Foresight Study on Singapore Urban Mobility: Methodologies and Preliminary Insights

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Abstract Singapore enjoys a world-class urban transportation system today, benefitting from a combination of long-term planning, continued investment in infrastructure, and readiness in adopting new technologies. However, planners will always need to prepare for uncertain futures, and understand driving forces and global trends that affect future urban mobility. In this paper, we present an ongoing foresight study on Singapore's urban transport and mobility up to 2030. Our objectives are to develop a shared understanding of the current state of the transportation system, highlight long-term challenges and opportunities, and establish networks between stakeholders. Through environmental scanning and expert interviews, our preliminary findings indicate that mobility-on-demand services, multi-modal transport, and e-commerce are the dominant future drivers of change in the urban mobility landscape. In addition, ageing population, growing population and travel demand, inefficiencies in urban freight, shortage in skilled manpower, and a general resistance to big policy changes are the key challenges facing Singapore urban mobility in future. Finally, in terms of technology, autonomous vehicles, real-time traveller information, and shared mobility are seen as potential game-changers for the future.

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1 Introduction

This paper is a part of an ongoing foresight study on urban transport and mobility in Singapore. The project is in a series of foresight studies examining the Future of Cities at the Lee Kuan Yew Centre for Innovative Cities, Singapore University of Technology and Design.

Our core objectives are to develop a shared understanding of the current situation and issues in urban mobility in Singapore, facilitate future policy implementation by highlighting long term challenges and opportunities, and establish networks between experts and stakeholders in the mobility sector. Specifically, this study concerns only the land transport domain in Singapore, covering both passenger and freight sectors with government agencies and organisations in the transport domain as the audience.

The rest of the paper is organised as follows. First we develop the context by discussing the need for a foresight study on urban mobility in Singapore in Sect. 1. Next, we discuss our foresight methodology in Sect. 2. In Sect. 3, we discuss some of the preliminary insights we have gathered so far. We conclude in Sect. 4 by reviewing the insights and discussing our future work plan.

1.1 Singapore's Leading Role in Transport

Singapore has done well in developing a world-class urban transportation system over the past few decades, and plays a leading role in the region. In private transport, it enjoys the benefits of electronic road pricing, which was introduced in 1998 and helps to manage congestion by moderating the number of vehicles entering the central business district. In the area of autonomous vehicles, trials started in early 2015 to prepare the country for the future. As for public transport, the country's Mass Rapid Transit has made extensive use of driverless trains since 2003.

Despite the good quality of transport services in Singapore, uncertainties in the future cannot guarantee continued service quality. There is a need to pre-empt and plan for the future, meaning that planners should not only master daily operational issues, they must also develop a well-informed, long-term understanding for transport to address challenges that lie beyond the horizon.

1.2 Singapore's Context, Challenges, and Long-Term Planning

Singapore's cultural and political context differs substantially from many other high density cities in developed nations. The country's government is often in a strong position to pass legislation swiftly, develop the long-term vision for the country,

and set in motion detailed development plans that are rapidly implemented. Thus, it is contingent on the government to ensure that its plans are realistic and practical.

A number of groups in the Singapore public service and academia are tasked with the responsibility to plan for the long-term future. Examples include the Centre for Liveable Cities at the Ministry for National Development, the Futures Division at the Ministry of Transport, and the Institute of Policy Studies, which is part of the Lee Kuan Yew School of Public Policy at the National University of Singapore. Other government agencies and research institutes also publish reports or conduct seminars to share thoughts about the future.

In the realm of transport, Singapore's Land Transport Authority was formed in 1995 to spearhead improvements to the land transport system, and published a white paper [9] to chart plans for the decade ahead. This was followed-up with the Land Transport Masterplan [10] that looked towards 2020, and the next revision [11], that planned for 2030.

