2040 SCENARIOS

FOR THE FUTURE OF MOBILITY IN SOUTH AFRICA

"Reinventing Point A to Point B Mobility"

March 2019

MOBILITY CENTRE FOR AFRICA

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CORPORATE AUTHOR:

VICTOR RADEBE, EXECUTIVE DIRECTOR AND FOUNDER

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1 EXECUTIVE SUMMARY

The Mobility Centre for Africa (NPC) is committed to advocate for the development of future mobility solutions in collaboration with its partners in government, industry and academia. This initiative is still driven by what we refer to as the "wicked 4" problems associated with the transport industry which are road crashes, affordability, emissions and traffic congestion. During the past 18 months of its existence, the MCA has convened a number of roundtable meetings, conferences and workshops to deliberate on various topics that affect mobility in South Africa.

1.1 2040 Mobility Scenarios

This scenario paper was necessitated by the need to start a conversation on how the major drivers of change will impact the future of mobility in South Africa. A high-level stakeholder workshop was convened in November 2018, at which MCA tabled a discussion document in a form of a draft scenario position paper on the future of mobility. Rather than deliberate on the enabling technologies that have been disrupting the transport industry, it had become necessary to delve deeper into the drivers of these changes. These were identified as follows:

These drivers were further analysed for certainty and impact, with urbanisation and sharing economy emerging as the two major drivers that will have a huge impact on the future of mobility in South Africa.

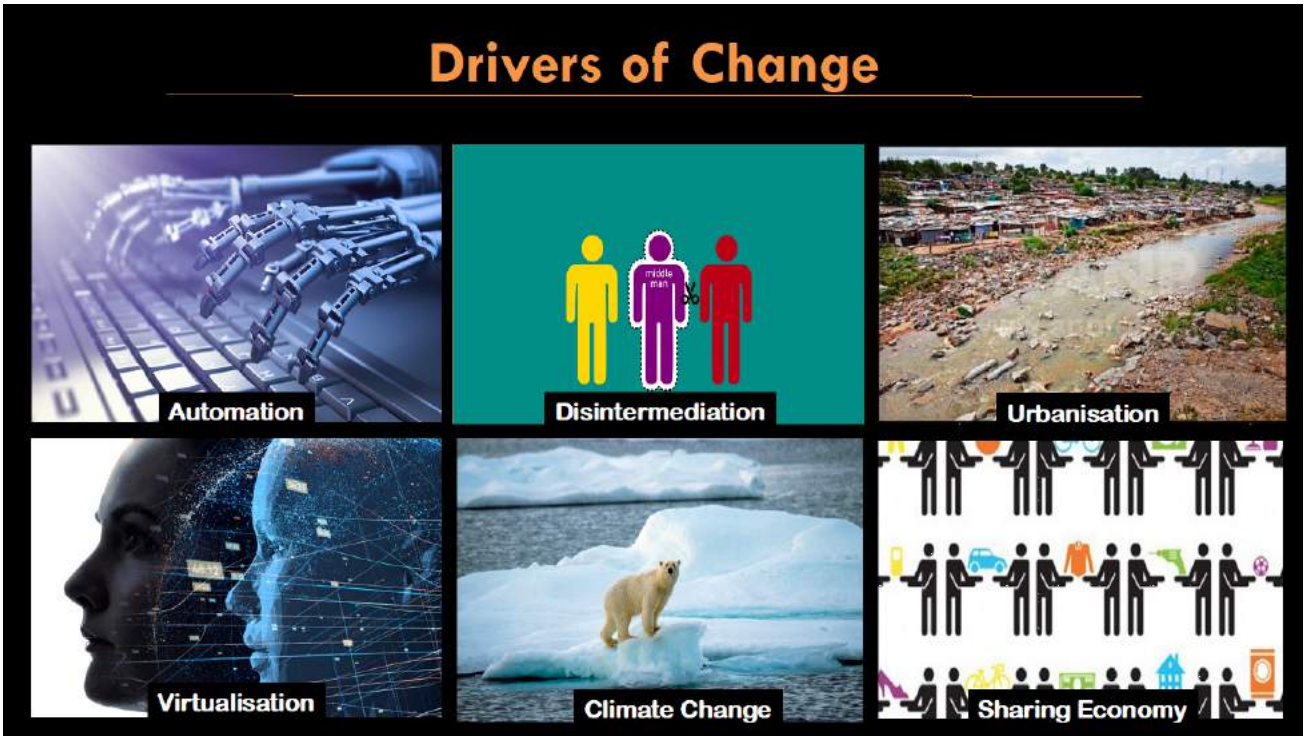

Figure 1: Drivers of Change

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From these drivers of change four possible scenarios emerged:

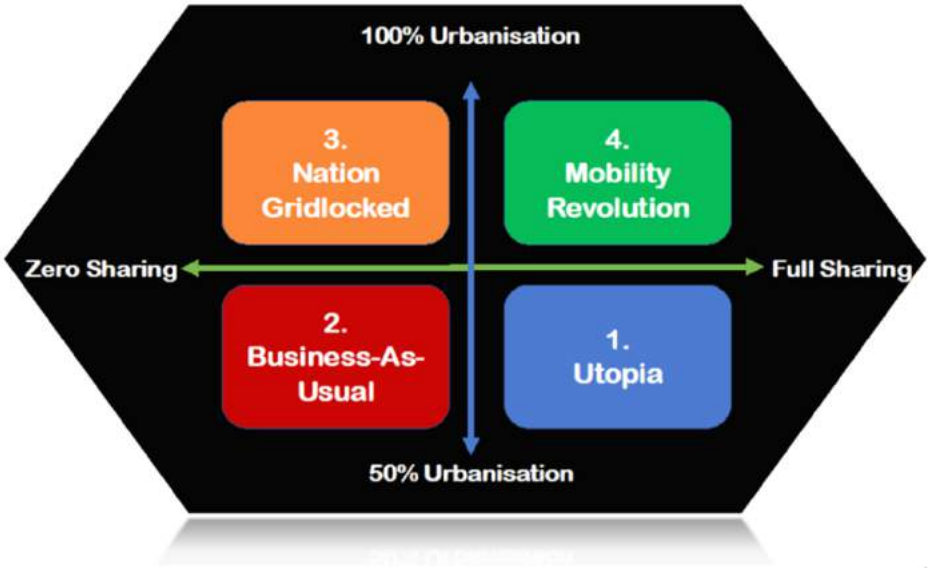

Figure 2: Four Possible Scenarios informed by Drivers of Change

Whilst all these 4 scenarios are probable, the most plausible one is that of Mobility Revolution owing to the fact that the rate of urbanisation in South African cities is expected to continue and that the adoption of shared mobility will continue to grow. This scenario presents new challenges for transport authorities in that the pace of change will accelerate.

The 2020s will see a continued rise in the adoption of mobility platforms that will disrupt and change the way we move from point A to B. South African cities are in the process of rolling out various transport infrastructure projects like the Bus Rapid Transit systems. On the passenger rail side, the Passenger Rail Agency of SA and Gautrain are in the process of expanding and upgrading their services. Whilst these services will address mass-transit for goods and services along the trunk routes, the challenges of first and last mile remain unresolved. Private car owners are clinging on to their vehicles and minibus commuters are voting with their hard-earned Rands and are not supporting these public transport services in droves. Only Gautrain services are experiencing a rise in patronage but at huge cost to the Gauteng Government in the form of monthly subsidies of over R100 million per month.

1.2 Mobility-as-a-Service

The increase in the adoption of mobility platforms will lead to the emergence of a mobility ecosystem that will integrate all platforms that include public transport. This is Mobility-as-a-Service. One of the promises of this ecosystem is that it will put the users of mobility services at the centre and will empower them with freedom to choose how they travel. To the extent that all mobility services including public transport are digitised into a platform, MaaS will integrate all information that will match demand with supply at any time of the day.

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1.3 Trends to Watch and Game Changers

MCA has identified four game changing technologies that will have huge implications for the Future of Mobility in South Africa and they are as follows:

The expected rollout of 5G by major network operators from 2020 will enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication at speeds that will accelerate the deployment of connected and ultimately autonomous vehicles.

As connected and autonomous vehicles are driven on any particular roads, they learn about anything there is to learn not only about the road conditions. Artificial intelligence will enable these vehicles to process all data they collect to a point of being able to decide and take correction action on any given situation.

Blockchain is expected revolutionise shared mobility and eliminate the need for a central payment engine to settles mobility billings. Probably the biggest opportunity for this technology will be on peer-to-peer transactions, through its distributed ledger system.

Drone technology is fast becoming the next big thing in smart cities and is bringing efficiencies in jobs that are defined with the 4-D of Drones: Dangerous, Dirty, Dear and Dull. Drone technology is being applied in sectors life mining, agriculture, security, mapping, geospatial, policing, etc. Two trends to watch closely are urban air mobility and drone deliveries.

1.4 Strategic Implications for South Africa

These mega trends present both opportunities and challenges not only for the South African government, but the broader transport industry and the academic institutions. Policy and law makers will be under pressure to keep pace and respond to a fast-changing environment, with little time to develop policies and enact appropriate legislation to enable new innovations. The incumbent industry players, particularly those in the minibus taxi industry will have to embrace technology and unlearn all business models that have taken them thus far. They will have to disrupt themselves by instilling a sense of urgency. Academia will have to develop the right body of knowledge that takes cognisance of the local environment and develop fit-for-purpose talent that can rise up to the challenges of the age of the 4th Industrial Revolution.

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2 ACKNOWLEDGEMENTS

The MCA would like to acknowledge the following organisations that contributed in the workshop of November 27, 2018 and in various consultations:

Road Traffic Management Corporation
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SAP
vodacom
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GoMetro
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aidc Automotive Industry Development Centre Your partner in becoming globally competitive
CSIR our future through science
SANRAL SOUTH AFRICAN NATIONAL ROADS AGENCY SOC LTD
HALA
ITS SOUTH AFRICA
TRACKER
Royal HaskoningDHV Enhancing Society Together
aurecon
GridCars®
productivity sa Inspiring a Competitive South Africa
CITY OF TSHWANE IGNITING EXCELLENCE
Joburg a world class African city

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MCA would also like to acknowledge further contributions from the following thought leaders:

Mr Adheesh Ori – Africa Automotive Risk Advisory Leader, Deloitte Africa

Adheesh is an advisory services professional with experience in the core disciplines of Strategy, Analytics, and operations. Adheesh has spent 14 years in providing clients with solutions to increase sales or reduce costs. He has a deep understanding of the Consumer and Automotive Industries. Adheesh is the Africa Automotive Risk Advisory leader for Deloitte and has worked with OEMs, captives and dealers.

Mr Ivan Reutener – Director Northern Advisory Group and Botswana, Royal HaskoningDHV

As a Leading Professional in Smart Mobility, Ivan is recognized for his excellence in contributing to, and accelerating the development and implementation of sustainable development and innovation. Thousands of people's lives are changing because of his influence in the industry. Together with public and private clients, he is committed to enhancing society by relieving traffic and transport pressures in our ever-expanding cities.

