KEY INSIGHTS

> The incumbent system of personal mobility, based principally on private ownership of internal combustion engine vehicles, is collapsing under the weight of the rapidly accumulating negative externalities inherent in the system.

> As this elaborate system falters, numerous innovations are giving rise to a more sustainable system—one capable of addressing many of those negative externalities while delivering considerably more value to consumers.

> Although still in its nascent stage, the new system is rapidly solidifying around the provision of on-demand services across various modes of autonomous, connected, electric and shared transport.

> In order to successfully navigate the transition from the incumbent to new system, companies across the value chain must evolve their businesses or face displacement by new and existing competitors.

> For investors, this presents a compelling opportunity to deploy capital for the long-term, amidst an environment of generally low growth. However, it also signals a period of heightened risk, as investments with exposure to the decline of the incumbent system come under pressure.

> Overall, we believe it is critical to zoom-out in order to view personal mobility outside of the bounds of any single challenge, innovation or sector. We believe this broader, more holistic lens is what enables investors to identify and adapt to changes others have yet to see.
The Sustainability Insights Series draws on Generation’s deep base of proprietary research to provide readers a holistic view of developments occurring across key areas of the economy.

In the case of mobility, Generation’s proprietary research dates back to the firm’s inception and includes the following Roadmaps and Solutions Summits:

- **2004** Automobiles
- **2008** Fuel economy & emissions
- **2009**
- **2010** Sensors
- **2011** Market for electric vehicles: Transport & logistics
- **2012** Machine-to-machine
- **2013** Automobiles: Sharing economy – automotive Fuel cells
- **2014** Autonomous car: Connected car Sustainable Urbanisation*
- **2015** Fleet telematics: Future of mobility*
- **2016** Bus & rail go digital P2P car sharing Solar and storage Cyber security Automobiles

*Accompanied by Solutions Summits

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I. INTRODUCTION

The incumbent system of personal mobility, based principally on private ownership of internal combustion engine vehicles, is no longer sustainable in major urban areas. Although this system facilitated decades of economic growth throughout the 20th century, it also resulted in the mass accumulation of negative externalities related to public health, the climate and social inclusion. Today, the escalation of these indirect costs is driving the system towards breaking point.

However, as it falters, a more sustainable form of personal mobility is emerging. By harnessing innovations in technology, business models and policy, the new system, more suited to the realities of the 21st century, has the potential to avoid many of the negative externalities of the past while delivering considerably more value to consumers going forward. It centres on the use of on-demand services across various modes of autonomous, connected, electric and shared transport.

In this paper, we examine the transition from the incumbent to the new system through the broad lens of sustainability. Our aim is to provide investors with a holistic framework through which they may assess complex changes as they unfold. We begin with a description of the starting point, the incumbent system, and then examine how negative externalities are constraining growth. From there we explore the innovations in technology, business models and policy we see giving rise to more sustainable forms of mobility. We then share our vision for a new system.

II. THE INCUMBENT SYSTEM OF PERSONAL MOBILITY

Since the mid-20th century, consumers in urban areas have largely relied on privately-owned internal combustion engine vehicles (specifically cars and motorbikes) to meet the majority of their personal mobility needs, with services such as public transit and hired cars playing a supplementary role (‘The incumbent system’; see Diagram 1). While systems vary by urban area, due to differences in income levels, density and quality of public transit, most share these common characteristics.

The auto industry forms the backbone of this system, with each segment playing a key role in the provision of personal mobility products and services. The first segment includes ‘Tier-1 suppliers’ responsible for providing finished hardware and software components to car and motorcycle manufacturers, as well as lower tier suppliers of other component parts and raw materials. Whereas lower tier suppliers compete primarily on the basis of price, Tier-1 suppliers differentiate themselves on the function and reliability of their products. The next segment includes manufacturers, responsible for proprietary engine design and vehicle assembly. Their core value proposition comes from manufacturing complex products with near zero error rates. They also compete heavily on the basis of brand value to retail consumers. Manufacturers typically have close relationships with retail sales providers in the next segment of the value chain. This group includes the product dealerships responsible for developing a network of consumers at the point of sale. Lastly, a host of end service providers serve consumers throughout the lifetime of vehicle ownership, such as petrol stations (i.e. energy suppliers), consumer finance and insurance companies and other maintenance and service providers. Other types of vehicles, including buses and trains, originate from similar value chains, albeit with different technological specifications and end customer profiles.
**Diagram 1**

**Incumbent system of personal mobility**

> Centred on the use of privately-owned internal combustion engine vehicles with services playing a supplementary role
> Evolved from adoption of (i) internal combustion engine technology, (ii) private ownership and mass production business models and (iii) policies designed to maximise capacity for private vehicles
> Supported by hardware-driven value chain

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<th>TECHNOLOGY</th>
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<td>Internal combustion engine technology</td>
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**Diagram 2**

*‘In 50 years, every street in London will be buried under nine feet of manure’ (The Times, 1894)*

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With 300,000 horses in London and 100,000 in New York, each producing 15-35 pounds of manure a day, officials from both cities came together in 1889 to debate the ‘Great Horse Manure Crisis’ at the world’s first international urban planning conference.

