Discussion paper issued without formal editing

FOR PARTICIPANTS ONLY
10 November 2020
ENGLISH ONLY

UNITED NATIONS
CENTRE FOR REGIONAL DEVELOPMENT

In collaboration with

Ministry of the Environment, Government of Japan
United Nations Economic and Social Commission for Asia & the Pacific

INTERGOVERNMENTAL 13th REGIONAL ENVIRONMENTALLY SUSTAINABLE TRANSPORT (EST) FORUM IN ASIA

10-11 NOVEMBER 2020
Virtual meeting via video conference in Webex platform

Changing the course of Asia's transport sector through transformational changes

(Background Paper for EST Plenary Session-1)

Final Draft

This background paper has been prepared by Prof. Peter Newman, Curtin University, Australia, for the 13th Regional EST Forum in Asia. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

Changing the course of Asia's transport sector through transformational change

Background Paper for the Thirteenth Regional EST Forum in Asia, November 2020, Virtual.

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Acknowledgements

This study was written by Professor Peter Newman and was funded by the United Nations Centre for Regional Development (UNCRD). Professor Newman would like to acknowledge the contribution to the background paper by Dr Karlson Hargroves, Curtin University Sustainability Policy Institute (CUSP), Perth, Australia and Daniel Conley, University of Adelaide, Adelaide, Australia. Professor Newman would like to also acknowledge UNCRD staff Mr. C.R.C. Mohanty, Environment Programme Coordinator, and Dr Ganesh Raj Joshi, Researcher, Environment Unit for their valuable guidance.

Executive Summary

To be completed following first round of review.

Notes: The Executive Summary will provide a succinct summary of the key messages of the Briefing Paper that are of particular relevance to EST member countries. A number of options will be presented that can support transformative change in the transport sector, such as innovative policies, integrated land-use and transport planning, state-of-the-art technologies, innovative funding and financing, improved institutional capacity, and good and transparent governance. Moreover, it is equally important for countries to enhance strong cooperation, collaboration, and networking, building among local, national, and international communities for achieving sustainable urban development.

1. Introduction

The need for transformational change in Asia's transport sector

There is great need for transformational change in Asia's transport sector and if done strategically it can deliver a number of benefits for Asian cities. This need comes from significant congestion, pollution and road safety issues that have been well documented and explored in past EST Forums and associate background papers (Hargroves *et al*, 2018[1]). There is a range of potential mechanisms to support such a transformation, including: transport policies, infrastructure development, technological intervention, institutional arrangements, and innovative financing mechanisms, among others. Key to the implementation of transformational approaches will be to harness new and emerging technologies as this report will outline, including: electric mobility and associated infrastructure; Artificial Intelligence in traffic management; integrated land-use and transport planning; the activation of development opportunities along corridors using integrated shared transit; and the use of online distributed ledgers.

In the past decade the Transport sector has seen great progress in the design and deployment of next generation transport systems and new technologies that can provide member countries with a range of benefits. There is a number of key innovations that can provide mobility that is cheaper, smarter, and cleaner, with improved ride quality. The way that these types of technologies are navigated will have a direct impact on the very functioning of cities, affecting quality of life, accessibility, commuting times, and the level of urban regeneration that can be unlocked by effective and efficient transport networks. However, it is often difficult to identify the operational considerations associated with such new technologies which can hinder progress and slow implementation of options that could deliver substantial benefits. This background paper seeks to highlight a number of such considerations to allow member countries to quickly and strategically benefit from next generation transport systems and new technologies.

Anticipated benefits for Asian cities

Cities across Asia are facing growing transport related pressures that call for new approaches. This situation poses several threats to cities such as growing costs of congestion, increased health impacts from transport pollution, and increased road accidents and fatalities. In addition, due to novel coronavirus (COVID-19), the transport sector in Asia has been highly affected, and particularly the public transport system has been almost paralyzed for a long period of time in many cities. This calls for consideration of new approaches and technologies that can be used to not only build the resilience of cities but also deliver real sense of safety, mobility, and economic activity which need transformational changes in the entire transport sector.

There are a number of new options that can help to transformative change can be achieved in the transport sector, through innovative policies, integrated land-use and transport planning,

[1] Hargroves, K., Conley, D., Spajic, L., and Gallina, L. (2018) 'Sustainable Urban Design Co-Benefits: Role of EST in Reducing Air Pollution and Climate Change Mitigation', Background Paper for UNCRD Eleventh Regional EST Forum in Asia, Mongolia, Ulaanbaatar, 2-5 October, 2018.

state-of-the-art technologies, innovative funding and financing, improve institutional capacity, and good and transparent governance. Moreover, it is equally important for countries to enhance strong cooperation, collaboration, and networking, building among local, national, and international communities for achieving sustainable urban development. The transition to electric mobility and associated infrastructure; the application of Artificial Intelligence to traffic management and integrated land-use and transport planning; the activation of development opportunities along corridors using integrated shared transit; and the use of online distributed ledgers are some example for the transformation in the transport sector in Asia and the Pacific.

In this context, the upcoming 13th Regional EST Forum in Asia under the theme of "Changing the course of Asia's transport sector through transformational change" identify and discuss number of transport policies, planning, infrastructures development, state-of-the-art technologies, innovative funding and financing mechanisms, better institutional capacity development, good and transparent governance, and cooperation and collaboration opportunities for changing the course of Asia's transport sector for achieving 2030 Agenda for Sustainable Development/SDGs, in particular-SDG 11.

Transport in a Post COVID World

Since the COVID-19 pandemic was announced by the World Health Organisation (WHO, 2020[2]) in March 2020, governments around the world have responded with various forms of restrictions on human movement and interactions, ranging from city wide shut downs to restrictions on the size of gatherings, in order to slow the spread and contain the virus (OWD, 2020[3]). Forcing behavioural changes and transforming the way people communicate, work and live, these restrictions have substantial affected transport, providing a unique opportunities to revise and rethink transport strategies and options going forward (Zhang and Hayashi, 2020[4]). This part presents an overview of findings from an investigation into five transport related areas that have been impacted by the COVID-19 pandemic and highlights the current and likely future implications these may have on Asian cities. The impact areas include: General global impacts; Changes to perceptions of acceptable pollution levels in cities; Changes to perceptions around active modes of transport; Changes to perceptions around shared transit options; and Implications for the freight and logistics sector.

- *General Global Impacts:* Due to the contagious nature of the virus, COVID-19 has made an impact on almost every nation's economy at environmental, economic and social levels both negative and positive. For instance there has been a dramatic reduction in greenhouse gas (GHG) emissions and fine particulate matter (PM2.5) in many of the world's cities due to restrictions on vehicle use; but also there has been and an increase levels of waste and a decrease in recycling rates due to contactless customer service (Zambrano-Monserrate *et*

[2] WHO (2020) Timeline: WHO's COVID-19 Response, Online, World Health Organisation (WHO).
[3] OWD (2020) Policy Responses to Cornavirus Pandemic, Online, Our World in Data, 3rd August 2020.
[4] Zhang, J. and Hayashi, Y. (2020) Impacts of COVID-19 on the Transport Sector and Measures as Well as Recommendations of Policies and Future Research: Analyses Based on a World-Wide Expert Survey, May 27, 2020, Social Science Research Networks (SSRN).

al, 2020[5]) The global economy is predicted to contract by a little over 5 percent, in part as a result of businesses that are considered non-essential being forced to close and resulting high unemployment rates being recorded around the world (ICAO,2020[6]). Socially, many people are left feeling isolated where low-income earners, indigenous peoples, older persons, young people and people with disabilities are most affected. With less face-to-face interaction, many workplaces and educational facilities have adapted to online communication and learning, making previously largely overlooked option to work-from-home now a mainstream mode (Zhang and Hayashi, 2020[7]). Given the disruption caused by COVID-19 it is very likely that some of the altered behaviours and patterns may endure such as a greater focus on localisation, reduced travel, and higher levels of staff working from home, each will have an implication for the transport sector.

- *Perception of Acceptable Pollution Levels:* Many cities experienced the lowest level of air pollution in living history as COVID-19 restrictions on travel meant substantially less vehicles were allowed on the roads. As less vehicles are travelling and pollution levels decrease, people around the world have experienced visible changes in their surrounding environments such as clear, blue skies in areas usually covered in grey smog clouds. For instance the lock-down in Wuhan China resulted in a 63 percent reduction in air pollution (Cole *et al*, 2020[8]), and in Delhi the level of PM2.5 was within the recommended WHO guidelines for the first time in decades. Cities such as Seoul experienced a 54 percent decrease in PM2.5, Sao Paulo a 32 percent decrease, and Los Angeles a 31 percent decrease during lockdown (IQAir, 2020[9]). Such significant improvements to air pollution are very likely to change the perception of residents in cities around the world as to what is an acceptable level, and this is likely to strengthen calls for further reductions. Given that the majority of air pollution is a result of transport fuel choices this suggests that greater focus will be placed on low emissions fuels and electrification in the coming 2-5 years than would have been prior to the pandemic (Lombrana and Warren, 2020[10]).
- *Perceptions around Active Modes of Transport:* Throughout the pandemic, active modes of transport, such as localised walking and cycling, have gained unprecedented popularity and government support as extra efforts are made to maintain good mental and physical health under shelter-at-home conditions (Zhang and Hayashi, 2020[11]). At first given the short term localised context it may seem that there will be little long term impact on the transport system, however as residents experience the benefits of active modes which are cleaner, healthier and cheaper, there are growing calls for embedding these options across entire cities. A number of European cities already have strong active transport infrastructure in place, while cities in the United Kingdom such as London have transformed roads into

