METHODOLOGY

Foresight Study on Urban Mobility in Singapore 2040

November 2016
A foresight study focuses on developing multiple future scenarios to cover the spread of different possibilities that can occur as a result of today’s decisions (Hejazi, 2011). It assumes that the future is not an extrapolation of a set of predetermined trends and innovations. Instead, it builds on the principle of an uncertain future that can be shaped by today’s actions. The intention of foresight studies is not to predict the future correctly, but rather, to prepare stakeholders for a future that is inherently uncertain.

Typically, a foresight study uses a combination of different methods at different stages. Finding the right combination of these methods is one of the most important steps in the exercise. Some of the methods are quite simple to use and do not require significant expertise, while others are complex to develop and very time consuming. Furthermore, some methods are more practical when used for short-term projections, while others are better suited for long-term forecasts.

By evaluating more than 880 foresight studies conducted in Europe and other parts of the world, Popper (Popper, 2009) showed that on average five to six methods have been adopted for each foresight study. The process of selecting the most appropriate foresight methods for our study is a challenging task since there are more than 30 different foresight methods in literature and there is no specific guideline for systematically selecting the methods for our foresight study.

Popper (Popper, 2009) classified foresight methods into four attributes based on their ability to gather or process information, namely Creativity, Expertise, Interaction, and Evidence.

Creativity is about a mixture of original and imaginative thinking; methods relying on the inventiveness and ingenuity of individuals, or developed through brainstorming sessions. Expertise refers to the skills and knowledge of individuals in a particular area to make decisions, and provide advice or recommendations. Interaction recognises that expertise gains considerably from being brought together and challenged to articulate with other expertise. Finally, Evidence recognises that it is important to support analysis with reliable documentation and measurement indicators.

After reviewing foresight methods in the literature, we selected our methods by considering the time horizon of the project and Singapore’s context, as well as the four fundamental attributes of the foresight methods (shown in brackets next to each method). The selected methods and the foresight methodology are summarized in Figure 1.

1. Environmental Scanning/Literature Review (Evidence): Environmental scanning helps to understand the nature and pace of change in the environment, and to identify important economic, social, environmental, technological and political trends. Literature review represents a key part of the scanning process. We conducted a detailed environmental scanning by reviewing related urban mobility foresight studies done globally, academic literature, and mass media articles from newspapers and magazines.

2. Expert Interviews (Expertise and Evidence): Expert interviews are structured conversations used to gather insights from individuals who are specialists in their respective fields. We conducted structured interviews with 51 experts involved in various aspects of urban mobility in Singapore.
3. **Focus Group Discussions** (Interaction): Focus group discussions provide insights into how people think. We conducted two focus group discussions to understand future users’ behaviour, concerns and ideals regarding transport in future Singapore.

4. **Technology Scanning** (Expertise): Technology scanning helps to identify critical technologies under development that can have game-changing effects on the system. The process of scanning helps to chart the course of these technologies and how they fit into future scenarios. Based on the insights gathered through environmental scanning and expert interviews, possible game-changing technologies in urban mobility were identified. For each potentially disruptive technology identified, the team examined its possible role in Singapore’s mobility system, documented the current state of development, and detailed challenges to their development and application.

5. **Future Scenarios and Workshop** (Creativity and Interaction): Scenario planning is one of the most well-known and most cited technique for planning for the future. Edgar and Alänge (Edgar et al., 2014) defined scenario planning as the process of creating various plausible views (scenarios) of the future by considering the impact of uncertainties and driving forces. Scenarios help to identify future options and prepare stakeholders to tackle uncertainties. By organising a scenario planning workshop, we brought together stakeholders from our expert interviews as well as local transportation planners, and individuals referred by other participants. This workshop helped in selecting key drivers of change and creating and analysing possible scenarios for Singapore’s urban transportation landscape in 2040.

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**Figure 1. Overview of the foresight methodology**
We conducted a detailed environmental scanning by reviewing related urban mobility foresight studies done globally, academic literature, and mass media articles from newspapers and magazines.

We identified twelve foresight studies on urban mobility and logistics around the world (see Table 1). Since Singapore is a developed city, we focused mostly on studies that were conducted on other metropolitan areas. Many of these cities face similar issues such as increasing congestion, increasing and ageing population, as well as changing social behaviour. These studies covered time-periods from as near as 2018 to 2100, with the bulk of studies looking towards 2040. Moreover, these studies have been conducted by diverse interest groups ranging from global consulting firms (e.g., Deloitte), independent international organisations (e.g., Forum of the Future), to academic institutions (e.g., New York University), and government departments (e.g. New Zealand’s Ministry of Transport).

Through this process, we identified some of the drivers of change that are commonly being discussed in several cities. Some of the influential drivers of change common among cities include vehicle automation, virtual travel, robotics and intelligent transportation system integration, rise of on-demand transport service models, uncertain energy mix and prices, climate change and environmental sustainability.

To supplement insights from our review of foresight studies around the world, we also compiled regional and local factors that were potentially influential, in particular, the threat of terrorism, which has affected public transport in several cities. Another factor is Singapore’s smart nation vision, which requires the country to develop greater innovative capacity, and encourage companies to place engineering at the core of their businesses to harness technology to the fullest. Lastly, Singapore recently committed to reduce the country’s carbon emissions intensity by 36 percent by 2030, based on 2005 levels. This pledge at the COP21 climate talks in Paris in 2015 is likely to impact the transportation sector, which is a substantial contributor of greenhouse gas emissions in Singapore.
### Table 1. Summary of 12 previous foresight studies on urban mobility

<table>
<thead>
<tr>
<th>Foresight Study</th>
<th>Foresight Year</th>
<th>Cities / Region</th>
<th>Key Drivers of the Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Townsend, 2014)</td>
<td>2030</td>
<td>United States Megacities</td>
<td>energy mix and price, vehicle automation, global trade of technology, economic instability, virtual travel, individualism</td>
</tr>
<tr>
<td>(Van Voorst tot Voorst et al., 2014)</td>
<td>2040</td>
<td>Dutch Urban Centers</td>
<td>individualism, globalisation</td>
</tr>
<tr>
<td>(Office of Science &amp; Technology, 2006)</td>
<td>2056</td>
<td>United Kingdom Urban Centers</td>
<td>environmental sustainability, public acceptance of intelligent infrastructure</td>
</tr>
<tr>
<td>(DHL, 2012)</td>
<td>2050</td>
<td>Megacities</td>
<td>energy price, climate change, political stability, global trade, income distribution, ICT &amp; robotics, changing consumer needs, urban development, scarcity of resources, legislations, material technologies</td>
</tr>
<tr>
<td>(Martins et al., 2012)</td>
<td>2018</td>
<td>Brazil Urban Centers</td>
<td>investment in infrastructure, efficiency of legislation and quality control</td>
</tr>
<tr>
<td>(Auvinen et al., 2012)</td>
<td>2100</td>
<td>Finland Urban Centers</td>
<td>energy mix, climate change, legislations, urbanisation, virtual travel, ITS integration</td>
</tr>
<tr>
<td>(Zhao et al., 2012)</td>
<td>2030</td>
<td>Jinan, China</td>
<td>urbanisation, environmental sustainability</td>
</tr>
<tr>
<td>(Lyons et al., 2014)</td>
<td>2042</td>
<td>New Zealand Urban Centers</td>
<td>cost of energy, virtual travel</td>
</tr>
<tr>
<td>(Gazibara et al., 2010)</td>
<td>2040</td>
<td>Megacities</td>
<td>energy mix and supply and demand, governance model</td>
</tr>
<tr>
<td>(Zmud et al., 2013)</td>
<td>2030</td>
<td>United States Megacities</td>
<td>price of oil (energy), climate change, investment in infrastructure</td>
</tr>
<tr>
<td>(Fishman, 2013)</td>
<td>2020</td>
<td>Megacities</td>
<td>vehicle automation, virtual travel, ITS integration, mobility-on-demand, real-time information, dynamic pricing</td>
</tr>
<tr>
<td>(Ecola et al., 2015)</td>
<td>2030</td>
<td>Chinese Megacities</td>
<td>pace of economic growth, constraints on driving and vehicle ownership, environmental conditions</td>
</tr>
</tbody>
</table>
EXPERT INTERVIEWS

We conducted structured interviews with 51 experts involved in various aspects of urban mobility in Singapore. The objective of the interviewing process was to gather insights from people who are specialists in their respective fields. According to European Foresight Platform, “Foresight is, by definition, a participatory, discursive activity that should be based upon the best available evidence and judgment. These conditions make the use of expert panels a natural choice in foresight exercises.” (European Foresight Platform, 2010)

SAMPLING AND RECRUITMENT STRATEGIES

The first step in the process was to select a suitable pool of experts to interview. We had three criteria in our selection process. First, the pool of experts should have ample representation from each of the three sectors: government, academia, and industry. Second, at least 20% of all the experts interviewed should be from the freight sector. Third, experts interviewed should have at least 5 years of experience in their respective fields. This meant we typically approached experts who were in senior leadership positions in their respective organisations.

We primarily used three ways to identify and reach out to suitable experts. First, we attended seminars and workshops from July 2015 to the end of 2015 to network with potential interviewees. This approach gave us access to some foreign representatives as well, who had come to Singapore to present in seminars and conferences. On meeting them at respective events, we explained our project objectives and asked them for a suitable interview slot.

The second approach involved browsing through websites of known companies and emailing suitable individuals, introducing the project and asking for an interview. This approach helped us get interviews with several high-ranking experts with deep understanding of and influence in their fields, which includes start-up founders, CEOs of large companies, and directors in relevant departments.

Lastly, the third approach we used was to ask for referrals from our interviewees at the end of each interview. Referrals proved to be a great way in reaching out to high-ranking experts who typically only engage through known contacts. Overall, we managed to include experts from wide ranging organisations in all three sectors (government, academia, and industry). The percentage of experts from each sector and percentage mix from passenger and freight sectors are shown in Figure 2a and Figure 2b.