Although the incumbent system has served consumers for close to a century, today it is giving way to new forms of personal mobility. To understand why, we first examine how negative externalities are constraining further growth of this system and then explore the innovations giving rise to a more compelling alternative.

**III. ACCUMULATED NEGATIVE EXTERNALITIES ARE CONSTRAINING THE INCUMBENT SYSTEM**

Negative externalities refer to tangible and intangible costs borne by third parties. They are the often unintended impacts of doing business. While tolerable at low levels, negative externalities can drive systems to breaking point once they cross unsustainable thresholds.

This was the case in the early 1900s during the last transition in personal mobility. After decades of economic growth and urbanisation following the Industrial Revolution, major cities, such as London and New York, had become crowded with people and horse-drawn vehicles. Piles of manure lined the streets, blocking the flow of traffic and spreading both disease and stench. As congestion increased, so did the number of road accidents, to the point of causing a greater number of human fatalities per capita than they do today. City officials spent their time continually removing not only manure, but also dead and injured horses from city limits. Moreover, with the radius of personal mobility limited, urban workers had little choice but to live in this unpleasant environment, fully absorbing the cost of negative externalities.

Today we see similar dynamics at play. Although the negative externalities associated with the incumbent system have not changed, the magnitude of their impact has. At current levels, these unintended consequences are severely impairing public health, the climate balance and social inclusion. To understand why, we explore three major developments occurring over the past 50 years.
DEVELOPMENT 1: GROWING CONGESTION CONTRIBUTING TO URBAN AIR AND NOISE POLLUTION AS WELL AS TRAFFIC ACCIDENTS

From 1965 to 2015, the urban population increased four-fold to four billion people and the stock of passenger cars and motorbikes grew six-fold to approximately 900 million units each.\(^9\) The expansion of urban infrastructure, however, has not kept up with this rapid pace of growth. As a consequence, congestion has now reached severe levels in cities around the world. Congestion not only slows the speed of commerce, but also takes a direct toll on public health. First, it increases urban air pollution, ‘the modern-day manure’, as the more time vehicles spend in traffic, the more particulate matter they emit. Air Quality Index values are now in frequent breach of the 0-100 level deemed as moderately safe.\(^10\) This causes millions of premature deaths each year, along with a higher incidence of respiratory illness.\(^11\) In addition, congestion contributes to stress levels, as it wastes time and raises noise levels.\(^12\) Furthermore, a growing number of vehicles in circulation also increases the likelihood of traffic accidents, responsible for killing 1.3 million people annually.\(^13\) Lastly, in many cities, congestion drives up the cost of housing in central areas due to the increasing desire on the part of those who can afford it to avoid an increased commute time. This pushes lower income earners, who cannot afford higher housing costs, farther outside of cities, causing them to disproportionately bear the time-burden of congestion.

DEVELOPMENT 2: RISING GREENHOUSE GAS EMISSIONS DISRUPTING THE CLIMATE

Over the past 50 years, the atmospheric concentration of carbon rose by 80 parts per million (ppm), 10-20% of which is attributable to the use of oil-derived fuels for passenger vehicles.\(^14\) With the atmospheric concentration now ‘permanently’ above 400 ppm,\(^15\) average global temperatures have risen more than 1.0°C above pre-Industrial levels.\(^16\) As a result of higher average, and also maximum temperatures, extreme weather events (e.g. more powerful cyclonic storms, heavier downpours and blizzards, larger floods and longer, deeper droughts) are occurring with greater frequency. Ice caps and glaciers are rapidly melting, which accelerates sea-level rise (a threat to the survival of island nations and coastal cities and towns), while also reducing the supply of fresh water.\(^17\) Should the concentration rise above 450 ppm, the level climate scientists associate with a +2.0°C average increase, not only could we see a non-linear intensification of these impacts, but we also run the risk of unleashing positive feedback loops capable of driving average temperatures well above +3.0°C.\(^18\) When temperatures reached these levels during the Pliocene,\(^19\) there were no continental glaciers in the northern hemisphere and sea levels were 10-25 metres higher.\(^20\) In light of these risks, the total cost of using oil and other fossil fuels to meet our energy needs is rapidly outweighing its benefits.