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[5] Zambrano-Monserrate, M., Ruano, M., and Sanchez-Alcalde, L. (2020) Indirect Effects of COVID-19 on the Environment, Science of the Total Environment, Volume 728, 2020.
[6] ICAO (2020) Effects of Novel Coronavirus (COVID-19) on Civil Aviation Economic Impact Analysis, Air Transport Bureau, International Civil Aviation Organisation (ICAO).
[7] Zhang, J. and Hayashi, Y. (2020) Impacts of COVID-19 on the Transport Sector and Measures as Well as Recommendations of Policies and Future Research: Analyses Based on a World-Wide Expert Survey, May 27, 2020, Social Science Research Networks (SSRN).
[8] Cole, M., Liu, B., and Elliott, R (2020) Wuhan’s lockdown cut air pollution by up to 63% – new research, The Conversation, 13 May 2020.
[9] IQAir (2020) COVID-19 Air Quality Report: 2019 coronavirus pandemic lockdowns result in unprecedented reductions in deadly particle pollution. IQAir, 22 April 2020.
[10] Lombrana, L. and Warren, H. (2020) A Pandemic That Cleared Skies and Halted Cities Isn’t Slowing Global Warming, Blomberg, 08 May 2020.
[11] Zhang, J. and Hayashi, Y. (2020) Impacts of COVID-19 on the Transport Sector and Measures as well as Recommendations of Policies and Future Research: Analyses Based on a World-Wide Expert Survey, SSRN.

walking and cycling paths in response to the pandemic (UNESCAP, 2020[12]). As more people begin to change their behaviours and incorporate active modes into their daily lives, perceptions around their role in the transport system will shift and will likely lead to greater calls for active modes to be offered in cities around the world rather than a return to automobile dependence (Harris, 2020[13]). To maintain a healthy lifestyle, the World Health Organisation (WHO) recommends at least 150 minutes of physical activity per week. Hence purely for health related reasons by encouraging active transport modes through infrastructure such as exclusive walking and cycling lanes, wide footpaths, interconnected parks and resting areas, along with associated reductions in vehicle emissions, these recommendations could easily be achieved, delivering a multitude of benefits (UNESCAP, 2020[14]).

- *Perceptions around Shared Transit:* Along with perceptions of active modes the perception of public transport, or shared transport, have been affected. The pandemic has heightened concerns over health and cleanliness of shared transit services, resulting in a reduction in ridership (UNESCAP, 2020[15]). Consumers look favourably upon brands or businesses who are making visible efforts towards protecting their health and safety (Arora *et al*, 2020[16]), thus it is important that transport operators communicate effectively to their passengers about capacity concerns and hygiene protocols while operations return to normal. Given the need to shift from individualized private transport to shared options in order to make pace with the growth of the world's cities such shared transport options will need to adapt to provide safe, hygienic and effective transport options in the future.
- *Freight and Logistics:* Due to 'shelter-at-home' conditions and other restrictions imposed by governments in response to COVID-19, the freight and logistics sector has endured changes in demand and operation due to shifts in consumer behaviours and essential cargo requirements. Implications of the pandemic include an increased shipping demand, increased online shopping, decrease in retail loyalty as up to 70 percent of consumers are estimated to have tried alternative brands (Arora *et al*, 2020[17]), and an increase in quantity and importance of essential cargo delivery to aid in crisis relief (European Commission, 2020[18]). In response, some air-cargo operators have coordinated short-term action plans to ensure access to essential services (SADC Secretariat, 2020[19]). Further a number of 'Economics Response' platforms have been created to monitor the effect of the pandemic on trade. Such changes in air-cargo operation include the introduction of "green-lanes" for essential cargo and restricted times for passenger flights, from which China has achieved a

[12] UNESCAP (2020) COVID-19 Prompts Rethinking of Mobility and City Planning, United Nations Economic and Social Commission for Asia and the Pacific, UNESCAP.
[13] Harris, S. (2020) 'Post lockdown London: Parking spaces and traffic lanes to vanish to encourage walking and cycling', Online, ITV News, 06 May 2020.
[14] UNESCAP (2020) COVID-19 Prompts Rethinking of Mobility and City Planning, United Nations Economic and Social Commission for Asia and the Pacific, UNESCAP.
[15] UNESCAP (2020) COVID-19 Prompts Rethinking of Mobility and City Planning, United Nations Economic and Social Commission for Asia and the Pacific, UNESCAP.
[16] Arora, N. Robinson, K., Charm, T., Grimmelt, A., Ortega, M., Staak, Y., and Whitehead, S. (2020) Consumer sentiment and behavior continue to reflect the uncertainty of the COVID-19 crisis, Online, McKinsey and Company, 08 July 2020.
[17] Arora, N. Robinson, K., Charm, T., Grimmelt, A., Ortega, M., Staak, Y., and Whitehead, S. (2020) Consumer sentiment and behavior continue to reflect the uncertainty of the COVID-19 crisis, Online, McKinsey and Company, 08 July 2020.
[18] European Commission (2020) European Commission Guidelines: Facilitating Air Cargo Operations during COVID-19 outbreak, 26 March 2020.
[19] SADC Secretariat (2020) SADC Regional Response to COVID-19 Pandemic: An Analysis of the Regional Situation and Impact. SADC Secretariat, Bulletin N. 2.

45-minute timesaving on cargo delivery (International Economics Consulting, 2020[20]). With special provisions and priority awarded to air-cargo operators, the European Competition Network have raised concern over operators abusing these positions to increase prices and benefit from the pandemic unfairly (European Commission, 2020[21]). Much of the future is unpredictable, however as more consequences of the pandemic are acknowledged, it is important to consider how to best prepare and adapt freight and logistics systems for an ever-changing environment while ensuring fairness across the industry is maintained.

Asian cities are especially susceptible to the effects of the COVID-19 pandemic as they are typically densely populated, have high levels of ridership on public transport, account for 40 percent of domestic flight passengers worldwide, and heavily depend on trade. Ridership levels have dropped on public transport, causing people to look towards cities such as Kathmandu that had high levels of engagement in active transport at 42 percent of the population before the pandemic (UNESCAP, 2020[22]) for inspiration on how to manage social distancing and travel. Domestic travel and worldwide trade are two big contributors to the economy in Asia, both of which have been heavily impacted throughout the pandemic. As China makes up 20 percent of the global intermediate goods trade (Ugaz and Sun, 2020[23]), many nations have been confronted with these impacts and in the future, may look to diversify their markets and depend less on global trade or resources. The implications of the COVID-19 pandemic will be felt for decades and it will be important for cities around the world, especially highly populated Asian cities, to consider how these implications can inform decisions around the future of their transport systems.

It is clear that the pandemic has brought more than just temporary changes to the world that we live in, and we will need to learn from the experience and seek to improve our living spaces and transport systems. It is also clear that the transport sector needs to take more responsibility for its contributions to poor air quality and greenhouse gas emissions. Along with the impact categories presented above consideration should also be given to ways to encourage active modes of transport and the transition to electro-mobility. Previously unpopular options, such as active modes of transport and tele-commuting are now mainstream, and governments should consider implementing relevant infrastructure such as walking and cycling routes, along with work-from-home incentives and support. As essential goods are prioritised and shifts in customer demand vary, the freight sector must consider how best to manage this unpredictability and more adaptive options for the future.

[20] International Economics Consulting (2020) The Impact of COVID-19: Reflections on the Transport and Logistics Sector, International Economics Consulting.
[21] European Commission (2020) European Commission Guidelines: Facilitating Air Cargo Operations during COVID-19 outbreak, European Commission.
[22] UNESCAP (2020) COVID-19 Prompts Rethinking of Mobility and City Planning, United Nations Economic and Social Commission for Asia and the Pacific, UNESCAP.
[23] Ugaz P. and Sun, S. (2020) Case Study: China's Trade Facilitation responses to the COVID-19 Pandemic, United Nations Conference on Trade and Development, Article No. 52, Transport and Trade Facilitation Newsletter, Special COVID-19 Edition.

2. Transformative Vehicle Technology Options

This part provides an overview of opportunities for Asian countries and cities to use state-of-the-art technologies to enhance the transformation of the transport sector for multiple benefits. This includes an overview of the potential value of specific technologies such as: alternative energy vehicle technologies (such as hybrid and electric buses, cars, motorbike, bicycles, and scooters); and shared transit options (such as trackless trams, bus rapid transit, light rail, and mass rail).

The race to next generation vehicle technology

In the last 5 years there has been a significant increase in availability of electric vehicles with substantial improvements to battery technology revolutionizing the design of most forms of transport. Not only can battery powered vehicles significantly improve fuel economy in hybrid vehicles they can shift a nation's energy economy from being based on physical fuels to being based on electricity with many local economic benefits. This has major implications for Asian cities for both the types of vehicles that will be used in the coming decade and the requirement for supporting infrastructure. Electrification of vehicles will not only significantly reduce air pollution form vehicles in cities, which can extend the benefits realized due to COVID-19 restrictions on travel, but it will also provide the opportunity for domestic energy industries to grow and implement decentralized renewable energy options. This transition will allow a significant reduction in greenhouse gas emissions from vehicles and power generation.

With a growth rate of electric vehicles of over 40 percent per year, predictions for how quickly the internal combustion engine will be phased out are now coming down into the 2020's (Dia, 2019[24]). The reason electro-mobility is disruptive is similar to solar and wind: the vehicles are rapidly reducing in cost as battery packs have reduced from $1,000/kWh in 2010, to less than $200/kWh in 2020. In addition the technology is preferred for many other social and environmental reasons, especially cleaning up local air pollution (Dia, 2019[25]; Dia et al, 2019[26]; Newman, 2020[27]). Bloomberg New Energy Finance (in McKinsey, 2018[28]) now suggests capital costs of electric vehicles will be equal to internal combustion engine vehicles ICE in 2022, but the operational costs will be much lower for electric vehicles. The types of electric vehicles to roll off assembly lines in large numbers in the early 2020's will be long range passenger vehicles, closely followed by electric buses (Transport and Environment, 2018[29]) and electric trucks (Liimatainen *et al*, 2019[30]), some decades before ships and planes.