These long-term plans for transportation were not drafted in isolation. The 1991 Revised Concept Plan by the Urban Redevelopment Authority plotted a 25-year development trajectory [21]. More recently, reports such as the 2013 Land Use Plan [14] and the Population White Paper [16] were released in succession, and each had core assumptions that were used in the 2013 Land Transport Masterplan. In this latest series of plans, Singapore's population is projected to grow to between 6.5 to 6.9 million by 2030, and massive developments are expected for Singapore's rail network, which will double in length to about 360 km by 2030.

Other studies have also covered transportation. The Economic Review Committee discussed advancing transportation infrastructure in strategic developments to catalyse growth in areas such as One-North, Tuas, and Jurong Island, and also provided a detailed set of recommendations on how to develop Singapore into a global integrated logistics hub [15]. More recently, to commemorate Singapore's jubilee celebrations, a vision for urban mobility was written by the Centre for Liveable Cities [19].

Over the years, the variety of studies and master plans has contributed immensely to the quality of transportation services present in Singapore today. However, there are two key challenges that policymakers must be mindful of when doing long-term planning.

First, the focus on policy solutions for single scenarios makes it difficult for planners to prepare for uncertainties. For example, the earlier Concept Plans based infrastructure provisions on the assumption of a fixed population target, which changed substantially with each revision. This had knock-on effects on the construction of transportation infrastructure, which takes many years to build. Policies need to be flexible to cater to uncertain futures, and responsive to swiftly address changing needs.

Second, many studies emphasise a prescriptive approach to policy, leaving the discussion about driving forces and global trends on the back-burner. For example, few would have anticipated that the rapid adoption of smartphones over the last few years would have led to the widespread use of mobile apps such as Uber, Google Maps, and GrabTaxi for transport. If car sharing and public transport become the

dominant modes of transport over the next 15 years, fewer roads may be needed to handle traffic in the coming decades, and policymakers may decide to slow down road construction in anticipation of that future.

Are there opportunities for Singapore to take advantage of new technologies that could result in improvements of many orders of magnitude? Are current policies forward-looking such that they can deal with an uncertain future? Are there experts in the field who are working on potentially-disruptive technologies that policymakers should start exploring today?

2 Foresight Methods for Singapore Urban Mobility

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 [7]. 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. It is not the intention of foresight studies to predict the future correctly; but more 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 [18] 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 [18] 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. And finally, **Evidence** recognises that it is important to support analysis with reliable documentation and measurement indicators.

After reviewing foresight methods in the literature, we decided to select our methods by considering the time horizon of the project and Singapore's context, and also by exploiting the four fundamental attributes of the foresight methods. The selected methods are as follows:

Environmental Scanning/Literature Review (Evidence attribute): 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.

Expert Interviews (Expertise and Evidence attributes): Interviews are structured conversations which are used to gather insights from experts who are specialists in their respective fields.

Future Scenarios and Workshop (Creativity and Interaction attributes): Scenario planning is one of the most well-known and most cited technique for planning for the future. Edgar and Alänge [4] defined scenario planning as the process of creating several varied but 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 the world of uncertainties.

Technology Roadmapping (Expertise attribute): Technology roadmapping helps to identify critical technologies under development that can have game-changing effects on the system. The process of roadmapping helps to chart the course of these technologies and how they fit into future scenarios.

Apart from technology roadmapping, our selected methods have been frequently used in foresight studies as discussed in Popper [18]. However, we decided to include technology roadmapping since urban transport in Singapore will be significantly affected by technological developments in the future. It is worth mentioning that these are the main methods used in the transport and mobility foresight studies that we have reviewed so far, which we discuss later in this paper.

3 Preliminary Insights

3.1 Environmental Scanning and Literature Review

We first reviewed the Singapore land transport masterplans [9–11] and the Intelligent Transportation System (ITS) Smart Mobility Vision 2030. These documents helped us to understand Singapore's context and identify key areas that the government is focusing on for the future.