DEVELOPMENT 3: WIDENING GAP IN QUALITY OF ACCESS TO PERSONAL MOBILITY

During the same 1965-2015 time period, global income per-capita rose 17 times from USD 589 to 10,004,\(^21\) enabling millions of consumers to become car or motorbike owners for the first time. While motor vehicle ownership increased around the world, developing countries with average per-capita income of USD 3,000-10,000 experienced the fastest rate of growth (on average, more than twice as fast as developed countries).\(^22\) For example, in emerging economies in Asia,
motor vehicle ownership rose by 7-10% per annum versus the OECD country average of 3%.23 Cars and motorbikes, however, require extensive infrastructure in the form of highways, streets, traffic management systems and parking structures. A sharp rise in the number of vehicles therefore presented government officials with the challenging task of building out required infrastructure while still supporting public transit options for non-vehicle owners. In many cases, competition for mobility-related budgetary resources resulted in a negative feedback loop, whereby reduced spending on public transit caused the quality of the experience to decline, thus driving even greater numbers of users to switch to private vehicles. This in turn led to additional spending cuts and ultimately further reductions in quality.24 At the same time, this vicious circle also increased congestion, because motor vehicles move far fewer people per hour than public transit (see diagram). The result was a system of personal mobility with significant disparities in quality of access—with lower income earners limited to lower quality public transit and walking, medium income earners bearing the financial burden of vehicle ownership and high income earners unable to escape high levels of congestion despite benefitting from a broader range of options.25

With relatively high rates of growth in per-capita income expected to continue in Asia and other parts of the developing world,26 we see the incumbent system as reaching a limit to its ability to effectively serve a broad range of consumers. In the words of the former mayor of Bogotá, Enrique Peñalosa, ‘an advanced city is not one where even the poor use cars, but rather one where even the rich use public transport.’27

Today, policymakers, business leaders, entrepreneurs and consumers are much more aware of the consequences of all three areas of accumulating negative externalities, and as such are driving a shift towards a more sustainable system.

IV. INNOVATION IS ENABLING THE ADOPTION OF A MORE SUSTAINABLE SYSTEM

With the incumbent system facing meaningful challenges, innovators are introducing more sustainable forms of personal mobility, capable of avoiding many of the negative consequences of the previous system, while delivering more value to consumers.

This also occurred during the last profound transition in personal mobility. In comparison to old 19th century system, the now incumbent system was: (i) free of horse-related negative externalities and (ii) offered consumers the freedom to move at higher speeds whenever and wherever they pleased. Its path to mass adoption began with technological innovations, most notably the introduction of electrical ignitions to internal combustion engine vehicles in 1911.28 It progressed in 1913 with the advent of a new business model based on moving assembly line production and the ‘living wage’ opened the door to an age of private ownership of mass produced vehicles.

Diagram 6 [66]

Family on motorbike

As developing countries have built out the extensive infrastructure required to support private vehicles, public transit has often suffered as a result.

Diagram 7 [71]

Moving assembly line production

The combination of moving assembly line product and the ‘living wage’ opened the door to an age of private ownership of mass produced vehicles.
growth in an otherwise depressed post-war economy.\textsuperscript{31} While the U.S. was the first to adopt this system, other countries soon followed.

Today, enterprising individuals are again harnessing the power of innovations in technology, business models and policy to drive adoption of more sustainable forms of personal mobility. We explore each of these areas in turn before bringing them together in the form of a new system.

**TECHNOLOGY INNOVATIONS**

Three types of technological innovations are revolutionising the personal mobility landscape: autonomy, connectivity and electrification.

> **Autonomy**

Autonomy refers to the use of software to perform tasks previously performed by humans. Increasingly sophisticated forms of autonomy are now possible following decades of simultaneous and mutually-reinforcing advancements in computer hardware, computer software and data storage. When applied to personal mobility, autonomy allows software programmes embedded in vehicles to take over responsibilities from drivers. It is often described across five levels, beginning with Level 1 of ‘no feet’ assistance in accelerating and/or braking and progressing to Level 5 of ‘no driver’ fully autonomous vehicles. Many premium vehicles already come with Level 1-2 features and Tesla’s Model S arguably has some Level 3 functionality.\textsuperscript{32} Several manufacturers are now working towards Level 4-5 with launch dates ranging from 2018 to 2025.\textsuperscript{33} The exact timing will depend on how quickly these players can complete the remaining software and data requirements needed for algorithms\textsuperscript{34} and mapping programmes.\textsuperscript{35} Another critical factor is the speed at which policymakers can draft and approve regulatory guidance.\textsuperscript{36} Initially, the use of autonomous vehicles is likely to be limited to fleet owners operating within select ‘geo-fenced’ smart cities. Densely populated, easily mapped, developed urban areas with mild climates make the best candidates.\textsuperscript{37} Over time, further advancements in regulation and mapping software will be needed to broaden adoption across geographic areas and into the hands of retail consumers.

