UITP ADVANCING PUBLIC TRANSPORT

REPORT

# BUS NETWORK PLANNING

## FROM THE OPERATORS' PERSPECTIVE

OCTOBER | 2022

International Association of Public Transport (UITP)
Rue Sainte-Marie, 6 | B-1080 Brussels | Belgium

Tel: +32 2 673 61 00
info@uitp.org
www.uitp.org

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## INTRODUCTION

*Public transport planning activities are usually unnoticed by riders but have a major impact on achieving high live quality standards in urban areas. Planners are not only in charge of the design of coherent and performant networks but organising a complex and delicate system of infrastructure, vehicles and people to serve customers year-round.*

*The higher floors of skyscrapers would never be visited without a system of elevators providing efficient vertical mobility. Beyond enabling the existence of the building, this form of collective mobility has a notorious positive impact on properties' value. Similarly, public transport provides the horizontal transport needed for cities to be sustainable, liveable, prosperous and efficient.*

*With such responsibility, public transport authorities and operators work very hard to plan the service of today and the networks of the future accompanying the cities in fulfilling citizens' mobility demands and meeting their carbon emission reduction targets.*


*London landmarks. © Bob Blitz, 2022*

# FOREWORD

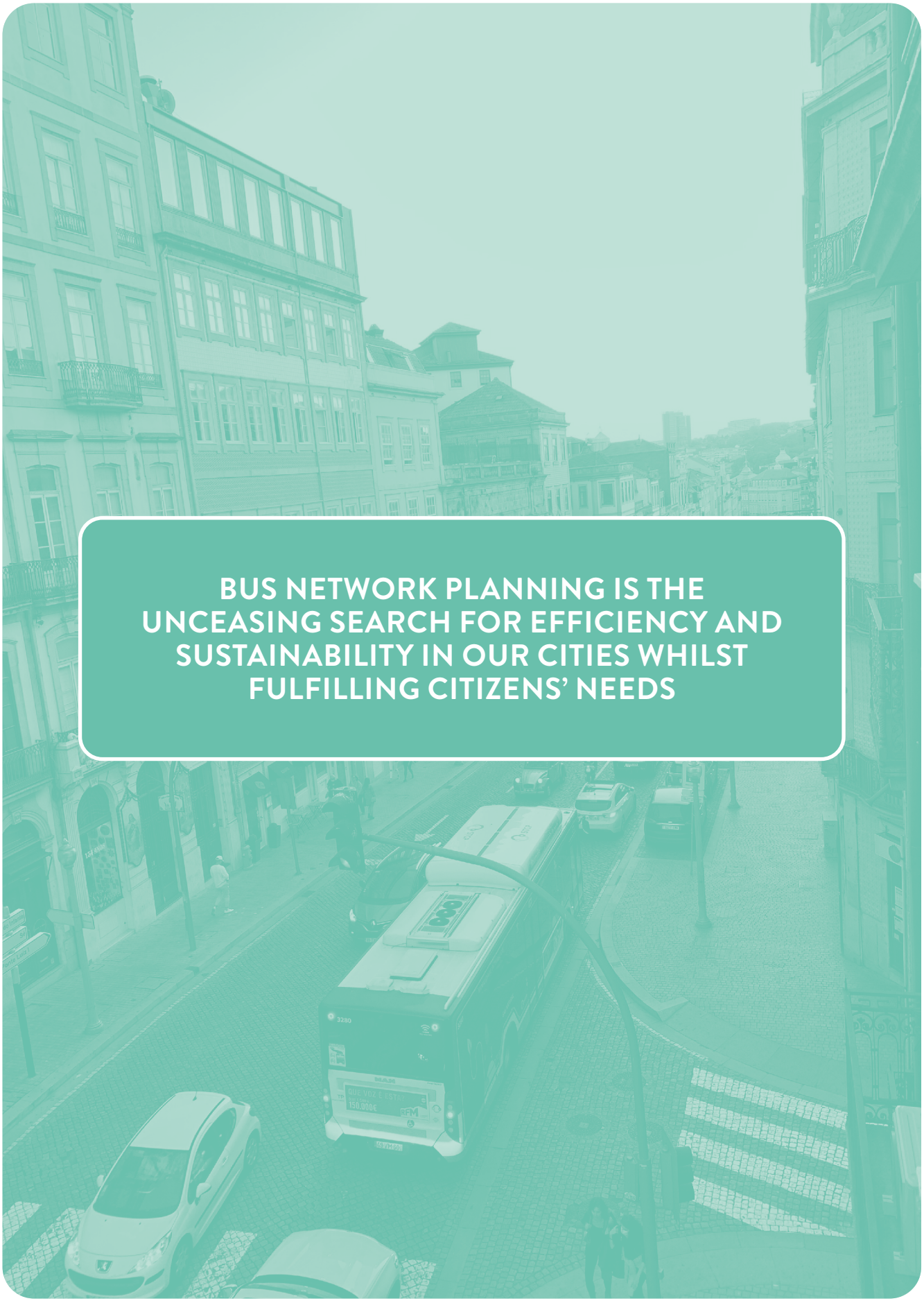
*Bus operators require outstanding planning to successfully achieve their objectives. Continuously ensuring public transport supply matches customers' needs and performs with high-efficiency levels are some of the bus operators' main challenges and activities.*

*Being a more and more professionalized position in public transport operators and authorities, the bus planner role has been taken to a next level, as the use of innovative and sophisticated planning tools and technologies allows for delivering richer and more flexible solutions to ever-evolving mobility needs.*

*Many different topics related to bus network and system planning are outlined in this document, aiming to raise awareness and foster further discussion on selected topics, while supporting fellow bus planners and cities to achieve a sound, efficient and customer-oriented bus system, that can contribute to improve the quality of life in our cities.*

*This document is a collaborative effort of the members of the UITP Bus Committee Bus Network Planning and BRT working group, along with many professionals within the UITP network who contributed with their expertise and experience.*

**ANTONIO GARCÍA PASTOR**
Director of Operations at Avanza Group ADO, Madrid
UITP Bus Committee Vice Chair, Bus Network Planning & BRT Working Group leader



**BUS NETWORK PLANNING IS THE UNCEASING SEARCH FOR EFFICIENCY AND SUSTAINABILITY IN OUR CITIES WHILST FULFILLING CITIZENS' NEEDS**

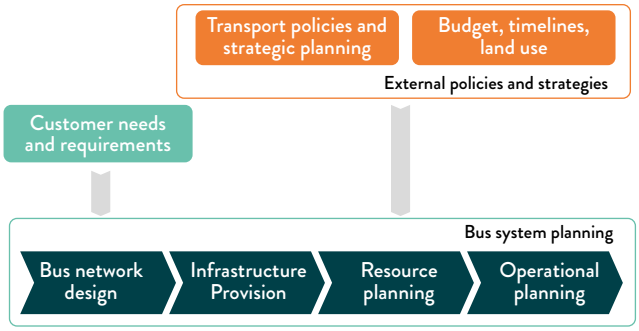
## DEFINITION OF LEVELS OF PLANNING: STRATEGIC, TACTICAL, AND OPERATIONAL

Bus network planning is addressing citizens' mobility needs and shortcomings through an outstanding bus network design, backed by an optimal bus system. The latter refers to the bus operators' internal affairs with a strong organisational and technical component, while bus network planning incorporates customer needs and policy drivers.

In other words, above and beyond the routes, stops, and headways, bus system planning is the exercise of preparing the bus service supply to meet a targeted level of service, within a fixed budget and a specific timeline.

It is worth mentioning that incorporating individual customers requirements and needs is often not achievable, thus this key input usually turns into an average, contributing to shape the public interest.

Figure 1. Bus system planning process




Transposing the strategic, tactical and operational approach to bus network planning looks like this.

Figure 2. Bus network levels of planning

| | | |
|---|---|---|
| **Strategic level** | | Example: bus network design |
| What system and design will be implemented? | General principles linked with customer needs and external planning | Definition of a bus network with headways and frequencies and stops |
| **Tactical level** | | Example: bus network design |
| How the system will be implemented? | Definition of services resources and quality levels | Detail of itineraries, and definition of LoS (punctuality, regularity, etc.) |
| **Operational level** | | Example: bus network design |
| How the system will be managed? | Operational and resource management | Detail scheduling and rostering, shifts management, AVL operational arrangement, safety provision |

Strategic planning usually falls under the responsibility of the public transport authority or regulator, and deals with the overall planning principles and ensuring the bus service meets citizens' needs. Tactical and operational planning is usually within bus operators domain, transposing the network planning requirements to vehicles and driver rostering.

However, the role of operators and authorities depends very much on the local context, and examples of regulator agencies with high degrees of involvement in tactical and operational planning can be found.

*Exclusive right-of-way for BRT bus in Bangkok. © Manel Rivera, 2022*

## THE POLICIES AND STRATEGIES INFLUENCING BUS PLANNING

Major bus network redesigns are within the frame of higher-level city or metropolitan development and mobility plans as well as other cross-sector plans such as air quality and energy transition.

Land-use master plans fix population density and land use mix objectives in cities, thus setting the form of public transport network design and patronage in the long term. Improving public transport supply through enhanced bus services among others is a quick tool to rise population density and liveability of an urban area, hence fostering prosperity.

Public transport boosted population growth and prosperity in cities, being London, Paris, New York, Munich and Vienna a representation of many examples. Indeed, accessibility through public transport is a key parameter in bus network planning, which keeps driving bus rapid transit implementations across the globe, and more importantly in the fast-growing cities in the global south.

In denser areas with sufficient public transport supply there is a higher propensity to opt for modes other than private cars. The shorter trip distances associated with high-density areas naturally lend themselves to walking and cycling. Higher-density areas also involve a high concentration of activities, thereby allowing public transport to efficiently connect those locations where the origins or destinations of trips are concentrated.[1]

Sustainable Urban Mobility Plans (SUMPs), in all their equivalent forms, are an instrument to boost the quality of life in cities through fostering and balancing sustainable transport modes.

Acting as the backbone of sustainable transport systems, public transport plays a key role in achieving greener and liveable cities around the world. For this, public transport operators need to play an active role in the definition of the mobility and land-use plans, contributing their first-hand experience, vision and needs.

