What are the limitations and challenges of Singapore's current transport system? And what reforms and innovations do you think are required to overcome those limitations and challenges, particularly in terms of improving mobility for all?

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Abstract

An unfortunate reality that many commuters have to grapple with daily is the increasing unreliability of our much-touted transportation system. Breakdowns by the Mass Rapid Transit (MRT), Light Rail Transit (LRT) and the all too frustrating scenes of bus bunching have continued to vex and frustrate all but the most patient commuters. This paper measures the success of our transportation system against its goals of achieving “First-and-Last-Mile Connectivity”, reduced waiting time and mobility for the disadvantaged and attributes the inability of our transportation system to achieve these goals to both structural and policy problems. The duopolistic market structure in Singapore’s rail industry and infrastructural deficits in the provision of “First-and-Last-Mile Connectivity” are to blame for Singapore’s transportation malaise. To resolve these issues, the implementation of both policy reforms and infrastructural expansion is required. The further liberalisation of our rail industry and the adoption of optimal business practices from foreign operators are proposed to inject dynamism and efficiency into the industry. Also, we propose the adoption of new technologies and innovation to resolve problems with “First-and-Last-Mile Connectivity”, in the form of a new form of light rail and the introduction of driverless cars. In conjunction with the development of new townships in Singapore, these innovations can be implemented in the developmental plans of Singapore to achieve the Government’s goal of achieving a green, ‘car-lite’ and smart city. Finally, we propose collaboration between the Government and the rising ride sharing platforms to implement schemes to capitalise on the latter as a form of providing mobility to all, particularly the elderly and disabled. The ascendancy of mobile technology will undoubtedly help to further public interest in this regard. Ultimately, a phase-by-phase implementation of the above-proposals, based on ease and effort, should take place to resolve the transportation woes of Singapore. (297 words)

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Chapter 1: Traffic Jams –Problems with our transport system

1.1 Inadequacy of current measures to improve rail system

Despite the Government's acquisition of the operating assets of SMRT Trains and SMRT Light Rail under the New Rail Financing Framework (NRFF)[1], it is unlikely that commuters will see a significant improvement in the service provided due to the duopolistic structure of the market. Additionally, the limited pool of engineering talents and resources in the rail industry in Singapore also diminishes the likelihood of effective competition[2]. Thus, resource limitations and the persistently high barriers to entry into the rail market continue to impede improvement in the quality of service provided.

1.2 Flaws of current feeder services

Current feeder services have been integral in complementing mass transit by providing "First-and-Last-Mile Connectivity" for all commuters. Yet, the latest breakdown on the Bukit Panjang LRT, along with frequent bus bunching[3], appears eerily familiar[4] [5]. Bedevilled by a plethora of problems since its inception, the persistence of perennial glitches has proven that the "Bukit Panjang line isn't a paragon of reliability"[6]. Additionally, feeder bus services continue to suffer from bus bunching[7] despite the recent implementation of the bus-contracting model due to factors such as poor traffic[8]. Essentially, the development of hassle-free "First-and-Last-Mile Connectivity" in these 2 pivotal mediums remains stagnant.

[1] Singapore Land Transport Authority (LTA). "SMRT Trains and SMRT Light Rail to transit to New Rail Financing Framework." Accessed 4 November 2016. https://www.lta.gov.sg/apps/news/page.aspx?c=2&id=aa0d44f9-e909-46f2-92af-792f2efe4992

[2] Lee Kuan Yew School of Public Policy. "The Evolution of Public Transport in Singapore." Accessed 4 November 2016. http://lkyspp.nus.edu.sg/wp-content/uploads/2014/01/Transport-Planning-for-Singapore.pdf

[3] Bus bunching refers to a scenario whereby two buses plying the same route appears at bus station at the exact same time. This may have been due to the inability of one of the buses to follow the schedule.

[4] Tan, Christopher. " A fussy LRT system in need of overhaul." The Straits Times. September 29, 206. Accessed 7 November 2016.

[5] Teo, Kok Seah. "Inject more competition into feeder bus routes." The Straits Times. July 1, 2016. Accessed 7 November 2016.