Dr Mjumo Mzyece – Ass. Professor of Technology and Operations, Wits Business School

Previously, he led the Smart Industries (ICT and Advanced Manufacturing) unit at The Innovation Hub, the innovation agency of the Gauteng Provincial Government. He has extensive international experience in various leadership, operational, R&D, academic and consulting roles, including at blue chip firms such as IBM U.S., Econet Group, and Agilent Technologies. He is now the Associate Professor for Technology and Operations Management at Wits Business School.

Mr Shubham Bhusari – Digital Mobility Innovator at Royal HaskoningDHV

Shubham has recently completed an MSc in Civil Engineering and Geosciences specialising in Transport & Planning, from Delft University of Technology, The Netherlands. He completed his MSc thesis at Royal HaskoningDHV in October 2018, which included a real-road safety assessment of an instrumented Tesla Models S. He now works with the same company in a dual role that links smart mobility and road safety with the digital services required for the advent of smarter and sustainable vehicles onto roads.

Mr Bill Russo – Founder and CEO of Automobility Shanghai

Bill Russo is the Shanghai-based Founder and CEO of Automobility Limited, a strategy and investment advisory firm helping its clients to create the future of mobility. His over 35 years of experience includes 15 years as an automotive executive, including 14 years of experience in China and Asia. He has also worked nearly 12 years in the electronics and information technology industries. He has worked as an advisor and consultant for numerous multinational and local Chinese firms in the formulation and implementation of their global market and product strategies

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3 BACKGROUND

At MCA we make a clear distinction between “mobility” and “transportation”. Without delving into what the definitions of these terms are, we view transportation as a means to an end. The end is mobility, which is defined in the Oxford Dictionary as “the ability to move or be moved freely and easily”. True mobility is therefore about accomplishing a journey from point A to B “freely and easily”, that is, in our case without any risk of being involved in a crash, stuck in traffic congestion, cost-effectively and with minimal exposure to greenhouse gas emissions.

Unfortunately, just about all means and modes of transportation fail to help us achieve true mobility and this brings us to the MCA’s focus problem statement. This problem statement is encompassed in

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what we refer to as the "wicked four" problems that continue to bedevil the transport industry and mobility in general. They are as follows:

Road Crashes (aka Accidents) - These crashes claimed over 14,000 lives in 2016 and have a societal cost of over R142 billion (Labuschagne, et al; 2016).

Traffic Congestion - According to the Tom Tom Traffic Index of 2017, South Africans are spending at least 30% more time travelling due to traffic congestion. This represents market failure and has huge implications for the country's productivity.

Emissions – The transport industry accounts for almost 23% of total energy-related CO2 emissions worldwide (Creutzig, et al., 2015).

Affordability – Poor people are spending up to 40% of their hard-earned income on transport and these commuters use predominantly the minibus taxis that do not enjoy government subsidies, see Figure 1 below

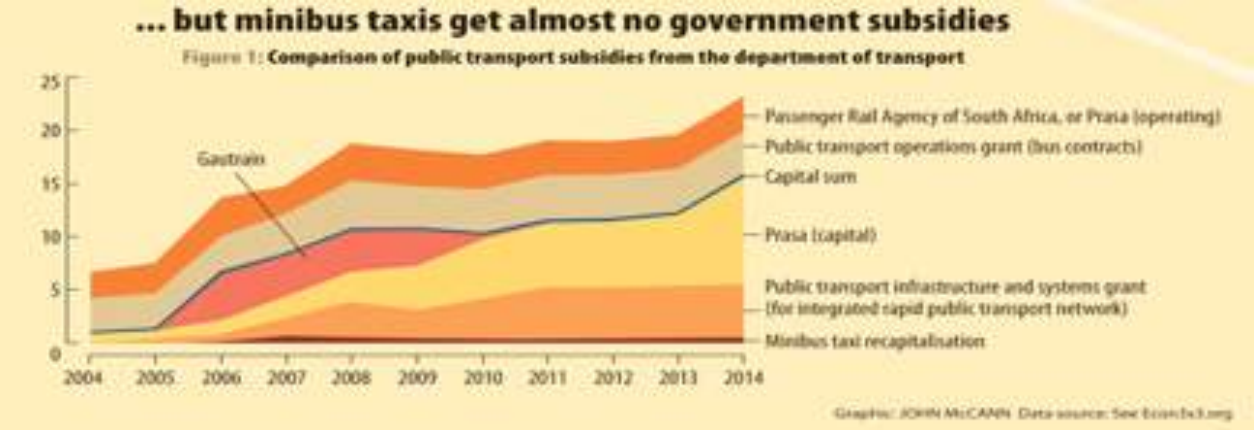

Figure 3: Public Transport Subsidies

3.1 Milestones of the Mobility Centre for Africa (MCA)

The MCA is in its 3rd year of operation since its establishment back in October 2017. Over the past 16 months this non-profit company achieve some key milestones in its mission to advocate for

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meaningful interventions to prepare the nation for the future of mobility. Some of the highlights of the past year include the following:

Table 1: MCA Milestones

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Date	MCA Milestone Described
October 2017	**1st Future Mobility Roundtable, Durban –** This was the launch of the MCA and was attended by various stakeholders from government, industry and academia.
November 2017	**2nd Future Mobility Roundtable, Johannesburg** – The event was hosted at the IDC in Sandton and covered topics like shared mobility, future of the automotive industry, green mobility, etc.
January 2018	**3rd Future Mobility Roundtable, Cape Town** – This event focussed on the legislative and regulatory environment, governing transport industry.
April 2018	**4th Future Mobility Roundtable, Ekurhuleni** – An "unconference" that looked at 2055 scenarios for future of mobility in line with the City of Ekurhuleni's and Gauteng Government's vision 2055.
May 2018	**Smart City Reverse Trade Mission to the US** – MCA participated in this trade mission that was sponsored by the US Trade Development Agency. MCA presented along with aspiring smart cities of Johannesburg, Ekurhuleni, Cape Town and Tshwane to the technology community in San Francisco, USA.
June 2018	**5th Future Mobility Roundtable, Durban** – This event had the theme "Green Mobility" and saw the MCA launch its Driving Green Challenge for South African cities to encourage them to "green" their fleets.
July 2018	**Visit to France** – Visit to Manufacturers of AVs in France – MCA visited Navya in Lyon and EasyMile in Toulouse and experienced the autonomous driving in both cities.
October 2018	**Future Mobility Africa 2018** – MCA hosted its inaugural Future Mobility Africa at the Durban ICC under the theme: "Future of Mobility in the Age of Industry 4.0". This conference was addressed by Minister of Transport, Dr Blade Nzimande.

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Date	MCA Milestone Described
November 2018	**Stakeholder Workshop** – MCA convened a stakeholder workshop to solicit input on the development of this Position Paper. The workshop was attended by various experts and thought leaders from government, industry and academia. At this workshop a draft document was presented, and breakout sessions deliberated on key themes on how the future of mobility will unfold in South Africa in the period to 2040.
February 2019	**Move 2019, London** – MCA was represented at this event, brought together various mobility start-ups and unicorns to share experiences and insights on how technology is shaping mobility and what the future prospects. Various topics covered smart cities, green mobility, drone technology, etc.
March 2019	**Launch of 2040 Scenarios for Future of Mobility in South Africa** – MCA will be unveiling this paper at the 4th Industrial Revolution Summit that will be hosted by the Moses Kotane Institute, a research entity of the KwaZulu-Natal Provincial Government.
The Future?	**AV Pilot Program, Future of Mobility Advocacy, etc.** – MCA is still committed to launching the first Autonomous Vehicle Pilot Program in Africa. To this end MCA has received the support of the Gauteng Department for Roads and Transport and the National Department of Transport. The National Regulator for Compulsory Specifications (NRCS) has already issued MCA with a Letter of Authority to bring the Navya Autonomous Shuttle to South Africa. MCA has filed an application with the National Department of Transport to be exempted from the provisions of the National Road Traffic Act 93 of 1996 as it relates to operating an autonomous vehicle on a public road. Other parties that have shown an interest in this project include CSIR, City of Tshwane, University of Johannesburg, The Innovation Hub, Tracker, City of Durban, etc.

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4 INTRODUCTION

The objective of this Scenario Paper is to start a robust debate on the necessity for South Africa to prepare for the next wave of innovation and disruptions that could have devastating consequences for the automotive and by extension the broader transport industry. To this end, MCA in collaboration with its partners and stakeholders is seeking to provide strategic foresight and develop possible scenarios for the future of mobility in South Africa. A draft Paper was tabled at a Stakeholder Workshop that was held on November 27th, 2018 at the MCA offices in Woodmead. This final draft is the result of intense deliberations that took place at that workshop and subsequent input from other key stakeholders in South Africa and abroad. MCA aims to use this document to influence policy direction of government, particular as it relates to future of mobility that will be Connected, Autonomous, Shared and Electric or C.A.S.E. Mobility.

The structure of this paper starts with the analysis of the ***2018 and 2019 global mobility trends***, which is followed by the ***methodology*** on how the scenarios were developed. The Paper then delves into the ***possible futures, strategic insights and projection of scenarios***. The last part of this paper is the analysis of implications for future of mobility in South Africa and possible mobility ecosystem that will emerge in the future.

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5 GLOBAL MOBILITY TRENDS

The global mobility trends are driven by what are said to be the 3 revolutions, viz., SHARING, AUTOMATION and ELECTRO-MOBILITY (Sperling, 2018). Whilst these trends are playing themselves out in the automotive industry, there has been spill-over effects in vertically integrated mobility value chains like mass-transit modes like rail and aviation on the one end and other emerging nano-transit modes like dock-less bikes, electric scooter, aquatic and aerial drones.

In this book, Sperling asks very pertinent questions like: “Will the three revolutions usher in more vehicle use, increase urban sprawl, more marginalisation of the mobility have-nots, more expensive transportation, and higher green-house emissions?” The answer to these questions would differ from one region to another. This has resulted in major disruption of business models in the automotive and the broader transport industries, with legacy OEMs scrambling to either catch up with mushrooming start-ups or try to control the pace of change.

5.1 Connected and Autonomous Vehicles

The biggest driver of connected and autonomous vehicle (AV) technology is the need to improve road safety and to ultimately go driverless owing to the fact that up to 90% of all road crashes are caused by human error (Shinar & Gurion, 2019). Humans are prone to fatigue and are susceptible to numerous distractions like infotainment and the need to stay connected at all times even when driving. Distracted driving due to use of mobile phone is a rising cause of crashes.

Autonomous vehicles have the potential to contribute immensely to road safety the computers that are powering these vehicles are not prone to some of the human shortcomings (Acheampong & Cugurullo, 2019). Various test and pilot programs have sprung up in a number of global cities with the Google sister company, Waymo leading the charge. The company was reported to have had recorded no less that 16 million kilometres of testing on public roads without any fatal accident.

However, the safety notion of AVs was tested in the United States and led to huge debates on the safety of AVs. In March 2018 the autonomous driving system of a Tesla Model X SUV hit a concrete lane divider in California and killed the driver. In the same month an Uber Volvo XC90 SUV self-driving car could not respond timeously to a homeless woman who was pushing a bicycle across the road in Tempe, Arizona, and crash into her and killing her instantly. This led to the company shutting down its whole AV testing and development unit. A year later prosecutors decided not to pursue criminal charges against Uber.

