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How Does Asia's Transport Sector Respond to COVID-19 for Achieving Greater Resilience and New Opportunities?

(Background Paper for EST Plenary Session-2)

Final Paper

This background paper has been prepared by Prof. Peter Newman, Curtin University, Australia, for the 14th 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.

Sustainable Shared Transport Resiliency and Operating Considerations Post-Pandemic

Background Paper for the Fourteenth Regional EST Forum in Asia, October 2021, Virtual.

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Executive Summary

The COVID-19 pandemic has shaken the world and its transport system, although in this disruption there is opportunity to examine public behaviour in transport use and optimise systems for moving people safely, efficiently and sustainably. The long-term response from transport agencies and governments to the pandemic now embraces the bigger global agendas relating to climate resilience and hence must develop transport systems that combine more resilience to pandemics and to climate change in both adaptation and mitigation. Both pandemic and climate preparedness will need to engage across agencies, the private sector and greater portions of the population.

Short-term system changes and patronage behaviour will likely remain for some time in the future of transport systems, such as the focus on localisation, increased hygiene, and the consideration to contacts between people and in managing levels of vaccination, in the design of services and stations. There is a fundamental need for heavy investment in infrastructure connectivity, to achieve the Sustainable Development Goals. Public-private partnerships can play a vital role in this direction, especially the collaboration of transport agencies and city authorities – an essential method for achieving decarbonisation.

The COVID-19 pandemic severely reduced shared transit ridership as a sharp response to avoid people crowding - up to 90 percent in China and 80 percent in Singapore. Transit between jurisdictions and nations dropped, such as passenger air travel falling to nearly zero globally in April 2020, only achieving 20 percent year-on-year in October 2020. The freight and logistics sector was also significantly affected by border restrictions, increased sanitation requirements, and increased delivery expectations, at a time when many have turned to online shopping. According to Earley and Newman, "*The question that remains is, what will it take for transport to recover, and when it recovers, how can it be improved to be more resilient and to serve people, their communities, and their economies in a more sustainable and equitable way?*"

The first responses in Asia are shown in the paper and are summarised in Table 1.

Table 1: Sustainable transport actions by countries as part of COVID-19 Recovery Plans

Action	Countries
Electric vehicle promotion and charging infrastructure	Bangladesh, P.R. China, Indonesia, Nepal, Pakistan
Electric vehicle promotion in rural areas	Bangladesh, P.R. China
Renewable electricity—Electric vehicle integration	Bangladesh, Nepal
Cycling programs and infrastructure	the Philippines, P.R. China
Integrated transport planning	P.R. China
Rural road improvements	Bhutan
Zero emission shipping	Japan, P.R. China
High emission diesel vehicle replacement	P.R. China
Transport energy efficiency improvements	Indonesia
Financial assistance to transport workers	the Philippines
Public utility vehicle modernization	the Philippines

Source: Earley and Newman (2021)[1]

[1] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

To deliver such programs requires new tools and increasingly these involve digital tools that offer rapid enhancement of transport systems, by utilising human-centered data to allow transport agencies to better understand the movement of people and goods to inform traffic management. It is also able to include the development of digital infrastructure to support work-from-home approaches. Various tools have been developed – for instance, Google has created COVID-19 Community Mobility Reports from mobile data (from android phones), available online for free to help policy makers understand their residents' behaviour. An emphasis on digital infrastructure will allow the optimisation and improved resiliency of physical infrastructure.

Nations have already started using their pandemic response to improve systems, such as The Philippines aiming to shift from road-based transport to more sustainable intercity passenger transport and mass freight transport. The development of the nation's first subway and the development of 1000 km of rail has aided in this shift. The Maldives – an ocean nation comprised of over 1000 islands and 99 percent water – recognise that a planned, sustainable transport network is critical for their government to provide food, fuel, and medicine between otherwise isolated communities. Most ASEAN nations and Japan are collaborating to introduce capacity building programs for cities to support them in strategic planning and developing investment plans which include transport.

Advances in battery technology have allowed new electrification of transport, not just for electric autorickshaws, cars, buses and trucks, but e-motor bikes and e-cycles are providing both freight and passenger services in Asian cities with wider ranges and cheaper fuel costs. There are new forms of transit such as e-trackless trams which can offer the services and economic invigoration of tram systems without the high impact and investment of conventional supportive infrastructure. Such e-transport can be integrated into new net zero urban development enabling net zero cities to emerge.

World governments typically aimed to curb the spread of COVID-19 by initially cutting all mobility and slowly reintroducing access and services with different functionality – India entered a nationwide lockdown, Hanoi reduced shared transport services by 80 percent, Beijing introduced pre-booking for trains, and Guangzhou reduced service capacities to 50 percent. In many countries tracking measures were put in place that included locational sign-in applications and track-and-trace applications using smart-phones. In Taiwan, citizens who were in hotspots or quarantine were tracked to improve virus-spread data and quarantine control respectively. Service was protected with the mandate of mask usage and body temperature and symptom checks, while requiring check-in to vehicles and stations to help trace disease spread.

The hygiene of services has been the focus of all transport authorities, resulting in varied and unique best practices. Singapore has employed anti-microbial coatings which have been shown to kill the COVID-19 virus in the underground system, while China has used cameras linked to AI software, placed alongside ticket machines, for facial recognition and thermal imaging that recognises potential Covid carriers and non-mask wearers. They also use filtration systems to sterilise air using UV light that can sterilise the bus or train's air in twenty minutes. Alternatively, Singapore and the UK are considering increased support for staggered work hours to spread the commuter crowding in services byreducing peak loads on systems.

Priorities in transit systems have changed towards moving people safely, with greater focus towards personal non-motorised modes, and the roles of stakeholders has evolved to facilitate this. The Philippines Government increased the promotion of 'active transport' such as walking and cycling, having developed over 500km of bike lanes in 2021. In the post-Covid period these initiatives will become more important and will be supported by major infrastructure upgrades that assist with climate resiliency and multiple SDG goals.

Cities have an increasingly important role in activating stakeholders for the post-Covid economy. Their efforts will include the adoption of new processes, technologies and partnerships which according to Newman (2020)[2], "*will flow through the fabric of the city, just as it has in each other wave of innovation, with many setting their recovery agendas to achieve new goals and outcomes in zero carbon and zero poverty that will establish them as leaders*". This will call for a range of new stakeholder roles across the transport sector as the focus shifts away from providing infrastructure and services to private vehicle owners and towards the provision of clean, efficient and fast shared transport options that are designed around corridors of urban regeneration and economic development. Cities as stakeholders will have greater consideration of relocalised centres, tailored innovations, lower car dependency, symbiotic partnerships and renewed urban manuals for a climate and pandemic resilient society.

Summar of key recommendations:

1. Lessons from Covid in service delivery.
    a. Smart technology systems have enabled public confidence to return to the use of transit systems when applied to reducing concerns over Covid and these lessons can be used to further create confidence in the safety and security of public transport.
    b. Hygiene management on livery and in air conditioning should be continued as the Covid-based innovations create more healthy spaces.
    c. Face recognition and thermal imaging at ticket presentation sites can be continued as ways of ensuring health priorities
    d. Vaccination passport recognition can be part of any future ticketing systems.
2. Lessons from Covid in freight management.
    a. Freight can be managed effectively through the worst of a pandemic and hence is likely to be able to manage through other disasters and major climate resilience challenges.
    b. Digital communication systems and optimisation with new AI software are likely to be the basis of continuing these impressive outcomes in resilience.
3. Lessons from Covid in local mobility and digital meetings.
    a. Localasation of activity for a much greater range of activities from local open space, shops, cultural centres and meeting places, are likely to continue as a high priority and need the infrastructure for active transport, including the new e-mobility devices that are simple to use locally.
    b. Replacing routine meetings with digital communications is now routine, high quality and cost effective, especially in reducing travel with its associated air pollution, and

[2] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

such options can be continued with many enabling conditions. However, the need for face-to-face meetings will always be needed for creative, community-building, culturally significant and economcally important meetings, and hence transport systems will always be needed.

