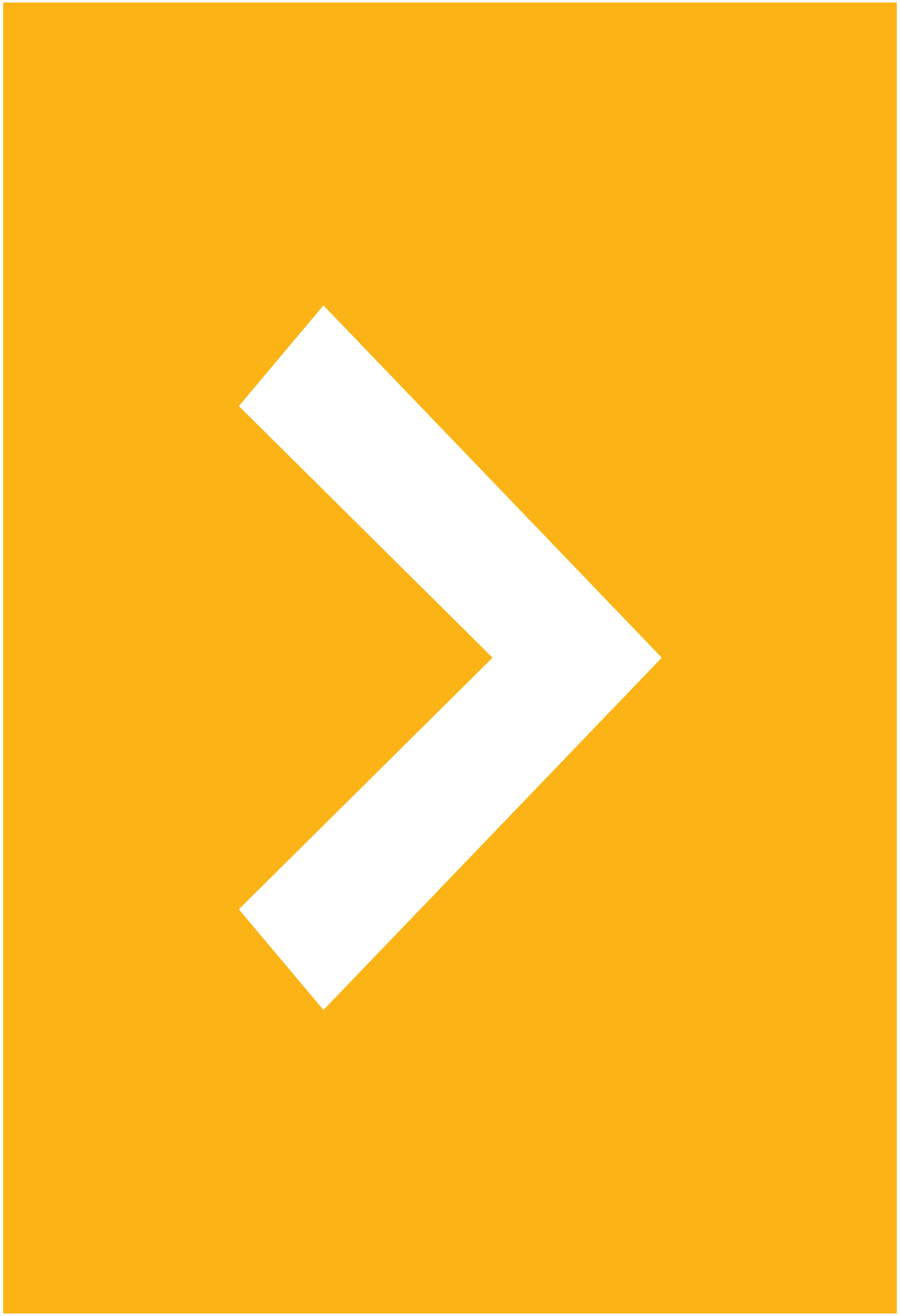
The Future of Transportation

Mobility in the Age of the Megacity

The Visa Transportation Center of Excellence is a global service aimed at transforming the consumer travel experience by bringing together the power and scope of Visa's programs including the Visa Developer Platform, Visa Token Service, Visa Ready for Transit and Visa Global Transit Solutions with its global network of Innovation Centers and Studios. Visa has created a collaborative environment that enables developers to reimagine the consumer journey across any mode of transportation they take along with the building blocks to make that vision a reality.

VISA everywhere you want to be



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1 | Preface

The world's cities are expanding at a rapid rate, with more people now living in urban environments than ever before.
As metropolitan populations grow, it's imperative for both prosperity and quality of life that cities improve the efficiency and efficacy of their infrastructure.

The key to success of any metropolis is the ability to move people and goods quickly and easily, every day. The future of public and private transportation is one of the major issues facing urban planners and societies, and will require cooperation from a range of players, from think tanks and public authorities to strategic partnerships with private corporations.

The aim of this report is to establish the challenges consumers currently face when making their daily journeys in some of the world's largest cities, and to determine what developments and changes could help improve their travel experience in the future.

Visa commissioned a third party to ask consumers living and working in major metropolitan areas around the world how they get around in the city and what their expectations are for the coming years. By understanding the current picture, we can better assess the basic improvements that can and should be made to lay the groundwork for the future.

As consumer behaviour continues to change, our research partner also looked at the appetite for different kinds of car sharing services and Mobility as a Service (MAAS) that are becoming increasingly popular in many of the cities surveyed.

The study then examined the challenges and concerns consumers have in their daily commute, to gauge their current pain points, and take them into account when working with stakeholders to develop future infrastructure.

Finally, the research considered the factors that would encourage consumers to increase their use of public transport – the aim is to see how Visa and other businesses can collaborate with public transport authorities to improve the overall consumer experience. This tallies with the UN goal of developing "integrated policies to improve the lives of both urban and rural dwellers"[1].

Visa believes that technology – particularly connected devices – has the potential to transform the world's bustling cities of today into efficient megacities of the future.

Companies such as Visa have an important role to play, both in helping streamline the commerce underpinning transportation, as well as acting as the 'connective tissue' that helps cities see the broader patterns of consumer activities. By seeing the bigger picture, we can help create smarter, better-designed cities for the people who live there.

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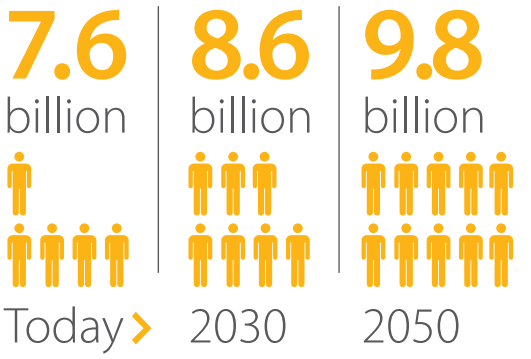
2| Introduction

Today, there are more than **7.6 billion people** living on this planet, with another 83 million born each day. At this rate, the number of humans is expected to reach **8.6 billion** by 2030, rising to **9.8 billion** by 2050[2].

World population

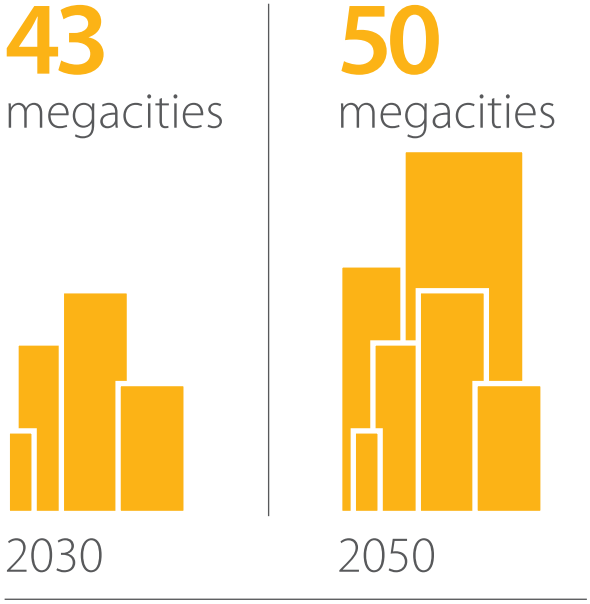


Where do these people currently live? More than half of them are in cities, with the world's urban population standing at **4.2 billion**, compared to **3.4 billion** in rural areas (and that latter figure is expected to fall to **3.1 billion by 2050**). This trend is about to accelerate. According to the UN, 55 per cent of the world's population currently lives in urban areas, with this projected to increase to 68 per cent by 2050[3].

The reasons for the increasingly urban concentration of the global population are varied and differ depending on the type of society in each country. Factors that draw people to cities include promises of jobs, greater prosperity, cultural attractions, better education and shorter commutes. The economic factors are often more acute in countries where opportunities in rural areas are limited.

Rise of the megacity

As a result of the growth of urban populations and the rural-to-urban shift, more and more megacities will emerge. The UN defines a megacity as having a population greater than 10 million people. One in eight people currently lives in 33 megacities around the world. By **2030**, it's projected that there will be **43 megacities**; the number rises to **50 by 2050**. The majority of these will be in developing regions, with the fastest-growing cities likely to be those in Asia and Africa that currently have populations below one million.



This second wave of urban migration shows the huge importance of developing high-quality, well-planned infrastructure to provide urban dwellers with the resources and everyday services they need.

There is already significant pressure on roads and mass transit systems across the world. Many cities are seeing congestion, overcrowding and major problems when a piece of infrastructure, however minor, fails. In cities throughout the world, transportation infrastructure is stretched to capacity, and sometimes beyond.