Private companies working in auto tech are attracting record levels of deals and funding, with autonomous driving start-ups leading the charge. Along with early-stage start-ups, VCs, and other investors, large corporations are also angling to get a slice of the self-driving pie.
These are some of the global automotive and technology brands that are involved in various AV tests and pilots (CB Insights, 2018)

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Table 2: Legacy OEMs & OEM Partnerships

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Legacy OEMs & OEM Partnerships

Volkswagen	**- Began investing in autonomous driving initiative in 2016** **- Unveiled self-driving shuttle concept car called the "Sedric" in 2017** **- The Vizzion — the fourth in Volkswagen's line of autonomous car concepts — was unveiled at the 2018 Geneva Motor Show.**
FCA WAYMO	- Began partnering with Fiat Chrysler in 2016, - Achieved 4,000,000 self-driven miles by Waymo autonomous vehicles in November 2017, reached 10 million miles in 2018. - Waymo publicly revealed its custom-designed, self-driving hardware in February 2017, planning to sell an integrated hardware and software package. It opened signups for the first public tests of its customized Chrysler Pacifica minivans a couple months later, quickly followed by its Lyft partnership. - In Q2'18, Waymo announced the purchase of 62,000 new Chrysler Pacifica minivans, increasing the size of its self-driving fleet by about 100x. - The company settled a US$245 million lawsuit against Otto Waymo's proprietary lidar designs.
Audi	- First auto company to deploy hands-free driving - Flagship self-driving A8 model approved for street driving in Europe - Former Tesla Autopilot manager hired as CTO of self-driving tech subsidiary - AI-enabled traffic jam pilot - Partnered with Airbus to develop flying car. - Part of German consortium with BMW and Daimler that bought mapping company, Here for US$3 billion.
VOLVO Autoliv	- Sought to build a reputation for safety in self-driving tech - Partnership aims to commercialize driver assist technology by 2019 - Self-driving technology deployment target date of 2021 - Autoliv and Volvo Cars establish Zenuity. - Sold over 24,000 XC90 AVs to Uber - Partnered with Autoliv for ADAS.
Baidu 百度	- Built "Android of autonomous driving" for development of self-driving tech - Opened AI research lab in Silicon Valley - Permission from Chinese government to begin testing self-driving technology on roads in 2018
PSA GROUPE	- PSA's self-driving car travelled 300+ kilometres without supervision between Paris and Amsterdam in 2016 - Partnered with nuTonomy in 2017 to install self-driving tech in Peugeots

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Legacy OEMs & OEM Partnerships

TATA ELXSI engineering creativity	- Tata Elixsi showcases valet system and focuses on autonomous vehicle security - Tata Elixsi, a division of the TATA group, showcased technology in January 2015 for an autonomous parking valet, in which the car understands where open spots are and uses sensors to park itself. While it's unclear when these features will be rolled out to Tata Elixsi's line-up, the company has made it clear that it is moving towards autonomous vehicles. - In June 2017, the company licensed Autonomai, its middleware AV platform, to one of the top five OEMs. The software connects hardware (cameras, radars, etc.) with the AI and machine learning algorithms used to train AVs in complex driving scenarios
TESLA	- Released Autopilot, its semi-autonomous driver assist technology, in 2014 - Three recent fatal crashes involving Autopilot have hurt Tesla's reputation - In August 2018, Elon Musk announced the upcoming release of Autopilot Hardware 3, now slated for 2019.
TOYOTA	- Established Toyota Research Institutes in Michigan and Silicon Valley. - Pursuing both "evolutionary" and "revolutionary" strategies to AVs - R & D budget of US$10 billion p.a. - Toyota develops "Guardian Angel" approach to autonomy, invests $2.8B - Invested $22M in University of Michigan for robotics and AV research - Focused on a "guardian angel" self-driving system, where a car will intervene when a human driver is about to make a mistake - Invested $2.8B in Ford spinoff dedicated to autonomous technology - Made a strategic investment into Uber
NISSAN RENAULT	- Piloting robot taxi in Yokohama, Japan in partnership with gaming company, DeNA. Nissan/Renault tests self-driving taxis, promises 'significant autonomous functionality' by 2020 - Expanded self-driving technology testing in 2016 - Partnered with Bosch, Continental, Aptiv and Magna for technology
BMW intel Mobileye	- Showed off autonomous car concept at CES 2016 - Plans to deploy Level 3 self-driving car on the road by 2021 - Opened second autonomous driving campus in Munich in 2018
DAF DAIMLER IVECO MAN SCANIA VOLVO	- DAF, Daimler, Iveco, MAN, Scania, and Volvo complete truck 'platooning' trip - Main project involves self-driving truck "platoons" connected through wireless signals - Started testing self-driving connected trucks on the road in Oregon in 2017
Ford	- Ford partnered with Domino's & Postmates to test self-driving deliveries - Plans to roll out autonomous vehicles by 2021 - Acquired AI start-up Argo for US$1 billion - Invested into Lyft - Partnering with Domino's and Postmates on autonomous delivery pilots

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Legacy OEMs & OEM Partnerships	
GM, Lyft	- GM, Lyft aim to deploy thousands of self-driving test cars in 2018 - Launched semi-autonomous Super Cruise in 2018 Cadillac CT6 - Filed petition in January 2018 to run commercial ride-sharing business through autonomous Chevrolet Bolts - Received $2.25 billion from SoftBank to support autonomous work
HONDA	- Honda also testing autonomous cars, offering semi-autonomous features in Civic - Introduced semi-autonomous driver assist on Civic models - Deal with Waymo to build new type of autonomous delivery vehicle expected to finalize soon
HYUNDAI	- Hyundai focuses on affordable driver-assistance technology, aims to release self-driving SUV in 2025 - Focus on creating affordable driver-assist technology - Aiming to bring an autonomous vehicle to market by 2025 - Invested in Israeli technology firm Autotalks
JAGUAR LAND-ROVER	- Jaguar Land Rover focuses on drive assist, partners with Waymo to build self-driving cars - Deploying a fleet of 100 self-driving research vehicles on the road in Britain by 2020 - Partnered with Waymo in 2018 to build a fleet of self-driving electric cars - Supplies cars for Waymo's fleet of ride-hailing vehicles

Table 3: Technology Companies, Start-ups, etc.

Technology Companies, Start-ups, etc.	
MAGNA	- **Magna also pursues lidar, autonomous tech** - **The Canadian auto supplier giant has long been the subject of self-driving interest as the world's largest automotive contract manufacturer.** - **Supplies legacy automakers with capabilities ADAS. In 2016, Magna partnered with solid-state lidar start-up Innoviz to round out the sensor package for its self-driving system. The supplier has also tapped iPod visionary and Nest co-founder Tony Fadell for its tech advisory committee.**
HUAWEI	- Huawei autonomous R&D team tops 200, tests smartphone road-recognition tech at Mobile World Congress 2018 - Partnered with Vodafone to work on cellular car-connecting technology - Created own driverless car R&D team with 200+ engineers - Test drove self-driving Porsche Panamera at MWC 2018
Microsoft	- Microsoft pursues collaborative strategy with automakers, offers Azure cloud - Supplying Azure cloud services to companies working on self-driving cars - Working with Toyota on robotics, AI, and self-driving car development - Supplying HoloLens technology to Volvo in self-driving partnership - Microsoft has also reportedly weighed taking a stake in the HERE high-definition mapping service, currently owned by BMW, Daimler, and Volkswagen.

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Technology Companies, Start-ups, etc.

NVIDIA PACCAR	- Nvidia, Paccar working on autonomous trucks - Unveiled 8 teraflop computing platform designed for AVs in 2016 - Unveiled plan to build self-driving trucks in 2017 - Partnered with Baidu, Tesla, Bosch, and Toyota
SAMSUNG	- Samsung enters the driverless race; tests driver assists technologies on roads - Received approval from South Korea to publicly test self-driving cars in 2017 - Acquired Harman for US$8 Billion
SoftBank Group	- SoftBank's SB Drive venture pushes forward - SoftBank Group's SB Drive, an autonomous vehicle joint venture between the Japan-based giant and research company Advanced Smart Mobility, received a $4.4M investment from Yahoo Japan in March 2017. SB Drive focuses on advancing self-driving technology, especially related to public and community services such as buses. - SB Drive is conducting trials and testing the commercial viability of fixed-route buses for community public transportation, as well as autonomous truck-based freight delivery.
	- Uber program bogged down in controversy, with its future in doubt after fatal crash in March 2018. - Hired 40 engineers from Carnegie Mellon Robotics Lab to work on self-driving tech for Uber in Pittsburgh - Have since faced legal troubles and criticism over its role in a fatal crash involving a self-driving - However, in August 2018, Uber announced a US$500 million investment from Toyota and a plan to jointly work on autonomous vehicle development.
Valeo	- Valeo shows off autonomous driving tech at CES 2018 - Partnered with Mobileye in 2015 to work on an affordable self-driving car - Unveiled technology at CES 2018 for identifying and analysing individual passengers within a car
YUTONG	- Yutong has successfully tested driverless buses - Chinese bus manufacturer Yutong has been researching driverless buses since 2012. The company claims to have successfully navigated a bus on an inter-city road in central China's Henan Province. The bus can switch between manual and automatic mode. - Greyhound Australia started a six-month trial of Yutong's T12 coach in June 2018.
ZF	- ZF, Nvidia, Baidu partnering to build an autonomous car for china - Invested in portfolio of self-driving tech companies, including Hella - Partnered with Nvidia on integrating self-driving platform chipset into production vehicles
BOSCH	- Internally dedicated 2K+ engineers to working on driver assist technology - Partnering on with TomTom for mapping and Mercedes for vehicles
CISCO	- Cisco works on building the data layer of the self-driving car movement Started building autonomous driving infrastructure with Michigan DOT in 2017 - At CES 2018, announced project to build technology bringing gigabit-speed connectivity to smart cars
Continental	- Focus on driver-assist technologies and smart car infrastructure - Opened Silicon Valley R&D lab in 2017 - In 2018, announced partnership with Nvidia to build self-driving vehicle systems

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Technology Companies, Start-ups, etc.	
amazon	- Filed patent in 2016 for autonomous lane-switching technology - Working on a multi-function autonomous vehicle with Toyota - "e-Palette" will debut at the 2020 summer Olympic games
	- Building employee transportation network; currently have 66 self-driving minivans on the road in California - Some setbacks for Apple's self-driving car program, Project Titan, in 2016 - Hired former Waymo and NASA engineer in June 2018 to head Project Titan
DiDi	- Didi Chuxing hires Uber, Waymo engineers for its AI lab - Opened AI lab in Silicon Valley autonomous driving tech R&D in March 2017 - Announced demonstration of a working self-driving car in February 2018 - Received permission from California to undertake further public testing of its technology
APTIV	- First company to test self-driving tech on the streets of Singapore, and later in Boston - Conducted 5,000+ self-driving taxi rides in Las Vegas in collaboration with Lyft
easy MILE	- French start-up that builds autonomous shuttles - Deployed shuttles in over 30 cities worldwide
navya	- Another French start-up that builds its own shuttles and has built over 100 since it was formed in 2014. - Has now built a robo-taxi that will be showcased at the CES 2019 in Las Vegas.
Meet olli	- Built by the American automaker, Local Motors. - Powered by IBM Watson for data analytics and AI.

