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8th July 2022

# COVID-19 Cross-Group Benchmarking Review of Recent Activities: Public Report


Contents



Imperial College London
Projects

## Overview

The purpose of this document is to help operators optimise their response to the ongoing COVID-19 pandemic by sharing knowledge and experience from a wide range of organisations globally, including many of the largest operators in the world's major cities. The focus is on both short-term measures to deal with specific challenges arising from the pandemic in the present, as well as on longer-term impacts, such as the funding crisis or more permanent changes to travel patterns and behaviour, that operators are having to respond to and plan for.

This document summarises recent updates and key findings related to COVID-19, sourced from the benchmarking group members and activities within the groups: over 100 metro, rail, bus and light rail operators participate in the international benchmarking groups (see Appendix A for a list of benchmarking groups and members) managed through the Transport Strategy Centre (TSC) at Imperial College London.

All information provided is anonymised to respect confidentiality rules of the benchmarking groups (unless any information has been sourced publicly).

Full references of relevant literature on COVID-19 in the transport industry are provided at the end of this document, along with a short description for each piece of research.

ABBG COMET IMRBG
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RIAMBIG

## Fuel and cost of living crises add further dimensions to ridership recovery journey, as the public transport sector continues to recover from COVID-19

In recent months, we have seen a growing number of countries and cities relax COVID-19 restrictions, particularly in the UK and some of Europe, as well as much of the US following recent announcements in April to remove the US national mask mandate for public travel. In line with the national easing of COVID-19 restrictions seen in many parts of the world, the public has responded accordingly and public transport ridership experienced **strong recovery** following the initial interruptions seen due to the Omicron variant as it surged around the world. However, the latest outbreaks continue to cause significant disruption to day-to-day life across the China region in particular, with lockdowns and restrictions recently experienced in locations that have been seeing the bulk of the cases (e.g. Hong Kong, Shanghai, Beijing). For many cities in the region, the latest wave of infections saw significantly increased community transmission. Thus, strict containment measures were introduced over a prolonged period of time and as such, **more severe impacts** were felt compared to previous outbreaks.

We have seen in past editions of this report how governments and the public transport sector are looking to **pricing strategies** and new **ticketing offers** to incentivise public transport travel. Of course, the COVID-19 pandemic and resulting changes in travel patterns continue to be a key driver for new ticketing initiatives however the need for such offers is further bolstered by current environmental and economic circumstances around fuel pricing and increases in cost of living. This report summarises more recent examples of fare promotions, which range from fare-free months, half price discounts to heavily discounted travel to provide some level of **financial relief** to the public whilst also encouraging a **sustainable ridership recovery** and more sustainable travel choices to be made. The new €9 summer pass which the German Government has announced for all nationwide travel is one example of a recent fare incentive designed to target multiple objectives: at a fraction of the cost of regular tickets, the promotion is hoped to both boost public transport use and support sustainable travel, and to provide some relief to travel cost over the summer months.

More broadly, the ability to provide heavily discounted fare options somewhat raises the question of whether there is more that can be done to deliver financial measures or different types of cuts to encourage people to return to cities on public transport. Schemes that come to mind are **tax free commuter passes** or commuter benefit programmes, an example of which is the Washington Metropolitan Area Transit Authority's SmartBenefits programme: employers enroll in the programme to provide their employees with tax-free commuting. Interestingly, some countries have a legal requirement for employers to cover some or all of the cost of employee travel, although the specifics may vary and include factors like per diem rates or certain conditions being met (e.g. in the case of Brazil, public transport travel is covered where costs exceed 6% of an employee's monthly salary). In one last example, the German government cut VAT from 19% down to 7% in 2020 for long distance travel over 50km as part of climate measures.

Schemes, as those discussed above, are not necessarily new and have existed since before the pandemic. However, there seems to be further potential to review more opportunities for wider implementation and development of **similar initiatives** to drive ridership growth – whether this be as part of a COVID-19 recovery strategy, a sustainability approach or to reduce the impacts of the cost of living crisis. Of course, the rising costs of fuel and electricity are also widely felt by the public transport industry and present an additional challenge to providers in their financial recovery journey. Along with other rising costs, such as pressures on wages in the public transport sector, the significant additional energy costs providers are currently facing and will continue to face, may be considered a hindrance to offering customer pricing incentives.

# Europe and Latin America leading demand recovery, as Asia/Pacific continues to recover from Omicron

## Recent Metro Demand Trends

Average **metro ridership** by region as a proportion of pre COVID-19 demand *(weekday demand indexed to January or February 2020)* is shown in Figure 1. The graph is based on daily demand data collected in the COMET metro benchmarking group.

As reported in our previous report, the **impact of the Omicron variant** on metro demand is evident across all regions, with impacts first seen in Europe in December where average metro demand dipped to 56% of pre-pandemic demand in the first week of January. North and Latin America followed with demand dropping to 25% and 51% respectively during the month of January. In the case of the Asia/Pacific region, Figure 1 shows that average metro demand has fluctuated throughout the first quarter of 2022, largely driven by the impacts of new and more significant COVID-19 outbreaks in the China region.