In this position, public transport operators can contribute to the design of the public space by bringing in the public transport perspective, to ensure perfect synchronisation with pedestrians, bikes, and other modes to persuade drivers out of their cars.

High bus average speed and reliability levels are key to ensuring public transport accessibility and attractiveness. Should pedestrianization or traffic calming measures affect public transport performance, the envisioned reduction in private-car usage might not be achieved to the full extent, as the competitiveness of public transport versus cars would be constrained.

Figure 3. Share of total daily trips undertaken by sustainable transport modes – walking, cycling and public transport – of the total number of daily trips compared with urban population density in metropolitan area (horizontal axis). UITP 2015


1 UITP Mobility in cities database, 2015. Available for UITP members on MyLibrary

# BUSES AND TRAMS COMPLEMENT WELL WITH PEDESTRIANS AND CYCLING MOBILITY -IF DESIGNED ACCORDINGLY-

*Buses interacting with pedestrians in Gent. © Manel Rivera, 2022*

Buses are suitable for interacting with active modes in concrete environments, in the light of ensuring accessibility and providing efficient bus service satisfying everyone's mobility needs while keeping high bus network competitiveness levels. As a result, an increase is forecast for both public transport and active modes share, along with a reduction of car use within and towards low-emission zones.

Recommendations on this can be found in the 2017 'Ensuring Optimum Accessibility Of Pedestrian Zones' UITP policy brief.

Furthermore, clean technologies, in particular zero-emission vehicles, provide new opportunities for closer interaction between buses and the people around them. The demonstration led by Chalmers - with the support of UITP and Volvo - in the EC-funded project 'European Bus System of the Future 2'[2] in Gothenburg involved testing an indoor bus stop, leading to encouraging results.

*Indoor bus stop Chalmers Lindholmen in Gothenburg. © Vastrafik - Hakan Ludwigson, 2016*

*"A bus stop turned into a living room with lots of green plants, a place to meet, study or have a cup of coffee[3]."*

With this vision, UITP is an active member of Horizon 2020 EC-funded project SUMP-PLUS consortium to support cities bridging the gap between planning and implementation and contributing to putting mobility at the heart of sustainable urban transformation.

2 For more information: www.ebsf2-project.eu/demonstration-sites/gothenburg
3 For more information: www.chalmers.se/en/areas-of-advance/Transport/news/Pages/Passengers-turned-the-electric-bus-stop-into-a-living-room.aspx

## THE HOW AND WHY THE PLANNING PROCESS STARTS

A bus network is constantly evolving. As the most-flexible, high-capacity mode, bus routes undergo a metamorphosis from their creation until the point they give way to newer structures.

The stimuli for triggering bus routing metamorphosis are numerous and diverse. Performance is the primary driver for bus network planning, measured in terms of passenger satisfaction, network coverage, mode share or service efficiency.

Minor bus routing changes or stop location adjustments are frequent, and usually arise organically from operations' experience through observation and data analysis, enlightened by passengers and drivers' suggestions or are due to the continuous service monitoring by planning staff.

Zooming out, the need for capacity or service-quality improvement in a specific corridor leads to a focused analysis of a selected city area. Depending on the outcome of the study and the available resources, concurrent routes will be adjusted, coordinated and planned to increase overall capacity. Alternatively, a higher-capacity mode will be introduced, typically a BRT line.

### NANTES - FRANCE

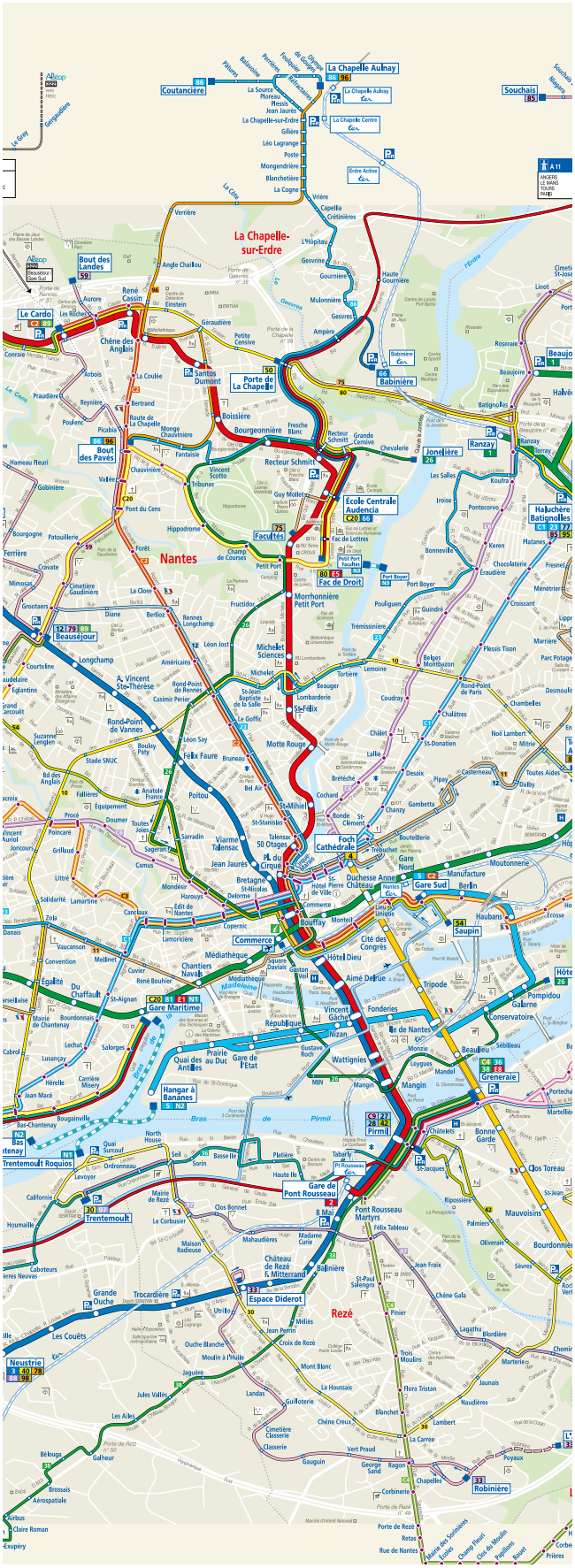
Nantes public transport network hierarchy was conceived and the most appropriate mode according to the forecast demand was chosen for each corridor.

Exclusive right-of-way tramway lines for corridors of over 40,000 passengers/day.

Exclusive right-of-way busway routes - similar to tramway lines - for corridors carrying 15,000 - 40,000 passengers/day.

Chronobus routes, benefiting from bus priority measures offering high-frequency services that increase the density of the high-capacity network, carrying between 5,000 - 15,000 passengers/day).

Complementary local and feeder lines for lower demand connections.




*Nantes' public transport network hierarchy mapped.*
*© Semitan, October 2022*

City or metropolitan area-wide bus network redesigns are rarely undertaken more than once in a decade, and typically follow a top-down approach. They start by establishing the main principles to meet the strategic goals, percolating into tactical and operational planning stages until implementation.

Many cities around the globe are undertaking major bus redesigns, to:

- Serve the customers better
- Improve overall network efficiency
- Increase public transport capacity
- Improve bus system's financials
- Rebalance the offer versus usage trade-off
- Improve integration of new mass-transit modes or extensions
- Maximise the return on new service contracts
- Embrace electric bus operations
- Adapt to new mobility demands and needs
- Accompany land-use planning and city growth
- Meet political will and programmes.

## BUS NETWORK PLANNING GUIDING DOCUMENTS

Guidelines are essential for any public transport agency. They are used to ensure that the transit agencies provide service that is in line with their mission. They guide agencies when developing and maintaining comprehensive, cost-efficient public transport service to meet the needs of those who live, work and travel in the service area. Guidelines provide structure for consistent and fair evaluation of existing and proposed services, by determining where, when and how frequently service should be offered. They ensure that finite resources are distributed where they are most needed.

Guidelines should be written in a way that they do not need to be changed frequently. As long as an agency continues to provide the same types of service, it should continue to use the same guidelines. For example, New York City has been using the same official guidelines since the 1980s.

Guidelines can address the following issues:

### SERVICE TYPES

- Route design guidelines determine the proper application of different routing patterns and determine when it is appropriate to introduce Bus Rapid Transport (BRT) and other premium services. They can also address:
  - the number of branches
  - direct or indirect route paths
  - Intermodal connections.

### COVERAGE DENSITY

- Service coverage guidelines help determine the appropriate spacing between bus routes considering population accessibility targets. These can include bus stop guidelines that identify the appropriate distance between bus stops on different types of routes.

### SERVICE SPANS

- Span of service guidelines identify the hours and days a local bus route should operate. These may vary according to the day of the week or season.

### SERVICE FREQUENCY

- Schedule guidelines establish the minimum service frequencies (known as 'policy headways') for bus services.
- Loading guidelines determine how much service should be provided, based on the number of customers at the route's busiest point.
- Some agencies have different guidelines for turn-up-and-go services versus those types where one needs to consult a timetable. Other agencies may vary loading guidelines by whether the service is a grid or a feeder. Feeder services can have higher maximum loads, as most customers board or disembark at the same stop.

### MECHANISMS FOR CHANGING SERVICE

- Service change guidelines specify the process for making major and minor changes to bus and subway service, such as changes in routing, stop patterns and/or hours of service.

### RELIABILITY

- Agencies can use service guidelines to set targets for reliability

### TEMPORARY SERVICE

- Detours caused by road works or other construction.
- Special events.

- Cost per passenger
- Agencies can set a maximum cost per passenger to ensure that the provided service is used.

Guidelines can also ensure that the bus service is aligned with the overall mission of the agencies or the city. For example, London's guidelines refer to the following goals:

1. supporting economic development and population growth
2. enhancing the quality of life for all Londoners
3. improving the safety and security of all Londoners
4. improving transport opportunities for all Londoners
5. reducing transport's contribution to climate change and improving its resilience

While guidelines are important, they should not be prescriptive. They can be infringed in the service of necessity or overarching goals.

## PATH TOWARDS A SUCCESSFUL IMPLEMENTATION

Overhauling a bus system is a complex task, one that implies numerous processes and key actions that should not be omitted in order to ensure successful implementation. It is out of the scope of this report to deliver an exhaustive checklist although some thoughts to support fellow bus planners in planning and delivering are provided.