5.1.1 AV Readiness

The full deployment of AVs is still far off and is not expected to go mainstream before 2030. Every time when MCA speak about its plans to launch an AV Pilot Program, the scepticism that comes is that South Africa is not ready for AVs. Well, it turns out that as of 2019 no country is ready fully deploying Level 5 AVs. In 2019 global professional services firm, KPMG, publish an Autonomous Vehicle Readiness Index, which evaluated various countries' readiness for AVs (Threlfall, R., 2019). From the report it is not clear what readiness this report measured, whether to deploy or just to test. Nonetheless these were the top 10 countries:

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Table 4: Top 10 Countries in Autonomous Vehicle (AV) Readiness

First	Netherlands
Second	Singapore
Third	Norway
Fourth	United States
Fifth	Sweden
Sixth	Finland
Seventh	United Kingdom
Eighth	Germany
Ninth	United Arab Emirates
Tenth	Japan

Four criteria were used to measure the scores of each country, and they were:

- Policy and Legislation;
- Technology and Innovation;
- Infrastructure; and
- Consumer Acceptance.

5.2 Shared Mobility

Rising costs of owning vehicles coupled with rapid urbanisation and inward migration into cities like Johannesburg, is forcing transport planners and policy makers to look for innovative and smart mobility solutions to ease the growing congestion. Up to 30% of cities' open spaces are dedicated to cars, which lie idle for up to 95% of the time and up to 90% are single occupancy vehicles (Cohen & Kietzmann 2014). Cities are forced to provide not only for increased roads capacity but parking of these vehicles as well. The low average utilisation of vehicles (5%) has paved the way for shared mobility start-ups and these new business models have been welcomed by aspiring smart cities.

Three start-up unicorns are credited with having brought the sharing economy to the transport industry and they include Uber, Lyft and Didi. Whilst Lyft has chosen to stay within the US market Uber ventured into over 100 countries but lost the battle in China to Didi. The latter company had a different business model to that of Uber by partnering with the taxi industry as opposed to displacing them. Shared mobility has since developed into other business models, which include the following:

- **Ride-sharing** – This include ride-hailing that has been popularised by Uber, Lyft, Didi and Taxify.
- **Car-sharing** – A subscription service that gives subscribers access to a pool of cars as and when they need them. Companies providing this service include Zipcar, Car2Go, Getaround and South Africa's very own Locomute. Two types of car-sharing have emerged:
- **Free-floating** – Where the subscribed car, after its use, can be dropped off anywhere within a prescribed area instead of dropping off the vehicle from the station it was subscribed from. This mode is also known as one-way car-sharing.
- **Station-based:** Where the subscriber needs to return the subscribed car back to the station it was subscribed from, which is less flexible then the former option.

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- **Car Pooling** – This service is provided through a platform that let car owners offer rides to subscribers in return for a share of their costs. Top international companies include BlaBlaCar, Turo, Go-Kid and South Africa's start-ups uGoMyWay, Jumpin Rides and CarTrip.

- **Micro-Transit** – This include non-car first and last mile shared mobility providers using bicycles, scooters, motorbikes, etc. Companies in this category include oFo (bike sharing), Mobike (bike sharing), Scoot, Bird, Lyft and even automakers like Ford.

Figure 4: Major Shared Mobility Brands

Source: Shared Mobility Principles for Liveable Cities

The biggest disruptive elements of shared mobility will be on business models that are still based on private car ownership. The emerging shared mobility business models are beginning to offer similar benefits to private car ownership without having to "invest" in an asset that is only used for 5% of the time. One of the most promising replacements to private car ownership one-way or floating car-sharing schemes that entail short rental without having to return the vehicle to its original pick-up point (Mounce & Nelson, 2019). This car-sharing scheme gives travellers flexible mobility in that they can use it in conjunction with other shared mobility options and public transport.

5.3 Electro-Mobility

Following the Kyoto Protocol signed in 1997 and the very latest Paris Climate Change Agreement signed at COP 21 in 2015, several countries have implementing various measures to reduce the effects of climate change and the transport industry has been one of the key focus areas (Pereirinha, et al., 2018). Most of these countries have targeted the reduction of internal combustion engine vehicles (ICEV), especially diesel vehicles in favour of electric vehicles (EVs). Countries like the United Kingdom have put in place plans to fully eliminate the use of ICEVs by 2040 and limit its sales by 2030.

In 2018 over 2 million EVs were sold globally, which represented 2.2% of all vehicle sales (Perkins, 2019). Almost half of these EV sales were in China, which posted a growth of 76% from the 2017 comparative. Figure 2 below shows how China and the USA dominated the EV sales in 2018 (Irle, 2019).

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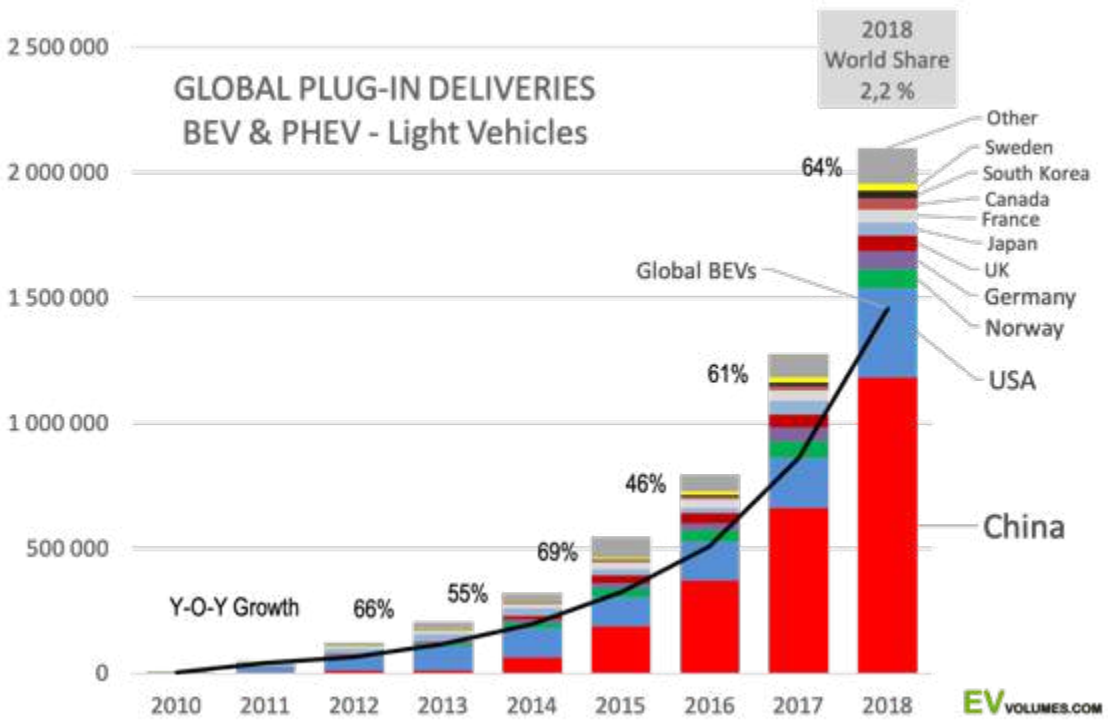

Figure 5: EV Total Global Sales for 2018

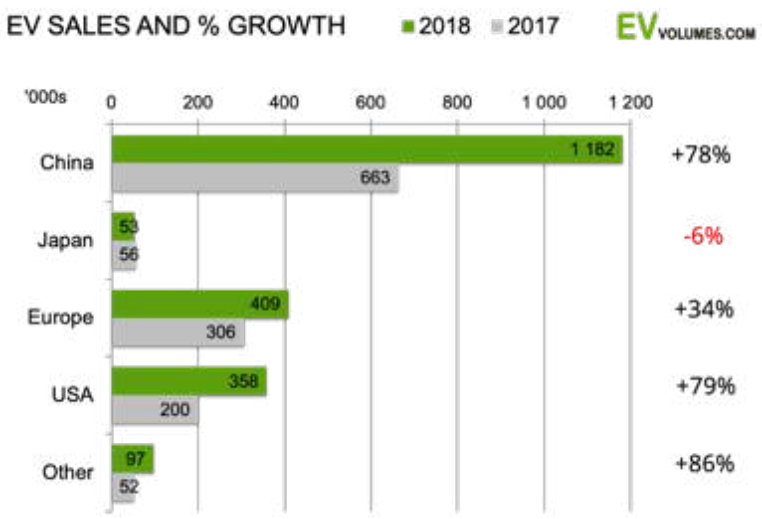

Figure 6: EV Total Global Sales Growth by Country for 2018

A survey research conducted by the International Energy Association found that the global fleet of EVs is likely to soar and some of the findings included the following:

- Up to 25% of all vehicles sold in ***China*** will be EVs by 2030.
- Over 130 million light passenger vehicles by 2030 will replace up to 3 million barrels of ***oil*** per day (in 2017: 380 000 barrels).
- Up to US$ 3 billion in ***taxes*** were lost in 2017 due to EV adoption and this is expected to increase to US$92 billion by 2030.

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- Fifteen times more ***batteries*** will be required by 2030 an equivalent of 10 gigafactories will have to be built.
- Demand for ***lithium and cobalt*** is expected to grow tenfold, which could drive prices of these commodities upwards.
- ***Charging stations*** are expected to grow to over 120 000 in 2018 from the 2017 levels of 90 000.
- The grid's ***power delivery capabilities*** will become an issue as significant power is required to recharge a battery in a short time
- ***Oil companies*** are entering the EV market with Shell acquisition of "The New Motion", the Netherlands owner of the largest network of charging stations.
- OEMs are racing to develop the ***ultra-fast charging*** technology to keep up with Tesla.
- Some of the ***bold moves by OEMs*** include BMW's 25 models by 2025, Porsche's 50% of all vehicles by 2023, JLR shifting entirely towards electric and hybrid by 2030, etc.