**Discussion Questions**

During these interviews, experts shared their views on the top trends, challenges, and technologies for the future of transport. In addition, they discussed specific issues within their realm of expertise, sharing insights about the underlying forces influencing change in their sectors.

As each interview averaged about an hour in length, the number of topics covered and the depth of discussion varied depending on the experts’ areas of interest. However, a general set of questions were prepared in advance to guide the interview process. This list of questions is as follows:

1. What are the three most influential future transport trends in your opinion?
2. How has the transportation landscape changed in the last few years? How do you think the transportation field will change in the future?
3. What do you think are the three biggest challenges in Singapore’s transportation system over the next few years, and further on into 2040?
4. What are some of the transportation-related technologies that you think will play a game-changing role in shaping mobility landscape in Singapore?

A written transcript was created for each interview and audio recordings were made for some of the interviews.

**Findings**

In order to distill the key drivers from interviews, we conducted a two-step process. First, we used audio recordings and written transcripts of interviews to identify challenges, trends, and technologies. We used Excel sheets to record these entries. Second, we analysed the inter-dependencies of these challenges, trends, and technologies to account for redundancies and cluster them together into five different categories. These categories, known as Influencing Areas, are explained in detail in *Drivers of Change* section.
FOCUS GROUP DISCUSSIONS

The main objective of conducting focus group discussions (FGDs) in this study was to understand views about the future of urban mobility from users in Singapore who constitute a sizeable proportion of the demand. More specifically, our aim was to understand users’ behaviour, concerns and ideals regarding getting around in the future, as well as any current challenges they experience with regard to mobility services. Understanding the social perspective on urban transportation and mobility can potentially encourage planners and policymakers to explore non-structural alternative forms of policy intervention.

FGDs have, across years and disciplines, been considered an efficient means of eliciting views and dialogues among several people at a time (Kitzinger, 1995). Being often semi-structured in nature, FGDs encourage people to think more critically about issues, allow for debates, and stimulate new topic discoveries that researchers may not have conceived of.

SAMPLING AND RECRUITMENT STRATEGIES

Singapore citizens and PRs aged between 19 and 40 years old who were living in Singapore were invited to participate in the FGDs. There were two sessions and each lasted for 120 minutes with eleven participants each. The first session was conducted on Friday 22nd January 2016 at the Singapore University of Technology and Design, and the second was conducted on Monday 1st February at The Future of Us Exhibition at Marina Bay Sands.

To reach out to the first group of focus group participants, aged 19 to 24 years old, we designed posters and approached institutions by email for permission to display these posters within their compounds. These posters were emailed to post-secondary or tertiary institutions, namely, the Institute of Technical Education, the National Technological University, the National University of Singapore, and the Singapore University of Technology and Design, where they could be printed and physically displayed. Interested parties would then voluntarily access a link provided on the poster and register with the following details: first/last name, age, email address, contact number, sex, household type, primary mode of transport, and school/institution. Thus, the sampling was primarily based on a combination of purposive and convenience sampling strategies.

Purposive sampling occurred at two instances of this study; first, where we deliberately selected and contacted various institutions with the intent of obtaining a pool of post-secondary aged students, and second, where we selected, from the list of participants who registered, individuals who met the fundamental eligibility criteria and who could provide diversity of representation in the sample (e.g. by their gender, ethnicity, mode of transport and so on). Convenience sampling occurred in our study where participants who chanced upon the posters circulated in the different venues could register for the event on their own accord.

To recruit participants for the second focus group discussion, we employed email and social media platforms to recruit participants aged between 25-40 years old. We circulated an email poster internally, to inform staff from across various departments in the Singapore University of Technology and Design (SUTD) about the event. We also posted recruitment advertisements bearing similar content on our posters on three social media websites which are publicly accessible: Kiasu Parents, V-R Zone, as well as Hardware Zone. Participants who were interested registered through the online link.
listed on the poster or advertisement. As with the earlier recruitment drive, this recruitment rested upon convenience and purposive sampling approaches.

Convenience sampling took place when we circulated the event’s details to platforms that we were familiar with and had access to, i.e. the three social media platforms and SUTD. There were no restrictions on who could sign up for the event until we conducted the next phase of screening participants (i.e. purposive sampling). This was an effort to ensure that participants met the basic eligibility criteria and that the group would comprise individuals of different ethnicities, ages, genders, occupations, and primary modes of transport.

**DISCUSSION QUESTIONS**

The focus group discussion was guided by the following semi-structured schedule of questions. This approach of interviewing affords both structure to guide the thread of discussions and a degree of latitude for participants to elaborate beyond the scope of ideas and topics indicated in the schedule. Using semi-structured schedules, facilitators also had the liberty to discern and adapt their questions to the trajectory of participant conversations.

1. What do you like/dislike most about travelling in Singapore so far? Please cite one or two personal examples from your experience.

2. Receptiveness to active mobility and car-lite vision: What is the maximum distance you are willing to walk and/or cycle? What factors will encourage you to cycle/walk more to work?

3. In 2030, MRT lines will be doubled and you can access a MRT station by at most 10 minutes of walking. How might this affect/influence your decision to use public and private transport then?

4. How many of you here might consider riding/owning a car in the near future?

5. Receptiveness to sharing economy: What do you think of using shared car/taxi rides or shared/pooled commuting?

6. Suppose you fast-forwarded life to 2040 and are at the age that your parents are now. How might life look like for you at that time? (E.g. In terms of work, school, shopping, socialising, etc.)

7. What smartphone apps do you use now? What apps would you like to use 20 years from now?

8. Discuss your vision of the ideal local transport system in 2040.

9. What are your thoughts/views about location privacy? (Location privacy is defined for participants, if necessary. This line of questioning prompts respondents to share their opinions on the future ERP2 system in which all movements are captured in the system.)

10. If you were an employer in the future, would you allow your workers to telecommute?

11. What other things about transport that you believe are important do you think we have yet to discuss, given our topics so far?

**ANALYTICAL STRATEGY**

Findings from the focus group discussion were derived from analyses of the verbatim transcripts of voice recordings of all focus group discussions. The transcripts were systematically analysed using qualitative research coding strategies. Coding was designed to make sense of participant responses in ways that are consistent with one of the study’s objectives, i.e. to identify the drivers of change influencing future mobility in Singapore. Participants’ verbal and non-verbal expressions which
signify certain events, actions, reactions, beliefs, values, attitudes, aspirations, deliberations, concerns, experiences, and feelings relevant to the research’s interest are instances of code-worthy items.

Coding was conducted by means of a word processor. The main coding strategy employed in this study was influenced by Glaser and colleagues’ (Glaser et al., 1967) grounded theory approach to coding.

**FINDINGS**

The key themes that emerged from the focus group discussions are as follows: (i) participants’ reasons in opting for or using one travel mode over another, (ii) their experiences with the travel modes currently available to them, (iii) their behaviours in response to these past or current travel experiences (e.g. coping or accommodating strategies), and (iv) their future expectations and aspirations with regard to mobility services in Singapore in 2040.

We categorised external and internal factors that appear to influence one’s choice of travel mode. External influences refer to extrinsic conditions, situations and circumstances that are encountered by individuals as ‘givens’ in their physical, natural and social environments. They may affect their decision to utilise one travel mode over another, and be perceived as strengths or constraints. For instance, an individual living in a particular locale may be pleased with the existing public transport infrastructure in the area, as opposed to an individual in another locale where similar infrastructures remain underdeveloped.

Internal influences refer to a set of values or ideas that are learned, internalised and espoused by individuals about what is considered desirable (as defined by social or personal measures). These factors may wittingly or unwittingly affect individuals’ decision to travel using one mode of transport as opposed to others. From participants’ responses, some underlying influences that lead to the development of internal influences could be inferred. These were labelled as “sources of values” and used to explain variations in participants’ values.

Individuals adapt in the face of adversity. If they perceive existing mobility services to be challenging or unsatisfactory, they actively circumvent these experiences by employing different strategies (Mote & Whitestone, 2011). Coping mechanisms or strategies arise when mobility services do not meet individuals’ expectations and/or needs, as informed by their direct experiences and use of these services (i.e. prior/existing choice of travel mode) and prevailing societal or personal values that may influence their expectations. For instance, a typical mobility service provider’s goal to move mass populations from point A to point B efficiently may not be appreciated by individuals who prefer mobility services that furnish both efficiency and comfort, or if it fails to accommodate to certain segments’ needs, e.g. the elderly, or parents with young children.

Based on the FGD findings, we construct a theoretical model (Figure 3) to display the interrelationships between key categories of participant responses.
Figure 3. Theoretical Model of Social influences on Transportation in Singapore

External and internal influences, their interplay with each other and with participant sources of values, were found to explain participants’ preferred travel mode at any one given time. The experience of traveling on particular, or different travel modes, has in turn, the effect of acting as a feedback channel that reshapes one’s values and expectations toward current mobility services as well as their expectations for future mobility services in Singapore. Arrows marked as “feedback” indicate how individuals’ history of experiences with any given travel mode(s) has the effect of recursively moulding their expectations and perceptions of the current mobility system. This explains why individuals’ commuting/travel experiences was listed as one of the “sources of values” in the theoretical model. For instance, there were instances in the FGDs where participants detailed how certain infrastructural modifications in the public transport system positively improved their commuting experience. They made references to recent developments, such as MRT line extensions and bus enhancement programmes which made public transportation much more amenable to participants than before.

Finally, participants were asked to suggest recommendations for the “ideal” mobility system that they would like to experience in Singapore in 2040. Their expressed mobility service expectations and desires also emerged during the ongoing discussion about current mobility services. This data provides the main content for the category created as, “Future Expectations” in Figure 3.