Autonomy is a powerful tool for advancing personal mobility. Most significantly, it promises to greatly reduce driver-related accidents (i.e. 94\% of total). In recognition of this potential, policymakers in Europe, the U.S., Japan and Korea have already made five-star safety ratings contingent on the installation of automatic emergency braking based on intelligent sensors (set to go into effect in 2018). Among other knock-on effects, this development will eventually have a significant impact on the auto insurance business.\textsuperscript{38}

In addition to improved safety, autonomy is likely to improve the efficiency of travel, thus serving to reduce emissions and particulate matter while improving the consumer experience. Furthermore, autonomous vehicles can help to broaden personal mobility options for non-drivers, including the young, elderly and disabled. Finally, autonomy promises to free drivers from time spent operating machinery, initially by assisting them and eventually by removing their responsibilities altogether. Although many people enjoy driving on open roads, few enjoy doing so within congested urban areas.
Connectivity refers to the connection of people and objects to one another and to stores of information. In the context of personal mobility, connectivity has the power to transform vehicles from largely mechanical, disconnected entities into connected nodes within extensive webs of users, vehicles and infrastructure. In its basic form of ‘tethered connectivity’ (i.e. connection via smart phones or electronic devices), consumers are able to access services such as real-time navigation. In its more advanced form of ‘embedded connectivity’, vehicles are able to transmit sensor-generated data to the Cloud, potentially facilitating real-time vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. Connected vehicles may help alleviate negative externalities tied to congestion by improving traffic flow and safety features. With real-time data, transport authorities can dynamically charge congestion prices and manage traffic signals. In addition, manufacturers have the ability to push software updates to vehicles in real-time, addressing malfunctions when, or even before, they occur. Manufacturers have also been able to add more advanced safety features into vehicles, such as automatic emergency calls, which reduce response times to accidents. In terms of value to consumers, improved safety is particularly important, typically falling within buyers’ top three criteria. Reduced travel and servicing time due to more efficient navigation and automatic updates, in addition to a growing number of options for in-vehicle infotainment, are also attractive benefits.

Today, connectivity is advancing rapidly as part of the broader shift towards autonomy, taking it from a ‘nice-to-have’ to a ‘must-have’ in vehicles.

Electrification
Electrification applied to personal mobility refers to the incorporation of electric drivetrains and batteries into vehicles. This type of energy system can either function alongside internal combustion engines (i.e. plug-in hybrid vehicles ‘PHEV’) or independently (i.e. battery electric vehicles ‘BEV’). In internal combustion engine vehicles, the 200-part engine is the primary driver of both price and performance, while in electric vehicles the battery holds the key to both, as it accounts for 35-50% of the total cost and determines the range of the vehicle. Another key point of differentiation is the lack of a tailpipe, as BEVs do not produce emissions when driven.

In recent years, developments in both batteries and vehicle emissions standards have increased the attractiveness of electric vehicles relative to internal combustion engine vehicles. In terms of batteries, from 2008 to 2015, the average price fell by a factor of four, while energy density increased by a factor of five (see diagram below). Over the same period, regulators in major auto markets tightened fleet emissions standards for cars by an average of 20% (see policy innovation section), placing upwards pressure on cost. Today, electric vehicle penetration rates are still relatively low, with the estimated 1.3 million electric cars, 200 million electric motorbikes and 173,000 electric buses in circulation equating to less than 1% of total vehicles in most markets. However, these numbers do not reflect the significant investments made to-date by governments, battery manufacturers and vehicle manufacturers, which are accelerating adoption and pushing the market towards critical tipping points. For example, by 2017 electric cars will be available at a retail price under USD 30,000.
post-subsidy with a minimum range of 200 miles—two factors considered critical to mass-market adoption. With industry leaders planning to expand capacity to over 100 gigawatt hours by 2021 (see Diagram 13), we expect to see continued improvements in price driving even greater consumer demand and adoption.

Adoption at mass-market levels has the potential to significantly reduce negative externalities associated with the incumbent system. In contrast to internal combustion engine vehicles, electric vehicles do not emit carbon or particulate matter and produce little noise. The ability to locate the smaller sized engine in the back of the vehicle as opposed to the front (e.g. Tesla Model 3) also increases safety. These features promise to improve health and wellbeing issues. Furthermore, electric vehicles offer a compelling solution to reducing total ‘wheels-to-wheels’ carbon emissions. For one, they are more energy efficient than internal combustion engine vehicles—where only 1% of fuel consumed is used to move passengers and 13% to move the physical car, with the rest, 86%, lost to the engine, transmission and idling time. When combined with renewable power charging stations, they have the potential to reduce emissions from the vehicles themselves to almost zero.