4. Lessons from Covid in the green economic recovery period.
    a. Transport is enetering a rapid change period as new technology for the green economy reaches maturity with solar/wind power and batteries becoming highly cost competitive, and electromobility for all forms of land transport become the mainstream basis for passenger and freight movements in cities and regions.
    b. Procurement of fleets for cars, autorickshaws, buses, trucks and trains can now be worked out to enable this transition to decarbonised vehicles.
    c. Demonstrations of how net zero corridors can be created using new technology mid-tier transit allied with net zero stations and associated redevelopment precincts. Such projects can best be done through partnership projects with private developers and local communities.
    d. Testing of new fuels by use in shipping and aviation will continue to be needed followed by scaling up of the best results, before significant adoption of climate resilient international shipping and aviation.

1. Introduction

Since the COVID-19 pandemic was announced by the World Health Organisation (WHO) in March 2020,[3] 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.[4] These restrictions have substantially affected mobility by forcing behavioural changes and transforming the way people communicate, work and live, although also providing a unique opportunity to revise and rethink transport related approaches and strategies.[5] The impacts of the pandemic have called for reconsideration of a range of transport related areas, such as: perceptions of acceptable pollution levels in cities caused by transport fuels; perceptions around the appeal and use of active modes of transport; perceptions around the use of shared transit options; and implications for the freight and logistics sector.[6]

Public transport plays an essential role in society, ensuring access to education, employment, healthcare, recreation and other daily activities including social interaction.[7] As with many sectors of the economy it is important for the transport sector to explore and understand various options to manage the new and changing systems that emerge from the pandemic, and to improve the current systems at an environmental, economic and social level. Asia's transport sector will be facing several critical challenges in future due to the existing and emerging challenges like climate change, increasing frequency and magnitude of natural disasters and health emergencies like COVID-19 pandemic.[8] The transition of quality of life after disasters is dependent on transport systems' resiliency.[9]

Given the significant 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.[10] With less face-to-face interaction, many workplaces and educational facilities have adapted to online communication and learning, making previously largely overlooked, and long advocated, option to work-from-home now a mainstream mode.[11] It is important to understand that from a transport perspective there is much to learn from the COVID-19 experience, such as the fact that many cities experienced the lowest level of air pollution in living history due to travel related restrictions. For instance Wuhan China saw a 63 percent reduction in air pollution,[12] and in Delhi the level of PM2.5 was within the recommended WHO guidelines for the first time in decades.[13] Given that the majority of air pollution is a result of transport energy

[3] WHO (2020) Timeline: WHO's COVID-19 Response, Online, World Health Organisation (WHO).
[4] OWD (2020) Policy Responses to Cornavirus Pandemic, Online, Our World in Data, 3rd August 2020.
[5] 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).
[6] Newman, P., Hargroves, K. and Conley, D. (2020) Changing the course of Asia's transport sector through transformational change, Background Paper for the UNCRD Thirteenth Regional EST Forum in Asia, November 2020.
[7] Plenary Session, 14th EST Forum, UNCRD 2021
[8] Plenary Session, 14th EST Forum, UNCRD 2021
[9] Plenary Session, 14th EST Forum, UNCRD 2021
[10] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.
[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.
[12] 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.
[13] Lombrana, L. and Warren, H. (2020) A Pandemic That Cleared Skies and Halted Cities Isn't Slowing Global Warming, Bloomberg, 08 May 2020.

choices it is likely that there will be a strong focus on transitioning away from fossil fuel use in transport towards electro-mobility.

With COVID-19 attention has come to the cleanliness of shared transport options, which has historically been a factor that affects patronage. Post-pandemic there will be a range of efforts to respond to health concerns in shared transport options in order to get cities moving again. The requirement to provide sanitised shared transport services during the pandemic response has provided an opportunity to design, implement and improve a range of measures that will continue to enhance patronage of such services post pandemic, such as: protective clothing for staff and passengers, station entrance track-and-trace applications, temperature checks, enhanced online reservation options, increased disinfection and cleaning practices, penalties in place for not wearing masks, and quick response to localised outbreaks.[14] Post pandemic such measures can be used not only to reduce the risk of future spread of such a virus, but also to mitigate a range of health concerns which will provide a safer and cleaner shared transport system. Along with electrification this will be a key element of the shift globally away from individualized private transport and towards shared transit options in cities.

There is a need for reshaping transport connectivity as an aftermath of COVID-19. Even before the pandemic, there were infrastructure shortages, a lack of digitalisation, un-balanced passenger-freight models, inefficient and fragile transit agreements, manual checks at border crossings, and divergent standards on vehicles, drivers and international transit. Post COVID -19, there is a need for heavy investment and facilitation of infrastructure and operational connectivity to support SDGs and sustainability targets.[15]

[14] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.
[15] Plenary Session, 14th EST Forum, UNCRD 2021

2. Effects of COVID-19 on Travel and Mobility in Asia

Across Asia, a range of restrictions have been used (See Table 2), including lockdowns, due to COVID-19 in order to restrict movement of residents to trips deemed essential (essential services, shopping, medical services, providing care). Shared transport systems introduced mandatory mask wearing and increased cleaning of equipment and vehicles, however not all countries reduced patronage due to the severe need for shared transit services. Significantly for economies in Asia, as a result of the COVID-19 pandemic international tourist arrivals in many developing countries has been reduced by 80-90 percent.[16] Cities in China experienced shared transit rider reduction periods of up to 90 percent, while Singapore's Mass Rapid Transit system had a maximum decrease of 80 percent.[17] Globally, passenger air transport fell to nearly zero in April, 2020 and as of October, 2020 had recovered just 20 percent relative to the previous year.[18]

Table 2: Transport restrictions adopted due to COVID-19 as of October 2020

	Domestic Travel	Urban Public Transit	International Transport	Other measures
Australia	Require closing	None to limited measures	Total border closure except New Zealand	Partial school closures, stay at home requirements in high-risk areas
Azerbaijan	Require closing	None to limited measures	Total border closure	
Bangladesh	None to limited measures	Recommended closing	Ban on high-risk regions	
Bhutan	Require closing	Recommended closing	Total border closure	
Brunei Darussalam	Recommended closing	None to limited measures	Mandatory quarantine	Schools open with measures in place
Cambodia	None to limited measures	None to limited measures	Mandatory quarantine	Gradual reopening schools, closed entertainment.
Fiji	Night curfew in effect			Schools open with measures, workplaces at 50%
Georgia	Recommended closing	None to limited measures	Total border closure	
India	Require closing	Require closing	Ban on high-risk regions	
Indonesia	Recommended closing	Staged opening of public transit	Total border closure	Schools open in low-risk areas, workplaces open with measures

[16] UNCTD (2021) 'COVID-19 and Tourism: An Update - Assessing the economic consequences, United Nations Conference on Trade and Development, 2021.
[17] Gkiotsalitis K (2020) Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions, Transport Reviews, Vol. 41, 2021 – Issue 3
[18] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

Japan	None to limited measures	None to limited measures	Ban on high-risk region arrivals	
Kazakhstan	Recommended closing	Require closing	Total border closure	
Lao PDR	None to limited measures	None to limited measures	Ban on high-risk regions	
Malaysia	Restriction on high-risk areas	None to limited measures	Total border closure	Workplaces open except for entertainment,
Mongolia	None to limited measures	None to limited measures	Total border closure	
Myanmar	Require closing	Require closing	Ban on high-risk regions	
Nepal	Require closing	Require closing	Total border closure	
New Zealand	None to limited measures	None to limited measures	Total border closure	
Papua New Guinea	None to limited measures	None to limited measures	Quarantine arrivals with GPS tracking	
The People's Republic of China	Opened by 10 October	Required face masks and use of contact tracing apps	Ban on high-risk regions, mandatory quarantines	
The Philippines	Recommended closing	Recommended closing	Total border closure	Age-based stay-at-home requirements
The Republic of Korea	Generally open except high-risk areas	None to limited measures	Ban on high-risk regions with mandatory quarantine	
Singapore	None to limited measures	None to limited measures	Quarantine arrivals	
Sri Lanka	None to limited measures	None to limited measures	Total border closure	
Thailand	Recommended closing	Recommended closing	Mandatory quarantine, certain travellers welcome	
Timor-Leste	None to limited measures	None to limited measures	Ban on high-risk regions	
Uzbekistan	Require closing	Recommended closing	Total border closure	
Vanuatu	None to limited measures	Recommended closing	Total border closure	
Viet Nam	Screening in place	Recommended closing	Total border closure	