Implications of Findings

As Figure 3 depicts, the conditions affecting participants’ choice of particular travel modes are varied and interdependent on one another. While being by no means exhaustive, the model attempts to provide a comprehensive framework that reflects the diversity of values and practical conditions governing individuals’ choice of travel mode, which is mutually influenced by one’s direct encounters with current mobility infrastructures. The findings brought into scrutiny the various conditions (classified as “external” and “internal” factors respectively) that participants indicated to influence their choice of travel mode in Singapore. We were also able to infer some of the underlying conditions believed to account for participants’ expectations and perceptions of the current mobility system (see “sources of values” in the model).
Participants’ self-initiated descriptions of their expectations and perceptions of Singapore’s current mobility scene also toadied in understanding users’ coping strategies deployed in response to the challenges they encountered with local, existing mobility infrastructures.

Last but not least, participants’ narratives expressed their aspirations for the transport scene in Singapore in the near future and in 2040. These aspirations were largely predicated on participants’ state of knowledge of technology developments, personal values, expectations and personal experiences with the current transport system. Upon closer inspection of participants’ aspirations, one may realise that they are largely a translation of one’s values and expectations toward the current mobility system. For instance, individuals’ wish for high-speed travel reflects their value of time-saving.

**Applicability of FGD Findings**

The variables constituting the external and internal influences serve to remind stakeholders using these findings that a “typical” commuter should be considered and defined with reference to some fundamental parameters, such as access to certain transport infrastructures, lifestyle needs, purpose of travel, as well as values pertaining to time and cost. Given the relatively well-established transport infrastructures in Singapore and its residents’ affluence, transport users in Singapore are less likely to be confined to a single travel mode option. In view of this, understanding the circumstances in which individuals consume different and/or mixed travel modes - as explored in this study - may also prove to be as or more applicable than examining their allegiance to a sole, dominant travel mode.

Findings from the FGDs were also instructive in alerting us to the possible risks and opportunities that would apply to each driver of change. For instance, while technology in the form of autonomous or self-driving vehicles (AVs) and electric vehicles (EVs) is one of the more significant drivers of change, the FGD findings signalled potential resistance to this particular innovation. Specifically, a number of participants from different age groups defended the value of social and human interaction as well as the experience of driving their cars without additional automation. Participants’ views toward AVs thus offered us some insight on the likely prevalence of this technology in the future, or at least its demand by certain segments of the population. This finding was thus anticipated as a possible “risk” of AV technology uptake.

Variations in values and experiences as well as intrapersonal value contradictions add another layer of complexity for researchers to understand and predict users’ travel mode decision-making process. First, individual’s values and expectations may be contradictory and/or not simultaneously attainable. For instance, while participants’ values of obtaining maximum comfort and time-cost efficiency may be attained through the virtualisation of work and school institutions, thus potentially dispensing with the need for commuting altogether, many vetoed this idea. Participants expressed wariness toward the full realisation of virtualisation, which they feared would spawn the decline of face-to-face human interactions (another value). As another case-in-point, participants were observed to have adjusted their expectations and/or value priorities (e.g. cost-savings), in order to achieve other values (e.g. comfort) or manage certain mobility demands (e.g. purpose of travel or travelling with less mobile dependents). While many participants prized the value of cost-savings, their purpose of travel and desire for greater comfort motivated them to use private modes of transport that may in fact cost more and not necessarily offer them greater time efficiency. This conundrum of competing or contradictory values faced by users demonstrates how users’ decision-making can be a complex
process. It also calls into question how individuals come to prioritise their values and expectations—an area which warrants future research.

Next, understanding the personal significance of driving to individuals bears relevance to this study as it offers us some form of prediction as to whether particular transport technologies are likely to meet with resistance and, if so, for what reasons. For example, individuals who associate AVs with the abdication of control over the vehicle or the loss of a skill, can be expected to offer less support for AVs in the market. The findings also shed insight on why private car commuting and car ownership have persisted over the years despite multiple incentives to attract commuters to public transport.
When it comes to our perception of technologies, we often underestimate how much a certain technology can evolve in medium to long term period, such as a decade or 25 years. In order to develop a more concrete perspective of what technologies can have the most game-changing influence on the future, especially in the mobility sector, we first need to develop the right frame of thinking. One way to do this is to reflect back on the last 25 years and think of what technologies that we take for granted today did not exist in 1990. It is eye-opening to realise that smartphones, dynamic maps, social media, and even internet did not exist then. Today, these technologies are norm in our routines.

We have discussed in detail nine technologies (Table 2) that were identified from our expert interviews, focus group discussions and environmental scan of professional, academic, and mass media sources. Several other technologies, such as flying cars or hyper-loop train in Singapore, also came up in our research but most experts and stakeholders agreed that these are either technologically or policy-wise not suitable for Singapore’s context.

Table 2. Game changing technologies in urban mobility

<table>
<thead>
<tr>
<th>Technology</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Analytics</td>
<td>The analysis of big data gathered via smartphones, online services, sensors, payment systems and even personal vehicles; can provide clear and usable information on real-time happenings to commuters.</td>
</tr>
<tr>
<td>Mobile Technology (including applications for shared mobility)</td>
<td>High level of smartphone penetration provides a platform for many types of mobile applications to meet huge demands. Apps can change users’ behaviour and modes of interacting with the world, becoming an interface for socialising, shopping, commuting and other aspects of life.</td>
</tr>
<tr>
<td>Connected Vehicles and the Internet of Things</td>
<td>Connected vehicles use wireless technology to communicate with infrastructure (V2I), other vehicles (V2V), or other objects such as pedestrians or personal devices (V2X). Vehicles that communicate through cellular telematics are part of the Internet of Things (IoT), a vast network of smart connected objects that use sensors to gather information and communicate.</td>
</tr>
<tr>
<td>Autonomous Vehicles</td>
<td>Autonomous vehicles (both private and public), known as self-driving or driverless vehicles, are capable of handling all aspects of driving on all types of roads and in all environmental conditions.</td>
</tr>
<tr>
<td>Electric and Alternative Fuel Vehicles</td>
<td>Electric vehicles rely on electric powertrains and significantly reduce noise and air pollution. Alternative fuel vehicles run on biofuels, compressed or liquid natural gas, or hydrogen.</td>
</tr>
<tr>
<td>Personal Mobility Devices</td>
<td>Personal mobility devices (such as electric scooters, hover boards, skateboards, etc.) are relatively lightweight, can travel up to 25 km/h, and typically carry a single person.</td>
</tr>
<tr>
<td>Shared City Cars</td>
<td>City Cars are “right-sized” vehicles (usually for 1-3 people) for use in urban areas, are more fuel efficient, lightweight, and require fewer materials in construction. They are economical to buy and use and fit well into the car Sharing systems that allow people to own and rent cars, or collectively own cars.</td>
</tr>
</tbody>
</table>
Drones and Freight Robotics
Adoption of drones (or known as a type of Unmanned Aerial Vehicle) and robots to perform freight movements in urban areas.

Artificial Reality and Telecommuting
Virtual Reality is an immersive artificial simulation or recreation of real-life situations that may influence transportation patterns by substituting actual commuting with telecommuting from remote space outside a central office and allowing people to engage in activities in a virtual world.

The intention of this technology scanning is to describe technologies, their current state and role in Singapore’s mobility system, and detail challenges to their development and future expectations in the next 25 years. Lastly, we have provided essential reading material at the end of each technology section for interested readers. Following this, we have matched the function of each technology to public policy objectives and created a chart to showcase their interdependencies as well as impact on future scenarios. For detailed Technology Scan, download the section from website http://www.mobility.sutd.edu.sg/foresight.
Drivers of Change

Environmental scanning, expert interviews, focus group discussions, and technology scanning helped to identify key drivers of change. We collected 54 factors with direct or indirect impact in shaping mobility landscape of the future. After clustering them for consistency and dependency, we categorised them into 19 key drivers of change. Then, we sorted these 19 drivers into 5 influencing areas: demographics and urban form, evolving travel behaviour, transportation technologies, macro factors, and global drivers. The key drivers of change identified are summarised in Table 3. These drivers are then used in the scenario generation process in the scenario planning workshop that follows.

Influencing Area: Demographics & Urban Form

Ageing Population

“Senior citizens are not very active in terms of weekday travel. However, looking deeper into the issue, it seems that they are not able to travel freely.” – Transportation Research Professor at a local university

Singapore faces a rapidly ageing population, with 13.1% of citizens and PRs aged 65 and above in 2015 compared to 12.4% in 2014 (Ministry of Home Affairs, 2015) This demographic shift is seen as the most influential driver of change by experts. Combined with Singapore’s low fertility rate, which was 1.25 babies per woman in 2014 (Ministry of Home Affairs, 2015), and increasing life expectancy - 82.8 years in 2014 (Department of Statistics, 2015), it is evident that mobility needs of the population are evolving, and provisions have to be built into the system to cater to changing requirements.

This driver is not unique to Singapore. Among the foresight studies we reviewed, Future Demand by the New Zealand Ministry of Transport identified the ageing population as one of the key drivers of change when they generated scenarios for 2042 (Lyons et al., 2014). The needs of the ageing population can be sorted into two different categories: pedestrian needs and commuter needs.

Experts suggested that Singapore’s road network is built primarily to cater to cars, often at the expense of pedestrians. For instance, pedestrians might have to walk hundreds of metres to the nearest junction to cross the road and on top of that, cross three-ways to reach the opposite side of the road. Secondly, overhead bridges in Singapore demand climbing staircases on both ends, which often results in pedestrians resorting to jaywalking and being more exposed to accidents. With the country’s ageing population, the mobility system has to be redesigned to make pedestrian walking hassle-free and much more comfortable without compromising safety. There may also need to be a rebalancing of priorities, such as introducing more at-grade crossings that favour pedestrians over vehicular traffic.