According to the land transport masterplan 2013, some of the key challenges Singapore faces include population growth that will increase mobility demand, more congestion on roads with a reduction in available space for new roads, and an ageing population. In addition, the ITS Smart Mobility Vision 2030 discussed areas of technological development that can manage demand and plan for seamless future mobility. These areas include real-time information availability, connected cars, shared mobility, enhanced traffic management systems for road pricing, autonomous vehicles, and green mobility.

Next, we reviewed foresight studies on urban transport/logistics. Singapore, as a city state, has its own set of land constraints. As an instance, residential areas coexist with business districts, parks and other commercial areas whilst in other megacities such as London, Seoul and New York, dense city centres are surrounded by suburbs. Nonetheless, many of these megacities have similar issues, such as increasing congestion and urban density, increasing and ageing populations, changing social behaviours, and dependency on combustion engines in automobiles. We also looked up other studies on general urban megacities in order to widen the scope of our literature review.

We reviewed twelve studies which were conducted by diverse groups, ranging from global consulting firms (e.g., Deloitte), independent international organisations (e.g., Forum of the Future), academic institutions (e.g., New York University), and government departments (e.g. New Zealand's Ministry of Transport). These studies cover time frames from 2018 to 2100, with a bulk of studies focused around 2030. The results are summarised in Table 1.

The results show that Future Scenarios, Expert Interviews and the Environmental Scanning/Literature Review are the most frequent methods used in the transport related foresight studies. Moreover, alternative energy/cost of energy, environmental sustainability, mobility-on-demand, virtual travel, vehicle automation, ageing population, and urbanisation are the dominant future drivers of change that urban cities around the world are focusing on.

3.2 Expert Interviews

Our study is ongoing, and we are conducting a series of interviews with experts from the government, academia, and industry professionals within the land transport sectors in Singapore. These interviews will help us to gather insight on current/future challenges, upcoming trends, industry evolution, and technology development.

Based on the interviews conducted so far, we identified a variety of challenges facing transportation in Singapore. These cover day-to-day operational issues such as managing peak hour traffic and resolving the first and last-mile problem, technological issues such as big data in intelligent transport systems, and global challenges such as climate change and urbanisation. We classified these challenges into four broad categories as follows:

Demographics, particularly in terms of the ageing population, was seen as a key challenge as senior citizens would need more assistance to get around. Also, the increasing resident population and foreign workforce will give rise to denser towns and the need to increase transport capacity.

Culture was also cited as a huge challenge, especially in terms of adopting more efficient modes of transport. The affluent population in Singapore considers cars as status symbols, shunning public transport and car sharing and cycling. Next, users have overly-high expectations of public transport in terms of cost and reliability. In

Table 1 Literature review on urban transport/logistics foresight studies

Foresight study	Foresight year	Cities/region	Foresight methods					Key drivers of the future
			Literature review	Expert interviews	Workshops	Future scenarios	Others[a]	
Townsend [20]	2030	United States Megacities	•			•		Cheap alternative energy, Vehicle automation, economic growth, individualism
van Voorst tot Voorst and Hoogerwerf [24]	2040	Dutch Urban Centers	•	•		•		Mobility-on-demand, virtual travel, legislation against free use of vehicles, vehicle automation
Intelligent Infrastructure Futures [17]	2056	United Kingdom Urban Centers	•			•	•	Environmental sustainability, public acceptance of intelligent infrastructure
DHL [2]	2050	Megacities		•	•	•	•	Energy price, environmental sustainability, political stability, global trade, individualism, robotics, rise of Asia, ownership to rental model
Martins et al. (2008)	2018	Brazil Urban Centers		•		•	•	Investment in infrastructure, efficiency of legislation and quality control
Auvinen et al. [1]	2100	Finland Urban Centers	•				•	Urbanisation, alternative energy sources, ITS integration, environmental sustainability
Zhao et al. [25]	2030	Jinan, China	•	•	•	•		Urbanisation, environmental sustainability