Concern over the growth in consumption of battery minerals has been seen as a constraint on this rapidly growing Li-ion battery market (Olivetti *et al*, 2018[31]). Responses to this show that

[24] Dia, H. (2019) Rethinking Urban Mobility: Unlocking the Benefits of Vehicle Electrification. In Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A., White, S., Eds.; Palgrave Macmillan: Singapore.

[25] Dia, H. (2019) Rethinking Urban Mobility: Unlocking the Benefits of Vehicle Electrification. In Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A., White, S., Eds.; Palgrave Macmillan: Singapore.

[26] Dia, H., Taylor, M., Stone, J., Somenahalli, S., and Cook, S. (2019) Low Carbon Urban Mobility. In Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A., White, S., Eds.; Palgrave Macmillan: Singapore.

[27] Newman, P. (2020) Cool Planning: How urban planning can mainstream responses to climate change. Cities 2020, 103, 102651.

[28] McKinsey (2018) Electrifying Insights, September 30, 2018.

[29] Transport and Environment (2018) Electric Buses Arrive on Time: Marketplace, Economic, Technology, Environmental and Policy Perspectives for Fully Electric Buses in the EU.

[30] Liimatainen, H., van Vliet, O., and Aplyn, D. (2019) The potential of electric trucks–An international commodity-level analysis. Appl. Energy 2019, 236, 804–814.

[31] Olivetti, E., Ceder, G., Gaustad, G., and Fu, Z. (2017) Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metal. Joule 2017, 1, 229–243.

these minerals are needed in very small quantities compared to iron and aluminium and the growth of assured supplies with ethical and transparent mining systems as well as growing recycling opportunities, suggest these concerns are being addressed (IRP, 2019; World Bank, 2018; Kester *et al*, 2020[32]; Newman, *et al* 2018[33]; Lee *et al*, 2020[34]). However reduced consumption is a necessary agenda for multiple reasons. Disruption is demand-driven, like the smart phone, but those cities adapting to new systems with solar panels, battery storage, and electric vehicles are also seeing common-good outcomes that they can assist (Garnaut, 2019[35]). These public benefits are especially seen in how electric vehicles are assisting electro-mobility in the new forms of micro-mobility and in new mid-tier electric transit which have multiple benefits in overcoming automobile dependence.

Not only will electrification of vehicles improve fuel economy and reduce greenhouse gas emission it will also create new urban business opportunities with strong local and domestic demand. For instance the Shenzhen Bus Group has recently become the first fully electric bus fleet in the world and found that not only did this shift reduce the running cost of buses but the need to also secure real estate for charging facilities across the city has provided the opportunity to provide charging and maintenance services to other electric vehicles within the city (such as garbage trucks, taxis, and private vehicles). Cities around the world are now considering how to best support the transition to electrification of mobility and grappling with the best way to provide supporting infrastructure. Micro-mobility options such as electric scooters, skate boards, bikes and auto-rickshaws are ideal ways to enable end-of-trip integration, and can work with autonomous shuttles to provide an integrated Mobility-as-a-Service offering for end-of-trip travel.

New transport options presented by emerging technologies will require management to enhance station precincts for walkability and not just promote more car-dependent end-to-end travel (Currie, 2018[36]). This should include how driverless electric shuttle buses can carry people to the station precincts (providing first and last kilometre solutions) without ruining the walkability qualities of the area (Glazebrook and Newman, 2018[37]). Evidence is showing that private services such as Uber are increasing the vehicle kilometres travelled rather than decreasing it as many had anticipated, causing greater congestion and accessibility issues (Schaller, 2018[38]). Countering this trend will require a different approach to mobility that favour road-based transit integrated with these end-of-trip options. Recently emerging e-scooter and car sharing business models may hold the key to reducing car ownership and use. Membership of car-sharing services has been shown to reduce vehicle use and car ownership rates (Muheim and Reinhardt, 1999[39]; Becker *et al*, 2018[40]), which may enable a balance to be

[32] Kester, J., Sovacool, B., Noel, L., and de Rubens, G. (2020) Between hope, hype, and hell: Electric mobility and the interplay of fear and desire in sustainability transitions. Environ. Innov. Soc. Transit. 2020, 35, 88–102.

[33] Newman, P., Wills, R., Edwards, C., and Yates, C. (2018) Lithium Valley: Building the Case to Establish Western Australia As a Manufacturer of Energy Metals and Power Storage; Regional Development Australia, Kwinana Industries Council and Curtin University: Perth, Australia.

[34] Lee, J., Bazalian, M., Sovacool, B., Hund, K., Jowitt, S.M., Nguyen, T., Manberger, A. Kah, M., Greene, S., and Galeazzi, C. (2020) Reviewing the material and metal security of low-carbon energy transitions. Renew. Sustain. Energy Rev. 2020, 124,

[35] Garnaut, R. (2019) Superpower: Australia's Low-Carbon Opportunity; Latrobe University Press: Melbourne, Australia.

[36] Currie, G. (2018) Lies, Damned Lies, AVs, Shared Mobility and Urban Transit Futures. Journal of Public Transportation. Vol 21 No. 1., pp. 19-30.

[37] Glazebrook, G. and Newman, P. (2018) The City of the Future, Urban Planning, Volume 3, Issue 2, Pages 1–20.

[38] Schaller, B. (2018) The New Automobility: Lyft, Uber and the Future of American Cities, Schaller Consulting, New York.

[39] Muheim, P. and Reinhardt, E. (1999) Carsharing: the key to combined mobility. World Transport, Policy Practice, 5 (3), 58-71.

[40] Becker, H., Ciari, F. and Axhausen, K. (2018) Measuring the car ownership impact of freefloating car-sharing – A case study in Basel, Switzerland. Transportation Research Part D: Transport and Environment Volume 65, December 2018, Pages 51-62.

obtained with demand-based systems like Uber/Lyft and autonomous vehicles (Calthorpe and Walters, 2016[41]).

The autonomous transport technologies that have come out of motor vehicle research combined with new ICT and smart systems, have not yet found a proper niche in any city. The claims being made based on time savings, safety and environmental grounds include the idea that no other forms of transport will be needed other than autonomous automobiles. There are already signs that such claims may in fact not live up to this initial hype as visions of cities given over completely to driverless vehicles are unlikely, meaning that the positive benefits of these new technologies may never be fully realised (Newman *et al*, 2017[42]). On the other hand, the autonomous, electric and stabilization transit technologies developed for High Speed Rail (between cities, over 300 kph) and Metros or Suburban Rail (within cities, over 150kph) have developed the speed, capacity and ride quality that have led to spectacular increases in ridership (Newman and Kenworthy, 2015[43]; Koglin, 2016[44]). These technologies are able to guide trains at high speed to provide passengers with a level of comfort and safety that is unparalleled in the history of mobility.

However, the ability to compete with private cars within cities requires an autonomous vehicle that can provide transit capacities and speeds similar to or greater than cars (such as light rail or bus rapid transit) so that connection can be achieved along unserved corridors or between corridors. This is usually a missing link in transit systems as light rail transit (LRT) and bus rapid transit (BRT) are disruptive to cities in their construction and expensive compared to a normal bus line. Buses are rarely able to generate the speed or ride quality that would compete with a car (Kenworthy and Schiller, 2018[45]) so the cities of the world have been allowing cars to fill this transport niche and enabling them via expensive urban infrastructure and highways. The results can now be seen in urban congestion, air pollution, road accidents and urban sprawl as well as many social and economic issues associated with car dependence (Newman and Kenworthy, 2015[46]).

Emerging Leaders in shared transit options

Shared Transit Vehicles

Perhaps the most significant innovation in electro-mobility in terms of common-good outcomes is the electrification of public transport (Glazebrook and Newman, 2018[47]). The electrification of heavy train and tram systems is a mature technology based on overhead catenaries, however Li-ion batteries have revolutionised the electrification of public transit. The response in recent years has been the development of autonomous transit that can fit inside car dependant cities to provide many of the journeys unable to be served by faster urban rail systems. This is the niche of LRT and BRT, however in order to provide effective solutions for

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[41] Calthorpe, P. and Walters, J. (2016) Autonomous vehicles: Hype and potential. Public Square: A CNU Journal. 6 September 2016.
[42] Newman, P., Beatley, T., and Boyer, H. (2017) Resilient Cities: Overcoming Fossil Fuel Dependence, Second Edition, Island Press.
[43] Newman, P. and Kenworthy, J. (2015) The end of automobile dependence: How cities are moving beyond car based planning, Island Press.
[44] Koglin, T. (2016) High Speed Rail Planning, *Policy and Engineering*, Vol IV Trends and Advanced Concepts in High Speed Rail, Momentum Press, New York.
[45] Kenworthy, J. and Schiller, P. (2018) An Introduction to Sustainable Transportation: Policy, Planning and Implementation second edition, New York and Abingdon: Earthscan from Routledge.
[46] Newman, P. and Kenworthy, J. (2015) The end of automobile dependence: How cities are moving beyond car based planning, Island Press.
[47] Glazebrook, G. and Newman, P. (2018) The City of the Future, Urban Planning, Volume 3, Issue 2, Pages 1–20.

the world's growing cities the technology used must overcome the issues of disruption and cost as well as keeping all the good qualities of an LRT or BRT.