Also, transport operators have to anticipate mobility requirements of the ageing population. For example, bus captains have to alight to help elderly or handicapped passengers board and alight from the bus, which takes a few minutes. With the tight frequencies at which buses operate, bus schedules are disrupted, resulting in frustrating commuter experiences such as bus bunching. Finally, a changing employment landscape necessitates a responsive transportation system. A greater number of older people may be engaged in work. Half-day work shifts, which older workers may prefer, have the potential to change traffic patterns during AM/PM peak hours. Whether it be dedicated public bus services for the special needs group or driverless vehicles for private mobility of ageing population, the question is how influential this driver would be in shaping future urban mobility landscape in Singapore?
Table 3. Key drivers of change that will influence the future urban mobility in Singapore

<table>
<thead>
<tr>
<th>Demographics and Urban Form</th>
<th>Key Drivers</th>
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<tbody>
<tr>
<td>Ageing Population</td>
<td>Evolving mobility needs due to the increase in number of senior citizens.</td>
</tr>
<tr>
<td>Population Size</td>
<td>Increasing population resulting in congestion within city centers. Competition between using land for roads, housing, public spaces, etc.</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>Evolving socioeconomic status – changing educational attainment and income per capita - aspirations of car ownership and social expectations, influencing vehicle ownership and preferred travel mode choice</td>
</tr>
<tr>
<td>Multi-zone Districts</td>
<td>Multi-zone districts that change the patterns of travel, such as the flow of people, travel distances, and purpose of travel.</td>
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<tr>
<th>Evolving Travel Behaviour</th>
<th>Key Drivers</th>
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<tr>
<td>Multi-Modal Transport</td>
<td>Shifting commuter behaviour to adopt as well as government policies to promote a multi-modal approach in getting from point-to-point.</td>
</tr>
<tr>
<td>Shared Mobility</td>
<td>Adoption and commercial interest in shared mobility systems such as car sharing, carpooling, ride-sharing, and mobility-on-demand services such as Uber and Grab. This applies to companies and commuters for both passenger and freight.</td>
</tr>
<tr>
<td>Active Mobility</td>
<td>Adoption of cycling and walking, especially for the first and last mile travel.</td>
</tr>
<tr>
<td>Virtual Travel</td>
<td>Telecommuting and teleworking resulting in changes in mobility demand.</td>
</tr>
<tr>
<td>E-commerce</td>
<td>E-commerce activity such as online shopping for goods and services, resulting in changing travel behaviour.</td>
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<tr>
<th>Transportation Technologies</th>
<th>Key Drivers</th>
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<tr>
<td>V2X Infrastructure and Communications</td>
<td>Communication between road infrastructure and vehicles, with capabilities that include dynamic traffic routing to respond to incidents on the roads, increased safety as vehicles communicate their intentions to each other, and improved congestion management with platooning.</td>
</tr>
<tr>
<td>Autonomous Vehicles</td>
<td>Self-driving vehicles for private and public passenger transport, as well as for freight.</td>
</tr>
<tr>
<td>Real-time Information</td>
<td>Use of real-time information, big data and Internet-of-Things, mobile apps, and intelligent transport systems.</td>
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<tr>
<td>Personal Mobility Devices</td>
<td>Personal Mobility Devices such as electric scooters, unicycles, etc.</td>
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<tr>
<th>Macro Factors</th>
<th>Key Drivers</th>
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<tr>
<td>Government Policies</td>
<td>Regulations and policy initiatives that drive or limit transportation demand and supply, including commercial investments and innovations.</td>
</tr>
<tr>
<td>Environmental Awareness</td>
<td>Environmental awareness, resulting in greater public and commercial interest in electric &amp; alternative fuel vehicles. Also, increasing awareness of environmental impact of transportation systems and infrastructure.</td>
</tr>
<tr>
<td>Greenhouse Gas Reduction</td>
<td>Influence on transportation policies due to Singapore’s intention to reduce greenhouse gas emissions intensity by 36% from 2005 levels by 2030</td>
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<tr>
<td>Innovative Capacity</td>
<td>Singapore’s capacity to innovate is ranked behind several other developed countries. There is increased drive to foster home-grown innovations rather than importing ready-made solutions</td>
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<tr>
<th>Global Drivers</th>
<th>Key Drivers</th>
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<tr>
<td>Cost of Energy</td>
<td>Drastic fluctuations in global oil prices influencing innovations and developments in transportation sector.</td>
</tr>
<tr>
<td>Global Terrorism</td>
<td>Greater concern about transportation system security and resilience.</td>
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POPULATION SIZE

“Almost every problem goes back to population. Classroom places, housing, hospital beds, transportation, and even Wi-Fi. The government shouldn’t tell us how many cars it wants. Rather, it should tell us how many people it wants to have in the country.” – Senior Transport Correspondent at a local media conglomerate

The second most influential driver in this category is Singapore’s population size, which requires balancing the need for road infrastructure, housing, commercial districts, and public recreational spaces. With a fixed land space of 718.3sq. km (Department of Statistics, 2015) and an increasing population that rose by 1.2% from June 2014 to June 2015 (Ministry of Home Affairs, 2015), there is an ever-increasing strain on land.

Many major cities around the world have identified rising urban populations as a key driver of change. A foresight study conducted by Rand Corporation and the Institute for Mobility Research, The Future of Mobility: Scenarios for the US in 2030, states, “The share of Americans living in urbanised areas has increased. In 1970, roughly equal shares lived in central cities, central metropolitan areas (that is, suburban areas), and rural areas. By 2010, about half of Americans lived in suburban areas, one-third in central cities, and one-sixth in rural areas” (Zmud et al., 2013).

Similarly, one of the six themes chosen by a study conducted in Finland to envision the transport system in 2100 considers the ‘majority of the population living in just few urban centers’ (Auvinen et al., 2012). Another study conducted in Jinan, China, also considered population growth as one of the major drivers in creating its scenarios for the future (Zhao et al., 2012).

Another factor that contributes to the increasing population in Singapore is the country’s reliance on foreign manpower to supplement the resident workforce. According to several experts in both passenger and freight industries, there is a shortage of local manpower for both lower-skilled labour, such as drivers for logistics vehicles and public buses, as well as high-skilled labour such as rail engineers. An influx of foreign labour in turn increases the load on the country’s infrastructure and transportation network.

Singapore does not have a mix of urban, suburban, or rural areas, being an island city-state. Although there is a general consensus by experts that the increasing urban population will result in rising congestion and public dissatisfaction, it is unclear whether government policies will evolve to curtail or cater to rapid population growth.

SOCIOECONOMIC STATUS

The Singapore population’s educational attainment is high, and expected to increase further. Based on a projection by the International Institute for Applied Systems Analysis, close to 90% of the Singapore’s population in 2040 would have attained at least post-primary education, and 44% would have tertiary education (World Bank, 2015).

Over the past few years, the median monthly household income in Singapore has increased from $6,006 in 2009 to $8,292 in 2014 (Department of Statistics, 2015). A typical Singaporean household comprises two income earners and two dependents, though household sizes are trending
downwards. As a result, income per capita has moved up, and people have higher disposable incomes. Singapore’s per capita income stood at US$38,087 in 2014 (World Bank, 2015).

Among some of the factors identified during our focus group discussions, commuters’ choice of travel mode is influenced by service reliability, accessibility, punctuality, availability, convenience and comfort. In addition, some experts noted that it might be due to higher incomes influencing cultural norms that shared mobility services such as carpooling, taxi sharing, and ride-sharing are not popular.

Singaporeans’ demand for high-quality mobility services will continue to increase. The question remains as to how government and transportation providers will adapt to these ever-rising mobility service demands and standards.

**Multi-zone Districts**

“A lot of people spend around 2 hours a day for their daily commute. That is way too much. We need to rebuild towns and land planning to make it more friendly, comfortable and dynamic.” – Transportation researcher at a local research institute

Singapore was built with a single-zoning approach to city planning. According to one expert, factories had to be built outside the city when Singapore was rapidly pursuing industrialisation as they were a major source of pollution. As a result, industrial areas such as Jurong and Tuas are predominantly single-zone districts located far from residential centres.

It was believed that having a good MRT or bus network in those areas was not financially feasible due to low ridership. As a result, most people commute to these industrial areas by car. However, as the operating model of public transport operators shifts towards one where the government bears more financial risk than commercial public transport operators in providing services to far-flung areas, a greater number of public buses may ply single-zone districts in the near future.

Single-zone districts generate many more trips as people have to travel longer distances for different activities such as work, school, shopping, and so on. Today, the shift towards cleaner industries in Singapore prompts urban planners to rethink the concept of single-zone districts. More multi-zone districts have been planned, which will have a significant impact on changing people’s travel patterns and play various roles such as economic hubs, housing, schools, shopping malls, food streets, and etc. These multi-zone districts will change travel flow patterns and reduce total travel time.

**Influencing Area: Evolving Travel Behaviour**

**Multi-Modal Transport**

“It’s not about transport. It’s about mobility; moving people and goods.” – Transportation research lead at a local research institute

“It will be integrated, it must be integrated, with a diversity of transport modes we don’t even imagine today, with a complexity we are not realising today.” – Regional Manager in an international transport research organisation

In 1997, the European Commission defined intermodal transport, or multi-modal transport, as the movement of goods in which at least two different modes are used in a door-to-door transport chain
(European Commission, 1997). The Commission believed that more multi-modal transport meant more integration and complementarity between modes, making for a more efficient transport system.

The increasing adoption of multi-modal transport for both passengers and freight provides greater flexibility in route planning, increased resilience in the face of maintenance and breakdowns, and more choices for commuters in deciding between different travel options. In a hypothetical multi-modal system, a commuter will use a personal mobility PMD for first-mile transport, park the device, and transfer to a mass public transport system such as the train or bus for the next leg of the journey. At the end of the public transport leg, the commuter may use a shared vehicle service, or hop onto another PMD for last-mile transport.