*The best of plans won't work without proper implementation*

Acknowledging that, once the planning experts have delivered the final proposal and has been approved, the focus is to ensure a smooth and fine implementation. A bus network redesign implementation is most of the time a big project thus requiring a thoughtful project management approach.

### USERS AND CITIZENS

The main beneficiaries and those most affected by the changes in the bus service provision will be the public transport users and citizens in general. It is vital to analyse how these people are likely to respond to the proposed changes: which changes will be well received, and which may be perceived negatively. Acknowledging this will help design and perform the outreach activities.

### STAKEHOLDERS

It is important to identify and keep engaged the different stakeholders that will be involved during the change process. It is essential to ensure full coordination between the key actors during implementation: the municipality, the operator or operators, vehicle manufacturers, technology providers, communication and outreach agency, construction companies if infrastructure changes are involved, etc.

### TIMING AND SEQUENCE OF IMPLEMENTATION

Whether the new bus network is rolled-out at once or gradually, selecting the right time for implementing the planned actions also has a relevant share in the project's success. It is worth evaluating the possibility of sequencing several implementation phases, especially in terms of network performance during the intermediate phases before completion, to ensure a coherent and performant bus network is in operation at all times.

### COMMUNICATION CAMPAIGN

The communication campaign must be scaled according to the planned changes in the bus network. A campaign not reaching the users may generate dissatisfaction, complaints, and eventually a failed project. On the contrary, bombastic communication actions can also generate disappointment and frustration among users and citizens.

Besides, passenger information channels must be exploited to the maximum extent. Furthermore, due to its complexity, digital static and real-time information systems need special attention as experience shows a tendency to malfunction during the first hours or days of implementation.

### ADAPTATION DURING AND AFTER THE IMPLEMENTATION PROCESS

Because planning and deployment of a new bus network can expand for a long time, certain adaptability must be kept to accept the natural evolution of the city. The functionality of a street may have changed between the time a line was planned and the time this planning is executed. Also, room for minor changes has to be kept during the implementation process to accommodate uncaptured needs. This capacity for adaptation and quick reaction must remain after implementation to quickly react and refine the service as soon as operations yield sound and stable performance parameters and users' feedback.

# RELOCATING A SINGLE BUS STOP IS ALSO BUS NETWORK PLANNING

## RELOCATING A SINGLE BUS STOP IS ALSO BUS NETWORK PLANNING

Bus operators undertake bus system planning - and more specifically network planning - tasks on a daily basis. Although significant changes occur less frequently, bus services can experience minor tweaks for many reasons.

Regular bus services are constantly affected by both predictable and unpredictable incidents, which can force temporary or permanent bus route changes and prevent relocations. Public works, demonstrations, seasonal street activities, weekly public markets, are predictable events which impact on buses is known in advance and allows planning accordingly in order to minimise the effect on passengers.

Bus planners need to have an eye for detail. Stop location is a sensitive task, one that strongly impacts bus customers and the rest of the street users. Even during temporary bus stop relocations, a proper location for bus stops need to be ensured, meaning that it:

- Guarantees comfort, safety and accessibility
- Minimises dwell time
- Eases manoeuvrability
- Nurtures the public network effect, easing interchanges between bus routes and other modes
- Strikes the right balance between coverage and speed by appropriately distancing the stops
- Fosters commercial speed and regularity by ensuring seamless reinsertion of traffic
- Ensures safety for all other road users.

*Temporary bus stop in Budapest. © Manel Rivera, 2019*

Bus operators have in-depth knowledge of the local environment and have an interest in providing rapid and reliable bus services, both to increase attractiveness and reduce operating costs. Bus planning departments at the authority and operator levels must be part of the operational street design and traffic management working groups at municipal and metropolitan scales, to help ensure efficient public transport supply.

Furthermore, bus stops are often too close together, undermining bus competitiveness and the passenger experience by increasing journeys and waiting times. Therefore, striking the right balance between coverage and commercial speed is one of the key tasks for bus planners, one which has gained interest and support in the past years.

### TRANSLINK REBALANCING BUS STOPS PROJECT IN VANCOUVER, CANADA

**In metro-Vancouver, bus stops are too close together.** TransLink aims for stop spacing of 300 to 800 metres for frequent service. This is equivalent to a five- to ten-minute walk between bus stops. However, two-thirds of bus stops are closer than this - sometimes appearing twice on the same block.

**Distances between bus stops affect travel time.** When stops are too close together, it increases the length of the trip for everyone. By carefully removing stops, TransLink can reduce the amount of time buses spend weaving in and out of traffic to serve bus stops.

**Travel time affects customers and operating costs.** TransLink buses spend one-sixth of their time at bus stops. That adds up to more than 700,000 hours or about $73 million CAD in operating costs each year. Making a small change in stop spacing can have a large impact on operating costs. Balancing bus stops on 25 of the most frequent routes could save TransLink up to $3.5 million CAD per year.

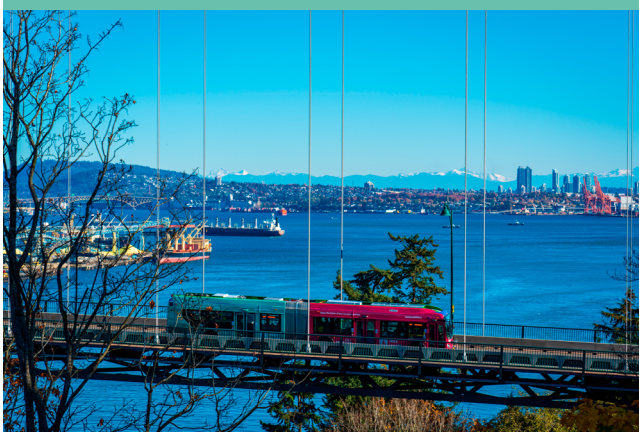
**Balancing bus stops is a win-win proposition.** For TransLink customers, bus stop balancing means shorter travel times, more reliable services, a more comfortable ride. It also reduces operating costs, allowing for reinvestment in longer service spans or higher frequencies. For cities, businesses and residents, bus stop balancing means more kerb space that can be used for patios, bike racks, pedestrian bulbs, queue jumps, short-term loading zones or on-street parking.

**Bus stop balancing requires careful trade-offs.** TransLink considered many factors in depth to strike the right balance between convenient access and reliable service. These included accessibility, customer safety and comfort, topography, service type, distance between stops, adjacent land use, stop usage and transfers. TransLink also analysed demographic data to ensure that its proposal would not disproportionately affect seniors, people of colour or low-income households.

**TransLink pilots changes with input from key stakeholders.** TransLink develops proposals with input from key stakeholders including bus operators, municipal staff, business improvement associations, schools and parent advisory committees, senior living and activity centres as well as medical centres. It also posts signs at stops that directs passengers to an online survey. TransLink revises the proposal based on feedback received, and pilots bus stop changes for six weeks. Based on feedback and results, TransLink then determines which stops to change permanently.

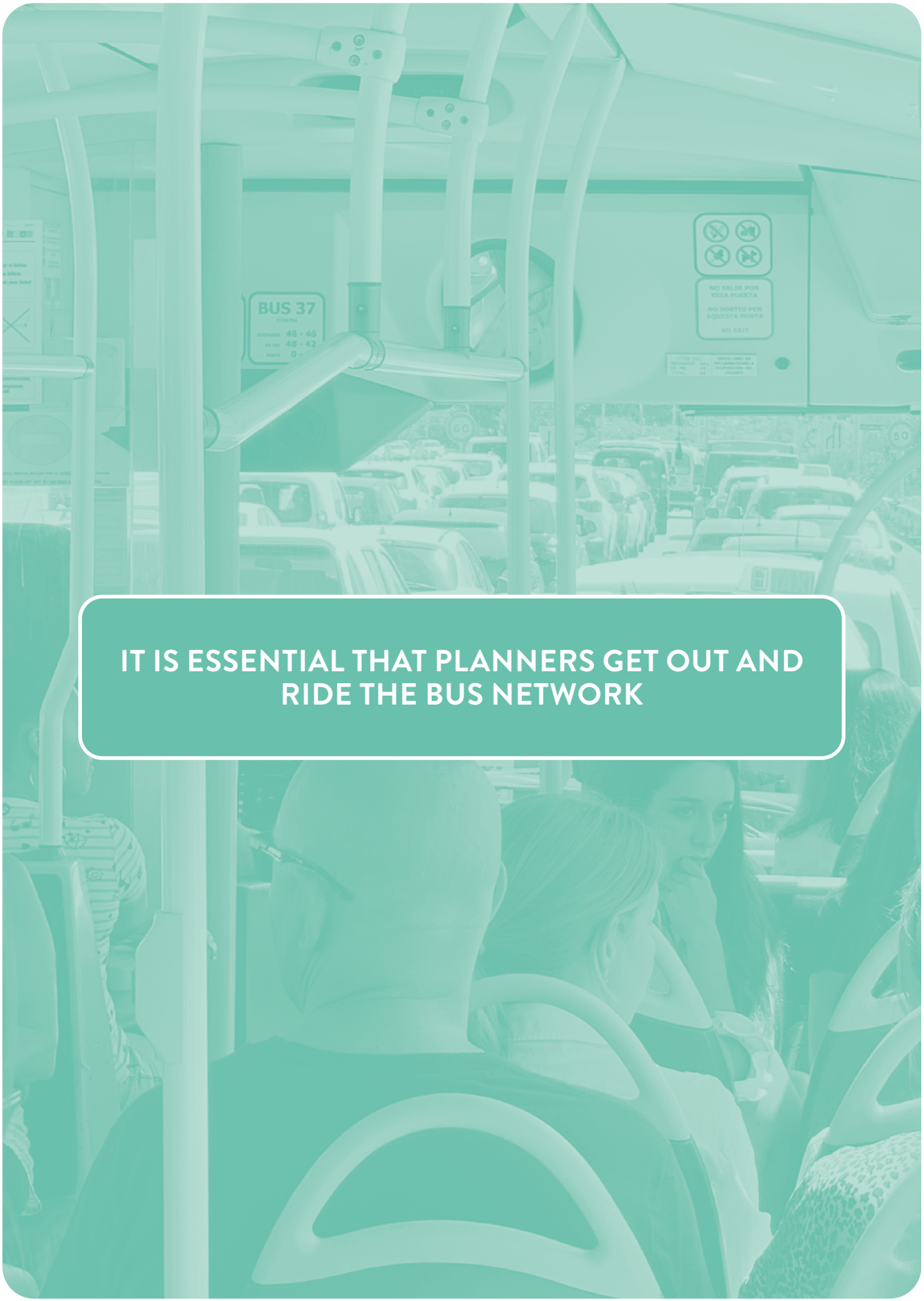
**Bus stop balancing has reduced travel time and operating costs.** Since 2020, TransLink has balanced bus stop on five routes. This has saved riders up to ten minutes per round-trip at the most congested times of day. It has also reduced peak fleet requirements and saved $700,000 CAD in annual operating costs. These savings will be used to introduce a new bus route.


