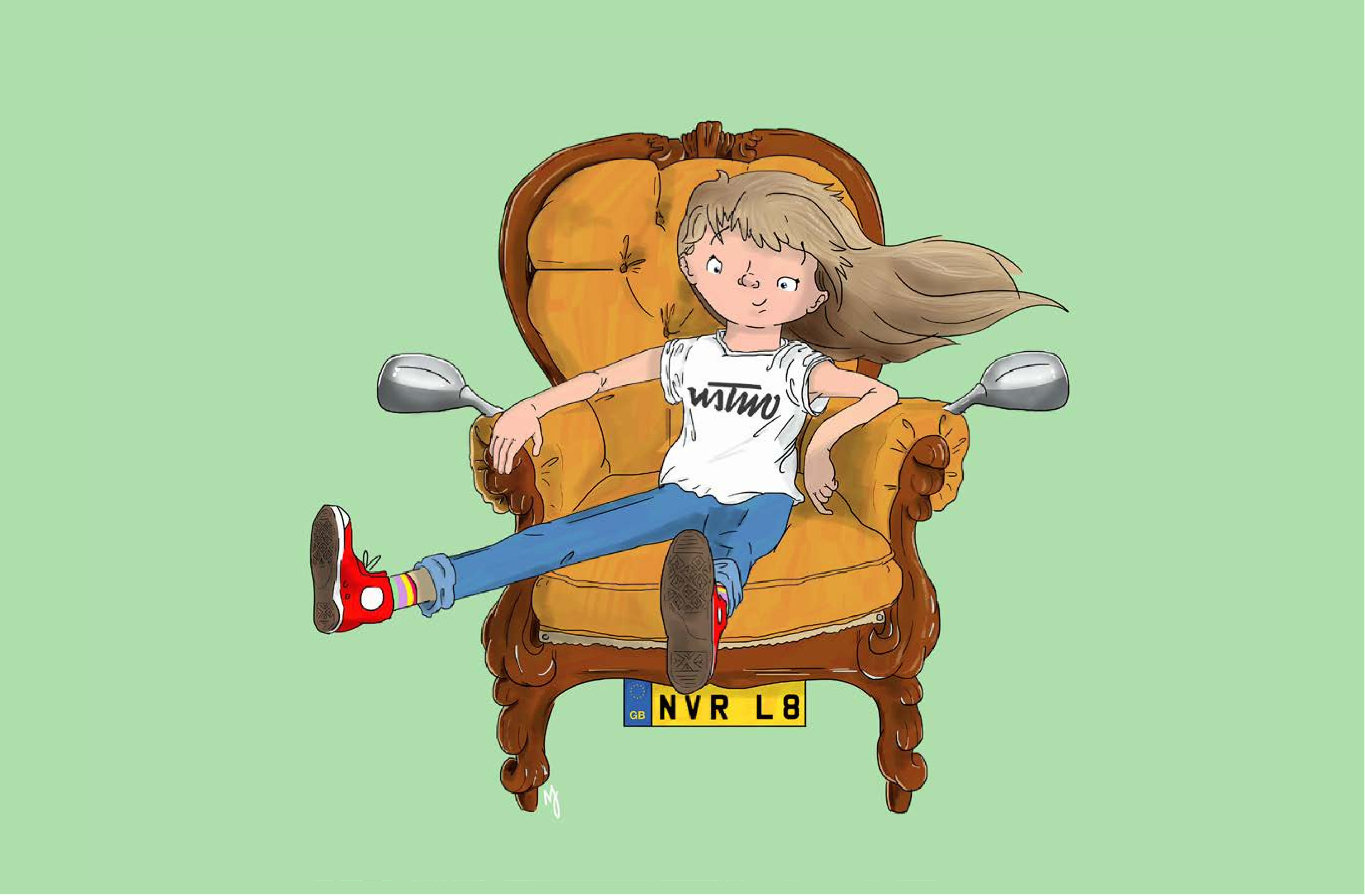
Automated Armchair
by Matthew James
Year: 2022

“More exciting, more comfortable and more luxurious than ever before. The Automated Armchair is all about the sitting experience. No instruments, no pedals, no dials... chill. With design and style like no other and wheels so lightweight it doesn’t have any, you will never take another chair on the road. Sit down, put your feet up and let the chair take you there.”


ustwo
GB
NVR L8

HOW CAN WE DESIGN FOR THE BIGGER PICTURE?

Topic: Holistic Problem Solving

78 minute read

Dem Gerolemou
Product Designer

ustwo **LDN**

SUMMARY

Why has a car company committed to working on energy consumption? In their latest mission statement, Tesla – an automotive company – failed to mention cars once. Instead, their approach suggests they are looking at the mobility ecosystem as a whole, adopting a much more flexible approach about what a car actually is.

In this section, our contributor Dem argues the merits of holistic problem solving through the lens of Tesla's Mission Statement Part Deux. He explores how by looking at the whole picture we can begin to see opportunities, rather than problems – creating scalable, sustainable and more accessible solutions.

INTRODUCTION

Rapid innovation in the automotive sector illustrates the competitive nature of the race to anticipate and satisfy consumer needs, although it's an uneven picture. We see swift iteration and improvement in some areas, while other parts of the car experience are left ripe for whoever decides it is time. It's common practice for manufacturers to push out new models every year with significant improvements in the more competitive areas of focus, but to pay less attention elsewhere, resulting in things like car dashboards experiencing only a slow trickle of progress.

As a consumer, it seems like a glacial pace of progress. However, the reality is that many auto manufacturers operate internal labs to research and develop new technologies, many of which will never see the light of day, but some which will go into building the cars of tomorrow – VW MOIA[1] is an excellent example of this. Prioritising which of these focus areas should be given the resources to be taken to market is no easy task.

Long lead times are due to a combination of legacy process, legal procedures, and social conventions – a prime example being the capability of AVs which are becoming increasingly impressive yet there are plenty more battles to be won before they become commonplace on our roads. Questions around ethics, laws, on-boarding, and infrastructure all preface this next generation of transport, as we have covered earlier in the book.

This is understandable – but no fun for the consumer. We're used to getting updates on tap for the majority of our services. Thankfully, there are those out there attempting to shake up these dated models of improvement in the auto space. Tesla, for example, is exploring a new model of development by pushing updates direct to consumers' vehicles, offering new functionality, and arguably redefining what it means to own a car. It has been publicised[2] that every Tesla model is shipped with the necessary sensors to allow full autonomy when the software update permits. It's forgivable to overlook the sheer scale of the impact which this may have, but we believe that this framework of iteration sets up the future of the auto industry to seriously benefit.

It's no secret that manufacturers are exploring paradigm-shifting technology with the intention of bringing full autonomy to our vehicles and enabling them to run on sustainable energy. BMW, VW and Tesla are just a few of the companies who are playing in this space, each defining their own narrative of how they believe the future will look.

What's special about this is that in some of these narratives it's not just vehicles that are being spoken about. In fact Tesla, the company we all know for making cars, has committed to bringing consumer energy consumption solutions and the sharing economy into its remit – that's a car manufacturer delving into energy. There are plenty of questions we can ask to understand why Tesla may be doing this and we want to use this section to explore the company's approach to the problem. It appears that Tesla has an eye on the bigger picture as it continues to gracefully exploit the merits of taking a holistic approach to problem-solving.

Tesla's relatively unique approach to making cars may be one of the benefits of being such a young company operating in a mature market. It was able to capitalise on the years of learnings made in the auto industry before boldly publishing a 10-year plan while still in its infancy back in 2006[3]. A mere decade down the line and we were greeted by a new set of goals for the coming decade[4]. Take a minute to read through Tesla's original goals and let the scale of achievement sink in. Considering the company's performance, it's not implausible that it may have a solid chance at checking off each of the new goals in the coming years.

If you're as curious about the implications of this as we are, then this read is for you. We'll be exploring holistic problem-solving, uncovering where it's taken us in the past, where it could take us in the future, and why it's such an important design tool. We'll do all of this through the lens of Tesla and its recently published mission statement, teasing out challenges and opportunities along the way – because there will be some.

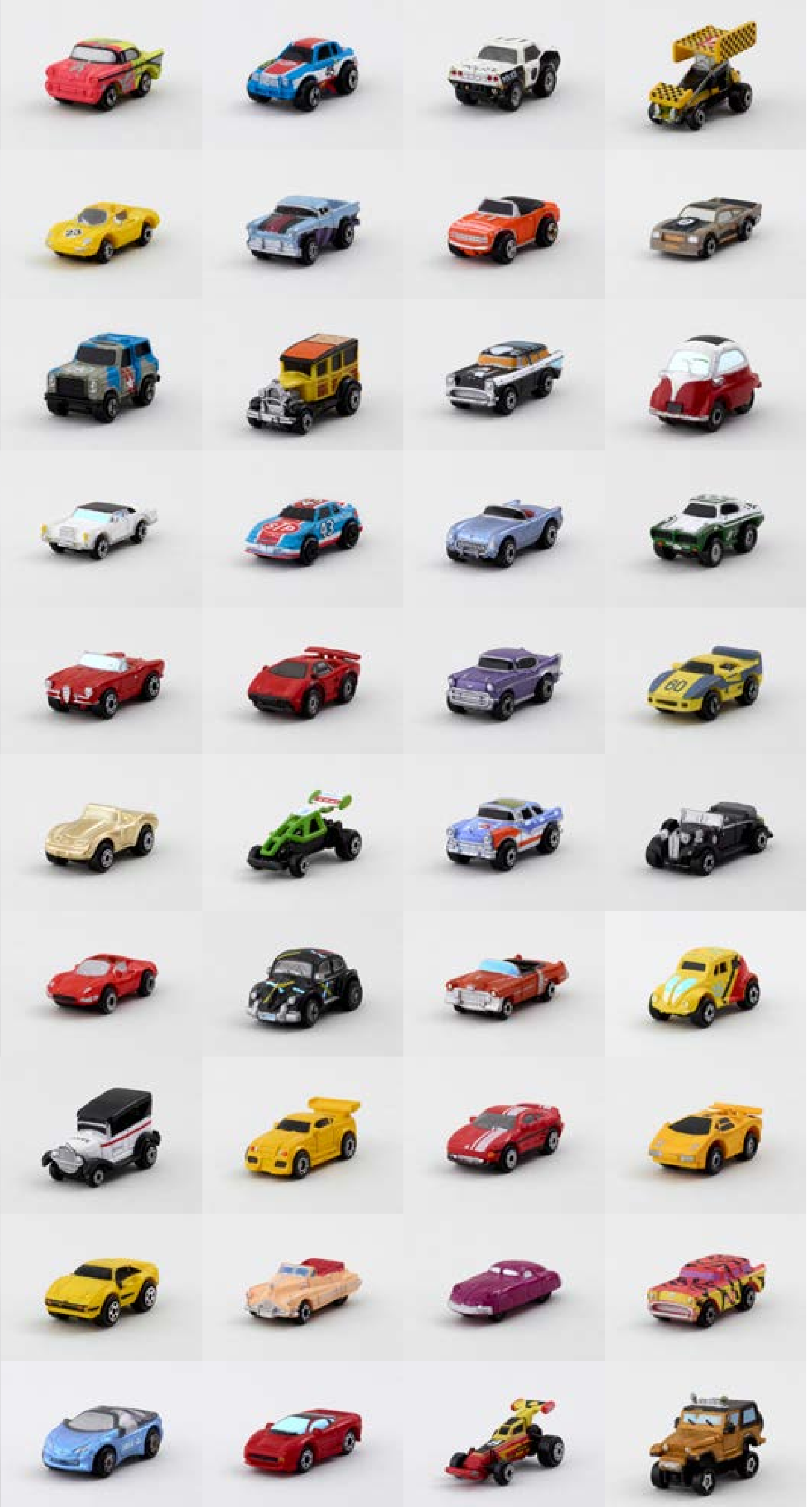
DECIPHERING THE MODERN CAR

Understanding what a car means to us in today's society involves the tale of a dated solution being scaled in directions which it wasn't designed for, causing these vehicles to dictate how urban infrastructure has been developed.

Born from one of many attempts to solve the problem of getting from A to B, cars empower their owners to make on-demand journeys to anywhere that the infrastructure permits. Other solutions include trains, planes, and bikes, each catering to a slight variation of the original problem. The commonality between these modes of travel remains simple – they are designed to transport people or goods – a means to an end. They were designed to be tools for us to leverage in our daily lives.

These tools have outgrown their training wheels pretty quickly, and now offer far more than the utility of travel. People enjoy watching the world pass by from the window of an aeroplane, there are trainspotters, and others who choose to collect and maintain cars, sometimes even miniature cars[5].

These use-cases do not change the fact that our vehicles are essentially tools. That doesn't stop us from assigning value to them. These tools have become status symbols, places of sanctuary, and items to cherish. What's more, they are a self-perpetuating problem and solution. Ownership of a car means that an individual may choose to live further away from their "point B", building increasing reliance on these vehicles, and stimulating the continued growth of a car-centric infrastructure. For this reason we've ended up in a place where we are heavily dependent on our cars, satisfied that they are a solution to the problem – one which they caused – yet they are merely alleviating the symptoms caused by the problem. There's no need to explore the minutiae of the details here – we have critiqued the model of car-ownership before[6] and concluded that private ownership comes at the expense of accessibility and efficiency (read more on the ustwo blog).



You don't have to be too critical to begin framing what a better solution might be. How can we better utilise our existing solutions, and how could we build more sustainably going forward? Going back to Tesla's mission statement helps us understand why a car company is committing to working on energy consumption.

Here seems like the perfect time to introduce the concept of holistic problem-solving in a little more depth. Many of the problems brought about by cars could have been solved if they were designed more holistically, with an understanding of how they would fit into societies of tomorrow, and how they interplay with the rest of their owners' lives. After all, if a car is a means to an end then surely that end should be a significant factor in the car's design?

Micro but Many
Tim's toy car collection - 1,100 plus strong
microbutmany.com

SOLVING PROBLEMS, HOLISTICALLY

Picture this scenario. You're in the kitchen making macaroni cheese when one of the two spotlight bulbs gives out, leaving part of the kitchen poorly lit. You need to take action before you can finish cooking your meal. There are three options.

You could:

A. Adjust the other spotlight to better illuminate the kitchen, which will do until this bulb blows

B. Run to the nearest shop and pick up any suitable bulb, replacing the broken bulb

C. Adjust the other spotlight as an interim solution, but then jump online to order a set of eco smart-bulbs, using this as an opportunity to prepare your home for the smart-appliances that you see yourself adopting over the coming year

Each of these solutions results in a sufficiently illuminated kitchen in the short term. The main difference in these options is the longevity of the solution. Option A, the duct-tape solution of the group, fixes the problem for now, until something else goes wrong. If another bulb goes, there'll be no quick-fix and you'll be left without light. A resourceful response, but a short-sighted one. Option B is more sensible. You'll be back at optimal performance, but the selection in the local shop is limited and we're stuck with an inefficient bulb. Option C treats the inconvenience as an opportunity. We use the necessary spend as an investment into something which increases in utility over time. This is holistic thinking. We are solving the problem at hand, while beginning to build towards solving future problems that we will come to face. The mindset here is treating a problem as an opportunity.

There are plenty of examples which demonstrate where this approach has taken us in the past, one of the most relevant being the contemporary smartphone. Mobile phones were created to satisfy the need to make calls on the go, over time growing into a platform that solves a vast landscape of problems based around portability. A powerful camera that doesn't weigh a kilogram? Sure. On-the-go web browsing? Fine. Music curation and discovery in your pocket? Not a problem. The value is not in the execution of the solution, it's in the approach taken. The optics of the Samsung SCH-V200[7] camera did not change the game, nor did the design of the interface of the first dedicated music application (they weren't always called apps). The longevity of the principle behind these features is what spoke the loudest, still informing the design of mobile phones, even today.

Phones are now considered powerhouse platforms with which anything is possible. Businesses need mobile presence, we expect there to be "an app for that", and we rely on phones as platforms to empower us to be ourselves. That is holistic problem solving. The action of being able to take a picture on your phone and use or view that picture in other contexts is arguably the most poignant piece of the SCH-V200's legacy, comfortably trumping the technology behind cramming a lens into a phone. This is the same reason why the iPhone changed things, and why its design has defined an entire platform.

The Tesla ecosystem

DP.15

DESIGN PRINCIPLE UNLOCKED:

15. SOLVE PROBLEMS HOLISTICALLY

Consider the person's needs and the full end-to-end user scenario even when designing for a small part of it. This will help to give the solution a more contextually appropriate design.

This type of problem-solving is most commonly incremental. It's why we see advancements over time and the reason that we can look at a Ford from the '60s, recognise it as a car, but understand it to be a dated model. For those who aren't familiar with the story of The Ship of Theseus, it's an old thought experiment which posed a question about continuity. If something is incrementally changed until everything has been replaced, is it the same object? Luckily for us, our favourite version of the paradox exemplifies the value of iterative, holistic problem-solving.

The original tale explains how Theseus' ship was preserved with occasional maintenance work, carried out until every part had been replaced. How about a modern version, with the original wooden oars replaced with carbon fibre sport oars featuring miniature propellers from Greek startup oar.io; the hull replaced with a lightweight IoT-connected replica able to utilise satellite data to predict fluctuations in the earth's gravitational pull and leverage them in circumnavigating the globe; and of course, the sail, which had significantly decayed over time, replaced with ultra-light solar-sails, enabling the vessel to not only travel the seas at rapid speeds, but also to soar through the heavens at the speed of light? Was this still Theseus' ship, or was it the future of travel? In this version of the tale, a problem is an opportunity. A broken hull can be replaced by the same version, or improved to future-proof the ship by increasing its utility.

How can we take this principle forward? It's constantly hammered into us that cars are being reimagined and redefined due to the inefficiency of the infrastructure we've built. We're now solving a legacy problem. How can we use it as an opportunity, like the lightbulb scenario, and begin to design a solution that solves future problems? In some ways, Tesla's Mission Statement Part Deux has this covered. Considering that Tesla is predominantly recognised as a car-manufacturing company, it's very telling that none of its four goals explicitly mentions cars as an end:

1. Create stunning solar roofs with seamlessly integrated battery storage
2. Expand the electric vehicle product line to address all major segments
3. Develop a self-driving capability that is 10X safer than manual via massive fleet learning
4. Enable your car to make money for you when you aren't using it

The Tesla ecosystem

We find this really exciting. These goals proudly illustrate that we can begin to solve bigger problems by starting with those currently at hand. Tesla is indicating that it views cars as utility platforms. Being less precious about what a car is means that we can reap benefits in areas of our lives beyond mobility. Addressing the "ecosystem as a utility" approach here allows more accessible, efficient, and scalable outcomes in multiple areas. So let's delve into what the future could look like, taking a look at two of the main areas that could be tied together through the next generation of the mobility-tools that we call "cars".

TRAVEL TODAY

Mobility is a universal need, with tremendous influence over societal planning and growth trends. This is particularly apparent when we look at how our cities have developed over time.

As populations steadily grow, we continue to tweak our transport solutions to suit – however this approach is not sustainable or holistic. As touched upon earlier, our solutions have resulted in a self-perpetuating problem in which our infrastructures grow increasingly reliant on them making it even more difficult to innovate and replace them.

Roads around major cities are often congested, privatised train networks run inefficient services, and there is an over-dependence on public transport systems which are simply not equipped to match supply with demand. A significant portion of the research for this piece was done while in transit, during which we experienced tickets being declined, delays caused by strikes, technical issues, and people on the train tracks. We wrestled through overfilled stations, reshaped our working days to accommodate a change in commute, experienced a service where a train was cancelled as they had "lost four coaches", and were caught in gridlock because some horses found their way onto the M25.

But we carry on, and it's because our livelihoods depend on it. Things could be so much better, but since we cannot do without there is a lack of impetus for service providers to fix these problems. Where we work, where we live, and who we spend our time with are dictated by our ability to travel. Travel is a necessary, functional byproduct of the lives we choose to live. It's a pretty loaded topic, which is why we want to think about the question: what does better look like? Short of eradicating the need for mobility or starting again, how can we iterate upon what we currently have? Where are we trying to get to?

We believe that the answer to this question is simple:
Today, we spend time, *travelling*.
Tomorrow, *we will spend our time*, **while** travelling.

Let's explore some common scenarios and some of the solutions we have to hand. Imagine that we live in Guildford, have been offered a job several miles away in north London and are now planning how we'll be commuting to it. A popular choice would be to buy a car and use it to commute, pick up the shopping, and for weekends away. An appealing proposition, so let's take a look at how this would work:

PRIVATE CAR OWNERSHIP AND USAGE

Purchase >	Maintenance ><	Usage
Research	Admin	Planning
Decision	Hardware maintenance	Travel to car
Finance model	Fuel	**Travel** (active)
Admin	Storage	Parking
		Walk to destination

The extent we go to for on-demand mobility.

What a mess. When we stop and think about the need that this is catering to, it's shocking how many parts there are to this experience. Things are far more complicated than they should be for getting from A to B. Considering that the purpose of owning a car is mainly to drive it, it's striking how minimal the "driving" part of owning a car actually is. Just as a dog is not just for Christmas, a car is not just for the journey.

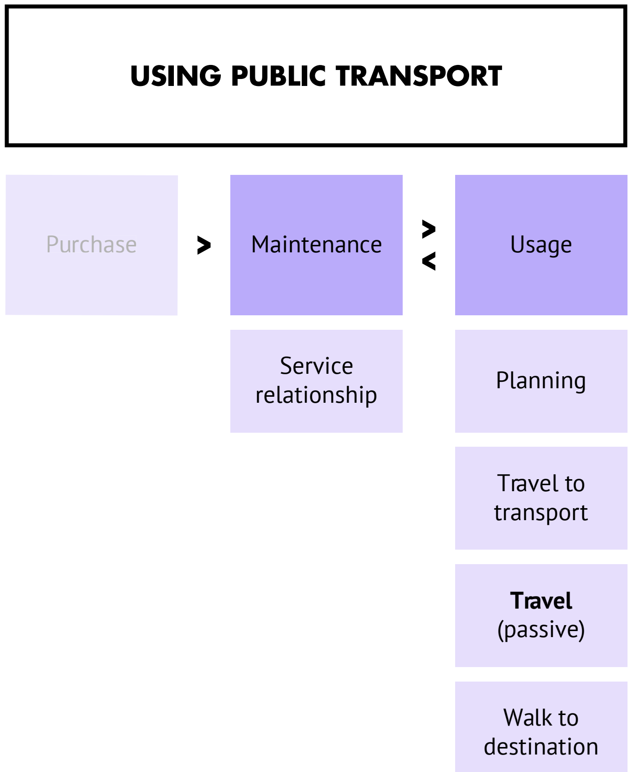
The weighted responsibility in keeping your car insured, roadworthy, fuelled, stored, cleaned, and licensed is vast. The value proposition in owning a vehicle is a degree of freedom, empowering the individual to make journeys as and when they please. It's a nice concept, but in practice is subject to so many constraints that the notion falls flat: what is congestion like today? Where can I park? How close to my final destination will I be able to stop? How much fuel do I have? Is it safe to leave my car in this area? Have I hidden the sat-nav? Do I need to hide the sat-nav? The amount of care required to sustainably own and use a car is clearly significant, but perhaps this is part of the charm. It helps us to build pseudo-personal relationships with our vehicles as this amount of personal investment stimulates attachment. Whatever it is, it's a hefty commitment – we can see how ustwo study participant Françoise considers her car a pet.

Take this model and scale it up over all the years that we've used cars. You end up in 2017, with heaps of money spent by local councils to improve the roads to support the huge amount of congestion (which is bad enough to make Elon Musk start a tunnel-boring company[8] to reduce the load). Privately owning a vehicle and planning a journey was a luxury several years back. Now it's a costly, and arguably unnecessary, waste.

The average car has five seats, but if you take a look at fellow drivers out on the roads, there will often be only one or two people in any one car. Imagine if when you ordered a package from Amazon it turned up in its own van. Now imagine how many Amazon deliveries are made on your road each day – the roads would be gridlocked with delivery vans. Thankfully it doesn't operate like this, and each individual delivery is planned in context with the rest. This is how our journeys should be made. With this luxurious concept of context, there could be a fraction of cars on the road and the same amount of journeys made. Alas, cars and cities were not designed with the problems of today in mind in as much depth as they perhaps should have been.

It's a real shame that the idea of on-demand travel hasn't been executed in a particularly contemporary way, as it is a fantastic solution to our mobility needs. Thankfully, however, we're finally seeing mainstream solutions to these problems. Some examples are companies like HelloCar which smooth over the purchasing experience, and easyCar Club which lets us rent cars easily, covering maintenance costs and responsibilities. Taking a step back, we're also seeing some companies like Tesla attempt to tackle the whole problem in one.

But let's not get ahead of ourselves. These services have not been around for long, so let's take a look at what's informed them. What has the alternative to car ownership been up until now? Well, for those of us who have the same need of A-to-B mobility, but decided against private car ownership, there's shared, public transport.



The, arguably simpler, extent we go to for shared mobility.

At a glance this seems fantastic. We've managed to reduce the mess of "admin" to simply managing service relationships – the rest is directly related to the journey. The real value proposition here is frequent, cheap, and accessible transport for all. In theory, public transport is fantastic, but as with car ownership the execution is not quite as contemporary as we need. Fortunately, AVs will begin to address this, being able to act as both private vehicles and shared, public transport.

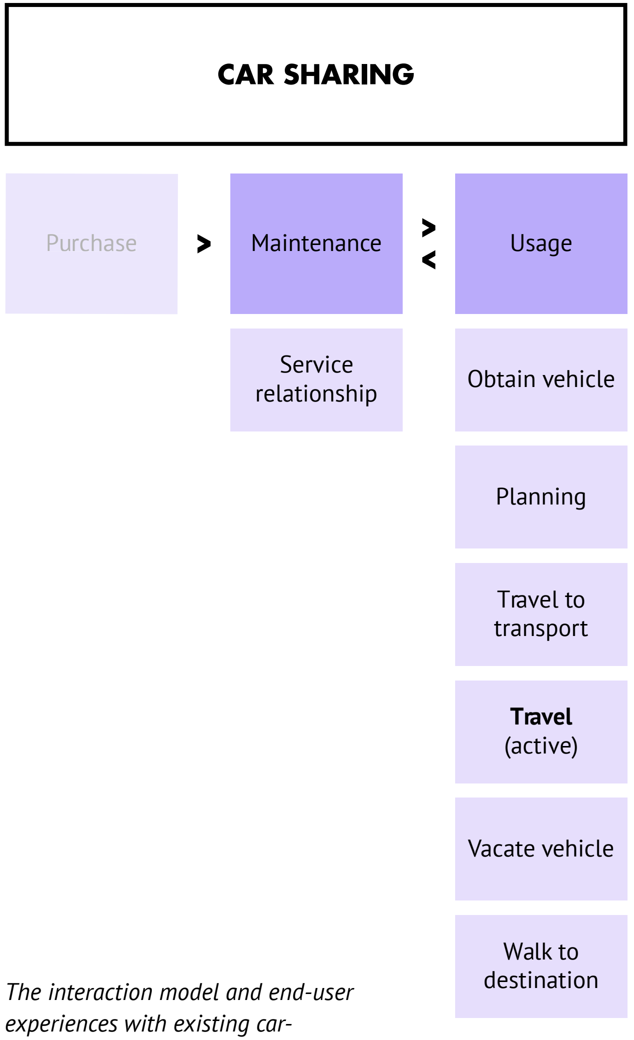
So, our journeys are still made in isolation – we haven't solved that yet. But offering a fixed set of parameters within which we can travel forces us to align parts of our journeys to one another in such a way that begins to simulate the efficient route-planning we could make with context. We have a finite combination of transport links to make our journeys with, which can result in personal inefficiency, but societal efficiency. If everyone squashed into a single carriage of a train were to instead drive their own car, the impact to traffic would be far greater than it is via public transport, even if it means we may get to point B a little slower. The personal inefficiency comes in the form of connecting the dots. As there are so many dots to connect, it's quite common that a journey made using public transport will utilise multiple forms of it. Your journey might start with a drive to your local tube station, then a train into town, a switch to a different train, and then a bus further out of town, ending with a walk to your final destination. It's simply not feasible to create direct links for everyone, so we begin to paint our own pictures with the various solutions at our disposal.