Investment is being made and work being done to improve matters, but it seems that many urban planners and authorities are making huge infrastructure investments that may provide only temporary relief for transport networks and the people who use them.

The Crossrail project in London, for example, is predicted to be at capacity soon after the Elizabeth Line opens. For a project that started nine years ago, has seen 130 million working hours completed to date[5], and tallied billions of pounds of investment – while also causing considerable disruption – this is a startling notion.

Another major road project – this one located in Atlanta in the US – recently took aim at one of the city's worst traffic bottlenecks.

While the three-year construction effort is expected to bring relief to an interchange designed for 100,000 vehicles per day, but which sees 420,000, it will take a decade more to build the additional 120 miles of roadway that are needed to relieve overwhelming daily congestion .

The future for mass transit systems in megacities should be an exciting one. Technology is likely to play a major role in improving the experience of seamlessly using the networks of buses, trams and subterranean railways – to make these systems something that people are able to tolerate, or even enjoy, at the best price. But there will be plenty of challenges to overcome along the way, as the following report demonstrates.

Global Consumer Insights

3| Global Consumer Insights

Mass Commuting in the City

As cities become ever busier, with growing populations and more people travelling into them for work or leisure, commuting times have risen in recent years, with that trend expected to continue.

Public transport

The research commissioned by Visa found that **44 per cent of urban residents use public transport as a way to get to work**, **school** or university, rising to **54 per cent for personal travel**. Travelling on public transport seems to result in longer journeys, with a mean **weekly travel time of 3 hours 35 minutes**, compared to **3 hours 17 minutes** for private modes of transport.

Longer journeys

Visa | View

Longer commute times change the balance of commerce by shifting where and how purchases are made – both virtual and physical – and will require added services to be introduced (eg, click-and-collect).

Overall, 46 per cent of the people surveyed have seen their commuting times increase over the past five years, and 37 per cent expect longer commutes over the course of the next five years. The pressure on public and private transportation is causing frustration, with overcrowding cited as the largest barrier to public transport use.

When you consider that the research found that people make an average of about 6 journeys to work/school/university every week, the extra minutes of travelling – and the corresponding aggravation – are a cost to individuals, employers and society at large.

The effect of commuting time should not be underestimated, with research by the UK's Office for National Statistics suggesting that a longer commute impacts people's wellbeing, including their happiness, anxiety levels, life satisfaction and the extent to which they feel the things they do in life are worthwhile.

The ONS research found that our satisfaction and happiness decrease for every additional minute of our commute, which contributes to increased anxiety.

Across the regions surveyed, Australasia (51 per cent), Africa (50 per cent) and Asia (47 per cent) saw the highest proportion of respondents whose commuting times have increased over the past five years. The same three continents also had the highest proportion of respondents expecting to commute for longer in the future, with Africa leading the way at 45 per cent. South America had the lowest proportion of respondents who expect their commute to increase, at just 23 per cent.

A lower proportion of respondents (37 per cent) from cities with high public transport usage said they have seen their commuting time increase over the past five years, or expect it to increase over the next half decade (30 per cent). This may partly be due to the fact that the cities in which they live have public transport infrastructure that has benefited from ongoing investment, and is likely to do so in the future.

4| What do public transport commuters want?

Give me comfort

Overcrowding is an issue that many public transport users face: it's cited by respondents across all regions as the biggest barrier to public transport use.

When asked what factors would prompt them to avoid a mode of transport, respondents to the research commissioned by Visa cited overcrowding as the number-one reason for buses, tubes/subways/rapid transit systems and trains. This is hardly surprising, as overcrowding can make people uncomfortable and lead to potentially dangerous situations. To combat this, public transport stations in some cities, such as London, often close their gates at peak hours to control the flow of people, further exacerbating the frustration of commuters.

Focus on the basics

Other factors influencing whether consumers will use public transport include reliability (arriving late to work or a social gathering, or having the train home cancelled, can be hugely frustrating), cleanliness, quality of customer service, cost, convenience and long travelling times.

These findings highlight the importance for public transport authorities and service providers to get the basics right if they are to improve the travelling experience.

Make it simple

Using public transport is always going to have its frustrations, and payment is often at the root of many common complaints.

The research commissioned by Visa revealed that **long queues** are the most common frustration when it comes to paying for **public transport** (cited by 52 per cent of respondents). But this wasn't by any means the only complaint around payment: 47 per cent said the need for different tickets for different modes of travel is an issue, 44 per cent said not knowing how much to pay is a problem, and 41 per cent cited services being cash-only.

Long queues

Again, these frustrations worsen the experience of using public transport, making people less likely to use it and more likely to drive their own cars.

Across the generations

When asked about the factors that influence the modes of transport they choose, it's noticeable that older generations prize convenience more than younger respondents.

Sectors influencing choice

Baby boomers aged 56 +

Convenience	82%
Reliability	84%
Overcrowding	72%

Gen X aged 46-55

Convenience	79%
Reliability	82%
Overcrowding	71%

Millennials aged 26-45

Convenience	74%
Reliability	76%
Overcrowding	67%

Gen Z aged 18-25

Convenience	62%
Reliability	67%
Overcrowding	55%

In the research commissioned by Visa, **convenience** was cited by 82 per cent of **Baby Boomers** (those **aged 56** or over), compared to 79 per cent of **Generation X respondents** (**aged 46-55**), 74 per cent of **Millennials** (**aged 26-45**) and 62 per cent of those in **Generation Z** (**aged 18-25**).

Another big difference between generations was around **reliability**, cited by 84 per cent of **Baby Boomers**, compared to 76 per cent of Millennials and 67 per cent of Generation Z. It was the same for the time to reach a destination: 80 per cent of Baby Boomers and 81 per cent of Generation X respondents mentioned this issue, compared to 67 per cent of Generation Z.

Overcrowding was more of a concern for **Baby Boomers** (72 per cent) than for Millennials (67 per cent) and Generation Z (55 per cent).

The issues that would cause people to avoid using certain modes of public transport also saw some variation across generations.

For buses, 36 per cent of Baby Boomers surveyed by our research partner said they would avoid travelling on them as they're not convenient, compared to 24 per cent of Millennials and 21 per cent of Generation Z, who may be more prepared/able to walk farther to bus stops and willing to switch buses to reach their destination.

The same is true of tube/subway/rapid transit systems, with 35 per cent of Baby Boomers put off by a perceived lack of convenience, compared to 23 per cent of Millennials and 19 per cent of Generation Z respondents. For trains, unreliability was more important to Baby Boomers (39 per cent) and Generation X (40 per cent) than to Millennials (29 per cent) and Generation Z (25 per cent).

There was also a large discrepancy across generations around cycling, with younger generations surveyed less concerned about safety: 36 per cent of Generation Z said they would avoid cycling due to safety concerns, compared to 44 per cent of Millennials and 55 per cent of Baby Boomers.

Digital technology

The majority of people surveyed embrace digital-only payment for transportation, particularly younger generations. While 41 per cent of **Baby Boomers** expressed frustration with digital-only payment, this drops to a third **(33 percent) of Millennials and just over a quarter (28%) of Gen Z**. The greater familiarity younger people have with digital technology may explain this in large part. However, the need to have different tickets for different modes of transport seemed to irk Millennials and Generation X more than Baby Boomers and Generation Z.

The major issues

These are important issues for public transport authorities and service providers to understand, particularly when you consider that

On average respondents to the research feel use of services would increase by 27 per cent if it was easier to pay for public transport.

In cities with subway/tube/rapid transit systems, only 13 per cent of those surveyed use their own car to get to work, school or university, compared to 42 per cent of those in cities without these services.

Indeed, living in cities such as London, New York and Paris, which all have well-established underground systems, is synonymous with using the tube/subway/metro to get around.

Higher public transport usage in these cities is likely to be because these transport networks are often the most convenient way for people to get around, with infrastructure for payment and information services already in place. While overland trains have a similar level of infrastructure, they are more likely to be used by people travelling into and out of cities rather than around them, with many commuters using a car to get to the station where they board the train.

In cities where the tube and subway systems have been in place for many decades, they are widely used by the population living in and around the cities. And because these systems are used so much, they are often the ones leading the way, looking for innovations to improve the travel experience.

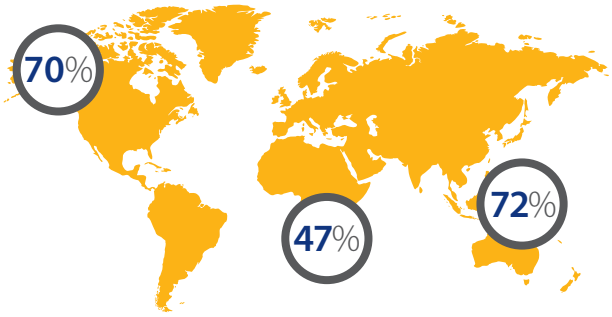
While cities like London set an example today for smarter transportation, when we look at Smart City initiatives in Dubai and, in the longer term, SouthEast Asia and Sub-Saharan Africa, the developing regions will leapfrog current thinking in mass transit.

By partnering with cities, tech companies and others to plan for a better future, Visa can raise the important questions and use our payments infrastructure to provide insights and intelligence.

5| The Car Remains King

Across all cities surveyed, the personal car remains the top mode of transport for both commuting (60 per cent) and personal travel (61 per cent), according to the research Visa commissioned.

Australasia sees the highest car use, with 72 per cent of respondents driving to and from work, school or university, and 77 per cent doing so for personal travel. **North America** isn't far behind, with 70 per cent of people using a car for their commute and 68 per cent for personal travel. **Europe** and **Asia** see significantly lower car use, with **Africa** the lowest with 47 per cent of respondents using a car to commute and 46 per cent for personal journeys.