Whilst China is the leading EV market, accounting for almost half of all global EV sales in 2018, Norway is the best example of a successful adoption program. Norway has only 2,5 million registered vehicles but has the highest percentage of EV at 37% and is the 3rd biggest market for EVs. In 2018 this share of EVs rose to 49% of all vehicle sales in this country. No other country came close to it, see Statista report below:

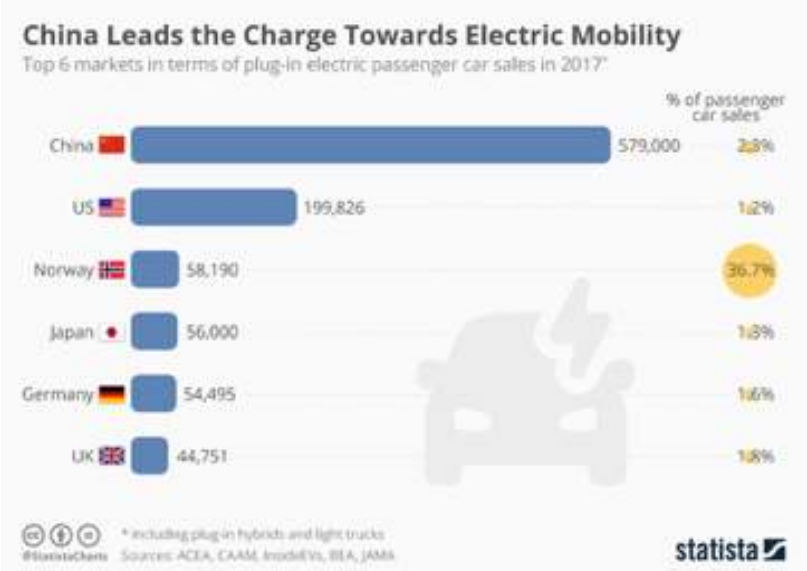

Figure 7: Top EV Global Markets

Source: Statista, 2018

How did such a small oil-producing nation achieve such a great feat? The Norwegian EV program goes back to the late 1980's when the government started promoting EV's using famous musicians. But the biggest for EV adoption was the country's incentive program that was launched in the mid-1990s'. These incentives included annual exemption on registration taxes, free road tolling, free

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municipal parking, no import duties, 50% reduction in company car tax, VAT exemption, access to bus lanes, etc.

Not only did the government offer incentives for EV owners but its targeted ICE vehicles with disincentives like a 50% increase in fuel prices, especially diesel. In 2017 diesel car sales fell from 31% to 23%. Whilst Europe is planning to ban the sale of ICE vehicles by 2040, Norway is targeting 2025 to go completely green!

According to Bloomberg's energy predictions, EV sales are expected to overtake ICE sales by around 2038 ahead of the complete ICE vehicle ban by EU and UK in 2040.

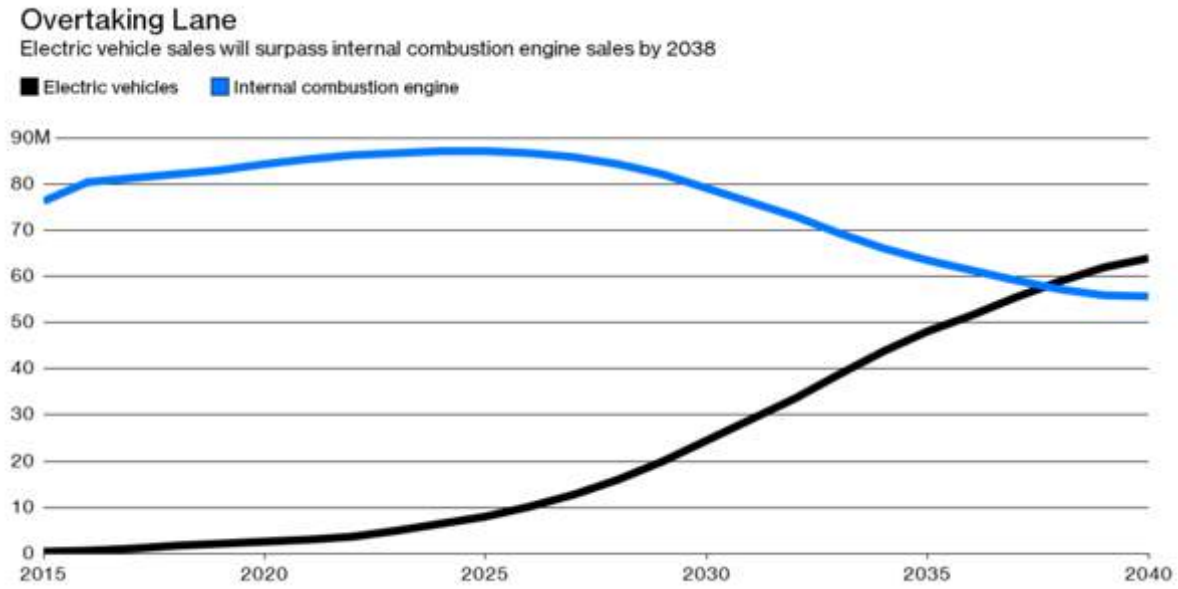

Figure 8: EV-ICE Sales Forecast to 2040

Source: Bloomberg New Energy Finance, 2018

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6 METHODOLOGY

6.1 Strategic Tools and Concepts

6.1.1 The Iceberg Model and Systems Thinking

The disruptive changes that are shaping mobility and the transport industry could best be illustrated using the Iceberg Model of Systems Thinking. This model argues that the observable events and patterns are shaped by systems structures and mental models (Monat & Gannon, 2015). Events are daily events that we experience like road crashes, traffic congestion, etc. Patterns are the accumulation of events and they reflect a trend. This could be the high incidence of road crashes during holiday periods like Easter and festive seasons. System structures are the manner in which parts of a system are organised (Kim, 1999). These systems define the patterns and the observable events. An example of a system structure could be the Apartheid spatial planning that made the majority of people to live far away from economic nodes which leads to high travel costs (patterns) and ultimately speeding by minibus taxis (events).

In the area of mobility it is not unusual for enabling technologies like IoT, AI, etc. to be confused with drivers of change when in fact the latter are mere enablers. These drivers of change tend to be less observable and would lurk beneath the surface and they include drivers like disintermediation (that is driving e-commerce), automation (driving autonomous driving), sharing economy (driving shared mobility) and so forth. Figure 5 below depicts some of these changes.

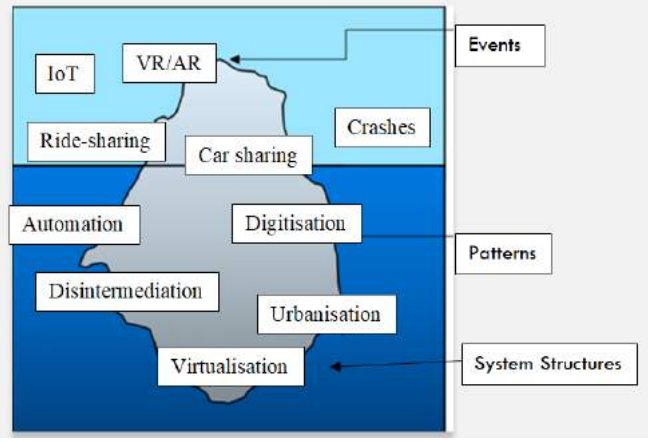

Figure 9: Iceberg Model

The Iceberg Model enables systems thinking that looks at an issue like road crashes in a much broader sense. Systems thinking digs deeper and reveals what is really happening in a situation more than what seems to be happening.

6.1.2 DEFT Analysis

This tool identifies and distinguishes amongst drivers, enablers, friction and turners. According to Gordon (2010) the individual elements of the DEFT Analysis can be defined as follows:

- **Drivers** – These are forces that cause and sustain trends. Mobility examples could include globalisation and urbanisation that drive traffic congestion on South African roads.

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- **Enablers** – They are catalysts and provide support change. Examples include cloud computing that is enabling the processing of Big Data.
- **Friction** – These are inhibitors to change and they include slow adoption of technology and poor legislative and regulatory support.
- **Turners** – These are opposing forces that are actively working at blocking a trend. The recent labour resistance to clean energy by the unions (NUMSA and NUM) in support of the coal mines are a case in point.

This DEFT analysis has enabled MCA to have foresight on how the future of mobility in South Africa will unravel in the next 21 years to 2040. The analysis will also help identify the real blockers of a trend and what it would take to unblock the friction. For policy makers this analysis will help focus on the enablers of the desired changes like a move from private car ownership to shared mobility

6.1.3 Weak Signals in the Horizon

No one can state categorically and clearly how the future of mobility will turn out to be in South Africa by 2040. However, using the foresight provided by tools like the DEFT Analysis and the Iceberg Model, one is able to pick up some of the minor trends that could be much bigger in a few years' time. A weak signal is defined as an issue that attracts very little attention but could have huge implications for the country or a business. In the mid-1990's the internet was a very weak signal for Microsoft, and they didn't take it seriously but caught on quickly.

In the research done by Hiltunen (2008), identifying weak signals involves scanning the macro environment and picking up emerging issues that could otherwise be overlooked because they seem insignificant. In the era of Industry 4.0 picking up weak signals is far more important given the pace

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at which change happens. For instance, ride-hailing was a new concept when it started but its growth has caught many new markets by surprise.

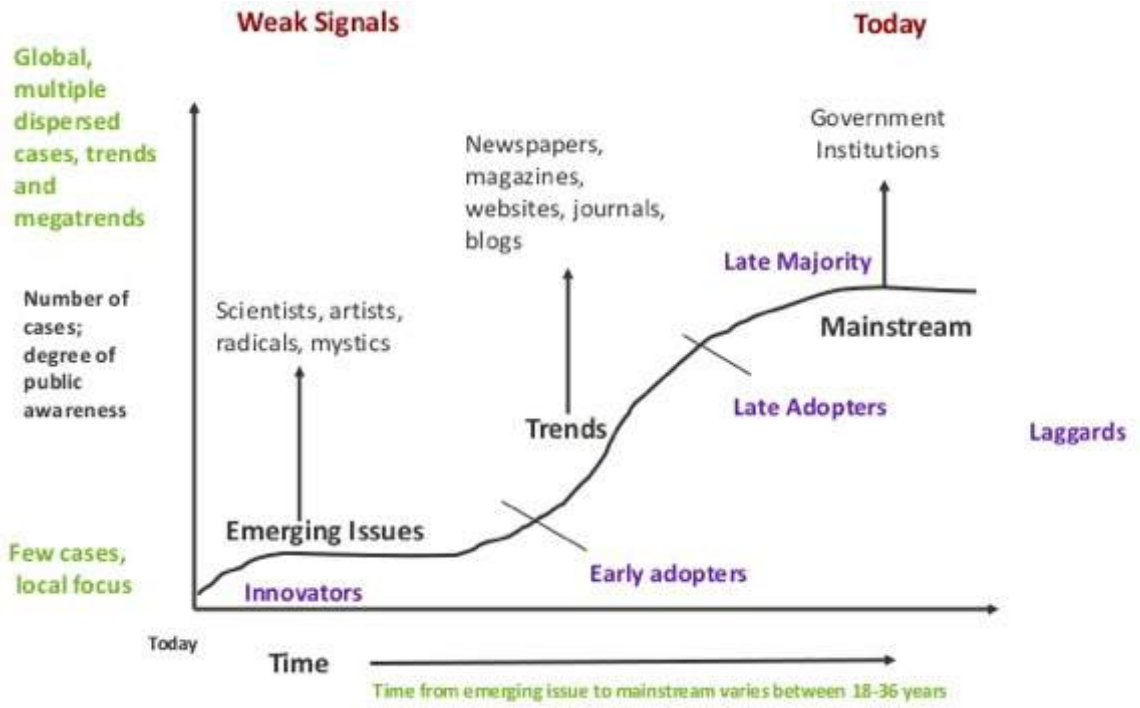

Figure 10: Evolution of Weak Signals

Source: Adapted from the work of Molitor and Schultz

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Innovators and early adopters or disruptors are able to catch the weak signals in their embryonic stage and run with them whilst incumbent players dismiss them as a passing fad. By the time the emerging issues reach the bottom of the S-curve change becomes exponential and the major of industry players are unable to adapt. For the South African market MCA has identified the following weak signals, which government and industry would ignore or dismiss at everyone's peril:

- **Zero Car Ownership** – The growing use of shared mobility platforms is challenging private ownership and in North America this trend has begun to affect the purchases of second household vehicles or delayed them.
- **No-name Car Brands** – When one orders a ride through ride-sharing or car-sharing platforms they seldom specify the car brand but are only concerned about costs and whether or not the vehicle meets the mobility needs of the time.
- Road Virtualisation – Creating a road digital twin will go a long way in enabling Vehicle-to-Infrastructure (V2I) communication even when physical road markings have faded.
- **Near-Zero Crashes** – Autonomous vehicles have a huge promise of eliminating road crashes and fatalities that have become normal on our roads.
- **Zero ICE Vehicles** – Countries in the developed world are planning to completely phase out ICEVs in favour of EVs.
- **Off-Grid Electric Vehicles** – Energy experts are predicting a world with abundant renewable and clean energy to the point wherein vehicles begin to be sources of energy themselves.