At the end of the day, we're making lots of little compromises, which are part of the trade-off for the perceived value offered by public transport. Convenience is an obvious reason to adopt public transport, but there are other interesting reasons too. For example, in Copenhagen citizens are more likely to cycle as it's likely that their bosses do too, whereas in India, a car is a status symbol. To further complicate things, there's another benefit to public transport that we haven't touched upon yet. If we get lucky and manage to get a seat on our chosen method of transport, we suddenly have time to play with – time to read, talk, think, rest or sleep.

This is an interesting area for exploration as it illustrates how other factors have affected our mobility needs. The blatant inefficiency of having to travel to a dedicated transport hub and wait is an inconvenience, but in return the individual may gain back time. A few decades ago this wouldn't have had too profound an impact – you may have gained some time to read a book or newspaper, spoken to those around you, or perhaps taken some knitting to do. Now that we have access to computers in our pockets, travel time can become precious time for us to enjoy. We're able to read articles, catch up on TV shows, play games, or even work – we can capitalise on this time in transit by turning it to our advantage using technology. While this added utility is incredibly valuable to us, there are bottlenecks we're facing due to things we may not have been able to predict.

Our public transport was designed in a time when society was very different and so we're now facing infrastructural problems that were simply not relevant at the time. The fact that there were no smartphones during the introduction of the London Underground meant that reception wasn't a consideration – today we have no constant signal when underground; the best we can do is to offer routers at stations. Despite this frustration, many of us still prefer to have this idle time to ourselves than having to drive. So yes, public transport seems to address some of the friction points of car ownership, but there are some clear trade-offs, and ample space for improvement. Wouldn't it be great to have the best of both? The efficiency of a direct journey and the "personal" time of travelling by train?

Now that we've taken a quick look at our two main solutions to mobility, let's look forward. We'll touch upon the current landscape where companies are beginning to remove friction points from the private vehicle model, and then look at what an ideal future of the model could look. Where's the happy medium? How can we stop thinking of our solutions in the two camps of "private vehicle" and "shared vehicle" and begin thinking about eradicating mass inefficiencies? What about car-sharing? This is a step in the right direction. Individuals have the opportunity to make private, on-demand journeys, but are no longer solely responsible for the vehicle. Sounds appealing, right? It looks it too:



The interaction model and end-user experiences with existing car-sharing services.

The majority of the "admin" related to car ownership is eradicated when we apply the sharing economy model. The service provider who holds responsibility is able to capitalise by generating revenue by sharing their vehicle. For the end user who simply needs to travel, the mission of buying a car and financing it is removed, the majority of the maintenance responsibilities are removed, and we're left with a model which seems more appropriate in catering to the need: "I need to get from A to B." If every car currently parked on the side of the road worked like this then we could get away with using far fewer vehicles to fulfil everyone's needs. Think about how many hours a day most cars are left unused. The fact that we walk past literally hundreds of empty vehicles to get to a train station is ridiculous. We could fix this, and some companies are.

As ever, the companies exploring this space are facing a whole new set of problems related to our mobility needs. In theory, the idea of car-sharing is revolutionary, but in practice we're not quite ready for it. As we touched upon earlier, our cities have grown around our legacy solutions. This means that new and disruptive models may not fit well with existing infrastructure.

If we dig a little deeper, we can see that this issue revolves around supply and demand. In order for the public to fully adopt car-sharing services, such as those offered by the autonomous vehicle future, they need to reliably meet their needs. There must be a vehicle available nearby when users need to travel. The pressure this puts on service providers is huge since demand is not even. While cars are still very much manual and rely on being driven from place to place, this will be a difficult problem to solve. For now, we're dealing with services which apply a digital service layer to our existing tools, increasing their utility but still not solving the bigger problem. An example of this would be Car2Go, which faced issues when users would drive cars into central parts of Berlin and leave them there, travelling home via public transport. This meant that there was an excess of vehicles in central Berlin with unmet demand in the outskirts, requiring redistribution. We'll come back to this problem later, but for now it helps to illustrate why mass adoption is still a little way off.

While mass adoption is still a while away, so is social acceptance of reformed service management as part of travel. Some of us may use apps to summon vehicles or perhaps purchase train tickets, but generally these services operate in relative isolation. Managing our Oyster cards for public transport here in London isn't the smoothest of experiences. There are many disjointed platforms and steps and it doesn't seem to make sense in our current technical landscape. If you imagine the relationship you have with your bank, you can manage the majority of your engagement in-app. No more reliance on visiting the branch – you can transfer, send and receive money, you can open and close accounts, manage payees, and get help from some of the better banking apps. We'd love to see this in service management for our mobility needs. We want to be able to do everything from our phones. There are some surface-level digital mobility tools – some cars have apps, some public transport systems offer digital admin tools, and we're using journey planners. Unfortunately, these operate largely in isolation. Of course, progress is being made in this space. Services like Android Auto and Apple CarPlay are beginning to build bridges, but we want our holistic solution. If we can have a smart washing-machine[9], why can't we have smart mobility?

So, in our current landscape of car-sharing, there are a few hurdles to clear. The digital product space is still fresh, and we're yet to be able to exhaustively manage our service relationships with our travel solutions. Due to restrictions in our existing tools and infrastructure, we're struggling with supply and demand issues and will continue to do so as we rely on "legacy" vehicles. The bold model through which Tesla is facing this is by incremental updates, selling vehicles that fit well in our current landscape, but with the capability to adapt to the next stage, helping to stimulate the necessary infrastructural change over time. This rich data that companies such as Car2Go are capturing will be the very lifeblood of Tesla's car-sharing model.

Understanding travel needs and sharing this data with autonomous vehicles creates the powerful solution we're waiting for. Demand will no longer be an issue. The shared fleet will be able to accurately and effectively redistribute itself to cater to real needs. Users will no longer need to worry about the service falling short, which removes a significant amount of friction in service adoption. It's a popular trend in technology at the moment, and for good reason. Our consumption data can help supermarkets stock products that we want, help our streaming services play us music that we'll love, and help us to find information that we need. Now it will be able to help us get to where we need to be.

How does this look in practice?

TESLA (AUTONOMOUS*) OWNERSHIP AND USAGE

Purchase	Maintenance	Usage
Research	Admin *	Summon vehicle
Decision	Hardware maintenance *	Planning *
Finance model	Fuel *	**Travel** (passive) *
Admin	Storage *	Vacate vehicle
	Income (passive) *	Walk to destination

*The experience of a Tesla owner once full autonomy is integrated. Automated tasks indicated by *.*

TESLA (AUTONOMOUS*) USAGE

Purchase	Maintenance	Usage
	Service relationship	Summon vehicle
		Planning *
		Travel (passive) *
		Vacate vehicle
		Walk to destination

*The experience of a Tesla user once full autonomy is integrated. Automated tasks indicated by *.*

Finally we're seeing things simplified and it's very appealing, making everything about travelling as simple as possible. If an individual chooses to own a car then the "everything but travelling" part needs to be made significantly easier and pared down to as passive an experience as possible. Things like storage will hopefully be less of an issue as autonomy suggests that the vehicle could sort that out itself. Fuel will also be eradicated as a concern thanks to Tesla's incredible commitment to using clean energy (Tesla's Powerwall and Supercharger stations mean that users will generally not need to worry about fuel). Even general maintenance will become easier, with the possibility of the car driving itself to the nearest garage.

For the end user, for those of us who simply need to travel, it's even better. There's very little to do but travel. We no longer need to worry about fuel, we won't need to plan, we won't need to travel to a vehicle, and we won't need to drive ourselves. In this glorious future we'll only have to manage the service relationship (which, through design could be a fantastically simple experience) and travel. No more "which station is closest?", no more "where did I park?" – just travel. Summon a car, get in, and off you go. Utilisation of the data we spoke of earlier could mean that demand is met so well that a car will always be nearby to cater to our needs.

As with every exciting idea, there are hurdles to jump; and with the grandiose scale of this enthralling idea they're pretty hefty. Global infrastructure has been built around our existing transport systems which makes stimulating change an enormous task. While car technology has improved in leaps and bounds, the proposition of what a car is has remained unchanged for quite some time. Here we return to the two opportunities we highlighted previously: to increase the efficiency of the tools we currently use, and to better plan for the design of the future tools which we will one day use (a challenge in itself as "the future" isn't a specific date, which means we that have to constantly shift our design and planning). Despite all of its flaws, the model of car ownership is not going to reform, nor disappear, overnight.

Thankfully, Master Plan Part Deux evangelises the fantastic introduction of consumer value brought about through iterative software updates. When Tesla is ready to release a car-sharing system, users will not be required to purchase new vehicles. Tesla will be able to tap into the network of connected vehicles already on the roads, and offer this capability through an update. Now that is huge. This makes the epic challenge slightly more digestible. We're able to continue as we are, rolling out vehicles for the future which still fit into the infrastructure of today. Several years down the line our infrastructures will have naturally grown to accommodate these new vehicles, and we'll be comfortably fixing the mess we've been growing.

"Add your car to the Tesla shared fleet just by tapping a button."

Tesla, Master Plan Part Deux

One of the consistent friction points across all of the mobility solutions that we've explored is the overheads in service management and maintenance. By allowing users to add their car to a shared fleet just by tapping a button, Tesla is taking a reductionist approach to encouraging service adoption. As an owner there are currently a series of complicated hoops to jump through to rent out your car. Minimising the work that needs to be done here will go a long way. As an owner, you may be able to capitalise on your vehicle while it's not needed without a hefty commitment, by adding it to (and presumably removing from) a shared fleet with the tap of a button. Since it's such an easy thing to do and presumably on a platform that we are comfortable with, owners may be more likely to share their vehicle, which could begin to address the Car2Go problem.

Taking it a step further, perhaps Tesla could offer an incentive to encourage users to share their vehicles when demand is high. Full autonomy solves our supply and demand problem, the convenience of the service offers immense value to all parties, and the knock-on effects of sharing vehicles will cause ripples for many years to come. For example, the data captured from users' travel needs and journeys could help in planning – vehicles could pre-emptively drive themselves to areas with predicted high demand and low local supply, meaning that the success of services like these are no longer dependent on equalised travel needs among cities.

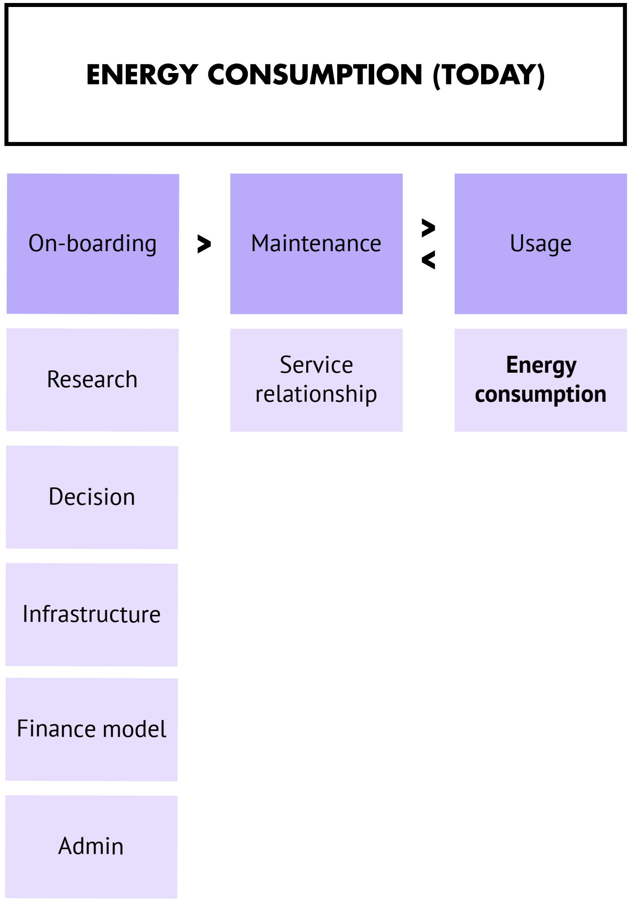
Taking things a step further, this in turn means that areas which are currently poorly connected may begin to thrive. As populations grow, demand may also grow. As demand grows, the supply will follow suit, which could in turn stimulate local economies and level the playing field by removing strain on major cities. We can even imagine a future where the space occupied by motorway hotels can be used for something else as long roadtrips may not need to be broken up for rest breaks. So this "tapping a button" may have pretty profound effects down the line.

Something that we believe will be a significant factor in the success of this is the platform. As mentioned previously, familiarity is a powerful tool and making users feel comfortable about sharing their vehicles and borrowing others' could make or break such a service. The obvious go-to here is the smartphone. It's a device that the majority of Tesla customers will own, already using them to complete every imaginable task from texting their partners to plastering their photos with Drake stickers[10]. Thus it makes sense that when Tesla states that it wants to make car-sharing as simple as "tapping a button", it's safe to presume that it means in the upcoming Tesla car-sharing app that it'll be working on, as opposed to a physical button in a vehicle.

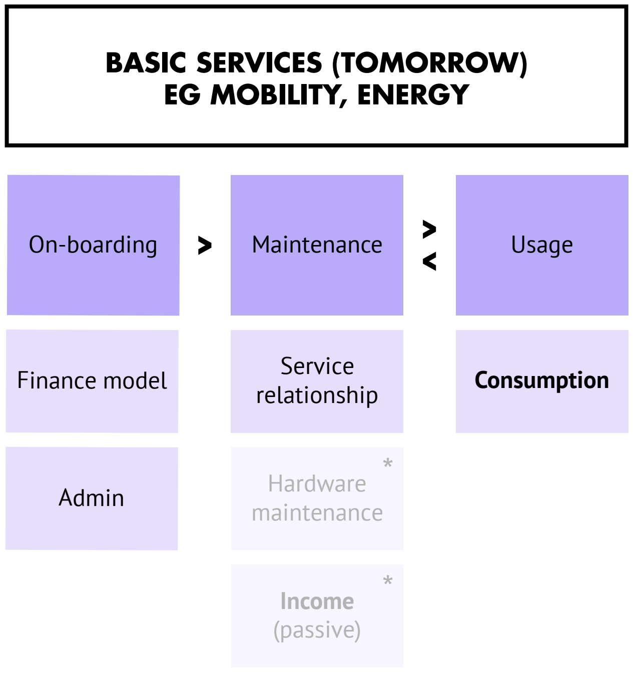
Micro but Many

This really could swing things either way. A great experience could encourage rapid adoption and accelerate us towards an autonomous shared-vehicle future, while a poorly-designed product (something we would not expect from Tesla) could cripple attempts. To avoid this, we need to think back to the light bulb scenario we explored earlier. Tesla is building a solution that needs to scale. At the moment it looks like tapping a button, presumably on a smartphone, but in years to come when we're no longer using phones to carry out tasks, how will this work?

The relevance of our current solutions will no doubt diminish in time, but how can we ensure that longevity is a factor in design? This is the risk of designing an app as opposed to designing an experience. We've dived deep into the challenges and opportunities of the future of mobility so far, but we're at a point now where things can really start to get exciting – because we're thinking holistically. This is an opportunity to design an experience which can solve long-term, high-friction problems for a vast amount of users. Once again, thinking back to the light bulb, what other problems can we solve when designing this solution? We've been able to think about how the future should look by thinking of the context of our solutions. But what if we take this experience, and explore the context of that?



The current interaction model for home energy consumption.



It keeps going. With every solution we design, looking to solve a problem, we can always take a step back and look at the bigger picture. The experience map we have been working towards in this research builds bridges, yet there are always more dots to connect. The mobility needs of an individual can operate in tandem with a mass of other resources we have to deal with in our lives. Travel is a need, as is energy. There are similarities between how we consume these resources, suggesting that there can be unity in experience. We very briefly mentioned how Tesla is building Powerwalls (consumer units which are able to store solar energy), and we spoke about our excitement that Tesla's new mission statement doesn't explicitly mention cars in all of the goals. We break down the implications of Tesla's approach to energy in an extended version of this piece which can be found at ustwo.com, but the takeaway lesson here is that it involves plenty more simplification of the complicated experience map you can see above. Where we face boring bits of service relationship management, why not connect the dots? Instead of managing multiple services, wouldn't it be great if we had one touchpoint to manage them all? Energy and mobility are still quite a small part of our daily lives and the services that sustain us, but by tying parts of our interactions together Tesla is beginning to remove some of the admin from living, which is pretty special when you think about it. ◆

*A plausible interaction model for basic needs in the future, ownership being a variable. Automated tasks indicated by *.*

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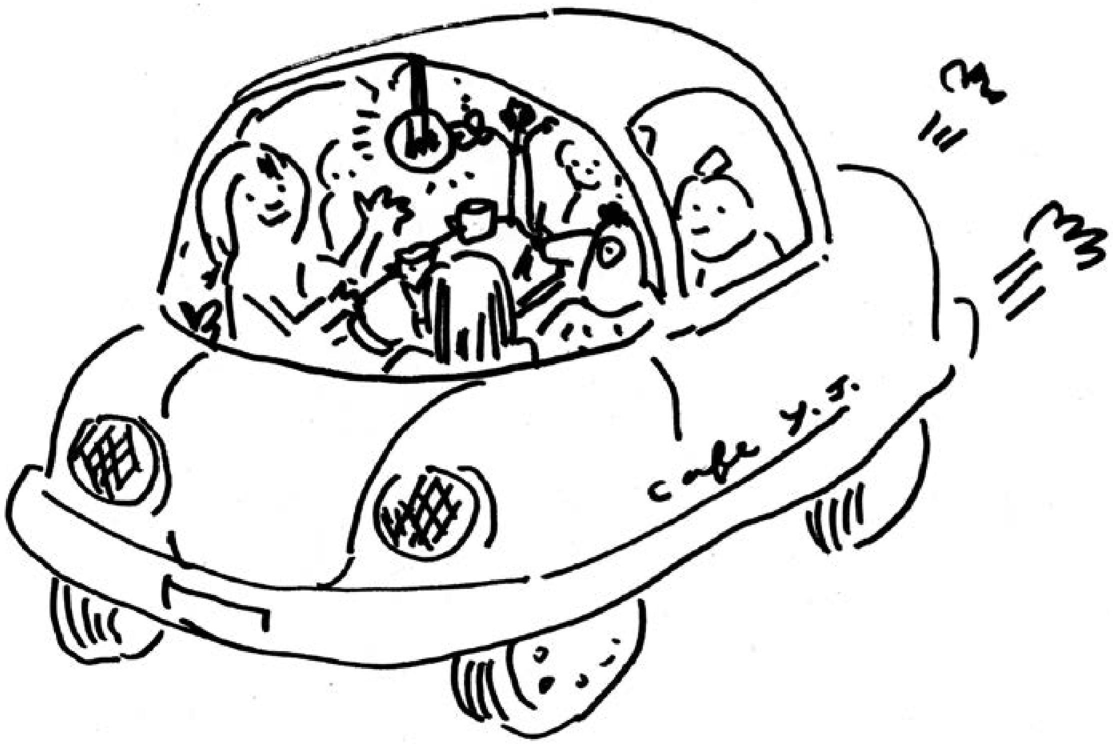
Ca(r)fé
by You Jung Byun
Year: 2017

“Don’t waste your time on the road - be productive, be social, be relaxed, just like you are in a café!”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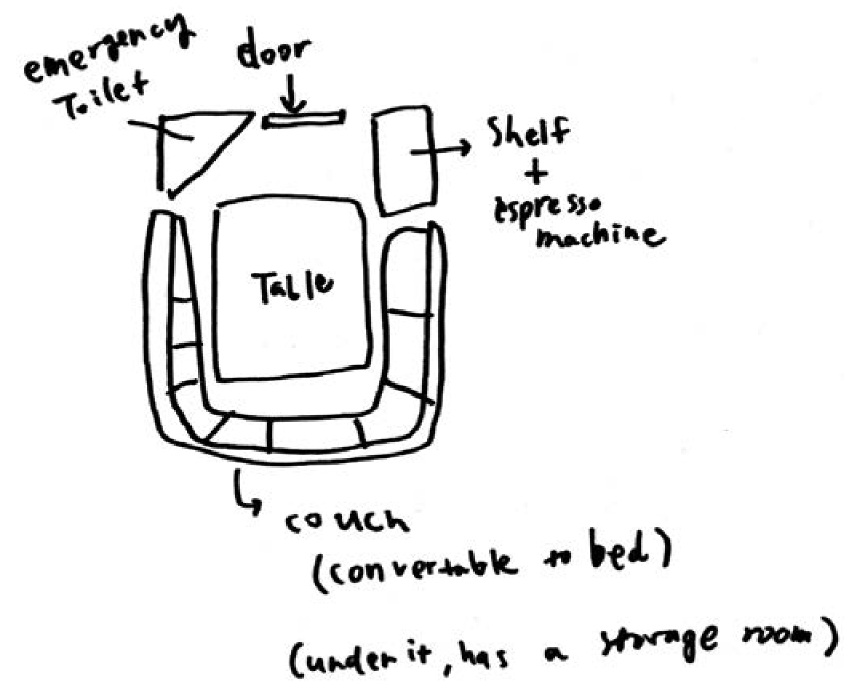

emergency Toilet
door
Shelf + espresso machine
Table
couch
(convertable to bed)
(under it, has a storage room)

HUMAN–AV DESIGN PRINCIPLES

Topic: ustwo's AV Design Principles

6 minute read

What is a *Human–AV Design Principle*? Throughout the research and writing of this book, we have unearthed a number of consistent and ubiquitous user-centred design considerations that we feel are vitally important in designing any user experience within and around an autonomous vehicle. These Human–AV Design Principles act as a guide to keep us creating the most inclusive and most appropriate user experience ensuring that the user gets the best possible journey from their ride. These are principles, not laws and so are subject to change and iteration. We would love to get feedback from you and we hope that you too will use these when you're designing for the human, and not for the robot, in an autonomous journey future.

01. HUMAN AUTONOMY IS THE GOAL

Ultimately we are creating autonomy for humans, not for the robots. Everything we design is for that human goal – we are not done when the robot is fully autonomous.

02. BUILD ON THE HERITAGE

The automotive industry is one of unique heritage with romantic notions of freedom and travelling to faraway lands. The passion for the automobile is well established and it's heritage is unrivaled. Combining this heritage with the benefits of modern technology would be something we would love.

03. EMOTIONAL AND FUNCTIONAL NEEDS

There's more to a journey than simply the functional need to get from A to B. Any journey includes many human and emotional needs such as comfort and human interaction.

04. BUILD TRUST IN THE EXPERIENCE

Anxieties in new technology need to be alleviated for their early adoption and continued use. So build trust early and keep it going throughout the lifetime of experience.

05. BALANCE ANTHROPOMORPHIC PROJECTION

The anthropomorphic characteristics of an AV's exterior need to consider both the idea of a robotic car as a friend or creature, as well as a tool to make life better, so that it is not feared and treated with respect.

06. ESTABLISH AND MAINTAIN A HUMAN ROBOT RELATIONSHIP

If a stranger is rude to you, you won't want to interact with them again. The same applies to a robot. The AV must acknowledge and reciprocate human manners and behaviours. For example, when a person waves to thank an AV for letting them cross the road, the AV must display acknowledgement of the gesture back to the human.

07. DEGRADE GRACEFULLY FOR THE SENSES

There should always be reasonable fallbacks for interactions, without overtly relying on any one interaction channel. For example, audio interactions for vision-impaired people should have visual counterparts for people who cannot hear or understand auditory information.

08. ACT HUMAN, BE ROBOT

Utilise both human and machine advantages by instilling the beneficial nuance of human behaviour while exploiting technological benefits ie quick response times of machines.

09. RESPECT FOR THE FAST METAL BOX

The AV does not need to be submissive to the actors it shares the road with, it just needs to convey an understanding of the situation. We feel that AVs need to be treated with the same respect as a person would treat any other vehicle or machine so that it can safely integrate with society.

10. COMMUNICATE CAPABILITIES

The user must understand the capabilities and failings of the AV so that they can either operate it appropriately, ride in fully-autonomous mode safely, or know when it is safe to enter autonomous mode.

11. REMOVE ALL LIABILITY FROM THE USER

Liability in case of an accident in AVs is ambiguous and confused. For users to truly adopt the technology, OEMs or service providers should accept liability in 100% of cases, removing that confusion.

12. THE AV SHOULD NOT ASSUME TOO MUCH

Prediction or assumption of human driving behavior and intention is a complex task. One that should not be relied upon in designing systems - so the AV should only speak for itself and it's intentions, not others.

13. DON'T ASK, OBSERVE

People say one thing but do another – this disparity is human nature. In user testing or mining for insights, it's more accurate to observe what people do, rather than ask what they would do.

14. MITIGATE CONCERN EARLY

While the technology is earning trust, people will feel concern using AVs. Continued sources of stress from the all-new experience of a driverless can cause stress levels to rise. Concerns left unmitigated may result in panic.

15. SOLVE PROBLEMS HOLISTICALLY

Consider the person's needs and the full end-to-end user scenario even when designing for a small part of it. This will help to give the solution a more contextually appropriate design.

16. THE AV SHOULD TELL US IT UNDERSTANDS ITS SURROUNDINGS

It is important that people know what the AV see's and that it understands where it is for them to trust it. An AV can also communicate an approaching hazard to vehicles behind it.

17. THE AV SHOULD TELL US WHAT IT'S GOING TO DO

While driving we communicate our intent by using indicators while turning or slowing down to let people cross. This should be the same for the AV so that people understand it.

18. THE AV SHOULD RESPOND WHEN INTERACTED WITH

Feedback mechanisms are needed for people to know that the AV has seen or heard them, ie when being hailed, an AV should acknowledge the human interaction and respond.

19. UTILISE THE LANGUAGE OF PHYSICS

The laws of physics communicate an awful lot to us – in a language that we need not learn. We know, for example, that a moving object leaning right implies that the object will turn right.

20. THE AV SHOULD BE INDEPENDENT AND NOT SUBMISSIVE

The AV needs to show that it understands the rules of the road and that it is a machine that is to be treated carefully and with respect. It should not be submissive to other actors of the road so that it is not bullied or tested or cause danger.

21. THE AV SHOULD BE EMPATHETIC AND INCLUSIVE

People should feel independent and empowered around an AV irrespective of whether they have mobility issues or not. So affordances should be designed to enable people to feel respected and treated with discretion, ie the AV's floor base lowering itself to allow any person to enter without aid.

PUTTING THEORY INTO PRACTISE

Topic: Tackling AV Design Challenges

25 minute read

SUMMARY

In this section, we use Central London as a stage to stress-test our principles and ideas in real-world situations. The area is already on a path to becoming an Ultra Low Emission Zone by 2020 and this regulated environment makes it the perfect hypothetical testing ground for AVs.

With human needs front of mind, we'll highlight some problems that might come up and provide a methodology to approach them. We'll explore hailing an AV, what these silent machines should sound like as well as presenting our own vision of what an AV should look like...

INTRODUCTION

So far we have theorised about humanising autonomy. So what do our design principles mean in practise?

Here we will set the stage for the future of AVs in cities and try to illustrate some of the human problems, needs, and opportunities that might emerge. We will then look at methods to research those needs and design strategies for AV services and products. Some of our challenges cover themes, while others are more focused. The idea is not to find solutions with a few pages of text, but to figure out a point of view and research methodology.

We also think that the near future (ten years from now) will be that of co-existence between man and machine, not with fully-autonomous vehicles everywhere, but an in-between state, where AVs and driven vehicles live together. We are probably not driving towards the two extreme of a utopian dream or dystopian nightmare, but rather into shades of grey. We may never ride in Herbie or meet Replicants. The real societal problems of inequality in mobility will continue to exist.