Source: Compiled from ADB (2020),[19] Benson (2020),[20] and (UNCRD (2020)[21]

[19] ADB (2020) COVID-19 and Transport in Asia and the Pacific: Guidance Note. Asian Development Bank.
[20] Benson, T.(2020) Oxford COVID-19 Government Response Tracker Regional Report—EAST ASIA PACIFIC 1-31, October 2020.
[21] UNCRD (2021) Thirteenth Regional Environmentally Sustainable Transport (EST) Forum in Asia. United Nations Center for Regional Development (UNCRD), Japan.

The impact of COVID-19 on the world's mobility is yet to be fully appreciated however it is clear that it has had a significant impact on local and regional transport. The world faces a mix of crises stemming from COVID-19 pandemic, all with current and potentially giant implications for the international 2030 agenda. Asian countries and cities can foster a massive transformation in their developing sectors including transport – improving economic and inclusive prosperity with immediate action.[2223] In the world recovery from COVID-19, there are already reactions and changes in behaviour and policies. The Asian Development Bank (ADB) is similarly evolving – promoting inclusiveness, integration, involvement, and interconnectedness.[24]

Many cities responded by enforcing strict restrictions on mobility, especially shared modes like metro's and subways' trains and us services, affecting millions of people around the world. The COVID-19 response demanded major shifts in the transport sector with greater consideration of multi-modal transport including e-mobility and non-motorised transport.[25] The freight and logistics sector was also significantly affected by border restrictions, increased sanitation requirements, and increased delivery expectations, at a time when many have turned to online shopping. According to Earley and Newman, "*The question that remains is, what will it take for transport to recover, and when it recovers, how can it be improved to be more resilient and to serve people, their communities, and their economies in a more sustainable and equitable way?*"[26]

Resiliency must be an integral part of transport policies, plans, programmes and budgets for transport infrastructure design and development in Asian countries and cities. Transformative policies, institutions, programmes, and investment decisions in transport sector are necessary to improve resilience of the countries and cities, especially in pandemics. Public-private partnerships can play a vital role in this direction, especially the collaboration of transport agencies and city authorities – an essential method for achieving decarbonisation.[27]

[22] Mr. Liu Zhenmin, Under-Secretary-General for UN Department of Economic and Social Affairs (DESA), 14th EST Forum, UNCRD 2021
[23] Mr. Nurul Islam Sujon, Minister for Railways, Bangladesh, 14th EST Forum, UNCRD 2021
[24] Mr. Bambang Susantono, Vice-President for Knowledge Management and Sustainable Development, Asian Development Bank (ADB), 14th EST FORUM UNCRD 2021
[25] Mr. Mahinda Amaraweera Minister for Environment, 14th EST Forum, UNCRD 2021
[26] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.
[27] Plenary Session, 14th EST Forum, UNCRD 2021

3. Opportunities for human-centred utilisation of technologies for sustainable mobility

In the response to COVID-19 there are a number of opportunities to improve mobility in the world's cities that are being incorporated into a number of countries COVID-19 recovery plans, as summarised in Table 1. Governments are already conducting proposals, though more work is needed for the reduction of risks of disasters through improved planning. Increased exchanges can improve planning effectiveness and evolution of ideas.[28] It is critical to place engagement and inclusion at the centre of initiatives, adapting to local culture and needs of citizens, businesses and geography in order to engage diverse stakeholders. Digital connectivity as a key feature of thriving communities so that they can learn from one another to promote more livable cities for all groups of society and build human capital to seize smart city opportunities.[29]

In the area of digitisation there will likely be a focus in two areas, namely: the use of human-centred data to allow transport agencies to better understand the movement of people and goods to inform traffic management,[30] and the development of digital infrastructure to support work-from-home approaches. Digitisation can utilise mobile phone data to build a comprehensive picture of personal logistics for entire cities or communities. For instance, Google has created COVID-19 Community Mobility Reports from mobile data (from android phones), available online for free to help policy makers understand their residents' behaviour.

The provision of digital infrastructure is important to allow work-at-home practices which avoid the need for transportation, such as online learning, online shopping and tele-commuting options. A continued push, both in rural and urban areas, to implement strong digital infrastructure will continue to be important even after the present pandemic is over. Such infrastructure will deliver a range of benefits to residents such as improving access to services, such as online banking, education, etc, while allowing them to stay closer to home. During pandemic times, digital infrastructure is key for identifying outbreaks through social tracing, but in normal times, such infrastructure can also be used to facilitate better community planning, improved transport services and better urban logistics and e-commerce.[31] When considering the opportunities for electro-mobility post pandemic there are a number of promising areas including the electrification of private, commercial and shared transit vehicles.

The Maldives – an ocean nation comprised of over 1000 islands and 99 percent water – recognise that a planned, sustainable transport network is critical for their government to provide food, fuel, and medicine between otherwise isolated communities.[32] The Philippines aim to not only recover from COVID-19 but to use this opportunity to accelerate the transformation of their transport. There is high potential for achieving significant shifts from road-based transport to more sustainable intercity passenger transport and mass freight transport. The development of the nation's first subway and the development of 1000 km of

[28] Mr. Tetsuo Saito, Minister, Ministry of Land, Infrastructure, Transport and Tourism, Government of Japan, 14th EST Forum, UNCRD 2021
[29] Mr. Dato Lim Jock Hoi, Secretary-General of ASEAN, 14th EST Forum, UNCRD 2021
[30] Hargroves, K. (2021) Introducing the 'FreightSync Roadmap' - A Pathway to Linking Freight Vehicles and Transport Systems, Project 3.73 – Road Freight and Network Efficiency, Sustainable Built Environment National Research Centre (SBEnrc), Australia.
[31] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.
[32] Aminath Shauna, Minister of Environment, Climate Change and Technology, Government of Maldives, Plenary Session 14th EST FORUM UNCRD 2021

rail has aided in this shift.[33] From a purely technological point of view there is much innovation that can be applied. The electrification of trains and trams is well established with more recent efforts focused on the electrification of busses and private cars.[34] Advances in battery technology has also provided the potential for a broader range of e-mobility, including personal e-bicycles, e-rickshaws, and new trams which can avoid the need for overhead gantries to provide power, as well as tracks in roads (originally needed to overcome issues with cobblestone streets), by utilising rubber tires balanced by advanced stabilisation and guidance systems – such as in the Trackless Tram.[35]

However this is not where the innovation ends, but rather it only begins by ensuring clean and efficient vehicles are used for shared modes that can be designed to serve corridors. Such corridors provide the opportunity for the development of a string of vibrant station precincts that provide a range of development opportunities, along with recharging facilities for electric vehicles, such as micro-mobility options, cars, light commercial vehicles and the trams themselves.[36] In particular electric micro-mobility options will be important for many Asian cities to provide local transport and reduce the use of cars for short trips, with some 46 of journeys by car in the USA being 3 miles long or less.[37] Currently the greatest uptake of electric mobility has been in China, as shown in Figure 1.