6.2 The Purpose of the Scenarios

The core question for this scenario exercise is: Where will the Future of Mobility take South Africa in 2040? This question does not only look at the automotive industry, but the whole mobility value chain and the whole ecosystem. The emergence of the disruptive platform business models like the ride-hailing, car-sharing, load-pulling and consolidation (freight industry), etc. is necessitating the development of a mobility ecosystem to ensure integration and synergy. The proposed scenarios and ecosystem are meant to open a debate about the future of mobility in this country and begin to think about how the nation will move in 2040.

6.3 The Drivers of Change

Over the past 8 to 10 years there have been drivers of change that have been shaping the transport industry and mobility. MCA has identified the following as key to driving change in the next 21 years:

- **Virtualisation** – Technology is enabling the creation digital twins wherein physical assets like cars and roads can be digitised. Other applications include virtual mobility, which is being applied in areas like distance learning and virtual tourism, which are being enabled by

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technologies like Virtual Reality and Augmented Reality. In the development of autonomous vehicles, these technologies are enabling the simulation of real-world scenarios. The Google sister company, Waymo has been able to simulate over a billion miles of autonomous driving in contrast with the only 8 million miles done in live environments.

- **Disintermediation** – The essence of the sharing economy is based on the elimination of the middlemen and links owners of mobility assets with users. Intermediaries like travel agents are being bypassed in bookings of accommodation, where platforms created by companies like AirBnB link property owners with travellers. Travel platforms like TripAdvisor allow travellers to share experiences directly without the help of travel consultants and/or grading agencies.

- **Sharing Economy** – The sharing economy eliminate the opportunity costs of owning a mobility asset like a car. More and more people are discovering the joys of having access to a mobility service or asset (car-sharing) as and when they need it without being burdened with owning an asset that has such a low utilisation (5%). Of all the assets households acquire, motor vehicles are the most underutilised. Shared mobility will challenge the fundamental business models of automotive OEMs, which primarily selling cars to private individuals. In future car ownership will be affected by increased shared mobility.

- **Climate Change** – Transport is one of the major contributors of greenhouse gases and this has prompted governments worldwide to promote the adoption of electric vehicles (EVs). Highly industrialised countries like China have developed incentives for buyers of EVs. These countries have even set target dates for the full abolition of internal combustion vehicles (ICE), most of which are 2040. OEM's have also responded by launching new EV models like the Nissan Leaf, Jaguar iPace and BMW I3. Most of the OEMs plan to produce EV version of every car they produce by 2025.

- **Urbanisation** – The World Economic Forum estimates that the world population that lives in cities will have grown to 70% or over 10 billion. According to the 2016 Census 65% of South Africans live in urban areas. The massive migration to cities is placing a huge strain on transport systems, some of which are outdated and inflexible. These urbanisation trends are raising demand for alternative transport and mobility services and this creates a breeding ground for disruptive business models and technologies.

- **Automation** – The rise of the machines has been affecting just about every industry and the automotive industry is no exception. Every activity that is monotonous, repetitive and mundane is a candidate for automation and driving is one of those activities.

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In some instances, these drivers work together and could be enablers to other drivers. For instance, digitisation can enable virtualisation someone's presence is digitised into a hologram and "teleport" someone's virtual presence into another location. Furthermore, drivers like urbanisation and immigration could drive climate change by worsening the emissions of greenhouse gases.

6.4 Ranking for Impact and Certainty

The global effect of these aforementioned drivers would have varying consequences from one country to the next. It is therefore necessary to contextualise each driver to local conditions of a particular country like South Africa. These drivers would then be plotted on a graph the one of Figure 7 below on the basis of certainty each driver materialising and the impact of that eventuality.
The graph would work in conjunction with allocate scores for impact and certainty as follows:

Table 5: Ranking of Drivers of Change

Driver	Certainty (1 to 10)	Impact (1 to 10)	Ranking out of 100 Certainty x Impact
Urbanisation	**9**	**9**	**91**
Sharing Economy	**7**	**9**	**56**
Climate Change	6	7	42
Disintermediation	4	7	28
Automation	4	7	28
Virtualisation	4	6	24

6.5 Completing the DEFT Analysis

For each of the drivers identified above the DEFT analysis would be completed as per Table 4 below.

Table 6: Future of Mobility DEFT Analysis

Driver	Enablers	Friction (Inhibitors)	Turners
Disintermediation	- eCommerce; - Ride-hailing.	- Poor Internet Access; - Legislative environment	- Resistance by incumbent operators;
Sharing Economy	- Car-sharing; - Ride-sharing; - Car-pooling; - Mobile internet; - Data analytics; etc.	- Unresponsive legislation; - Costly data packages; - Slow internet speed.	- Resistance by metered taxis; - Violence and intimidation.
Climate Change	- Green Mobility, Energy Storage,	- Lack of Incentives - Policy uncertainty	- Anti-Renewables lobby by unions;

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	Battery Technology		- Vested interests (e.g. oil companies).
Urbanisation	- Poverty; - Drought; - Porous borders.	- Shortage of land for settlements; - Lack of infrastructure and services.	- Xenophobia.
Virtualisation	- Cloud computing; - High internet speed.	- Slow internet; - Innovation policy.	- Lack of technology skills sets.
Automation	- Connected & Autonomous Vehicles; - Robotics; - Machine Learning; - AI, IoT, etc.	- Geneva Convention; - Poor legislation.eg	- Unions fearing of job losses; - Threat of cybercrime.

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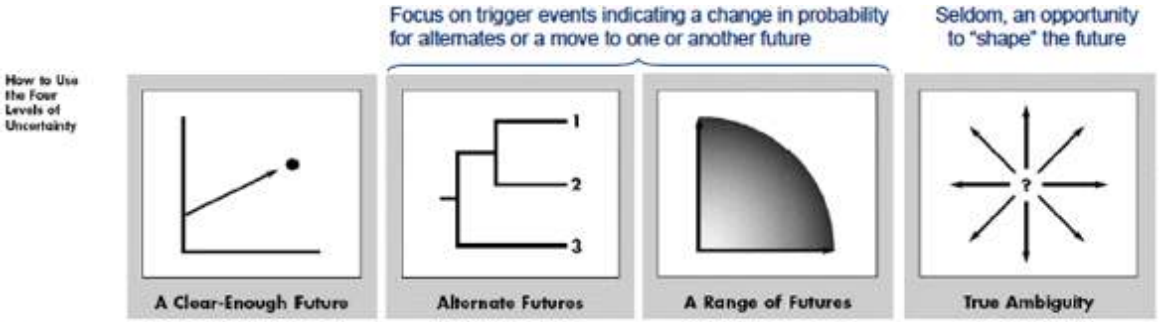
7 STRATEGIC FORESIGHT AND POSSIBLE FUTURES

7.1 Strategic Foresight

Mapping out the strategic futures for mobility in South Africa requires strategic foresight that will invoke systems and critical thinking. This entails taking a step back and looking beyond the conventional and a thorough analysis of drivers of change and their related enablers, friction and turners. In addition to this foresight it is necessary that industry leaders and policy makers scan the environment and the horizon for weak signals that might have a huge impact when they reach maturity. This will result in an agile and flexible strategy that will respond to future changes and the challenges that will result. Adaptive and resilient institutions will be "future-proof" and will respond far more proactively to changes in the macro environment.

7.2 Strategy and Uncertainty

Strategic thinking is about having good foresight and developing roadmaps that will deal with the unknown futures. According to Courtney (1997) organisations are constantly being faced with at least four possible futures that are clear-enough, alternative, range and true ambiguity as depicted in Figure 8 below. For each of these four possibilities Courtney proposes the use of different analytical tools to manage the uncertainties.



	A Clear-Enough Future	Alternate Futures	A Range of Futures	True Ambiguity
What can be known?	A single forecast precise enough to determine strategy	A few discrete outcomes	A range of possible outcomes, but no 'natural' scenarios	No basis to forecast the future
Analytical Tools	"Traditional" strategy tool kit	• Decision analysis • Option valuation models • Game theory	• Latent-demand research • Technology forecasting • Scenario planning	• Analogies, pattern recognition • Non-linear dynamic models
Examples	Strategy against a low-cost airline entrant	• Long-distance telephone carrier's strategy to enter de-regulated local-service market • Capacity strategies e.g. chemical	• Entering emerging markets • Developing or acquiring emerging technologies in consumer electronics	• Entering the market for consumer multi-media applications • Entering Russian market, 1992

Figure 11: Possible Futures

Source: Courtney, 1997 – Harvard Business Review

In spite of uncertainties looming in the horizon, institutions often choose to adopt one of three possible postures or combination there as per Figure 9 below. For Shape the Future posture an organisation could either be a leader or has a reputation for leading in various aspects. Countries like the city state of Singapore and the city of Dubai tend to adopt this shaping posture in all their smart cities programs. Some organisations are happy to stay close to the early adopters. This second posture requires agility

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and speed to respond to the changing environment. The last strategic posture is that of keeping one's options open by being cautious about just adopting any change or following any trend.