SETTING THE SCENE

What if, in ten years' time, there are no traffic lights in central London, and the whole area is a zero emission zone, with autonomous and electric vehicles the new norm?

One of the most crowded parts of the city, central London is a juxtaposition of old and new, with the London Eye looking across the River Thames at Big Ben, tech companies nestling alongside stately villas, and the occasional horse-drawn carriage amid the most expensive petrol-powered vehicles. It's the most populous and polluted area of the city, with the greatest number of tourists and commuters – it reached its peak yearly particulate levels within the first three weeks of January 2017[1].

A massive cause of the pollution is the growing presence of personal and shared vehicles. This has prompted the establishment of a Low Emission Zone, which will become an Ultra Low Emission Zone by 2020, according to the Mayor's London Infrastructure Plans 2050[2]. There is a massive impetus towards the introduction of electric vehicles, cycle-only zones, and connected infrastructure to control traffic – all of which will require a large mental shift for the area's populace.

This also makes central London a prime candidate for the introduction of AVs and related services, such as on-demand taxis, and lightless traffic junctions and crossings. We need to look into ways of establishing trust early (one of our key design principles) in order to make the area better for habitation through the use of technology. There are many opportunities and problems which might arise, some of which we will now tackle.

HUMAN DESIGN OPPORTUNITY 1: HAILING A DRIVERLESS TAXI

There is something unique about the ubiquitous taxi – the yellow cab in New York, the black cab in London, or the black and yellow cab in Delhi. They can all be hailed by anyone on the street, making them egalitarian vehicles, equally accessible to all. It doesn't matter who the person is – as long as they can pay for the journey, the driver will stop and let them in. A simple wave of the hand gets the driver's attention and you can pay with cash. Mediaeval perhaps, but it works.

But what about the Ubers and the Lyfts? Born out of San Francisco's bustling startup ecosystem, people need a smartphone and an app to use them, along with a linked bank account. With this many hoops to jump through, many people are naturally isolated from the services. Children or non-tech savvy people are effectively be discriminated against and stick to the old-school method of hailing standard taxis.

Thus a challenge presents itself when an AV is acting as a taxi. Without the driver, who mediates the interaction with a potential customer? Who recognises the person hailing the vehicle and who collects the fee for the journey? Will it be necessary for every person using the service to declare who they are via technological means? These important questions come together as our first human design challenge – how do you hail an AV?

HUMAN DESIGN OPPORTUNITY 2: SILENCE IS DEADLY

The death of the internal combustion engine (ICE) is on the cards. Studies estimate that electric vehicles (EVs) could replace 14% of ICE vehicles by 2025, up from the present paltry 1%. While staggering, it will still be some time before we see a greater uptake.

The predominant characteristic of the ICE is the sound it makes, caused by controlled explosive reactions being mechanically converted into motion within a metal apparatus. The howl of a V8 is very different to that of an inline-four, which is again very different to a motorcycle's V-twin (the "potato-potato" of a Harley-Davidson is surely unmistakable). Engine sounds become brand characteristics and allow people to know what's coming round the corner, whether they like it or not. EVs, on the other hand, have the potential to be extremely stealthy, almost silent. While reduced sound pollution and soundscapes are a boon, that comes with a curse of sorts – no one can hear them coming. And potentially all AVs will be based on EVs, according to current trends.

With no sound cues, accidents with pedestrians or other road users are more likely, making the National Highway Traffic Safety Administration (NHTSA) require all EVs to produce a noise when travelling under 19mph[3] (30kph). This has to be an engineered sound – it's not one made naturally by the engine. What will its characteristics be? Where should the sound be directed? How will the brand define an EV's sound or will all brands sound the same? We have approached this issue methodically, developing a point of view which we will share as part of our solution to the second human design challenge – silence is deadly.

HUMAN DESIGN OPPORTUNITY 3:
USTWO DESIGN AN AUTONOMOUS VEHICLE

It's hard to imagine what the perfect city AV could be. There's an opportunity here for automakers and designers to come at the mobility problem from a different angle, moving past skeuomorphic legacies that might hold us back. The fact that most AVs will probably be electric means a substantial reduction in external bulk, because of the lack of engine and traditional transmission systems. Then comes Level 5/6 autonomy, where no human steering input is required, further opening up opportunities for the interior to be made into a livable space.

Bearing this in mind, along with the need for AVs to coexist with humans and other machines on our central London stage, we will hypothesise what a driverless vehicle might look like. This exploration takes into account our research and understanding that there's more to people's mobility needs than simply the vehicle and its technology. The illustration of our AV idea also serves as a provocation to you, our reader, to hopefully start a constructive conversation about the future.

A DETAILED LOOK AT OUR CENTRAL LONDON STAGE

When we begin any project, we always look back into history and then forward into the future, trying to draw an arc of progress by understanding the origins of important developments. For example, how the computer shrank from the size of a room in a research lab to appear in every home, and then in every pocket. This helps us understand the changing dimensions of perception, technology, and even adoption.

THE FORWARD-LOOKING ARC OF HISTORY

Let's start by taking a group of streets in central London – Piccadilly Circus perhaps. It's a bustling hub of tourists, workers, and traffic – personal vehicles interspersed with taxis, black cabs, and the eponymous red London buses. Here are two snapshots of the area known as "London's Times Square"[4]:

Interestingly, the scene has not changed that much since the 1940s, in terms of the number of people calling this area their home and workplace. Incandescent lamps have given way to neon, and then LEDs, and people now have smartphones in their hands, instead of books under their arms. The actors themselves have more or less remained the same, but there have been some big shifts in terms of the importance given to them:

1. People have taken greater precedence over traffic with:

- Laws limiting pollution
- Increased space for foot traffic and crossings
- Public transport and cyclists have been given their own lanes
- Parking is regulated, but complex

2. Automation technology has slowly taken over road functions:

- Traffic lights have replaced policemen, becoming more connected in the process
- Crossing lights have become more automated to regulate the flow of traffic
- Cameras keep an eye on traffic violations

Times Square 1949
Credit the photoman

Times Square 2016
Credit the photoman

A video put together by Simon Smith[5] brilliantly juxtaposes the old and new faces of London using images taken during the 1920s by cinematographer Claude Friese-Greene, capturing the essence of the two times magnificently. If you can spare a moment to watch it, you'll see the changes in traffic and the people-centred patterns on the road. Lane markings have become more pronounced and the number of bicycles has increased.

Change from people to automation[5]
During the 1920s, cinematographer Claude Friese-Greene travelled across the UK with his new colour film camera. His trip ended in London, with some of his most stunning images, and these were recently revived and restored by the BFI, and shared across social media and video websites.

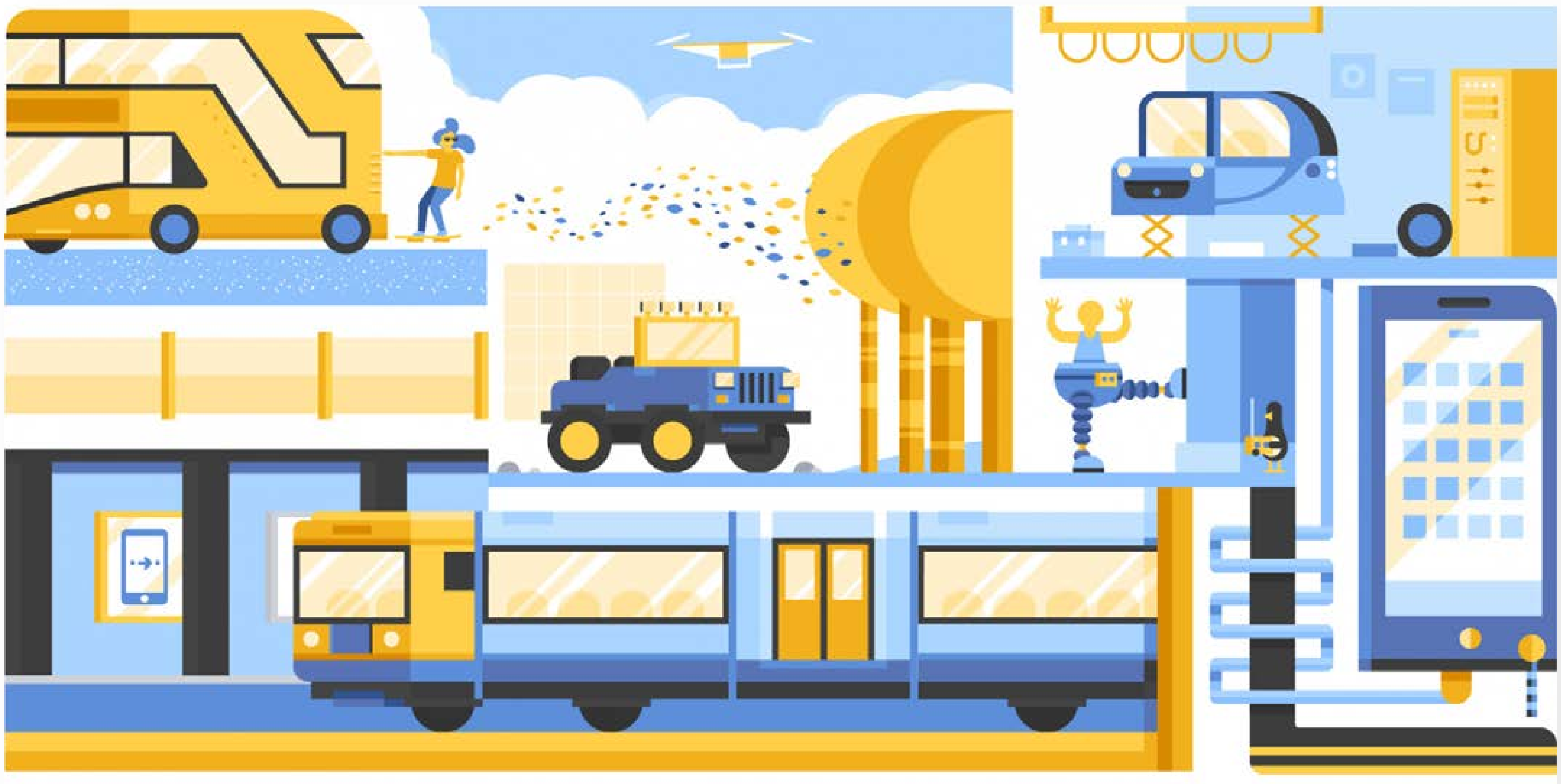
TfL JamCam

Piccadilly Circus is an area that suffers from many traffic jams during peak hours[6], something which can be watched on Transport for London's (TfL) Jam Cam feeds. These feeds highlight the constant interaction of public transport and consumer vehicles with the pedestrians. It's really quite meditative to see the ebb and flow of the traffic.

By tracking the progress and adoption of technology, something we do naturally at ustwo (the Gartner Hype Cycle[7] is also one of the many tools we use to project future technologies), we can posit multiple changes that will happen with the advent of AVs, based on the premise that pedestrians will still be given high priority.

Changes might apply to the different actors in the mix (the introduction of AVs with zero emissions), the environment (a greener Central London), and also the changing mindsets of the people using the space (trust, sociability, and improved mobility). The Mayor's plan for 2050[2] calls for all these elements to be looked at in detail as we drive towards "a more liveable city".

Now, let's look at the changes through the lense of human centredness, rather than just from the technology and infrastructure perspective.



CHANGE 1:
NEW ACTORS – LANES, LANES, LANES!

The addition of laned traffic in cities (incidentally, the first bus lane was introduced in Chicago during 1940[8]) has simplified mobility, increased travel efficiency and speed, and reduced accidents. For cyclists there is comfort in knowing that a stretch of road is your own and this increases the perception of safety, which has resulted in an increase in the number of cyclists on the streets[9]. Adoption of greener, cleaner, healthier mobility is being eased by infrastructure.

This change in perception through the use of lanes could be used to help people adjust to robots on the street, increasing predictability and trust (as discussed in Morality & Ethics).

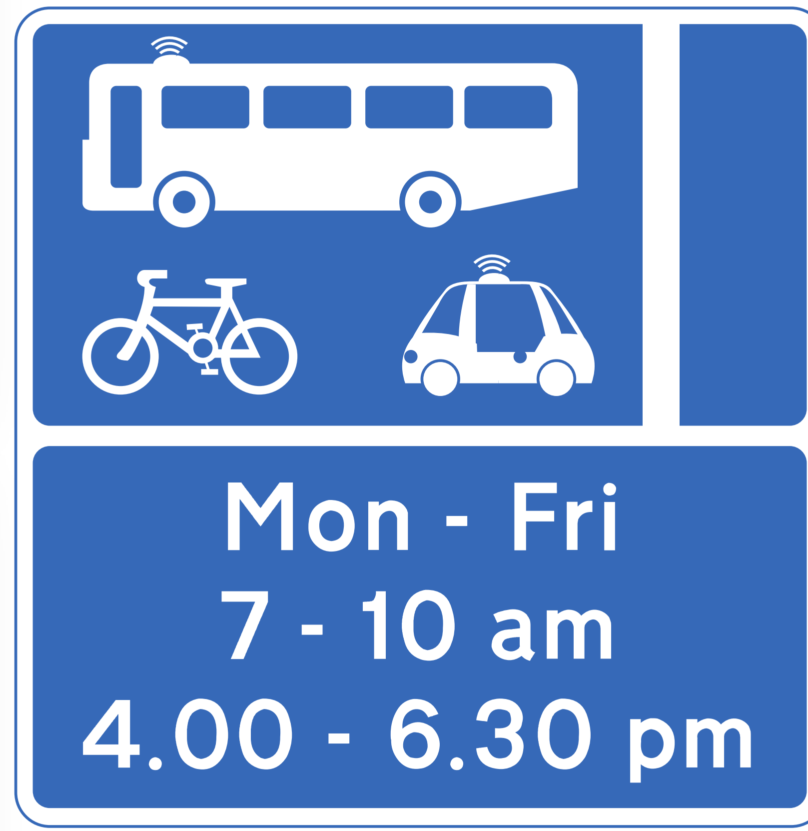
This becomes even more important when we consider that AV technology is likely to be first employed for public transport services. Trains and subways are continually increasing their existing autonomous capabilities – buses and taxis or new "shuttles" could be next, as is already being explored by the Gateway project[10] in south London.

Incremental and steady adoption will be the key to gaining the trust of Londoners. An example of this is the adoption of Oyster cards[11], which have been steadily increasing in use as a cashless means of travel since the successful ten-year rollout[12] plan began in 2003.

Will this be the future of lanes? Lanes and time zones for mixed use by AVs, buses and cycles.

Bus lane

Cycle lane



Shuttle lane

Our concept for an AV lane

CHANGE 2: FREE-FLOWING TRAFFIC AND FEWER TRAFFIC JAMS

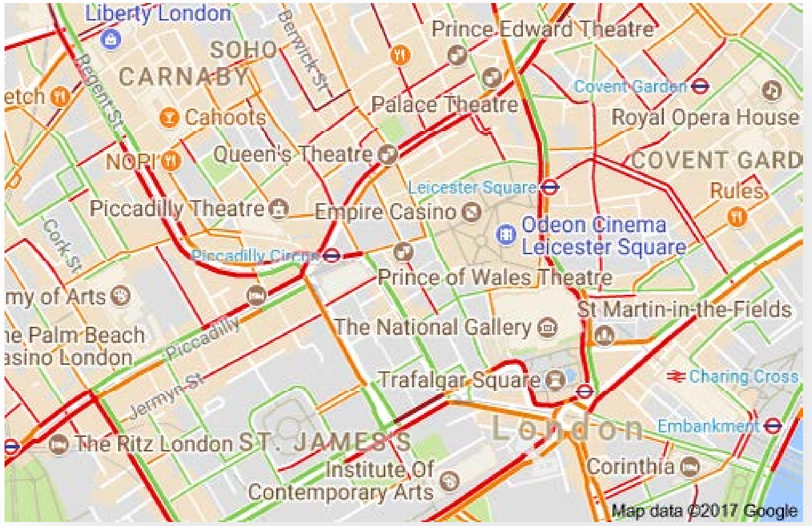
Despite better roads and tighter regulations, the traffic around Piccadilly Circus still gets pretty heavy during peak hours, resulting in slow-moving traffic or the worst-case scenario – traffic jams.

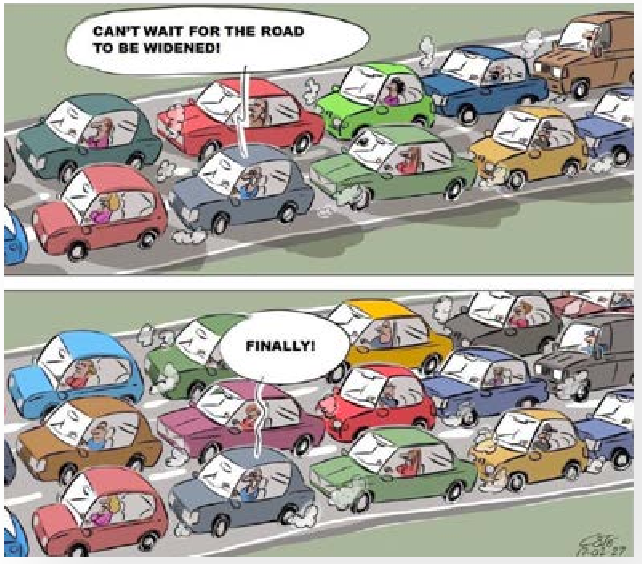
Traffic conditions at 18:11 on the September 6th 2017, showing heavy movement of vehicles (red) around Piccadilly Circus, via Google's traffic report. In economics this phenomenon is known as "induced demand" [13] – where the supply of a service generates more demand. For instance, the addition of more lanes on a road does not necessarily result in a freer flow of traffic, but might instead increase traffic density. Induced demand has long been a blight for large cities.

City planner Jeff Speck[14] has called induced demand:

> *"the great intellectual black hole in city planning, the one professional certainty that everyone thoughtful seems to acknowledge, yet almost no one is willing to act upon."*
>
> **Jeff Speck**
> City Planner

However, there has been some progress in the reduction in demand for precious road space. The addition of dedicated lanes for cycling and public transport is one way in which demand has been reduced. Unfortunately, the number of commercial vehicles has increased due to the rise in ecommerce[15].





Gridlock at Picadilly Circus
Google Maps

Arrival Royal Mail

The next big revolution is, of course, in autonomy and connectivity among vehicles. A revolution which is already seeing AV trials on the streets by numerous services like grocery delivery service, Ocado[16].

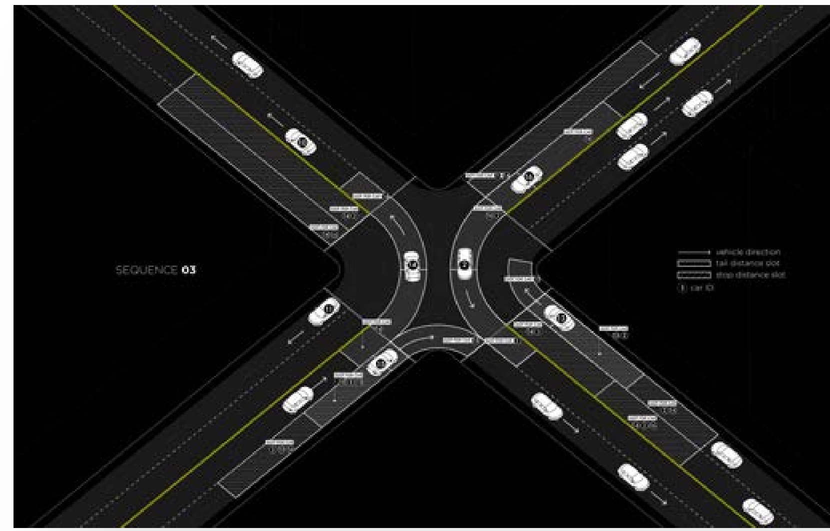
The UK Post Office[17] is trialing electric vehicles that have the potential to be fully-autonomous when legislation allows.

The other side of autonomy is the potential for Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2X) communication, which has been explored as a major alleviator for road stress and a way of increasing capacity by smoothing traffic flow. This communication is a sort of “sixth sense” for vehicles, allowing them to predict movement and literally see around bends.

Remember the project by MIT's Senseable City Lab we described in Human–AV Interaction? The one with the slot-based intersection through which a steady stream of connected autonomous vehicles moves. It's an amazing vision and one that's almost perfectly suited for central London.

The adoption of AVs will take a significant amount of time to reach mass penetration, but it's much-needed. According to Bryant Walker Smith, writing in the Santa Clara Law Review[18], the widespread or universal adoption of autonomous driving could actually increase system capacity:

> *"Three potential aspects of automation could drive this increase, which in turn could accommodate and ultimately foster more demand. First, automation, particularly cooperative technology that facilitates rapid communication among vehicles (V2V), could increase the amount of useable road space in the longitudinal and lateral dimensions.*
>
> *"Second, automation could increase total functional capacity along corridors that include several parallel highways (and that therefore offer more than one potential route). Better real-time travel information could be used to route some vehicles to comparatively underutilized highways. Third, automation could reduce the number of small disruptions to vehicle flows (such as unexpected braking, lane changing, hesitating, jockeying, and rubbernecking) and the rate of crashes and other incidents. The combination of smoother flowers and more useful travel information could also increase the predictability."*
>
> **Bryant Walker Smith**



MIT Senseable City Lab

Free-flowing traffic will remain a utopian dream if we do not consider the significant issues that might occur with the introduction of AVs on our roads. Here are some such issues which might crop up from a driver's or cyclist's point of view:

- Can this AV see me?
- Will it obey the road rules?
- Can I trust it? Can I trick it?
- Will I be safe on the road with it?
- Can I communicate with whomever's controlling the vehicle?
- Who is more important on the road? Me or the AV?

Answering these questions is critical.

V2X communication protocols give AVs another sense or even a superpower – the ability to detect and predict pedestrian movement. Cameras and sensors at lights and along roads and buildings offer a way to look at the patterns of human movement. Studies such as Real Time Pedestrian Path Prediction Using Global and Local Movement Patterns[19] conducted by the University of North Carolina, demonstrate the potential in tracking the movement of individuals and crowds.

Understanding these patterns of movement might allow AVs and platoons of connected vehicles to harmoniously cohabit the streets with people. These patterns might help the robots soon to be living among us embrace the chaotic and erratic nature of us human beings.

"CYCLISTS AND PEDESTRIANS, PRESUMABLY, BECOME MUCH MORE IMPORTANT. AN AUTONOMOUS VEHICLE COULDN'T POSSIBLY HIT ONE, SO THAT WOULD BE INTERESTING FROM A SOCIETAL LEVEL. IT'S KIND OF LIKE THE CAR IS LESS ABOUT STATUS AND IT'S JUST ANOTHER FORM OF TRANSPORT. THE BALANCE OF POWER COULD BE REALLY INTERESTING, AS A CYCLIST, YOU NORMALLY HAVE A CLOSE CALL EVERY COUPLE OF DAYS DON'T YOU... I WOULD FEEL SAFER AMONG AUTONOMOUS VEHICLES."

Neil, ustwo study participant

CHANGE 3:
MINDSET – PEOPLE CO-EXISTING WITH NEW VEHICLES

There's a certain beauty to watching the multitude of people traverse central london. There's diversity in its many forms – young and old, rich and poor – and people with varying physical capabilities.

This rich group of co-existing pedestrians are the "lifeblood of a healthy city"[20], and so it is quite salient that the Mayor's infrastructure report suggests the development of people-friendly roads in London, at the cost of £2-4 billion. An interesting part of that same report is the co-existence of smart and autonomous vehicles. It is worded in the document as:

- Verifying the safety of AVs and ensuring they are capable of responding to other road users eg pedestrians and unexpected events
- Managing the interaction between AVs and conventional vehicles in the interim period

The primary consideration here is safety, which we agree should be tackled first. But we also feel that trust, consistency and adoption go along with it, which have been less explored, but are equally important. Trust issues start with the first contact people have with a new piece of technology, coming with bias, trepidation, and maybe even fear. A lack of trust comes from not having a clear mental model about how a certain system works. The challenge is to turn that around.

For instance, consider street crossing signals[21] – a ubiquitous infrastructure element, but one which has undergone great evolution over the last century. The very first one was used in Bridge Street, Westminster in London in 1868. It used semaphores to show the right of way for horse carriages and then for people, replaced by lights at night operated by policemen. The experiment actually failed because a policeman was hurt when one of the gas lights exploded. This caused massive issues with trust and so their use was curtailed for the next few decades.

Police crossing notice, 1868

Over the next 150 years came various levels of control and automation. First, there was the electrification of these signals as individual units, then came pedestrian control, and finally the creation of a connected body of signals in a particular region of the city. As connected systems, crossing signals are used with embedded sensors, such as cameras, to regulate both human and vehicular traffic.

TfL is planning to implement a further improvement to crossing signals in London in the form of it's new SCOOT advanced lights:

> *"Expanding the use of innovative Split Cycle Off-set Optimisation Technique (SCOOT) technology across London, which can change traffic signal timings based on traffic levels second by second, from half of all signals to three quarters of all signals by the end of 2018. On average, installing SCOOT at a junction reduces traffic disruption by between 8 and 12 per cent."*
>
> **Transport for London**

The ways that people interact with crossing lights and the laws that govern them have also evolved over the years. Trust of a singular signal in the early days was at quite a low level; rules were seldom observed by drivers. But over time, this improved with better driver education[22] and improved awareness of pedestrian laws – and an understand of the advantages to traffic flow.

However, connectivity of crossing lights and the automation of the signals is an invisible interaction, running in the background. The algorithms that control the flow of people and the data that the cameras gather cannot be seen. This raises privacy concerns[23] which may worsen, given that cameras and sensors will feature on AVs.

This understanding of how things work – the mental models – forms the basis of trust in automated features. This was demonstrated by Matthias Beggiato, in relation to the use of automated cruise control[24]. He found that trust and acceptance in an important automated feature such as cruise control, increases with people understanding how the system works and in progressively building a strong mental model.

There are two faces we need to trust – the direct or apparent interactions a person has with the technology and the invisible interactions between systems. Apparent interactions speak about safety, comfort, and ease of use. Invisible interactions speak about personal privacy and societal considerations – a tougher challenge for designers to build confidence in. This is very much true when building trust mechanisms for AV systems.

Different levels of confidence might be required for different forms of AVs – personal, shared, commercial, or public transport. The fundamental feedback mechanisms of these vehicles might be standardised, much like turn signals (indicators) and the procedure to operate them is now. Turn signals communicate intent to pedestrians and are universally understood across countries, which means they should not be lost or re-engineered.

But what is not standardised is the human tendency to negotiate (the pedestrian and a driver while crossing a road) or make sense of a driver's motivation to slow down or speed up. Motivations are generally quite tacit and dependant on the driver's nature. For instance, a patient mother versus a delivery driver. A driver might also be more lenient towards a slow elderly citizen or a child crossing the street, compared to a teenager.

With an AV, these elements of negotiation and motivation are more difficult to decipher. Negotiation between people happens with eye contact and a nod or a shake of the head – elements missing in driverless transport. And then there is the quietness of electric vehicles – how do you know when a vehicle is approaching? There is a saying among bikers – "loud pipes save lives" – a simplistic justification for loud exhaust systems, but a valid point nevertheless.

Negotiation and motivation in interactions also depends hugely on the type of service the vehicle is offering. Negotiating with a bus driver to stop is different to hailing a taxi. This is something which we will talk about in the next change.

CHANGE 4:
MINDSET – PEOPLE CO-EXISTING WITH NEW AUTONOMOUS SERVICES

Mobility services have been undergoing a revolution in this smartphone-enhanced, connected world. We can now figure out how long the bus will be or summon an Uber with relative ease. With everything just a few finger taps away, who needs to own a car in the city?

Connectivity between vehicles and the ability to reach out to service users, has helped organisations such as TfL to sharpen their services and increase reliance on public transport systems in the city, further reducing the demand for personal vehicles.