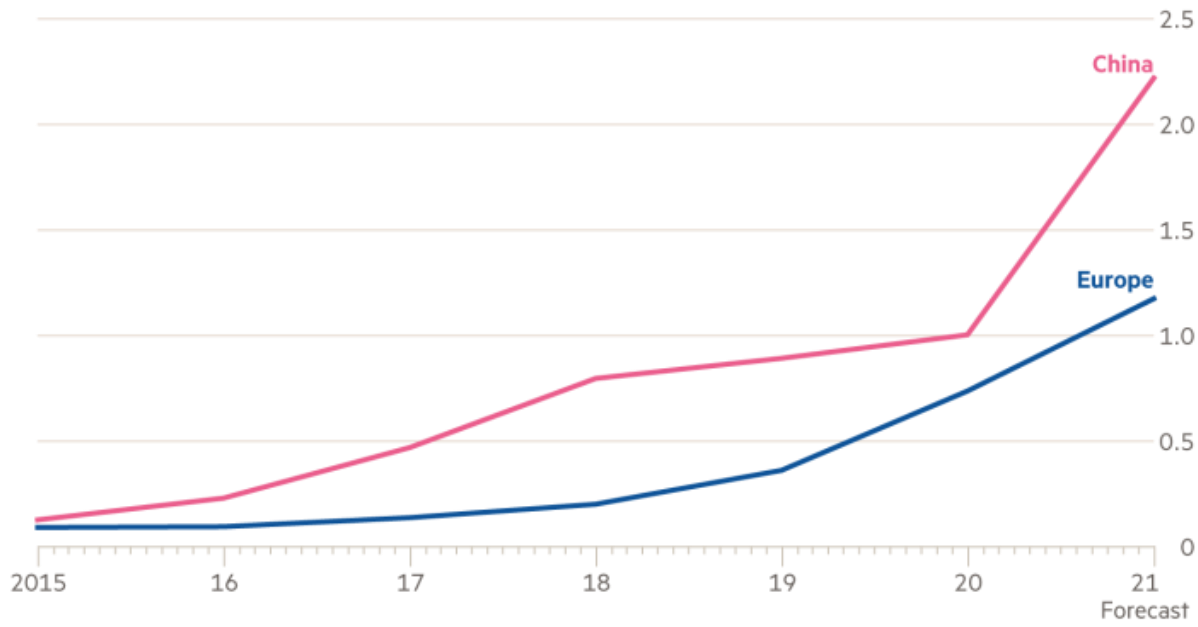

Figure 1: Sales of battery electric vehicles in China and Europe in millions (2015-2021)

Source: LMT cited in Campbell and Miller (2021)[38]

[33] Mr. Artur P. Tugade, Secretary of Transport, Government of the Philippines, 14th EST FORUM UNCRD 2021
[34] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy
[35] Surico, J. (2021) The Popularity of E-Bikes Isn't Slowing Down, The New York Times; 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?. Journal of Transportation Technologies, 9, 31-55.
[36] Glazebrook, G. and Newman, P. (2018) The Future City, Urban Planning, Volume 3, Issue 2, Pages 1–20.
[37] Ajao, A. (2019) Everything you wanted to know about scooters and micro-mobility. Forbes, 01 February 2019.
[38] Campbell, P. and Miller, J. (2021) 'Electric Vehicles: the revolution is finally here', Financial Times, 04 October 2021.

Such precincts can provide services and allow people to reduce travel to central areas, helping to replace highly congested car dependent road systems while delivering urban regeneration.[39] According to Newman (2020)[40], "*This has been a major agenda for most cities for the past 20 years but new electro-mobility is now enabling this agenda and thus is likely to be a big part of future urban economic development strategies*". Transit activated corridors brings together transport, development and energy by acting as a key initiator of activity. It can give greater potential for public transport due to COVID-19, including rail and trackless trams.[41] With the rapid increase in online shopping and the need for parcel delivery services which are done using road based vehicles, such precincts present the opportunity for parcel hubs with parcels carried on trams and trains and delivered to stations for personal collection on the way home from work or other trips.

Such multi-function precincts can benefit from advanced data management using artificial intelligence and machine learning to interrogate data captured via sensors to manage energy, water, waste, transport, and to continuously learn from users. Thus, Newman (2020)[42], "*The centres become something like a set of neural networks that are constantly improving the ecosystem in which they operate*". ASEAN and Japan are collaborating to introduce capacity building programs for cities to support them in strategic planning and developing investment plans with consideration of case-by-case situations, to improve consideration of city development which fosters inclusion, sustainability and connectivity.[43]

[39] Newman, P., and Kenworthy, J (1989) Cities and Automobile Dependence, An International Sourcebook, Gower; Newman, P., and Kenworthy, J. (1999) Sustainability and Cities: Overcoming Automobile Dependence, Island Press; Newman, P. and Kenworthy, J. (2015) The End of Automobile Dependence: How Cities Are Moving Beyond Car-based Planning, Island Press.
[40] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.
[41] Plenary Session, 14th EST FORUM UNCRD 2021
[42] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.
[43] Mr. Dato Lim Jock Hoi, Secretary-General of ASEAN, 14th EST FORUM UNCRD 2021

4. Best practices and lessons from mitigation of COVID-19 for resilient mobility in Asia

In response to COVID-19 a range of protocols have been developed that seek to mitigate the negative effects while maintaining transit services in an effort to balance economic and public health outcomes. Measuring the effectiveness of such actions to mitigating the spread of the virus via shared transport is however difficult due to it being the early stages of the response and multiple efforts need to be coordinated across cities and nations.[44] Due to a number of complimentary factors, including the level of globalisation and interconnectivity of the world's peoples, the COVID-19 virus spread rapidly with some promising examples of digitisation and electrification facilitating rapid responses.[45] For instance Singapore successfully utilised digital services for disease surveillance to inform and implement public instructions and policies to curb the spread of the virus.[46]

Rapid responses by authorities were shown to be critical in curbing the spread of the disease. The suspension of public gatherings and shared transport services, especially in emergency zones, was undertaken in cities around the world and shown to be an effective measure. Notably, shared transport modes were a key connector between Wuhan and surrounding cities.[47] During the pandemic countries and cities responded differently with nation-wide lockdowns in India,[48] reductions to shared transport activities by 80 percent in Hanoi, seat pre-booking for trains in Beijing,[49] and in Guangzhou services were maintained with 50 percent capacity and increased as appropriate.[50]

In many countries tracking measures were put in place that included location sign-in applications and track-and-trace applications using smart-phones. In Taiwan, citizens who were in hotspots or quarantine were tracked to improve virus-spread data and quarantine control respectively.[51] The tracking of citizens meant that virus-spreading hotspots could be identified and contained, including the closure of hubs exposed to the virus. The Taiwanese Government utilised ‘disease logistics’ and other data to enact quick and firm actions while maintaining transparency with the population – improving adherence of rules and demonstrating effective leadership.[52]

Mask wearing, especially where social-distancing is not possible (such as in dense shared transport services), was quickly recognised as an effective prevention measure and adopted in many countries, with many denying access to shared transport services for people not wearing