As well as the impact on road congestion, a high number of cars on the road has a detrimental impact on the environment, with air pollution levels in many cities having a negative effect on citizens' health.

Research from universities in Oxford and Bath found that air pollution from cars and vans leads to health bills of close to £6 billion per year in the UK[8]. The cost to the UK's National Health Service and society is highest in cities, with the average health cost of a car in inner London standing at £8,000 for the vehicle's lifetime, and that for diesel vehicles costing twice that.

In response to these issues, the EU plans to halve the use of conventionally fuelled cars in urban areas by 2030, and phase them out completely by 2050[9].

In Hamburg, one of the cities included in the Visa research, there are plans to ban cars from a number of roads to convert them to pedestrian and bike zones by 2034[10]. The same city was also the first in Germany to ban some older diesel cars from its centre[11], following national legislation giving cities the right to put such measures in place to improve air quality.

Car use is less pronounced for younger people, with only 42 per cent of Generation Z respondents using a car to get to work, school or university, or for personal travel. In comparison, 67 per cent of Millennials use a private car for either work or personal travel, with 61 per cent of Generation X and 59 per cent of Baby Boomers using a car for work, and 66 per cent of both generations using cars for personal travel.

The lower car use seen with Generation Z has been attributed to various factors[12], including rising car insurance costs, a decline in disposable income, environmental concerns, and people waiting longer to have children, meaning that a car is not seen as a necessity until later in life. In addition, owning and regularly using a car in congested cities with well-established public transport networks may seem impractical, particularly when car share – in which people rent cars parked near to their location by the day or hour – is an option. This appears to be an alternative that younger people are more open to than older generations, according to our research.

Parking space

What do car owners want? An easier journey.

With so many people driving in modern cities, the most disliked aspect of driving is attempting to find a **parking space**, cited by 64 per cent of those surveyed by the research commissioned by Visa. **Baby Boomers** and **Generation X** tend to dislike this aspect to a greater extent than **Millennials** and **Generation Z**.

This is followed by the risk of getting a fine if you park longer than anticipated (44 per cent) and paying more for parking time than needed (42 per cent).

Tolls and road charging systems were another source of annoyance, with queuing to pay a toll the most disliked aspect (42 per cent), followed by being uncertain whether you're in an area where you have to pay for road usage, such as a congestion charging zone (31 per cent).

Fuel available

Refuelling is a major aspect of driving that users of **public transport** don't have to consider. When asked what innovations they would be happy to see introduced to make refuelling easier, 47 per cent of people who use a personal car chose a mobile app that advises users of the cheapest fuel available in the local area, while 42 per cent expressed interest in an in-car system that performs the same function. In addition, 35 per cent cited a mobile app that recognises the petrol station you're at and debits your account for the fuel that goes into the car, with 31 per cent keen on an in-car system that does this.

Looking to the future

Such issues are likely to become more important in some parts of the world in the coming decades. For example, the increase in personal wealth across Asia is likely to lead to an increase in car ownership. New car sales in China in particular are forecast to grow strongly[13] due to a growing population and increased urbanisation. However, this will be tempered by the fact that new car sales in China are regulated by the government to ensure its cities are still able to function. Despite this, increased car sales will inevitably put more pressure on road infrastructure in cities.

But there are competing pressures to contend with that impact investment in highways and mass transit systems in the megacities of the future. For instance, there's demand for urban land upon which to build roads and parking facilities.

While the future of car use in the world's megacities looks mixed, 57 per cent of respondents said they'd be likely to use driverless cars. This varied across generations, with 40 per cent of Baby Boomers responding in the affirmative, compared to 62 per cent of Millennials.

A future where people are travelling in autonomous cars or using modes of transport with full internet connectivity would improve the travel experience for many people. In such a future, respondents said they would like to be able to watch more TV (31 per cent vs 21 per cent) or do more work (20 per cent vs 16 per cent) while travelling than they do today. The increased ability to focus on other activities while travelling could potentially improve quality of life by making journeys both more relaxing and more productive, contributing to a better work-life balance.

6| Hunger for Innovation

Perhaps because of frustrations with using public and private transport, there is an appetite from consumers to try new things. The rise of taxi hailing apps is a case in point, with 43 per cent of respondents already making use of them and a further 32 per cent willing to try them. There were generational differences within this: 59 per cent of Baby Boomers have tried or are willing to try taxi hailing apps, compared to 80 per cent of Millennials.

Visa | View

In order to make a shared economy work, we need rethink commerce - moving from a single payment transaction to a multiple payment transaction and how can this be facilitated securely and easily.

We also need to examine and support the ancillary services such as insurance as the liability shifts.

Car sharing

Car sharing services or mobility-as-a-service solutions, such as Zipcar or GetAround, are also gaining traction, with the research commissioned by Visa finding that 40 per cent of respondents are willing to try them and a further 20 per cent have already done so, and prepared to do so again. **Across the generations, 62 per cent of Generation Z respondents and 67 per cent of Millennials expressed interest in using these types of services, compared to 44 per cent of Baby Boomers.**

It seems people are open to innovations in transport technology – such as apps that provide clarity and improve convenience – if they can help them to avoid congestion or find fuel. (As well as the innovations mentioned above, 28 per cent of respondents who travel by personal car said they'd be happy to see the introduction of number plate recognition systems that can automatically debit drivers' bank accounts for the fuel they buy.)

However, innovations related to modes of transport themselves had less positive perceptions: 43 per cent of respondents are unwilling to try scooter rental, with 46 per cent citing concerns around safety. In addition, 37 per cent said they would be unwilling to try driverless taxis, with 60 per cent saying safety concerns could deter them.

New innovations

One finding of particular interest for urban transport authorities and services providers is that consumers would be more likely to use public transport if the associated technology were improved:

50 per cent of people open to new innovations said they would be more likely to use public transport if they had access to a consolidated app that allows them to plan and pay for journeys across a mix of public transport.

Younger generations are more convinced of the value of such a service: 64 per cent of Generation Z and 55 per cent of Millennials said they would be more willing to use public transport if they could use such an app, while Generation X and Baby Boomers were more circumspect (42 per cent and 32 per cent respectively).

7| Safety – Security – Reliability

Safety is an important consideration across all regions when it comes to choosing a mode of transport, with 78 per cent of respondents saying it's either quite important or very important. In addition, 76 per cent said both reliability and time to reach a destination influence their decisions to use different transport methods.

For public modes of transport, safety is less of a barrier than for private methods, with 27 per cent of respondents saying safety is the main issue that would make them avoid tubes/subways/rapid transit systems. The figure was 26 per cent for trains and 24 per cent for boats/ferries.

But when it comes to private modes of transport, 46 per cent said safety was the main issue that would make them avoid cycling and 39 per cent said the same for using cars/motorbikes/scooters – this figure rose to 47 per cent for cities with high public transport usage. The concerns are well founded in some cities: Transport for London figures showed that, of the 131 people killed on the UK capital's roads in 2017, 114 (87 per cent) were walking, cycling or riding motorcycles[14].

The other major area of concern is security of personal data. This is hardly surprising given data breaches like the one suffered by Uber in 2016, which saw the personal data of 57 million customers and drivers compromised by hackers[15].

Data privacy

Despite these concerns, many people are open to sharing personal data if it improves their travel experience. A sizeable 46 per cent said they would be deterred from using new ways to pay for public transport due to concerns about data privacy, and yet 51 per cent would 'probably' or 'definitely' share their location data if it was used to improve their transport experience. Millennials were particularly open to sharing their location data, with 57 per cent prepared to do so, compared to 48 per cent of Generation Z, 46 per cent of Generation X, and just 37 per cent of Baby Boomers.

8| City Comparisons

When looking at the factors that impact public transport usage, it's instructive to look at what the data revealed about certain cities around the world.

For example, commuting times in some cities have risen more than in others. Mumbai had the highest proportion of respondents (62 per cent) who said their commutes had become longer over the past five years, followed by Delhi and Dubai (both 61 per cent). These cities also made up the top three in terms of people who expect their commute to increase further over the next five years.

It's no coincidence that these three cities are rapidly growing megacities with transport infrastructure that is struggling to keep up. In the case of Dubai, however, the greater wealth of the country is likely to mean more money is available to improve roads and public transport to alleviate the problems.

In contrast, Tokyo (28 per cent) and Osaka (26 per cent) in Japan and Busan in Korea (26 per cent) – which all have well-established, modern public transport systems and slowing population growth – were among the cities with the lowest proportion of respondents who felt their commute had increased in the past five years. The same three cities were also among the lowest in terms of respondents who feel their commutes will increase.

Sao Paulo and Rio de Janeiro, however, showed relatively high proportions of respondents saying their commute times have increased (53 per cent and 54 per cent, respectively), but low proportions expecting commutes to increase further (21 per cent and 24 per cent). This contrast could be related to transport infrastructure improvements made for the global sports events held in Brazil in recent years.

Car usage varied widely across the cities in the survey. The highest car usage for work, school or university was in Los Angeles (83 per cent), Shanghai (also 83 per cent), Beijing (81 per cent) and Delhi (78 per cent). The lowest was in Alexandria (16 per cent), Tokyo (23 per cent), Osaka (27 per cent), Cairo (29 per cent) and London (39 per cent). The highest car usage for personal journeys was also in Los Angeles, along with Beijing and Melbourne (all 80 per cent), with Alexandria again the lowest at 15 per cent.

The cities with the highest car usage are often the most sprawling, meaning public transport is less able to serve all areas (Los Angeles is often described as a city where 'everyone' drives), but also where large sections of society have high disposable incomes to spend on cars. The low figures in Japan and London could be attributed to the widespread and sophisticated public transport systems present in those cities. In Egypt, Cairo has a big problem with road congestion and has a metro system, but lower levels of wealth may also contribute to lower car use there, as well as in Alexandria.