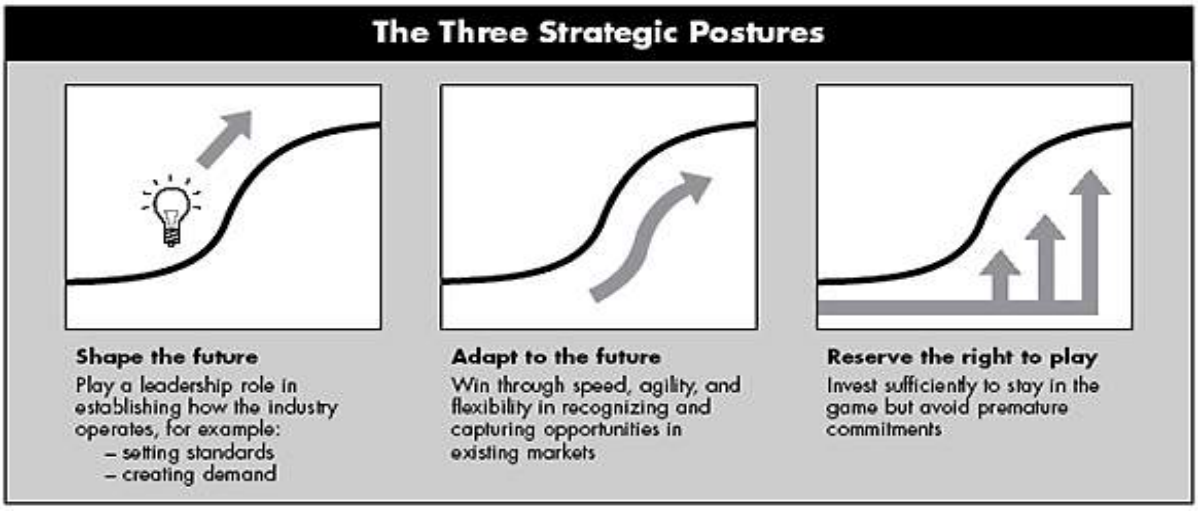

Figure 12: Three Strategic Postures

Source: Courtney, 1997 – Harvard Business Review

In the case of South Africa, these possibilities present interesting options for government and the broader transport and technology industries. One area wherein South Africa could shape the future is in area of the automotive industry, where this industry is highly developed and is not only the biggest new vehicle market in Africa but exports up to 60% of all production. South Africa can adopt a strategy of shaping the future in the African continent whilst adapting to the future of this industry in the global market. The third possible strategic posture of "reserving the right to play" is not a viable option especially in the automotive industry.

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8 FUTURE OF MOBILITY SCENARIOS

The drivers of change that are shaping the future of mobility differ from one country to another. Based on the analysis and ranking of drivers above, two drivers stand out, namely, sharing economy and urbanisation. Whilst this ranking of drivers of change might be relevant for South Africa, they might affect other countries differently.

8.1 The New Zealand Case Study

A scenario planning for New Zealand on the future of mobility identified the collaborative consumption on transport (or shared mobility) and automation as the two drivers that will shape mobility in that country (Fitt, et al., 2018). The sharing economy and its effect on collaborative consumption on transport seem to be a common driver in both South Africa and New Zealand. However, in this study automation was identified as one of the major drivers. This could be motivated by the fact that New Zealand has had extensive experience in testing of connected and autonomous vehicles. In this report projected scenarios for the future of transport in New Zealand were depicted as follows:

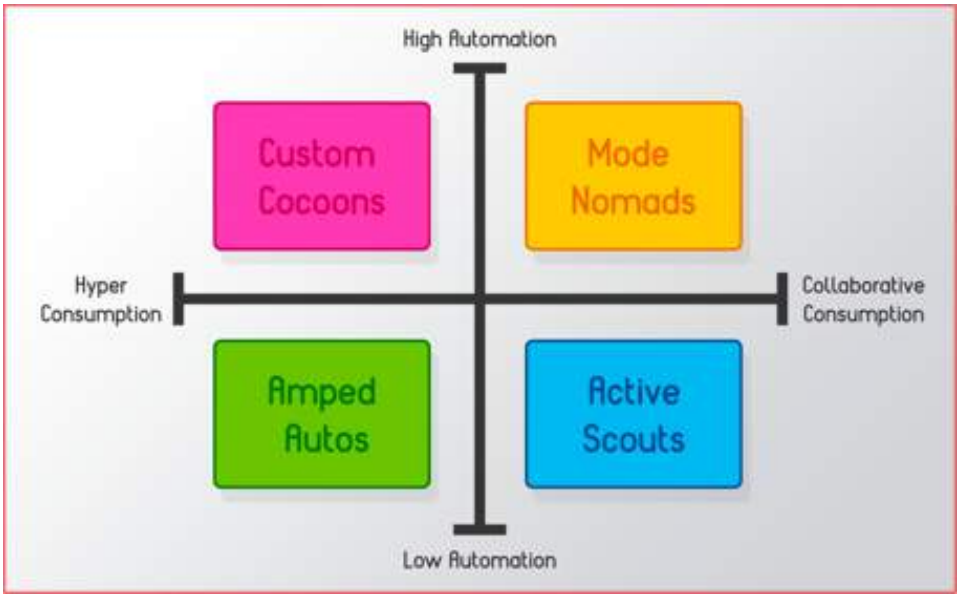

Figure 13: New Zealand Future of Mobility Scenarios

The report further describes these 4 scenarios as follows:

- **Mode Nomads:** Developed AV market shared amongst travellers and often alternating with walking and cycling in dense urban areas.
- **Custom Cocoons:** Almost everyone owns their own driverless car.
- **Active Scouts:** Seeking out the best ways to travel and using a variety of different options.
- **Amped Autos:** People love to drive, so much so that motor-racing is the national sport.

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The report does not go deeper into analysing the plausibility of these four scenarios and only presents these scenarios for further research and debate.

8.2 Proposed South African 2040 Scenarios for Future of Mobility

Following the outcomes of the deliberations of the MCA stakeholder workshop of November 27, 2018 and subsequent input of various industry though leaders and academia; the two main drivers that are expected to impact future of mobility in South Africa are sharing economy and urbanisation. These drivers were also confirmed on the ranking done in this report on certainty and impact. The choice of these drivers can further be justified as follows:

- **Sharing Economy** – The high cost of ownership of vehicles and poor public transport services in South Africa are opening up opportunities for disruptions in this area. Higher levels of shared mobility will have a high impact on the adoption of shared mobility services like ride-sharing, car-sharing, car-pooling, etc. For the purpose of this report, sharing is not only confined to sharing of use of mobility assets but all information about those assets in relation to the users. One area wherein shared mobility platforms are expected to have a huge impact in South Africa is in the minibus taxi industry. The recent launch by Uber of minibus service in Egypt could be a catalyst that can lead to the “uberisation” of the South African minibus taxi industry. This development will affect 70% of the daily commuters or 15 million South Africans.

- **Urbanisation** – For the purpose of this study, urbanisation into South African cities entail movements not only the rural areas but also inward migration from neighbouring countries. According to a UN Report titled: “The World’s Cities in 2016”, 55% of world’s population lived in cities in 2016. In the same year, according to national census recorded 65% of South Africa’s population living in cities. The country is therefore more urbanised than the global average and this has put a huge strain on the transport infrastructure and provision of transport services.

The relationship between these two drivers can be depicted as per the graph in the figure below. The resulting four distinct scenarios can be described as follows:

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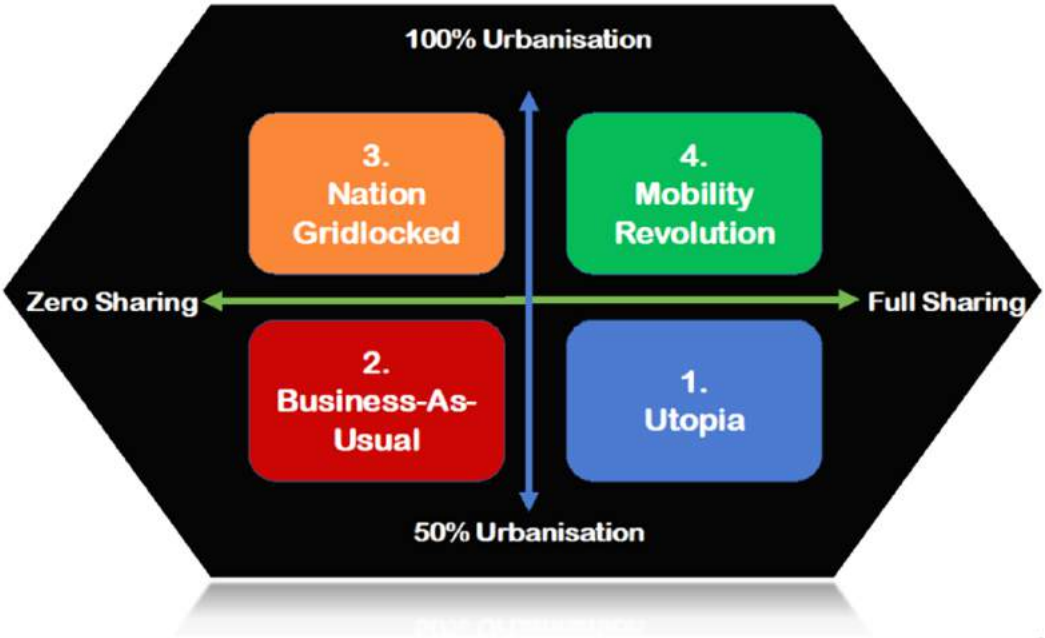

Figure 14: Future of Mobility Scenarios

- **Scenario 1: Utopia** – This scenario assumes that the rate of urbanisation will slow down in the 2020's and 2030's, staying below the WEF predicted 70%. In this scenario shared mobility services will increase. This would be an ideal situation, which will ensure that the provision of mobility platforms move to shared platforms thus reducing the single-occupancy vehicles in favour of mass-transit and high-occupancy vehicles. In this scenario private car ownership would be reduced. However, the plausibility of this scenario is doubtful on the issue of urbanisation only. For instance, the Statistics SA predicts the Gauteng province to grow by another 1 million residents from 2016 to 2021.

- **Scenario 2: Business-as-Usual** – This scenario presupposes that urbanisation levels will not grow and there will less sharing of mobility assets. This scenario is highly improbable on both urbanisation and sharing. Shared mobility is in South Africa is still in a growth trajectory, especially with the expected uberisation of the minibus taxi industry. The scenario is also not plausible for the same reasons given in Scenario 1.

- **Scenario 3: Nation Gridlocked** – In this scenario private car owners will cling on to their vehicles whilst urbanisation continues leading mobility infrastructure keeping up with the rising demand. Traffic congestion levels would increase due to lower shared mobility options and car. This scenario is plausible on the urbanisation side, but this cannot happen without creating a strong need for mass-transit and shared mobility services. This rapid urbanisation will spur demand for shared mobility. This scenario is therefore improbable from the point of view expected lower sharing.

- **Scenario 4: Mobility Revolution** – This scenario is the most plausible for the reasons advanced in Scenario 1 and 3. Urbanisation is expected to continue to escalate in the period to 2040, especially in city regions like Gauteng

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9 TRENDS TO WATCH AND GAME CHANGERS

No one knows how the future of mobility in South Africa will be in the period leading up to 2020. Nonetheless, there are signs that are pointing to a start of a mobility revolution that would need some proactive interventions that are better than how we responded to the introduction of ride-hailing.

9.1 The Rise of Mobility Platforms

During the past 9 years or so the world has seen an emergence of mobility platforms that started with the launch of Uber in May 2010. This start-up company revolutionised the way people move from point A to B. This revolution not only disrupted the business models of metered taxi industry but also affected how vehicles are used. OEM's having been mulling the impact of this on how it would ultimately affect private car ownership, which has kept these automobile giants in business for over 100 years. Ride-sharing and car-sharing platforms are threatening the very existence of car brands and future travellers will no longer be concerned about which car brand takes them on a short trip.

One of the criticisms of mobility platforms like the ride-hailing ones is that they are all operating in silos, one vying to outperform the others in a very competitive environment. For instance, Uber partners are required to work exclusively on this platform without combining it with others. Some applications have also been introduced that seek to integrate all ride-hailing platforms but have not been successful.