[44] Royal Academy of Engineering (2020) A rapid review of the engineering approaches to mitigate the risk of COVID-19 transmission on public transport, National Engineering Policy Centre, Royal Academy of Engineering.
[45] Walcott, D. (2020) How the Fourth Industrial Revolution can help us beat COVID-19, World Economic Forum; Sehmi, G. (2020) Three emerging digital technologies for the new normal in transport, World Bank Blogs
[46] Pung, R. (2020) Effectiveness of Containment Measures Against COVID-19 in Singapore, Epidemiology, Cambridge University
[47] Zheng, R., Xu, Y., Wang, W., Ning, G. and Bi, Y. (2020) Spatial transmission of COVID-19 via public and private transportation in China. Travel Medicine and Infectious Disease; Jiang, F., Deng, L., Zhang, L., Cai, Y,. Cheng C. and Xia, Z. (2020) Review of the clinical characteristics of coronavirus disease 2019 (COVID-19). Journal of General Internal Medicine
[48] Gettleman, J., and Schultz, K. (2020) Modi Orders 3-Week Total Lockdown for All 1.3 Billion Indians, The New York Times
[49] Xinhuanet.com (2020) Beijing Metro Pilots Peak Station Entry Reservations. Xinhuanet.com.
[50] Tran, T., Le, T., Nguyen, T. and Hoang, V. (2020) Rapid response to the COVID-19 pandemic: Vietnam government’s experience and preliminary success, Journal of Global Health; ITDP (2020) How China Kept Transit Running During Covid-19, Institute for Transportation and Development Policy.
[51] Wang, C. (2020) Response to COVID-19 in Taiwan Big Data Analytics, New Technology, and Proactive Testing, JAMA Network, Journal of the American Medical Association.
[52] Chen, S. (2021) Taiwan’s experience in fighting COVID-19, Nature Immunology

a mask.[53] Other entrance-control measures include body temperature checks, such as for shared transport passengers in order to quickly identify those that may be symptomatic. Initially this was done through wide implementation of manual checking of temperatures at station entrances using digital thermometers, and in the later stages this was replaced by the use of cameras to monitor entire passengers passing through the station, as shown to be effective in Wuhan.[54]

The cleaning of shared transport service vehicles to avoid transmission of disease is critical both during and after a pandemic, with a number of promising new options emerging. For instance, anti-microbial coatings which have been shown to kill the COVID-19 virus have been employed in the underground system in Singapore. The coating lasts up to 180 days (depending on wear) and can maintain train carriages as microbially clean after daily use, only requiring monitoring of high wear areas such as grasping poles and handles which require more layering or additional sanitation.[55] Improved ventilation in stations and vehicles can improve air freshness, decreasing the prevalence of viruses and other unwanted contaminants in the air.[56] In China, public buses have been outfitted with virus mitigation AI systems to detect fever and alert the driver, and use filtration systems to sterilise the air using UV light that can sterilise the bus's air in twenty minutes.[57]

Together with methods to sterilise and clean shared transport vehicles and stations efforts are also underway to reduce the peak loading of passengers. For instance the UK Government is considering staggering work hours to spread the commuter transit load on the system,[58] while Singapore has already normalised flexible working hours and the government is now encouraging greater uptake[59] – which will decrease congestion and hence lower rider density, disease transmissibility and overall transport system investment.[60] Reduction of transit loads reduced the level of interaction between people and reduces the chance of virus transmission. Additional measures include contactless payment methods in stations and on shared transport services to eliminate the use of physical currency that can carry viruses.

[53] Howard, J., Huang, A., Li, Z., Tufekci, Z., *et al* (2021) An evidence review of face masks against COVID-19, Proceedings of the National Academy of Sciences of the United States of America; Brooks, J. and Butler, J. (2021) Effectiveness of Mask Wearing to Control Community Spread of SARS-CoV-2. JAMA. 2021:325.
[54] Glover, C. (2021) China to Roll Out Temperature-Taking Infrared Cameras, TechMonitor.
[55] CNA Insider (2020) How COVID-Safe Is Public Transport? Buses, Trains & The Coronavirus, CNA Insider.
[56] Shen, J. (2020) Prevention and control of COVID-19 in public transportation: Experience from China, *Environmental Pollution*, Volume 266, Part 2, November 2020.
[57] Ingham, L. (2020) Coronavirus-fighting smart bus rolled out in China, Verdict
[58] BBC (2020) Coronavirus: Staggered work times considered when lockdown eases, British Broadcasting Corporation
[59] Zoey, L. (2021) Back to the office: 7 things you need to know as Singapore shifts to more flexible way of working amid COVID-19, Channel News Asia
[60] Government of Singapore (2021) Updated safe management measures at workplaces, Government of Singapore.

5. Trends and stakeholder roles in shared transport in post-pandemic Asia

A shift in priorities

After transit systems were so severely impacted by considerations to reduce virus to human interaction, there will remain human behavioural considerations in the design of systems. Particularly in attempts to taper COVID-19 spread while countries aim to return to normal economic operation, changes in use of transport systems will occur to maintain public health, which are likely to lead to overall increased ridership compared to pre-pandemic levels. Physical infrastructure developments may include wider sidewalks, pedestrianized streets, dedicated bike lanes, electric scooter pathways or car-free zones.

Digital resources can improve the use of these systems by improving ability for planning and trip coordination and hence efficacy and efficiency of the systems. Government will serve a major role in orchestrating these changes, while third-party stakeholders can provide supportive technical and specialist input. In their COVID-19 infrstructure response, The Philippines Government increased the promotion of 'active transport' such as walking and cycling, having developed over 500km of bike lanes in 2021.[61]

The Ministry of the Environment of Japan has initiated the development of an online platform on sustainable and resilient recovery from COVID-19, with support from the UNFCCC, that is being managed by the Institute for Global Environmental Strategies (IGES). The platform provides a comprehensive list of initiatives that countries are implementing as part of COVID-19 response and recovery efforts.[62] A recent survey conducted by UNESCAP identified a number of key priorities of governments and experts, as part of such recovery efforts, including:[63]

- The protection of transport workers.
- Adaption to changes in the transport market behaviour.
- Strengthening cross-border connectivity.
- Supporting economic growth, including job creation.
- Increasing the resilience of freight transport.
- Improving digitalization of transport services.
- Integrating decarbonization and sustainable transport.

According to Earley and Newman[64], such intentions can be aggregated into three main categories of ways to help countries move towards improved connectivity in Asia-Pacific, namely:

[61] Mr. Artur P. Tugade, Secretary of Transport, Government of the Philippines, 14th EST FORUM UNCRD 2021
[62] IISD (2020) Ministerial Launches "Platform for Redesign" to Overcome Climate Change, COVID-19, International Institute for Sustainable Development.
[63] Ducrest, A. (2020) Regional Transport Cooperation in Asia and the Pacific. In: Intergovernmental 13th Regional Environmentally Sustainable Transport Forum in Asia, United Nations Center for Regional Development, Nagoya.
[64] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

1) Digitalization: This involves harnessing smart infrastructure, paperless trade, distributed ledgers, and intelligent transport/logistics options.
2) Resiliency: this involves taking advantage of multi-modality, operational connectivity, and transport facilitation at borders.
3) Decarbonization: This involves making better use of rail, waterborne transport, energy efficiency and renewable energy.

As a result financial institutions are increasing their support of such actions as part of agendas to achieve "Net Zero" outcomes (referring to net zero greenhouse gas emissions mainly) that are quickly becoming necessary to attract investment.[65] Very low interest rates are also now available and the era of building back with the Paris Agreement and the SDG's as the agenda, is now much clearer.[66] However, nations must work out what this means in their infrastructure programs.

A Focus on Net-Zero Transport

Public and private sector decision-makers are experiencing rapidly increasing economic pressure to diversify urban and regional travel *away* from automobile dependence.This has been made explicet as part of COVID-19 restrictions where cities have seen substancial improvements in urban air quality. There have been many rationales for overcoming automobile dependence over the years,[67] but the most cogent in the days of climate change policy is the need for net zero cities (Seto *et al*, 2021)[68]. Net Zero Cities are designed to contribute to reducing greenhouse emissions to less than 50 percent of the 2005 level by 2030 and by 100 percent by 2050.