In terms of reasons for people to avoid public transport, overcrowding was cited as more of an issue in Brazil's Sao Paulo (77 per cent), China's Shanghai (76 per cent) and India's Delhi (74 per cent), with the other cities surveyed in those countries (Rio, Beijing and Mumbai) not far behind. These are rapidly growing cities with huge populations needing to get around. Overcrowding was less of a concern in Berlin (60 per cent), Osaka (58 per cent) and Hamburg (the lowest at 55 per cent). These cities aren't growing at the same rate and have well-established public transport systems to serve current populations.

Cities and countries analysed in this study

Mumbai had the highest proportion of respondents (62 per cent) who said their commutes had become longer over the past five years, followed by Delhi and Dubai (both 61 per cent).

Mumbai and Delhi (both 38 per cent), Mexico City (37 per cent) and Cairo (35 per cent), with the smallest increases in St Petersburg (18 per cent), London and Sydney (both 20 per cent).

Ease/speed of payment was most important in Delhi (80 per cent), Sao Paulo (79 per cent) and Mumbai (77 per cent).

Tokyo (28 per cent) and Osaka (26 per cent) in Japan and Busan in Korea (26 per cent) – which all have well-established, modern public transport systems and slowing population growth – were among the cities with the lowest proportion of respondents who felt their commute had increased in the past five years.

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Visa | View

We continue to trend towards globalisation. Along with an increase in travel will be increased expectations for consumer-friendly experiences wherever they go. Visitors will want the same payment experience that a local has. Removing the need to register or sign up for a fare card to use multi-modal transit will require a joined-up network and standards-based approach to reach critical mass.

Over time, we need to see a consolidation at the commerce level to improve access.

The cities with the highest figures have relatively immature public transport systems, meaning payment is an area that has had less time to evolve, while the other cities have had more time to develop their payment systems to meet customer expectations.

London's Oyster card, first introduced on the London Underground in 2003, is often cited as a well-implemented transport payment system. Roughly 100 million Oyster cards have been used to date, setting the stage for the success of open-loop payments (paying directly with a debit or credit card), enabling London's buses to become completely cashless .

The extent to which people said they would use public transport more if it was easier to pay reflected the maturity of public transport systems in different cities. The biggest increases were expected in Mumbai and Delhi (both 38 per cent), Mexico City (37 per cent) and Cairo (35 per cent), with the smallest increases in St Petersburg (18 per cent), London and Sydney (both 20 per cent).

The picture was broadly similar in terms of how much more likely people open to new innovations would be to use public transport if they had access to a consolidated app to plan journeys across different modes of public transport and to pay their fares. The biggest increases were expected in Beijing (84 per cent), Delhi (83 per cent) and Cairo (75 per cent), with the smallest increases in London (34 per cent), Paris (33 per cent), Tokyo (31 per cent) and Osaka (29 per cent).

9| How to Drive a Move to Mass Transit

Our research shows that congestion, over-crowding and safety are all significant barriers to the efficient, reliable and scalable transport that modern megacities and their citizens need. While sometimes this will require large infrastructure projects, this study reveals that these issues can also be effectively tackled through improved tools and processes for a fraction of the cost.

While there is a need to increase overall capacity of transport networks, particularly as cities grow and more megacities emerge, innovation to tackle existing problems could bring huge benefits for citizens and boost the usage of public transport in many cities. This would in turn bring additional benefits such as reducing air pollution and congestion, and improving mental health in growing cities and megacities around the world.

As mentioned, getting new transport systems into vast and growing cities is a huge task that could be held back by high costs, a lack of political will or a lack of public sentiment to having large swathes of the city ripped up. Just think of Boston's 'Big Dig', which at the time was the most expensive highway project in the US. Estimated to be completed in 1998, it was eventually completed in December 2007 at a much higher cost than planned after being beset by various issues. Instead, focusing on the areas that can be improved more quickly and cost effectively will be crucial, at least in the short term.

The concept of marginal gains – in which a series of small, cost-effective changes can add up to significant overall improvement – is important here and is something supported by Visa's data.

For example, making it easier for people to pay for transit via open-loop methods or to buy and pay for transport tickets through a reliable and easy-to-use mobile app will reduce the need for people to queue to buy tickets during the Monday morning rush hour. Or improving theability for people to plan their journeys in a way that intelligently routes them around potential bottlenecks would make commutes quicker and more efficient.

Improving the ability to share real-time and longer-term trend data would support these kinds of innovations. Flows of information can help manage the flows of people, traffic and other moveable elements in a transport network, providing a way to react to immediate issues. But such information can also help prepare for future needs and innovate new processes to alleviate the impact of small operational problems (such as a signal failure, a faulty subway train or an area of unexpected congestion) on the wider network. Resilience is a key part of urban planning, avoiding bottlenecks where one item of infrastructure can disproportionately affect a city if it fails.

Added together, the benefits these changes could bring would lead to a major improvement to the overall travel experience.

Visa | View

We think that journeys will increasingly be multi-modal (e.g., car share to train to bike share). We need to think about how disparate ecosystems can come together from a payments perspective to give people a joined-up commerce experience. Payments is the connection between these various modes of transportation, so we need to make it as frictionless as possible.

And improvements to the transport experience can bring wider economic benefits. There is scope to bring more people to the high street by providing better car parking facilities or bike lanes and bike parking, for instance. This would improve the economic outlook for bricks-and-mortar retailers, as the experience of visiting physical shops will become more appealing.

To make these kinds of changes possible, the future of transport will be all about building partnerships to make scalable improvements. There is a major opportunity to do this in all of the cities covered by our research, with public transport authorities, transport service providers, local and regional government, and payments technology providers (such as Visa), and the people who use the services all able to contribute.

With our research revealing that half of people open to new innovations would be more likely to use public transport if they had access to a consolidated app that allowed them to plan journeys across a mix of public transport and to pay their fares, there is clearly scope for collaboration among different stakeholders to have a positive impact on customer experience.

The insights from this research should help all of these stakeholders improve transportation in existing and emerging megacities, by highlighting the issues that consumers are most concerned about in each location. In turn, this will inform transport innovations and policy to ensure that transport will be able to evolve and develop in a way that supports the increasing demand and changing needs of people living in the world's megacities and beyond.

Technology Landscape Survey

10 Technology Landscape Survey

Cities are Facing Congestion and Strained Infrastructure

The role of cities is increasingly important in terms of population[17], economy and technology - with urban populations rapidly increasing, a GDP per capita typically double that of rural areas[18], and the target for most R&D investment in technology[19]. However, cities are also facing challenges. Notably, the way people move causes many pain-points in everyday life when highways are congested, public transport is overcrowded, and environments feel unsafe. Movement within cities currently constitute two-thirds of all distance traveled by people, and this is set to increase with urbanization and gridlock.

By 2050 the average urban driver will spend 106 hours a year in gridlock if current trends hold – a doubling compared to today[20].

The costs of congestion are significant – potentially costing countries 0.5 to 5% of annual GDP[21].

Simultaneous with the increased importance of cities, we are also seeing rapid advances in technology that is characterized by breakthroughs in fields such as artificial intelligence, robotics, nano-technology, quantum computing, wireless technologies and fully autonomous vehicles. Consequently, we are seeing exponential pace of development that is commercially driven and focused on urban markets. Given the demand and concentrated nature of Big Data on movement, cities are an ideal environment for development and learning. This also affects in a shift in how we view infrastructure, as innovations such as ridesharing and mapping applications can be included as key digital infrastructure for mobility.

It is possible to address some of the pain-points associated with moving within a city, so that not all solutions require investment in physical infrastructure by cash-strapped public transport agencies.

The aim of the Future of Technology overview is to show how current applications of technology can provide solutions for mobility in cities, with a focus on consumer pain-points[22] – such as making mass-transit systems cleaner, safer, more efficient and reliable, and making it easier for those who drive to find and pay for parking and fuel.

The global cost of congestion – traffic jams are estimated to depreciate the global economy with $1.4 trillion annually[23]– will increase with the number of cars doubling from 1.1 billion to 2 billion by the year 2030.

Much of this development is driven by developing countries that are already facing lacking infrastructure[24]. Challenges and the impact of applying the solutions listed in this report – either by private enterprise or city governments – will vary. It is likely that a European city with centuries old infrastructure will require different solutions than a newly developed city in the Middle East.
The applications listed here therefore serves as a list with options for further evaluation in each context. Some applications have uses aimed for public mass-transit operators, while others are likely to be used by private enterprise and this might also vary depending on the local setting.

In the following sections that relate to specific pain-points of mobility, each section briefly covers relevant technologies and lists applications.

11 | Technology Solutions

Technology and Big Data make it possible to understand cities

It is now possible to identify activities within cities in unprecedented ways because of the internet of things and increasing amounts of urban big data that can tell us how various policies, development, and activity impacts the economy. For example, using application data such as Yelp restaurant reviews can suggest that a city should send their health inspectors to restaurants where reviews mention cleanliness[26]. LinkedIn search activity can provide a day-by-day measure of job search behavior, impact of changes in employment policy, and how various parts of a city are connected professionally[26]. Digitalized records, such as building permits and social benefits can provide valuable insight towards how a neighborhood is changing[27].

Visa | View

Artificial Intelligence in combination with Big Data can be used to crunch huge amounts of data about behaviour and trends – both historical and real time – to anticipate demand and ensure that trains, cars, buses, etc, are where they are needed in a timely way. More importantly, real-time data can direct MAAS users to where there is spare capacity based on actual conditions. By creating a system that works in a predictive manner to ensure that assets are in place where they will be needed as well as directing users to where there is less congestion, cities, transit operators and private companies can create a vastly improved consumer experience.