Conversely, connectivity has also increased the demand for delivery services. We can now get anything from a simple pizza to a week's groceries delivered within a few hours without leaving the house.

"Truck (Light Goods Vehicle, LGV) traffic is increasing in Central London, possibly related to the rise in ecommerce. This is the only vehicle type to show more roadway volume in all three zones of London."

Inrix[25]

"The causes of rising congestion include an increase in certain types of vehicle, particularly delivery vans and minicabs, and a reallocation of road space away from private motor traffic."

London Assembly[26]

What these on-demand services have actually created is a steady increase in demand for certain types of transportation and a huge number of jobs – there are now an estimated 21,000 black cab drivers in London, and nearly 30,000 full or part-time Uber drivers. In fact, services like Uber have threatened the livelihood of trained taxi drivers across the world, leading to backlashes. There have been no estimates on the numbers of specifically delivery-related vehicles on the road, but as our previous graph shows, LGVs have seen the highest rate of increase in the last few years.

It is no wonder then that in central London there is a steady stream of service vehicles on the roads. From buses to delivery vans, to scooters and taxis, it's a mechanical menagerie that has to coexist with the pedestrian traffic.

Right now the drivers are human, with the ability to negotiate with other people on the road, and to empathise with their passengers. But companies are coming to realise that the biggest cost incurred in these services is the people who operate them – the drivers, the fleet managers, and the mechanics.

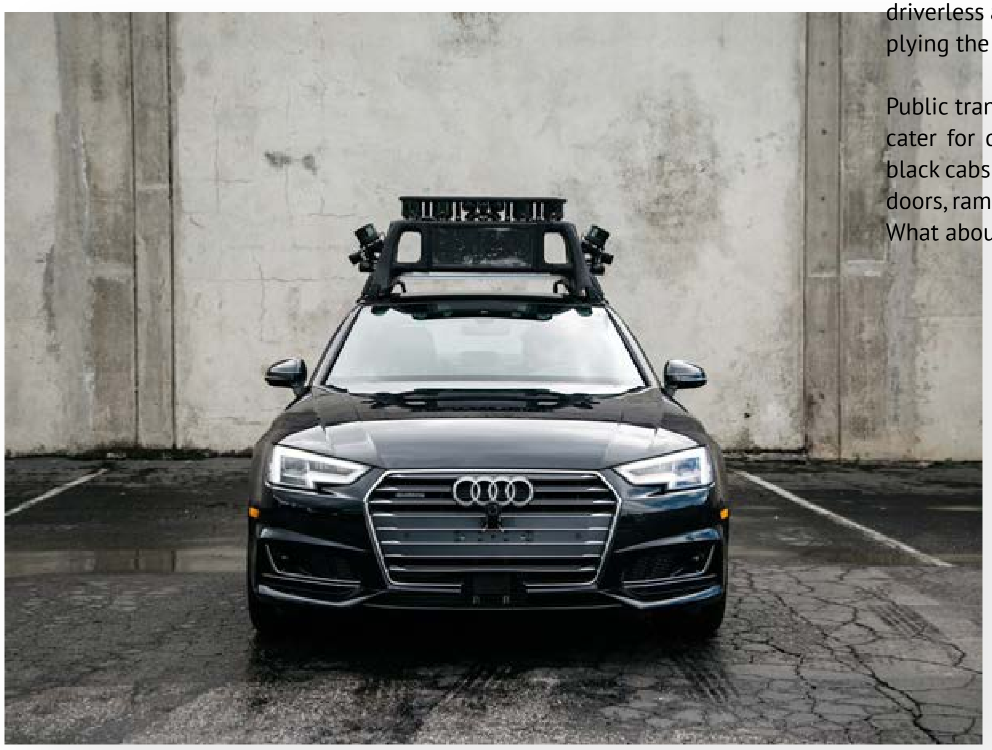
According to estimates in San Francisco, an autonomous Uber taxi would cost 35 cents per mile, versus the $2.86 per mile a passenger currently pays (assuming an average gas price of $2.36 per gallon). The average taxi in the US costs $3.46 per mile. This significant drop in price to the consumer will have an obvious knock-on effect – an increase in demand[27].

The push for driverless vehicles clearly makes significant economic sense. Driverless vehicles can operate tirelessly and will cost significantly less. Companies like Uber and Lyft[28] are already partnering with technology firms like Waymo and Drive.ai to come up with driverless pilot schemes across the US. Similarly, the Post Office in the UK will soon be running autonomous experiments[17] across London.

This will not mean the death of driving associated jobs just yet. With the legalities and the technological limitations of these driverless cars, a human will need to mind the helm of the vehicle. There is also the “last mile” delivery problem to consider – people will still be needed to find the door of your home, push the button for the bell, climb the stairs, and hand you the parcel.

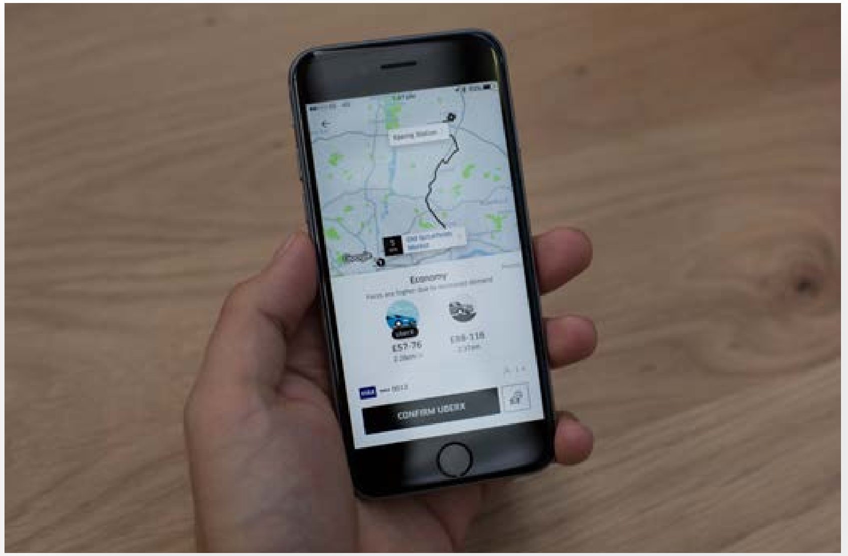
So, economics, and ultimately public safety, will push the behemoth of autonomy forward onto our public roads. Service vehicles might be the first to become driverless and the resulting increase in efficiency might see more of these vehicles plying the streets, when induced demand will rear its ugly head again.

Public transport vehicles must be accessible by law, although they do not need to cater for door-to-door transportation which some people might need. London’s black cabs are regulated to have significantly better accessibility standards (sliding doors, ramps etc) than everyday vehicles, which includes cars in the Uber network. What about AVs?

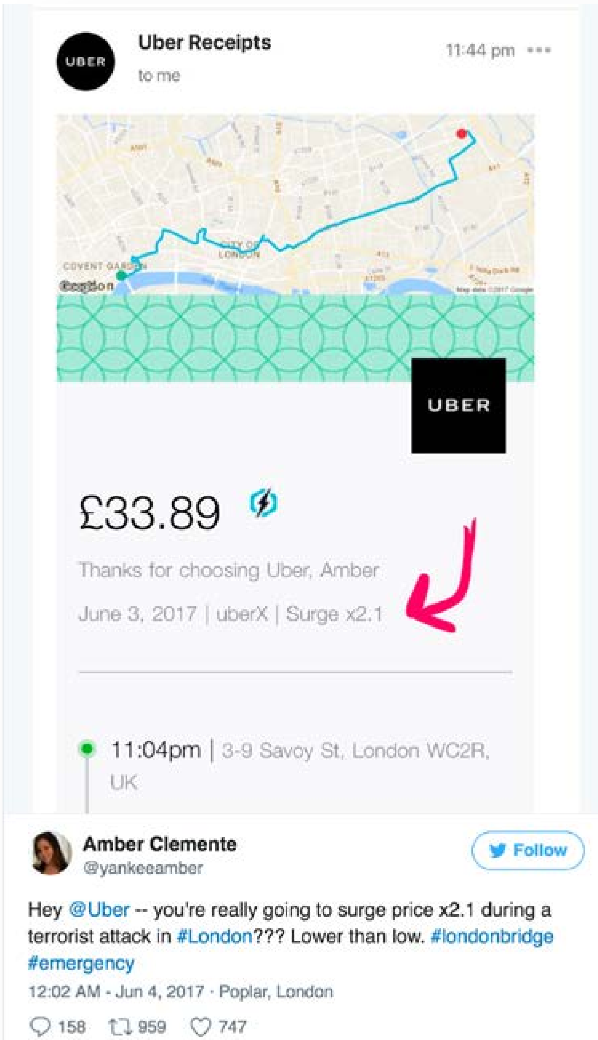


Lyft Drive.ai
Lyft and Drive.ai are partnering to shape the next generation of on-demand driverless taxis.

Smartphone-enabled services marginalise the elderly, the very young and the vision-impaired. Services that require users to submit bank or credit card details are not accessible to all. By using such services you are making certain sacrifices in your privacy, giving out your movement and mobility data. These data points can be used for or against you, both actively and through unconscious biases in a service's algorithm (personalisation of a service versus targeted advertising). In stark contrast, services like the London black cab can be hailed and paid for in cash, all with a certain degree of anonymity and privacy.



Human drivers also understand context. For instance, consider the terror attacks on London Bridge in 2017. People were fleeing the scene, scared and panicking. Black cab drivers understood the situation and responded as human beings do, ferrying people away from the area in groups, taking little or no payment at all. But the algorithm governing Uber's services considered the increased demand an opportunity and surged the prices at a very crucial time for people[29] who were running for their lives. Who's to blame here – the algorithm or the captive drivers and riders? What would an AV do in this scenario when there is nobody to negotiate with or understand the situation?



So with autonomy and the loss of a human driver come big issues in usage, contextual wisdom, and inclusion. Some questions immediately comed to mind:

- Will we see a larger dependence on smart devices as the technological medium for conversing with the vehicle?
- Will it even be possible to hail a driverless taxi?
- In a bus or a shared vehicle, who will be the authority figure?
- How will we settle disputes with fellow passengers?
- Who cleans and maintains the vehicle between stops?
- Who is going to help people into the vehicle when they need assistance?
- To whom do people speak when they just want some company?
- How do we stop an autonomous taxi in an emergency?
- How do we pay for the ride? Will the vehicle accept cash?

"IF THE VEHICLE HAS A FAULT… WHO GETS THEM SERVICED? DO THEY GET SERVICED? THAT'S THE THING I MEAN – WHAT HAPPENS IF SOMEONE GOES OUT AND THEY'RE SICK IN IT? WHO CLEANS THE SICK UP? OUT OF AN AUTONOMOUS CAB? SO THE NEXT PERSON ORDERS IT… THERE'S A BIG PILE OF SICK WAITING FOR THEM. THERE'S NOTHING TO STOP THAT HAPPENING. YOU WANT IT TO TURN UP IN PRISTINE CONDITION, BUT I CAN IMAGINE THEY PROBABLY WON'T."

Dave, ustwo study participant

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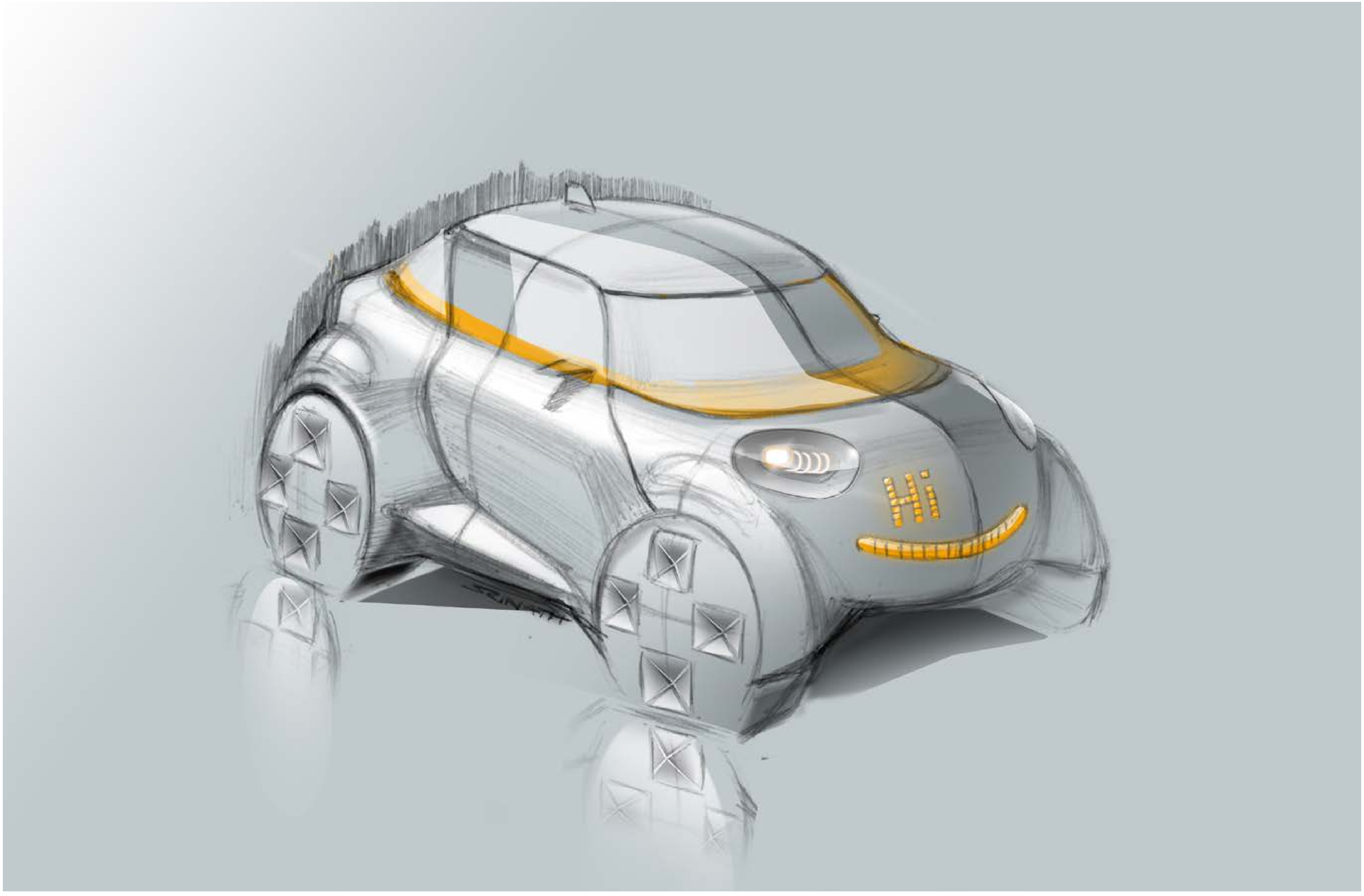
Artificially Human
by Srinath
Year: 2025

"With urbanization, there is shrinkage in space and it is causing a lot of traffic on roads. Because of rapid increase in cars on the road, the unavoidable congestion is leading to behavioural changes in daily commuters. In my opinion they are becoming more aggresive because of the helpless situation.

Automobiles are used as an expression of one-self, the current styling trend is also moving towards "aggressive styling" which we might also link to the behavioral changes. If this is true, then we are in an alarming situation.

In the future, automobiles should be a means to de-stress people and one such possibility is with automation. We can use automobiles to evoke positive emotions. With this in mind, this concept takes a more amicable form (rather than alien). The face of the car will have illumination in a shape which emits happy gestures and notifications. The major thought while generating the concept is to provide a wrap-around glass canopy to have a feel of surroundings, buildings, rainfall etc. All to remind us that we are humans at the end. of the day."


Hi

DESIGN CHALLENGE 1:

HAILING A DRIVERLESS TAXI

Topic: The Other Roles Missing When Removing The Driver

20 minute read

SUMMARY

How do you go about hailing a taxi when there isn't a driver? Who mediates the interaction with the passenger(s) and who collects the fee? If the adoption of ride hailing apps are anything to go by, the requirement of a digital device to get a taxi will be innately exclusionary – leaving no option for children and those who aren't technically savvy.

Here we dig into this challenge, looking at the interaction requirements and behavioural changes that will allow people to call an AV taxi in the most inclusive way possible.

INTRODUCTION

Taxi services are symbols of our great cities, with their little quirks and behaviours. Some of these quirks are even embedded in the vehicles themselves – for example, a London black cab must be tall enough to accommodate someone wearing a bowler hat!

A certain sense of exclusivity also comes with the black cab, from years of regulation and the intensive training to gain "The Knowledge"[1] required to become a cabbie. The iconic London black cab is also efficient, safe, comfortable, has informative drivers and is generally quicker than the average car (as they can use bus lanes). They also double as a tourist attraction in their own right.

Hailing a black cab is a ritual for anyone in London. It is a great leveller – everyone does it the same way, with a wave of the hand. Once the driver finds somewhere to stop next to you, you tell them where you need to go, hop in, and a verbal contract is made. Whoever you are, the black cab will get you there – quite an egalitarian service.

In essence, hailing a cab is a series of human interactions – a wave, shared glances and nods, hunched verbal negotiations – mediated by a vehicle. This set of interactions is either amplified, or in certain cases eradicated, by technology. With app-based taxi services like Uber and Kabbie, negotiations and choice happen from afar through digital interactions within the app. But the primary interaction of recognition when the vehicle approaches you is a ritual which is not lost.
You still identify the vehicle through means such as the licence plate, and a wave or a nod to get the driver's attention.

Technological negotiations, on the other hand, infer a certain amount of pre-knowledge and affluence – such as the ability to procure a smartphone, learn how to use it, and have a functioning bank account to connect to certain services. You might also need to pre-emptively release some information about yourself, which may aid personalised services, but at the expense of privacy. The technology might not be very inclusive, with certain segments of the populace automatically locked out – some older people don't own smartphones and many do not believe it is safe to share bank details. Technological services can thus be seen as not very egalitarian.

With the advent of AVs, there are bigger questions. With whom does a prospective passenger negotiate when there is no driver? How do they know the vehicle has seen them? Can they wave at a cab and have it slow down for them? Will the act of hailing a cab disappear completely?

We believe that the act of hailing or calling for a taxi (don't shout at London cabs by the way, it's not really allowed) is an egalitarian act which should not be lost amid the growing tendency to remove or lose human interactions in service design with the introduction of technological media.

So let's dig deeper into the set of interactions and the needs which make up the background of hailing a cab. Our aim is to design a set of behaviour that future AVs should follow, in order to make for a successful driverless experience – at Level 5/6 autonomy.

UNDERSTANDING THE HAIL – THE NEEDS AND MECHANISMS THAT GOVERN IT

Cabs can be hailed by anyone – a simple wave of the hand does the trick. Consider the different interactions that occur when you are negotiating with the driver; there are certain needs and potential problems which both actors need to consider. We can then extrapolate these interactions by considering AVs as social robots.

PROXEMICS

To provide some context, let's consider proxemics[2] – the study of space and how people perceive and interact within their immediate surroundings and the actors within those surroundings.

"People have a definite sense of personal territory – intimate, personal, social and public. Different types of interactions take place in different zones. Eg you move in close to scribble your idea on the board, and then you step back to reflect on it... These rhythms are present in all our creative activities (proxemics)."

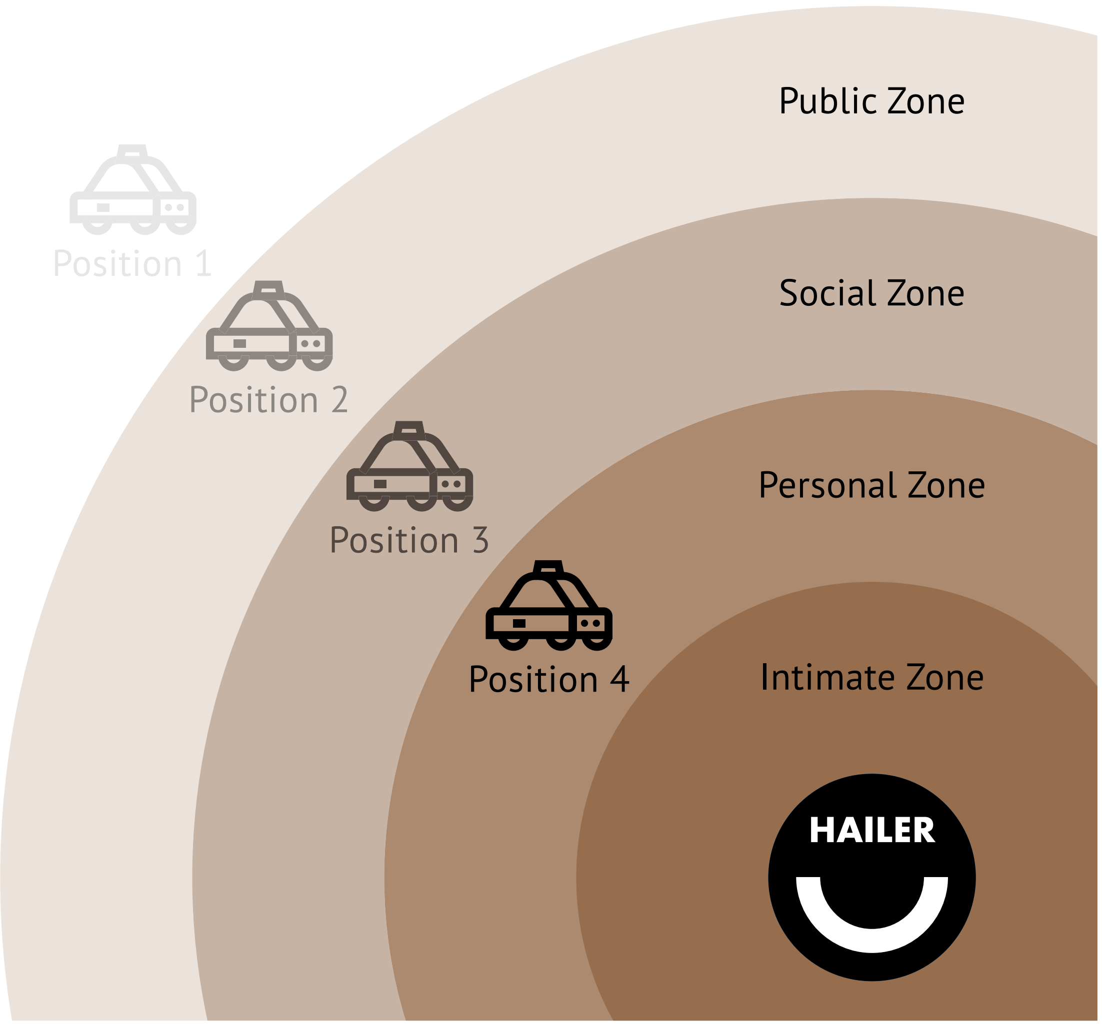
Wendy Ju
Stanford University[3]

As Ju mentions, the different zones around a person and the nature of the zone's perception define the interactions. Public, social, personal and intimate zones surround the person we're focusing on – we'll call them the hailer for short.

HUMAN DRIVER + HAILER

To examine how proxemics works, look at the above diagram which shows the various zones around a person hailing a present day cab with a driver. The cab, when being interacted with, moves from position 1 in the public zone to the personal zone in position 4, when the hailer perhaps gets into the vehicle. For argument's sake, let's assume that the hailer is not using a phone or smartphone during the interaction.

The intimate zone, just around the hailer might, or might not be, encroached by the cab or the driver. It is a zone which might travel with the person as he gets into the cab and it's the zone reserved for the most intimate interactions – with friends, family, or loved ones. When talking to the cab driver once inside the vehicle, this intimate zone might be broached in certain instances, but we will not consider it in great detail in our hailing exploration.


Public Zone
Social Zone
Personal Zone
Intimate Zone
Position 1
Position 2
Position 3
Position 4
HAILER

FIELD OBSERVATION AND NOTES

In position 1, the cab and the hailer are in a position to interact, but they are not actively signalling to one another.

In Position 2, in the public zone, the interaction between the two actors is subtle and implicit. The hailer sees the cab, sees the signal that it is free for a pick up (the yellow light is on) and proceeds to wave at the cab. The cab might or might not see the hailer. If seen, the cab driver moves closer to the hailer, across the road, either by changing direction or slowing down.

Many interaction types when hailing a taxi

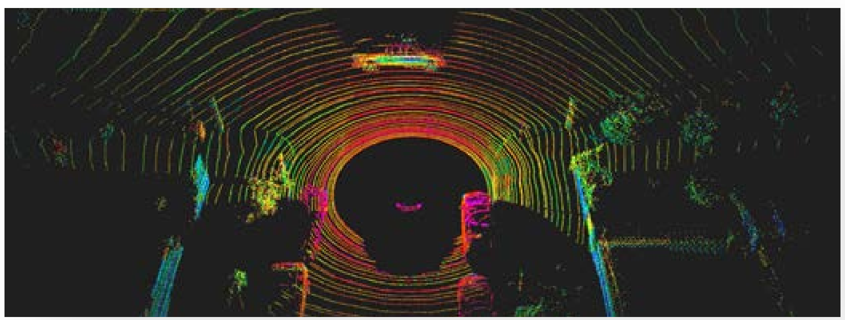
In Position 3, in the social zone, the interaction might be more pronounced as the negotiation between the actors intensifies. The hailer might still be gesturing to the cab, and would be able to see the driver. A nod from the driver completes the human-to-human interaction and the cab moves towards the hailer, gently slowing down. The nod is critical as an element of recognition when there is more than one hailer present (perhaps outside a railway station). There is an "if" in this scenario: if the cab is not able to stop close to you and has to beckon you over or point for you to approach them elsewhere (quite typical in London, where there are curbside areas where vehicles cannot stop). This is a complex interaction, as the knowledge about permitted stopping areas lies with the driver and they have to convey this to the hailer in the most effective way possible.

In Position 4, in the personal zone, the cab either parks close to the hailer or the hailer approaches the cab. In the personal zone, the driver can make an assessment about the hailer and ask where they want to go. This assessment is important for the driver to decide if they need to get out and lend a helping hand, or activate the ramp to help the person to get in. In return the hailer speaks to the driver, lets them know where they need to go or perhaps asks for help. The hailer finds and opens the door and makes themselves comfortable, prompting the driver to proceed to the destination.

So we can see that the act of hailing a cab contains many interactions, which if done successfully, complete the narrative. Now let's consider the case of no driver – a robotic AV interacting with the hailer. Let's look into the possible problems, again considering the proxemic zones.

PROBLEMS, QUESTIONS AND OPPORTUNITIES

The robotic actor – the AV – has to take in multiple inputs and provide relevant feedback by interacting with the hailer throughout the different zones. A steady ramping up of signals and gestures from the public to the personal zones.



LIDAR
What a LIDAR enabled AV might see, from VOYAGE blog

TAXI
London black cab sign, which couples as an "available" sign

Beyond the public zone the AV cab is a travelling observer, passively looking for obstacles, observing traffic rules, and looking out for Hailers beckoning to the vehicle.

Questions which might pop up now are:

- *What gesture and what negotiation would trigger the "hailing" set of interactions by the AV cab?*
- *When would the AV cab move from being a passive observer to an active participant?*
- *How does the hailer know that the AV cab is empty and is open to negotiation?*
- *Will it be as it is now, with a lit sign on the roof, or could it be a lot more apparent?*

In the public zone and position 1, the AV cab has "seen" the trigger gesture by the hailer and has to respond accordingly. It also needs to compute the best position to move into to close in on the hailer. From the hailer's perspective there needs to be feedback about the vehicle's intent and whether there has been recognition at that point. The AV cab also need to provide feedback to other road users that it is taking an action.