These targets set an ambition agenda considering that current city infrastructure will need to begin the transition to low carbon options across entire cities in the near term to meet the 2050 goal rather than maintaining business-as-usual. This is a powerful agenda for cities. In the quest for zero-carbon outcomes, city-regions around the world are considering or embarking on programs to convert automobile dependant urban fabric towards a spatial template more amenable to the needs of public and active travel users as well as shifting to renewables-based electromobility.[69]

The need to intensify land development along main roads and enable a more comprehensive shared transit system is something that has happened in the past as cities began to spread out after the industrial revolution. The streets were often called 'Boulevards' and this has become a core concept in transport planning that tries to do more than just increase traffic flow down a corridor. Invariably such extra qualities are about local place and amenity with an emphasis on landscaping, cultural artifacts and walkability. A new approach to boulevards is needed on main roads where a combination of urban regeneration and improved transit is required that

[65] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.
[66] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy
[67] Newman, P. and Kenworthy, J. (1989) Cities and Automobile Dependence, an International Sourcebook; Gower: Aldershot, UK: Newman, P. and Kenworthy, J. (199) Sustainability and Cities: Overcoming Automobile Dependence; Island Press: Washington, DC, USA; Newman, P. and Kenworthy, J. (2015) The End of Automobile Dependence: How Cities Are Moving Beyond Car-based Planning; Island Press: Washington, DC, USA.
[68] Seto K, Churkina G, Hsu A, Keller M, Newman P, Qin B, Ramaswami A (2021) From Low- to Net-Zero Carbon Cities: The Next Global Agenda, Annual Review of Environment and Resources 46:23.1–23.39
[69] Newman, P. and Kenworthy, J. (2015) The End of Automobile Dependence: How Cities Are Moving Beyond Car-based Planning; Island Press: Washington, DC, USA; Newman, P., Hargroves, K., Desha, C. and Izadpanahic, P. (2021) Introducing the 21st Century Boulevard: A Post-Covid Response to Urban Regeneration of Main Road Corridors, Current Urban Studies: Vol.9 No.3.

involves tram-based corridor transit. In today's world of net zero cities such a tram-based boulevard needs to use renewable electricity for both the transit and the station precincts, creating net zero corridors that can expand into their surrounding suburbs.[70] An increasingly popular template for these new boulevards involves what we refer to as 'urban corridor intensification', which is the intensification of land uses around urban and suburban arterial roads, and the retrofit of those roads with low-cost transit infrastructure that represents a significant upgrade from the limited capacity and speed of conventional buses.

The intensification process is inherently needing to be a place-based approach that creates outcomes from the many groups of people committed to the corridor. This has become known as 'Movement and Place' strategies and developed initially out of corridor planning undertaken by Transport for London.[71] The journey of a city to reduce its automobile dependence and at the same time create a transition to a net zero city, will involve learning from other cities and finding its own relevance and appropriate technology.

There are however pitfalls that cities can fall into. Ultimately, as argued poignantly by Bertolini (2017)[72], the development of urban corridors with increasing densities and functional mix anchored by medium or high-capacity public transport infrastructure, not only depends on the recognition of the inherent synergies between transport and land use settings in such environments, but it must impact on their translation into policy priorities in both fields of planning. This will become even more evident when cities begin the transition to net zero outcomes and seek to make tram-based boulevards a key mechanism in how this can be achieved efficiently and with multiple benefits. It also depends on decision makers proactively identifying and critically appraising specific opportunities for change, whether that concerns funding, technology, public opinion, stakeholder alliances or market dynamics, and capitalising on them at suitable moments in time. The opportunity to learn from this in American and Australian cities is an obvious next step as well as the leap-frog opportunities in emerging cities where most urban development is occurring and where the need for net zero with SDG benefits will be even more important.[73]

Net Zero Carbon development is very much on the global agenda. It is often seen as something that needs large scale deployment of renewable energy in large solar farms or wind farms that feed green energy into existing centralised electricity grids. However, as in every previous era of technological innovation there are definitely changes to the urban system that will follow waves of technology change. The net zero technologies that are now fast becoming mainstream rooftop solar, batteries, electric vehicles, and smart technologies, all of which can be integrated to form clean and renewably powered precincts. These technologies work best when applied directly into the urban area that needs to go net zero as this will significantly save energy, time and space.

Different urban fabrics from central, inner, middle and outer suburbs through to peri-urban and rural villages, can each use these technologies in different ways. Fundamental will be the focus on a precinct scale that optimises the technologies but will depend on creative architecture and urban planning systems to enable the shared systems of delivery and shared local governance.

[70] Newman, P., Hargroves, K., Desha, C. and Izadpanahic, P. (2021) Introducing the 21st Century Boulevard: A Post-Covid Response to Urban Regeneration of Main Road Corridors, Current Urban Studies: Vol.9 No.3.
[71] Newman, P., Hargroves, K., Desha, C. and Izadpanahic, P. (2021) Introducing the 21st Century Boulevard: A Post-Covid Response to Urban Regeneration of Main Road Corridors, Current Urban Studies Vol.9 No.3.
[72] Bertolini L (2017) Planning the Mobile Metropolis. Transport for People, Places and the Planet. Palgrave Macmillan, London, UK
[73] Ndlovu, V. and Newman, P. (2020) How Can Developing Cities Leapfrog into the Future with a Technology Like Trackless Trams*? Journal of Transportation Technologies*, 10, 198-213.

The other important aspect of such a transition will be how to include people-positive and nature-positive outcomes as well as climate-positive outcomes.

Solar and wind in large centralied locations cannot be simple substituted for nuclear, coal or gas for a range of reasons. Solar and wind that is located in close proximity to consumption and supported is by storage (mostly from batteries in homes, business, communities and electric vehicles) are variable sources capable of supplying users virtually on demand at the lowest volume of energy required at a particular time in a particular location. Electric vehicles can also provide vehicle-to-grid (V2G) services from their batteries. How they fit into the distributed, transactive grid is beginning to emerge with substantial opportunities for transit vehicle fleets of electric buses, trains and cars or transit-based corridors with recharge hubs for all electromobility in station precincts.[74]

The Role of Cities to Activate Stakeholders

Cities are the heart of the effort to recover from the pandemic and will be critical in achieving a strong and robust response to COVID-19, building more intelligently, with increased collaboration and sharing of best practices.[75] Dr. Han Seung-Soo, Chair of the High-level Experts and Leaders Panel on Water and Disasters (HELP) claims that we are at a critical juncture in human history and that it is apparent that post COVID-19 cities must be more resilient to sudden shocks, such as pandemics, and to gradual changes, such as climate change. He states, 'Cities are containers of our society' where robust infrastructure is required to ensure safety, mobility and enhanced livelihoods for citizens.[76]

Over the last decade a number of cities have focused on responding to climate change through a range of programs and policies with part of this focus now shifting to COVID-19 recovery efforts, with many such efforts meeting both imperatives by delivering recovery outcomes that contribute to reduced greenhouse gas emissions and other social and environmental outcomes. Such efforts will include the adoption of new processes, technologies and partnerships which according to Newman (2020)[77], "*will flow through the fabric of the city, just as it has in each other wave of innovation, with many setting their recovery agendas to achieve new goals and outcomes in zero carbon and zero poverty that will establish them as leaders*". This will call for a range of new stakeholder roles across the transport sector as the focus shifts away from providing infrastructure and services to private vehicle owners and towards the provision of clean, efficient and fast shared transport options that are designed around corridors of urban regeneration and economic development.

As with the rise of 'automobile dependence'[78] this shift will see the urban fabric that we take for granted forever altered. No longer will sprawling suburbs that are reliant on private vehicles dominate the minds of developers, but rather the attraction of vibrant precincts based around effective shared transport options that aggregate economic and social activity and provide expanded levels of accessibility. In particular the developing world will have the opportunity to leapfrog old technologies and capture numerous benefits associated with renewable energy, urban greening, electro-mobility, AI and data analytics, distributed ledgers, and a range of

[74] Newman, P. (2020) COVID, Cities and Climate: Historical and Potential Transitions for the New Economy, *Urban Science*, 4, 32.
[75] Mr. Dato Lim Jock Hoi, Secretary-General of ASEAN, 14th EST FORUM UNCRD 2021; Mr. Bambang Susantono, Vice-President for Knowledge Management and Sustainable Development, Asian Development Bank (ADB), 14th EST FORUM UNCRD 2021.
[76] Dr. Han Seung-Soo, Chair of the High-level Experts and Leaders Panel on Water and Disasters (HELP), 14th EST FORUM UNCRD 2021
[77] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.
[78] Newman, P., and Kenworthy, J (1989) Cities and Automobile Dependence, An International Sourcebook, Gower

enabling technologies. For instance China has led the way in mainstreaming many of these innovations and has captured the associated economic and social benefits.[79] According to Newman (2020) [80] such an approach has 5 key features, namely: relocalised centres; innovations tailored to the urban form; significantly lower car use; the development of symbiotic partnerships; and the renewal of the manuals of urban professionals.