From a conceptual standpoint, this type of data is broadly categorized into four categories :

- Digitalization of records. Increasingly digitalized public and private records such as geo-located crime data, building permits and credit card transactions.
- Application provided information on user preferences. Searches on Zillow, reviews on Yelp and similar applications can identify the preferences of users.
- Sensor information on the urban environment. Sensors across cities can tell us where people are, pollution, light, and what type of activities that are taking place at various places (such as shopping, eating or drinking).
- Sensor information on movement. Most notably, identification of movement through smartphones is part of this category, but also network connected cars and public transport.

Besides relating to how people move from point A to B, movement is now a data generating activity that creates better consumer profiles for marketing campaigns, market analysis, risk management and pricing. Examples of how consumer profiling based on location is applied are car insurance premiums set by where the car is typically driven, and that Google provides adds based on geographical location.

For the purpose of making mobility – both in terms of mass-transit and cars – more efficient, an understanding of movement is highly valuable for applications such as introduction of new routes based on understanding of how people move between areas[29].

Visa | View

Data shared from private industry – particularly payments – can provide insight such as peak times for commerce, where people are shopping, parking, when people are traveling and from where. This can help provide valuable information that can help plan additional states, parking, add bus lines, etc.

If done in an anonymized way, sharing no individual's identifiable information data convergence improves consumer profiling and enables for context-based intelligence – so that we know that someone is at a coffee shop (as their device location and mapping data is converged) and we can understand where they came from and how they got there. One potential application is for immediate and targeted campaigns – perhaps an offering for nearby food that matches their mutual preferences (say through order history on UberEats) pops up on their phones. However, any system that relies on data would need to have a foundation of consumer awareness, trust and consent for this to be applied.

From a policy perspective, digital cities with converged data layers of social activity, commercial transactions and movement offer unprecedented ways of ways of evaluation. Rather than asking citizens if they want to pay for an urban park, city officials will be able to see if movement changes when someone has the choice of walking through a standard streets-cape or through a park[30] . When urban big data is crossed with an exogenous event such as a new means of payment for public transport, tolls, or a new subway line, the economic impact will be possible to pin point in ways that have not been previously possible. Not only will this give insight into how development has impacted cities but will also provide valuable tools for city government and commercial actors on what policies and investments to undertake in the future. As an example, seeing when millennials are spending more time in new and 'cooler' areas is a likely predictor of gentrification.

This development requires that privacy concerns are addressed. Notably, recent development of encryption technologies allows for conclusions to be drawn, while still not decrypting the data[31]. searches, sorting and computations without decryption is challenging, but offers new possibilities for data collection and analysis without threatening personal integrity.

11.1 | Technology Solutions for Mass-Transit

Safety in Urban Environments

Movement identification is relevant in relation to the finding that reliability and travel time are the second and third most important factors for consumers when making their choice of transportation mode (after safety)[32]. Initially, the results highlight the importance of the basics – getting it right in terms of cleanliness and security. But also, efficiency, reliability and ease of payment is important. Below are sections that cover each pain-point with applications that can provide solutions.

Visa | View

All the services discussed in this research rely on an "always on / always available" connectivity infrastructure. Even though we have capabilities to offer offline solutions such as London's TfL network, for a seamless experience – particularly for real-time insights – then development of a robust infrastructure such as 5G is required.

Safety in Urban Environments

From a technology point of view, ways of monitoring environments through sensors that detect movement and activities together with algorithms that analyze such data is highly relevant for the provision of safe environments. Sensors and AI for interpretation of the inputs are significant in this context. Notably, Automated Face Recognition, AFR, algorithms can use identification as a way of tracking movement, facilitating payment, understanding facial expressions to identify if someone is tired and so on. This kind of algorithm is what enables Facebook to automatically tag someone in a photo – by comparing facial features with photos a person has been previously tagged in, and if it is sufficiently similar an automatic tagging will be suggested on new photos.

Below are listed applications of technologies that improve security within urban environments:

- Over 90 U.S. cities have sensors that detect gun-shot noise and automatically notifies law enforcement (there is an app on police officer's phones[33]. Triangulation of sound waves enables for identification of the location of the gun, which both allows for faster reaction by law enforcement and provides a database of crime that can be used for better understanding of patterns of crime. There is however question regarding if this reduces gun related crime[34].

- **Anomaly Detection** refers to intelligent monitoring through sensors and systems that can detect suspicious activities from video and audio surveillance[35]. Technologies that identify behaviors such as someone raising a fist against someone else, a car slowing down as it approaches someone who is walking alone at night, or a person who browses into parked cars. AI algorithms learn from increasing amounts of data, so that abnormal behavior – such as an assault – can be filtered out from normal behavior. An alert from the system results in a police officer zooming in on the cameras and sending the same video to police cars[36].

A smaller study on the efficiency of a suggested system for anomaly detection through video surveillance found that after a learning period of 1 week, the system was exact enough to reach a false alarm rate of 2.2% and a 91% identification rate of actual suspicious behavior. The system was less efficient in large crowds and is more suitable for places with fewer people such as building entrances[37].

- **Video Content Analytics** coupled with block chain technology can create chains of evidence[38]. This is already implemented as part of video content solutions, so that CCTV footage not only identifies suspects, but also (as described by the company Kinesense); "has a built in hashing technology that secures digital evidence from the point of ingestion, through review and to the creation of reports. These hashes can confirm the authenticity of any exported evidential report and prove the chain of custody."[39]

- Crime sensing using big data[40]. Social media data, such as posts on Twitter could potentially provide important information on crime. A field of research on computational criminology covers this type of study, with recent findings indicating that there is still more need for research on how to use this type of data together with software that analyses text to understand real-life occurrences of crime, although studies point towards it having predictive power[41].

- **Automatic Facial Recognition**, AFR, solutions can integrate with existing video surveillance systems for identifying individuals[42]. NeoFaceWatch and Kinesense are two companies that develop this type of product that offer services aimed at various security needs, such as law enforcement and airport security, but also for civil identification purposes such as for banking and financial services. In Britain, this technology has already led arrests of a criminal that was identified in a large crowd[43]. AFR technology is most widely applied in China, where the government recently identified a suspect at a concert with 60 000 people when AFR was linked to CCTV footage[44].

- Another relevant technology is **Automatic Number Plate Recognition, ANPR**. Reading of number plates is already applied in large parts of the world, with police cars scanning the environment for cars reported to be of interest. This type of technology can have a wide variety of applications, such as for payment of tolls, such as in Stockholm, Sweden[45]. There are several algorithms associated with this type of technology, with Optical Character Recognition (OCR) reading the number plate, and other technologies that identify cars and the location of the number plate.

- Lastly, databases with aggregated data on crime (that is geo-coded) also enables for identification of crime hot-spots, and more specifically geographically moving crime hot-spots, which can be used in models that predict crime so that police resources can be more efficiently allocated. These models are vastly superior to the work of human crime analysts, showing a 7.4% increase in crime prevention as a function of patrol time when such models are applied in randomized trials[46].

Making Cities Cleaner

Cleanliness is one of the most important drivers of consumer choice on travel, and a pain-point for many consumers – with **69% stating that cleanliness is important**[47].

Technologies that build on sensors that collect information, connectivity that communicate it, and algorithms that create insights provide several already available solutions that can make cities and public transport cleaner. A review by the company Mobileye on how the waste recycling industry is impacted by connecting devices – the Internet of Things, IoT – provides insight into how technology can be applied[48].

Below are listed are applications of technologies for waste management and recycling:

- Sensors that detect **overflowing trash bins** and vandalism are sold by the company Nordsense[49] which are already being installed across San Francisco[50]. With this data, pickups can be optimized and the speed of how quickly bins fill up can be predicted. This system has led to an 80% decline in overflowing and a 66% decline in street cleaning requests.
- Solutions specifically aimed at cleaning trains and busses are scarcer. **Solutions aimed at increasing efficiency and lowering costs for cleaning inside of trains** are provided by the company Vogelsang, that sells CleanUnit cleaning cabinets – a booth set up on train platforms and bus bays[51]. It includes all necessary cleaning equipment as well as water access. The company also offer automated solutions for disposal of toilet waste in trains and busses. Further advances in AI and robotics are likely to be necessary before automated cleaning solutions come to market.

Efficiency, Reliability and Overcrowding

Reliability and travel time are found to be the second and third most important factors for consumers when making their choice of transportation within cities. Similarly, overcrowding is also perceived as a significant pain-point[52].

Technologies that build on creating insight from movement of people are central to making public transport more efficient (i.e. decreasing travel-time) and reliable (i.e. minimizing delays and disruption).

Identification of crowds and travel patterns can make it possible to more efficiently mitigate overcrowding. Notably, this is made possible by smartphones and other connected devices – such as cars, taxis and buses – that continually upload their position though GPS[53]. This is what allows for applications such as navigation systems that returns the most efficient route while considering data movement of other vehicles.

An overview of smartphone applications (as of 2016) that influence travel choice is provided by the U.S. Department of Transportation,

and covers mobility applications such a ridesharing, parking, real-time information provision, and public transport apps (amongst others)[54].

From a technological point of view, a challenge lies in that GPS does not enable for tracking in indoor settings – most notably in subway systems. Indoor positioning systems (IPS) are systems that address this limitation and allow for indoor location-based services[55] (ILBS) such as tracking the location of products in a warehouse, devices at a hospital, and the provision of guidance tools for firemen in low visibility environments.