From the viewpoint of an aspiring smart city, an ideal mobility ecosystem would that which integrates all modes of transport around the public transport mass-transit systems like buses and trains. This would give travellers much wider choices from the use of buses and trains right down to shared bicycles and scooters. This is Mobility-as-a-Service, which seek to seamlessly combine all transport options of different providers through subscription services or on-demand purchase of ad-hoc transportation services. This can be referred to as the platform of platforms or the ultimate mobility ecosystem.

MaaS promises to be the panacea for some of the most wicked transport problems of congestion, emissions and inefficient transportation (Li, 2019). Whilst mobility platforms like ride-sharing work as travel brokers between travellers and transport providers, MaaS serves to unify these platforms into

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a single ecosystem that includes public transport. A Transport Knowledge Hub report depicted MaaS as follows (Kamargianni, Matyas, & Li, 2017):

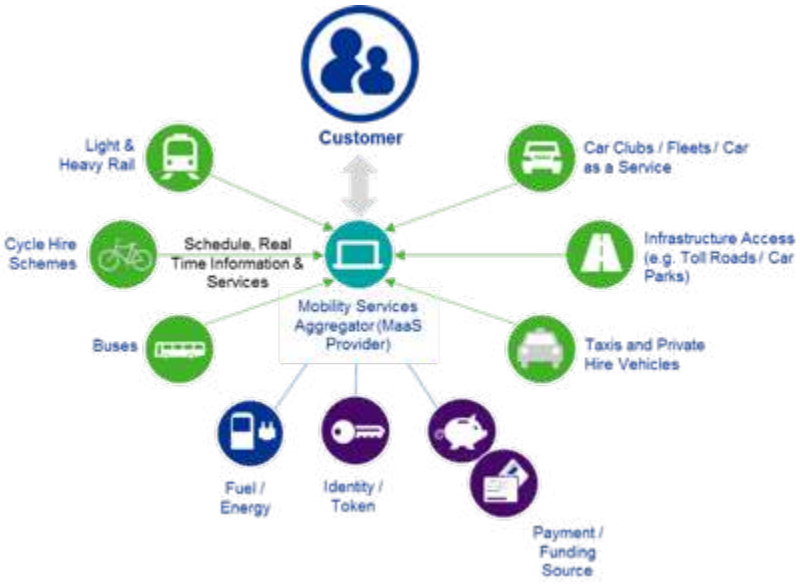

Figure 15: Mobility Ecosystem

9.2 Game Changers

Some of the weak signals that could have huge game-changing implications for the Future of Mobility in South African are as follows:

5G The incremental improvements of connected and autonomous vehicles will require not only broad internet coverage but will need it at higher speed with near-zero latency. Current 4G networks with higher latency are one of the barriers to the realisation of full Level 5 autonomous vehicle (AV) technology. An autonomous vehicle is expected to generation about 4 terabytes of data, which is equivalent to the data generated by over 3,000 smart phones. Not only will AV technology be dealing with sheer volumes of data, but this data will be coming at huge speeds, which current networks are unable to deal with. To enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communicate Autonomous vehicles will need much faster networks and ***5G networks*** will revolutionise this change.

AI As an AV is driven in any particular road it learns about anything there is to learn not only about the road conditions and ***artificial intelligence*** will enable it to process all data it collects. For instance, it will be validating road conditions and all surroundings with the information that had been learnt by another vehicle. If the conditions have changed the AV will update this information and it will also be empowering another vehicle that is 5 seconds behind. This second AV will take note of this information and will act accordingly. In turn the second vehicle will learn about how to deal with this new information, which could be a new pothole or any hazard that require proactive action. AI will enable AVs to take all necessary steps without the intervention of humans. In the event of possible a

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number of AVs will collectively "decide" how to deal with a particular eventuality. For instance, AI will enable even ethical decision like who gets to live and who should be sacrificed.

Blockchain is expected revolutionise shared mobility and will eliminate the need for a central payment engine that settles mobility billings. Probably the biggest change will be on peer-to-peer transactions, through its distributed ledger system. One of the biggest fears of AI-empowered AVs is cybercrime, which could compromise not only a single vehicle but could comprise the entire ecosystem. Such a breach could cause a total shutdown of the whole system and this could cause untold damage that could be worse than that seen on the movie, Fast and Furious 8. Not only will blockchain be able to process transactions safely, this technology could detect any breaches to the ecosystem and will be able to deal with and block any fraudulent transaction. Furthermore, blockchain will enable mobility providers and travellers to share and monetise their own data with minimal transaction costs (Shaheen, Totte, & Stocker, 2018).

Drone technology is fast becoming the next big thing smart cities is bringing efficiencies in jobs that are defined with the 4-Drones of Drones: Dangerous, Dirty, Dear and Dull. Drone technology is being applied in sectors life mining, agriculture, security, mapping, geospatial, policing, etc. The biggest challenge for cities and air navigation authorities is integrating controlled and uncontrolled air spaces. The biggest disruption of drones will come in the form of drone deliveries and passenger drones. Aircraft manufactures Bell, Boeing and Airbus have started building and testing passenger drone prototypes and have also been joined by Uber. On drone deliveries Amazon has been testing use cases for parcel deliveries in a number of global cities.

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10 STRATEGIC IMPLICATIONS FOR SOUTH AFRICA

There has been much hype about the 4th Industrial Revolution and this phenomenon has occupied the minds of policy law makers. From the President to ministers and MECs, a speech is never complete without the mention of 4th Industrial Revolution and how South Africa needs to prepare for it. This energy and enthusiasm should be welcomed because the effects and impact of technology on human life should be front and centre in all spheres of government, academia and industries.

In revisiting the MCA's identified 4 wicked problems of transport, it is our belief that these problems in themselves will drive or force a change in certain areas.

10.1 Uberisation of the Minibus Taxi Industry

One major prediction that MCA is making is that of the uberisation of the minibus taxi industry. There are strong convictions that there are very strong turners that will resist this change, but it is expected that some operators might begin to see the benefits of an Uber-like platform that will connect drivers with their passengers. At MCA we foresee the digitisation of the taxi ranks, wherein riders will see all taxis going their way and they can select their rides as much as drivers will be able to see the passengers going to a particular destination. This platform will be able to match demand with supply at any point in time.

Figure 16: Uber Bus Launched in Egypt in 2018

10.2 South African Automotive Industry

The South African automotive industry produces no less than 600,000 vehicle per annum and exports up 60% of these vehicles to some of the developed countries. These countries include other major vehicle-producing nations like the United States and Germany. Owing to technological advancements in the global automotive industry, these export markets are all at various stages of testing and deploying of connected, electric and autonomous vehicles. Within the next 10 to15 years South Africa

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will be expected to meet the demand of these vehicles from the export markets. It is therefore imperative that South Africa prepares well in advance to be ready to meet this demand before 2030.

Figure 17: Connected, Electric & Autonomous Vehicles

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11 CONCLUSION

The period leading up to 2040 will be characterised not only by massive changes in the area of mobility but by the pace at which those will changes will unfold. Some of these changes will be very disruptive and have potential to decimate industries or sectors like we are seeing with the metered taxis. This industry is very small in comparison to the minibus taxi industry but the disruptions and violence that started with the launch of Uber in 2014 has not yet abated. It is the responsibility of not only government but the transport industry at large to prepare for these changes and not to be caught off-guard.

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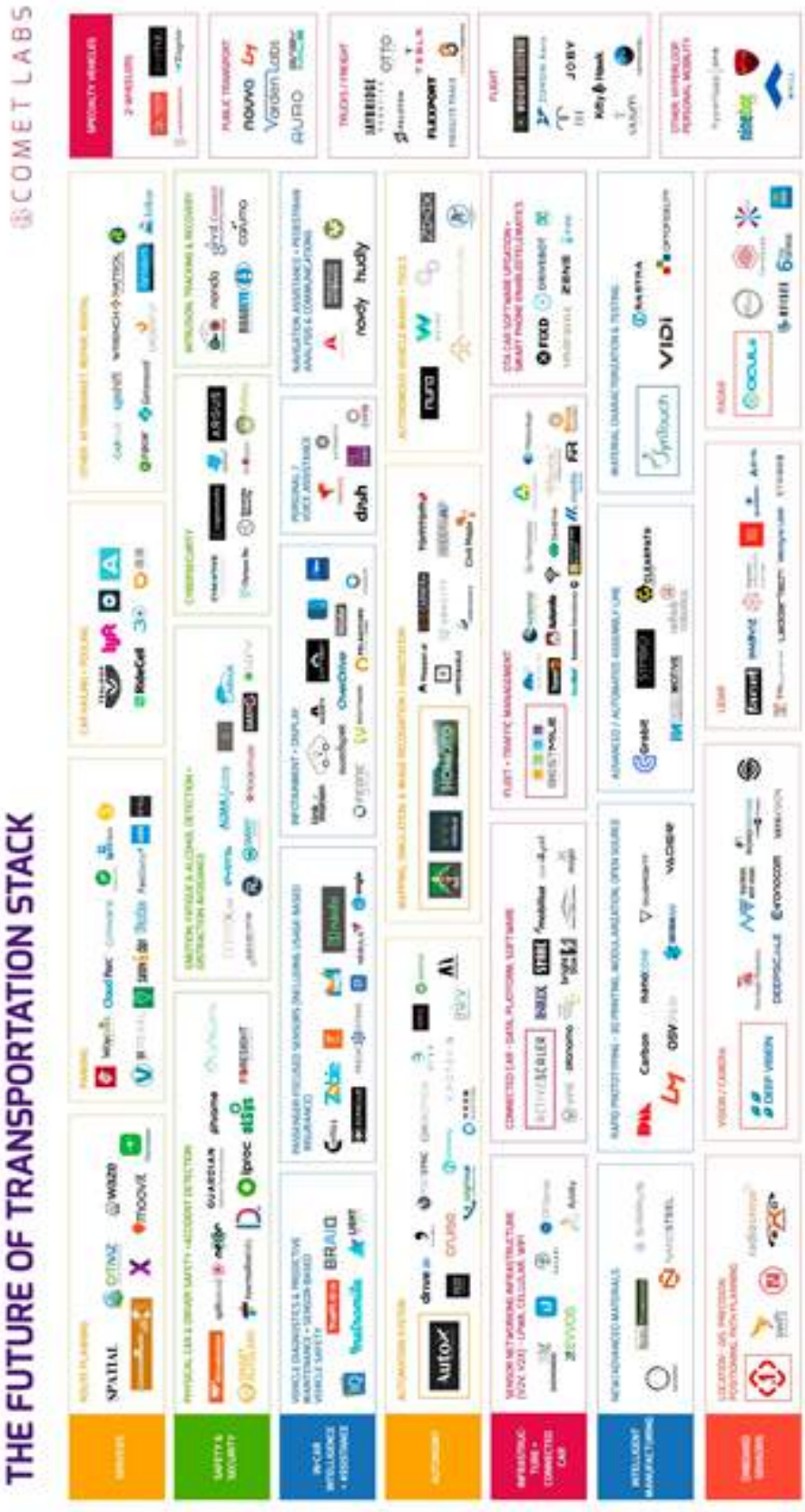
13 Appendices

13.1 Appendix 1: Future of Transportation Stack (Source: Comet Labs)



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