[6] See 4.

[7] Lim, Adrian. "Bus riders enjoy shorter waits with Tower Transit." The Straits Times. August 28, 2016. Accessed 7 November 2016.

[8] See 7.

Chapter 2: Laying the Rails –Reforming our rails

2.1 Introduction of foreign operators

Taking into account Singapore's limited pool of rail engineering talents and resources, which impedes the introduction of significant inter-firm competition, the entry of foreign rail operators into the domestic market is a crucial step in improving market contestability. Research done by the Stockholm School of Economics Institute for Research[9] and the Organisation of Economic Cooperation[10] has shown that the introduction of an open access rail system[11] has significant improved productivity and safety in suburban rails, coupled with significant increases in rail infrastructure investment. Notably, in the Swedish case study, the introduction of foreign rail companies, such as the French Connex and Veolia and the Hong Kong Mass Transit Railway (MTR) increased competitive pressure on the local Swedish railway operators[12]. From Sweden's example, it can be postulated that the participation of foreign operators in Singapore's rail industry under the NRFF will bring about similar effects.

The effects of this would be two-fold. Firstly, the introduction of foreign experts into our domestic rail industry will mitigate the absence of competition caused by our manpower and technical limitations. As a result, the introduction of real competitive pressures in the market will motivate incumbent firms to improve their service quality and reduce productive inefficiency, translating into better service quality and prices for commuters. Secondly, with seasoned foreign industry veterans working in conjunction with local personnel, technology transfer and knowledge diffusion is likely

[9] Alexandersson, Gunnar (2016). *Lessons from railway deregulation and tendering in Sweden* [Powerpoint Slides]. Retrieved from http://nordicpublictransport.com/wp-content/uploads/31_Gunnar-Alexandersson-2016-06-16_Alexandersson_Railway-deregulatio4_n.pdf

[10] Casullo, Lorenzo "The Efficiency Impact of Open Access Competition in Rail Market". July 2016. Accessed 4 November 2016.

[11] An open access system refers to one whereby private firms compete with another to run operations on the tracks, as opposed to competition for the tracks themselves.

[12] See 9

to happen. Consequently, this will improve dynamic efficiency within our local rail operators as well, leading to innovation and long-term welfare gains.

2.2 Adoption of the MTR's 'R+P' model

A salient feature about the Hong Kong MTR is its high farebox recovery ratio[13], which stands at 187% (the world's highest) and its overall profitability as a company[14]. In part, the MTRC's (Mass Transit Railway Corporation) financial success can be attributed to its 'R+P' model[15]; from 2001 to 2005, 52% of the MTRC's revenue came from property development while only 28% came from railway[16]. Not only does the 'R+P' model aid MTRC's balance sheets, it also plays an important part in complementing the social and economic objectives of the Hong Kong government while benefitting Hong Kong society at large. The direct benefit from the 'R+P' model, such as land premiums shareholder cash dividends, amounted to HKD$140bn while its positive externalities (e.g. reduced pollution, increased public transport usage) brought the amount to way beyond HKD$140bn[17]. Impressively, all of this was accomplished at minimum cost to the Hong Kong government.

Under the NRFF, the financial burden on the Land Transport Authority (LTA) will undoubtedly increase due to its assumption of the capital expenditure formerly borne by SMRT. Hence, the adoption of a similar model in Singapore may help to alleviate the financial burden faced by the LTA. Yet, rather than a wholesale replication of the MTRC's 'R+P' model, certain adaptations must be made to localise it. Currently, the LTA only contracts out jobs for station and rail development to private firms[18]. While

[13] Farebox recovery ratio refers to the fraction of operating costs that are covered by fares paid by the commuters
[14] Lee, Min Kok. "Dubbed the 'best in class': 6 things about Hong Kong's MTR rail system." The Straits Times. October 29, 2015. Accessed 4 November 2016.
[15] The 'R+P model' refers to the 'railway + property' model that is a hallmark of the MTR. On top of its rail operations, the MTR also ventures into property development.
[16] Robert Cervero and Jin Murakami. "Rail + Property: A model of sustainable transit finance and urbanism". May 2008. Accessed 4 November 2016.
[17] See 16.
[18] Chow, Jermyn. "Foreign contractors sought for MRT deals." The Straits Times. May 6, 2013. Accessed 7 November 2016.

maintaining the current form of a private-public partnership (PPP), the LTA will mandate the development of certain necessary infrastructure. In this way, the LTA can ensure that the development of station-areas remains commuter-centric and can be harmonised with supporting transport infrastructure. The station-areas shall then be leased out to developers at preferential rates who could in turn rent out storefronts in these stations to business-owners in a B2B scheme.