Turning to the consumer, price typically ranks as the number one buying criterion when selecting a vehicle. In this respect, electric vehicles are becoming increasingly attractive relative to internal combustion engine vehicles and in terms of their payback period. As for overall experience, electric drivetrains offer faster acceleration and a quieter ride. They can also save time: consumers who drive fewer than 300 miles per day can leave their vehicles to charge overnight; maintenance and servicing demands are less frequent; and premium parking is increasingly available. These benefits are becoming even more attractive as ‘range anxiety’ declines in line with improved batteries and growing numbers of charge points.

**BUSINESS MODEL INNOVATIONS**

Just as Fordism unlocked the power of internal combustion engine vehicles, today sharing models in the form of multimodal, mobility-as-a-service (‘MaaS’) platforms, are laying the foundation for the spread of autonomous, connected and electric vehicles. Multimodal refers to different vehicle types, such as motorbikes, cars, buses, rail, boats and bikes. MaaS platforms refer to digital interfaces through which consumers can order and pay for on-demand, seamless, hyper-local, customised journeys.

Multimodal MaaS platforms rely on the power of network effects (see diagram). Although we have yet to see the development of a fully-fledged platform, we have seen companies in critical verticals consolidating user bases and broadening their
service offerings. Below we explore these developments and examine how multimodal MaaS platforms have the potential to provide consumers and society at large with a compelling value proposition.

> Building block 1: vehicle sharing platforms

Today there are several different types of vehicle sharing models in operation, including business-to-consumer (B2C), business-to-business (B2B), peer-to-peer (P2P) and ride-hailing platforms.

Under B2C sharing models, consumers rent vehicles for short periods of time through digital platforms. This model began in the car segment in the early 2000s when new entrants, such as ZipCar, disrupted the rental market through the use of digital service platforms as opposed to physical rental offices. Both incumbent rental car companies, such as Avis and Enterprise, and automotive companies, such as BMW and Daimler, have a strong presence in B2C car sharing after acquiring many of the original start-ups. This segment has now grown globally from 350,000 members in 2008 to two million today.

It has also spread across different types of vehicles. For example, bicycle-sharing programmes are now in place in over 600 cities worldwide. Operating companies typically run these schemes in conjunction with local governments aligned in providing alternatives to motorised transport over short distances. Electric scooter and motorcycle sharing is also taking off, with growing networks in cities such as Barcelona and San Francisco. We have also seen developments around bus sharing, such as with Didi’s 2015 launch of leased bus fleets intended to complement public transit options on popular routes.

In the B2B market, companies manage fleets of cars for corporates or communities, with the promise of increasing utilisation and ease of use in comparison to traditional leasing programmes. Services range from infrastructure management to financing to cleaning. In 2015, RCI Mobility launched its B2B business, Glide Mobility, after acquiring Nissan CarSharing. In the same year, Didi unveiled its Enterprise Solutions business segment.

The P2P model, ‘the Airbnb of vehicles’, aims to leverage underutilised assets by connecting private vehicle owners with renters. With cars parked an average of 96% of their useful lives, the economic rationale behind the model is strong. However, we have yet to see any one platform reach scale, despite attempts from numerous players such as iCarsClub, Drivy and Turo. This could change as companies find ways to boost user density.

Finally, ride-hailing offers vehicle sharing with the added service of a driver. Although it initially began in the hired car segment, it has now expanded into other modes, such as rickshaws and minibuses. Uber was arguably the first company to enter this market, with a platform offering on-demand car journeys, transparent wait times, seamless mobile payments and quality control via its two-way ratings system. Although Uber was able to complete over one billion trips in the span of five years, today the company faces stiff competition. Notably, in 2016 Uber sold its stake in China to Didi, its local rival. Didi completed two billion trips in less than four years by embedding its ride-hailing platform within China’s leading messaging service, Tencent’s WeChat platform.
CHANGES IN LOCAL POLICY

In London, the transport authority is dissuading the use of private vehicles by increasing fees in Congestion Charge and Low Emissions Zones, while at the same time incentivising alternatives, such as through the development of Cycle Superhighways, BRT lanes for low and zero emission buses and pedestrianised areas.

Similarly, in support of multimodal transport, policymakers in Bogotá have prioritised investments in public transit, cycling infrastructure and pedestrianised areas. TransMilenio BRT now moves 2.5m people per day. The city has also put in place its own service platform, Sistema Integrado de Transporte.

In Johannesburg officials challenged citizens to live in a city free of cars by closing down major roads in its business district as part of the month long EcoMobility World Festival in 2015. This followed several years of putting in place transport alternatives, including BRT in 2009, light rail in 2012 and bike lanes connecting the city with townships in 2013.