- In **Europe**, metro demand recovered strongly following reduced demand due to the Omicron outbreak in December and early January. Demand has been on an upward trend throughout 2022 and recovered to **81%** in early May, based on initial available data.
- In **Asia/Pacific**, metro demand recovery has been interrupted due to large outbreaks in many cities: Hong Kong and several cities in Mainland China have had to respond to **new and much more widespread waves of the virus** which have had a significant impact on day-to-day life in these cities due to the tightening of restrictions and city-wide lockdowns (e.g. Shanghai was under a city-wide lockdown in April and May 2022, and the city has yet to reopen fully following the reemergence of cases in several areas). Although some cities remain under tight COVID-19 restrictions, average demand for the Asia/Pacific region as a whole has been recovering in recent weeks as cities begin to emerge from the impacts of their Omicron outbreaks and ease restrictions. Latest available data suggests that average demand for the Asia/Pacific region remains above **70%** since mid-April.
- In **North America**, 2022 demand recovery remains strong, albeit below other regions which has been the case throughout the pandemic. Average metro demand has recovered to **47%** in late April/early May, and current demand is at the highest levels for the region since before the pandemic.
- Throughout much of the pandemic, **Latin American** demand had been slow to pick up. Recovery trends for the region changed slightly in mid-2021 when month-on-month growth was seen and, despite a big drop in demand due to Omicron in January (51%), demand has recovered strongly and has been sitting **above 70%** since mid-March. Latin American demand now follows a close recovery trajectory with Europe and exceeds Asia/Pacific demand in recent months (79% in early May based on initial data).

## Comparison of Recent Multi-Modal Demand Trends

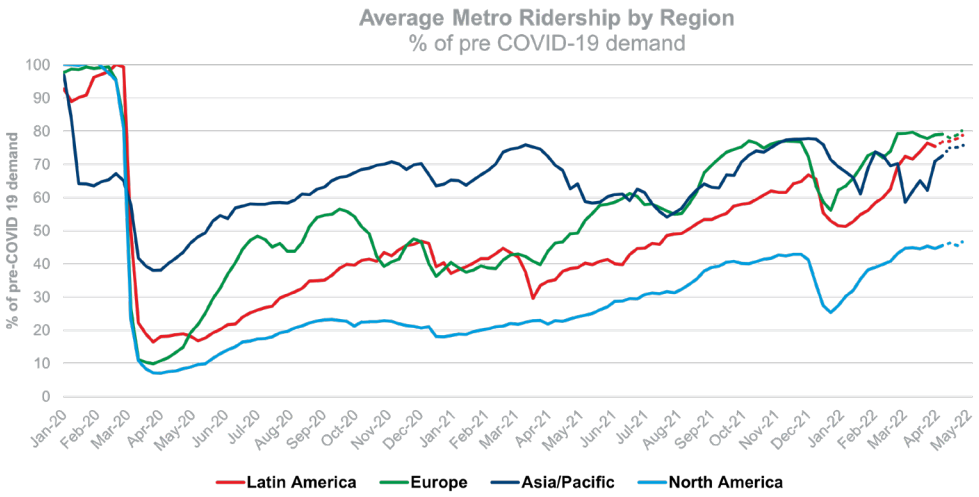
Figure 2 shows average **bus, light rail, suburban rail, and metro ridership** *(monthly total demand indexed to corresponding 2019 month)* by region, based on available data in the benchmarking groups and supplemental data from the US National Transit Database for US operators.

- In the **Asia/Pacific** region, 2022 demand has been on a **downward trend** across metro and rail modes, driven by the impacts of the Omicron wave. *Note that the metro selection for the Asia/Pacific region excludes metros in China and India, and the suburban rail and bus demand trends are based on a small sample.*
- In **North America**, multimodal demand trends across bus, light rail, suburban rail, and metro are all showing strong growth following the impacts of Omicron in January 2022, which saw demand across the modes drop between 35%

**Figure 1:**

Average metro ridership by region as % of pre COVID-19 demand

Source: TSC/COMET



(metro) and 15% (bus, lightrail) .

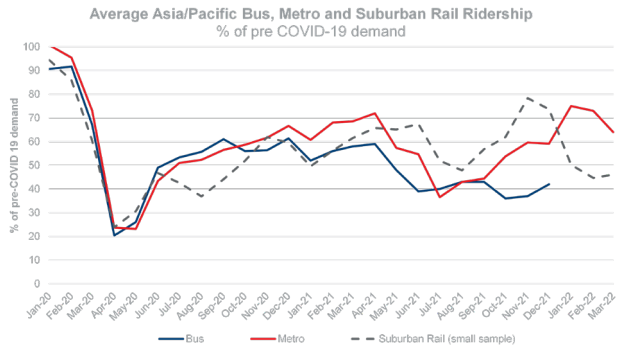
- The bus sector continues to lead demand recovery (**63%** of pre-pandemic demand on average in March), followed by light rail at **58%**.
- Light rail and bus demand recovery levels have consistently remained above levels seen for metro and rail modes (by approximately 20%+).
- Demand for suburban rail and metro recovered to **43%** (February) and **44%** (March) of pre-pandemic demand respectively.

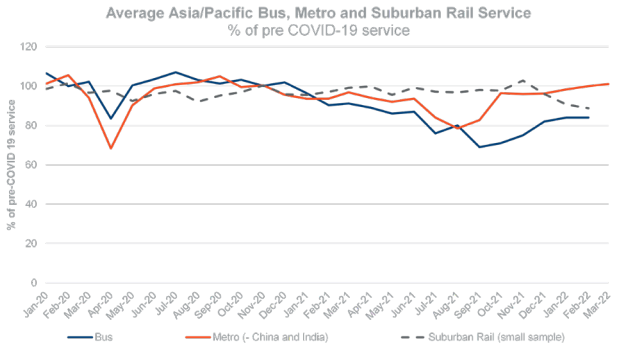
- Demand recovery trends across modes in **Europe** show that metro demand (**62%** in January) was more impacted than bus demand (**74/75%** in December/January) during the peak of the Omicron wave. Both modes have recovered strongly since and reached levels of **78%** (metro) and **86%** (bus) in March, some of the highest levels seen for both modes in the region since before the pandemic. European cities were some of the first to fully relax COVID-19 restrictions and target a return to pre-pandemic life, which is contributing to higher numbers of customers returning to public transport.