Arthur D. Little Future Lab and UITP stated in their report The Future of Urban Mobility 2.0 that “mature cities with a high share of sustainable transport modes must fully integrate the travel value chain to foster seamless, multimodal mobility to increase the overall attractiveness of public transport by service extension”. This applies to the majority of cities in Europe as well as Hong Kong, Singapore, Seoul, Tokyo, Toronto and Buenos Aires (Van Audenhove et al., 2014). Deloitte University Press, in their study, Digital-Age Transportation: The Future of Urban Mobility, also identified “a well-connected system of systems that enables users to easily move from point A to point B regardless of mode and service provider” (Fishman, 2013) as one of the five key features of future transportation. Lastly, a foresight study conducted by UK government states that, “Intelligence in the infrastructure could allow us to provide an integrated transport system with seamless interchanges. As individuals, intelligence will also increase our choice and help us to find the best way to get to where we want to go” (Office of Science & Technology, 2006).

In our interviews, experts mentioned that one of the major challenges Singapore faces today is the lack of collaboration between transport planners, designers, and operators, which in turn leads to weaker integration of different transport modes in enabling multi-modal travel. Singapore also faces a major challenge in first- and last-mile connectivity, with as much as 30% of total travel time being spent on those journeys. Nonetheless, there was optimism in how Singapore was tackling the situation. Experts we spoke to shared that transport companies and urban planners are now focusing on the entire experience of the journey, rather than separate components. It remains to be seen whether this approach to mobility will ensure seamless connectivity within a more highly-integrated multi-modal transport system by 2040.

**Shared Mobility**

“If we can create the perception that it is easy and convenient get a vehicle on-demand, it will have big implications on the transportation system.” – Foreign academic/expert in transportation

“There has been an industrial wave, dot com wave, and a social media wave. The next wave will be sharing economy wave. It will be game changing.” – Founder of a local mobility service start-up

The average occupancy of cars in Singapore is about 1.7 people (Menon et al., 2006), indicating immense inefficiencies in a system that is already under the strain of increasing urban density and land scarcity. This problem is in every modern city. However, as mobile technology and smartphone apps become mainstream, several car sharing systems have surfaced in an attempt to utilise this excess capacity. The success of ride-hailing apps like Uber and Grab is one such testament to this trend.
Spieser et al. (Spieser et al., 2014) found that Singapore’s vehicle population could be reduced by two-thirds if everybody used shared mobility. Experts we spoke to agreed that reducing the city’s car population of close to 700,000 vehicles would be beneficial, and free up valuable land for other uses. They also noted that people in other parts of the world are increasingly adopting shared mobility because they believe that owning cars that spend more than 90% of the time in garages is not an effective use of their limited financial resources.

In addition, foresight studies we reviewed identified shared mobility as one of the most influential future mobility modes. For instance, a study by Arthur D. Little’s Future Lab and UITP stated that shared mobility is rising at a fast pace, with 115 shared cars per million around the world in 2013, compared to 89 shared cars per million in 2011 (Van Audenhove et al., 2014).

This trend is evident in the freight sector as well. Customers expect more on-demand and urgent deliveries, and are willing to pay higher delivery fees for such services. As such, several on-demand logistics start-ups have entered the market. A foresight study by STT Netherlands also discussed shared mobility in the freight sector by naming one of its scenarios ‘LinkedIn for Freight’. In this scenario, people would not need to send packages via third-party freight companies. Instead, they can use a logistical matching system to send packages via their social network. (Van Voorst tot Voorst et al., 2014).

Social networks and two-way feedback systems have enabled shared mobility systems as they are signifiers of trustworthiness. Traditionally, a central authority determines whom we can trust, such as in the case of government accreditation for doctors. However, social networks now fulfil this role in an informal way and diffuse search costs by tapping on the knowledge of the crowd or by enabling filtering of search results. For instance, Uber uses a two-way rating system where passengers and drivers rate each other, allowing both parties to know how trustworthy the other party is and to accept or reject patronage based on one’s rating.

Experts noted that growth in shared mobility services is most pronounced outside of Asia, especially in places where cars are seen as status symbols to a lesser degree. There was a general consensus that cars are still seen as status symbols in Singapore, and that high upfront costs of ownership have aggravated the problem: users mentally account for the high cost of a vehicle by using it as often as possible, even when it is not required, to justify the price paid.

Nonetheless, major automotive providers have identified this trend and are hedging their bets. An automotive expert highlighted that car manufacturers have traditionally focused on manufacturing, but are starting to get involved in providing on-demand mobility solutions today. Although it may be idealistic to declare that all vehicles can be shared, experts agree that shared mobility systems will form a significant part of modal split in the future mobility landscape, partly because growth in vehicle numbers will be limited compared to Singapore’s population growth. However, it is difficult to measure today how significant the impact will be by 2040.

**ACTIVE MOBILITY**

“I don’t mind walking or cycling if the weather is good. But since we cannot accurately predict the weather, I take public transport to be on the safe side.” - Focus Group Participant
Experts believe that Singapore’s population density and increasing focus on a healthier lifestyle will usher in active mobility (namely walking and cycling) as a popular mode of travel, especially within the residential towns outside of the city centre.

Although Singapore has some basic pedestrian and cyclist infrastructure, such as footpaths running alongside roads and ramps for cyclists to manoeuvre up and down footpaths, cycling only about accounts for 1% of all trips in Singapore. In contrast, nearly 30% of Dutch commuters almost exclusively commute by bicycle (Block, 2016).

Experts and focus group participants believe that active mobility is not popular in Singapore because of the lack of adequate infrastructure to promote cycling and walking. For instance, roads do not have dedicated lanes for cyclists, making cycling more dangerous. Moreover, bicycle parking provisions are very limited at train stations and most offices lack shower facilities which are necessary because of Singapore’s humid climate.

Some experts were optimistic that Singapore could significantly encourage walking and cycling as viable commuting options if more infrastructure, such as sheltered pavements for bicycles and pedestrians, were developed. One expert mentioned that people are willing to cycle up to 7km, provided the entire experience is perceived as safe, convenient and rejuvenating. Another expert suggested that Singapore should focus on making walking along the streets more engaging by placing a greater emphasis on aesthetics and comfort. He added that walking in Hong Kong or London is more interesting than in Singapore, because there is more to see along the journey.

However, all experts agreed that the trend towards more active mobility will continue in Singapore. With initiatives such as more park connectors already in the pipeline, more people will be encouraged to incorporate walking and/or cycling into their journeys. Such an encouraging outcome was also predicted in the study Megacities on the move by Forum of the Future, in which future scenarios for 2040 prominently featured active mobility (Gazibara et al., 2010). The question remains how significant the impact would be to lessen the strain on motorised transport?

**VIRTUAL TRAVEL**

“Internet and telecom technology will make [telecommuting] a norm. This would enable people to work from home or mobile locations, providing tremendous opportunities for transport planners to disperse demand.” - Head of Department in a leading international university

“There will be more work and [schooling] from home, and the main reason people leave their homes would be for socialising and to participate in recreational activities.” - Focus Group Participant

Some experts we interviewed believe that the definition of travel itself will evolve in the future. The rise of virtual technology will disrupt how people work, shop, socialise and learn by eradicating the need to be physically present. Apart from reducing total travel demand, it will spread peak demand over different times of the day as work hours become more flexible.

IBM Singapore, which offers its employees flexible work hours, has already demonstrated tangible results arising from this practice. Employees would be at the office about three times a week and work remotely on other days. In doing so, IBM reaped benefits in rental cost savings and recorded higher levels of employee happiness. In fact, the company won the Work-Life Sustained Excellence
Award in 2014 for consistently achieving outstanding success in work-life strategies (Tripartite Committee on Work-Life Strategy, 2014).

Several studies we reviewed also emphasised virtual travel. A study by Deloitte University Press considered telecommuting to be one of the major trends for its scenarios (Fishman, 2013). Another foresight study by the New Zealand Ministry of Transport selected “physical or virtual accessibility preferences” as an input to create scenarios (Lyons et al., 2014). Lastly, an STT Netherlands study stated that in 2040, virtual travel would be a fully-fledged alternative to a physical journey. Although projection used to be restricted to a 2D screen with unreliable sound quality, virtual travel would be just as if it were real life. People would not need to be physically present to participate in activities, and the virtual world could satisfy the biological urge to travel (Van Voorst tot Voorst et al., 2014).

Currently, one major challenge to this driver of change is managerial and employee acceptance. While employers can benefit from reduced costs, staff retention and being able to tap on additional sources of manpower, they face several drawbacks such as loss of supervision over employees, equipment and software acquisition costs, communication costs and reduced data security. Employees may also be hesitant to accept telecommuting due to social isolation, perceived impediments to career progression, and feelings of “guilt” despite greater time flexibility and reduced transport costs.

Another major inhibitor of virtual travel is the inability to create an immersive environment that completely replicates the 3-dimensional world we live in. However, with major companies like Facebook and Microsoft investing in virtual reality technologies such as the Oculus Rift and HoloLens, the question remains how the experience of Virtual Travel might more closely resemble in-person experiences in the future?

E-COMMERCE

“We notice more imports into Singapore due to the increase in online shopping. This is coupled with the shift of manufacturing services out of Singapore, reducing exports. As [such direct business to consumer] operations increase [and exports decrease], there will be a greater need for bikes and smaller trucks.” - General Manager at a logistics services company in Singapore

E-commerce in Singapore started with groceries, and evolved to include goods such as flowers, apparel and electronics. Experts predicted a significant rise in e-commerce in Singapore, which would result in an increasing demand for freight services.

One of the foresight studies we reviewed, Scenarios for the Brazilian road freight transport industry, has also identified the surge in e-commerce as one of the most influential drivers of change in its 2018 scenarios (Martins et al., 2012).

There has been disagreement between experts in whether this trend will lead to an increase in overall travel demand, as the nature of trips shifts from passenger journeys to freight. Experts from the freight industry cited inefficiencies in home deliveries such as failed deliveries. Since most HDBs in Singapore do not have drop-off facilities, these situations often necessitate redeliveries or customer collection, increasing the total number of trips generated.