*An example of signage informing customers of the change and asking for feedback. In neighbourhoods with a high proportion of people who don't speak English, signs were translated. © Translink*



*Translink bus driving through Lion Gate Bridge in Vancouver. © Lee Liu, 2022*


*Vancouver bus routes 4 and 7 bus stop balancing map. © TransLink*




**IT IS ESSENTIAL THAT PLANNERS GET OUT AND RIDE THE BUS NETWORK**

## SPOTLIGHT THE ROLE OF BUS PLANNERS

In a planning authority and bus operator, bus planners are the key individuals for making a bus service change happen. This makes their recruitment a key factor in the success of a bus network. Generally, they will have a wide range of responsibilities depending on their level of seniority, but will work on developing strategies, policies and detailed tactical plans for bus service changes.

At most levels, bus planners would be expected to have a university degree in a relevant discipline or equivalent experience and often a post-graduate qualification. They will need strong analytical skills and good written and verbal communication skills. Given the amount of data involved, they will need excellent data collection and analysis skills with the ability to research and interpret the outputs. Increasingly, more specialist planners will have more advanced coding skills for data analysis, rather than relying on simple tools such as Excel. They would need a detailed understanding of the range of modelling and analytical techniques used in transport planning, the ability to direct their use appropriately and detailed knowledge of business case principles and an understanding of how they should be applied.

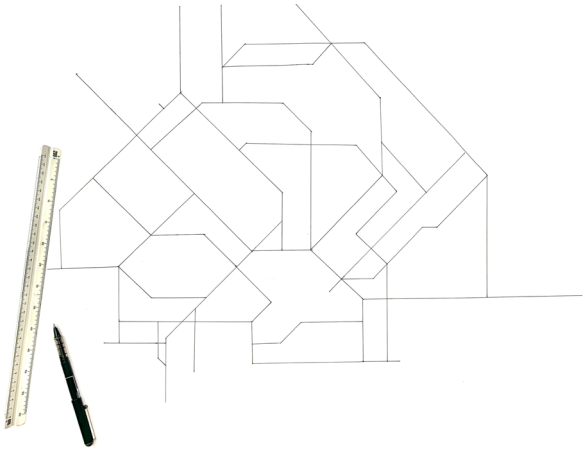
As well as data skills, they would be expected to have a knowledge of public transport issues in general, the structure of the public transport industry and the characteristics of their local travel market. Gaining hands-on knowledge of bus operational issues, governance of their authority, and the various national and local legal processes required to undertake service changes is also recommended. They will have a grounding transport principles and applications in general, and in particular in public transport service planning and reliability issues as well as the metrics for measuring these aspects.

Bus planners need to be skilled problem solvers, capable of resolving complex issues with skill and judgment and the ability to think clearly under pressure. They will often be working on a number of projects simultaneously, so will need to be capable of managing workloads and adopting a flexible approach to problem solving.

Planners often need to prepare their plans within tight timescales. They need to build working relationships, both with colleagues such as those in the operational areas and with external stakeholders being mainly customers, selected user groups and public authorities to achieve the desired outcomes. At a more senior level, they will need the ability to influence key decision makers and successfully facilitate joint decision making, including building and securing stakeholder support for service changes, across and outside the planning authority.

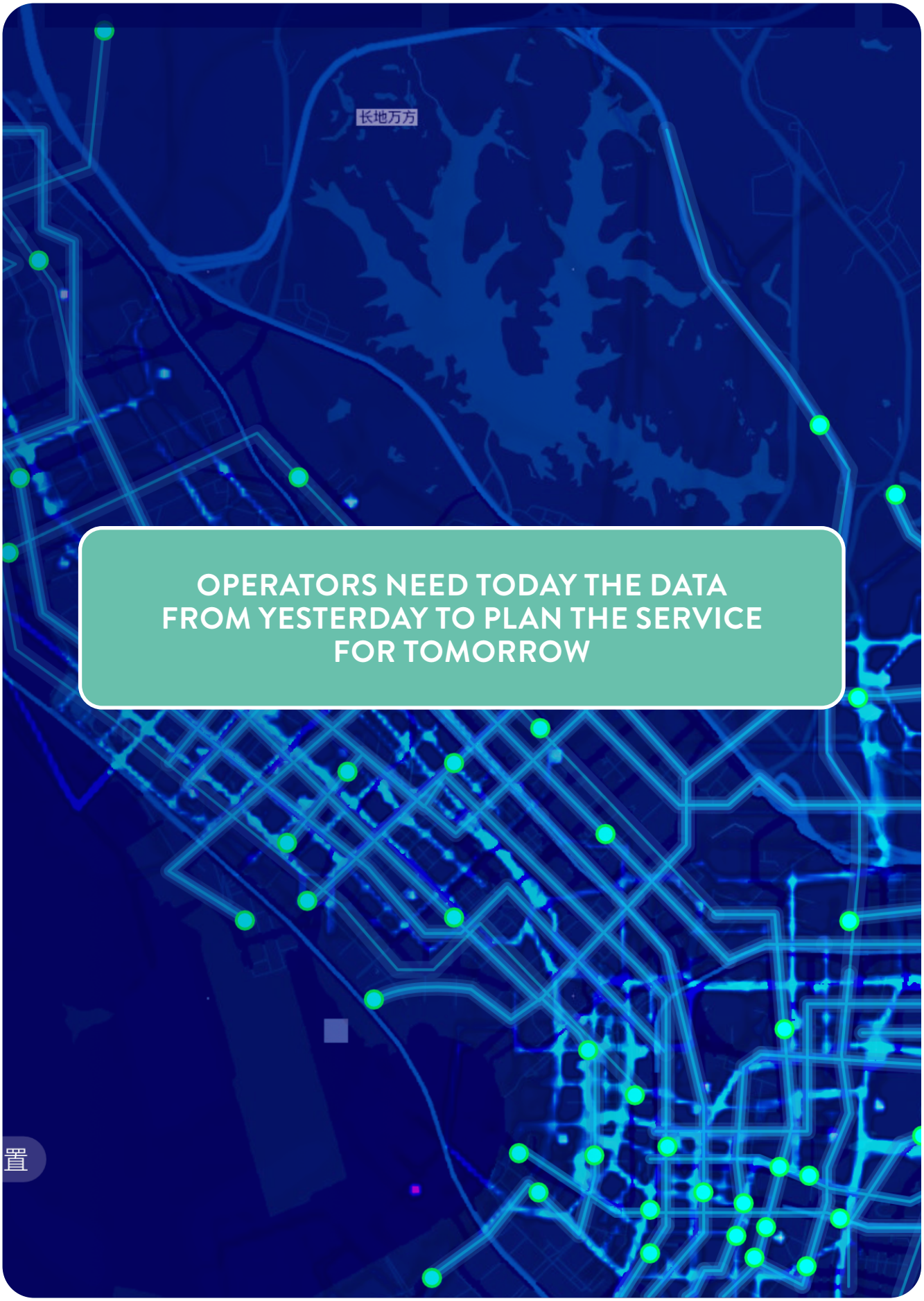
With the rise in hybrid working, planners can increasingly be based at home, but it is essential that managers encourage the planning staff to get out and ride the network they are working on. That way, they can experience first-hand the problems and challenges of bus travel at different times of the day.

Recruitment and retention of people with such varied skills can be difficult, as there is competition for these abilities, and public authorities generally cannot match salaries offered in the private sector. However, most bus planners are highly motivated in the specialist work they do, and will often accept slightly lower salaries in return for the job satisfaction their chosen career provides.



*Bus network sketch. Manel Rivera, 2020*


*Customer information signage in Barcelona, © TMB.*




**OPERATORS NEED TODAY THE DATA FROM YESTERDAY TO PLAN THE SERVICE FOR TOMORROW**

## THE IMPORTANCE OF DATA-DRIVEN DECISION-MAKING

### MONTREAL - CANADA

In Montreal, Canada, an origin-destination survey has been carried out every five years since 1970; the 2018 edition was the 11th of its kind. Up to 6,000 people were requested to fill an online questionnaire in addition to the 71,000 household surveys undertaken by phone[4].

The dataset provided by these 11 editions provide a reliable baseline for transportation planning in Greater Montreal. It optimises alignment of policies, public transport projects and bus and rail services to the residents' needs.

Keeping the frequency and format of the data collection is key to ensuring a manageable and comprehensible analysis of mobility trends.

As well as traditional household surveys, digitalisation and smartphone market penetration have opened a wide range of possibilities that impact public transport and more specifically bus network planning.


*Passengers boarding a bus in Montreal. © STM, 2012*

Public transport operators and authorities rely constantly on complementary data sources to monitor operations and service schedules. The outcomes of thorough service monitoring and reporting through data are inputs for planners to draft further network improvements. These data sources include:

- Ridership data
  - smart transit and EMV card data: only boarding time and location are generally available. However, some agencies use tap-in and tap-out strategies for distance-based fare collection, leading to accurate origin-destination data.
  - automatic boarding and alighting counting devices
- Operations data from automatic vehicle location systems
- Vehicle-state data from the CAN bus
- Real-time and recorded onboard and traffic images
- Data collected from smartphone agencies' apps
- Origin-destination on-board surveys
- Household surveys
- Anonymised mobile data from the mobile network operators
- Road and stations infrastructure availability and changes
- Population density and demographic data.

Continuous service monitoring through flexible data analysis and visualisation tool allows bus service adaptability, allowing minor improvements to be introduced that can serve customers better and improve efficiency.