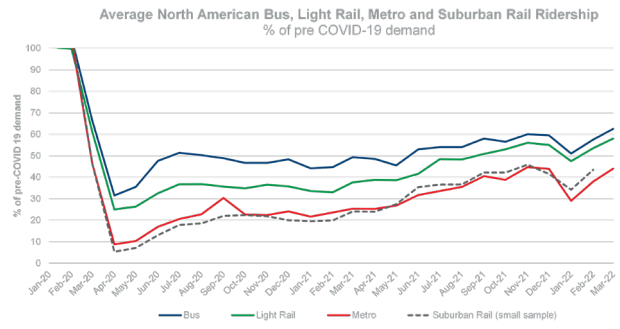
## Comparison of Recent Service Level Trends

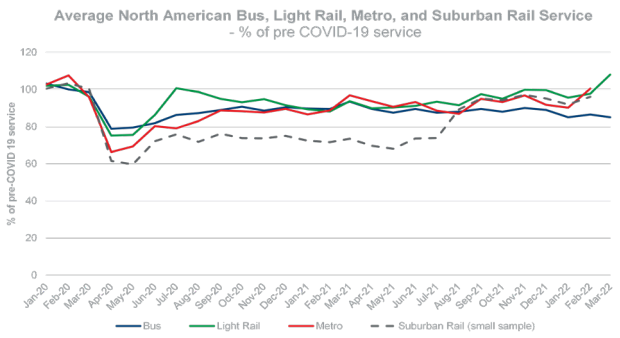
Figure 2 also shows **average service levels by region by mode** as a proportion of pre COVID-19 service (*indexed to corresponding 2019 month*). Across the regions, service levels have remained high throughout the pandemic or have been restored to high levels.

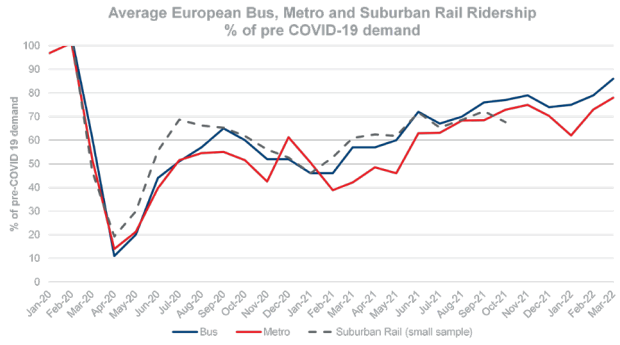
- In the **Asia/Pacific** region, bus service levels for the region had been gradually decreasing since the beginning of 2021. However, service levelled out at the beginning of



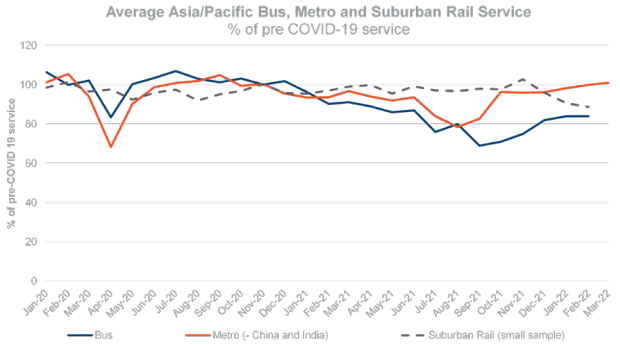




**Figure 2:**

Average ridership/service by mode/region as % of pre COVID-19 demand

Source: TSC bus, light rail, suburban rail and metro benchmarking groups / National Transit Database (Federal Transit Administration)

the year (sitting at **84%** in February). Metro service levels have largely remained at high levels (**>98%** since January ). Suburban rail service has generally remained high in Asia/Pacific, however Figure 2 shows a gradual reduction in 2022 down to **89%** in February. *Note that the metro selection for the Asia/Pacific region excludes metros in China and India, and the suburban rail and bus demand trends are based on a small sample.*

- All modes in the **North America** region experienced some level of reduction in service in January 2022, ranging from **85%** (bus) to **96%** (light rail) of pre-pandemic service. Light rail, metro, and suburban rail modes have since recovered to high service levels (**>96%**) in February and March. Bus service however, has not recovered and remains at **85%** in March.
  - North American bus operators continue to face challenges related to staffing shortages which are having an impact on service delivery.
    - Based on available data for 9 US bus operators, service levels were down by **6%** (ranging from 2% to 14%) on average since late 2021. A primary factor for this level of service reduction is related to ongoing issues around staffing. *Note that the data excludes temporary service reductions, missed trips/lost vehicle km, and does not capture scenarios where staff shortages have prevented planned service increases (i.e. the actual impact on operators' ability to provide service is even greater).*

## Practical examples to manage COVID-19 operational challenges

This section summarises recent information on practical examples or decisions around practices being considered by transport operators to manage operational challenges arising from the COVID-19 pandemic.

### Mask wearing on public transport still largely a requirement for passengers

Despite recent relaxations of mask wearing policies by several public transport organisations (or their governments), the requirement to wear a mask for travel on public transport systems generally continues to be mandated for the large majority of the world's public transport users.

The UK was one of the first countries to relax masking regulations on 19th January 2022, although some public transport operators, including Transport for London and Newcastle Tyne & Wear Metro, continued to mandate mask wearing for passengers at the time. It wasn't until more recently, with the removal of all remaining COVID-19 restrictions by the UK government in March, that public transport organisations changed their masking policies and brought them in line with government advice.

Across Europe however, there continues to be a sliding scale of mask rules, with some countries (e.g. the UK, Ireland, Norway, Denmark, the Netherlands) no longer requiring public transport users to wear masks and some maintaining strict rules, such as requiring medical grade masks (e.g. Germany).