It is unclear how widespread e-commerce would be in 2040, so the question remains how much will it impact the mobility flow patterns around the island?
INFLUENCING AREA: TRANSPORTATION TECHNOLOGIES

V2X INFRASTRUCTURE AND COMMUNICATIONS

"By 2030, I foresee that most, if not all, vehicles will be connected to traffic operations centres [and receive] dynamic advisory in real time. The traffic operations centres would be able to assess road space demand in real time and advise vehicles on various aspects - congestion, speed guidelines, recommended routes, traffic rules, and so on." – Senior manager in a global technology company

Most experts opined that Vehicle-to-Vehicle and Vehicle-to-Infrastructure (V2X), will be a highly influential driver in shaping Singapore’s future mobility landscape.

With the advent of smart devices and the Internet, and technologies such as GPS and 4G telecommunication networks, experts predicted that vehicles will be able to transmit streams of data with time, distance and usage parameters. This would facilitate proactive traffic management and provide predictive insights, leading to better traffic forecasts and safer travel as vehicles become more aware of their surroundings in their immediate vicinity and across the transportation network. V2X systems, in conjunction with data analytics, would also offer alternative travel routes differentiated by distance, travel time, and price, for motorists to make more informed travel decisions.

In Singapore, the next generation of Electronic Road Pricing (ERP2) is considered to be at the forefront of V2X implementations. With GPS-based tracking and communication for all vehicles, ERP2 would be able to provide real-time information to commuters and aid in dynamic road pricing, parking, and usage-based tax and tariff schemes. Experts believe that this could be a game-changer for congestion management in Singapore, as decades of policy targeted at managing the vehicle population could be overhauled to focus on usage based on distance, travel route, and time to deliver the same or even better outcomes.

Deloitte University Press, in its study Digital-Age Transportation: The Future of Urban Mobility, identified V2X as the foremost feature of future urban transportation. (Fishman, 2013) Another foresight report by the United Kingdom’s Office of Science and Technology reiterates this, stating that advances in science and technology could provide the ability to control the movement of goods and people, with vehicles connected to each other and to the surrounding infrastructure so they become an integral part of an intelligent system (Office of Science & Technology, 2006).

However, there are pertinent concerns, such as privacy, safety, and the development and adoption of international and industry standards, that may hinder its adoption. The question remains whether V2X infrastructure and applications can have as much impact on the mobility sector as smartphones have had on everyday lives.

AUTONOMOUS VEHICLES (AVs)

“Artificial intelligence is better at driving because it doesn’t drink, take drugs, or fall asleep.” – Director at one of the leading consulting firms

“Personalised mobility will be pretty relevant [in the future]. There are good reasons [why] big companies are putting a lot of money in [this field].” – Transportation research lead at a local research institute

Lee Kuan Yew Centre for Innovative Cities
Singapore University of Technology & Design
Experts believe that commercial AVs will hit the roads in the near future and may even become mainstream as early as 2030. Even though it would take many years for AVs to completely replace conventional vehicles, AVs have the potential to reshape Singapore’s transportation infrastructure.

Deloitte University Press featured AVs in one of its three future scenarios. In this scenario, AVs will pick commuters up from their departure location, dynamically route the vehicle based on destination and traffic flow situations, and travel down an automated roadway in a platoon formation. In the vehicle, commuters will have access to everything they need, ranging from work applications to entertainment. The AVs will drop commuters off at their destinations and park themselves at a designated parking area (Fishman, 2013).

In an ideal scenario, road management might not even require traffic lights or lanes as AVs are fully-aware of their surroundings. Moreover, AVs can satisfy the mobility requirements of many diverse groups, even segments of population that are not able to drive, such as children, the elderly, or disabled.

In the realm of public transport, experts suggested that AVs will make the bus transport network more efficient and solve manpower constraints that Singapore currently faces. AVs could also address problems such as bus bunching caused by unanticipated congestion. With AVs, buses will be able to adjust their speeds in real time to reduce bus bunching – something that is not easily done with human drivers.

AVs may also solve another challenge that Singapore currently faces: the inefficiencies in taxi demand and supply, which result in a lack of capacity during peak hours and rainy conditions, and excess capacity during non-peak hours. Experts believe that AVs will be able to redistribute themselves in real time, adjusting supply during peaks and troughs to make the taxi industry more efficient.

Finally, AVs could have a huge impact on the freight sector, transporting goods around the clock and alleviating manpower issues. A foresight study by STT Netherlands identified a scenario for freight known as ‘No People Around’. In this year 2040 scenario, products will find their own way to consumers through AVs, robots, and support functions such as tracking and tracing; humans will no longer be directly involved in the transport of goods (Van Voorst tot Voorst et al., 2014).

However, according to experts and focus group participants, the two factors that are holding AV technology back are the public’s fear and hesitation in giving up control to AVs, and liability issues such as identifying responsible parties in the case of accidents. As such, it is unclear how quickly and widely AV technology would be adopted, and whether governments in Singapore and around the world would be nimble and judicious enough to develop clear, supportive and comprehensive policy frameworks to make full use of AV technology.

**Real-time information**

“Mobile phone technology is the biggest invention that changed everything, even in mobility.” – Transportation technology lead in a government organisation

According to experts, another major technology driver will be real-time information accessibility enabled by mobile phone and telecommunications technology. With Singapore’s Smart Nation aspirations, people anticipate that high-speed internet will become more prevalent, and devices that
are constantly connected online in the Internet of Things will become commonplace. Both planners and mobility providers are poised to leverage mobile technology to continually push real-time information to commuters to make transportation more efficient. An expert mused that mobility flows and demand management are now planned using historical data, but this is set to change in the future as planning will take into account live information, in addition to historical and projected demand. To do this, organisations will rely on Big Data analytics, aggregating data from disparate sources to improve the quality of traffic and develop better outcomes for commuters.

In addition, real-time reporting of traffic conditions and predictive forecasting will allow drivers to optimise routes to their destination based on factors such as cost and time (Fishman, 2013). This can be supported, for instance, by real-time pricing information provided by a mobility cost tracker app.

Even in the freight sector, consumers’ expectations are driving companies to offer more real-time information. A logistics expert shared with us how technology is becoming an important part of the supply chain, particularly in improving delivery performance. Companies need to move goods rapidly, similar to just-in-time methods, to reduce the need for warehousing and also to promptly fulfil deliveries.

However, concerns about safety and privacy are pertinent in the age of real-time information collection and sharing; the question remains as to who will have access to consumer information, to what end, and where the out-of-bounds markers will lie.

**PERSONAL MOBILITY DEVICES**

“I once saw someone using an electric scooter to take away food from the food court. He was maybe in his late 30s, and didn’t need to step off his scooter throughout the whole process.” – Senior Transport Correspondent at a local media conglomerate

Experts mentioned that the use of personal mobility devices (PMDs) such as skate scooters, uni-wheels, hoverboards, electric scooters, and Segways are gaining popularity. This trend is happening for a few reasons. First, these devices are convenient for first- and last-mile connections, to and from transit points. Second, there is a greater emphasis on cycling and walking in many first-world cities worldwide, resulting in the development of special lanes for cyclists, such as in London (Green, 2015). For instance, Singapore has a broad network of park connectors, which are supported by cycling paths placed alongside pedestrian walkways in neighbourhoods such as Tampines and Ang Mo Kio. Third, rapid improvements in lithium ion batteries in recent years have increased the range of these devices and made them faster to recharge.

According to one expert, although the wide adoption of such devices is unlikely, the younger generation will find them useful. In the next five years, these devices will become more powerful and portable, and have greater range and variety. Most experts voiced out that there is a need to develop infrastructure and pass regulations to license PMDs to improve public safety. Given these issues, it is unclear if industry developments and commuter adoption will be significant enough for PMDs to play a major role in our transportation system by 2040.
Influencing Area: Macro Factors

Government Policies

“Transportation is a multi-faceted system. Each Minister has his own ideas, but doesn’t have enough time to gain wisdom. Missteps can take years to undo. An example is the COE quota system. Quotas were first based on deregistration figures, then estimated scrappage. We’re now back to deregistration figures.” – Senior Transport Correspondent at a local media conglomerate

Many experts believe that the responsiveness of government in crafting effective legislation is critical in shaping the future mobility system. In many countries, market forces dictate trends and legislation responds. However, some were of the opinion that Singapore is largely driven by government policy, and market forces simply adapt to that. As such, it is believed that the Singapore government’s role in influencing the city’s future mobility will be much more significant than elsewhere.

On one hand, an expert was heartened that the government has accepted that market forces are going to change the conventional ideas about transportation in Singapore. Thus, instead of banning companies like Uber and Grab, the government is seriously considering how to work with them instead. On the other hand, many experts raised concerns that the government’s policymaking is not user-centric. There is great resistance to new business models that challenge the status quo.

The underlying concern is that technology and trends in transportation are evolving faster than policies can keep up, and companies in Singapore are reluctant to take action and market their products and technologies widely without clear signals from the government. For instance, personal mobility devices are still not licensed as a category of vehicles although guidelines have been published, shared mobility service providers are still unsure whether regulations will be overhauled because of concerns raised by taxi operators, and industry experts working on EVs are hesitant to promote them because of uncertainty over whether the government will provide charging infrastructure around the island.

Government policies, in one form or another, have been identified by several foresight studies as one of the most influential drivers. Megacities on the move created scenarios based on top-down and bottom-up governance models (Gazibara et al., 2010), while both The Future of Mobility: Scenarios for the US in 2030 (Zmud et al., 2013) and Scenarios for the Brazilian Road Freight Transport Industry (Martins et al., 2012) have identified extremes such as the rigorous application of regulation as well as the lack thereof as key drivers of change.

Either way, it is believed that the Singapore government’s role in influencing the city’s future mobility will be much greater than elsewhere. Will this be beneficial for Singapore in today’s technology-driven era?