*"Periodic assessments update the routes' schedules to better match the demand and ridership patterns."*

*Sarah Wyss, MTA New York*

Besides the vast data sources available, it is also important to have an excellent long-term data collection and analysis strategy, one that will ensure a high-quality dataset for analysis, model calibration and forecasting of the performance of potential new service scenarios. Moreover, Covid-19 crisis strengthened the need for agile and trustworthy data analysis in extremely dynamic times to adapt the bus supply to the needs in the shortest possible time.

Of course, such a strategy must embrace operators' specific needs and tackle the contemporary challenges of dealing with such a significant amount of data: rationalise data collection and ensure efficient usage.

4 Please add footnote: https://www.artm.quebec/origin-destination-survey/

## DATA-DRIVEN PLANNING AND SERVICE MONITORING IN SHENZHEN, CHINA

Shenzhen Bus Group Operations Department is constantly reviewing the operational data collected, including passengers' origin-destination matrix. It produces a time-based passenger heat map to properly adjust the service scheme.

For intelligent planning and operations, the hardware is as important as the software. While procuring new vehicles, the operations, technical and new energy, safety management, and IT departments work closely together to come up with a list of equipment for collecting information and assisting the daily work of departments and fleets. Equipment includes cameras to provide live video feeds from both inside and outside the vehicle for further analysis along with sensors to collect various data from different parts of the vehicle. This information is consolidated with the Controller Area Network (CAN bus) data and transmitted back to the servers via a SIM card.

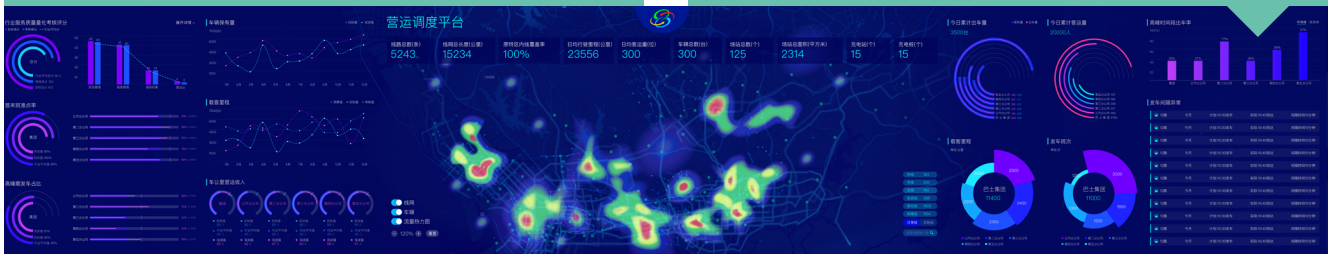
The software, on the other hand, can be considered as more of a separate component in terms of procurement and application. Shenzhen Bus Group (SZBG) began procuring and developing its own management software for the departments and fleets back in early 2000. At the outset, the software was actually standalone, and there was no back-and-forth data communication. In order to enhance work efficiency, SZBG began its own development and requiring developers to leave out APIs for data communication between systems and buses and for other extended applications. SZBG later installed a group of servers and started the intelligent transportation platform data visualisation project. This makes the data more accessible and readable for multiple departments.

The operations department use the tool to ensure passengers´ needs are accommodated and to maintain high service quality standards. To do so, the operations department crosschecks ridership data and the planned service supply, in order to verify routes performance. The platform can also provide previous day ridership in a 3D visual, with ridership on the Z-axis, and location and time on the X- and Y-axes respectively, to help the dispatcher fine-tune the service through easy-to-read data.


*SZBG service monitoring dashboard. © Shenzhen Bus Group*

The bus network planning team benefits from a passenger heat map, built upon origin-destination data classified in 30 minutes time blocks, helping decision-makers to effectively evaluate bus network expansions and route changes.

On top of data-based analysis, SZBG has installed seven cameras on the vehicles, looking to the front, back, doors, driver and passenger cabins, to provide a remote real-time look-and-feel for the bus and network performance.




*SZBG service monitoring dashboard. © Shenzhen Bus Group*

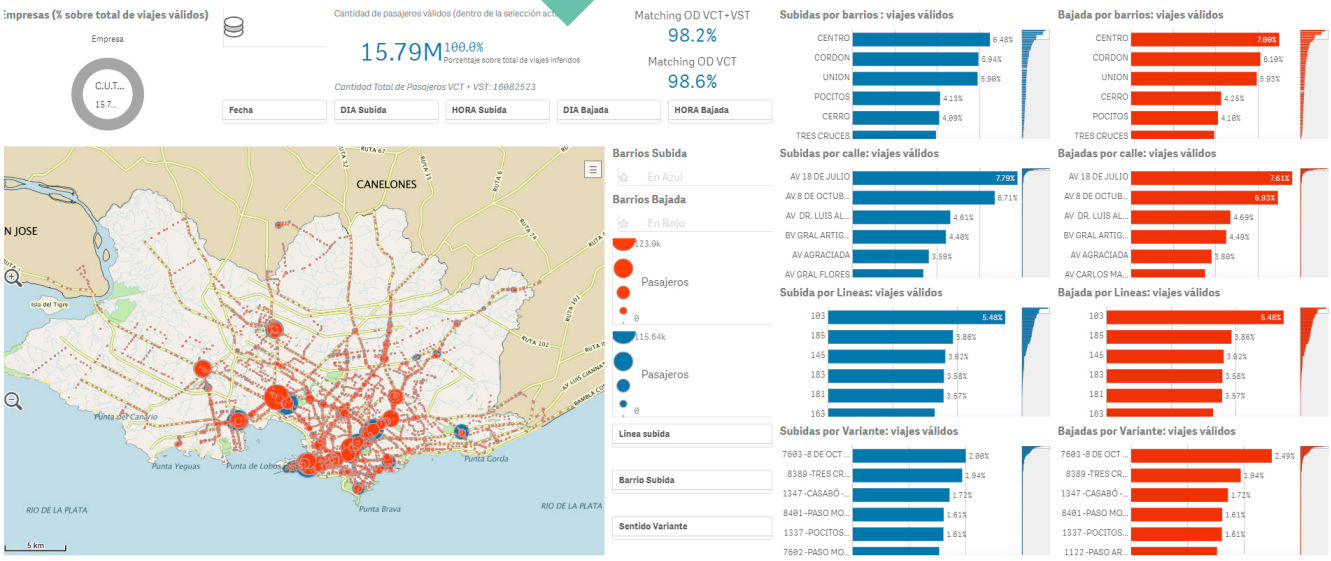
## REMARK FROM MONTEVIDEO, URUGAY

On the other side of the globe to Shenzhen, Intendencia de Montevideo in Uruguay commissioned an algorithm to reconstruct the origin-destination matrix based on recurrent trips, achieving 93-95% of accuracy with respect to field surveys and observations. Cutcsa, the main bus operator, who already participated in calibrating the algorithm, is currently extensively exploiting smartcard data for continuous bus service patronage monitoring.

*"Using this fine algorithm, we have the opportunity to deeply analyse our customers' behaviour to ensure our bus network is updated to their mobility needs. Beyond figures and spreadsheets, the software allows us to understand through pre-set charts and geographic information tools passengers' boardings and off boardings in an area, track transfer patterns, or visualise travel behaviour for different days of the week, specific dates, and time"*

*Álvaro Santiago, Deputy Manager at Cutcsa*


*Electric bus in Montevideo. © Cutcsa*




*Cutcsa data analysis visualisation tool. © Cutcsa*


*STIB - MIVB electric bus charging in Porte de Namur-Naamsepoort terminus in Brussels. © Manel Rivera, 2022*

## PLANNING FOR ELECTRIC BUSES

Introducing battery-electric buses is a paradigm shift for how operators understand their operations, as dedicated charging infrastructure will be needed for the first time. Electric buses have a major impact on bus system planning, and require a holistic approach to ensure a smooth transition from diesel or natural gas operations to zero-emission bus operations.

Transitioning to electric bus operations provides an opportunity to rethink the bus network and to improve traffic conditions for public transport vehicles.

Of course any bus will perform better on routes featuring bus priority measures, although the effect on battery-electric buses might be even greater. Currently, planning for electric buses has a lot to do with range, thus reducing braking and acceleration efforts which drain battery reserves helps optimise the electric bus design, reducing its cost and eventually increasing the vehicles' capacity.

Battery electric buses imply new ways of financing and procuring, and are heavily linked to smart charging infrastructure, particularly when opportunity-charging strategies are adopted. As a result, this has a major impact on how bus services are planned and operated on a daily basis. Bus routing and scheduling require greater assistance from IT tools incorporating new e-bus-related variables, while bus planners are acquiring new skills through dedicated training.

In a nutshell, the IT tools used for scheduling need to incorporate these new variables:

- the battery characteristics of the vehicles
- the state of health of the battery
- the availability of charging infrastructure defined in strategic and system deployment plans
- charging strategies
- passenger loads and line profile.

These IT tools help operators increase the mileage load on electric vehicles, always according to the design range, and avoid assigning the electric buses to the shorter shifts only.

In addition, planning for an electric bus system must include the energy supply and grid access perspective. It is worth learning from the experience of the Netherlands, where following the Paris Agreement, a rapid electrification of transport fleets and other activities has been achieved. However, the electrical power grid has reached its maximum capacity for supplying electricity to large consumers. This is impacting electric bus system planning and operations, as the charging infrastructure for electric buses is not 100% fulfilling the service need.

While major investments on the power grid are planned for the mid to long term, bus operators and authorities in the Netherlands are currently implementing peak shaving measures, adding constraints to the bus system planning activities.

5 For more information: www.assured-project.eu/

## UPCOMING TRENDS IMPACTING BUS NETWORK PLANNING

Bus systems are undergoing a massive transformation, mainly driven by the transition to zero-emission drivelines but also impacted by fast-paced technology developments, social trend changes and mobility environment evolution.

Bus operations are unavoidably affected by the culture of immediacy, and bus planners are no exception. They are coping with the transformation of urban mobility priorities, which has seen obsolete bus network layouts being revamped one after another.

New bus networks for new mobility trends, less overall car-dependency, are – in many cases - evolving from complementary services to networks capable of leading the transition towards less-polluted and cleaner cities.