To do this has meant merging innovations from High Speed Rail such as autonomous operation, stabilization and ride quality, with the best parts of a light rail and a bus, to create a new form of urban transit technology called Autonomous-Rail Rapid Technology (ART) or a 'Trackless Tram'. Significant advances in the merge of the most effective elements of transit technology have been coming from a range of bus and rail manufacturers from around the world but much of the recent excitement has been generated from the CRRC developed Trackless Tram System (see Figure 1) in China. A Trackless Tram system is a superior technology for urban transit systems and it stands to be the public transport catalyst that many city planners have been waiting for since the dominance of automobile dependence.[48] Not only is this technology a potential game changer for cities struggling to attract investment in traditional light rail projects, if implemented through an entrepreneurial approach in collaboration with the private sector it stands to unlock significant re-development options.

Figure 1: The Trackless Tram System developed by CRRC and demonstrated in Zhuzhou, China.
Source: Compliments of CRRC Corporation.

It is important to realise that the Trackless Tram System lends itself to an entrepreneurial approach where secure private sector investment can be attracted to create new development around station precincts, referred to as the 'Entrepreneur Rail Model' (Newman *et al*, 2017[49]; Davies-Slate *et al*, 2018[50]). This is particularly relevant where cities are growing and hence private investment is likely to be looking for opportunities; this can apply to cities all around the world but especially in developing countries where growth pressures are high. Such an approach can allow both emerging and developed cities with inadequate legacy transit systems to 'leap frog' the currently adopted transport technologies to strengthen economic development

[48] Newman, P., Hargroves, K., Davies-Slate, S., Conley, D., Verschuer, M., Mouritz, M. and Yangka, D. (2019) "The Trackless Tram: Is it the Transit and City Shaping Catalyst we have been waiting for?". Transportation Technologies, 9, 31-55.
[49] Newman, P., Davies-Slate, S. and Jones, E. (2017) The Entrepreneur Rail Model: Funding urban rail through majority private investment in urban regeneration, *Research in Transportation Economics*, Volume 67, May 2018, Pages 19-28.
[50] Davies-Slate, S., Conley, D., Newman, P., Hargroves, K., and Mouritz, M. (In-Press) Entrepreneurial Financing of Transit Activated Corridors: Reinventing an Entrepreneurial Approach to Transit, Curtin University Sustainability Policy Institute, Curtin University, Australia.

and assist in the Sustainable Development Goal of providing an '*inclusive, safe, resilient and sustainable city*'.

Hence as outlined above innovations in electric vehicles, self-driving technologies, precision tracking, and high speed stabilization have now been combined to create the next generation of urban transport system based around what is called a "Trackless Tram". Trackless Trams are effectively the same as traditional light rail except they run on rubber tyres avoiding disruption from construction of in-road rail systems and are powered by on-board batteries that are quickly recharged at stations avoiding overhead cables. These innovations alone can significantly reduce the cost compared to a traditional light rail system. As with Light Rail, a Trackless Tram System (TTS) provides a rapid transit option that can harness the fixed route assurance necessary to unlock new land value appreciation that can be leveraged to contribute to construction and running costs whilst creating urban regeneration. The adoption of Trackless Tram Systems is likely to grow rapidly as a genuine alternative to car and bus systems, supplementing and extending the niche occupied by Light Rail Transit (LRT).

A Trackless Tram effectively starts with a standard light rail carriage that is narrow and has multiple entry doors with a turning radius and climbing gradient comparable to a bus, and then provides four new attributes:

1. It harnesses electric drive systems and on-board battery technology to avoid the need for overhead cabling or a fossil fuel engine, with recharge at either stations or end of run areas for longer periods;
2. It substitutes the steel wheels of a train with bus inspired solid core rubber tyres to avoid the need for rails and the associated disruption of local economies due to extensive period of construction works on roads and underground services;
3. It provides train-type bogeys with low set axles and hydraulic systems designed to prevent sway and bounce; and
4. It adopts autonomous technology through optical guidance systems to provide a precise and smoother ride quality and precision entry to stations.

Considering the system configuration, the Trackless Tram system uses a dedicated corridor to provide rapid transit services that is supported by fixed stations and a Control Centre much like light rail or traffic management centres. This means with a strong rationale for fixed routes and stations that there is potential to attract development around stations as it will unlock development potential for easy access to such services. However, it is also able to be diverted around blockages or quickly recalled should the need arise unlike an LRT.

Micro-Mobility Options

In addition to shared transit vehicles, often referred to as Mid-Tier Transits, there is a race to commercialise all sorts of types of micro-mobility options. Such options are typically small, local transport technologies that support walking, such as electric tuk-tuks, electric bikes, electric scooters and electric skateboards that are becoming a major part of the electric vehicle revolution (Ajao, 2019[51]). The growth of these modes in Chinese cities (Gao *et al*, 2018[52]) and places like Delhi (now with the fifth biggest recharge system in the world's cities, see StartUS, 2020[53]) is driven by the need to reduce air pollution but they are also part of the active transport movement that is showing substantial health benefits when reducing car dependence (Stevenson and Thompson, 2019[54]). Some 46 percent of car journeys in the US go just 3 miles or less, which can simply be replaced by micro-mobility and 30% of micro-mobility riders are doing just that (Ajao, 2019[55]).

Electric micro-mobility can also develop a range of new functions relevant to local centres (a growing focus for the new economy), which could include local delivery of on-line parcels. The rapid growth in parcel delivery vans has been a major part of growing traffic in the US (Schaller, 2018[56]) and can be solved if parcels were delivered locally by small electric vans that could also be autonomous. They can be delivered regionally by Trackless Trams along corridors providing parcels to station precincts where local Delivery Vehicle Hubs can be located. All forms of electro-mobility need recharging and in cities these can become part of a new Recharge Hub or battery-storage precinct that is based strategically to support the grid balance needed to ensure universal access and resilience. These Recharge Hubs can be available to the multitude of micro-mobility vehicles that can be supportive of local economies, and also provide the last-mile linkages for electric transit as it services a corridor of economic development.

The benefits of micro-mobility in enabling local centres to work without cars and to enable transit systems to work without the need for car-dependent corridors, is certainly rapidly emerging over the past decades (Gehl, 2010[57]; Matan and Newman, 2016[58]). Transit was seriously damaged during the COVID-19 pandemic, but so was car traffic, so the growth of local walkability and active transport has been a global phenomenon with many cities building this into permanent change (Harris, 2020[59]; Davies, 2020[60]; Laker, 2020[61]). At the height of the Pandemic in late April, across Scotland the public transport was down by up to 95%, car use was down by 70% and cycling was up by 120% (Transport Scotland, 2020[62]). Re-localising the city like this becomes a strong positive outcome from the move to active transport with its support in micro-mobility and new electric transit systems as well as the localised power systems emerging from the solar-battery-based power systems to further the 'transformation' of local town centres. It is a sign that a new policy orientation has emerged from COVID-19.

[51] Ajao, A. (2019) Everything you wanted to know about scooters and micro-mobility. Forbes, 1 February 2019.
[52] Gao, Y.; Kenworthy, J.; Newman, P.; and Gao, W. (2017) Transport and mobility trends in Beijing and Shanghai: Implications for urban passenger transport energy transitions worldwide. In Urban Energy Transitions, 2nd ed.; Droege, P., Ed.; Elsevier: Berlin, Germany, 2017.
[53] StartUS (2020) Electric Vehicle Charging: A Global Startup Hub Activity Analysis. StartUS Insights.
[54] Stevenson, M.; Thompson, J. (2019) Health and The Compact City. In Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A., White, S., Eds.; Palgrave Macmillan: Singapore.
[55] Ajao, A. (2019) Everything you wanted to know about scooters and micro-mobility. Forbes, 1 February 2019.
[56] Schaller, B. (2010) The New Automobility: Lyft, Uber and the Future of American Cities; Schaller Consulting: New York, NY, USA, 2018.
[57] Gehl, J. Cities for People; Island Press: Washington, DC, USA.
[58] Matan, A. and Newman, P. (2016) People Cities: The Life and Legacy of Jan Gehl; Island Press: Washington, DC, USA.
[59] Harris, S. (2020) Post Lockdown London: Parking Spaces and Traffic Lanes to Vanish to Encourage Walking and Cycling.
[60] Davies, A. (2020) The Pandemic Could Be an Opportunity to Remake Cities. Wired 2020.
[61] Laker, L. (2020) World cities turn their streets over to walkers and cyclists. The Guardian, 11 April 2020
[62] Transport Scotland (2020) COVID-19 Transport Trend Data—20–26 April 2020; Transport Scotland: Edinburgh, UK.

3. Transformative Information Technology Options

This part outlines a number of computer-based transformation suitable for transport systems in Asian cities. A key focus is to provide insights as to how such technologies can transform transport systems in Asian cities, with a focus on network and supply chain logistics management to deliver cost effective, efficient, and attractive mobility options for all so that no one is left behind.

Harnessing Big Data to improve transport

Using data to improve the management of transport networks is nothing new, however the coming decades will see a massive shift in how data is generated and harnesses which will completely change the game (Hargroves *et al*, 2017[63]). Those that can quickly identify and access the important data and use it to enhance decision making will find it a very powerful tool; however, it has some complexity that is yet to be unravelled. For transport managers, efficient data access and use has the potential to enhance the ability to digitally simulate transport planning options, inform the greater utilisation of existing infrastructure and modal interconnections, and significantly improve disaster and emergency responses. However, after these early wins comes the real value, being able to predict issues or bottlenecks before they occur. Given the right data and software this can be done by comparing historical records to real time data streams to see if current conditions are shaping up in a similar way to conditions associated with past issues, such as congestion hot spots.