Environmental Awareness

“Electric Vehicles are well-suited for urban areas. They are good for the environment because they are quieter and have lower emissions. They also have fewer mechanical parts, resulting in lower maintenance.” – Transportation research lead at a local research institute

Despite popular assumptions that Singaporeans are cost-sensitive and less concerned about the environment, some experts strongly believed that the general population is becoming more environmentally conscious due to global media campaigns and the promotion of environmentalism over social networks. Over time, this could shift people’s behaviour in favour of more environmentally-
friendly modes of mobility such as public transport and active mobility, even if they are less convenient compared to personal vehicles. One expert postulated that the next generation of Singaporeans would be much more aware of environmental concerns such as climate change due to Singapore’s education. Several posited that EV technology is mature enough to work in Singapore’s landscape, if the government provides the necessary charging infrastructure.

Environmental impact and stewardship has been identified as one of the influential drivers of change by almost all the foresight studies we reviewed. Reports such as Intelligent Infrastructure Futures (Office of Science & Technology, 2006) and Visioning and Backcasting for Transport in Jinan (Zhao et al., 2012) created future scenarios using this driver. In addition, a study in Finland identified environmental awareness as one of the six major themes for the future mobility landscape. The study envisioned excellent air quality in Finland’s metropolitan areas due to emission-free operation of the transport system, and that water vapour would be the only vehicle-based emission from hydrogen-driven vehicles (Van Voorst tot Voorst et al., 2014).

Lastly, experts in Singapore believe that Electric Vehicle technology is already mature enough to work in Singapore’s landscape, if the government provides the necessary charging infrastructure. Will this trend ensure that Singapore’s future mobility system is greener than that of today?

**Commitment to Greenhouse Gas Reduction Target**

At the 2015 United Nations Climate Change Conference in Paris, Singapore’s Deputy Prime Minister Teo Chee Hean reiterated Singapore’s intention to reduce greenhouse gas emissions intensity by 36% from 2005 levels by 2030 (National Climate Change Secretariat, 2016a). To this end, the National Climate Change Secretariat (NCCS) has set its sights on GHG reductions in energy-intensive sectors such as power and utilities, industry and transportation.

The power generation sector has already implemented a fuel switching programme since the early 2000s by using liquefied natural gas (LNG), which results in less pollution. In fact, more that 95% of power generation in Singapore is now produced from LNG (National Climate Change Secretariat, 2016b), and the marginal abatement cost for further GHG emission reductions is hefty.

Singapore’s industries are critical to Singapore’s economy and growth prospects, and there is a limit on the amount of emissions that can be reduced in a cost-efficient way. As a result, the onus of meeting GHG emission targets will likely need to be taken up by the transportation sector – the third-largest consumer of fossil fuels in Singapore.

Reducing GHG emissions within the transportation sector could involve promoting a shift from private to public transportation as well as vehicles that produce lower emissions.

**Innovative Capacity**

The Global Competitiveness Report by the World Economic Forum has ranked Singapore as the world’s second-most competitive economy overall for five consecutive years (Schwab, 2015). Despite being placed in the top ten economies for 9 out of 12 criteria, there are concerns that Singapore’s capacity to innovate is ranked behind several other developed countries despite having a well-established, first-class knowledge infrastructure.
Innovation is regarded as a critical factor that will shape the future of Singapore in all sectors, both public and private. There is growing evidence to support the importance of innovation and its implications on the future. For example, the Lee Kuan Yew School of Public Policy (LKYSPP) at the National University of Singapore has commissioned a study to explore ways to improve innovation at the national level (Lee Kuan Yew School of Public Policy, 2016). However, due to population dynamics such as transnational mobility, brain drain due to emigration, and cultural values that reward conformity, it is challenging to characterise Innovative Capacity in a single metric.

When discussing innovative capacity in the context of transportation, a few questions are pertinent. Does Singapore have a suitable environment that can encourage and foster home-grown innovations? Can Singapore produce best-of-breed solutions that customize global innovations for the local market? Or will the country experience a dearth of innovation, resulting in the continuous import of ‘ready-made’ innovations from the global marketplace?

**INFLUENCING AREA: GLOBAL DRIVERS**

**COST OF ENERGY**

Over the past decade, crude oil prices have fluctuated wildly on the world market. Prices were fairly stable in the ‘90s, trading between US$20 to US$35 per barrel, but rose to more than US$100 for a few years (Ecola et al., 2015). In early 2016, oil traded at US$30-35 per barrel – a price so low compared to recent years that it has started to destabilise some oil-producing countries.

Energy supply is complex; price fluctuations are often attributed to supply gluts or over-demand, but in a broader perspective, they encompass geopolitical issues, peace and conflict, and the rise of environmentalist movements around the world. Specific to transportation, oil prices affect investments in the development of alternative fuel vehicles and alternative sources of energy. The lower the price of oil, the lower the interest of investors in developing technologies that replace fossil fuels, and commuters in paying a premium for energy-efficient or alternative energy vehicles.

Several foresight studies conducted around the world have identified the cost of energy as one of the most influential drivers of change. These studies were conducted in the Americas (Townsend, 2014), Europe (Auvinen et al., 2012), and Asia Pacific (Lyons et al., 2014). In all of these studies, the price of oil was seen as a global driver irrespective of geographic location. Energy is important because the cost of gasoline and the availability and cost of alternatives affects the number of miles people drive, and the types of vehicles they drive (Zmud et al., 2013).

How critical would the cost of energy be in guiding government policy and commuters’ adoption rates for alternative fuel vehicles in Singapore?

**GLOBAL TERRORISM**

A recent survey indicates that Singaporeans are most concerned about global terrorism (Wong, 2016). The looming threat of ISIS has been heighten with incidents close to home, such as the terror attack in Jakarta on 14 January 2016 (Quiano et al., 2016). In addition, reports that Singapore’s ASEAN neighbours - Indonesia, Malaysia and the Philippines - have become hotbeds for ISIS recruitment have fanned the fires of fear (The Straits Times, 2015).
Singapore will find it difficult to insulate itself from potential terrorist attacks if they are launched often and in close proximity. Furthermore, Singapore’s transport system may be a target for terrorist attacks because of the city’s heavy reliance on public transport. As a countermeasure, there are increasing security checks at train stations and bus stops. However, this makes the public transport experience more inconvenient. Coupled with commuters’ safety concerns, it could result in lower usage of mass transit.

Whether terrorism becomes an important driver in shaping policies and commuters’ behaviour in the years to come is impossible to tell today. In the near future, the country may be forced to adopt more draconian measures to mitigate potential threats.
**INTRODUCTION TO SCENARIOS**

Uncertainty is central to foresight research. Many things can happen unexpectedly and simultaneously, and hence, the future is always uncertain. As such, decision makers must be prepared to exercise informed judgement when the unexpected becomes certain, through the envisioning of future scenarios.

No scenarios should go beyond the boundary of plausibility or “believability”. A good scenario must be challenging; scenarios that do not deviate from our business-as-usual perceptions are simply inadequate. Scenarios constructed by the Shell scenario team over the years, for example, often challenged our presumptions and preconceptions about the future (Wilkinson et al., 2015).

As “narratives of alternative environments” (Ogilvy et al., 2004), scenarios are not about predicting the future, but rather, serve as hypotheses of different futures that could highlight risks and opportunities associated with specific strategic issues. Different sets of scenarios should accommodate potential changes in perspectives with regard to strategic issues.

In sum, scenarios should be believable but should also contain future elements that are unthinkable, or improbable at the current level of technology. The scenario narrative, also known as a storyline, should also describe a broad range of alternative futures that are absorbing and convincing.

Every scenario planning exercise must have a focus on decision-making. Decision focus is shaped by asking the right questions such as “how much should we invest in electric vehicle infrastructure?” The timeframe of the issue in question also needs to be communicated.

In this study, we created possible scenarios of urban mobility in 2040.

**WHY DO SCENARIOS MATTER?**

Events and trends affecting the future can have cascading effects which are difficult to map intuitively and cognitively, let alone forecast (Schultz, 2015). Policy makers and stakeholders have to deal with deep uncertainty in exercising judgement when they plan for the future. Over the last few decades, scenario planning has emerged as an important tool for decision-making under such circumstances (Bishop et al., 2007).

Conventional long-range planning is a rudimentary process for planners and decision-makers within the transport sector, due to the massive amount of invested capital in mobility infrastructure that takes a long time to break even (typically 20 to 30 years). The usual prevalent techniques for forecasting future demands for mobility systems often miss the mark, as they rely on past records and historical trends to develop future projections.

The mobility sector is a complex system which is shaped by several variables and uncertainties. In such a system, future changes tend to be unprecedented, rendering historical data less usable for predicting the future. For example, the recent dip in oil prices was unanticipated by many because extrapolation of historical data on oil prices by and large indicated that prices were on the rise.
Many exogenous factors are often ignored in mobility planning (Rickards et al., 2014). We typically view mobility systems as local activities, which are context specific. However, it is imperative to consider global factors that play a crucial role in changing the local mobility landscape.

We used a scenario planning process to inform our long-range mobility foresight study. To this end, we engaged decision-makers and stakeholders in the development of scenario narratives to uncover and discuss implications realistically and constructively, enhance the legitimacy of scenarios by involving potential users, and to produce more creative scenarios through the inclusion of more perspectives (Alcamo, 2008). Through the scenario planning process, we have been able to explore interconnectedness of several key drivers of change that were not obvious at first. We have also been able to map their possible roles in shaping the future urban mobility landscape in Singapore, with the aim of preparing stakeholders for plausible alternative future conditions.

**SCENARIO PLANNING PROCESS**

A full-day workshop was conducted at Singapore University of Technology and Design in March 2016. In general, the scenario planning process follows the following steps:

1. Determine focal concern
2. Identify and prioritise drivers based on impact and uncertainty
3. Analyse drivers and deliberate possible end-states related to the drivers
4. Develop scenarios around these drivers
5. Apply scenario strategy

Workshop participants were chosen again based on purposive sampling. Invited participants were domain expert and stakeholders within the transport sector in Singapore. There were a total of 22 participants and they can be classified into three broad categories based on their professional affiliations: academia, government agencies and industry. This pool of participants comprised of participants from our earlier expert interview process, the local transportation planners, and individuals referred by other participants.