This is a market that has been valued at about USD 10 billion by the year 2020[56]. For mass market applications, cost is an important factor, and the major reason for why IPS systems typically use existing wireless communication infrastructures for positioning purposes[57], such as LTE, Wi-Fi, Bluetooth, and Wireless Sensor Networks (WSN). Wi-Fi is the most commonly used due to it being so persistent across cities, and WSNs are also common due it being a central part of the Internet of Things (IoT).

When other networks aren't available or if a closed system is desired, Wireless Sensor Networks[58] offer an alternative. These are networks of autonomous devices that monitor physical or environmental conditions. Each sensor sends information to a gateway that in turn provides connectivity to the rest of the wired world. Applications include patient monitoring in health care, sensors that collect system health data on the electricity grids and street lights, and provision of information on water and energy usage. This type of network can also provide a way to receive signals from devices – notably smartphones – and in turn return indoor locational data to the wired world through the gateway.

Communications between devices through near field communications (NFC) technology is what enables for smart-card ticketing[59], and even if these systems are primarily designed for ticketing various studies have used data from these systems to draw conclusions on mass-transit usage.

Below listed are technology applications that increase mass-transit efficiency and reliability:

- Wait times for buses can be shortened through **smartphone tracking**. Simulations in Chicago indicate that a smartphone-based system could cut wait time from 9 to 3 minutes when 20% of travelers' opt-in to participate[60]. It is also possible to estimate arrival times of buses by provision of real time information on the location of travelers through smartphones .

- GPS connected vehicles provides a good way of measuring congestion, in real-time, across a city[62]. Quantitative measures can be the ratio of average peak travel time to an off-peak/free-flow standard (so that 1.2 indicates a 20% longer peak travel-time compared to free-flow), travel delay, percent of congested vehicle-miles in relation to total vehicle-miles . With vehicles increasingly connected, the possibility to draw conclusions from this type of data could be used for road planning, knowledge on where to put additional resources for public transport, and other services where there is demand. Applications for trip-planning such as Waze provide real-time information on traffic and roadway incidents based on location data of vehicles.

Tracking systems

- Vehicle tracking systems can make public transport more efficient[64]. This type of **GPS system** is increasingly common in public transport and can be used to check schedule adherence of buses, automatic changes of bus signs, and through location triggering automatic announcements for passengers. Checking if a bus is following its route and if it is on time enables for real-time updates on delays and estimated travel time – a valuable service for passengers. An application that provide travelers with updates on travel-time and arrival is Tramtracker, in Australia[65].
  The company Swiftly develops this type of systems for real-time passenger predictions for public transport systems . Another company that sells analytics for public transport management is Moovel[67].

- **Using navigation-GPS data and Location Based Services (LBS)** data on movement of people, the company Streetlight Data develops analytics for travel patterns that make transport networks more efficient[68].

- Ridesharing firms such as Uber and Lyft use advanced algorithms to determine pricing and availability of drivers based on demand. Similarly, Micro transit firms and shuttle services are using movement data to predict demand. These types of applications use **algorithms that formulates routes and pick-up spots in real time**, based on demand. One illustration is the company Bridj , that runs an on-demand bus service in Sydney Australia . Similar services are Chariot (owned by Ford and operating in San Francisco, California and Austin, Texas) and Via (Chicago, Illinois) . Besides an application of technology (vehicle tracking, consumer profiling and algorithms), these services are also illustrative of the sharing economy and the trend towards mobility as a service.

Visa | View

Visa is leveraging current and new technologies to take advantage of secure connections to financial institutions – simplification means open-ing up to new partners such as transportation companies or platforms or looking into new form factors.

Behind the scenes, we are also improving back office offerings, making them flexible for online or offline, batch processing or real-time – al-ways with an eye to fraud prevention.

- To mitigate overcrowding, applications based on extensive of data from NFC passes (so called smart-cards) such as London's Oyster Card are relevant. This tells us the origin and destination of trips. Algorithms can use this to provide real time estimates of travel time so that users can make more informed decisions – avoiding congestion and consequently leading to less overcrowding. It also allows for analysis of factors that contribute to variation in travel time . In Seoul, South Korea, travel-times are continuously updated and shown on signboards across the city. In London, around 70% of commuters use an app such as Transport for London's journey planner that displays delays in real-time[75].

- **Algorithms applied to data from smart cards** can provide information on the purpose of trips. Someone who is taking a morning trip from a residential area to a commercial area, and then back in the evening, daily is probably going to work. Most recreational trips occur during off-hours. A model was found to accurately determine the purpose of a trip with work and home trips being correctly identified in 92% and 96% cases, respectively[76].

- **Smart card or contactless payment data identifies movement between various parts of a city**, telling us which neighborhoods are connected – such as neighborhood X and Y that might not be neighboring geographically but overlap considerably in terms of the people that spend time in them. **A potential use for this data would be to introduce direct travel routes**.

- **NFC signboards can send information on travel routes directly to someone's smartphone**. This would be an application similar to the smart shopping carts developed by Whole Foods, so that customers can upload shopping lists that updates when a product is put in the cart.

- Knowing where someone is going, and that they went there can also be used to **identify mis-choice or misuse of transportation**, i.e. that people do not take the most efficient route[78].

- **Location data and data on origin and destination of trips** can reveal where there are gaps in public transport and tell us the location of gaps between first-mile/last mile public transport availability[79].

- In addition to planning and demand modeling, **big data is used for predictive maintenance scheduling** of servicing of equipment, with fewer failures and increases in equipment life-span[80].

- Insight into movement patterns, can be used by **public transport operators** for event responses i.e. a breakdown or sports event can be analyzed from the perspective of which customers that are impacted and where alternative means of transportations should be deployed. If one knows patterns of individual users, there is also opportunity for personalized services such as sending texts or emails on change in service and advertisement for services along the route[81].

Making it Easy, Safe and Transparent to Pay

An essential part of making it easier to move around cities is payment – With 27 per cent of consumers stating that they would use more public transport if it was easier to pay and 50% would increase usage if there was a consolidated app that enables for both trip planning and payment. Various types of tickets at different modes of transport, complicated pricing structures and that it is time consuming to pay are pain-points experienced by consumers. Consequently, the ability to plan and pay for trips in a consolidated matter on your smart device, and that this application spans all modes of transport, is likely to increase mass-transit usage.

50%
Want an Easy
payment app

For current applications, technology relating to contactless payments are highly relevant. Credit cards, smartcards and devices such as smartphones typically use radio-frequency identification (RFID) that allows for uniquely identifying and tracking of objects through radio waves. A RFID system is based on a tag on the device or item that is identified, a reader that identifies tags by radio signals, and an antenna that directs these signals. Near field communications (NFC) devices are a sub-set of high-frequency RFID and is often used to allow consumer devices to communicate. It is the peer-to-peer communication ability that differentiates NFC – as devices act as both reader and tag – and enables for contactless payment solutions, such as payment through NFC enabled credit or debit cards. For public transport, it is increasingly common with contactless payments, and also the ability to pay with credit or debit cards – so no pre-bought pass is necessary.

Visa | View

While we need to continue the drive to contactless because it benefits both Public Transit Operators and consumers, we also need to look at the next generation technology that will eliminate the need for turnstiles

The role of Bluetooth and/or Wifi technology-enabled becomes increasingly important

NFC technology enables storing information on devices or in the cloud, so people can connect loyalty points, travel passes or payment credentials. Solutions such as Google Pay, Vodafone SmartPass or Softcard allow consumers to store their payment information on smartphones, as do retailers that have their own solutions for orders and payments such as Starbucks. Transactions through mobile devices are increasingly adopted across the world, and notably in developing countries to extend banking services to populations lacking necessary access to financial services (which is upwards of 50% of the world's population[82]). Mobile wallets are gaining popularity, with Chinese consumers taking the lead – Alipay (the online wallet provided by Chinese retailer Alibaba) and WeChat Pay handled 90% of mobile payments in China (totaling $16 trillion). The transaction volume handled by Apple Pay has gone up more than 500% since 2016, although that includes effects of introductions to new markets[83].

In terms of payment security, "Tokenization" is highly relevant in relation to mobile payments and refers to the process of protecting sensitive data through a random number called a token. Credit card fraud prevention is a common application, as the customer does not need to use their real credit card number for online purchases when using a token number instead. Tokenization is slightly different than encryption, as the purpose of the latter is to make information unreadable for anyone without a key while tokenization is about making a transaction without exposing sensitive data[84]. Tokenization is used when a credit or debit card is on file for subscription services, and with online retailers, and more recently mobile and online wallet solutions such as Apple Pay – there is in fact no actual credit card information on your phone that can be extracted by criminals.

In a longer-term perspective, developments of increasingly advanced algorithms for face recognition are relevant, as it is now possible to identify yourself using your face. A major benefit of this type of identification is that it is device independent – you could theoretically identify yourself everywhere so that you never need to carry any physical cash, card or smartphone and still be able to transact.

FaceID on iPhones is an example of this technology and can be linked to passwords and payment information.

Visa | View

The Role of Digital ID in the ecosystem is critical to the future. Digital Identification will be used to verify the payment as well as the person, linking the payment credentials with the driving credentials or transit pass.

Technologies can now detect faces quickly and with very high accuracy, based on both video and photos. The Chinese start-up Face++ develops a solution for mobile devices[85].
Facial recognition can offer convenience and increased security.

Recent developments in deep learning have made facial recognition algorithms efficient enough to be used for financial services[86].

Adoption of facial recognition for authorization of payments, security access and identification of criminals is more widely adopted in China, as a centralized database of ID photos exists, unlike in the United States. Applications now exist that not only verify identity through pictures of faces, but also verifies IDs and documents using insights and records coupled with advanced algorithms[87].