More recently, the US has relaxed its travel masking policy[1]. However, similar to decisions made by some UK transport organisations as mentioned above, a number of US public transport systems (or their states/local governments) are **maintaining their own mandates**:

- Operators in the state of New York and county of Los Angeles continue to require masking for passengers across their public transport networks. This follows a decision by the New York State and Los Angeles County Health Departments to maintain the mask mandate.
- The Milwaukee County Transit System[2] has maintained its masking requirement due to an increase in local COVID-19 infections[3] at the time of the national relaxation of masking requirements.
- San Francisco BART's board voted on 28th April 2022 to re-impose mandatory masking[4] for public travel. The current mandate is expected to remain in effect until 18th July 2022.

Beyond Europe and across Latin America and the Asia/Pacific region in particular, rules around masking on public transport remain widespread and are **expected to continue** to apply for some time. One exception is Metro Rio where masks have become optional since March 7th when the mask mandate was dropped in the city.

In general, where masking is no longer a requirement for travel, operators are communicating that mask wearing is recommended or that any passengers who wish to continue wearing a mask are welcome to do so.

A final example from Brussels differs slightly from other cities' masking policies in that masks are mandated only when travelling on public transport but are no longer required prior to boarding (including in stations), following a Government decision in March.

### Mandatory COVID-19 vaccination for passengers under consideration by Asian operator

We previously reported that a public transport organisation in the Asia/Pacific region had launched a COVID-19 vaccination mandate for staff in November 2021.

In a separate example, an Asian government is currently reviewing the possibility of mandating for its public transport users to be vaccinated to be eligible for travel. Such a mandate would have practical implications on the operation of a public transport system, such as checking the vaccination status of passengers for example.

One other example of a mandatory vaccination policy applied to public travel is **Via Rail** in Canada which requires all passengers aged 12 years and above to be fully vaccinated for travel on its services[5], in line with Canada's travel rules which

apply to air, rail (Via Rail and Rocky Mountaineer) and cruise travel.

The next closest example of such a policy would be Berlin BVG's "vaccinated, recovered or tested negative" requirement for passengers. In the case of Berlin, passenger status is reviewed by both roaming security teams and the police and any passengers who are unable to provide the necessary documentation incur a EUR €50 fine. Recently, Shanghai Metro introduced a similar requirement with passengers having to show proof of a negative COVID-19 PCR test when entering the metro network. This follows the end of two months of a city-wide lockdown at the beginning of June 2022

## Enhanced COVID-19 cleaning continues to be maintained in the public transport sector for now but some plans are being made for scaling back

Whilst enhanced cleaning regimes continue to be followed in the public transport industry for both passengers and employees, the question of **how and when to scale back efforts** is starting to be at the forefront of operators' minds.

- A European operator is considering bringing forward plans for scaling back cleaning efforts, initially targeted for 2023, to mid-2022. This operator highlighted potential challenges with scaling back cleaning of staff areas due to union resistance and may therefore maintain some of the practices for certain areas (e.g. in changing rooms).
- In North America, one operator scaled back their daily train disinfection efforts in line with national guidance as well as internal guidance from their safety department. Some of the enhanced cleaning efforts currently being maintained include the disinfection of high use areas on trains, and the use of an electrostatic sprayer in areas used by a member of staff who has tested positive or for precautionary reasons.
- Two European operators plan to gradually scale back their pandemic cleaning efforts with a return to the pre-pandemic cleaning regime in mid-2022.

The TSC is aware of several examples in Europe and the Asia/Pacific region where mainline rail operators have reverted back to pre COVID-19 cleaning in recent months. However, some lessons and best practices from the pandemic remain, such as upgrades in products for example.


Source: Spokane Transit Authority

Throughout the pandemic, COVID-19 messaging has evolved and continues to change now as restrictions and measures are eased, including communication to the public around cleaning. In one example, a North American operator communicated to the public that their traditional cleaning regime was being reinstated and the fogging of trains every night would cease. In this particular example, passengers welcomed the transition and it is believed that this is partly due to enhanced air filtration (MERV-14) considered to be a better measure for targeting an airborne virus, and partly due to passengers valuing having a clean train.

## The public generally welcomes the relaxation of COVID-19 measures on public transport but less receptive to dropping distancing measures

In the experience of two operators in North America and Europe, passengers were less positive about social distancing measures being removed and pre-pandemic capacities being reinstated. This perhaps suggests that whilst customers are potentially keen to return to pre-pandemic travel habits, the past years have changed their views on crowding and acceptable levels of comfort when travelling on public transport. Of course, many customers will continue to have reservations around travelling in crowded conditions from a safety perspective.

The public response will also be impacted by the way a change is communicated: for example, the North American operator responded to customer pushback by communicating that social distancing cannot be maintained alongside easing restrictions, and that the public transport network has an important role to play in the city's economic recovery.

## Irish Government reduces public transport fares by 20% until the end of 2022

The Irish Government has launched a national fare reduction for public transport travel for the remainder of 2022, the first of its kind since 1947. Public transport fares have been cut by 20%[6] and this measure has been introduced in response to the rising cost of living.

## NS Dutch Railways targets demand on select off-peak trains with a 60% fare reduction

In the Netherlands, NS launched a trial on 15th March 2022, the **"NS Deal Pilot"**[7], which entitles customers to travel between Den Haag and Eindhoven with a single ticket at a reduced cost by up to **60%**, when purchased at least one day in advance of the travel date. The trial is designed to achieve a better passenger distribution on-board trains and to attract customers to less busy off-peak train travel. As such, the level of discount applied to single tickets depends on the expected crowding for the service.

## 12 days of free public transport fares to encourage holiday travel across Greater Sydney

Transport for New South Wales offered a 12-day fare free period[8] over Easter (14th to 26th April 2022) for all public transport modes to boost travel and economic activity during the holidays.