When considering each of these features from the point of view of stakeholder roles in shared transport post-COVID the following is evident:

1) *Relocalised Centres*: With the rediscovery of the value of localisation as a result of COVID-19 mobility restrictions it is clear that healthy vibrant cities will be based around interconnected local centres that provide places to work, live and play.[81] Such a focus requires all involved in such centres to have a new relationship with the urban form, one that is far more proactive, inclusive and rewarding - which will provide common good outcomes and mobilise social capital to new levels. Stakeholders in such centres will be concerned with ensuring a safe, clean and productive system that exceeds the level of accessibility currently afforded by private vehicles. This will prompt greater civic involvement in a range of new areas, such as energy generation, storage and use, managed using smart systems.[82] These smart precinct systems can be linked along corridor (using advanced databases such as distributed ledgers) to provide a rich source of data for AI systems to ensure effective operation and response to outlier events.

2) Tailored innovations: Rather than adopting a one size fits all approach to cities each urban place will have its own combination of innovations that suits the people living and working there,[83] calling for different approaches to stakeholder engagement. For instance, dense urban centres will likely build on the enhanced accessibility available from walking to create multiple destinations shrouded with greenery and equipped with the latest smart city technologies. Corridor based transit city fabrics will likely focus on creating a system of renewable energy innovations to seamlessly deliver clean and cheap energy to vehicles, homes and businesses. Depending on the focus of the place the level of engagement and involvement of those interacting with it will change calling for flexible and inclusive governance mechanisms.

3) *Less Car Dependant:* The shift away from automobile dependence is likely to bring a different form of social interaction in the world's cities, changing from one where people travel in their own isolated pods between destinations to one where interaction and engagement with others is easy and supported along the journey. It is likely that when people move out of cars and enter the social fabric of a vibrant city they are more likely to be engaged with that community, and more likely to engender a sense of responsibility and contribution to the quality of life of all that live and visit there. However it will be important for smart technologies to be used to ensure safety, cleanliness, and effective operation of

[79] 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.
[80] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.
[81] Newman, P., Davies-Slate, S., Conley, D., Hargroves, K., and Mouritz, M. (2021) From TOD to TAC: Why and How Transport and Urban Policy Needs to Shift to Regenerating Main Road Corridors with New Transit Systems. Urban Science. 2021; 5(3):52.
[82] Newman, P. Density, the Sustainability Multiplier: Some Myths and Truths with Application to Perth, Australia. Sustainability 2014, 6, 6467–6487.
[83] Newman, P. and Kenworthy, J. (19999) Sustainability and Cities: Overcoming Automobile Dependence; Island Press: Washington, DC, USA.

such spaces along with the infusion of arts and cultural artefacts to catalyse interaction and create safe and welcoming spaces.

4) *Symbiotic Partnerships:* The shift towards vibrant transit precincts and away from automobile dependent sprawling cities will require new partnerships to secure the funding, expertise and collaboration required. In this new model long-term value is created and maintained largely by those that live, work and visit the precinct,[84] rather than by transient interests seeking to capitalise on sporadic periods of economic activity across a city. In order for complex precincts to function a package of symbiotic innovations and technologies will need to be created and adapted, calling for equally symbiotic partnerships[85] which will call for community based approaches.[86] Such approaches have been shown to deliver long term effective governance and financing arrangements to be built and maintained.[87]

5) *Renewal of Urban Manuals:* With a shift in development mindset towards interconnected precincts along effective shared transport corridors will come the need to renew the manuals used to create the urban form. Similar to the new approach to urban development this will call for a new approach to the development of such manuals and call for engagement and involvement from a range of new stakeholders.

[84] Sharp, D. (2018) Sharing Cities for Urban Transformation: Narrative, Policy and Practice. Urban Policy Res. 2018, 1–14.
[85] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.
[86] Hartz-Karp, J. and Marinova, D. (2012) Methods for Sustainability Research; Edward Elgar: London, UK.
[87] Salter, R., Merson, J., Rauland, V., Odell, P., and Sharp, D. (2019) Engaging Local Communities. In: Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A. and White, S. *eds*.; Palgrave Macmillan: Singapore.

6. Conclusions and Recommendations

Overall perspective

The growth of cities has been the basis of civilization and cities will now need to create a new future post-Covid. Due to the Covid pandemic, things that were ripe for change now have a new opportunity to be mainstreamed. Perhaps the world can create a new future that addresses the two big agendas of our day in an integrated way: zero carbon and zero poverty. What is certain is that transport wil play a big part in that transition and that it will need to be sustainable, shared and resilient. The innovations outlined in this paper and which appear to be critical to this agenda include:

- Distributed renewable energy and batteries, as well as technologies that create distributed energy markets;
- Electromobility and especially the associated new electric transit and e-micromobility, as well as the old but tried and true walkability;
- Smart city technology that enables all of these innovations to be integrated, to work better and to create the ecosystems of cities and regions as neural networks that learn and grow, showing us how to make each place in a city or region achieve zero carbon–zero poverty outcomes.

These changes are essentially integrated and can all be cost-effective, as they have shown their prowess at supporting economies in the time of this COVID pandemic. The hydrogen innovations are being targeted by many governments as an important opportunity for industry are unlikely to be much use for land transport but will be important for shipping and aviation. These may rapidly move to be ing cost-effective as they move beyond demonstration phases.[88] But the vast majority of new transport investment over the next two decades will be in electromobility and how it is best applied to cities and regions using zero carbon power. Investment will need to have assessment processes that enable rather than drive-away these innovations. Such changes will need new partnership processes that enable all levels of government to work with private finance and business, in close collaboration with communities, whose local values need to drive all development and help create local enterprises.

These processes will be a challenge for all urban leaders, professionals and politicians who must do more than simply wait for such technologies to solve everything. The need will be for solutions that combine this cluster of technologies with locally-oriented designs relevant to dense city centres, inner-city corridors, suburban centres with estates for various functions, and periurban, rural and remote villages. The human qualities and natural qualities of each place will be at the heart of how these new technologies can create relocalised places and connected corridors between places using these new technologies.

Transport professionals will soon see that they need to rapidly change the manuals of modernism built on a fossil fuel era and are still so prevalent in all engineering designs and statutory regulations. This will be a requirement from all politicians but must be delivered by professionals. It is critical that this happens quickly or else they will miss their early chances

[88] Geels, F., Schwanen, T. and Sorrell, S. (2017) Sociotechnical transitions for deep decarbonization. *Science*, 357, 1242–1244.

to be part of the next economic wave. Places that can quickly focus on how to mainstream their new planning and assessment systems to create new centres of zero carbon–zero poverty urbanism are likely to be the new post-Covid economy winners.[89]

Looking to the Future

The perspectives of the past thirty years may not work for the next thirty, especially as new technology for mobility is likely to be quite different to anything we have had before. There is a major change in energy from concern about oil scarcity driving our original research to a situation where oil is simply being replaced by electro-mobility in all its forms. Disruptive technologies abound and are multiplying in an unprecedented way across the whole transport field: burgeoning bike and car sharing schemes, e-scooters and other rapidly developing micro-mobility, Uber, Lyft and other similar transportation network companies, new kinds of electric cars and trucks including hydrogen fuel cells, autonomous cars and more. All of these systems are going to have respond to climate change as well as the historic issues of automobile dependence.[90]

Autonomous vehicles (AV's) providing 'mobility as a service' (MaaS) are touted as transforming our cities given they are expected to run on clean energy and be much safer so will eliminate many of the automobile's problems. However, AVs are just as likely to cause greater congestion issues. The important lessons we have learnt are that cities are shaped always by the human limits related to their travel time budgets and the urban system is likely to adjust to whatever is provided in transport and land use to ensure that this travel time daily limit is maintained. This will shape our cities in the future as it has in the past. The question is whether AV's are going to help solve such travel time issues as well as its claims of reduced pollution and safety improvements. The opportunities provided by AV's are its potential to be electric and to provide for transport demand without needing to own a car. Electric vehicles of all kinds will be needed without doubt to help solve the oil problem, but automobile dependence problems have always been about much more than oil. However, the same issues of automobile dependence as the past thirty years may exist depending on what kind of autonomous transport and what kind of urban fabric can be provided.