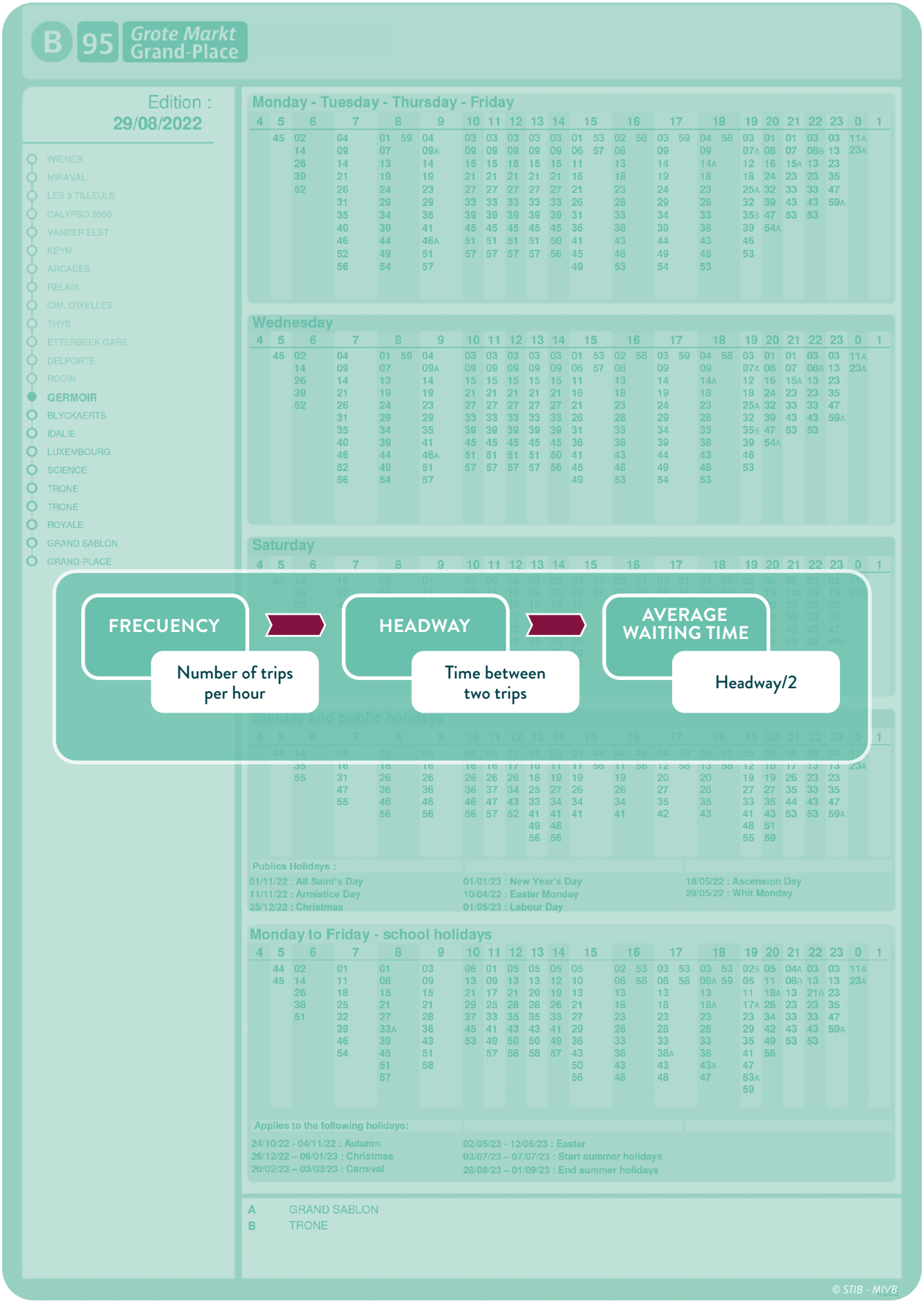
With an eye on system efficiency, customers are more than ever at the centre of the planning task. Bus planners are acquiring new skills, bringing professionalism to the bus planning sector around the world, and are increasingly using advances in technology to assist them in tailoring bus services to the identified passenger needs.

Of course, the COVID-19 pandemic brought changes in mobility patterns, some temporary, some more permanent. These have urged bus operators and authorities to adapt their services to these new scenarios, rebalancing their offer and the supply.

Here, some new trends and technological advancements are acknowledged.

- Bus operators are frequently fundamental actors in **intermodal transport chains**. This is being boosted by integrated planning and made real by a network of state-of-the-art mobility hubs, formerly understood as interchange hubs from a public transport perspective. Providing standardised seamless route finding and ticketing tools enhance public transport use, to be accompanied by a bus service supply increase when needed. In addition, digital routing tools reduce the need for network knowledge during trip planning, clearly influencing users' route choices.
- **Ride-hailing and transport on demand** bring the opportunity for increasing public transport coverage in low-density areas, complementing higher-capacity bus or rail services in urban and suburban areas.
- **Digitalisation,** through powerful planning software and data sources, is adding considerable momentum to innovative planning tools, taking bus planning practice a step further.
- The mass rollout of **battery-electric buses** is bringing a tremendous amount of new, never-seen-before constraints and variables to bus system planning.
- **Bus automation,** currently present in the form of low-capacity shuttles in specific applications and with few standard bus prototypes, will certainly impact the bus system planning. However, no major effects on bus network design are foreseen at this stage.
- Cities providing **fare-free public transport** services are increasing in numbers. Well-known examples are Tallinn, Luxembourg, and more recently the zero-lines in Madrid among others. Moreover, waiving the public transport fares (yet as a temporary measure) has been accelerated in the last months as a measure to tackle the effects of the energy and inflation crisis on citizens. Certainly impacting ridership absolute numbers and bus usage patterns, the bus network planning practice must forecast any disruptive effect by capitalising on existing experiences.


*EMT Madrid bus at night. © Manel Rivera, 2019*




FRECUENCY → Number of trips per hour

HEADWAY → Time between two trips

AVERAGE WAITING TIME → Headway/2

*Public transport-oriented roundabout in Aalsmeer. © Aerovista.*

## WHAT OPERATORS NEED TO BE EFFICIENT

Commercial speed is strongly correlated with bus efficiency and quality of service, as does regularity, heavily impacting passengers' average waiting time.

Under ideal conditions, the average waiting time is mathematically half the headway. However, real world scenarios are very different. Road traffic conditions and operational incidents add some variability heavily impacting passengers' waiting time and crowd management on buses.

*Average Waiting Time*$=(H/2)\times(1+C_{v,h}^2)$ where H is the bus route headway and Cv,h is the coefficient of variation of headway.

Minimising $C_{v,h}$ is a collective responsibility of authorities, operators and street designers to ensure bus service regularity. Assisted by strong political leadership leaning towards public transport-friendly cities, intensive collaboration between public transport authorities, operators, and city technical officials is encouraged to tackle the bottlenecks for efficient bus service and for incorporating bus priority measures in new developments and street redesigns.

### *Speed up buses*

Increased commercial speed means:

- Increased frequency with the same number of vehicles and drivers.
- Shorter trips and improved bus mode competitiveness.
- Increased revenue collection with small added marginal costs per kilometre.
- Reduced braking and acceleration, which helps reduce energy consumption, thus extending the range of electric buses and decreasing tailpipe emissions.
- Safer buses, by protecting bus drives with high-quality exclusive right-of-way lanes and other priority measures.

It is worth reminding some public transport-oriented street design best practices that are quickly appreciated and embraced by bus ridership.

## STRAIGHT ROUTES, EFFICIENT NETWORKS

Routes should be as straight as possible, avoiding wandering through the city and facilitating high average commercial speeds.

## MULTI-LEVEL BUS NETWORK IN BEIJING

① Express lines: Providing mass transit services to high population density areas, particularly to those not covered by the metro network.

② Regular lines: acting as the main body of the bus network, this is a dense network of high-frequency lines.

③ Feeder lines: a set of short and flexible routes, providing services in the neighbourhoods to and from nearby public transport hubs.

## BUS LANES AND QUEUE-JUMPING STRATEGIES

High-quality bus lanes are those that are properly designed and indicated, wide enough for buses to run safely at a constant speed and protected from traffic turns and illegal occupation.

### Voie Unique working group

Since 2020, the French institute Cerema has hosted a working group on benchmarking reversible single bus lanes in French speaking countries, with the participation of cities in France, Luxembourg, Belgium and Switzerland. This has been closely followed by UITP.

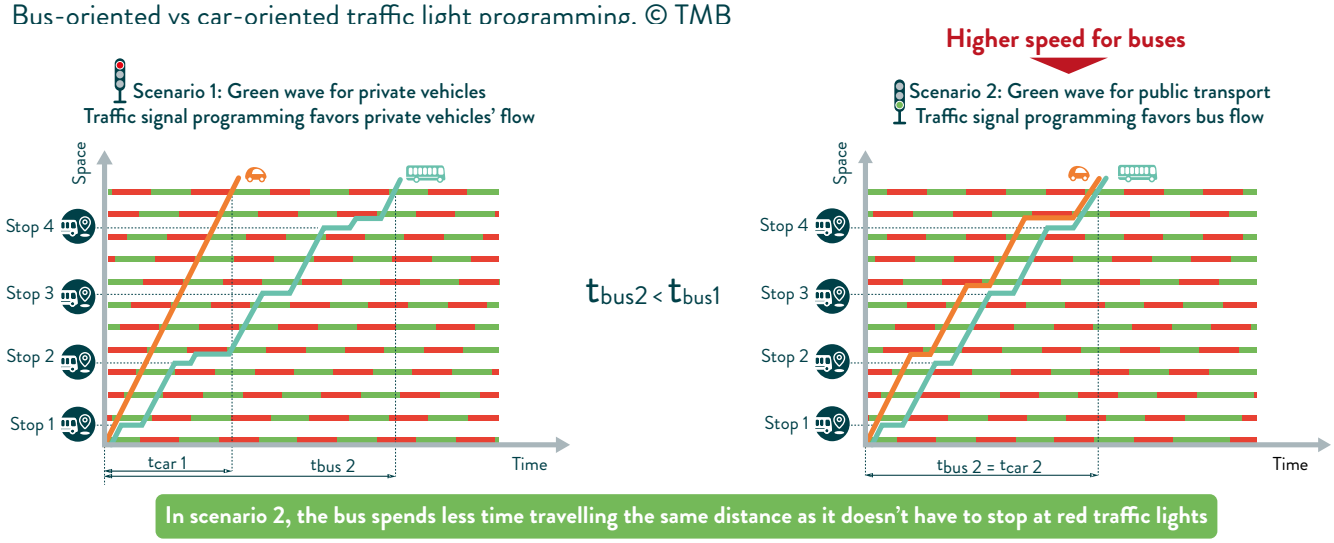
Conscious of urban space scarcity, the expert group is focusing on the benefits of reversible single lanes for improving bus service performance. These grant exclusive right-of-way to buses driving on congested narrow roads. From technology-free visual driving for short sections to advanced traffic signal management, many lane dispositions and configurations are being tested in many cities in France and beyond.