This scheme will not only reduce LTA's capital expenditures, but will incentivise firms to construct and upkeep dynamic and vibrant station-areas since the their long-term profitability is tied to these leases. Thus, similar to station-areas in Hong Kong near the MTR, the community at large will also reap positive externalities from the construction of these stations like the reduction in pollution from car use (for residents) and increased foot-traffic (for business-owners).

Chapter 3: The First Step –Towards a World Class "First-and-Last-Mile"

While Singapore's leaders have made laudable efforts in engineering conditions for "First-and-Last-Mile Connectivity" in view of the "Walk Cycle Ride SG" vision, current feeder services could be remodelled with the introduction of the "Caterpillar Train[19] Group Rapid Transit SG" (cTrain GRT SG) in larger new towns.

3.1 Caterpillar Train Group Rapid Transit SG (cTrain GRT SG) – Up and Down the Town

Pioneered by Emil Jacob, the Caterpillar Train (cTrain), an intriguing solution to mass transit, won the prestigious MIT Climate CoLab Competition – Transportation 2016[20].

The cTrain concept is an automated mass transit system of elevated weight trains substantially equipped with commuters-friendly features[21]. A series of archways running over the streets would support a thin network of cable-like pipes as trains run above and below the lines[22]. With its potential to increase accessibility, reduce emissions and ensure affordability, a similar concept with improved elements could be employed to our current feeder service. A joint venture could be formed between local public transport operators (PTOs) and Jacob- Innovations Limited Liability Company (LLC) to launch the cTrain GRT SG.

[19] Jacobs-Innovations, LLC. *MASS TRANSIT CONCEPT –cTrain- a comprehensive solution to mass transit.* http://jacob-innovations.com/cTrain.html
[20] Crucchiola, Jordan. "Far-fetched plan for mass transit is intriguing at least". Wired. January 13, 2016. Accessed 7 November 2016.
[21] See 19.
[22] See 19.

Figure 1: Sample logo for the cTrain GRT SG

cTrain GRT SG (ref. Figure 1) aims to be the leading "First-and-Last-Mile" provider in larger new towns[23] as its comprehensive network ensures that its accessibility is within a 200m radius of all GRT stations, complementing the "Walk2Ride" Scheme[24]. cTrain will be designed with a multitude of user-friendly features (ref. Appendix 1) to accommodate the needs of all commuters during both peak and non-peak periods.

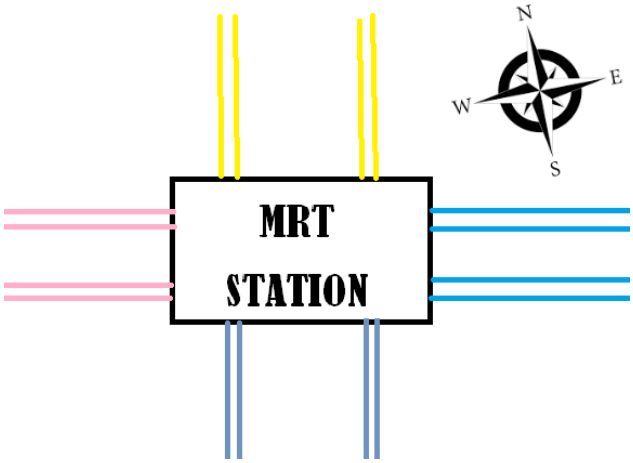

Figure 2: Proposed connectivity between MRT stations and the cTrain network

Ferrying up to 24 commuters via sitting room only, cTrains will run in the 4 cardinal directions from a central MRT station to the entire neighbourhood (ref. Figure 2), stopping at stations built based on the population density of the street or avenue. This significantly reduces travelling and waiting time as compared to the current LRT system which operates in a big loop. In response to larger volume during rush hours,