Below listed are current applications that make payments easier and safer:

- **Contactless payment based on NFC** offer the benefit of speed, taking almost half the time compared to traditional card payments or cash, saving approximately 15 seconds compared to cash and 7 seconds compared to card and pin-code payments[88]. To put that in perspective, in a line of 10 people, the 10th person saves 2.5 minutes in waiting time.

- **Carrier billing** After some form of identification – typically two-factor authentication – the mobile account is charged. This does not require any credit card or preregistration. Other payment solutions based on phones are SMS-payments, were the user sends a text message which in turn results in their phone bill or online wallet. This type of solution has been used for public transport – such as in Sweden. Today, most direct billing is done in smartphone applications, simplifying payment to one click.

- **Consolidation of payments** also adds simplicity for users, and in Hanover, Germany, public transport usage is billed in a single-month bill to users.

- **Mobile and online wallets** such as Amazon Payments and Google Wallet that allow users to store information necessary for purchases, such as passwords and credit card information in one place while tokenization keeps the data safe.

- Consolidated solutions for **payment and trip-planning** are in use in a few markets, notably Helsinki, Finland[89]. The application named Whim is developed by MaaS Global and allows for purchases of tickets, and combinations of private and public transport and even bike-sharing. Similar apps are developed by various companies, such as TripGo that allows for comparison and combination of modes of transport – public, private and commercial – and an API solution that allows for booking and payment[90]. Similarly, the company Moovel[91] offers an application that allows for searches, trip-planning and payment. Another application, used in Tel Aviv, Israel, is the HopOn for planning and payment, and an app that allows for controlling tickets even when offline[92]. In Switzerland, that national rail company cooperates with car- and bike sharing schemes. Although planning tools for multiple modes of transport are increasingly common, payment solutions spanning them all are less so.

- Other applications that are not consolidated – i.e. allows for trip-planning and payment across several modes of transport – are MuniMobile for fare payment within the San Francisco Municipal Transportation Agency system[93]. Examples of consolidated transit planners are Citymapper[94], Moovit[95] and Transit[96].

- Developments in **facial recognition** would offer a quick and easy way of payment – without lines and the need to carry a physical card. The Chinese company Baidu is in fact developing a system for people to pick up tickets for mass-transit by showing their face and are working with the government of Wuzhen, China, to use it for access to tourist destinations . Facial recognition on smartphones is already used on Alipay – the online wallet offered by Alibaba – so that people can pay with only their face as credential.

Visa | View

The most important question that we need to ask as we develop new solutions is that we challenge the ecosystem to include seniors, the un- or under-banked and those with physical challenges, to ensure that any solution includes all the components that can help these communities.

When designing the commerce ecosystem for the next generation of transportation, features and functionality need to be more basic, intui-tive and utilitarian for elderly or entrants into digital commerce while still retaining features that appeal to the digital native.

There should be thinking around different variations of apps, giving a simplified UI/UX that is intuitive for any demographic.

Amazon is working on a way of authentication so that shoppers can replace their password with a photo of their face. This type of verification selfie would have to be done in several angles to make sure that it's not just a stolen photo used for fraud purposes. In stores, it is not unthinkable that cameras coupled with facial recognition could provide a new way of payment. Basically, store infrastructure automatically connects with financial institutions and processes the payment, all based on facial recognition.

- Mobile near real-time bank transfers, with bank account information linked to phone number in applications such as digital wallet Venmo in the U.S., Swish in Sweden, MobilePay in Denmark and Vipps in Norway. Peer-to-peer payments can be made instantly, and companies also offer the ability to pay for products and services through these applications.

- **Identity fraud prevention** through blockchain would make it quicker and easier to pay as blockchain can be used to store identity information – so that authorized users can access this information and only known parties can verify transactions. Digital identity management allows consumers to control what information they want to share and enables for organizations to validate identity.

- It is possible to provide identification (for payments, among other things) through electronic IDs (eIDs). These are issued by many governments and take the form of a 'smart' id- card that when entered to a portable card reader allows for online identification when the user enters a correct Pin-code. It can also take the form of a smartphone application on which the user has a password or pin-code. When an organization requires identification – such as a bank or tax agency – they send a signal to the person's eID, so that identification is done when a correct password or code is entered. In Sweden, Mobile Bank Id is used by 73% of the population and is used for authentication by authorities, banks, health services and the instant payment service Swish. By October 2018, all organizations that deliver digital public service within the EU shall accept this type of identification.

- Facial recognition is also relevant in terms of payment security, with examples such as that the Chinese ridesharing company Didi, uses this technology for people to confirm that a driver is legitimate[98] and that in the U.S., the TSA is researching the possibility of using facial recognition to identify yourself when boarding a flight – replacing passports and IDs[99].

- Sweepstakes and contest API solutions such as HappyPay[100] allow for embedded customizable ways to gain customers and potentially users of public transport applications.

11.2 Technology Solutions for Cars

With advances in engineering towards greater autonomy and electrification, a major trend is that cars are becoming data gathering devices, that monitor environments and the driver, in addition to seamlessly making it possible to make purchases on the dashboard[101]. Current developments are resulting in increasingly intelligent AI based assistants[102] in cars, with algorithms that analyze speech an essential part. Automated Speech Recognition, ASR, or Natural Language Understanding, NLU, can now identify what is said, and by whom[103], with many applications for cars[104]. Algorithms that understand speech, movement, on-line sources, text, and aspects of the environment are rapidly converging[105] – allowing for AI based services that are increasingly intelligent that provide not only one specialized task, but various tasks.

AI assistants in cars provide a good illustration of how predictive analytics coupled with sensors and algorithms converge and enable for new services.

Visa | View

Voice activated assistants will become increasingly prevalent as they bring disparate apps such as City Mapper and other transportation / weather / traffic apps together and prompt appropriate suggestions in real time.

However, the use will be environment-dependent. While a voice-activated assistant may be ideal in an individual's car, using them in loud mass-transit environments will not be practical

This is why the value of the data gathered by a car is soon going to surpass that of the car itself[106], as sensors monitor the surrounding environment for mapping purposes and the mood and attention of the driver for safety applications – in addition to the car also collecting information on trip and purchase history.

Digital assistants will not only tell people what route to take, but also giving suggestions on products and services to buy on the way or at the destination. AI based assistants can create deep knowledge about destinations by understanding language, reading consumer reviews and articles – through algorithms that understand text – before using voice recognition to interact with the user to provide a destination for their needs. This type of AI is in fact developed by the company Here[107]. Driving monitoring systems that use sensors and technologies that detect if a driver is tired, or not paying attention can have a significant impact on safety, both in cars and public transport[108].

AI also enables for real-time predictions of travel and simulations, as GPS connected vehicles, sensors that detect traffic and construction, coupled with AI allows for both scenario analysis but also very accurate travel time estimates[109].

From the perspective of pain-points relating to car ridership, current applications that simplify finding parking and fuel, and payment of tolls and congestion charges are reviewed below.

Finding Parking

Finding parking is considered a major pain-point associated with travel by car (looking for parking in cities is the most disliked aspect of driving in cities according to consumers, with 64% identifying it as a pain-point).

In fact, U.S. drivers spend on average 17 hours a year looking for parking, and almost a third of drivers had been in a fight over a parking spot during the previous year[110].

Central to solutions that assist in finding parking, is mapping and real-time data – your car can already guide you to a parking garage, and sometimes the garage itself also has information on how many available spots there are on signboards (but this information might not be transmitted to the car). A major hurdle is then to have an inventory of parking spots, and also continually being able to see if there is a car on it – and this typically requires either physical infrastructure that senses if a spot is taken, or algorithms that use historical data and real-time information to predict the likelihood of a driver to find a space at a certain time and location. However, 57 million parking spaces United States and Europe are tracked by various applications that are used by 30 million people[111]. An issue with these apps is that city governments see their revenue from parking meters and fines decline[112]. The applications MonkeyParking and Sweetch that allow users to auction off their parking (if they have paid for more time than they need) has been banned from cities such as San Fransisco[113].

Below listed are applications that help users find a spot to park:

- ParkMobile[114] is an application with information on more than a million parking spots at 3,000 locations in North America. It is owned by BMW since 2016 and can be integrated into the car interface since 2018. It shows available garages, and in some cases also allows for payment of the parking fee in the car. Some garages also allow for opening the gate using a smartphone, and additional parking time can also be paid on the phone. Similar smartphone applications are Best-Parking, Parker, ParkMe ParkMe, ParkWhiz and SpotHero.

- The company Intrix collects traffic data and is a supplier to the navigation application Waze and adds their own user information to predict likelihoods of finding parking. Mapping solutions such as Waze and Google maps are working on integrating parking solutions.

- These services are integrating into cars, with applications such as Parkopedia and ParkMobile collaborating with Ford and Volvo to allow drivers to access parking services through the in-vehicle system, some of which are voice-activated[115].

- The city of Los Angeles has invested in sensors that track parking spots in downtown so that users can see availability through smartphone applications (such as LA Express Park[116].

- Applications can also make it possible for sharing parking spaces, so that users can rent out their driveway. One such application is Haystack that operates in Baltimore. Similar solutions are developed by city governments in Boston and Evanston[117].

Tolls and Congestion Charges

Tolls and congestion pricing are increasingly common across cities. Below listed are applications for payment that offer speed and convenience compared to payment booths – as queues associated with tolls is the biggest pain-point according to consumers.