Finally, in Vancouver, transport authorities reached their goal of 50% of all trips in the city to be taken by walking, biking or public transit in 2016, four years ahead of target, thanks to the use of public incentives.

> Building block 2: Journey planning platforms

Journey planning platforms are in development for both public transit and private vehicle users. In relation to public transit, the first generation of platforms have focused on integrating public transit data into mapping platforms. Examples include GoogleMaps, Citymapper and Moovit. They help consumers overcome the complexities of using public transport by combining different modes, transparently displaying prices and providing real-time information on wait times. Many now also provide information on vehicle sharing options. For example, GoogleMaps displays Uber journey times and fares alongside public transit options (see diagram). As a further step, many aim to integrate payment systems akin to the ‘Zurich Card’, which enables consumers to seamlessly pay for travel on all types of public transport and gain entry into local attractions. Aside from public transit focused apps, journey planning platforms also exist for private vehicles. For example, through the community-based app Waze, drivers share real-time traffic and road information in exchange for navigation assistance. In 2016 Waze partnered with INTRIX, the world’s leading supplier of quality traffic data, to add parking assistance to its services.

> Fully integrated multimodal, MaaS platforms

Over time, vehicle sharing and journey planning platforms have the potential to converge into multimodal models, integrating all modes (public and private) into one interface along with payment systems. This form could achieve powerful optimisation and individual customisation at the system level. Although multimodal MaaS platforms are not yet a reality, this could change quickly along with further advancements in autonomous, connected and electric vehicles and greater collaboration amongst different stakeholders (e.g. data sharing).

Multimodal MaaS platforms have the potential to play an important role in the development of a more sustainable system of personal mobility. Shifting consumers away from owning mobility assets and towards accessing mobility services could serve to reduce the number of vehicles in circulation over the long-term, as less would be required to move the same amount of people. However, over the short-term, we recognise the potential for the number of vehicles to actually increase as use of the incumbent system overlaps with the new system.

Multimodal MaaS platforms also have the potential to be more inclusive: for one, greater optimisation and customisation could enable a broader range of more affordable options. In addition, these platforms could help to bring down the total cost of personal mobility. While the incumbent business model of siloed ownership and services makes it necessary to maintain excess capacity in order to meet all use cases, under a dynamically managed model, idle assets would become productive, eliminating the need for providers and users to share the cost burden associated with them. Aside from these advantages, consumers would no longer have to choose between A, B or C (e.g. daily commute by bus, motorbike or car), but rather could choose a blended solution across A, B, C, D, E, F, etc. each time they move.

POLICY INNOVATIONS

From the 1930s onward, policy innovations helped to entrench what has now become the incumbent system of personal mobility. Today, policy innovations at both the local and national level are again speeding up the transition to the new system emerging today.
Local policies aimed at reducing use of private vehicles

At the local level, policymakers are using numerous tools to restrict the use of private internal combustion engine vehicles in urban areas. Measures include increasingly prohibitive congestion charges, restricted access areas, bans at certain times, speed reductions and parking charges. At the same time, local officials are also incentivising consumers to take public transit, cycle or walk by increasing the availability and attractiveness of these alternatives (see side bar on previous page for examples).

The introduction or extension of light rail has been one option adopted by several cities, such as Los Angeles and Melbourne, given it has higher passenger capacity relative to other modes of public transit, lower operating costs versus the metro and limited air and noise pollution compared to combustion vehicles. However, due to high capital costs, inflexible infrastructure and traffic interruption, it is not always a viable option, particularly in lower income countries. For this reason, many cities have instead (or additionally) opted for Bus Rapid Transit (BRT). BRT consists of dedicated, centrally positioned bus lanes with prioritised traffic signals. It achieves speeds similar to metros, but with a fraction of the capital expenditures and time required to build. In China, for example, BRT is in place in over 20 cities. Aside from these options, local officials are also increasing the number of dedicated bicycle lanes and car-free developments, which incentivise both cycling and walking.

The basic shift from the use of private vehicles to these alternative modes has the potential to significantly reduce negative externalities associated with the incumbent system, while at the same time improving communities (see table).

Global decarbonisation agenda driving national policies

Globally, policymakers are effectively restricting the use of oil-based fuels for transport in line with the decarbonisation agenda outlined in the 2015 Paris Agreement (the first universal, legally-binding global deal on climate). This plan necessitates the implementation of aggressive measures over the next 5-10 years.