*Counterflow protected bus lane in Valencia. © Aida Abdulah, 2022*

### *Car-traffic green waves unavoidably backfire on buses*

Every time buses stop for picking up and alighting passengers, public transport vehicles lose green waves pace, facing red lights after each stop. Considering commercial bus speed in traffic light programming and management automatically increase bus speed when bus lanes are in place. Using technology to allow traffic signals to favour buses actively is strongly encouraged. This will optimise bus services and, more specifically, electric bus range.

Bus-oriented vs car-oriented traffic light programming. © TMB




**In scenario 2, the bus spends less time travelling the same distance as it doesn't have to stop at red traffic lights**

## PASSENGER-ORIENTED BUS STOP DESIGN

Beyond being a waiting point, bus stop placement and design play a key role in the perceived quality of public transport and bus service speed and reliability.

It is desirable to review the bus stop condition throughout the network in terms of:

- overall bus stop spacing and nearby mobility attractors/generators
- prioritisation of the transfer stops to enhance the network effect
- barrier-free access to the stop and to board the vehicles
- quality and safety of the waiting space: lighting, bus shelters, high quality information and so on
- burden on bus commercial speed and service reliability
- ease of manoeuvrability for drivers.

The results of the assessment should see the drafting of a bus stop upgrading plan. This should immediately be executed to reach 100% universal accessibility and high standards of safety and waiting conditions quality across the bus network.

## MULTIPLE STOPS

On busy bus corridors, allowing two or more buses to stop simultaneously optimises bus lanes and intersection capacity, directly reducing journey times and improving regularity.

## ALL DOORS BOARDING AND EFFICIENT FARE COLLECTION SYSTEMS

Allowing users to board and alight buses through all available doors speeds up buses and increases capacity by allowing the optimum distribution of passengers in the vehicles. The number of doors and their positioning should encourage an optimum flow of passengers within the vehicle to reduce dwell time and increase passenger comfort. There should be seamless validation, thus eliminating onboarding delays.

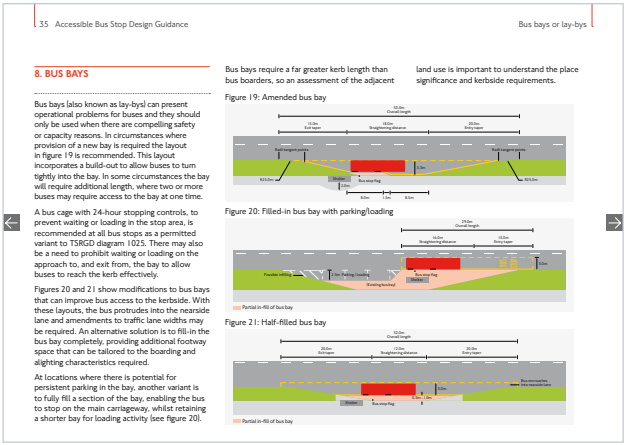
## GUIDELINES

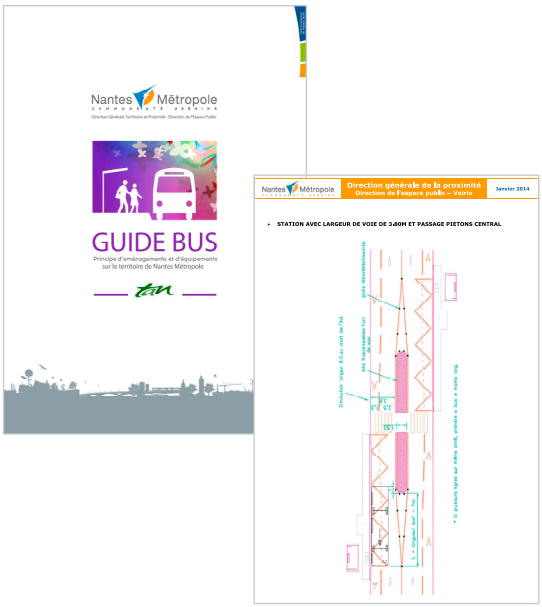
Bus-friendly street design guidelines contribute to ensuring long-term bus priority measures and bus stop quality, accessibility and performance enhancement. Although street design guidelines are heavily dependent on local and national road design principles, capitalising on international benchmark best practices and peer knowledge exchanges is encouraged to advance public transport quality standards.

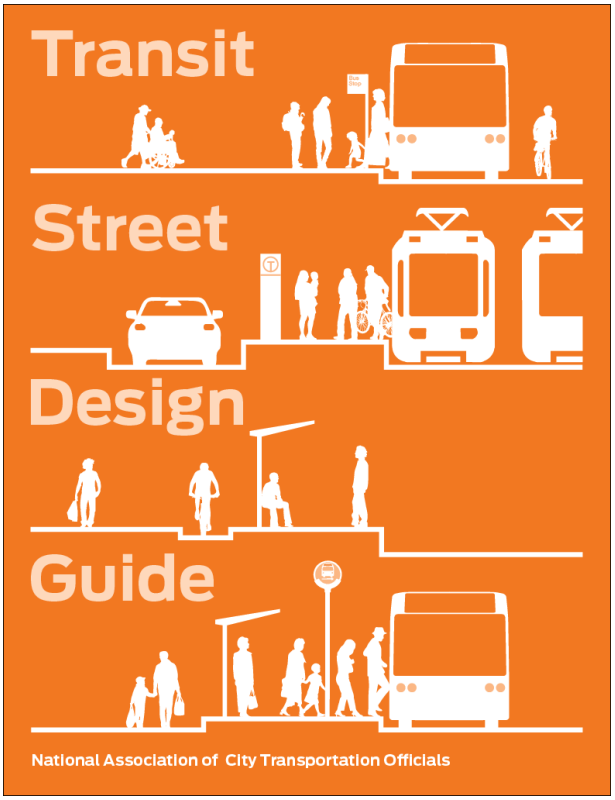

*Kassel kerb in Kassel central station bus stop. Kassel kerbs allow buses to better approach the kerbside at stops achieving full accessibility while minimizing the impact on tyres. © Manel Rivera, 2022*


*Multiple bus stop in Barcelona. © Manel Rivera, 2019*







*Examples of bus stop and public transport-oriented guidelines. © TfL, Nacto, AMB, Nantes Métropole*

## UPDATE ON THE NANTES ELECTRIC BRT

Nantes Busway was set up to complete the core backbone of the Nantes Metropole public transport network made of three tramway lines and one BRT line with similar quality standards but at a lower cost. Interestingly, the infrastructure was designed to allow conversion to light-rail mode whenever passenger demand justified the upgrade.

The BRT implementation allowed the service to be optimised, capturing some of the benefits of bus priority measures:

- Major improvement in quality of service (average commercial speed from less than 16 km/h to more than 20 km/h.
- Ridership doubled within seven years.
- Service punctuality increased from 75% to 95%.
- Optimised OPEX and CAPEX costs.

Compared to light-rail:

- Busway obtaining better perceived quality punctuation compared to tramway lines (8.1/10.0 vs 7.3/10.0).
- Greater operation's flexibility thanks to less-specific systems and operational benefits such as the possibility of overtaking.
- Lower CAPEX: Additional investment of €140m (infrastructure + vehicles) would have been needed in 2006 for light rail to achieve the same level of service.
- Lower OPEX: Lower maintenance costs lead to €0.7m savings per year for BRT compared to equivalent tramway operations in Nantes.
- Bus mode offered 50% lower capacity than tramways, hence less revenue per driven km.

*Nantes busway, © Semitan*

*Flash charger in Nantes. © Semitan*

Following ten years of operation, a lack of capacity on the line began to burden the competitiveness of the public transport corridor. Overcrowding drove a rapid decrease in riders' perceived service quality, with 2019 receiving the worst assessment since implementation.

In 2016, a project to increase the corridor capacity was initiated. As a result, natural gas articulated buses gave way to 22 electric double-articulated buses and 12 high-power opportunity chargers on multiple stops along the route were fully operational in 2020. The need for upgrading the system capacity, along with the readiness of e-bus technology, allowed Semitan to become a frontrunner in e-BRT deployment and operations.

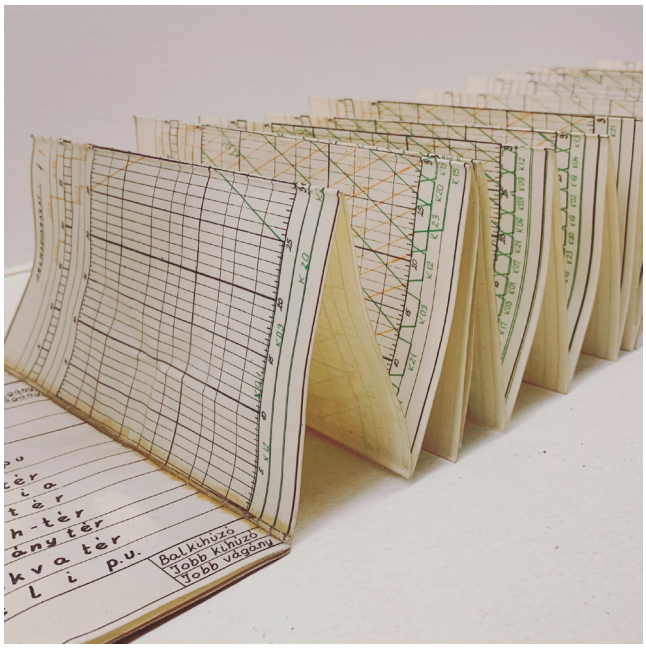
Among the key objectives of the upgrading project was to increase capacity by 35%, and to prove that electric BRT operations following a flash charging strategy had no impact on OPEX in Nantes' system.