## Discounted or free fare initiatives in Dayton, Salt Lake City, San Joaquin and St. Petersburg

In the US, the Utah Transit Authority (UTA) offered **free public transport travel** across all modes in February 2022. UTA has summarised its findings[9], including the results of customer surveys, which provides insights into public thinking around free fare initiatives. Looking at bus ridership, the UTA reports increases in February for both weekday (**+19%**) and weekend travel (**+37%** on Saturdays, **+44%** on Sundays).

In further examples from the US:

- Pinellas Suncoast Transit Authority in St. Petersburg **reduced fares**[10] by 50% for bus travel between 21st March to 31st May 2022.
- Greater Dayton Regional Transit Authority is offering **free weekend bus travel**[11] between 4th June and 4th September 2022.
- San Joaquin Regional Transit District (RTD) in Stockton offered a **week of free rides**[12] between 12th June and 18th June 2022, in celebration of the "National Dump the Pump Day" in the US which encourages commuters to travel by public transport over car use. San Joaquin RTD's website also provides a free fuel savings calculator as part of the initiative.

It should be noted that the above initiatives were not designed in response to the pandemic, but more in relation to reducing emissions and rising fuel prices. Nonetheless, the findings and impacts of such initiatives remain relevant to the ongoing process of reattracting public transport users lost during COVID-19.

## German Government announces 9-Euro-Ticket for rail and bus travel throughout Germany

The German Government has launched a new **EUR €9 ticket** for local or regional public transport travel throughout Germany[13]. Rail customers will be able to travel via Deutsche Bahn[14] services at a cost of only EUR €9 and the ticket will remain valid throughout the month of purchase. The offer will be available for travel in June, July and August 2022.

## Driver shortage placing stress on the US paratransit industry

Over the past two years, operators delivering paratransit services have had to adjust to evolving staffing challenges: from not having sufficient work for drivers at the peaks of the pandemic to now facing a **shortage of staff** to deliver the necessary service.

One operator reports a negative impact on service quality including on-time performance, which combined with increasing work hours and tighter schedules for drivers, is resulting in low morale. The operator introduced a temporary financial incentive to motivate and encourage drivers to take on more overtime by paying an extra USD $5 per hour for all overtime to encourage fixed route operators (separate collective bargaining agreement) to assist with paratransit services until they were able to fill vacant positions. Furthermore, the largest barrier to driver recruitment in the paratransit industry is identified as pay, and thus new pay scales have been approved to attract interest.

## Customer segmentation analysis by rail operator in Asia/Pacific region indicates a preference for commuter travel from Tuesday to Thursday

Initial research findings on customer segmentation undertaken by an operator in the Asia/Pacific region has found that the frequency of commuter travel has reduced to three or less times per week, with a clear **preference for work travel on Tuesday, Wednesday and Thursday** (Thursday being the busiest day of the week).


Source: NS

The reduction in the amount of commuting occuring on Fridays is however boosted by inbound leisure travel and similarly, an **increase in off-peak and weekend travel** is observed.

A North American railway has concluded similar findings for weekday travel on their network, with the commuter population including a larger proportion of employees in fields where the possibility of home working is reduced (e.g. health care, education, construction, transportation etc.) versus professions where home working options remain. Since 2021, the recovery of weekend travel has been faster compared to weekday travel and has been driven by the reopening and offer of leisure, hospitality, retail, entertainment and recreational opportunities/destinations across the region.

Similarly, analysis of metro travel demand has identified highest weekday ridership levels on Wednesdays and Thursdays. Figure 3 shows average 2022 metro demand over a week and by region, as a proportion of 2019 demand: additional to the weekday demand trends, this shows that all regions except Asia are seeing **strong recovery in weekend travel**.

On the topic of weekday vs. weekend recovery, we take a coser look at North American bus demand in Figure 4. This shows average bus demand recovery at **60%** for a weekday vs. **64%** for a weekend day based on latest available data for the end of March *(monthly total demand indexed to corresponding 2019 month)*. Over the past year, weekend bus demand in the region has typically exceeded 60% of pre-pandemic demand, excluding January 2022 when the impacts of the Omicron variant can be seen, versus weekday demand which for the most part has been sitting below 60%.

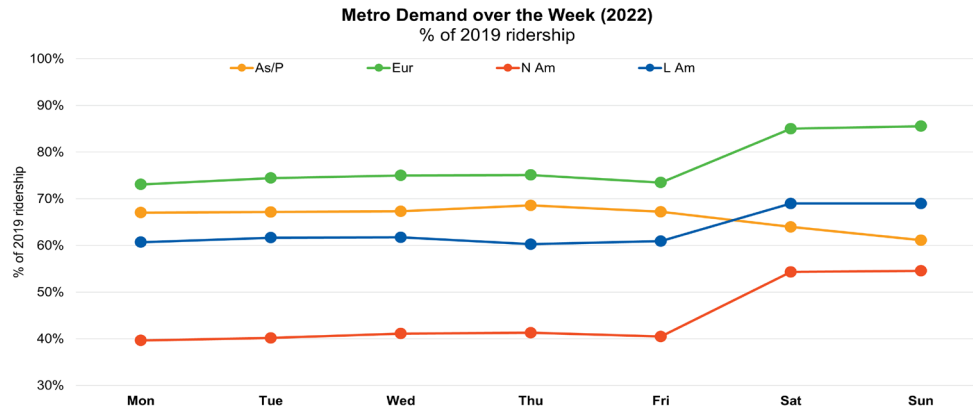



Figure 3: 2022 Metro ridership over a week, by region, as % of pre COVID-19 demand