When the term 'Big Data' is used, it typically means data sets that are so large they cannot be analysed using current methods. To get an idea of the scale we are talking about, consider that a study by transport researchers in Tokyo, that had access to GPS data from over 18,000 taxis across the city, generated some 360 million items of data per second. Given the scale of Big Data, this then calls for new computer-based data analysis software, referred to as 'Big Data Analytics'. For example, software such as 'Hadoop' is able to analyse data on many servers at once to run traffic scenarios and has been shown to be able to carry out collision analysis on 2.4 billion vehicles in just ten seconds.

It is not news that there is more and more data available about the transport network and its users. Data has long been collected on traffic counts, average vehicle speed, weather conditions, and traffic signalling. This data forms a valuable database of historical conditions; however, what is more interesting is the promise of new types of data that will become available very soon, such as data streamed directly between vehicles and infrastructure. What is even more interesting, is how the plethora of data generated by our ever digitising society can be harnessed for transport management, such as from social media, destination information and whatever is trending locally. So the big question becomes, how can Big Data be harnessed to enhance transport management in our ever growing cities?

Rio de Janeiro is an early leader in terms of integrating disaster sensing and management technologies. The city's Traffic Control Centre receives footage from over 900 video cameras

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[63] Hargroves, K., Stantic, B., Conley, D., Ho, D. and Grant, G. (2017) Big Data, Technology and Transport - The State of Play, Sustainable Built Environment National Research Centre (SBEnrc), Australia.

that is combined with 120 layers of associated data including data related to weather, emergency services, traffic conditions and utilities. The system has decreased the response time to natural disaster related emergencies in the city by 30 per cent (Berst, 2013[64]).

Figure 2: Rio de Janerio Traffic Control Centre

Based on the premise that increased social media activity in particular areas during a disaster can correlate to areas of greatest need for assistance, researchers in Korea have designed a process to identify such areas to inform response efforts (Choi, and Bae, 2015[65]).

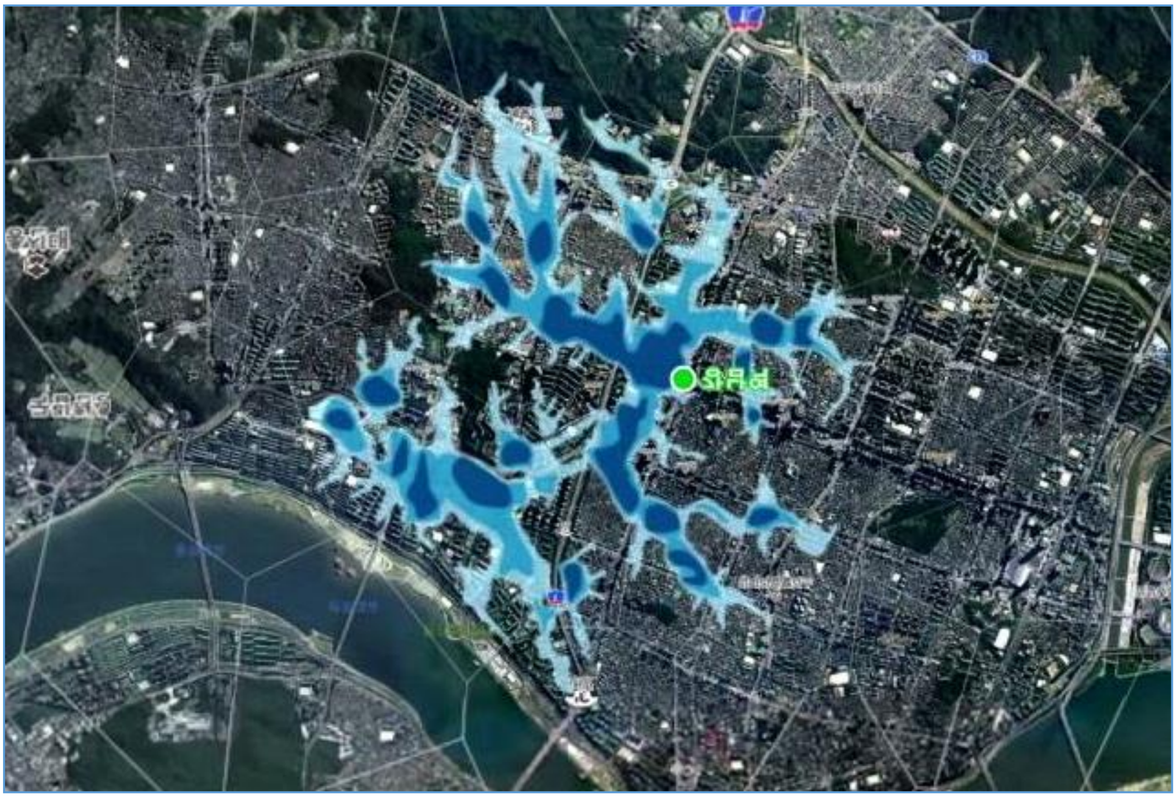

Figure 3: The 'Smart Big Board' mapping social media data flows during a disaster in Korea

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[64] Berst, J. (2013) 'Why Rio's citywide control centre has become world famous', *Smart Cities Council.*
[65] Choi, S., and Bae, B. (2015) 'The Real-Time Monitoring System of Social Big Data for Disaster Management', *Computer Science and its Applications,* Springer Berlin Heidelberg, pp 809-815.

Research by Australia's Sustainable Built Environment National Research Centre (SBEnrc) on the practical use of Big Data in transport has informed a set of recommendation for transport agencies (Hargroves *et al*, 2017[66]), namely:

- Be clear on the exact outcomes required from data analysis, ensure systems are tailored to these outcome, and only store what is absolutely needed.
- Ensure existing data is harnessed fully and systematically consider accessing new forms of data that have strong utility.
- See if there is potential for sharing data between transport agencies with multi-jurisdictional data standards to ensure compatibility.
- Consider the development of specific policies to ensure privacy concerns associated with Big Data are appropriately handled, such as storing as de-identified or derived trends.
- Ensure that in the case that sensors are added to the network that they are located at high priority locations and are able to communicate with the selected data platforms.
- Decide on the format, language and syntax of data and ensure historic datasets are formatted accordingly.
- Ensure software platforms can integrate private, mass transport and social data to both undertake predictive analysis and run simulations on the network to inform optimal use of existing infrastructure to defer capital expenditure and maintenance.

Using Artificial Intelligence to enhance ITS

The term 'Artificial Intelligence' refers to the capacity for computers to not only make decisions that were previously made by humans, but also to be able to make decisions that humans are not capable of making given the complexity, speed and volume of data. This is particularly promising for traffic management given the growing complexity of traffic networks in cities in Asia, with potential applications shown in Table 1. There are a number of efforts underway to explore the application of AI to the transport sector such as improved traffic management leading to less fuel consumption and associated pollution, increase road safety through driver assist technologies, improved routing of emergency vehicles, and improve transport planning. Artificial Intelligence can be a powerful tool for learning how to manage and predict flows of objects, making it particularly useful for the transport sector. For instance in 2016 data collected on crowd movement at the largest gathering of people in the world, the Kumbh Mela religious congregation in India was used to predict crowd movements and timings (Jain, 2018[67]).

According to a study by SBEnrc, AI is being used for traffic management in Malaysia and China, as part of the 'City Brain' program created by Alibaba, to process data from traffic lights, CCTV cameras, public transport, and other data streams, in order to assist the traffic management system to reduce traffic congestion and improve routing of emergency service

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[66] Hargroves, K., Stantic, B., Conley, D., Ho, D. and Grant, G. (2017) Big Data, Technology and Transport - The State of Play, Sustainable Built Environment National Research Centre (SBEnrc), Australia.

[67] Jain, M (2018) 'NITI Aayog paper seeks AI boost, praises its use in 'Kumbh Mela Experiment'', *Business Standard*, 06 June 2018.

vehicles. The Delhi Traffic Police have developed an AI based system based on radar monitoring to analyse traffic patterns, vehicle volumes, and vehicle counts in order to improve traffic management on motorways with the aim to all but eliminate the manual interface. AI is used in the UK to predict road transport risks and generate suggestions for mitigation interventions based on historical incidents and near-misses, weather data, real-time traffic information and driver risk profiles. In Germany a company has created an on-demand ride-sharing service that uses AI to optimise pooling configurations and routes to simulate demand and respond in real time, while managing dispatches, bookings, route planning and drivers. A Spanish company has created a system for detecting fare evasion in the Barcelona Metro resulting in a 70 percent decrease in fare evasion. [68]

Table 1: Applications of Artificial Intelligence to transport Systems

Identification of Transport Network Characteristic	Enhanced Traffic Risk Management
Enhanced Traffic Management	Optimisation of Ride-Sharing Services (MaaS)
Tracking Vehicle Behaviour	Detecting Fare Evasion and Turnstile Shadowing
Identification of Vehicle Breaches	Routing and Management of Drones
Enhanced Real Time Traffic Signal Optimisation	Enhanced Asset Management
Vehicle Prioritisation (Emergency and Shared)	Monitoring Vehicle Locations
Route Optimisation (Emergency and Freight)	Comparing Modal Trip Times

Source: Hargroves, *et al* (2020)[69]

Although Artificial Intelligence is not a new technology there is a number of underutilised applications for the transport sector, including enabling self-driving vehicles, analysis of traffic patterns, and prediction of traffic volumes (Katte, 2018[70]).