Some of the questions here might be:

- *What sort of feedback mechanisms, both implicit (eg a change in direction towards the hailer) and explicit (eg blinking of lights), should be employed by an AV cab to speak to the hailer?*
- *How does the AV cab negotiate with other traffic elements to move closer to the hailer?*

In the social zone and position 2, the AV cab needs to move closer to the hailer and further negotiations need to take place. Here the hailer needs to see more feedback from the vehicle and the vehicle in turn needs to understand the context of the hailer – where the person is, in case the AV cab cannot safely stop close to them.

We can ask:

- *What sort of feedback from the AV cab confirms that it has seen and is reacting to the hailer?*
- *What is the context of the pickup?*
- *What's the position of the hailer on the road and can the AV cab stop there?*
- *Is there more than one hailer, and if so, how does the AV cab signal who it is picking up?*
- *When are they hailing the vehicle?*
- *What are the traffic and road conditions for the AV cab to take into consideration?*
- *How does the AV cab provide feedback to the hailer if it cannot stop where they are?*

In the personal zone and position 3, the AV cab needs to understand the person who is hailing, their needs, and react accordingly. There should be a provision for the hailer to ask questions of the machine or ask for help if needed.

The questions here are:

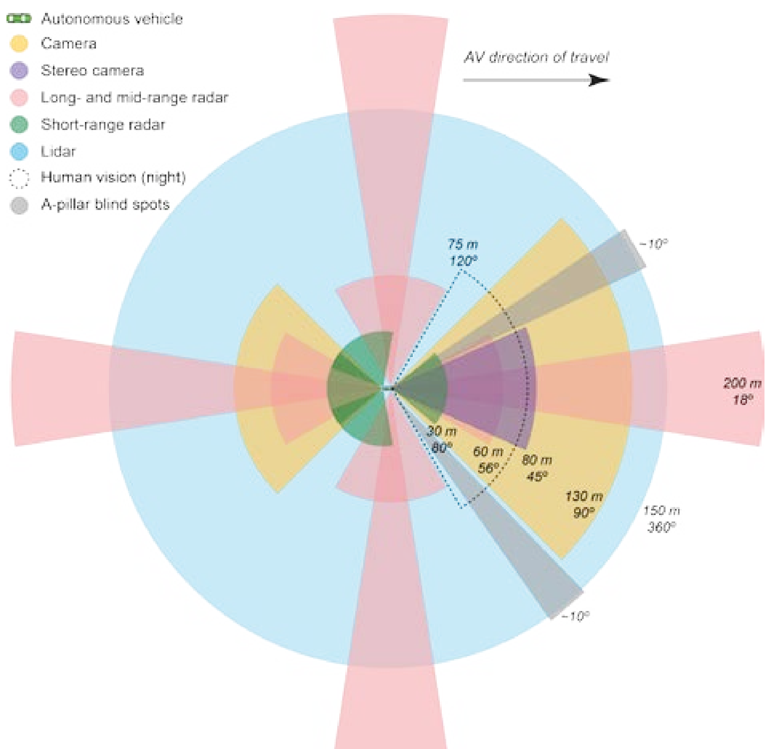
- *Who is the person hailing? What are their mobility needs?*
- *How can the AV cab assist or welcome the hailer, without the presence of a driver?* For example, by opening the doors.
- *Why is the hailer getting the taxi and what sort of feedback must be provided to them?*
- *Where is the hailer going?*

We will now proceed to figure out how to answer these questions. But before moving on, let's see if we can leverage some of the advantages that technology can provide over a human cab driver.

OPPORTUNITY – ADVANTAGES OF TECHNOLOGY

In the same way that human drivers have their advantages, robotic AVs might also have useful quirks in terms of sensorial recognition and personalisation that could be used in taxi services.

Our fictional AV cab will be a sensor-rich vessel, capable of making vast numbers of calculations and may possibly have a higher memory capacity than human drivers. A fantastic bit of research from the University of Michigan called Sensor Fusion[4] compares the reach of current human with AV sensors and is quite revealing:

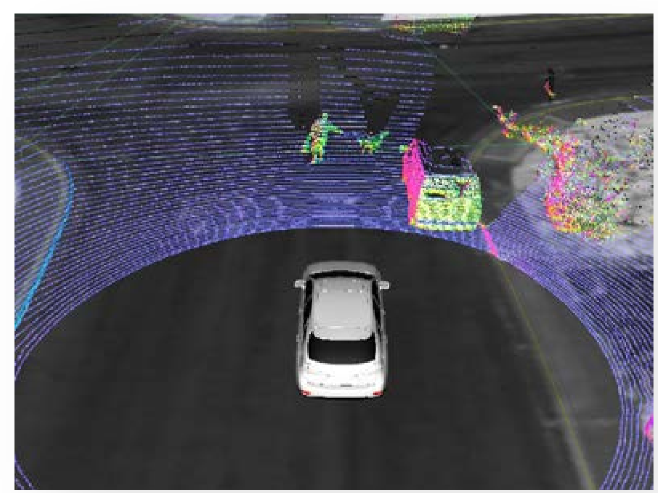


The research also compare the strengths and weaknesses of humans and machines, highlighting the decreasing cognitive function of fatigued or overloaded humans, when formal recall becomes impaired and short term memory is limited (see right).

However, despite the clear advantages of sensors, there are key tests in which AVs still do not perform adequately, due to their inherent disadvantages – their inbuilt limitations, fidelity, and inability to compute inferences via multiple sensorial data in real-time. Thus some traffic scenarios still pose a challenge for automated vehicles.

"You're probably safer in a self-driving car than with a 16-year-old, or a 90-year-old... But you're probably significantly safer with an alert, experienced, middle-aged driver than in a self-driving car."

Brandon Schoettle
Author of *Sensor Fusion*[5]



Brandon Schoettle
University of Michigan

Sensor fusion
Pedestrian, dog, and parked vehicle, as seen by LIDAR on a Google self-driving vehicle

Table 1
Summary of Fitts list of strengths and weaknesses across various aspects of function allocation between humans and machines/computers (adapted from Cummings, 2014; de Winter & Dodou, 2014).

Aspect	Human	Machine/computer
Speed	Relatively slow	Fast
Power output	Relatively weak, variable control	High power, smooth and accurate control
Consistency	Variable, fatigue plays a role, especially for highly repetitive and routine tasks	Highly consistent and repeatable, especially for tasks requiring constant vigilance
Information processing	Generally single channel	Multichannel, simultaneous operations
Memory	Best for recalling/understanding principles and strategies, with flexibility and creativity when needed, high long-term memory capacity	Best for precise, formal information recall, and for information requiring restricted access, high short-term memory capacity, ability to erase information after use
Reasoning	Inductive and handles ambiguity well, relatively easy to teach, slow but accurate results, with good error correction ability	Deductive and does *not* handle ambiguity well, potentially difficult or slow to program, fast and accurate results, with poor error correction ability
Sensing	Large, dynamic ranges for each sense, multifunction, able to apply judgement, especially to complex or ambiguous patterns	Superior at measuring or quantifying signals, poor pattern recognition (especially for complex and/or ambiguous patterns), able to detect stimuli beyond human sensing abilities (e.g., infrared)
Perception	Better at handling high variability or alternative interpretations,[3] vulnerable to effects of signal noise or clutter	Worse at handling high variability or alternative interpretations,[3] also vulnerable to effects of signal noise or clutter

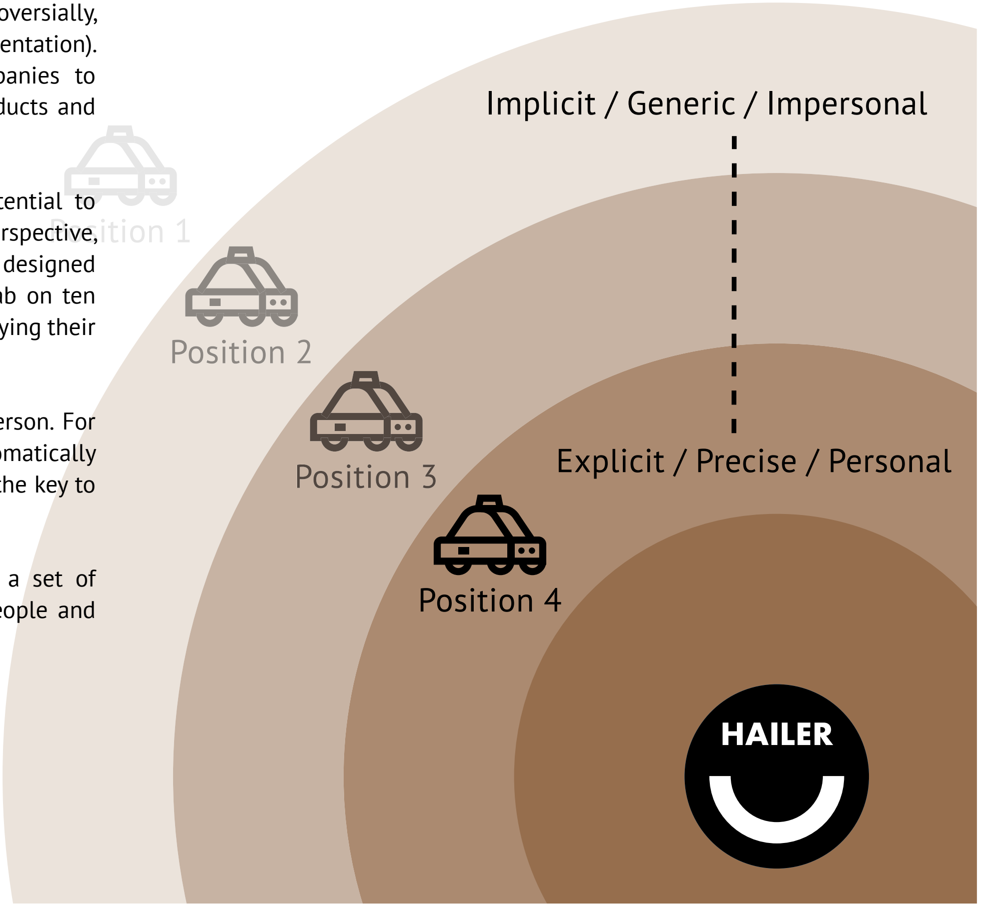
Brandon Schoettle
University of Michigan

Historically, human drivers are better at adapting to adverse situations, recognising faces, patterns, contexts and human emotion, but AVs are making great strides in that respect. An example put forward by MIT Technology Review[6] was that of facial recognition algorithms and cameras which are getting so incredibly powerful that companies in China are building systems which perform better than human beings. This has prompted their use to authorise payments[7] or catch trains (controversially, these systems also have the capabilities to detect IQ and sexual orientation). Companies like Face++[8] are providing "cognitive services" for companies to employ low-cost facial and body recognition systems within their products and environments. What fascinating and somewhat spooky times we live in.

So what does this mean for our AV cab, which might have the potential to exploit such technologies in the near future? From a service design perspective, personalisation through identification could be one such advantage, if designed well, without sacrificing privacy. For example, a person takes an AV cab on ten occasions, and on the eleventh time it is tailored to them, without identifying their name via any database.

Another advantage is repeatability of interactions for the identified person. For example, if the user is vision-impaired, the sliding doors could automatically open to welcome them – every time. This tireless consistency could be the key to building trust.

By considering these questions and opportunities we can draw out a set of concept interactions to be carried forward for testing - with actual people and actual contexts.



EARLY CONCEPT AND TESTING PROCEDURE

Going back to each of the zones, we can draw some hypotheses about how the AV cab should interact with the hailer, both on the first time they use the service and during further interactions.

Firstly let's look at the interactions and how they might change across the various zones. This gives us a mental model for playing with various media and communication techniques.

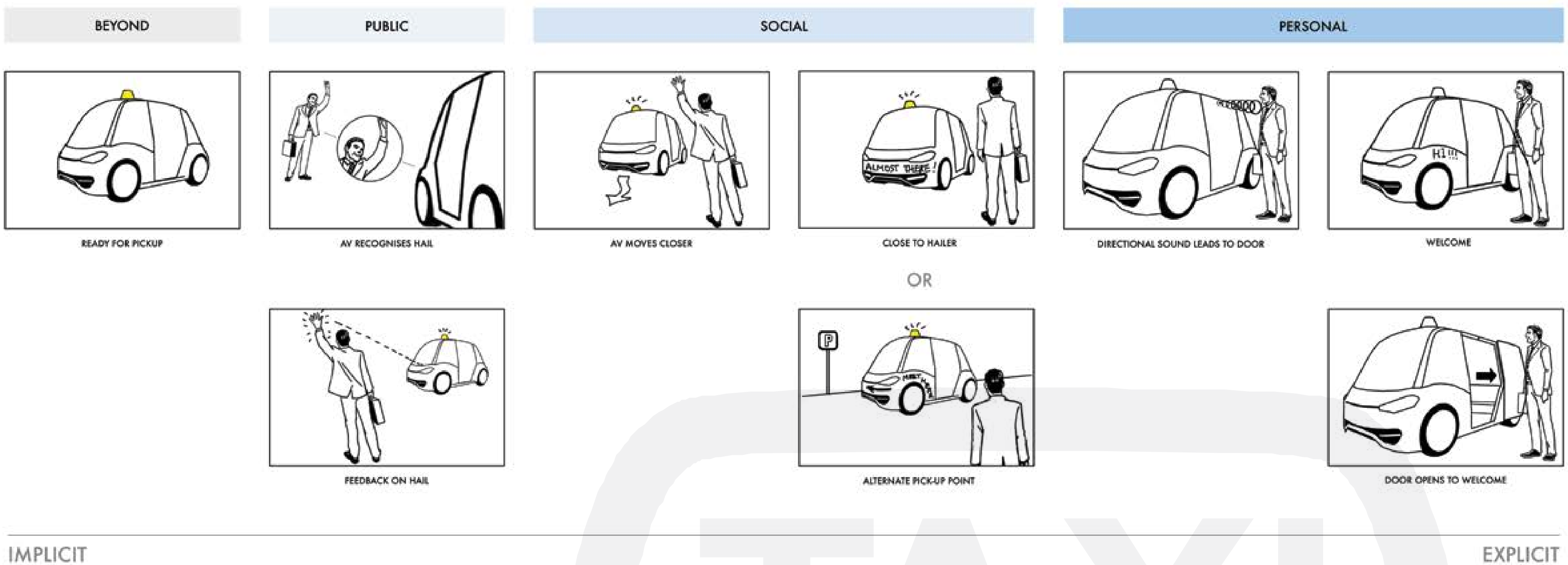
Implicit, generic and impersonal interactions in the public zone could enable communication from afar. For example, a simple change in direction or the AV cab slowing down on observing the hail gesture is an implicit interaction. You wouldn't want the cab to shout out your name from a distance, would you? It wouldn't be very discreet.

Explicit, precise and personal interactions in the personal zone enable closer communication. For example, welcoming the hailer with a few words or opening the doors for them is an explicit interaction. A personal gesture from close range.

Thinking about some of the questions and opportunities we talked about earlier, we can also make an interesting observation: there is a gradual shift of initiative in each zone. From the hailer calling to the AV cab, to the AV cab taking charge and welcoming the hailer as it gets closer – a human-to-robot handover of initiative,

It is also important to note that in order to make this as inclusive as possible, we should consider a range of interaction channels, from audio to visual.

Let's move on to detailed hypotheses for each zone. We have drawn out a storyboard of interactions from the first interaction with the AV cab up to entering the vehicle. Storyboarding scenarios helps us establish a preliminary narrative of how the actors talk to each other on a stage. Any hypothesis we might start off with is a "best case scenario" where all the interactions work perfectly. But these are subject to change and iteration during testing.


BEYOND
PUBLIC
SOCIAL
PERSONAL
READY FOR PICKUP
AV RECOGNISES HAIL
AV MOVES CLOSER
CLOSE TO HAILER
DIRECTIONAL SOUND LEADS TO DOOR
WELCOME
OR
FEEDBACK ON HAIL
ALTERNATE PICK-UP POINT
DOOR OPENS TO WELCOME
IMPLICIT
EXPLICIT

BEYOND THE PUBLIC ZONE

The AV cab displays visually that it is empty and ready for a pickup from afar, similar to present day cabs. The visual medium is similar to that of a lit sign atop the vehicle.

PUBLIC ZONE INTERACTIONS

The hailer gestures to an empty AV cab and is seen by it. The AV cab acknowledges the interaction via a visual mechanism (perhaps the sign itself flashes), and then proceeds to move towards the hailer just as a human driver would (an implicit interaction).

DESIGN PRINCIPLE APPLIED:
08. ACT HUMAN, BE ROBOT

Utilise both human and machine advantages by instilling the beneficial nuance of human behaviour while exploiting technological benefits ie quick response times of machines.

DESIGN PRINCIPLE APPLIED:
17. THE AV SHOULD TELL US WHAT IT'S GOING TO DO

While driving we communicate our intent by using indicators while turning or slowing down to let people cross. This should be the same for the AV so that people understand it.

SOCIAL ZONE INTERACTIONS

Further visual indications by the AV cab are required to confirm the acknowledgement of the gesture and then the AV cab moves into its correct position on the road (a mixture of explicit and implicit interactions).

The vehicle analyses the road and the hailer's position to figure out if it can get close. If it cannot, it needs to signal its intent to move to a place where it can pick up the hailer, perhaps via a screen or some other visual medium.

The hailer acknowledges the movement of the AV and notices where the AV moves to.

DESIGN PRINCIPLE APPLIED:
16. THE AV SHOULD TELL US IT UNDERSTANDS ITS SURROUNDINGS

It is important that people know what the AV see's and that it understands where it is for them to trust it. An AV can also communicate an approaching hazard to vehicles behind it.

DESIGN PRINCIPLE APPLIED:
18. THE AV SHOULD RESPOND WHEN INTERACTED WITH

Feedback mechanisms are needed for people to know that the AV has seen or heard them, ie when being hailed, an AV should acknowledge the human interaction and respond.

PERSONAL ZONE INTERACTIONS

As the hailer approaches the AV cab, it guides them to the door using directional sound which follows the hailer.

The AV cab analyses the hailer's situation – physical ability, number of bags, etc, and adjusts itself accordingly, by opening the boot (trunk), deploying ramps etc. The doors do not open automatically the first time of use, giving the hailer complete control for using the AV. A trust building technique for autonomy.

Or, since it is the second time the hailer is using the service, the AV cab knows what is required of it – for instance, the best seating position to suit the person and does open the door automatically.

The cab then opens the door to welcome the hailer into the vehicle, automatically if necessary.

The cab speaks to the hailer to ask for the destination.

DESIGN PRINCIPLE APPLIED:

21. THE AV SHOULD BE EMPATHETIC AND INCLUSIVE

People should feel independent and empowered around an AV irrespective of whether they have mobility issues or not. So affordances should be designed to enable people to feel respected and treated with discretion, ie the AV's floor base lowering itself to allow any person to enter without aid.

DESIGN PRINCIPLE APPLIED:

03. EMOTIONAL AND FUNCTIONAL NEEDS

There's more to a journey than simply the functional need to get from A to B. Any journey includes many human and emotional needs such as comfort and human interaction.

DESIGN PRINCIPLE APPLIED:

06. ESTABLISH AND MAINTAIN A HUMAN ROBOT RELATIONSHIP

If a stranger is rude to you, you won't want to interact with them again. The same applies to a robot. The AV must acknowledge and reciprocate human manners and behaviours. For example, when a person waves to thank an AV for letting them cross the road, the AV must display acknowledgement of the gesture back to the human.

This storyboard now forms the basis of our experiments and test procedure. Most of these interactions start from the assumption we made early on – that the hailer will not be using a smartphone or related device. The presence of such devices would definitely remove some constraints, but constraints can be beautiful and the application of constraints here will make the system we devise more egalitarian.

POSSIBLE NEXT STEPS - EXPERIMENT AND ITERATE

Since this is a thought experiment, we'd like to talk very briefly about the possible experiments and research ideas we can draw out from the storyboard. The essence of the experiment lies in changing the variables of the interaction and the nature of the experiment itself – whether it's real or virtual – while devising the tests.

Before we progress, we should note that we are only going to consider the user experience of the interactions and not worry too much about technological complexity. This is not a cop-out – we are doing this because we cannot predict the rate of technical progress. For instance, gesture recognition as it stands right now is at its infancy. People moving around, environmental conditions, the background colour occluding the colour of clothing or skin tone – there are numerous factors which need to be taken into consideration. The human eye and brain is able to do this with high fidelity, but machines are only just getting there. To employ gesture recognition in our scenario, the AV cab would have to recognise the hailing gesture from one of many that people might employ to hail a taxi, not to mention separate the gesture from all the noise in the background. So we will not let technological complexity completely distract us.

A. VARIABLE – FEEDBACK MECHANISMS AND CHANNELS

The channels the AV cab could use to communicate with the hailer might vary. Visual signals over longer ranges could be light signals or textual data. For instance, blinking headlights could acknowledge the hailer or words on the AV's external screens, if the vehicle is in the social zone.

Similarly, the AV can could shift reliance to audio channels as it moves into the personal zone, similar to that of a human driver interacting with the passenger (though not completely, in case the hailer is hearing-impaired). Advances in directional and projected sound might make communication to targeted persons in a group of people possible.

B. VARIABLE – IMPLICIT AND EXPLICIT INTERACTIONS

We have spoken about the range of interaction types, from implicit in the public zone to explicit in the personal zone. Varying the degree of implicitness as the AV cab approaches the hailer would be a big part of experimentation. For instance, starting with the language of physics – movement of the cab, via changes in direction and acceleration or deceleration – and ending with explicit interactions like that of opening the doors to welcome the hailer.

C. VARIABLE – PEOPLE WHO WOULD BE THE HAILERS

The recruitment of test subjects who would act as hailers would be critical in getting a range of inputs. Interaction strategies would vary based on qualitative testing with a spectrum of people – from the young to the old, from the sighted to the vision-impaired, to people with varying mobility difficulties. Qualitative experiments will provide early cues to the directions which are right for the scenario we construct. For instance, working with people with limited mobility, be they weighed down with bags or moving on crutches, will help us identify the best methods to welcome a hailer into the cab and help them settle in.

D. VARIABLE – RESEARCH CONDITIONS AND STYLE

Qualitative research conditions could vary from creating very believable environments to using virtual reality techniques for testing with actual people.

Believable field environments could be very much like the Ghost Driver[9] set of experiments conducted by Wendy Ju's team at Stanford, which featured a hidden driver to simulate an autonomous vehicle in experiments with pedestrians and cyclists.

Their tests were conducted using the "Wizard of Oz"[10] framework which is a user experience and dramatics technique which immerses the testers in the environment and makes them believe in the actuality of the interactions they are having with a makebelieve AV. (Ghost Driver is an extremely worthwhile read into people-centred research techniques.)

We could make virtual environments to create similar settings for AV and pedestrian interactions. While a lot more intrusive in terms of testing, they do provide for a lot more control of test conditions and environments for the researcher.

The next step is to actually take this thought experiment into implementation, which is a good segue into the next scenario. Here we will use virtual reality (VR) techniques for testing AV interactions in a rather interesting manner.

Stanford Autonomous Car

Teague VR[11]
Teague's experiments with virtual reality are a good example of this method.

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nuvint
(new generation interior
nuv+int = nuvint)
by Pawan Pagaria
Year: 2030

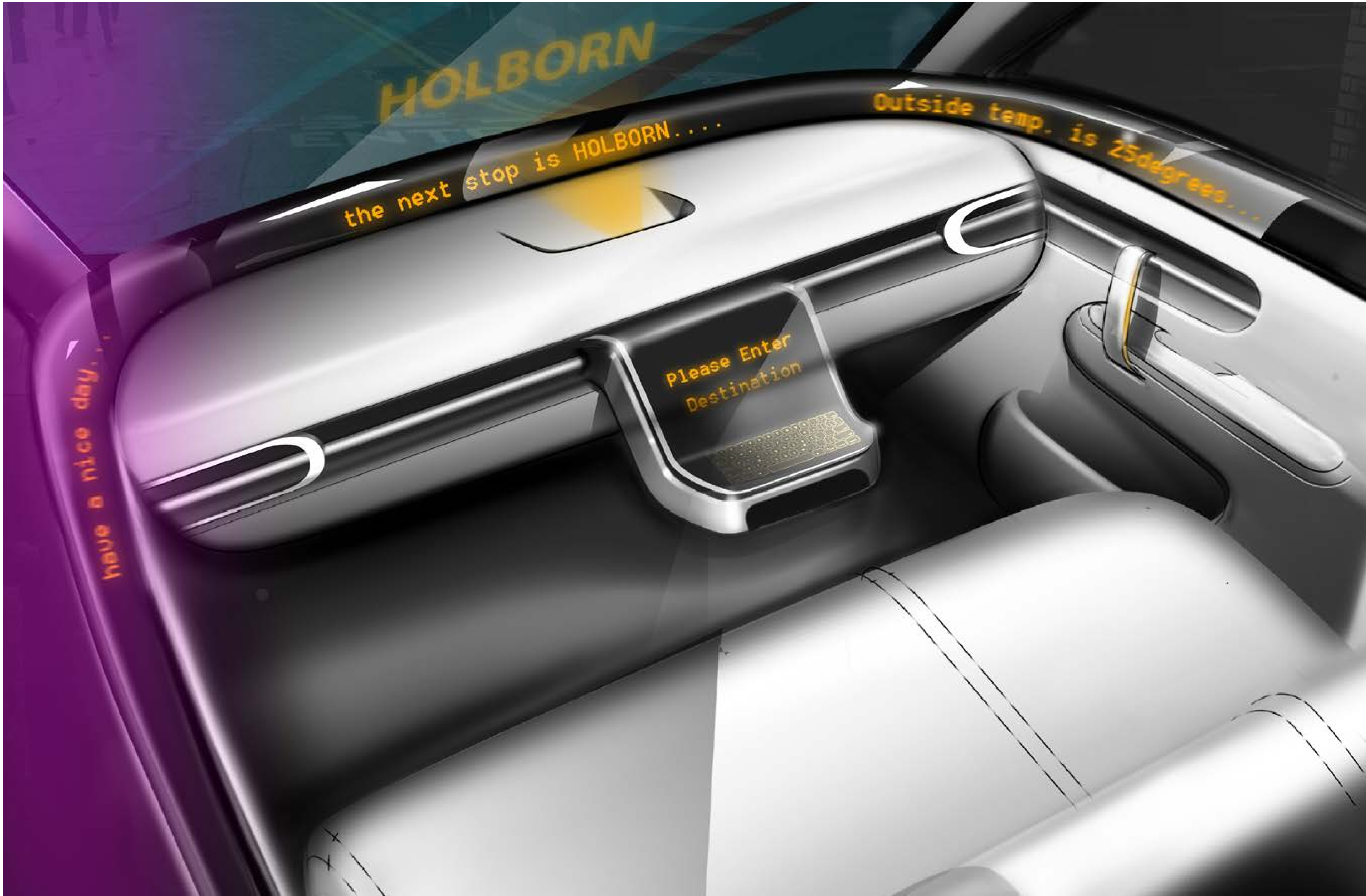
"My idea for autonomous car interiors is - CLEAN - COMMUNICABLE-CLUTTER-FREE.

By clean, I mean a clean and simple form of instrument panel which will go aptly with the prevalent technology at that time. No unnecessary ornamentation and distractions, just seamless integration of technology with the interiors of the car.

The wraparound form of the running display which continues on both the doors makes the interior space communicable and easy to interact with during driving.

A single input unit at the center with just touch screen, sleek audio interface on the roof and no mechanical buttons helps in complimenting it with the overall interior theme and makes it clutter-free at the same time. The simple sliding mechanism on the backrest of the seat helps in creating an interactive environment and makes the ride a joyful one.

Just sit in the next gen car with the intelligent 'nuvint', feed you destination & relax."


HOLBORN
the next stop is HOLBORN....
Outside temp. is 25degrees...
have a nice day...
Please Enter
Destination

DESIGN CHALLENGE 2:
SILENCE IS DEADLY

Topic: Designing For Silent AVs

26 minute read



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PROJECT
EXPERIMENT

SUMMARY

With so many unanswered questions hanging in the balance, testing AV hypotheses and concepts can seem like a guessing game. Virtual Reality, and other virtual solutions, help overcome this uncertainty and are a key way to progress from thought experiments to more tangible tests.