Source: COMET

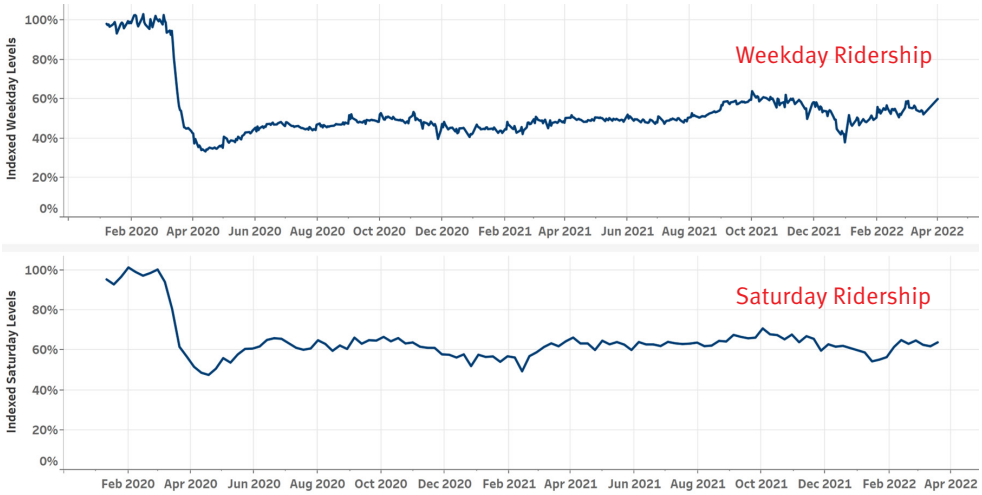



Figure 4: US bus ridership levels (weekday, Saturday) as % of pre COVID-19 levels

Source: ABBG

# Endnotes

1 https://tfl.gov.uk/campaign/safer-travel-guidance

2 https://www.ridemcts.com/who-we-are/news/mcts-will-continue-to-require-masks-on-buses-effec

3 https://county.milwaukee.gov/EN/County-Executive/News/Press-Releases/Mask-Mandate-to-Remain-in-Effect-for-Milwaukee-County-Transit-System-

4 https://www.bart.gov/news/articles/2020/news20200421

5 https://www.viarail.ca/en/plan/faq/covid-19

6 https://www.nationaltransport.ie/public-transport-fares-in-dublin-to-fall-by-20-from-monday/

7 https://www.ns.nl/en/featured/nsdeal

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9 https://rideuta.com/-/media/Files/Rider-Info/Free-Fare-February/FFF_Report_FINAL_Apr2022.ashx

10 https://psta.net/riding-psta/half-price-fares/

11 https://www.iriderta.org/about/news-and-media/rta-give-free-rides-weekends-all-summer-long

12 https://sanjoaquinrtd.com/trip-planner/

13 https://www.bundesregierung.de/breg-en/search/second-relief-package-2029058

14 https://www.bahn.com/en/offers/regional/9-euro-ticket-en

# References

## Relevant COVID-19 Literature


**Barbieri DM, Lou B , Passavanti M, Hui C, Hoff I, et al. (2021) Impact of COVID-19 pandemic on mobility in ten countries and associated perceived risk for all transport modes. PLoS ONE 16(2): e0245886.**
Description: A cross-country study researching the individual mobility patterns for all transport modes before and during restrictions. The study findings suggest that air and bus travel are perceived by the public to be the riskiest transport modes for COVID-19 transmission, and avoidance of public transport for commuting and non-commuting trips is found across all 10 countries included in the research.

**Dai J, Liu Z, Li R (2021) Improving the subway attraction for the post-COVID-19 era: The role of fare-free public transport policy. Transport Policy.**
Description: This paper reviews the impact of fare-free policies in three Chinese cities to attract passenger demand. The study identifies that the role of the fare-free policies in helping recover demand is limited and recommends the use of multi-pronged approaches in combination with fare-free policies.

**Di Carlo P, Chiacchiaretta P, Sinjari B, Aruffo E, Stuppia L, De Laurenzi V, et al. (2020) Air and surface measurements of SARS-CoV-2 inside a bus during normal operation. PLoS ONE 15(11): e0235943**
Description: Air and surfaces of buses in an Italian town were tested during regular operations with average passenger loads of 123 passengers per run. All air and surface samples tested negative for the presence of the Sars-Cov-2 virus, indicating the effectiveness of cleaning, ventilation, and social behaviour policies (i.e. social distancing and wearing of masks). It should be noted that the infection status of passengers at the time of testing was unknown.

**Dong H, Ma S, Jia N, Tian J (2021) Understanding public transport satisfaction in post COVID-19 pandemic. Transport Policy, Elsevier.**
Description: The aim of this research is to understand passengers' psychological responses to the pandemic over time as public transport begins to resume its operations with the pandemic almost entirely contained in China. A cross-sectional survey was conducted in eight cities of China where the public transport system had been temporarily closed because of the pandemic. The results indicated that (1) passengers' feelings of safety enhanced their overall satisfaction with regard to public transport, (2) state anxiety has a negative effect on perceived safety, (3) state anxiety increases as passengers are psychologically closer to the pandemic, and (4) passengers pay more attention to information that is psychologically closer to the pandemic and perceive lesser safety on public transport. These findings not only reveal the internal mechanisms behind how passengers perceive safety but may also provide insight for future disaster emergency management. Based on the results, some feasible suggestions are proposed to avoid the loss of ridership and help public transport systems recover.

**Gkiotsalitis K (2021) Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions. Transport Reviews, Volume 41, Issue 3, Taylor and Francis.**
Description: This literature review aims to systematically review and synthesise the literature on the impacts of COVID-19 on public transport to identify the need to adjust planning measures, and, on the other hand, the existing methods for public transport planning at the strategic, tactical and operational level. Intervention measures that can support public transport service providers in planning their services in the post-shutdown phase and their respective modelling development requirements are identified. This can support the transition from the initial ad-hoc planning practices to a more evidence-based decision making.