The purely automobile-based autonomous system will no doubt increase vehicle kilometers of travel (VKT) and urban sprawl will be given something of a boost if they save some time (though the history of transportation planning to save time has failed, rather, any time advantages have just been used to travel further). In any case, any possibility of time advantages will only happen if road capacity is increased to accommodate the increased VKT associated with demand-responsive vehicles looking for passengers. This is a major issue as the ability to increase road capacity further is very difficult politically if roads are used to obliterate large amounts of developed urban fabric or they will need to have tunnels built at huge expense.

Already it appears that Uber and Lyft are causing increases in VKT as they provide a better service than transit in some cities. TNCs such as Uber and Lyft combined with taxis are exceeding the total use of local bus services in the United States.[91] Schiller (2016) in turn

[89] Landry, C. (2019) Advanced Introduction to The Creative City; Edward Elgar: Cheltenham, UK.
[90] Newman, P., Beatley, T. and Boyer, H. (2017) Resilient Cities: Overcoming Fossil Fuel Dependence; Island Press: Washington, DC, USA.
[91] Schaller, B. (2018) The New Automobility: Lyft, Uber and the Future of American Cities; Schaller Consulting: New York, NY, USA.

provides a comprehensive and sobering review of the problems of unbridled use of AV's, which peels off some of the gloss and hype surrounding present discussions about them[92].

There will also be another problem. We would suggest that there will be strong reactions to excessive numbers of AV's in walking and transit city fabrics where walkability is needed because they threaten to wind back the gains in livability in such areas, that were hard fought by citizen groups and city governments over the last 30 years.[93] It is likely that most areas will ban AV's from high quality walkable areas as they simply will not be able to move through heavily pedestrianized areas. If AV's are channelled down a main road at high speed with no distance between them (as suggested) they will form an impenetrable wall worse than most freeways. So perhaps AV's will only be useful in outer areas which are built around cars, i.e. automobile dependent suburbs. If AV's simply strengthen the automobile dependence of a city on the fringe, this will rapidly reduce the ability to provide a better urban future as urban regeneration and transit investment are drained into urban sprawl as has now been shown over and over to be a serious issue. These are the same issues we faced 30 years ago but had begun to think we had seen a big change away from such automobile dependence.

There is another kind of autonomous transport that can be used to create 'Transit Urban Fabric' and which can still make the best of opportunities of the smart technologies that enable vehicles to be guided: BRT, LRT and Trackless Trams. All three, now called mid-tier transit, are electric and have various levels of autonomous and guidance technology enabling them to run fast along main roads. This can significantly increase capacity (up to 6 lanes of car-based traffic) and with their innovations that prevent noise and emissions they can enable development around stations due to their ability to unlock land value.[94]

Used to create 'Transit Activated Corridors' such a system can provide a much faster and more attractive ride quality along most corridors than bus-based systems - along old main roads that have lost their transit or new main roads needing a better system; especially will this work if done in partnership with private developers who can build innovative precincts around stations. They can be used in combination with shared mobility shuttles and micro-mobility for last mile connectivity [95] and could in fact be financed through associated land development at stations.[96] They could also be a key step in the transition to Net Zero Cities as each part of the transport and land development system can be electric and solar-based. [97]

Such Transit-Activated Corridors would be greatly enhanced by a city governance system that created these systems of transit and density along main roads. Such corridors would be turned into urban boulevards by closely coordinated governance via planning and transit agencies, rather than through the longstanding traffic engineering practices of traditional road agencies.

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[92] Schiller, P. (2016). Automated and Connected Vehicles: Hype or Hope. World Transport Policy and Practice, 22, 28-44.

[93] Newman, P. (2019) Driverless vehicles and pedestrians don't mix. So how do we re-arrange our cities? The Conversation, 28 November 2019.

[94] Newman, P., Davies-Slate, S., Conley, D., Hargroves, K., and Mouritz, M. (2021) From TOD to TAC: Why and How Transport and Urban Policy Needs to Shift to Regenerating Main Road Corridors with New Transit Systems. Urban Science. 2021; 5(3):52.

[95] Glazebrook, G. and Newman, P. (2018) The City of the Future. *Urban Plan.* 2018, 3, 1–20.

[96] Newman, P., Davies-Slate, S. and Jones, E. (2017) The Entrepreneur Rail Model: Funding urban rail through majority private investment in urban regeneration. Res. Transp. Econ. 2017, 67, 19–28;

[97] Newman, P., Davies-Slate, S., Conley, D., Hargroves, K., and Mouritz, M. (2021) From TOD to TAC: Why and How Transport and Urban Policy Needs to Shift to Regenerating Main Road Corridors with New Transit Systems. Urban Science. 2021; 5(3):52.

This is being done in European cities using Sustainable Urban Mobility Plans (Eltis, 2016)[98]. The extent of these changes will depend as always, on the politics of how how much automobile dependence is wanted over transit, walkability and dense urbanism.

Recommendations

Lessons from Covid in service delivery

a. Smart technology systems have enabled public confidence to return to the use of transit systems when applied to reducing concerns over Covid and these lessons can be used to further create confidence in the safety and security of public transport.

b. Hygiene management on livery and in air conditioning should be continued as the Covid-based innovations create more healthy spaces.
c. Face recognition and thermal imaging at ticket presentation sites can be continued as ways of ensuring health priorities
d. Vaccination passport recognition can be part of any future ticketing systems.

Lessons from Covid in freight management

a. Freight can be managed effectively through the worst of a pandemic and hence is likely to be able to manage through other disasters and major climate resilience challenges.

b. Digital communication systems and optimisation with new AI software are likely to be the basis of continuing these impressive outcomes in resilience.

Lessons from Covid in local mobility and digital meetings

a. Localasation of activity for a much greater range of activities from local open space, shops, cultural centres and meeting places, are likely to continue as a high priority and need the infrastructure for active transport, including the new e-mobility devices that are simple to use locally.

b. Replacing routine meetings with digital communications is now routine, high quality and cost effective, especially in reducing travel with its associated air pollution, and such options can be continued with many enabling conditions. However, the need for face-to-face meetings will always be needed for creative, community-building, culturally significant and economcally important meetings, and hence transport systems will always be needed.

Lessons from Covid in the green economic recovery period

a. Transport is enetering a rapid change period as new technology for the green economy reaches maturity with solar/wind power and batteries becoming highly cost competitive, and electromobility for all forms of land transport become the mainstream basis for passenger and freight movements in cities and regions.

[98] Eltis: The Urban Mobility Observatory (2016). Guidelines for Sustainable Urban Mobility Plans. European Commission's Directorate General for Mobility and Transport.

b. Procurement of fleets for cars, autorickshaws, buses, trucks and trains can now be worked out to enable this transition to decarbonised vehicles.

c. Demonstrations of how net zero corridors can be created using new technology mid-tier transit allied with net zero stations and associated redevelopment precincts. Such projects can best be done through partnership projects with private developers and local communities.

d. Testing of new fuels by use in shipping and aviation will continue to be needed followed by scaling up of the best results, before significant adoption of climate resilient international shipping and aviation.