The power of distributed electronic ledgers

The Term 'Distributed Ledger' refers to an online ledger (meaning a time stamped database of transactions and entries) that allows for greater streamlining of online transactions and data exchange, typically using Blockchain based technology. There are a number of efforts underway to explore the application of distributed ledgers to the transport sector with significant benefits available for Asian cities. For instance to provide the ability for real time road user charging of vehicles, to track products from the manufacturer to its arrival with the customer allowing for automated delivery confirmation as is being done in the UK, the use of digital driver's licenses as is being done in Australia. Early movers to apply the technology to transport include Toyota, having launched a collaboration with the MIT Media Lab to explore the value of the technology to the automotive industry. The focus of the initiative is to explore four main areas, namely: how it can assist uptake of automated vehicles, capture and share trip

[68] Hargroves, K., Stantic, B. and Allen, D. (2020) *Exploring the Potential for Artificial Intelligence and Blockchain to Enhance Transport – Final Industry Report*', Sustainable Built Environment National Research Centre (SBEnrc), Australia.
[69] Hargroves, K., Stantic, B. and Allen, D. (2020) Exploring the Potential for Artificial Intelligence and Blockchain to Enhance Transport – Final Industry Report', Sustainable Built Environment National Research Centre (SBEnrc), Australia.
[70] Katte, A (2018) 'How Allahabad Police Uses AI for Crowd Management and Service Delivery', *Analytics India*, 19 March 2018.

data from driverless vehicles, offer applications to enable greater ride sharing, and offer pay-as-you-drive options

Table 1: Applications of Artificial Intelligence to transport Systems

Verified Vehicle Ownership Documentation	Establishing Identification
Real Time Road User Pricing	Enabling Intermediary Free Ride Sharing
Congestion Zone Charging (Virtual Zones)	Vehicle Generated Collision Information
Collection of Tolls and Charges (Virtual Gantries)	Enhanced Freight Tracking and Authenticity
Automated Car Parking and Payments	Secure data exchange with commercial operators

Source: Hargroves, *et al* (2020)[71]

Another early mover is the 'Mobility Open Blockchain Initiative' (MOBI) which is a global non-profit consortium exploring how Blockchain technology can make transportation safer, more affordable and more widely accessible. According to MOBI Chairman and CEO, and former CFO for Toyota Financial Services, Chris Ballinger, '*Blockchain and related trust enhancing technologies are poised to redefine the automotive industry and how consumers purchase, insure and use vehicles*.' (Marinoff, 2018[72]). MOBI is currently developing Blockchain applications for vehicle identity and history, supply chain tracking, autonomous payments, and pay as you travel charging and insurance.

The Blockchain in Transport Association (BiTA) brings together over 300 companies from across transport, logistics and relevant technology sectors, including large players like FedEx, UPS and Schneider, to ensure consistent standards for the use of Blockchains in freight and logistics. According to BiTA, '*Members know that Blockchain is the way of the future … and understand that Blockchain isn't just an industry disruptor, it's technology that will revolutionize the way people do business*' (Baker, 2018[73]). Blockchain technology can be further enhanced by combination with artificial intelligence options such as machine learning and deep learning algorithms. According to a survey by Forbes Insights involving over 400 senior transportation-focused executives, some '*65% believe the logistics, supply chain and transportation sector is experiencing nothing short of a tectonic shift'* (Forbes Insights, 2018[74]). Further, the respondents highlighted a number of potential drivers for this shift, in particular '*technologies like artificial intelligence (AI), machine learning (ML) and increasingly, Blockchain*'.

[71] Hargroves, K., Stantic, B. and Allen, D. (2020) Exploring the Potential for Artificial Intelligence and Blockchain to Enhance Transport – Final Industry Report', Sustainable Built Environment National Research Centre (SBEnrc), Australia.
[72] Marinoff, N. (2018) 'New Blockchain Initiative for the Automotive Industry Announced in Dubai', Bitcoin Magazine, 02 May 2018.
[73] Baker, M (2018) 'Blockchain on the Rise and the Search for Solutions', *Freight Waves*, June 27, 2018.
[74] Forbes Insights (2018) 'How Blockchain May Impact Logistics, Supply Chain and Transportation: A Conversation with The Blockchain In Transport Alliance', *Forbes Insights*, September 4, 2018.

4. Transformative Planning Options

This part provides an overview of innovative planning approaches that can contribute to the transformation of the transport sector in Asian cities. A key focus is on the integration of land use and transport planning in order to building safe, resilient and sustainable cities. In particular the section will provide an overview of how transport and land development opportunities can be harnessed synergistically for mutual benefit through the application of a transit activated corridor approach to create 21st Century Boulevards in Asian cities - including a focus on innovative funding and financing mechanisms.

In addition to direct economic benefits and social outcomes, transit is also as a shaper of cities in ways that not only reduce car dependence but enable urban regeneration to create vibrant economic centres around stations and along corridors. If done with early developer involvement transit corridors can activate development potential in synergy with the transit services. Referred to as a 'Transit Activated Corridor' approach effectively the transit stations increase the value of development sites and the development attracts travellers on the transit system, working together to create economic development and jobs (Newman *et al* 2019[75]).

New approaches to transport and land use planning

Traditional transit along main road corridors has mostly been buses with some trams left over from previous eras, generally in conflict with traffic. In more recent times BRT and LRT have increasingly shown that there is a role for road-based transit which is on a lane of their own, that can reach to around 6-lanes equivalent of car traffic (Vuchic, 2005; Schiller and Kenworthy, 2019). Increasingly these systems have improved their service quality (Hidalgo and Muñoz, 2014[76]) through enhanced vehicle guidance, low floor disability access and stabilization of sideways movement. But as mentioned previously the arrival of electrification through on-board batteries has revolutionised these systems to provide quieter, emissions-free transport outcomes that are enhanced by big data analytics, artificial intelligence and digital ledgers.

The activation of development opportunities along corridors using integrated shared transit was pioneered in Asian Cities but has largely been overlooked as an economic development strategy. The need to reduce congestion and provide greater mobility services calls for a revival of this very successful approach, combined with the latest in technologies to provide a cost effective shared transit solution suitable for integration into existing road corridors. Given the level of growth in Asian cities the shift to focusing on corridor mobility options that are effectively integrated into land development is inevitably going to be the next big agenda in transport policy.

> *This will involve building on the success of 'Transit Oriented Development' or 'TODs' that was focused on individual stations and intended to help transform rail policy, to*

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[75] Newman, P., Davies-Slate, S., Conley, C., Hargroves, K., and Mouritz, M. (2019) From TOD to TAC: The Transport Policy Shift to Transit Activated Corridors along Main Roads with New Technology Transit Systems. Sustainable Built Environment National Research Centre (SBEnrc), Australia.

[76] Hidalgo, D. and Muñoz, J. (2014) A review of technological improvements in bus rapid transit (BRT) and buses with high level of service (BHLS). Public Transport 6, 185–213 (2014).

create 'Transit Activated Corridors', or 'TACs', that is focused on a corridor of stations with the intention to transform road policy.

There are now a number of options for shared transit suitable for application in main road corridors (such as buses, light rail and trackless trams) that can underpin quality urban development on, in and around stations, which can include access to 'last mile' options such as walking paths, shuttles and micro-mobility modes as mentioned. Rather than being a government responsibility as in the case of the majority of TODs the delivery of TACs will rely on effective partnerships between government and the private sector, calling for new approaches and strategic governance.

Precincts need to be built in a chain along the Transit Activated Corridor and this period of technological advancement is developing systems that work best at a precinct-scale, like solar, batteries, new small scale water and waste systems, and new local electric transport systems (Thomson *et al,* 2018[77]; Newton and Taylor, 2019[78]). Each precinct along a corridor will also have their own special place and purpose in the corridor. This special quality of place-based urbanism is fundamental to any urban regeneration as will be the need for biophilic features, circular economy materials and carbon positive buildings (Caldera *et al,* 2019[79]). But most importantly the necessary uplift in value that can release the funding/financing of a series of urban regeneration projects (seeking such new technologies), will only happen if there is a strong and competitive new technology transit system feeding the residents, workers and visitors to the precinct. Each precinct will therefore be an opportunity to show how they can use new technology in their project and most importantly how they can link into the new technology transit system.

Each of the precincts will need to have a station with potential to recharge a Trackless Tram, LRT or BRT and a set of buildings with potential to collect and store solar energy. Thus, the whole corridor can be part of the power system and indeed with battery storage at stations there is potential for them to be Recharge Hubs for all the micro-mobility and autonomous shuttles feeding into the station. Vehicle to Grid (V2G) services can be designed to allow electric vehicles to contribute to storage and grid stabilisation, increasing grid efficiency, stability and reliability (Yilmaz & Krein 2012[80]). Greater connectivity between vehicles and the grid will likely allow for discharging of power from transit and other vehicles when not in use, to respond to times of key peak demand. This is known as 'Peak Shaving'. Eshani et al (2012[81]) provide six potential services that electric vehicles will likely provide grids in the future ranging from peak shaving for between 15 minutes to 2 hours, down to assisting the starting of electric motors that require high-intensity electricity for a short period of approximately 15

[77] Thomson, G., Newton, P., Newman P. and Byrne, J. (2018) Guide to Low Carbon Precincts. Cooperative Research Centre for Low Carbon Living, Australia.

[78] Newton, P. and Taylor, M. (*eds*) (2019) Precinct design assessment: a guide to smart sustainable low carbon urban development. Cooperative Research Centre for Low Carbon Living, Australia.

[79] Caldera, S., Desha, C., Reid, S., Newman, P. and Mouritz, M. (2019) Sustainable centres of tomorrow: A Precinct Design Framework of Principles and Practices - Report for Project 1.62 Sustainable centres of Tomorrow: People and Place, Sustainable Built Environment National Research Centre (SBEnrc), Australia.