**Ku, D., Yeon, C., Lee, S., Lee, K., et al. (2021) Safe traveling in public transport amid COVID-19. Science Advances, Volume 7, Issue 43.**
Description: Simulation of the exposure to infection on public transport and analysis of the risk of infection in an environment where mandatory prevention measures are in place. The simulation finds that the mandatory wearing of masks provides a similar effect to a 2m social distance in preventing COVID-19, whereas social distancing with masks during peak hours reduces infection rates by 93.5% and 98.1%, respectively.

**Hörcher, D., Singh, R., Graham, DJ., (2021) Social distancing in public transport: Mobilising new technologies for demand management under the Covid-19 crisis. Transportation.**
Description: This paper reviews the literature of five demand management methods to enforce social distancing on public transport and the practical applicability of each method: 1. inflow control with queueing, 2. time and space dependent pricing, 3. capacity reservation with advance booking, 4. slot auctioning, and 5. tradeable travel permit schemes.

**Hunt, M. (2020) Covid-19 Transmission Rates on Rail, Technical report, RSSB.**
Description: A recent report by the UK Rail Safety and Standards Board (RSSB) estimated the infection risk on UK rail as a function of the inter-personal contact risk, the number of contacts per journey, and any mitigating factors. The risk of infection was estimated to be 1 in 11,000 journeys or 0.009% per journey. The report was published in August 2020, and so infection parameters were based on disease dynamics at that

time. Since then, infection dynamics have altered with the introduction of new variants, and the RSSB acknowledges that the quoted infection risk is likely to increase.

**Moreno, T. et al (2021) Tracing surface and airborne SARS-CoV-2 RNA inside public buses and subway trains. Environment International 147 (106326) 1-11.**

Description: Air and surfaces of buses and subway trains in Barcelona were tested - 30 out of 82 air and surface samples showed evidence of target RNA genes of the Sars-Cov-2 virus, with surface swabs showing more positive results than air samples. After bus cleaning, there was a reduction in positive surface swab samples, however 4 from 30 samples still yielded positive results. Further testing on the efficacy of cleaning is recommended.

**Mutambudzi, M. et al. (2020) Occupation and risk of severe COVID-19: prospective cohort study of 120 075 UK Biobank participants. Occupational and Environmental Medicine.**
Description: Research identifies that essential workers have a higher risk of severe illness from COVID-19. Risk to public transport workers is found to be double that of non-essential workers.

**Tardivo A , Zanuy AC , and Martin CS (2021) COVID-19 Impact on Transport: A Paper from the Railways' Systems Research Perspective. Transportation Research Record.**
Description: Analysis of the impact of the COVID-19 pandemic on the rail sector identifies resilience, return, reimagination, reform, and research, as the necessary steps to provide service and enhance rail competitiveness and resilience in the event of future crises.

**Yabe, T., Tsubouchi, K., Fujiwara, N. et al. (2020) Non-compulsory measures sufficiently reduced human mobility in Tokyo during the COVID-19 epidemic. Scientific Reports 10, 18053.**
Description: A study of mobility patterns in Japan showed that reductions in mobility (attributed to soft lockdown policies) were associated with reductions in the case reproduction number.

**Zachreson C, Mitchell L, Lydeamore MJ, Rebuli N, Tomko M, Geard N. (2021) Risk mapping for COVID-19 outbreaks in Australia using mobility data. Journal of the Royal Society Interface 18: 20200657.**
Description: COVID-19 outbreaks in Australia were found to be well predicted by mobility data - especially at locations associated with habitual travel patterns e.g. workplaces.

# Contact us

### The TSC at Imperial College London

The Transport Strategy Centre (TSC), previously known as The Railway and Transport Strategy Centre, was established in 1992 as a centre of excellence serving the railway industry on strategic, economic and technology issues. Today, the TSC is a globally recognised team specialising in performance benchmarking, research and policy for industry and government.

The Applied Research Team within the TSC works directly with industry to improve performance in public transport worldwide, based on a systematic process managed and facilitated by the TSC through multi-year international benchmarking projects.

Imperial College London is a global university with a world-class reputation in science, engineering, business and medicine. Well known for its excellence in teaching and research, Imperial College London is consistently rated in the top 10 universities worldwide.

## Thank you for reading this report.

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# Appendix A

## List of Benchmarking Groups and Members

COMET
Community of Metros
Benchmarking Group

### American Metros

- Emova (Buenos Aires – Argentina)
- Washington Metropolitan Area Transit Authority (Washington DC – United States)
- Honolulu Rail Transit (Honolulu - United States)
- MTA New York City Transit (New York – United States)
- New York PATH (New York - United States)
- Ottawa OC Transpo (Ottawa – Canada)
- Metrô Rio (Rio de Janeiro – Brazil)
- Metro de Santiago (Santiago – Chile)
- San Francisco Bay Area Rapid Transit (San Francisco – United States)
- Sistema de Transporte Colectivo (Mexico City - Mexico)
- Société de transport de Montréal (Montréal – Canada)
- Metro São Paulo (São Paulo – Brazil)
- Toronto Transit Commission (Toronto – Canada)
- Vancouver SkyTrain (Vancouver – Canada)

### European Metros

- Transports Metropolitans de Barcelona (Barcelona – Spain)
- Berliner Verkehrsbetriebe (Berlin – Germany)
- Société des Transports Intercommunaux de Bruxelles (Brussels – Belgium)
- Docklands Light Railway (London – United Kingdom)
- Metro Istanbul (Istanbul – Turkey)
- Metropolitano de Lisboa (Lisbon – Portugal)
- London Underground Limited (London – United Kingdom)
- Metro de Madrid (Madrid - Spain)
- Tyne and Wear Metro (Newcastle – United Kingdom)
- Oslo Sporveien (Oslo - Norway)
- Régie Autonome des Transports Parisiens Métro (Paris – France)
- Régie Autonome des Transports Parisiens RER (Paris – France)