- Payment of road tolls is sometimes done through number plate recognition – offering the benefit of not having to stop at payment stations. Payment through identification of vehicles through their number plates is applied in London and in Stockholm. The latter system was developed by IBM and automatically calculates the amount for every car and sends monthly invoices[118]. This provides an example of seamless linkage of sensor data and CRM systems that handle invoicing. If a car is not registered for automatic payment, an invoice is sent to the address of the owner as this information is held in a centralized database in Sweden.

- Vehicle Tracking systems have a potential application, as a car is continuously tracked through GPS. This can be used for insurance purposes (referred to as insurance telematics) as identification of how someone typically drives can be used to set insurance prices and prediction of payments. For tolls, it could have united consequences such a causing incentive to drive in areas not dimensioned for heavy traffic. The enabling technology is either installed by the auto manufacturer or subsequently installed. It is not only driving style, but also patterns that impact pricing – someone driving long distances during rush hour will be paying more than one who drives short distances during off-hours[119]. This type of data can also detect fraud, by analysis of driving patterns before an accident.

Visa | View

While tolls have been embracing new technologies for a decade, gas and parking are behind and are ripe for innovation. There is tremendous room for growth that could enable drive in / drive out for fuel and eliminate the need for a meter or pre-paid ticket to display when parking.

The shift from petrol-based services to electric charging stations is another area where data can play a tremendous role in helping to plan for mobile charging.

Finding and Paying for Fuel

Below listed are applications that help users find nearby gas-stations and compare prices . The reviewed solutions do not have a system for payment directly in the app, a likely consequence of gas-stations having little incentive to cooperate on this type of service.

- Gasbuddy is likely to be the best-known application with 60 million users and finds most of its information on prices from users who use the app at the pump – as users swipe their Gasbuddy card at the pump to get a discount. It also collects information on cleanliness of restrooms and service. GasGuru is a similar free app, and Geico offers a price comparison app.

- The application GetUpside allow users to send in pictures of their gas receipts and get a discount paid back by PayPal or check.

- Mapping solutions such as Waze and MapQuest are integrating fueling information, with the latter also allowing for restaurant reservations and information on traffic conditions in the application.

- AAA TripTik Planner is a free application that allows for planning of efficient routes with gas stations on the way.

- The mobile app Dash[121], that tells users if they are driving in a fuel-efficient way.

Autonomous vehicles

Technologies that enable for autonomous vehicles are rapidly developing. In human terms, Radar and Lidar constitute the "eyes" of an AV, and AI algorithms constitute the "brain" that analyses the percepts that are received from the Radar and Lidar beams.

AVs need to determine a precise location, in real-time, find obstacles, and do path planning. Software platforms use advanced vision algorithms to determine localization. Notably, these platforms need to work on multiple sensors on the vehicle that have a low-power usage and provide data in real-time[122]. Radars are based on sending radio waves, so that the time it takes for a radio wave to bounce back determines distance, and Lidar utilizes light energy so that the pulse hits an object and returns to the sensor. And while Lidar has the ability to send 160,000 such pulses per second, with an accuracy within one meter it is still not enough for an autonomous vehicle, where very precise identification of obstacles and objects is necessary – the car needs to know if a pedestrian is waiting at the sidewalk or has started to cross the street.

Solutions that couple high precision Radar (or Lidar) with AI are a central part of the development of autonomous vehicles as it enables for the AV to "see around corners" and identify potentially dangerous situations[123]. Technologies for increased autonomy, yet not without total disconnect from human involvement, are also developed. An example is a tele-operations platform that allows for remote operations of vehicles, so that a human can intervene in difficult conditions[124].

12| Future Developments

This Future of Technology overview has a focus on current applications of technology that can be applied within the near future to address pain-points associated with mass-transit and travel by car within cities. Although offering solutions, they are mostly incremental in nature. Looking forward, the bigger question is how movement by people within cities is changing? And what consequences will such change have?

What is clear, is that simultaneous trends are driving change – urbanization, the sharing economy, changing business models, and new technologies.

Technologies that enable for new ways of service-delivery are likely to change how people move. Increased working from home eliminates commuting trips and seamless ordering through Alexa or Siri replaces physical trips for consumption[125]. All of this raises new questions on when and where people will spend their time? And what will the impact on congestion be?

However, regardless of how and when we move, data convergence and overall trends point towards that mobility as a service will become increasingly integrated into the overall urban marketplace – with trip planning, purchasing and services in one interface.

It is likely that your voice operated digital assistant will follow you to a shared autonomous electric vehicle or subway, handle payment, give directions, plan your calendar and also provide suggestions on restaurants and shopping.

The emergence of autonomous vehicles, AVs, is likely to have a significant impact on movement within cities. These are likely to be shared and electric (so called shared autonomous electric vehicles, SAEVs). One such vehicle is believed to remove 9 to 13 cars from roads, therefore having a significant positive impact on congestion. A counterbalancing effect is however that people are likely to choose shared and autonomous vehicles over mass-transit[126]– there is therefore no consensus on the impact of this type of mobility service on congestion. However, the need for parking would decrease significantly, with one study predicting that the need would decline with 48% in Boston[127]. As significant portions of cities are used for parking purposes – such as 14% all land in the city of Los Angeles tied to parking[128] – this will have considerable impact for city planners that will have to decide what to do with this space. It has been predicted that shared autonomous vehicles will constitute 40% off all trips within an urban city centers (Boston)[129], and 25% of all auto passenger miles in the U.S. by 2030[131]– replacing both mass-transit and personal cars. In suburban settings, it will mainly take market share from personal cars. Researchers stress the need for policy and integration of AVs into the full ecosystem of mobility as part of influencing the mix of traffic mode. Consequently, applications for trip-planning and payment that cover various modes of transport will become more important.

Automakers are preparing for these changes, as illustrated by investments in carsharing and ridesharing applications[131] and technology relating to movement, such as autonomous vehicles and flying cars[132]. Data capture is also increasing with attempts to monetize data on user location and behavior through in-vehicle applications.

Often lacking in the debate about how we will move around cities is mention of mass-transit, which will remain the most efficient way of enabling millions of people to get from point a to b. This lack of attention is a likely consequence of change being less visible and relate more to how technology can be applied to operations and planning, as described in this Future of Technology overview. As private investment is driving technology and digital infrastructure, a challenge lies in that public entities run mass-transit, and that solutions for efficient and reliable movement requires coordination among many stakeholders across modes of transport. How policy will adapt to these changes is difficult to predict, but increased importance of private companies is a likely development.

To summarize, cities are facing both longer- and shorter-term challenges, and congestion and strained infrastructure are such that are imminent on the horizon. Out of the applications of technologies reviewed in this Future of Technology overview, none offer a solution that can be developed in isolation. A major challenge therefore lies in not only identifying relevant technologies that provide solutions that are suitable in the local setting, but also to manage implementation in concert with stakeholders such as mobility providers, technology companies, infrastructure owners and public transport agencies. And with increased involvement by private companies, there will also be increased need for action that protects consumer privacy.

About the Report

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Methodology

This study was conducted with 19,384 consumers living in either of the two biggest cities in 19 countries. All interviews were conducted online during July 2018.

The cities and countries covered were: Argentina (Buenos Aires, Cordoba), Australia (Sydney, Melbourne), Brazil (Rio de Janeiro, Sao Paulo), Canada (Toronto, Montreal), China (Shanghai, Beijing), Egypt (Cairo, Alexandria), France (Paris, Marseille), Germany (Berlin, Hamburg), India (Mumbai, Delhi), Japan (Tokyo, Osaka), Mexico (Mexico City, Guadalajara), Poland (Warsaw, Krakow), Russia (Moscow, Saint Petersburg), South Africa (Cape Town, Johannesburg), Sweden (Stockholm, Gothenburg), South Korea (Seoul, Busan), UAE (Dubai, Abu Dhabi), UK (London, Birmingham), US (New York, Los Angeles).

The respondents consisted of 65 per cent living in the inner city/centre and 35 per cent in the outer city and suburbs. More than half (55 per cent) were in full-time employment.

We asked people about the modes of transport they use, their commuting experience (including their biggest concerns), reasons for not choosing certain transport methods, and their views on payment for transport and different innovations that could impact their travelling experience.

Disclaimers

Appendix: Endnotes

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Notes:

About Visa Inc.

Visa Inc. (NYSE: V) is the world's leader in digital payments. Our mission is to connect the world through the most innovative, reliable and secure payment network - enabling individuals, businesses and economies to thrive. Our advanced global processing network, VisaNet, provides secure and reliable payments around the world, and is capable of handling more than 65,000 transaction messages a second. The company's relentless focus on innovation is a catalyst for the rapid growth of connected commerce on any device. As the world moves from analog to digital, Visa is applying our brand, products, people, network and scale to reshape the future of commerce. For more information, visit: https://vision.visaeurope.com/ and follow us at @VisaNewsEurope

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About Stanford's Disruptive Technology and Digital Cities Program

The mission of Stanford Engineering School's Disruptive Technology and Digital Cities Program is to transform commercially-viable technology into new opportunities for growth for existing Fortune Group companies. It is a first of its kind program in that the program also helps companies bridge the technology gap by helping them develop business modeling expertise to identify monetization opportunities. The program brings together faculty, Ph.D. students, and labs from the schools of Engineering, Law, Medicine, and Business. It is a one-stop clearinghouse for disruptive technology in Silicon Valley. Our members include Visa, Microsoft, Amazon, Cushman Wakefield, Blue Cross, and twenty five others – each company representing one industry segment.

The program was founded by Michael Steep, former Senior Vice President of Xerox PARC, and Ray Levitt, Emeritus Professor at Stanford Engineering School. Mr. Steep is Executive Director of the program and Adjunct Professor. He has a thirty-year track record as an operations executive in companies including Microsoft, HP, Apple, and PARC.

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