[80] Yilmaz, M. and Krein, P. (2012) Review of benefits and challenges of vehicle-to-grid technology .4th Annual IEEE Energy Conversion Congress and Exposition, ECCE 2012 - Raleigh, NC, United States.

[81] Eshani, M., Falahi, M. and Lotfifard, S. (2012) Vehicle to Grid Services: Potential and Applications. Energies 2012, 5, 4076-4090

seconds. Moving from theory to practical application in this area is still a focus of research and innovation efforts (Uddin et al., 2018[82]; Saldana, 2019).

Innovative funding and financing mechanisms

Through negotiations a partnership can be established to create Transit Activated Corridors that attract substantial private funding, making both the transit and development viable. This is done by harnessing the available land development opportunities and stakeholder expertise in the corridor and integrating new transit services to create station precincts that generate new value from enhanced land development opportunities. There are several existing procurement mechanisms that can be used or adapted to this model of transit development with different components of the procurement process (for example, real estate development, infrastructure delivery) able to be either internal to the overall planning entity or procured through contracts with an external parties.

Negotiated Partnerships

There is some precedent for negotiated partnerships involving local governments, businesses and communities to develop transit services along a corridor as part of a process of urban renewal (Mathur and Smith, 2012)[83]. In such cases they typically involve some early stage private sector involvement to advise on the redevelopment potential that could be unlocked by the project. These types of projects are led by local government agencies and can create good will around urban development among the private and community partners which can contribute significantly to value creation. Governments can also include special area levies and parking levies to assist with raising the funds, but only if they are worked out in partnership with business and community to enable greater economic value creation across stakeholders. Governments often own large land parcels within cities, and this land can be contributed to the partnership in return for an equity stake in both the land development and operation of the transit services. Two early examples of such approaches are in Portland and Seattle, where funding was predominantly public with some private sector contribution and some form of levy or tax applied to recover funds.

- *MAX Light Rail, Portland*: The project was funded by local, state and federal funds as well as a private funds as part of a ‘Local Improvement District Levy’ on local businesses which covered around 10% of the costs.
- *South Lake Union Streetcar, Seattle:* The project was able to attract the interest of local, state and federal governments. A fee from 760 land parcels was estimated to provide 52 percent of the total project cost. The City of Seattle issued government bonds to raise capital and linked them with the private funds.

Each of the examples show how a range of procurement and financing models can be used to support projects focused on urban renewal using transit infrastructure. However, in each example the process is dominated by government and little mention is made as to how the route

[82] Uddin, K., Dubarry, M. and Glick, M. (2018) The viability of vehicle-to-grid operations from a battery technology and policy perspective. Energy Policy. Volume 113, February 2018, Pages 342-347.
[83] Mathur, S., and Smith, A. (2012) A Decision-Support Framework for Using Value Capture to Fund Public Transit: Lessons From Project-Specific Analyses. Faculty Publications, Urban and Regional Planning.

and station locations is selected. As mentioned previously, this runs the risk of missing lucrative development opportunities along the corridor that can capitalise on the uplift from the transit activation. The only other option is to then apply a levy or business charge which makes it more expensive to operate in the corridor, particularly in close proximity to stations. Although there is an element of private sector investment and involvement in a negotiated partnership, the potential benefit from such involvement is not fully harnessed, leaving an opportunity cost and legacy in the corridor.

Joint Companies

Through the formation of a specially constituted company, multiple public and private sector stakeholders can be allowed to contribute equity towards developing the project, in a structure that is commercially motivated, and therefore has a strong incentive for entrepreneurship. The Hong Kong MTR is an example of this model. The Hong Kong Government owns 75 percent of MTR and has pledged to retain at least 50 percent, but it is independently managed on commercial principles, and is financially independent of government (MTR 2014)[84]. The remaining 2 percent% of MTR's shareholding is freely traded on the stock exchange. The MTR develops mostly residential property, and this is done through contractual arrangements with private developers (MTR 2014)[85].

Another demonstration of the potential of joint companies is the Metropolitan Intercity Railway Company in Japan, which built and operates the Tsukuba Express (TX), running between central Tokyo and Tsukuba. This company is owned by city, prefectural and metropolitan governments along the route, along with 189 private companies (Metropolitan Intercity Railway Company, 2017)[86]. A government plan initiated the idea of a railway line along the TX corridor, but the specific alignment was dependent on negotiations with landowners along the route, including options for land readjustment. Similar to the MTR, the Metropolitan Intercity Railway Company has the sole right to undertake land readjustment along this corridor under Japan's Integrated Development Law (Kurosaki and Ogura, 2013)[87], which can be viewed as a form of indirect subsidy.

The joint company model allows public and private land holdings to be combined into a single, commercially-focussed enterprise. Joint companies will be particularly useful when there are large areas of publicly-owned land along a proposed corridor, particularly when held by multiple jurisdictions or agencies. Government can retain control of the strategic direction of the project with this model.

Private Development

Fully or substantially private initiatives can also deliver rail projects that take advantage of land development and draw on other forms of own-source revenue as a source of capital funding and profitability for the project. This private sector dominated approach was the early history of rail, for example in Japan's railway-centred conglomerates (Cervero, 1998)[88], many of the

[84] MTR Corporation Limited (2014) "FAQ". Online.
[85] MTR Corporation Limited (2014) "FAQ". Online.
[86] Metropolitan Intercity Railway Company (2017) Tsukuba Express Report 2017.
[87] Kurosaki, F. and Ogura, M. (2013) Construction of Tsukuba Express and Urban Development Based on the Integrated Development Law, Selected Proceedings for 13th WCTR.
[88] Cervero, R. (1998) The Transit Metropolis - A Global Inquiry. Washington DC: Island Press.

tramways and street car lines laid down in the late nineteenth and early twentieth centuries (Warner, 1963[89]; Culpeffer-Cooke et at., 2010[90]) and substantial parts of the London Underground (Levinson, 2008)[91]. The private railway conglomerates are still in operation in Japan, although this method of funding railway expansions has largely ground to a halt around the world, possibly due to the focus on automobile dependence and lack of structure for government to effectively partner with the private sector. There has been a re-emergence of co-developed real estate and railways, to create Transit Activated Corridors, with two recent examples being the Brightline in Florida and the CLARA proposal in Australia.

– *Brightline, Florida:* Leveraging the private sector opportunities around new stations the Brightline rail project in Florida is 100% privately funded (Renne 2017)[92] and has been developed in partnership with the local and county governments and the local community (Newman *et al*, 2017). Project finance was raised through a mixture of debt, bonds and equity. Private developers did not seek public subsidies or grants other than federal low-interest bonds in order to provide a risk guarantee.

– *Private Fast Rail, Australia:* A private sector consortium has proposed a new rail project in Australia to link a number of capital cities on the east coast with a fast rail service. The consortium, 'Consolidated Land and Rail Australia' (CLARA), proposes to raise finance for the transit infrastructure solely through real estate sales at the various regional station locations. CLARA's proposal is to initially connect Sydney, Canberra and Melbourne with a high speed rail line with eight stations (Consolidated Land and Rail Australia Pty Ltd, 2016)[93]. The company has begun to acquire rural farming land around the intended stations locations and anticipates that the sale of such land will avoid the need to request public funding.

[89] Warner, S. (1963) Streetcar Suburbs, The Process of Growth in Boston, 1870-1900. Colonial Society of Massachusetts and the New England Quarterly.
[90] Culpeffer-Cooke, T., Gunzburg, A., Pleydell, I. and Brown, D. (2010) Tracks by the Swan: the electric tram and trolley bus era of Perth, Western Australia. Perth Electric Tramway Society Inc. Mount Lawley, W.A.
[91] Levinson, D. (2008) Density and dispersion: The co-development of land use and rail in London. J. Econ. Geogr, 8, 55–77.
[92] Renne, J. L. (2017) Make Rail (and Transit-Oriented Development) Great Again. Housing Policy Debate, 27(3), 472-475.
[93] CLARA (2016) The CLARA Plan. Consolidated Land and Rail Australia Pty Ltd.

5. Developing Transformative Partnerships

This section provides an overview of various options to develop partnerships to support a transformation in the transport sector. This section overviews levels that transformative partnerships can be applied and provide a comparison of causal and effectual approaches to inform transport and land agencies to enhance collaboration and capacity building.

Understanding the levels of transport planning

It is important for large scale transport projects that involve utilisation of road ways and stand to benefit development sites that a group of partners and stakeholders is formed from the very beginning of a project. Such an approach can reduce uncertainty and risk as a co-created vision can be developed between the parties that can be realised through collaboration (Sarasvathy, 2009[94]). In order to identify the varying levels that partnerships can be formed, Figure 4 considers three levels that transport planning processes can be performed at, namely, at the Strategic, Tactical and Operational levels (Van de Velde, 1999[95] Hensher and Macario, 2002[96]; Vuchic, 2014[97]):

– *Strategic planning* is typically at a high level and involves the formulation of general aims of the planning process and determines in broad terms what means can be used.

– *Tactical planning* is about making decisions on acquiring these means that can contribute to achieving the general aims, and on how to use these means most efficiently.

– *Operational planning* is about making sure that the tactical decisions become a day-to-day reality, and that this happens in an efficient way.

This part will use this framework to distinguish different opportunities for collaborating with the private and community sectors at different levels of planning.