We took this very approach when it came to examining the engineered sounds that AVs should make. Competing considerations such as safety, branding and noise pollution are all vying to define the soundscape of the autonomous future. In this section, we examine these factors, outline a methodical approach and explain why when it comes to our roads, silence is deadly.

INTRODUCTION

The advent of the electric vehicle (EV) has brought with it myriad benefits to the consumers that drive them, the cities that host them, and the environment at large. The same is the case with streets of London, with the looming promise of a zero-emission zone in the central regions, the 2040 ban on petrol and diesel vehicles in the UK and Europe[1], and the commitment of OEMs (eg Volvo[2]) and services (eg Uber[3]) to move towards an electric future.

However, pedestrians and cyclists cohabiting with these vehicles seem to be caught in the crossroads, as the lack of the roar of the internal combustion engine (ICE) and accompanying exhaust (tail) pipe, has proven to be an ever-growing risk. As EVs become AVs in the near future, and as AVs proliferate, this presents an ever-increasing problem. This is something that has been in the eye of policy makers, specifically the European commission[4] and the NHTSA[5].

As with many challenges, a problem can be turned into an opportunity. By using increasingly available data from sensors, as well as shifting the focus on to pedestrians' and cyclists' needs, we can explore different auditory concepts to communicate risk, with the goal of creating a safer relationship between them and the cars of the future, while also facilitating that dual benefit of reduced city sound pollution. A further opportunity arises by which OEMs can "own" a whole new and distinct soundscape for their brand, differentiating themselves from the rest, many of whom are simply mimicking the roar of the engine.

Follow us as we tackle this Vehicle-to-Pedestrian (V2P) challenge in the following pages in the same way we do on real-life projects with our automotive clients, often partnering with other experts to help us form rounded opinions with more appropriate prototypes and solutions.

UNDERSTANDING THE PROBLEM

Before we start any project, using the human-centred design approach, it is important that we first understand the human problem. Why should a person care about the exterior sounds a vehicle makes?

EVs lack discernable sound when they're operating at low speeds. Although this might be a positive aspect for many (in the form of less noise pollution), it has become an increasingly dangerous factor for cyclists and pedestrians – especially the vision-impaired. A 2011 study[6] by NHTSA showed that hybrid and electric vehicles are 37% more likely to cause accidents involving pedestrians, and 57% more likely to cause accidents involving cyclists. This leaves us with the problem we face today – pedestrians and cyclists having an increasingly difficult time knowing when EVs are near, resulting in an inability to recognise and avoid dangerous situations. Further to that, even newer ICE-powered cars are incredibly quiet, sometimes as quiet as EVs at lower speeds. Projecting into the future, engines and powertrains alike, all vehicles could be dangerously quiet one day.

In order to address this issue, several countries have passed regulations and guidelines which mandate that all EVs must emit some form of sound when driving at slower speeds. In the US, NHTSA recently passed a rule that brings the same sound requirements to "all hybrid and electric light vehicles with four wheels… traveling in reverse or forward at speeds up to 30 kilometers per hour (about 19 miles per hour)", because, as they put it "at higher speeds, the sound alert is not required because other factors, such as tire and wind noise, provide adequate audible warning to pedestrians." We argue that this should apply to all vehicles, not just EVs but ICEs too.

At ustwo we're driven by constant exploration and experimentation to address current issues that have a meaningful impact on people's lives. Our user-centred, research-backed focus, as well as our deep passion to build, test, and validate our ideas, serves as a great platform to explore a different approach for the future of external vehicular sounds.

So, to start that user-centred, research-backed approach, let's begin with some research into the current landscape of EV sounds.

THE CURRENT SOUNDSCAPE

Trucks and public service vehicles (PSVs), with their verbal reversing sound warning, or ambulances with their sirens, have used bespoke sounds to warn of their proximity for decades. These are effective for their own needs, but less so for commercial vehicles. Auto OEMs have been working on this problem since the late 2000s, just prior to the first commercial wave of EVs when concerns of pedestrian safety were starting to bubble up. One of the first examples was the Nissan Leaf's Vehicle Sounds for Pedestrians[7] (VSP) system. This model came with two distinct sounds: an "electric motor" type of sound for when the car is accelerating forwards, and an "intermittent" beeping-type sound for reversing. All a bit sci-fi for our liking.

Since then, car manufacturers like Renault and Fisker Automotive (now Karma Automotive[8]) have taken a different approach by replicating the sound of the ICE, in a skeuomorphic fashion. We spoke about skeuomorphism and how it's "not all bad"[9] in our first book. Using this approach as a starting point, OEMs are now "designing" these emitted sounds to be a representation of their brand, which you we can see Audi doing in their video online[10]:

Audi R8 e-tron sound creation

ICEs have been used to power vehicles for more than a century. This has resulted in car-related engine noises becoming deeply ingrained in modern culture and people's everyday lives, and serves as the primary benefit of keeping them for future vehicles – they're already familiar to pedestrians, a benefit we touch on in our design principles. With engine sounds there's nothing new to learn; the approaching, ever-increasing sound of an engine, the Doppler effect that communicates that a vehicle is getting closer to our location. This has become the clearest representation of danger we can get from a moving vehicle, and one of the primary ways pedestrians gauge their level of safety in relation to it. Currently, OEMs are using this well-established convention as one of the reasons to carry over ICE sounds to modern fully-electric vehicles.

When it comes to alerting pedestrians about vehicle-centric danger, another common sound source is the horn. Horn sounds usually serve as a clear, straightforward method to communicate potential danger to unsuspecting pedestrians nearby. As with engine sounds, they're also a familiar staple in modern city soundscapes.

Although engine and horn noises are the most common safety clues, we start running into issues if we want to convey a deeper understanding of the level of risk to a specific pedestrian or cyclist. Engine noises help us, at best, to make guestimations on where the car is in relation to us and how fast the car is moving, while a horn has both a lack of clear message (do I get out of the way or do I stop moving?) and a clear recipient (are you honking at me or someone else?). These sounds are somewhat dumb and impersonal, simply broadcasting that the car has arrived to anyone and everyone.

The truth is, both methods could greatly benefit from the additional data that cars are already starting to gather[11] (such as pedestrian and vehicle recognition, projected paths and road conditions) as a result of the auto industry's focus on autonomous driving in order to enhance pedestrian safety. An additional consideration is the large amounts of noise pollution caused by the myriad cars driving in and around cities.

Finally, we come to the ever-increasing reality that ICEs are slowly becoming dated technology. Is replicating the sounds of the past the right way to go, or should we be innovating? One of our team members put it like this:

"MIMICKING THE COMBUSTION ENGINE SOUND FOR ELECTRIC VEHICLES IS LIKE ADDING A HORSE'S NEIGH TO THE FIRST CARS EVER MADE!"

Kevin, ustwo VR Lead

Although a bit hyperbolic, this statement contains some interesting points. Engine sounds are a result of the internal mechanics of combustion engines, originally a mere byproduct (but now carefully crafted). If current vehicles (and the vehicles of the future) are to be powered by clean energy and ditch combustion engines altogether, should we be using a legacy sound as the ideal solution to this problem? How long can that metaphor last? Already we are seeing the universal hand gesture for "take a photo" change from button-on-top-of-camera action to tap-on-screen action as the technology has morphed from camera to smartphone. Interestingly, the shutter sound of the legacy technology as feedback remains.

At ustwo, we believe that this technological juncture, where EVs and AVs are increasingly gaining ground, is the perfect opportunity to challenge these norms and look at this problem from a new perspective.

FORMING A HYPOTHESIS

Any new concepts or ideas for vehicle-related sounds will both draw insights from, and impact automotive branding, city soundscapes, sound pollution and therefore the wellbeing of residents, as discovered in our research. Adding (or removing) any sound to an urban soundscape has the potential to impact cities in both positive and negative ways and can have real consequences to people's health[12]. Modifying an established soundscape[13] should aim to reduce noise pollution, support human health, and create better cities for its inhabitants.

As part of our research, we spoke to Myounghoon "Philart" Jeon[14], professor at the Department of Cognitive and Learning Sciences and Department of Computer Science at Michigan Tech University. We met Philart at the Auto UI conference in Ann Arbor in November 2016 where he was presenting his paper on in-car sound design. Philart shared his belief that safety has priority over the brand when designing external vehicle sounds. Moreover, he proposed that there is an opportunity for these sounds to "provide some information on what the car is doing." It's hard not to agree with either of these sentiments.

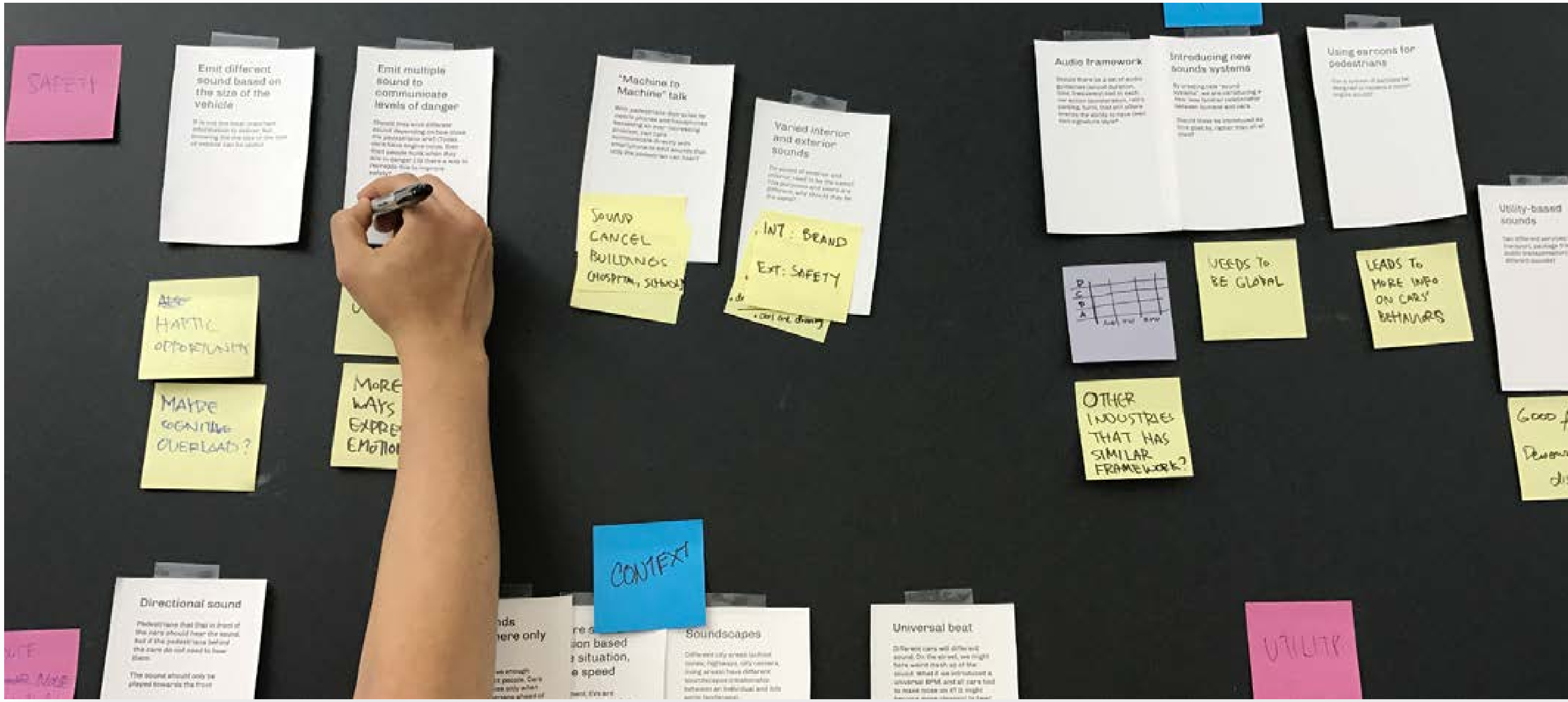
"WHEN WE DESIGN (AUTOMOTIVE) SOUND, WE NEED TO BALANCE BETWEEN TRADITIONAL SAFETY AND USABILITY VS AESTHETICS AND BRAND LANGUAGE. FOR THIS CASE SPECIFICALLY, SAFETY MAY HAVE PRIORITY OVER THE OTHER ASPECTS, BECAUSE VEHICLE VS HUMAN IS A REALLY CRITICAL POINT."

Professor Myounghoon Jeon, Michigan Technological University

We also spoke with Paul Jennings[15], professor at Warwick Manufacturing Group (WMG) at the University of Warwick, who has been engineering sounds for OEMs like Jaguar Land Rover for decades. Speaking on the impact of engine-like sounds on city soundscapes, Paul highlights the opportunity to reduce noise pollution as an important one to consider:

"WHEN YOU THINK ABOUT IT FROM A SOUNDSCAPE PERSPECTIVE, IT WOULD MEAN THAT THE FUTURE SOUNDSCAPE WOULD BE IDENTICAL TO THE CURRENT ONE. THAT SEEMS TO BE A BIG DISAPPOINTMENT, BECAUSE THE CHANCE TO REDUCE THE ADVERSE EFFECT OF TRAFFIC NOISE SEEMS TO BE A GREAT ONE."

Professor Paul Jennings, Warwick Manufacturing Group



Using what we have learned during our initial research, we can priorities the three key aspects we identified to be important in the design of exterior sound for AVs. In order of importance:

1. **Safety of pedestrians:** cyclists and drivers: safety is the fundamental aspect external vehicle sounds should focus on.

2. **Minimising sound pollution:** with the advent of AVs, we believe we are at a crossroads where we can shape future city soundscapes to become more pleasant. Considering how noise pollution impacts human health, we believe this is an important aspect to consider.

3. **Brand expression:** an exciting opportunity to use sound design as an important way for car manufacturers to create stronger and more exciting relationships with their customers, beyond mimicking an ICE.

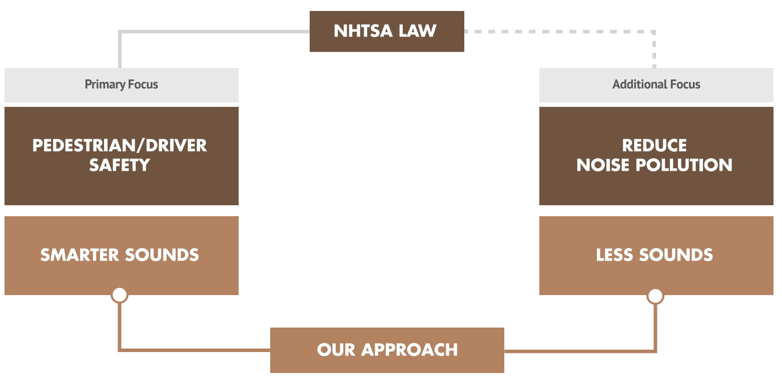
This order somewhat contradicts what many brands are attempting with their ICE clones, tinkering with the mock engine sound so that it's on-brand, perhaps over-focusing on this third element.

As we start to dive deeper, gathering more knowledge, dozens of exciting opportunities and thoughts come to mind. Following ustwo's mantra of getting our hands dirty as soon as we can, this is where we spring into life and start doing what we do best – design! Quick and dirty "design studio" sketch sessions form initial concepts that serve as a starting point to identify interesting possibilities, while we continue to develop, strengthen or disregard them via discussion, additional research, and iterative work.

THE CONCEPT

After discussing, analysing and mentally stress-testing all of our ideas, we can begin to see themes emerging. These themes help us to simplify and focus our design thinking and the ideas we want to pursue. This exercise leads us to the following breakdown:

OUR INTERPRETATION



We believe that the best approach to increase pedestrian safety is by using smarter sounds – sounds that communicate more and/or carry more meaning – while the best approach to reduce noise pollution is by using fewer sounds or less volume, for example, a vehicle emitting sounds only when and to whom it really needs to.

"Don't try to tailor your signal to the urgency of a situation, because that only works when there's one car and one person... When you have a complex situation, the best thing a vehicle can do is say here I am and here is what I'm doing."

Don Norman

In a complex situation, we tend to agree with Don Norman. However, we are trying to tailor the signal, for simple situations, contrary to Norman's advice. Although, with increasing sophistication of technology, we believe we are actually heeding his advice, we just think the system can handle a little more than one car and one person.

Our hypothesis then is...

We believe that an external audio system that is contextually aware – emitting the right sounds only when and to whom is necessary – could be a better solution to increase pedestrian safety while decreasing noise pollution.

As Paul Jennings put it, risk to a pedestrian is an important piece of information, so our concept should work towards effectively communicating the level of risk to the right person at the right time (or the vehicle's intention to many in complex situations). To do this, we can map out our assumptions on how pedestrians perceive danger, their surroundings, and what information they need to receive from a vehicle to have a strong sense of their level of safety or risk of danger. We can also include our ideas on what cars should communicate to people around them in order to support these needs. From this exercise we can map out what we are calling a "risk zones matrix" which maps out pedestrian needs (a single pedestrian to begin with), the vehicle's supporting actions, and any potential sound opportunities.

PEDESTRIAN-VEHICLE PROXEMICS

	ZONE 3	ZONE 2	ZONE 1	ZONE 0
PEDESTRIAN NEEDS	-	• Peripheral awareness of approaching vehicle	• If there is no risk, they do not want to be distracted • If there is some risk, they want to be informed • If there is high risk, they want to be alerted	-
VEHICLE ACTIONS	• Detects pedestrian	• Detects pedestrian type + attributes • Calculates "risk value"	• Ongoing calculation of "risk value"	-
SOUND OPPORTUNITY	-	• Communicate its presence • Communicate risk level	• Communicate its presence • Communicate risk level • Communicate action pedestrian should take	• Remove if no other risk is detected

1 PEDESTRIAN ENTERS VEHICLE'S FIELD OF VISION	2 VEHICLE SENSORS GATHER RISK FACTORS	3 SYSTEM CALCULATES RISK VALUE	4 SYSTEM EMITS AUDIO SIGNALS
The vehicle detects a nearby pedestrian and gets ready to calculate potential risk	Risk factors include: • Vehicle's actions • Vehicle's speed • Vehicle's projected path • Pedestrian quantity • Pedestrian's proximity • Pedestrian's projected path • Environmental conditions • Location • Setting	After gathering potential risk factors, the system outputs a risk value in the form of a number between 0-100. This number is then placed in the "risk zones" scale. Example: calculated risk factor is 65 out of 100	Finally, the system acts according to the sound rules within the zone the number was placed in Example: 65 falls into the "High Risk" Zone. The system then follows the rules within that zone

We love making these charts at ustwo: it helps us visualise intangible concepts. This zoning, also known as proxemics[16], allows us to understand pedestrian needs in relation to their proximity and awareness of an oncoming vehicle. The zones, from furthest to nearest, consist of:

Zone 3: The vehicle detects the pedestrian in the distance, but knows that there's no immediate danger. The pedestrian may not be aware of the vehicle.

Zone 2: The pedestrian wants to know that the vehicle is approaching, and expects a vehicle to communicate its presence. The vehicle should start using all available data to understand its surroundings and the pedestrian in order to make a more informed decision when it needs to.

Zone 1: The pedestrian wants to know if the vehicle poses any immediate danger and, if it does, it expects the vehicle to communicate the level of risk their position and trajectory puts them in.

Zone 0: The vehicle has passed and is no longer interacting with the pedestrian. All sounds stop.

In order for this system to work, vehicles will have to rely on as much contextual information as they can gather from sensors and cameras. Using vision and sensory systems already deployed in AVs will allow a context-aware external sound system to gather the information it needs to calculate, create, and emit a sound that best communicates the level of risk a pedestrian is in.

This diagram shows how the system detects level of risk and how it reacts to that risk level.

In short, the vehicle is able detect the level of threat it poses to a pedestrian or cyclist, using its myriad onboard sensors – factoring in many conditions such as proximity, speed, projected path etc – and in turn can emit the most appropriate sound, communicating to the pedestrian or cyclist the correct level of danger or urgency and therefore enabling them to act accordingly, potentially saving themselves from harm. The system only need do this when necessary, reducing its contribution to sound pollution.

With the concept established, some detailed design can begin. What should these sounds be if they're not mimicking the ICE? We know that understanding the role of sound is very important for the best V2P design, but we are not experienced sound designers ourselves. Here we can lean on the support of one of our partners, New York-based Man Made Music[17] (MMM), a strategic music and sound studio – experts in scoring experiences. With MMM we derived four sound concepts, each designed to convey these different levels of risk to the pedestrian by which to test with.

Binary sounds: Communicates risk in a binary manner. There is either no risk or high risk. This concept can be used to compare against more complex concepts so we can learn if there is value in communicating different levels of risk or not.

Staircase up sounds: Communicates the level of risk in four distinctive levels (low, mid, high, imminent) by altering different characteristics of the same sound source (ie tone or volume).

Smooth up sounds: Communicates levels of risk in an incremental manner. Change of the sound intensity is gradual as risk rises.

Traffic light sounds: Communicates levels of risk by using completely different sounds for each level of risk. A good visual representation of this would be the traffic lights, which use a different colour to communicate different things.

Along with MMM we can carefully design and craft these four sound concepts to use in our prototyping and testing phase. You can listen to our concept sounds on the ustwo Soundcloud page[18].

With the hypothesis set and the sound concepts designed, we now need to learn if pedestrians and cyclists are able gauge different levels of risks through vehicle-emitted sounds. In other words – does our concept work?

PROTOTYPING WITH VIRTUAL REALITY TO GATHER INSIGHTS

After discussing, analysing and mentally stress-testing all of our ideas, we can Prototyping with virtual reality to gather insights

As product designers and developers, we are able to make educated guesses on how humans will feel and act when using our products. But we never really know how people will react until the moment you put something in front of them. This is especially true with new and undefined Human Machine Interfaces (HMI). Because of this, we highly value building prototypes to test our ideas and assumptions.

Ultimately what we want to test with our prototype in this is case is:

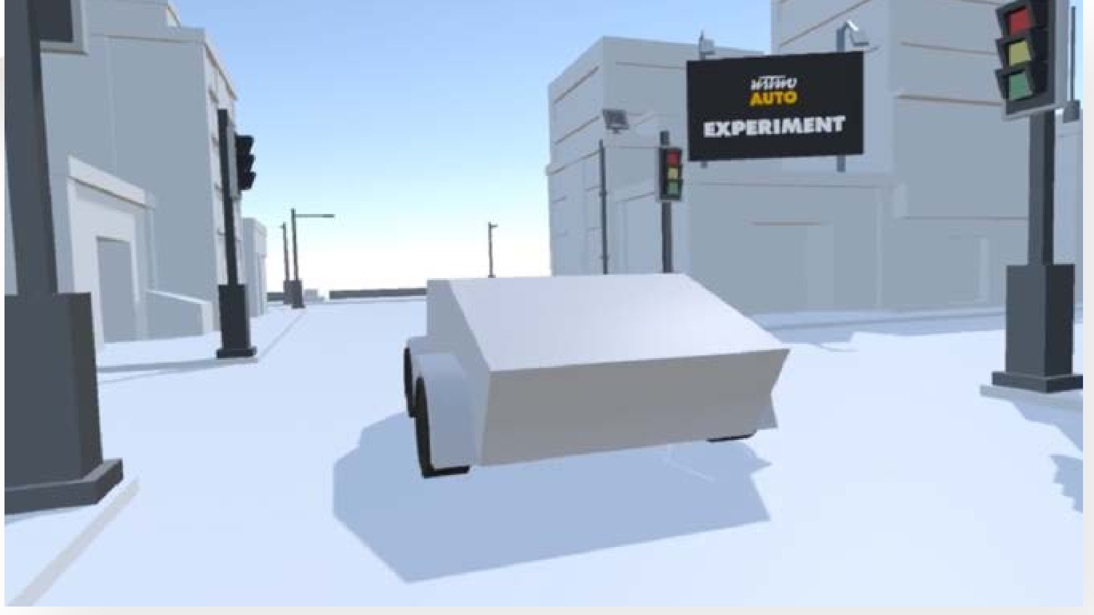
Will pedestrians be and feel safer if vehicles communicated the levels of risk through sound, using our concept?

Before we build our prototype, we will need to establish a real-life scenario in order to test our idea. It's usually a good idea to start with the simplest of scenarios, in this case: a car driving past a pedestrian while emitting different types of sounds in order to compare, like a form of A/B testing usually used for testing the performance of websites. This scenario would serve as the basis of our tests and a way to learn first-hand about our ideas and assumptions.

But how do we do this safely? We would prefer, if at all possible, not to kill anyone when we test things. We could simply install speakers on the exterior of a rented car – the closest thing to reality, but time-consuming, inflexible, and unsafe, the latter of which of course is what we are trying to improve. No, that won't work.

How about VR? Virtual reality is a cost-effective prototyping tool, not to mention time and even life-saving (certainly in test environments like this one). This is one of the reasons we have a dedicated VR team on hand at ustwo to support us with projects like this one (among many other weird and wonderful applications[19]). VR technology enables us to create simulations of the future. Before VR, these future visions could only be explored in the form of conceptual sketches or costly physical prototypes, but now we can actually experience them through virtual reality.

By creating a controlled VR environment, we are able to test safely, and easily and quickly iterate, document and reproduce our tests, all from the comfort of our studio. Now we can recreate a city scene, complete with roads, buildings, traffic lights, cars and even the city soundscape and place the user right in the thick of it, just like they were in a real city environment (well, almost).



Our VR test environment

TESTING AND INSIGHTS

Now it's time to have our users enter into our VR prototype[20] to see how they feel about our concept and how well (or not) it answers that initial question:

Will pedestrians be and feel safer if vehicles communicated the levels of risk through sound, using our concept?

First, our participants should get familiar with their surroundings by having a little look around to feel immersed in the world. Once comfortable, the tests can begin. Following the scenario we defined earlier, the virtual vehicle drives past the participants, within the VR environment, while emitting the sound concepts we created with MMM. The car drives past four times, emitting each of our four sound concepts with every pass.

Afterwards, we can gather qualitative data by asking each of our testers to describe the sound they heard, and compare it specifically to their risk assessment. The results of these tests are incredibly insightful. While we do not yet have a concrete indication of which concept was the best, we did gather four key insights that help to point us in the right direction:

1. Sudden sound change communicates risk. A sharp contrast between sounds seemingly signifies a change in the amount of risk more clearly than sounds with a gradual intensity build. Working with MMM helps us consider the psychology of sound and the behavioural concept that perception is based on the detection of change. In humans, the brain filters out any unchanging stimuli, favouring new sounds, so to signify increasing risk, a change in sound should be heard. Perhaps then the "traffic light sound" concept is the most effective in communicating risk.

2. Intensity alone does not signify risk. With a gradual build of intensity through volume, speed of notes, pitch, etc, the respondents felt there was a greater change in proximity or speed, rather than risk. While that's important to know, an increase in the intensity of the sound doesn't alone signify risk, which was the purpose of the test.

3. Musical or melodic sound may become a distraction. When it came to musical tones, supporting an earlier fanciful idea we had in which vehicles could contribute to a city symphony (or maybe cacophony), respondents claimed that their sense of risk was lowered, due to the tones feeling instrumental, as if from a song.

4. People perceive risk differently. Although participants heard the same sound, their perception of the risk varied slightly, perhaps informed by past experiences or culture.

As always with experiments we do at ustwo, our teams like to share and contribute to the communities we're a part of, and our experience with creating sound concepts for electric vehicles is no exception. As long as you have a HTC Vive set up, you can use our VR app to quickly test some sounds being emitted from a moving vehicles. This should be a great tool for sound designers working on external vehicle sound.

You can download ustwo's External Vehicle Sound Experiment VR App for HTC VIVE[21] and read more about this experiment on the ustwo blog[22].