[23] These larger new towns refer to upcoming Woodlands Regional Centre, Tampines Regional Centre and Jurong Lake District.
[24] Land Transport Authority. *Walk2Ride Sheltered Linkways at 59 MRT Stations.* https://www.lta.gov.sg/apps/news/default.aspx?scr=yes&keyword=Walk2Ride%20Programme

the central MRT station can accommodate up to 16 cTrain GRT SG to enhance the "First-and-Last-Mile Connectivity" for all commuters.

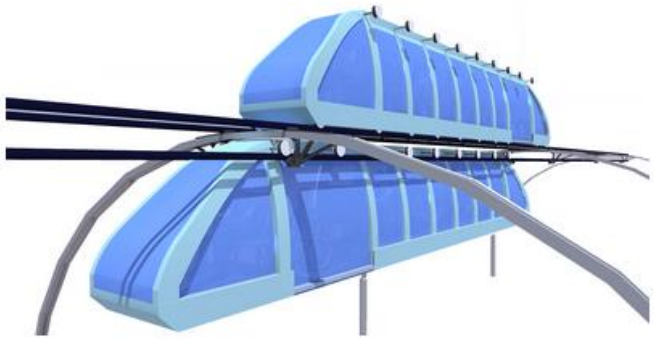

Figure 3: Rail operations of cTrain GRT SG

cTrain GRT SG is designed to move above and below the rails (ref. Figure 3) which positions itself in the middle segment above the street, reducing plausible adverse visual impacts on the urban landscape as it is placed furthest from either side of the built environment[25]. With minimal space requirements, cTrain GRT SG simplifies the production cost, size and visual impact of its supporting infrastructure.

[25] See 19

Figure 4: View of the cTrain network from the street

Rails will be buttressed by arched supporting structures planted on the sidewalk ways [26] (ref. Figure 4). The current cTrain concept proposes one rail to be constructed[27] but the construction of two rails with the same supporting structure (ref. Figure 5) could be undertaken by cTrain GRT SG as collaboration with local universities to cater to a growing population.

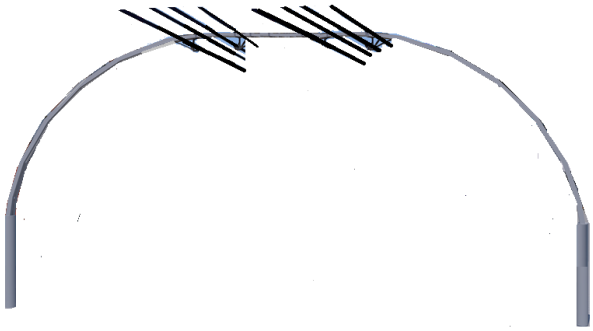

Figure 5: Proposed alteration to the rail infrastructure of the cTrain

Additionally, stations with optimal designs that integrate with the urban landscape will be situated along geographically denser streets and avenues to accommodate estimated large volume of passengers. An approximate halting time of 15 seconds at

[26] Climate CoLab. *What initiatives, policies and technologies can significantly reduce greenhouse gas emissions from the transportation sector?* http://climatecolab.org/contests/2016/transportation
[27] See 26.

every station will be programmed as the latest in-built feature (ref. Figure 6) will significantly reduce entry and exit time[28].

Figure 6: Exit and entry functions of a cTrain station

cTrain GRT SG can further customise its service by ensuring that it will circumvent stations without as many passengers during non-peak hours, improving its efficiency. The operation of cTrains aligns with our vision of attaining a "Cleaner, Greener and Smarter Home[29]" as it runs on electricity supplied by renewable energy sources. Rechargeable batteries will be installed in all cTrains to serve as back-ups under emergencies.