Decision level	General description	Decisions "Software"	 "Hardware"
Strategic Long term (5 years)	*What do we want to achieve?*	**General Aims** Transport policy Market share Profitability **General service characteristics** Areas Target groups Intermodality	
Tactical Medium term (1-2 years)	*Which services can help to achieve these aims?*	**Detailed service characteristics** Fares Image Additional services	Vehicles Routes Timetable
Operational Short term (1-6 months)	*How to produce these services?*	**Sales** Selling activities Information to the public ...	**Production** Infrastructure management Vehicle rostering and maint. Personnel rostering and mngt

Figure 4: Decision layers of public transport planning and general focus of each

[94] Sarasvathy, S. (2009) Effectuation: Elements of entrepreneurial expertise. Edward Elgar Publishing.
[95] Van de Velde, D. (1999) Organisational forms and entrepreneurship in public transport, part 1: classifying organisational forms. Transport Policy, 6, 147-157.
[96] Hensher, D. and Macario, R. (2002) Organisation and ownership of public transport services. Transport Reviews, 22, 350–357.
[97] Vuchic, V. (2014) Urban transit: Operations, planning and economics. Wiley.

Source: Van de Velde (1999)

Currently strategic planning for transport is undertaken at a high level by mostly governments, and then this filters down into tactical planning processes that are again mostly undertaken by government agencies, and then operations are either undertaken by the same government agencies that are doing the strategic and tactical planning, or tendered out to the private sector.

In October, 2018 the United Nations Centre for Regional Development convened a training course, facilitated by the authors of this report, for the Asia-Pacific region titled 'Railways as the Low-Carbon and Sustainable Transport Development Solutions in Achieving Safe, Inclusive, Efficient and Resilient Communities under the 2030 Agenda for Sustainable Development' which was attended by senior transport professionals from 14 EST Member countries. At this event, the participants explored the barriers and opportunities to create partnerships to deliver Transit Activated Corridors. The figure below visualises the responses, categorised into six themes, to the following question: *'What barriers do you see to creating public-private projects for land development and rail construction along corridors in your cities?'* It is evident from the figure that the main percieved barriers are at the strategic and tactical level.

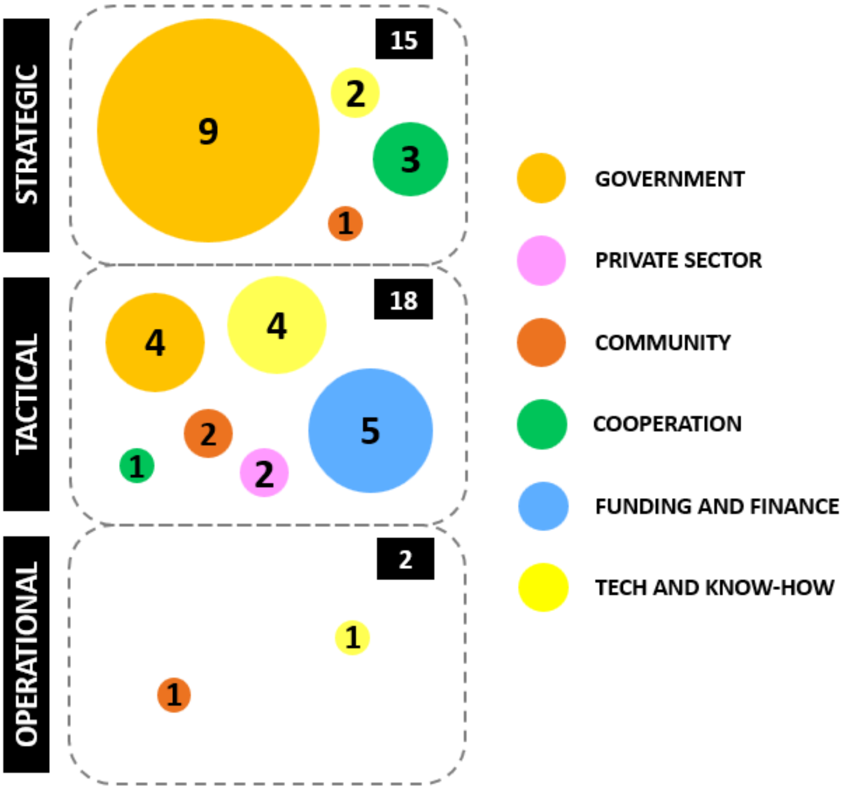

Figure 5: Summary of survey responses from United Nations Centre for Regional Development (UNCRD) Partnerships Workshop, Tokyo, Japan.

<u>Building partnerships and collaboration</u>

It is important here to make the distinction between what is referred to as 'causation' and 'effectuation' as distinct approaches to undertaking transport planning. An approach based on 'causation' is focused on responding to the cause of the problem and is rooted in analysis, prediction, strategy determination all before building partnerships. In contrast, 'effectuation' is focused on creating a solution to the problem and by bringing together partners from the beginning of the process and allowing stakeholder commitments to create opportunities. In short an effectual approach is recommended as it creates meaningful partnerships at the tactical and strategic level that are needed for transit and land use planning – while ensuring that solutions benefit the community.

Strategic Level Partnerships

The dominant approach to public transport strategy in cities around the world is grounded in causation logic. Typically, using this model the transport department establishes social and policy goals of the transport system. This establishes the aims that the city's transport system is intended to align with. This often takes the form of high-level strategic ambitions or vision, with general targets over time. These ambitions are developed by the government and are supported by 'consultation' with the community and industry, while often also forming the basis of a policy platform that is taken to an election – and thus has some social credibility if the government is elected based on these ambitions. However partnerships at the strategic level that follow causation logic are often restricted as they are dominated by the public sector. This misses the opportunity for governance processes that enable productive cooperation with the private sector rather than hinder it, to capitalise on this opportunity.

Strategic planning following the principles of effectuation are collaborative and it is important that guiding design principles are established to guide development of strategies and subsequent tactics and operations. These may be similar to those found under the causation framework, in that they include ambitions to increase active travel by a particular percentage over a given time frame, or to increase the ratio of transit-oriented urban infill development to urban sprawl over the coming decades. As mentioned an effectual strategic planning process establishes multidisciplinary partnerships from the beginning. These are not just with transport related entities, but also with urban development and land use interests. For example, commercial property developers and managers may realise the potential that transit provision provides to development areas as it enables new density and car-free lifestyles. In conditions of heightened uncertainty, as a means of reducing uncertainty general service target areas can be established at a strategic level. These can be influenced by development patterns, community concerns and ambitions, and perceived opportunities.

Tactical and Operational Level Partnerships

Tactical level planning then focuses on translating the aims developed at a strategic level into detailed service characteristics. This is the level at which the actual 'design' of the project takes place, and where much of the distinct features of the urban world take shape. In a public transport context, this level focuses on defining routes, timetables, vehicles and fares. Planning at this level is more focused on specific projects and commitments to bring about a specific future. Tactical planning following a causal approach is referred to as 'Predict and Provide' and is often undertaken using detailed computational modelling and forecasting techniques in order to establish a 'predicted future' for which infrastructure provision can respond. The most common example of the limitations of this approach, that is evident in cities over the world, is that of induced traffic demand as a result of highway expansions. Time and time again, modelling extrapolates existing conditions to predict more congestion, which must of course be mitigated by more highways, which then become more congested due to the greater demand it then encourages.

Given that transport and land use are not always thought of as being linked together at the strategic level, the structures and processes do not exist at the tactical level to capitalise on resulting opportunities. As a result, causal approaches to transit corridor development is primarily driven by government planners with strategic quantitative models, with plans confirmed and public funding secured based on this, with integrated land development and 'partnerships' considered at the very end, where there is minimal opportunity remaining for value creation.

However, tactical planning undertaken in an effectual way is partnership-driven based on extending partnerships that have been established at a strategic level. At a tactical level, partnerships can focus on understanding how routing and development can be delivered based on perceived opportunities by the private sector. An important element of effectual partnerships for tactical planning is allowing effectual stakeholder commitments to drive the process meaning that transit agencies to be flexible in their approach. Essentially, if stakeholders are willing to contribute to the means required to progress a transit project, the 'tactics' should be flexible enough to accommodate some form of appropriate value creation for them. For example, as previously mentioned the Brightline passenger railway service between Miami and Orlando was revived from an old freight railway by a real estate company with intentions of developing land within station precincts – which underpinned the finance. Local and County government provided necessary zoning changes and assistance with land assembly and public real improvement for community acceptance.

These partnerships should also involve the community. The 430-acre urban regeneration occurring in Kalasatama, Helsinki, is fully financed by the private sector with one-third of unit ownerships retained by the city government for government subsidised housing. This is win-win value creation and is guided by sustainable development principles. The developers follow an effectual approach to community building, where pre-commitments from buyers are collected (as with most development projects), however the key difference here is that those who 'buy in' are included from the very beginning to co-design the development and what should be included. These kinds of approaches are accommodated under effectual governance – particularly at the tactical planning level. Governments can engage in this by bringing in the private sector and the community and allowing those that demonstrate buy-in through effectual stakeholder commitments, whether this be with money or other means, to constructively discuss and debate the tactical details.

At the operational level the tactical decisions are translated into day-to-day practice. This includes the management of the sales staff and the drivers, the management and maintenance of the vehicles, and the management of the infrastructure to ensure that the services specified at the tactical planning level are achieved. Such activities can be managed effectively through the partnership approach that involves various stakeholders in order to ensure mutual benefits are achieved it actual delivery of the project and associated developments.

6. Conclusions and Recommendations

To be completed following the EST Forum.

Notes: The background paper will conclude with a set of concrete recommendations on how Asian cities can harness the opportunities presented in the background paper to transform their transportation systems and mobility services.

7. The Way Forward

To be completed following the EST Forum.

Notes: The way forward section will highlight how EST member countries can strategically incorporate the findings presented in the report. This will include specific links to delivering aspects of the 2030 Agenda for Sustainable Development/SDGs. This section will provide strategic elements toward the formulations of the successor of the Bangkok 2020 Declaration (2010-2020).