AV APPLICATIONS OF OUR CONCEPT

"SAFETY, SOUNDSCAPES AND BRAND ARE THE COMPETING ISSUES FOR THE EVALUATION OF EXTERIOR SOUNDS OF ELECTRIC VEHICLES."

Professor Paul Jennings, Warwick Manufacturing Group

Historically, the engine sound of a vehicle has been part of the brand expression. All brands strive to create an emotional and personal bond with their customers. The engine's sound, for the most part, has been designed for the benefit of car's owner. For some car owners, the sound of the engine may have been a key factor in purchasing the vehicle. However, as we move into an era of AV sharing, more and more cars might be perceived as utilitarian devices for mobility rather than something that the driver-come-passenger "wears". The question then is, who will OEMs be expressing their brand to, through external sound? The answer might be with the people outside of the car, rather than those who are in it.

We think these people care more about safety, functionality and a pleasant soundscape without noise pollution. Perhaps being quiet is the loudest way to express the brand. Think Apple's colourless white against the black and bright colours of the consumer electronics space for the sound space. This might be the time for OEMs to rethink the purpose of the external sound in general.

How can we apply these concepts and the insights to an actual AV? What applications can our design thinking have on production vehicles or live services? Remembering the NHTSA guidance, and our own applying to all vehicles, rather than just EVs, anything travelling under 19mph should emit an audible sound for the safety of surrounding pedestrians and cyclists:

"At higher speeds, the sound alert is not required because other factors, such as tire and wind noise, provide adequate audible warning to pedestrians."

Above 19mph, the communication is in implicit in the physics of the vehicle – sound is made by the physical aerodynamics and that is fundamentally understood by humans, just like how the very physics of the ICE emits the sound. This is something we often like to rely on and so we can apply one of our design principles here...

DESIGN PRINCIPLE APPLIED:
19. UTILISE THE LANGUAGE OF PHYSICS

The laws of physics communicate an awful lot to us – in a language that we need not learn. For example, a moving object leaning right implies that that object will turn right.

So how about that sub-19mph range? How can we apply the same design principle here, given this aerodynamic sound is missing? Well, what sounds are physically there? Wheels on the road. Could we amplify the physical sound of wheels against the road surface to the correct audible decibel to match the audibility of post 19mph sounds? A tarmac road would sound smooth, while a gravel road would flick stones and a wet road would have that "whoosh" effect – the sound of which would correlate with the speed, using a wheel encoder (wheel-mounted sensors used in the likes of the Google driverless car to measure velocity). This then could be applied to the brand or type of vehicle. For example, the tyres of a high performance sports car, with its strong grip, sound different against a road than a heavy goods vehicle. This sound could either be amplified in real-time from a decibel level perspective or contextually triggered from a library of appropriate sounds. The vehicle could even detect the environment's soundscape and place their sounds at some decibels or pitches that cut through the noise.

If we take a look at today's pedestrians, many of whom are transfixed by their smartphones or personal devices – the distraction of which is already causing an increase in V2P-related injuries[23] – and extrapolate that trend into a somewhat dystopian future, we could imagine that everyone will be staring at their smartphone rather than looking where they are going. We could even posit that an increased number of these people will be listening to music or making a call through headphones and so may not even be able to hear these vehicles at all. This is where understanding the context is as important as understanding the people within it. Our suggestion? Since these people are either already looking at their phones, or listening to their phones, or on their phones, why don't we send the risk communication directly to their phones or personal devices? An OS-level feature, open for certain secure signals from the city and its infrastructure – including AVs – could play these sounds through the headphones or speaker of the personal device, while a visual warning on the display and a haptic vibration could also warn pedestrians of oncoming danger.

DESIGN PRINCIPLE APPLIED:

07. DEGRADE GRACEFULLY FOR THE SENSES

There should always be reasonable fallbacks for interactions, without overtly relying on any one interaction channel. For example, audio interactions for vision-impaired people should have visual counterparts to balance them for people who cannot hear or understand auditory information.

By using a multitude of interaction channels, we cater for the majority of people, from blind and hearing-impaired people to the unobservant displaying inattentional blindness. Of course, this has the potential to get very annoying very quickly, so a smart and appropriate system will need to ensure that these alerts interject in the pedestrians lives only when necessary. We're sure people would rather be alive than finish listening to that song.

When it comes to AVs, one might question the need for these sounds. The autonomous car will surely be so safe that the human need not get out of its way or even be aware of its presence. We believe this is the wrong way to look at it for two core reasons:

1. Respect the fast metal box: these vehicles, fast and heavy, though smart, pose potential danger, and should be respected as such. A trusting, yet respectful relationship must grow between humans and autonomous vehicles.

DESIGN PRINCIPLE APPLIED:

20. THE AV SHOULD BE INDEPENDENT AND NOT SUBMISSIVE

The AV needs to show that it understands the rules of the road and that it is a machine that is to be treated carefully and with respect. It should not be submissive to other actors of the road so that it is not bullied or tested or cause danger.

2. Situational awareness: as humans, we will always want to be aware of our surroundings at all times – our fear of the dark comes from our not knowing what is surrounding us[24], what situation we are in. A part of our evolution is to know where we sit within a situation, known as situational awareness.

Of course, the surface has only just been scratched. More ideas, research opportunities, tests, and iterations are needed. As we look toward the future, and what could come next, we could develop our experiment further to help us understand the broader picture. How do these concepts actually influence the reaction time? How will the car handle more complex scenarios? What if the external sound was verbal? How do these concepts work across multiple cities and cultures?

As with many of the projects at ustwo, initial experiments, and the insights gained, form the foundation of a mature, human centred product, ensuring its successful adoption.

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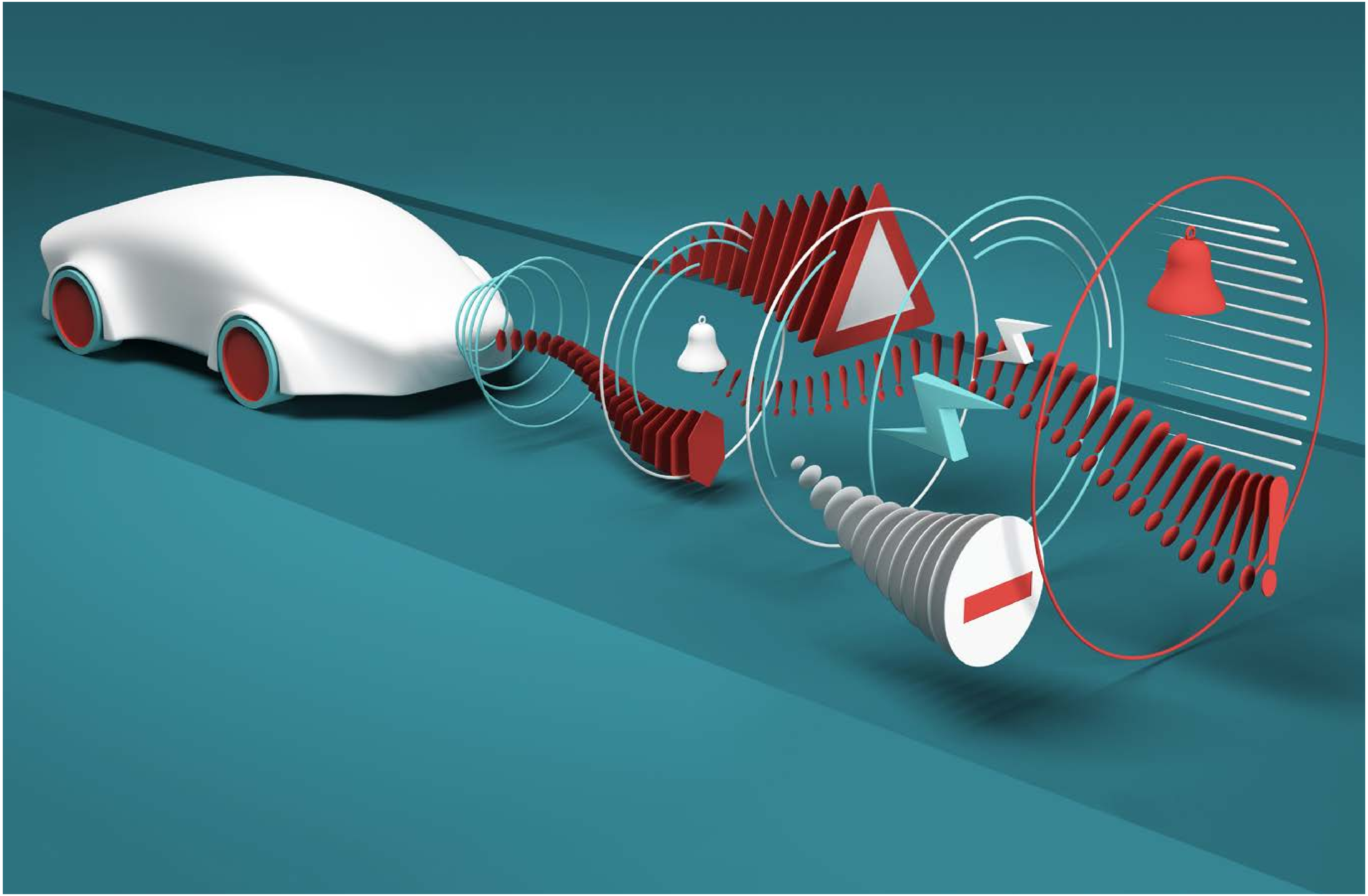
Vehicular Exterior Sound
by Rutger Paulusse
Year: 2020

““Automated vehicles ought to be harmless, not just to the passenger but to pedestrians too. I imagine these vehicles to be very communicative to people within its surroundings, especially about danger level. So I decided to create an illustration with its communication visualised, with the hopes for the safe autonomous future.”

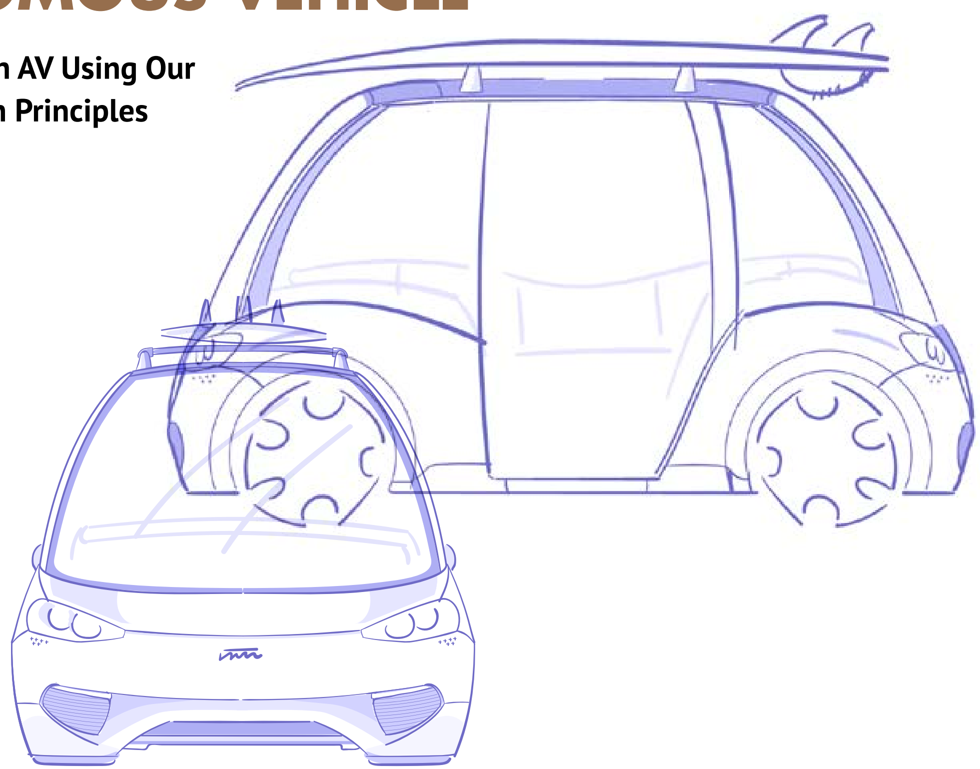


DESIGN CHALLENGE 3:

USTWO DESIGN AN AUTONOMOUS VEHICLE

Topic: We Design an AV Using Our Insights and Design Principles

11 minute read



ustwo
PROJECT
EXPERIMENT

SUMMARY

With AVs, there's a tantalising opportunity to start-a-new. We can finally scrap legacy inefficiencies, skeuomorphic over-dependencies and redundant features. With a greater proportion of vehicles running electrically, bulky engines are gone as are features such as the steering wheel – giving us more space than ever to play with.

Whilst it's true there are lots of opportunities to optimise the cars that we build, the concept we outline in this section is built on the foundational idea that there's more to people's mobility needs than simply the vehicle itself. Our AV concept also serves as a provocation, to start a constructive conversation about the future.

INTRODUCTION

“Skeuomorphic designs are often comfortable for traditionalists, and indeed the history of technology shows that new technologies and materials often slavishly imitate the old for no apparent reason except that is what people know how to do. Early automobiles looked like horse-driven carriages without the horses (which is also why they were called horseless carriages).”

Don Norman

So, we want to imagine the perfect city AV. It’ll probably be fully electric, so we won’t need an engine or transmission and that will mean less bulk. We probably won’t need a steering wheel either, so there’s likely to be much more space inside. We also need to bear in mind that the AV has to coexist with lots of other actors – human and machine – in our central London stage.

This illustration is a starting point to demonstrate some of our design principles. We share the files so that other designers can build on this with their own interpretations and expertise.

THE IDEA AND HOW IT FITS INTO OUR STAGE

It’s ten years into the future and fully-autonomous vehicles have started operating around the bustle of central London, mingling with normal cars, cyclists, and pedestrians. People can hop on and off as they please, perhaps hailing AVs through an application on the latest series of smart devices. Up to six strangers can board the vehicle, or it can be reserved for just one person, a couple or a group of friends, if you pay a little extra. In many ways the vehicle can perform as a black cab does, but with technological perks.

These vehicles mainly roll around within the city, but can also take you home, so commuters, the elderly, and families like to use them.

With this in mind, our illustrations were born out of a set of notes for us to design with. We thought it would be fun to share with you along with our illustrations themselves.

Let’s take it for a spin…

ustwo ROO

The ustwo Roo continues the age-old automotive industry tradition of being named after a powerful member of the animal kingdom. Just like our marsupial friends, the Roo safely carries its passengers as it hops around town. The ustwo Roo also demands respect from its fellow road users, while being friendly to pedestrians and cyclists. You wouldn't mess with a kangaroo, but you might pet it.

1. THE DRIVERS SEAT

Fully autonomous vehicles won't need a driver's seat or steering wheel, though some people would still like to sit in the "driver's seat". Maybe a driver's seat that can move inward? With a retractable wheel? The driver's seat may not be a literal thing, it could be about being in a place where someone feels in control. The equivalent of sitting on the sofa holding the TV remote control.

2. LESS NEED FOR FOCUSED AERODYNAMIC DESIGN

Aerodynamically speaking, if it's a city car it won't need much streamlining, so we can play with the shape a lot more. Also, since all propulsion will be below the car and at the wheels there is no need for engine room. The bonnet (hood) could be nearly eliminated.

As we know, mant cars are designed for stylistic reasons. Much of which comes from a sense of aero-dynamism to make the car go faster or actually so that it looks like it can go faster. Given our car is an EV and incredibly fuel-efficient and that it can reach the speeds it needs to with little difficulty, streamlining is less of a factor. The exterior design focus can then shift to the best user experience of the interior. Though it will still look sexy, of course.

3. NO CRUMPLE ZONE

Driverless cars may never crash. Studies show the average speeds within London to be slow, around 8mph, and AVs also won't have traditional engines. So do they need pronounced crumple zones at all? Can we bold in that regard? Other vehicle may crash into it, but there are other safety physicalities and systems to address this scenario. Booster seats for kids will be provided under the Roo's seating.

4. ANTHROPOMORPHISED / RESPECTED STANCE

The front grill of the car gives it a personality, as does its size and shape. You'd feel safe near a Google car – it's cute. On the flip side, you wouldn't bully an autonomous Humvee. This vehicle needs to command respect so that it's not bullied, yet seem friendly so as not to frighten or intimidate other drivers and pedestrians. It's face, shape, and size should have this balance, just like a kangaroo.

5. SOMETHING TO ORIENTATE THE VISION-IMPAIRED

If there's no driver, there's no need for wing (side) mirrors. But vision-impaired people use them to navigate and find the door. Let's remove the fully grown mirrors and replace them with an equivalent tactile counterpart.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6. FORWARDS AND BACKWARDS

With shared AVs of the future, routes are created algorithmically and on-demand. For that reason, it's more efficient for the AV to be able to drive both forward and backward with equal speed and agility. The vehicle then should be near identical both front and back.

7. BRANDING

As we discovered in the Branding and Service Design section, creating the right brand for the vehicle is incredibly important. To hop on board, the user will need to trust the brand itself. Some OEMs may want to spin-off a separate brand in order to build the appropriate image from the ground up.

8. ACCESSIBILITY FEATURES

Sliding doors: given congestion, increasing population, and people with disabilities, it's far less obstructive to have sliding doors rather than hinged doors.

"Curb safe": the Roo can lower so that its floor aligns perfectly with any curb height for a seamless entry into the AV for wheelchair users.

Handrails: internal handrails at both doors help all users in entering and exiting the vehicle.

9. A MEANS TO COMMUNICATE INTENT TO PEDESTRIANS AND OTHER CARS

Turn signals (indicators) today communicate intent as to left or right turning. Similarly, brakelights communicate the car is stopping. In the future, other sets of indication might be required, ie "accident ahead" or "changing lanes" or "Hello cyclist, I have seen you and I'll be careful" or "Hello pedestrian, you may cross in front of me". Displays front and rear might be required to communicate to others.

"EACH VEHICLE WOULD HAVE SOME PARAMETERS LIKE IF I WANTED TO GET SOMEWHERE IN A HURRY, I MIGHT HAVE TO TELL THE VEHICLE THAT I'D LIKE TO GET THERE QUICK OR IF I WANTED TO GET THERE COMFORTABLY BECAUSE I WANTED TO READ... I WOULD WANT A CAR THAT HAD THAT LEVEL OF CONTROL, IF I WAS GOING TO OWN ONE AND IF I WAS CYCLING AROUND ONE... I'D KIND OF WANNA BE AWARE OF WHAT MODE IT WAS IN — I THINK IF IT WAS IN A HURRY, IN A PARTICULARLY AGGRESSIVE MOOD OR WHETHER IT WAS PLAYING IT SAFE."

Neil, ustwo study participant

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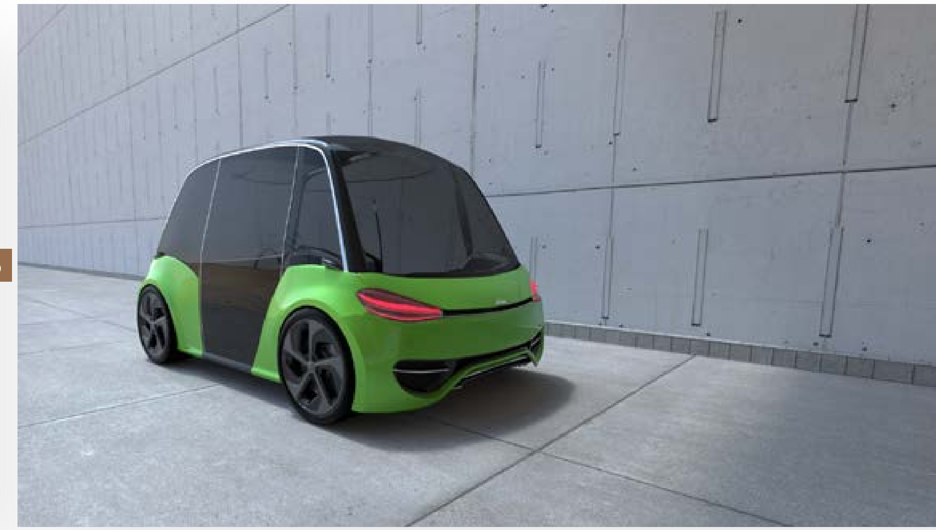

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10. DIRECTIONAL SOUND EMITTERS AND RECEPTORS

According to our sound design for electric vehicles exploration[1] it could be interesting to use directional sound to communicate audibly to individuals, such as pedestrians, rather than groups using a horn. This could be done with directional speaker technology or through the individual's personal device.

11. A LEARNER PLATE FOR AVS NEW TO CERTAIN TRAFFIC CONDITIONS

Some vehicles will need to graduate to certain road conditions over time, ie suburban environments to suburban environments in poor weather. Like a learner driver today, it would help others know they are less experienced. So, outside the car might it say: "learning rain mode"?

12. EXPERIENCE POINTS FOR AVS

A more granular version of the above, "experience points" can be a device to help others feel safer around the AV. Perhaps a number (denoting experience points) combined with iconography from point 9 on the rear and front of the vehicle? Or maybe just a medium and high rating. Think restaurants displaying their food hygiene rating in the window.

13. EASIER / DYNAMIC WAY OF IDENTIFYING A CAR (THAN A LICENCE PLATE)

When you're waiting for an Uber, you have to look out for tiny pieces of text on the licence plate. Some people can't see well, some people can't even read Latin characters. Is there an easier way to identify that a booked vehicle is your ride? Perhaps a "red fox" or "blue whale" system is easier to identify visually, paired with what is on your phone. This could be dynamic and change from fare to fare.

14. MOSTLY TRANSPARENT – ABILITY TO LOOK IN FOR SHARED VEHICLES MIGHT REDUCE INCIDENTS

People are less likely to misbehave or mistreat the vehicle or others if they feel they can be seen. Yet people in cars do enjoy some privacy. Finding a nice balance is important.

15. DYNAMICALLY TINTING WINDOWS

A glass box can get very hot very quickly, its windows causing uncomfortable amounts of glare. Windows that tint in reaction to the sun's rays may make the passenger's journey more comfortable, not to mention more privacy and added intimacy ;) .


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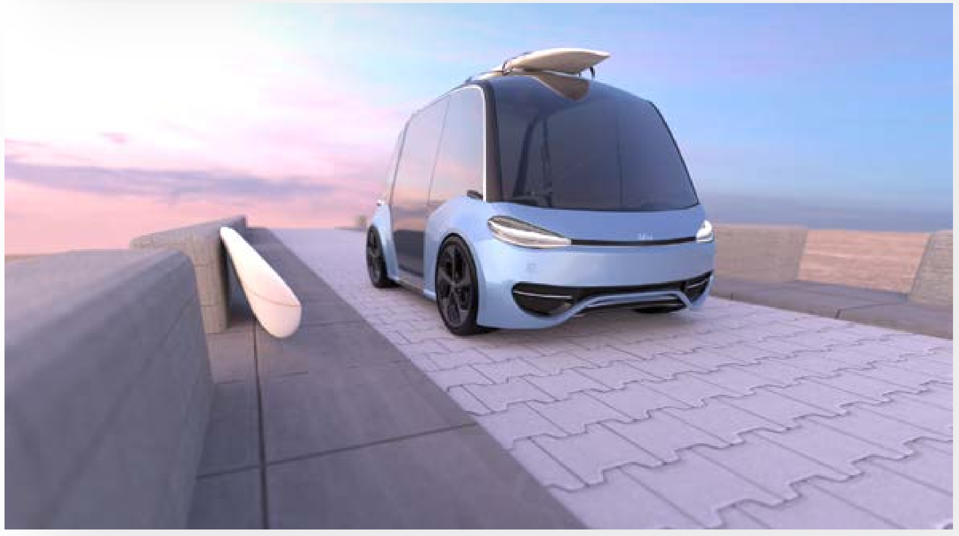


16. EMERGENCY STOP BUTTON IN THE INTERIOR

This is unlikely to be used, but will help with people who are anxious knowing they have the option. Perhaps not “emergency stop”, but just “stop”?

17. EMERGENCY EXIT SYSTEM

Of course when things do go wrong, it’ll need to be easy to escape the vehicle. The AV needs to know when to automatically unlock its doors and who to contact in an emergency. An emergency break window hammer might be useful if the machine just breaks down and stops responding, despite its safety systems.

18. ONBOARD ENTITY TO TALK TO

An MIT study[2] discovered that some people, when talking to a machine, need a physical entity to talk at. It’s hard to just talk into the ether. People need to direct their voices at something, either a person’s face or a microphone. Feedback too will need to come from a specified area. So a physical entity, an avatar, should be present to direct your communication to, like an Amazon Echo[3] for the car.

19. DEVICE CONNECTIVITY

Modern concepts show off plasma screens and lounges in driverless cars, but chances are people will be staring down at their own devices anyway. When people step into the Roo, their phone will instantly be connected, perhaps continuing the currently playing song through the car speakers rather than personal headphones, or bringing up that article on to the in-car display. A seamless transfer of media.

20. PERSONALISATION

The vehicle knows who you are, where you are going, why, how you like the temperature, the seat position and so on, so the car will calibrate to those preferences. Even though it’s a different car every time, it will *feel* like the same car every time.

21. WINDOWS AS AUGMENTED REALITY SCREENS

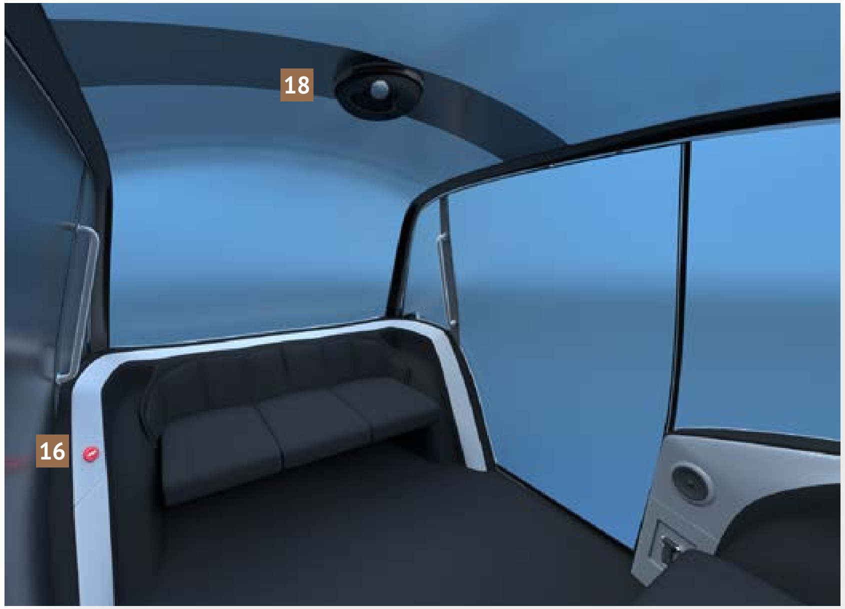
We suggest that kids can play augmented reality (AR) games on the windows of the vehicle, ie tap the yellow car (that drives past in real-life) to score a point. This interaction with the outside world could help prevent motion sickness, which is expected to rise. A bit like Toyota and Copenhagen Institute of Interaction Design’s *Window to the World* concept[4].

22. NO INTERIOR FAFF

Cars today have too much going on, with retrofit solutions to legacy problems. Also, without the need for driving controls, and designing from the ground up, AV interiors can be much simpler and roomier.

23. MODULARITY

These shared vehicles are out there in the field, being used in a huge beta test. We can iterate on both the digital and physical features of the car, using insights from the users, passengers and data, swapping what doesn’t work for something more useful.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24. INTERCHANGING THE ROLE OF THE VEHICLE (IE SHIFT FROM A TAXI TO A POLICE CAR)

During the day, when demand is high, shared driverless cars will be picking up and dropping off people. But when the demand is low, these vehicles may not have anywhere to go, so they need to be utilised. Perhaps they could deliver pizzas, or parcels, or act as ambulances and emergency vehicles. On-board storage as well as exterior lighting, livery and logos should be used to demarcate the role of the vehicle. Perhaps the yellow "paintwork" of a taxi during the day could change to a red and white paintwork of an ambulance in times of emergency. An extra "skin" or two for every AV. It's legal affordances on the road could shift when in "emergency mode" for example.