Capitalising upon the cTrain, both travelling and waiting time (along with commuters' dissatisfaction) can be significantly reduced. Despite the benefits cTrain GRT SG promises to deliver, it should be subsumed under the NRFF and the LTA shall be responsible for its regular maintenance. The birth of cTrain GRT SG will significantly

[28] See 26.
[29] Ministry of National Development. *A Cleaner, Greener and Smarter Home* http://www.mnd.gov.sg/cleangreensmarthome/

improve “Last-and-First-Mile Connectivity” in larger new towns as it complements existing transportation infrastructure.

3.2 Driverless Pods – Bringing You Anywhere, Everywhere

While the concept of driverless pods on non-guided networks was introduced a decade ago, it was quickly dismissed as investors are reluctant to fund this promising yet untested transit technology[30]. Transiting to a ‘car-lite’ Singapore, 2getthere Asia[31] has been formed to introduce automated vehicles in Asia[32]. While cTrains operate in bigger new towns, smaller ones can utilise driverless pods (ref. Figure 7), placing the final piece in the transportation puzzle.

Figure 7: Sample design of a driverless pod released by 2gethere Asia

These driverless pods will function as “Horizontal Elevators” and can be conveniently booked using proprietary mobile applications installed in ubiquitous mobile devices[33]. With its integration into the public transport network, driverless pods will ferry up to 12 passengers. To maximise occupancy rate and minimise travelling time, “smart

[30] Kenyon, A. “CyberTran: Small start-up has big dreams”. Richmond Confidential. October 31, 2011. Accessed 7 November 2016.
[31] Joint Venture between SMRT and Dutch company 2getthere
[32] See 20.
[33] Lee Kuan Yew School of Public Policy. *Shaping Policy for the Sharing Economy.* http://lkyspp.nus.edu.sg/wp-content/uploads/2016/05/Shaping-Policy-for-the-Sharing-Economy-Jean-Chia.pdf

routing system"[34] will be harnessed to ensure that destinations of passengers are within a 0.4km radius. These driverless pods will run on designated roads with a speed limit of 40km/h in order to ensure the safety of all commuters and pedestrians. Guided by thumb-sized magnets[35], the driverless pods will operate smoothly even under poor weather conditions, reducing the possibility of a traffic congestion. These pods could travel up to 300km on a single charge powered by specially developed batteries[36].

Figure 8: Artist's impression of Tengah[37]

Tengah[38] (ref. Figure 8), Singapore's 24th HDB town, can kick-start this initiative to provide seamless "First-and-Last-Mile Connectivity" to stations along the upcoming Jurong Regional Line (JRL). Surrounded by lush greenery and nature, Tengah envisions itself to be a car-lite new town constituting only driverless pods on its main roads[39]. During non-operating hours, driverless pods will situate themselves at

[34] "Smart Routing System" harnesses current GPS tracking system to streamline bookings (Pick Up Points and Destination) within the proposed distance, reducing waiting and traveling time.
[35] Embedded beneath every 2m to 3m in the road
[36] Lambert, Fred. "Toyota is planning long-range battery-powered electric cars for 2020 as its hydrogen fuel cells cars are failing." Electrek. November 7, 2016. Accessed 8 November 2016.
[37] Housing and Development Board. *Unveiling the Masterplan for Tengah: At Home with Nature*. http://www.hdb.gov.sg/cs/infoweb/press-releases/corporate-pr-unveiling-the-masterplan-for-tengah-08092016
[38] See 37
[39] Heng, Janice. "New Tengah HDB town heavy on greenery, light on cars". The Straits Times. September 9, 2016. Accessed 8 November 2016.

available carparks around Tengah. These carparks will comprise an underground space dedicated for the parking of these pods, equipped with an automated maintenance system to recharge the batteries installed.

Name	Expected size	Expected number of housing units
Tengah	700ha	55 000
Tampines North	240ha	20 000
Bidadari	93ha	10 000 – 11 000

Table 1: Information on upcoming towns[40]

Tengah serves as a leading model for other geographically smaller new towns (ref. Table 1) in Singapore, complementing the cTrain GRT SG network as well as "Walk Cycle Ride" Programme to provide a seamless "First-and-Last-Mile Connectivity" to all MRT stations in a car-lite Singapore.