The criteria for selecting workshop participants was guided by the following rules (Ogilvy et al., 2004):

1. To include people with a thorough knowledge of the issue to be addressed
2. To include a diverse team of participants from a wide range of management levels, perspectives and roles
3. To include people from different intellectual disciplines
4. To include people from different cultural backgrounds
5. To include thinkers from inside and outside sectors

To begin, an invitation was sent via email to potential participants, to which they could respond by indicating their willingness to participate. Participation in the workshop was strictly on a voluntary basis and there was no remuneration or honorarium offered to the workshop participants. Upon
confirmation, registered participants were provided with a scenario workshop booklet that explained the background of the project and the significance and potential impacts for each driver of change.

**DETERMINE THE FOCAL CONCERN**

The workshop opened with an introduction to the research project, the Future of Urban Mobility 2040. Participants were asked to recall one thing that had surprised them about urban mobility in the past 20-30 years. This exercise helped to orient participants’ mindset in recognizing that there could be a drastic or transformational shift in urban mobility over the given period of time.

**IDENTIFY AND PRIORITISE DRIVERS BASED ON IMPACT AND UNCERTAINTY**

The drivers of change discussed in Chapter 5 will eventually be formulated as the scenario kernel in this scenario process. Participants were briefed on the significance, potential impact and nature of uncertainty of all drivers. They were encouraged to consider other possible drivers of change which could potentially be included in this process.

They were then asked to identify drivers of change which were highly uncertain and which would have a high impact on the future of urban mobility. Following this, participants used blue sticker dots to mark highly uncertain drivers and orange sticker dots to mark high-impact drivers. They were allowed to use a maximum of three stickers on one driver of change. The blue and orange dot stickers were tallied and the result was displayed on a scatterplot as shown in Figure 4.

Top-priority drivers are highly uncertain and have a high impact on the future implications. While there were several drivers which were deemed extremely uncertain, they were not thought to have any significant impact on the future of urban mobility. These were not chosen as top-priority drivers. From the scatterplot, drivers with approximately equal points for uncertainty and impact scores were chosen. These included:

- E-Commerce
- Personal Mobility Devices
- Multi-zone Districts
- Virtual Travel
- Innovative Capacity
Analyse drivers and deliberate possible end-states related to the drivers

Participants were divided into three breakout sessions and asked to discuss possible end-states in 2040. End-states are short narratives describing how each driver might pan out in the future. They should be mutually exclusive: two or more end-states should not have overlapping ideas, and one should not be a subset of another. For example, e-commerce might become pervasive, rendering shopping malls obsolete, or people might turn away from e-commerce in favour of shopping malls. For any given end-state that should occur, the other should not.

During the deliberation process, participants were encouraged to discuss how each driver may impact and interact with other drivers. For instance, one might suggest that e-commerce can only become widespread when we reach a high level of innovative capacity. By digging deeper into the interactions among different end-states of various drivers, we determine the plausibility of proposed end-states for the year 2040. Each group was asked to consider rational analysis and imagination in doing so. Table 4 shows the end-states for the drivers created in one of the groups, and Figure 5 illustrates the related post-it notes used during the discussion for that group.
Table 4. Breakout session for one of the groups: Description of end-states for various drivers

<table>
<thead>
<tr>
<th>Drivers</th>
<th>End-State 1</th>
<th>End-State 2</th>
<th>End-State 3</th>
<th>End-State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Commerce</td>
<td>Pre-emptive Purchase</td>
<td>E-Social Shopping</td>
<td>Retail Mall Makeover</td>
<td>Need for Touchy Feely</td>
</tr>
<tr>
<td>Innovative Capacity</td>
<td>Single Ecosystem</td>
<td>Innovation Collaboration</td>
<td>Export Innovation</td>
<td>First Adopter</td>
</tr>
<tr>
<td>Multi-zone Districts</td>
<td>Organic Evolution City</td>
<td>Two-Layer City</td>
<td>Freight Nation</td>
<td>Time-Division Multiplex City</td>
</tr>
<tr>
<td>Personal Mobility Devices</td>
<td>First Last Mile</td>
<td>PMD-Everything</td>
<td>Walking Nation</td>
<td>--</td>
</tr>
<tr>
<td>Virtual Travel</td>
<td>Virtual-Everything</td>
<td>Access-as-a-Service</td>
<td>Virtual not-Reality</td>
<td>--</td>
</tr>
</tbody>
</table>

Figure 5. Post-it notes during the discussion to determine plausible end-states

Participants were then asked to regroup to analyse drivers in a plenary session. Each group would present the outcome of their group discussion on plausible end-states for all the five listed drivers. After listening to other groups’ end-states, participants noted down similarities and differences from their respective group analyses.

From the feedback gathered, some participants felt that other groups arrived at end-states that were unthinkable and too imaginative, while others felt that some groups were too conservative in deliberating plausible end-states thus producing end-states that did not deviate much from business-as-usual conditions. Views from individual participants were very diverse, and the workshop was on the right track in exploring alternative futures as broadly as possible.

**DEVELOP SCENARIOS AROUND THE DRIVERS**

Participants exercised systems thinking in discussing the appropriation of each driver for scenario plots and in delving deeper in the underlying patterns of each scenario. Some participants employed mind-mapping techniques to discover patterns or links that connected drivers to a scenario.
To a certain extent, this workshop adopted a method akin to morphological analysis for mapping and pattern discovery.

Morphological analysis is a method for investigating relationships of non-quantifiable, qualitative description of variables (Ritchey, 1998). For each driver, a range of variables (i.e. end-states) is assigned, and all variables are then arranged in a matrix fashion thus producing a configuration space or a morphological field (a.k.a. “Zwicky box”) (Glenn et al., 2009). Each configuration contains one value from each of these end-states, which will be the scenario kernel. Such a morphological field will produce $5 \times 5 \times 5 \times 5 \times 3$ (or 1,875) possible configurations. Some configurations may be judged as plausible because all end-states for that particular configuration are coherent and appropriate, making it internally consistent.

A thorough search for all configurations would result in some inconsistent as well as consistent configurations. After charting out possible configurations, participants selected two to three configurations that they considered logical, plausible and challenging for their scenario development.

Storylines are then built around selected scenarios to include the ‘moving parts’ of a scenario and perceive it as a whole system, instead of envisioning the future with mere static descriptions. This exercise helps to uncover counterintuitive consequences that may occur in future reality. As such, narratives should capture timing as well as path dependencies arriving at a particular scenario.

Participants were asked to imagine several newspaper headlines of varying timelines as part of their chosen scenarios, (Ogilvy et al., 2004) using time anchors leading to 2040 (2016, 2020, 2025, 2030 and 2035). The aim of using newspaper headlines to construct a narrative was not to capture an imagination related to the future of urban mobility per se but rather to encompass a broad narrative of social life of the future and provide an insightful picture of mobility infrastructure and transport options available in that period.

Each scenario was given a title to convey its plot or a distinct theme (Ogilvy et al., 2004). For example, a typical theme could be “Winners and Losers”, which portrays a zero-sum game – when a specific group or organisation wins, there will be another one who loses. Another common scenario plot is “Good News and Bad News” which is a scenario plot that is characterised by desirable and undesirable futures.

All participants from the three breakout sessions reconvened to vote on a scenario set. They were asked to select two scenarios that are distinct, differentiated, plausible and challenging; those with the highest votes turned out to be Shared World and Virtual World. A third scenario, Collapsed World, was created to provide contrast against the two more desirable future states. This future state results from failures of several systems due to lack of planning as well as unanticipated consequences of new technologies and policies.

In the next chapter, we discuss the two desirable scenarios and their implications in detail, while a sketch of the undesirable scenario paints a vivid contrasting picture of what might happen if we do not take actions necessary to move towards desirable futures.
APPLY SCENARIO STRATEGIES

A sense-making process aims to create a better understanding of future conditions despite uncertainties and complexities. By fully immersing themselves in a particular scenario, participants attempted to imagine who the winners and the losers would be. Participants were also asked to consider the implications of each scenario from the perspective of society, businesses and industries, and government agencies.

There were some interesting insights provided by participants. For instance, one participant expressed concern for automotive companies in which their current business model would no longer be viable in the future. Another stressed the importance of remaining vigilant and nimble in the face of changing political landscapes worldwide. Most government agencies have specific sectorial jurisdictions. However, societies and economies will be more interwoven in future, which could potentially render governmental silos ineffective. Most participants were compelled to anticipate the potential implications and challenges that various scenarios posed. All acknowledged that there will always be unexpected happenings – wild cards.

WILD CARDS

The last part of the scenario workshop was dedicated to making sense of hardly-anticipated events using the wild card method. Wild cards are low-probability, high-impact events which occur with little warning (Glenn et al., 2009). Because of their potential surprises and random nature, organisations have a tendency to ignore them. Wild cards have increased in reach and impact due to globalisation and technology. As a small, open economy, Singapore is not isolated from the impacts of wild card events occurring in other parts of the world. As potentially disruptive events that could alter not only human physical infrastructures but also our mind-sets and values, there is value in exploring wild cards to increase our preparedness and resilience.

Some examples of wild cards are:

- Virulent epidemics like “super-SARS” – devastating impacts that paralyse shared mobility
- Terror attacks and cyber warfare – taking over a government could be possible without even invading the country
- Singapore buys an island – suddenly there are more space to build
- Extreme climate change impact causing mass migration – Singaporeans flee the island-state for higher ground in other countries
- Disruption in energy supply route – no oil entering and leaving Singapore
- Earthquake – the “ring of fire” extends its reach to Singapore
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