Further to this, people could choose the "paint job" of the vehicle on the fly, using an app on their device. A "dynamic digital paint job" concept.

25. DISCOVERY AND EXPLORATION

The Roo is not just a utilitarian concept, it's about pleasure too. AVs can be used for a weekend away (with a surfboard or bike rack). It can help people discover new places (with a tourist voiceover mode or discovery mode). It can drive differently with car-sick kids on board. Moments that will make people smile.

26. NOT TOO SCI-FI!

All the concepts we see today are always so sci-fi and overly futuristic. We don't think they'll look too different to the designs seen now.

Q: WHY DO YOU THINK CHANGING COLOUR IS IMPORTANT?

"A: UM, JUST TO MAKE IT MORE... YOU KNOW... UM... INTERESTING..."

Yeva, ustwo study participant

We hope you've enjoyed the concept we've drawn out here. As always, these are provocations and points for further discussion with you, the reader – an equal participant in designing our driverless future. ◆

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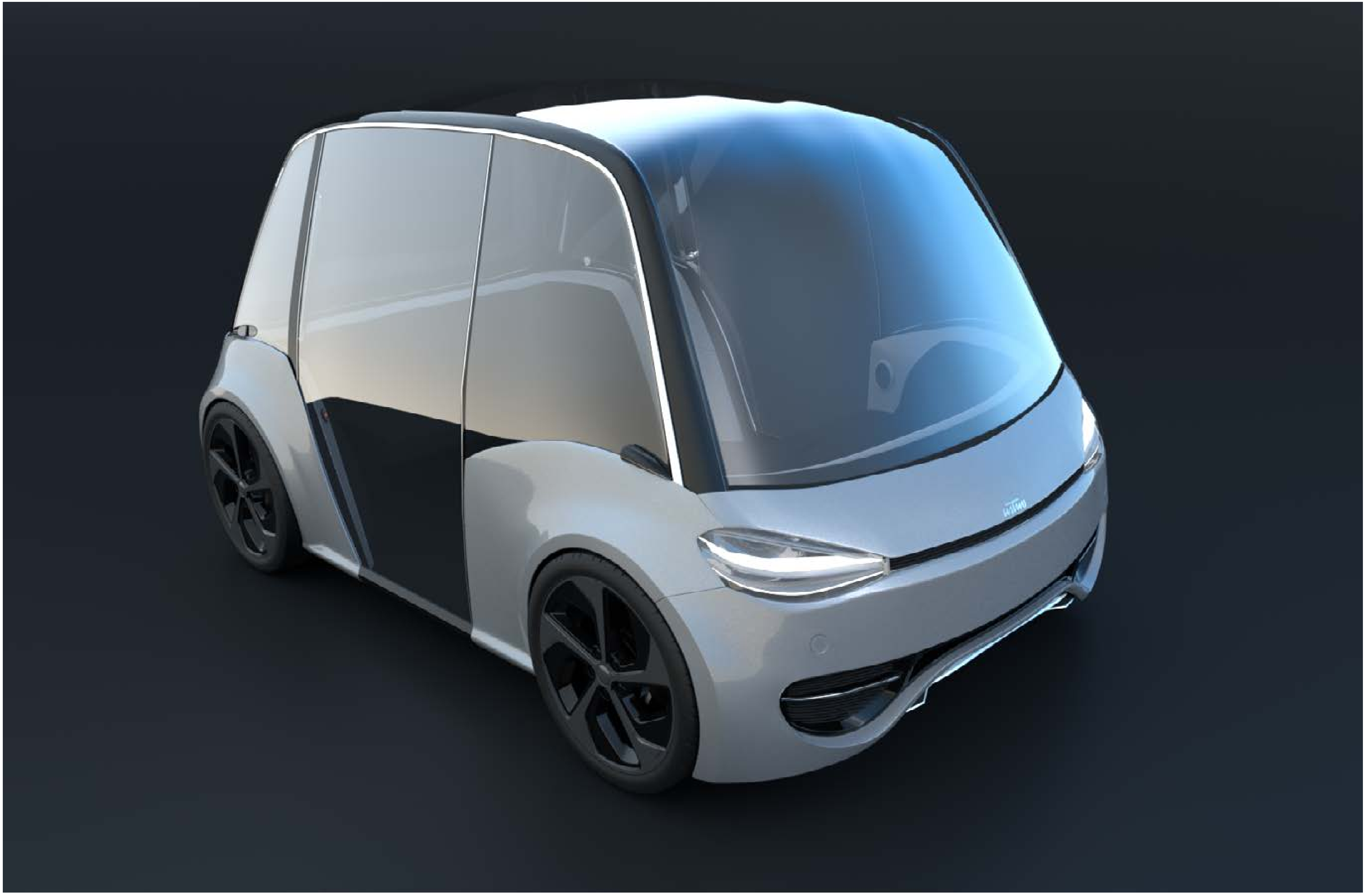
ustwo ROO
by Tim Smith, Harsha Vardhan and Ben Marsh
Year: 2028

"In 2028, noisy, dirty, and unsafe cars won't be there anymore. Instead, the road will be filled with peaceful, clean, and safe vehicles, like the ustwo Roo. Ustwo's autonomous car concept, named after the Kangaroo that hops around town with its passengers, is designed from the ground up and with a user-centred design approach.

The exterior design of the ROO is also inspired by two of our favourite cars; the Audi R8 and the classic VW Camper."



LEADING CHANGE

Topic: Automotive Digital Transformation

12 minute read

Lars Rosengren
Product Lead

ustwo **LDN**

SUMMARY

The automotive industry is going through fascinating change. Much like music, TV and retail, they are being profoundly disrupted by the new opportunities that technology brings.

Over the past couple of years, as cars have become more software oriented and connected, we've worked closely with partners in the industry. In this chapter, Lars draws on this experience to advise how companies can develop a strategy in the face of constant change, what some of the key building blocks for success are and the importance of keeping users needs at the center throughout.

INTRODUCTION

We have the privilege of working with large and small companies, across multiple industries – often as they are going through significant change. At present, the automotive industry is going through a great deal of transformation. Our entire perception of mobility is changing, the car is becoming more software dependant and a key component of a service platform, increasingly connected to other aspects of our lives. This is dramatically changing how automotive companies organise themselves and their propositions for the future.

In order to understand how to embrace these challenges and devise a strategy for the future, we need to have a good understanding, or diagnosis of the challenges we face.

In our original book on user-centred design in the automotive industry, we provided an analysis of some of the design challenges the industry faces. Since then, we have worked on a range of automotive projects that have provided us with a deeper and broader understanding of the industry dynamics, and where we can find some of the underlying challenges.

In this section, we aim to provide a strategic overview on why some grand ambitions don't quite reach their vision as intended – where we identify the challenges and propose a different approach to navigate a world of constant change.

This is not exclusive to the automotive industry, but we currently see this manifesting itself on a grand scale in the automotive industry and mobility sector due to technical advancements and social change.

SOME OF THE CHALLENGES

"A good diagnosis simplifies the often overwhelming complexity of reality by identifying certain aspects of the situation as critical." [1]

Richard Rumelt

There are a few challenges that most companies seem to face at one point or another, as they aspire to become more digitally equipped.

One of the biggest challenges in large projects is a lack of clear visibility of success or failure. We analyse commercial performance against competitors, but we rarely reflect on how we successfully or not so successfully deliver digital products and services. Nevertheless, implementation is a very big part of a successful digital strategy. It is not sufficient to have a "big picture" understanding of digital trends and technology to achieve successful digital services. It requires a fundamental rethink, getting your hands dirty, and understanding the dynamics of creating software platforms and services. This is especially important, because it is diametrically opposed to the process of building cars.

For a broader view on the dynamics of digital transformation, we recommend reading *10 Principles of Digital Transformation*[2] previously published on our blog. This chapter provides more of a field study perspective – what we have observed in the automotive industry, as companies go through great change.

Each company will face its own set of challenges, but in the process of working with several partners, we have identified some of the more common challenges.

WE CAN'T SEE THE FOREST FOR ALL THE TREES – EVERYTHING IS A PRIORITY

Automotive OEMs that embark on building an architecture for digital services will tend to do so on a grand scale. Inevitably, this is complex as it involves many generations of vehicles, backend infrastructure, and a multitude of touchpoints that the user can interact with. When approaching complex projects, it is more important than ever to have a clear understanding of priority and focus. Despite this, we have found that companies are often reluctant to prioritise, as there are many stakeholders to consider and it is very difficult to change the strict vehicle development plans. Unfortunately, this results in slow progress or products that are sub-optimised due to unclear focus.

WE DON'T UNDERSTAND WHAT MATTERS TO OUR CUSTOMERS, SO WE FAIL TO DELIVER REAL VALUE

Any real innovation will tend to stem from one of two sources – either core competences or a better understanding of customer needs. Automotive OEMs are usually very good at understanding their unique competences, but rarely have a deeper understanding of their customer. If you fail to provide genuine value to the end customer, it will make it very difficult to find a business model that justifies your investment in the product. More than ever, user-centred innovation in the automotive industry is a real opportunity to differentiate digital products and services.

WE NEED TO CATCH UP WITH THE COMPETITION

While you are a busy copying your competitors' features, they are busy innovating or improving them. That is why the idea of "catching up" is a flawed strategy. It is highly unlikely that you will be able to work faster and smarter than your competition, especially if you haven't done so historically.. Thus, your company will always be one step behind. While it might seem that more features is always better, and more valuable to the customer, evidence shows the opposite (eg the iPod, Leica, Monzo, Southwest Airlines, etc.) The perceived quality matters more to the end user than quantity.

WE PUT EMPHASIS ON VISION, BUT NOT ENOUGH EFFORT INTO IMPLEMENTATION

Most automotive OEMs have well-defined visions based on years of research and advice from expensive consultants. This is very important, and without a well-considered vision of the future, it is difficult to find true focus.

Nevertheless, it's important to recognise that building digital products and services is very different from building the next generation of vehicles. A car is complex to build and will last for many years. Digital services need constant improvement and maintain their quality by long-term, continuous iteration. Startups generally embrace the Thomas Edison quote "genius is 1% inspiration and 99% perspiration[3]" — or as Jim Collins expresses it: "Building a visionary company requires one percent vision and 99 percent alignment[4]." True commitment to a digital service platform requires commitment to organisational and cultural change, on every level.

WE WANT TO BE AGILE, BUT HAVEN'T DESIGNED OUR ORGANISATION TO SUPPORT IT

Today, the conversation about agile and waterfall software methods feels a bit outdated, but yet more relevant than ever. While teams are pushed to be lean and agile, organisations are still structured around upfront "fixed" plans, that maintain unrealistic milestones despite changing market needs. Often, this creates an internal conflict in process and expectations. In such cases, management tends to resort back to strict waterfall methods, because "agile failed" and if they just plan better success will come.

The reality is that change is inevitable, especially in software. It is impossible to plan the unpredictable. What makes a company successful is the ability to take an agile mindset to what it builds and respond quickly to change, not to apply agile routines and methodologies correctly. Continuous communication and feedback loops between leadership and delivery teams is what makes a difference, not scrum ceremonies (although this might give some direction on a team level).

DIRECTION – PRINCIPLE DRIVEN STRATEGY

While words can summarise years of observations and experience, to realise this in practice requires substantial organisational and cultural willingness to change. Often it will prove easier to achieve this change within your development teams, but unless top management recognises the same need for change, any initiatives will tend to fall short.

Each organisation and each product requires a slightly different approach. There is no such thing as a one-size-fits-all recipe, and that is why a process-centric approach will not automatically work for your organisation. Instead, we need to introduce the idea of a principle-centric approach, which is a more robust way to shape your digital strategy in a constantly changing environment.

新橋

Shimbashi Station, Tokyo

AUTOMOTIVE DIGITAL TRANSFORMATION: THE OPPORTUNITY

FINDING FOCUS IN CHAOS

In the past couple of years, we have been working closely with partners in the automotive industry. They are going through a fascinating change, both as companies, but also as part of a constantly changing technology landscape. We have already addressed some of the things that can go wrong and why they run into problems. Now, we'll discuss how companies can develop a strategy to face constant change and what some of the key building blocks for success are in such an environment.

The automotive companies are very good at building really complex hardware, and they have refined this process over almost an entire century. Now, they are facing a similar challenge to that which happened in the PC and mobile phone industries – cars are becoming more software oriented and connected. It is easy to say the automotive companies must change, and they need to work differently to be responsive such a context. Building products in a waterfall method over several years inevitably leads to obsolete software solutions, before the product is even launched. However, we believe we must respect the extreme complexity these companies face – both the new organisational needs, and a technology environment that is constantly changing.

In a world of great transformation it is incredibly hard to develop a sustainable strategy. Yet, over time, we have managed to find some ideas on how to approach strategy through chaos and complexity. **As things get more complex, it's hard to predict the future. You cannot rely on old methods to analyse your environment and decide the best path. Instead, you need to understand that certain things remain constant even in the midst of chaos. This is what guides us and prepare us for future change.**

This is not an exhaustive list, but here are some of the core principles to consider:

UNDERSTAND YOUR REAL CUSTOMERS

It is surprisingly easy to get tunnel vision, by following industry trends and expert analyses. However, because your competitors are generally following the same trends, you are unlikely to reach any remarkable innovation. Despite listening to our own marketing teams, we spend too much time focusing on who we would like our customer to be, and not enough effort genuinely trying to understand who are customers truly are, and how they behave. By investing time understanding our real customers, their lives and challenges, we will gain a deeper clarity of the problems they face and what opportunities there might be to make their lives better.

LEAD INNOVATION WITH USER INSIGHTS AND UNIQUE CORE SKILLS

Recognise that true innovation either stems from a deeper understanding of your customers or is rooted in unique core skills that only your company possess, which is difficult to replicate. Any time that innovation is misguided by quantity of features or more novel features than competitors, we are likely to stagnate and fall behind.

ONE CORE OPPORTUNITY IS WORTH MORE THAN 100 IDEAS

It might seem that following Mao Zedong's "let a hundred flowers bloom" sentiment is a good idea. The more features or opportunities we identify, the more chance of success, surely? Sometimes this is true: if three startups out of 100 are successful enough to outweigh the investment in the 97 that failed, then great. But it is important to recognise that this comes at a cost that most automotive manufacturers are not too keen to accept.

If you do not have a clear strategy as to how to monitor and experiment with 100 ideas, then shift all your effort towards those real innovations you identify, this could be even more painful. If you pursue 100 ideas with equal effort, it will be extremely expensive, your team will lose focus and your customer will be unclear about the value you offer. Therefore, it is typically better to experiment at very low cost, then narrow your focus to prioritise, and realise only the few ideas that are likely to be core drivers in your industry.

TAKE A HOLISTIC VIEW – YOUR COMPANY IS PART OF A BIGGER ECOSYSTEM OF CHANGE

Because automotive companies typically are already made up of complex ecosystems of suppliers and partners, it is easy to forget that your customer also lives in an ecosystem that's going through change. That is why it is important to understand your product as part of a social ecosystem, as well as a technological one. It might be wise to encourage your suppliers and partners to take an equally dynamic view of their role in the ecosystem. Just because your car radio came from one supplier 20 years ago, does not mean that same supplier is necessarily equally well-equipped to provide your in-car system today, which is infinitely more complex and interconnected. Perhaps they need to seek partners, in order to stay relevant as part of the supply chain.

BUILD FOR CONSTANT EVOLUTION, NOT OCCASIONAL UPDATES

Cars are typically built as standalone models. Manufacturers then review, analyse where the industry is going, and then make some improvements for the next model. Sometimes there are big innovations, sometimes just small evolution. In this context, it's easy to assume that as long as what is built has some flexibility and room for improvement, it's good enough.

However, growing customer expectations, and a competitive marketplace mean that software is built in a context where you may need to fundamentally re-engineer your entire system every two to three years. So to meet people's evolving needs for their personal ecosystems, the automotive industry must build systems that are intended for constant change. Not just a user interface facelift – new services, new security threats and new patterns of behaviour must be accommodated on a regular basis.

AS YOU SCALE UP, YOU INCREASE COMPLEXITY AND SLOW DOWN INNOVATION

Typically, companies that have historically built products on a large scale assume that putting more people on a project will speed up innovation and progress. Unfortunately, the opposite is often true. There is a reason why Amazon's Jeff Bezos advocates "two pizza teams" [4].

A small team can be constantly in tune with one another, and respond to change in a very agile manner, whereas a big team quickly increases complexity to even coordinate activities. This is one of the most crucial reasons we think large software projects in the automotive industry have been surprisingly slow, despite the amount of investment.

RECOGNISE THAT CHANGE WILL BE CONTINUOUS, AND SET YOURSELF UP TO RESPOND RATHER THAN PREDICT

Behind many of our ideas above, there is a realisation that we are not very likely to predict the future, or to mobilise our teams in due time towards that change. In other words, we can't plan one or two years ahead and set up our teams to build according to predefined plans.

We must set out to continuously learn from the market, and respond to change as effectively as possible. This way, it doesn't matter if we are building the wrong thing today, because we make sure we bring our ideas in front of customers as early as possible, and learn from mistakes. Tomorrow, we adapt our team's focus, so that over time we develop a clear idea of what brings true value. Then we can deliver this to our end customers at the time when it matters most.

So instead of planning for what we cannot control, let us identify the principles that guide us through change. Of course this is a broad analysis of our view of the automotive industry and large companies going through digital transformation in general. Each company might identify slightly different guiding principles that work within their context. While these principles can seem abstract, they could be broken down into a day-to-day mindset and rituals your team can follow to increase chances of success. ◆

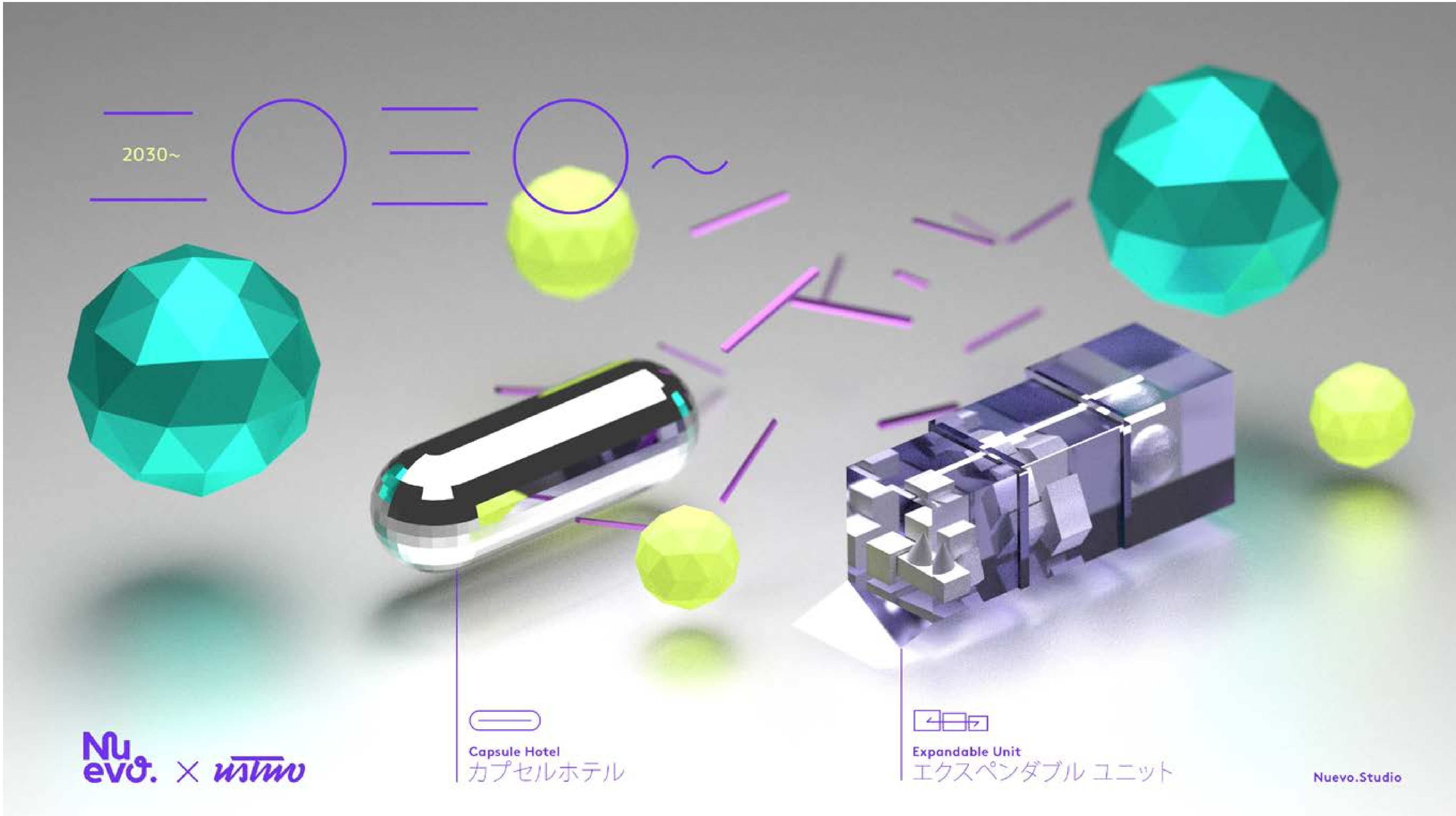
SOURCES

1. Richard Rumelt, *Good Strategy, Bad Strategy*
2. https://ustwo.com/blog/ustwos-10-principles-of-digital-transformation
3. Thomas Edison, *Harper's Monthly Magazine*, 1932
4. Jim Collins and Jerry Porras, *Built to last*, 1994
5. https://www.fastcompany.com/3037542/productivity-hack-of-the-week-the-two-pizza-approach-to-productive-teamwork

2030s Metabolist Mobility
by Alvaro Arregui
Year: 2030

"In a world where safety, accessibility, efficiency and sustainability would be required by law, some of today's big car manufacturers will become extinct, leaving design and technology-driven companies to lead the mobility industry. Clean autonomous hardware will be the only way to conceive "vehicles" from there onwards. Human driving, as we know it today, will be considered a safety threat and become illegal on public roads and streets, allowed only for recreation within closed circuits.

"Vehicles" will become a service, rather than a belonging, for the user. Without that sense of attachment, companies will have the opportunity to create multi-purpose hardware that can morph quickly, to be adapted to any demand with efficiency and profitability. Reusable modules and recyclable materials will enable constant updates and modifications, based on the user's needs and requirements and will blend seamlessly into the surrounding space, adding value when its main (mobility) purpose is not required. For instance, they could become gardens or intelligent illumination systems or media platforms..."


2030~
Capsule Hotel
カプセルホテル
Expandable Unit
エクスペンダブル ユニット
Nuevo.Studio

WHERE ARE WE GOING?

Topic: What's Next?

4 minute read

"The typical science-fiction depiction of AI is this loyal, obedient butler; you simply flip a switch, turn it on and it's ready to do your bidding. I feel like there's a huge story being glossed over." [1]

Ted Chiang

We are right in the midst of a mobility revolution enabled by technology and strangely enough the instruments of this revolution are beginning to, dare we say it, 'think' autonomously. Much like Ted Chiang's lovable digients (digital entities) in his novella 'Lifecycle of Software Objects' - we are seeing vehicles and systems that are learning how to live in their respective environments and negotiate with their human counterparts. A growing notion of intelligence from a childlike state, to an adult one we are comfortable giving additional responsibility to. Science fiction is nearly graspable.

Though there is still much discussion about the form these entities will take however.

"Driving an automated car is very much like riding a horse." [2]

Don Norman

"I'M GOING TO SIT IN THE BACK SEAT AND I'LL HAVE MY "ROBOT CHAUFFEUR" ON THE FRONT. WILL THERE BE A WAY OF CHATTING? BECAUSE THAT WOULD BE SO INTERESTING! THAT WOULD BE WONDERFUL ACTUALLY, OTHERWISE IT WILL BE TOO BORING."

Socorro, ustwo study participant

Socorro and Don Norman make interesting yet divergent thoughts about this future 'adult' state of the intelligent vehicle. Would it be akin to a creature living among us or would it be anthropomorphised to near human likeness (either physically or behaviourally)?

Funnily enough, looking back at history we can see interesting parallels about our first vehicle of mobility - the (semi) intelligent horse which then gave way to the dumber vehicle as we see today. Perhaps we are returning back to the intelligent "living" anthropomorphised creature with AVs?

Just like biological life AVs might adapt to their surroundings early to market AVs will have the chance to field test their characteristics in real world live environments, and on global levels, Sharing secrets with one another like chinese whispers (that can often go awry). Only those beneficial features and character traits will be taken over to the next model, or carried into the next system update, like inherited genes but assisted by another agency. While we think the city will change around the Pod, as many have discussed recently, we think the AV will also evolve to fit its surroundings as well. Technological advancements being more akin to evolution - survival of the fittest, in a symbiotic relationship with its environment. Perhaps AVs will become so "life like" in their behaviours and "personality" that they will even be afforded AV rights, like our human rights, or perhaps more realistically the Five Freedoms[3] of the animal kingdom - something Boston Dynamic's Spot might benefit from.

This early assisting agent for AV evolution will be the human beings, the communities and organisations working today towards this future. We will be doing the pruning, iteration and will be moulding the form and behaviour of the AV. This entire book is in its essence about the criteria we could use in guiding this evolution - which should be human centred and not technology led.

Thinking about people with all their diversity and glorious idiosyncrasies and the needs and desires that drive them. Providing mobility to people who really need it.

Thinking about the cities we live in and how to keep them sustainable for future generations.

Thinking about the cultural dynamics and mindsets that can affect adoption.

Thinking about policies and regulation which positively impact safety without stifling innovation and technological growth.

Thinking about the obvious moral, ethical and liability dilemmas which are to be solved as well.

Thinking about how technology can be empowering. Not just tech for tech's sake.

We also think that we cannot leave you without speaking about another key concept - the freedom of choice. When will AVs be on our roads? They are here now and becoming mainstream in the near future. Will they all be fully autonomous? Maybe not. Not everyone might subscribe to driverless transport and the thought of seceding complete control. There is an innate desire to be in control of one's own movement and experiencing a sense of freedom and even facing a challenge. Driving in itself can be an uplifting experience. We do think that providing people with this choice is paramount - despite the focus on safety.

We truly hope that this book with it's application of HCD can effect a shift towards these thoughts. Our belief is that the techniques we talk about can deeply influence the experience of living with these robots - not thinking about them as world conquering automatons but as benevolent and social entities. It is also our collective responsibility to begin an earnest conversation about these thoughts. A conversation which will be incomplete without you.

Let us know what you think. ◆

SOURCES

1. *Lifecycle of Software Objects*, Ted Chiang
2. https://www.wired.com/2012/01/ff_autonomouscars/
3. http://kb.rspca.org.au/Five-freedoms-for-animals_318.html

The Getaway Driver
by Hannah Nicdao *ustwo*
Year: 2060

"Some people drive to get away. When cars become driverless, that can be possible, two-fold! My ideal driverless car will be a place where I can get away, en route to my getaway! Additionally, cars in the future should STILL look shit hot. This car is modelled after the 1961 AC Aceca Coup. I love the rich character of classic bodies from the mid century... interiors can simply be reconfigured for prime relaxation. Automation and technology shouldn't negate style!"


4UTOM8

THANK YOU DIOLCH DHANYAVAAD

The obligatory thank you page, but a truly sincere one. We are unfathomably thankful for all of these individuals, groups and clients who helped us in all their weird and wonderful ways over the course of the year putting this book together. It's a cliché, we know, but we couldn't have done it without all these lovely people. Hopefully, one day, when you're riding in an autonomous vehicle, you'll see something that you had some involvement in… who knows.

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