[40] Ministry of Trade and Industry. *Population White Paper: "A Sustainable Population for a dynamic Singapore"* https://www.mti.gov.sg/MTIInsights/Documents/FAQs%20for%20White%20Paper.pdf

Chapter 4: Carpooling –The Sharing Economy and I

4.1 Rejuvenating Social Mobility Through Sharing Economy

While 8 in 10 households will reside within 10 minutes of a train station by 2030[41], there remains the imperative to encourage public transport usage amongst people with disabilities and senior citizens due to the lack of access to the nearest MRT.[42] The government could leverage on the emerging sharing economy by engaging these firms to partake in a partnership between the public transportation system and Ride Sharing Platforms[4344]. This partnership aims to increase the social mobility of this group of people as these Ride Sharing Platforms can be effectively utilised to fill up the "10 minutes gap" which may still exist despite the restructuring. With the success of the on-demand transportation pilot programme for senior citizens between Uber and Gainesville, Florida[45], a similar pilot programme can be adopted in Singapore. Tutorials in the four official languages[46] could be conducted to educate them on the usage of these platforms. Payment wise, user registration and co-payment can be adopted to prevent system abuse. Different criteria[47] can be used to assess the degree of co-payment. As the corporate social responsibility (CSR) landscape[48] continues to evolve with a positive outlook, it is indisputable that these sharing economy firms are incentivised to undertake this responsibility and contribute actively to the partnership proposed, improving social mobility and bridging an inclusive "First-and-Last-Mile Connectivity".

[41] Land Transport Authority. *MRT & LRT Trains.* https://www.lta.gov.sg/content/ltaweb/en/public-transport/mrt-and-lrt-trains.html
[42] Raghunathan, R., Balakrishnan, B., Smith, C., & Kadir, Mumtaz. "People with physical disabilities in Singapore – Understanding disabling factors in caregiving, education, employment and finance." June 2015. Accessed 7 November 2016. https://centres.smu.edu.sg/lien/files/2012/03/People-with-physical-disabilities-in-Singapore.pdf
[43] Uber and Grab
[44] Nashville MTA/RTA Strategic Plan. "Transit Strategies –First and Last Mile Connections" September 2015. Accessed 7 November 2016. http://nmotion2015.com/wp-content/uploads/2015/09/nMotion-First-Mile-Last-Mile-150920_FINAL.pdf
[45] See 44.
[46] Uber Newsroom. *More options for senior mobility.* https://newsroom.uber.com/creating-more-options-for-senior-mobility/
[47] Such as household income and distance traveled
[48] Thomas, T. "Sustainable business and corporate social responsibility." February 2007. Accessed 7 November 2016. http://www.sid.org.sg/web_publications/articles_detail/23

Chapter 5: Minding the Gap –Implementation in phases

Any improvement to our transportation system cannot be actualised overnight, and hence we propose the gradual implementation of the above-mentioned reforms and innovation in phases. Collaboration between ride sharing platforms and the Government can be materialised much faster than the implementation of driverless pods and the cTrain, both of which will require the construction of supporting infrastructure. Consequently, the PPP between the ride sharing platforms and the Government can be actualised in the short run to ameliorate the ease of transport for the disabled and the elderly while the necessary infrastructure is constructed for the other two solutions. Concurrently, the government can liberalise the rail market to gradually remedy the problems it faces. In the short to medium term, the two-pronged effects of both rail reforms and the use of ride sharing platforms can partially mitigate Singapore's traffic woes. In the long term, however, the continued growth of the population necessitates both policy and infrastructural expansion to be taken to accommodate the growing demands of a burgeoning population. Ultimately, the resolution of Singapore's transport woes would require a multipronged approach with the implementation of appropriate measures at the required phases to resolve.

(Manually counted and checked: 2000 words)

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Appendix

Appendix 1: Infographic on features installed in cTrain GRT SG[49]

[49] Neo, Xiaobin. (Photographer). (Accessed 10 November 2016). USB Charging Ports on Bus B, one the concept double- decker buses [Digital Image]. Retrieved from http://www.straitstimes.com/singapore/in-pictures-singapores-new-bus-fleet