One such measure is the use of increasingly strict vehicle emissions standards. Policymakers in leading auto markets have already put plans in place to meaningfully ratchet up requirements, with step-ups planned for 2020 and 2025. Compliance with these standards requires manufacturers to electrify at least part of their fleets. Aside from ‘sticks’, national policymakers are offering ‘carrots’ in the form of incentives for first time buyers of electric vehicles. For example, in the U.S. the government provides a USD 7,500 tax credit to first time buyers, in addition to incentives offered at the state level, such as sales tax exemptions and carpool lane access.
The need for speed

We have a 5-10 year window to implement the aggressive decarbonisation measures required to limit the average rise in global temperatures to +2.0°C; this includes greatly reducing the world’s dependence on oil-based fuels for transport.

Taken together, local and national policies are shifting the focus of personal mobility away from maximising system-wide capacity for privately-owned internal combustion engine vehicles towards optimising system-wide emissions, efficiency and resilience.

V. A MORE SUSTAINABLE SYSTEM

Under the new system, we expect consumers to increasingly meet their needs for personal mobility through the use of on-demand services across various modes of autonomous, connected, electric and shared transport. We anticipate many consumer segments, such as young urban dwellers, will choose not to own a vehicle, while others will own them to fill supplementary needs (e.g. long journeys).

As a whole, the new system has the potential to address the negative externalities associated with the incumbent system, while improving the value proposition to consumers by: (i) improving system-wide efficiency; (ii) nearly eliminating driver-related accidents; (iii) greatly reducing both urban air pollution and carbon emissions; (iv) enhancing social inclusion by offering a broader range of options across price points; and (v) increasing consumer satisfaction through individual customisation. Although the system introduces a new set of unintended negative consequences, such as safety risk from cyber-attacks and job losses from advances in autonomy, these challenges have yet to cross critical, systemic thresholds.

A mix of old and emerging mobility service providers is likely to be responsible for driving this system forward. Across the value chain, we expect to see the rise of parts suppliers focused on providing increasingly sophisticated software components; manufacturers with expertise in designing and manufacturing autonomous, connected, electric vehicles for shared-use; retail sales providers capable of uniquely satisfying consumers’ needs through data-driven mobility service plans and Lastly, end service providers serving the retail segment, as opposed to individual consumers, with offerings ranging from renewable charging stations to fleet-based insurance products.
A new system of personal mobility

> Centred on the use of on-demand services across various modes of autonomous, connected and electric transport, with product ownership meeting supplementary needs

> Driven by a shift towards (i) autonomous, connected and electric vehicle technology, (ii) multimodal mobility-as-a-service business models and (iii) redistribution of right of way to optimise for system-wide emissions, efficiency and resilience

> Supported by a software-driven value chain

VI. CONCLUDING REMARKS

The shift to the new system of personal mobility represents the transformation of a complex global system. For investors, this presents a compelling opportunity to deploy capital for the long-term, amidst an environment of generally low growth. However, it also signals a period of heightened risk, as investments with exposure to the decline of the incumbent system come under pressure. In our view, it is therefore critical to zoom-out in order to view personal mobility outside of the bounds of any single challenge, innovation or sector. We believe this broader, more holistic lens is what enables investors to identify and adapt to changes others have yet to see. It is the difference between a 19th century carriage driver and a horse with blinders.
1 Tangible and intangible costs borne by third parties may apply
3 Cars are more common in developed markets and motorbikes in developing markets on the basis of affordability; this is particularly the case in China, India, Indonesia, Vietnam, Thailand, Japan, Taiwan, Brazil, Malaysia and Pakistan; Pew Research Center, Car, bike or motorcycle? Depends on where you live, April 2015 (Available from: http://www.pewresearch.org/fact-tank/2015/04/16/car-bike-or-motorcycle-depends-on-where-you-live/); Institute for Transportation and Development Policy, Managing Two and Three Wheeler Traffic, January 2009 (Available from: http://cleanairasia.org/wp-content/uploads/portal/files/presentations/pres98.pdf)
5 Generation IM
6 The 19th century system of personal mobility centred on the shared use of horse-drawn vehicles, such as hired carriages, omnibuses and trolley cars.
8 Idem
12 Montgomery, Charles, Happy city: transforming our lives through urban design, February 2015
17 Idem
18 e.g. the melting of the Arctic ice-cap and many of the world’s glaciers will itself speed the rate of warming, as there will be less ice to reflect heat and more ocean surface to absorb it; at high levels of heat stress, the carbon cycle of plants and soil can reverse to the point of releasing as opposed to absorbing more carbon, which would severely exacerbate the rise in total emissions; Geological Society of London, Climate change: evidence from the geological record, November 2010 (Available from: www.geolsoc.org.uk/~media/shared/documents/policy/Climate%20Change%20Statement%20final%20%20%20new%20format.pdf?la=en)
19 The Pliocene refers to an epoch of the Tertiary Period, occurring from 10 to 2 million years ago
23 Idem
25 Idem
GENERATION SUSTAINABILITY INSIGHTS SERIES: TRANSITION IN PERSONAL MOBILITY IN URBAN AREAS