### Asian Metros

- Bangalore Namma Metro (Bangalore – India)
- Bangkok Expressway and Metro Public Company (Bangkok – Thailand)
- Beijing Mass Transit Railway Operation Corp. (Beijing – China)
- Delhi Metro Rail Corporation Ltd (Delhi – India)
- Roads and Transport Authority (Dubai – United Arab Emirates)
- Guangzhou Metro Corporation (Guangzhou – China)
- MTR Corporation Limited (Hong Kong)
- MRT Jakarta (Jakarta – Indonesia)
- Nanjing Metro Operation Corp. (Nanjing – China)
- Seoul Metro (Seoul – South Korea)
- Shenzhen Metro Operation Corp. Ltd (Shenzhen – China)
- Singapore Mass Rapid Transit Corporation Ltd (Singapore)

- Shanghai Shentong Metro Group (Shanghai – China)
- Syarikat Prasarana Negara Berhad (Kuala Lumpur – Malaysia)
- Taipei Rapid Transit Corporation (Taipei – Taiwan)
- Tokyo Metro Co., Ltd. (Tokyo – Japan)
- Sydney Metro (Sydney – Australia)
- Sydney Trains (Sydney – Australia)

**ISBERG**
International Suburban Rail Benchmarking Group

- Ferrocarrils de la Generalitat de Catalunya (Barcelona – Spain)
- Queensland Rail (Brisbane – Australia)
- S-Tog, Danish State Railways (Copenhagen – Denmark)
- PRASA – Metrorail (Cape Town – South Africa)
- MTR Hong Kong (East Rail, West Rail, Tuen Ma & Tung Chung Lines – Hong Kong)
- MTA Long Island Rail Road (New York – United States)
- London Overground (London – United Kingdom)
- Metro Trains Melbourne (Melbourne – Australia)
- MTA Metro-North Railroad (New York – United States)
- S-Bahn Munich, Deutsche Bahn (DB) Regio (Munich – Germany)
- Commuter Rail, Vygruppen (Oslo – Norway)
- San Francisco Bay Area Rapid Transit (San Francisco – United States)
- Sydney Trains (Sydney – Australia)

**IMRBG**
International Mainline Rail Benchmarking Group

- Danish State Railways (Denmark)
- Irish Rail (Ireland)
- Nederlandse Spoorwegen (Netherlands)
- Société nationale des chemins de fer belges (Belgium)
- New South Wales TrainLink (New South Wales, Australia)
- Via Rail Canada (Canada)
- V/Line (Victoria, Australia)

**GOAL**
Benchmarking Group of North American Light Rail Systems

- Niagara Frontier Transportation Authority (Buffalo – United States)
- Maryland Transit Administration (Baltimore – United States)
- Calgary Transit (Calgary – Canada)
- Charlotte Area Transit System (Charlotte – United States)
- Dallas Area Rapid Transit (Dallas – United States)
- Edmonton Transit System (Edmonton – Canada)
- Hampton Roads Transit (Norfolk – United States)
- Ottawa OC Transpo (Ottawa – Canada)
- Pittsburgh PAAC (Pittsburgh – United States)
- Tri-County Metropolitan Transportation District (Portland – United States)
- San Diego Metropolitan Transit System (San Diego – United States)
- Sound Transit (Seattle – United States)
- Toronto Transit Commission (Toronto – Canada)
- Utah Transit Authority (Salt Lake City – United States)

International Bus Benchmarking Group

- Transports Metropolitans de Barcelona (Barcelona – Spain)
- Société des Transports Intercommunaux de Bruxelles (Brussels – Belgium)
- Dublin Bus (Dublin – Ireland)
- IETT Isletmeleri Genel Müdürlügü (Istanbul – Turkey)
- Rapid Bus Sdn Bhd (Kuala Lumpur – Malaysia)
- Companhia Carris de Ferro de Lisboa (Lisbon – Portugal)
- London Buses (London – United Kingdom)
- Societe de Transport de Montréal (Montréal – Canada)
- MTA – New York City Transit & MTA Bus (New York – United States)
- Régie Autonome des Transports Parisiens (Paris – France)
- King County Metro Transit (Seattle – United States)
- SMRT Buses (Singapore)
- Coast Mountain Bus Company (Vancouver – Canada)

American Bus Benchmarking Group

- Capital Metropolitan Transportation Authority (Austin – United States)
- Maryland Transit Administration (Baltimore – United States)
- Niagara Frontier Transportation Authority (Buffalo – United States)
- Charlotte Area Transit Systems (Charlotte – United States)
- Dallas Area Rapid Transit (Dallas – United States)
- Des Moines Area Regional Transit Authority (Des Moines – United States)
- Greater Dayton Regional Transit Authority (Dayton – United States)
- Lane Transit District (Eugene – United States)
- Mass Transportation Authority (Flint – United States)
- Foothill Transit (West Covina – United States)
- Hampton Roads Transit (Hampton Roads – United States)
- Jacksonville Transportation Authority (Jacksonville – United States)
- Milwaukee County Transit System (Milwaukee – United States)
- Orange County Transportation Authority (Orange – United States)
- Pittsburgh PAAC (Pittsburgh – United States)
- Regional Transit Service (Rochester – United States)
- Rhode Island Public Transit Authority (Rhode Island – United States)
- Greater Richmond Transit Company (Richmond – United States)
- Omnitrans (San Bernardino – United States)
- San Joaquin Regional Transit District (Stockton – United States)
- Pinellas Suncoast Transit Authority (St. Petersburg – United States)
- Spokane Transit Authority (Spokane – United States)
- Utah Transit Authority (Salt Lake City – United States)
- Clark County Public Transportation Benefit Area (Vancouver – United States)

RIAMBIG

Railway Infrastructure Asset Management Benchmarking Group

- Queensland Rail (Brisbane – Australia)
- KiwiRail (New Zealand)
- Public Transport Authority Perth (Perth – Australia)
- Sydney Trains (Sydney – Australia)