(continued)

Table 1 (continued)

Foresight study	Foresight year	Cities/region	Foresight methods					Key drivers of the future
			Literature review	Expert interviews	Workshops	Future scenarios	Others[a]	
Lyons et al. [12]	2042	New Zealand Urban Centers			•	•	•	Cost of energy, virtual travel
Gazibara et al. [6]	2040	Megacities		•		•		Resource scarcity, environmental stability, demographics, energy mix, governance model, values of future society
Zmud et al. [26]	2030	United States Megacities			•	•	•	Price of oil (energy), environmental sustainability, investment in infrastructure
Fishman [5]	2020	Megacities			•	•		Vehicle automation, virtual travel, ITS integration, mobility-on-demand
Ecola et al. [3]	2030	Chinese Megacities			•	•	•	Pace of economic growth, amount and type of constraints imposed on vehicle ownership and use, environmental conditions

[a]Technology Roadmapping, PESTE Analysis, System Dynamics, Consistency, Cross Impact, and Cluster analysis, and Delphi method

addition, environmental sustainability is typically ignored. As for telecommuting, the practice remains unpopular in Singapore even though it can take vehicles off the roads.

Regulation was discussed frequently over the course of our interviews. In the realm of autonomous vehicles, liability for accidents caused by vehicles of different levels of autonomy remains an issue. For public transportation, Singapore's design-build-operate-transfer model must align budgetary constraints with operational needs for maintenance and future expansion. For transport innovations such as Uber, regulatory frameworks still lag developments. And in terms of the next generation of electronic road pricing, authorities need to assure motorists about data privacy.

City Logistics or urban freight has been less studied, but is now a growing challenge. Inefficiencies in delivery arrangements, such as the congestion of freight vehicles at shopping malls, and re-deliveries for undelivered residential packages result in longer delivery times and the need for more drivers island-wide.

Expert interviews also helped us to identify several dominant trends that are likely to play key roles in how people commute in future. These include mobility-on-demand, multi-modal transport, e-commerce, the rising middle class, cycling, and teleworking, to name a few. In addition, we distilled technologies that are likely to play game-changing roles in fuelling these trends. The three main trends and their associated technological advancements are discussed as follows:

Mobility-on-demand is a change from an ownership model to a mobility-on-demand model that experts have unanimously agreed will play a key role in the future. Some mentioned that driving license applications are decreasing among the younger generation in some countries. This means that people are more willing to accept mobility-as-a-service instead of investing in cars as assets. The two technologies that are likely to accelerate this trend are shared mobility systems, especially car-sharing and ride-sharing apps, as well as autonomous vehicles.

Multi-modal transport, which is using different modes of transport to commute from one point to another, is the second most important trend. According to one expert from one of the leading automotive companies in the world, many global automotive companies are beginning to provide end-to-end mobility by partnering with different organisations. The key technology for this system to work seamlessly is **real-time information** availability of all transport modes, and the ability of commuters to interact with these modes on demand.

E-commerce has been around for some time now, but experts say that it is growing at a significant rate in Singapore. This trend is linked to the increased use of smartphones, which has allowed people to go online to shop more frequently. E-commerce will not only disrupt how people shop, but also how people will work and socialise.

4 Final Remarks

In this paper, we introduced foresight studies and the importance of adopting such tools in planning for the future of urban mobility in Singapore. In this ongoing study, we have discovered that trends in mobility-on-demand, multi-modal transport, and e-commerce will influence the way that transportation will evolve in the future. These trends, when twinned with challenges in demographics, culture, regulation, and city logistics, will help to develop a framework to visualise different scenarios that Singapore might face in the future. Our next tasks involve conducting more expert interviews, preparing a technology roadmap to identify possible game-changing technologies in urban transport, and preparing and analysing scenarios to discuss and evaluate them at a scenario planning workshop.

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