Norton, Peter, Fighting Traffic: The Dawn of the Motor Age in the American City, 2002

Idem

e.g. Volvo, Tesla, BMW, Ford, Google, Baidu, Uber, NuTonomy


Level 1-2 automation depends on classical computer algorithms (e.g. if-then statements), whereas Level 3+ applies machine learning and pattern recognition technology from artificial intelligence; these algorithms require extensive databases in order to function; so far Google has collected data from the 2 million test miles its autonomous vehicle prototypes have completed; Hans, Alexander, Top misconceptions of autonomous cars and self-driving vehicles, September 2016, (Available from: http://www.driverless-future.com/?page_id=384); Google, Google self-driving car project: where we have been, 2016 (Available from: https://www.google.com/selfdrivingcar/where/)

e.g. HERE (a company recently acquired by Daimler, Volkswagen and BMW) is developing a product with three detailed layers, which will compete with other leading solutions, such as Mobileye’s Road Experience Management technology, Mobileye, BMW Group, Intel and Mobileye Team Up to Bring Fully Autonomous Driving to Streets by 2021, July 2016 (Available from: http://ir.mobileye.com/investor-relations/press-releases/press-release-details/2016/BMW-Group-Intel-and-Mobileye-Team-Up-to-Bring-Fully-Autonomous-Driving-to-Streets-by-2021/default.aspx)


HERE, Swiss Re, The future of motor insurance: how car connectivity and ADAS are impacting the market, 2016 (http://media.swissre.com/documents/HERE_Swiss+Re_white+paper_final.pdf); Morgan Stanley, North America insight: shared mobility disrupting auto insurance one mile at a time, December 2015

We note the growth of ‘edge computing’ as a complementary solution to cloud computing for processing and storage.

HERE, Swiss Re, The future of motor insurance: how car connectivity and ADAS are impacting the market, 2016 (http://media.swissre.com/documents/HERE_Swiss+Re_white+paper_final.pdf)


Japan Automobile Manufacturers, JAMA; Department of Energy, DOE; Goldman Sachs Global Investment Research


Tesla Model 3 and GM Chevy Bolt

Harrington, Rebecca, One dramatic chart shows why electric cars are about to become mainstream, March 2016 (Available from: http://www.techinsider.io/electric-vehicle-battery-cost-decreases-2016-3)

2020 estimates from Tesla data; 2022 estimates from General Motors data

McKinsey Global Institute, Resource Revolution: meeting the world’s energy, materials, food and water needs, November 2013


24 McCurry, Justin, Japan now has more electric car charge points than petrol stations, May 2016 (Available from: https://www.theguardian.com/world/2016/may/10/japan-electric-car-charge-points-petrol-stations)


26 These mechanisms allow them to remotely manage decentralised fleets of vehicles, as opposed to maintaining costly rental offices in premium locations, which in turn supports a compelling offering to consumers of on-demand, hyper-local access to vehicles at competitive prices; Bachman, Justin, Hertz Car-Sharing Would Be Perfect, If Not for Those Meddling Customers, October 2013 (Available from: http://www.bloomberg.com/news/articles/2013-10-29/hertzs-24-7-car-sharing-plagued-by-those-meddling-customers)


29 Cooltra website (https://www.cooltra.com/en); Scoot website (https://scoot.co/flag/

30 Crouch, Erik, Didi Kuaidi wants to make ‘tech buses’ a common commuter option in China, October 2015 (Available from: https://www.technasian.com/didi-kuaidi-bus-beijing-shenzhen)


33 Didi, Investor Day presentation, 2016

34 McKinsey Global Institute, Resource Revolution: meeting the world’s energy, materials, food and water needs, November 2011


36 Other competitors include Ola in India, GrabTaxi in Southeast Asia, Lyft in North America

37 Inrix, INVESTMENT MANAGEMENT LLP 2016


41 For example, ride-hailing platforms are already bringing hired car services into previously underserved areas. In New York City, Uber’s fastest growing pickup zones are in areas with below average incomes outside of the yellow cab prime zone; New York Post, How Uber is reducing inequality, September 2015 (Available from: http://nypost.com/2015/09/03/how-uber-is-reducing-inequality/)


44 Waze website (Available from: www.waze.com)


49 Financial Times, Brussels starts work on stricter CO2 targets for vehicles, July 2016 (Available from: https://www.ft.com/content/e8af880-4e80-11e6-b8c5-db83e98a590a)


52 Generation IM