An average of 4.5 minutes of high-power (600 kW) chargers per roundtrip are enough to deliver the vehicles' energy needs. Here, electric bus operations showed no adverse impact on vehicles' travel time. The system does not require overnight charging at the depot.

Optimal electric-bus operation conditions are provided by BRT features; that is, almost constant average driving speed with no stops at crossings, service regularity leading to uniform load distribution among vehicles and efficient driving skills. This has delivered excellent consumption rates for 24-metre-long electric buses of 2.5 to 1.7 Kwh/km, depending on climate conditions.

Nantes is clearly a successful use case, not only for BRT implementation but also for electric BRT operations in Europe, inspiring other cities around the world. Currently, UITP is coordinating the EC-funded project EBRT2030 to support sustainable urban transport by reducing operations costs, TCO, greenhouse emissions and traffic congestion through technical solutions, business models, operational scenarios and impact assessment processes. This will be achieved by deploying innovative, integrated, efficient, end-user-centric, economically viable and flexible solutions, which will be demonstrated in real-life cases in Europe and beyond.

## INNOVATIVE PLANNING TOOLS



*Planning scheme displayed at BKV Budapest Millennium Underground Museum. © Manel Rivera, 2019*

Bus system planning practitioners have traditionally relied on their knowledge of the local context on demographics and boundary conditions to feed the basic formulations that yielding the main planning parameters (such as number of buses and approximate demand forecasts).

However, the need for simplification resulted in relying on statistics that were overly aggregated. This quickly drew the focus away from the citizens' needs to purely academic routing problem solving, aimed at striking the ideal equilibrium between offer and demand.

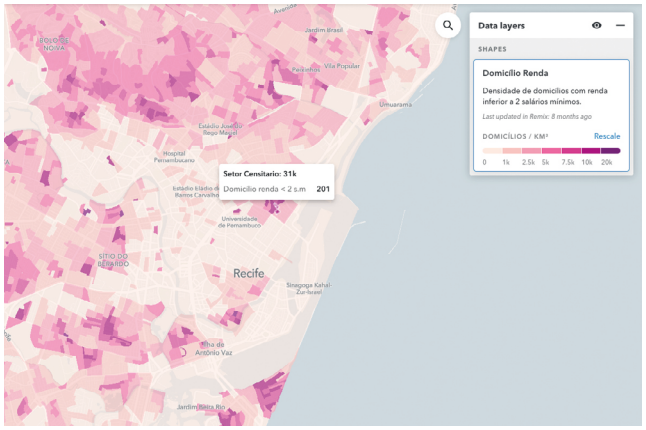
Traditionally hosted on local servers, robust bus scheduling and rostering optimisation tools have been in use for decades, delivering outstanding use cases of savings for bus operations worldwide. However, basic hand calculations and spreadsheets were still used for quick checks and rough bus planning estimates.

Increasingly, operators and authorities see the benefits of using light information technology tools to better incorporate the citizens into the decision-making process. Innovative, cloud-based software allows data granularity to be reduced and visualising crucial details combined. This supports practitioners in ensuring equity and justice in mobility access while bringing closer the social and economic optimal points.

> *"Only through the use of technology and constant innovation can we stay one step ahead of the challenges of evolving and demanding mobility."*
>
> *Jose Luis Hernández, Project Manager at Mobility ADO*

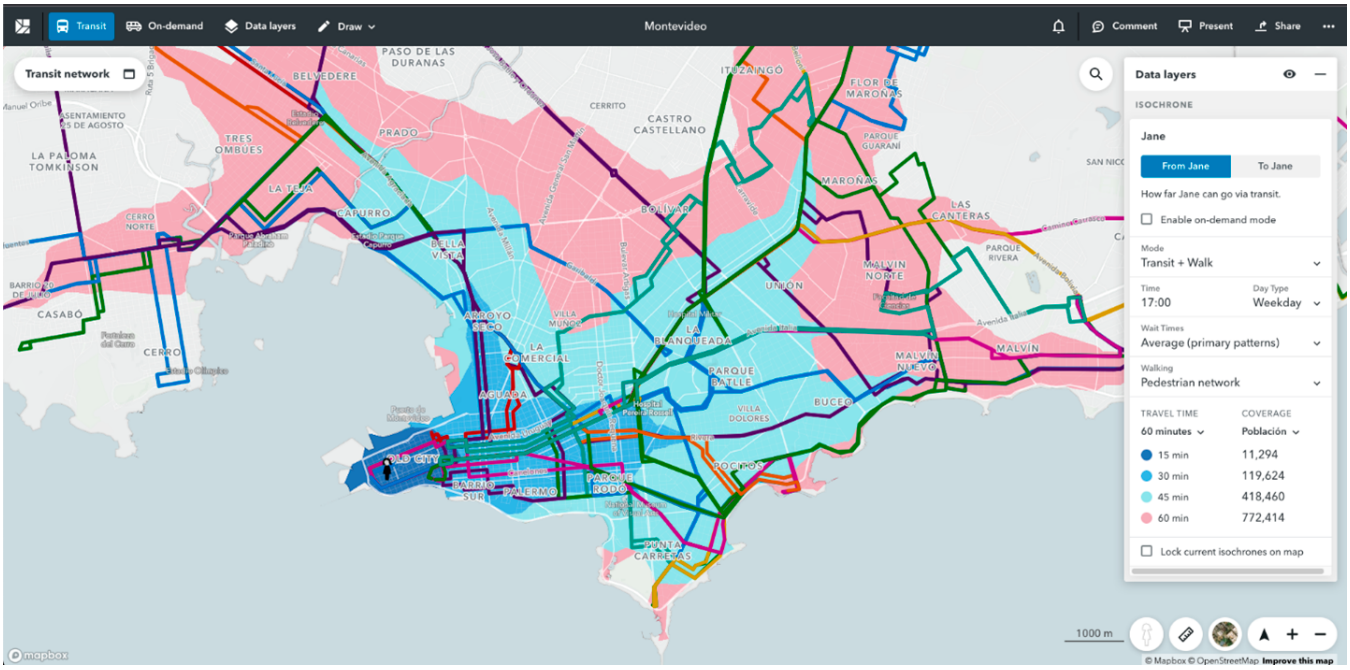
Innovative planning tools support planners in matching increasing expectations in the quality of the proposed solutions, and in overcoming delays in delivering alternatives to citizens' needs and political demands.

Quicker and more accurate reactions are facilitated by simulation tools, allowing the analysis of "what-if" scenarios to yield the optimal solution. As well as capitalising on the extensive local knowledge of the bus planner, the smart use of the available data is a key factor when evaluating impacts on citizens' quality of life and behaviour. Understanding where the most vulnerable communities are located, or the patterns of origin and destination of public transport users, is essential when evaluating alternatives. Innovative tools allow crosschecking with any available spatial demographic information (such as population density, household rent, car access or origin-destination data), enriching the analysis and taking bus planning tasks a step forward.




*Density of households earning less than two minimum wages per month in Recife, Brazil. © Remix by Via.*

Currently, finding a consensus among the key actors in the mobility ecosystem is mandatory during major bus network reorganisation endeavours. A collaborative pathway to improved bus services planning tools helps facilitate bi-




*Public transport accessibility analysis in Montevideo, Uruguay. © Remix by Via*

directional internal and external exchanges, thus easing the understanding between planners and end users.

*"We realised that collaborative planning tools ease the understanding between the bus operator and the service regulator, accelerating bus service improvement projects."*

*David Cañabate, Remix by Via.*

Major changes or partial network redesigns have a significant impact on the communities and their trust in public transport. Properly managing this impact is key to avoiding confusion and rejection from citizens and impacted social groups. For this, planners must be able to explain the reasons behind these changes in plain language. Visual and mapping tools certainly ease this process, such as isochronous maps and before-and-after routing tools.


*Local bus in Los Angeles. © LA Metro*

## LOS ANGELES METRO USE OF ADVANCED PLANNING TOOLS

In 2018, Metro started reimagining the Los Angeles bus system to improve how it met the needs of current and future riders through the NextGen Bus Study. The project was developed through consideration of both technical data and all the priorities and personal experiences. We heard from nearly 20,000 LA County residents via questionnaires and over 400 meetings, events, presentations and workshops. As a result of the study, the NextGen Bus Plan was developed to implement a new competitive bus system in Los Angeles County that is fast, frequent, reliable and accessible. The proposed improvements would:

- double the number of frequent Metro bus lines
- provide more than 80% of current bus riders with 10-minute or better headway
- improve and expand midday, evening, and weekend service, creating an all-day, 7-day-a-week service
- ensure a ¼-mile (400 meters) walk to a bus stop for 99% of current riders
- create a more comfortable and safer waiting environment.

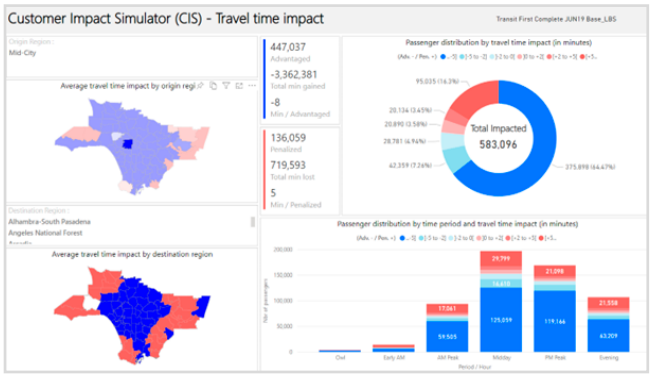
GIRO and LA Metro collaborated on developing the Customer Impact Simulator (CIS), a software

tool for transit planners. This calculates an expanded range of customer-benefit metrics and is integrated into the NetPlan module of GIRO's HASTUS public transit optimisation software. The CIS uses the transit agency's origin-destination matrix that use the Location-Based Service (LBS) data along with Metro's fares information. It enables planners to evaluate the impacts of different network scenarios on travel time and service quality, based on customers' travel patterns and behaviour. By estimating expected ridership, the CIS also allows planners to scale service levels more precisely and forecast potential crowding issues when planning network adjustments.

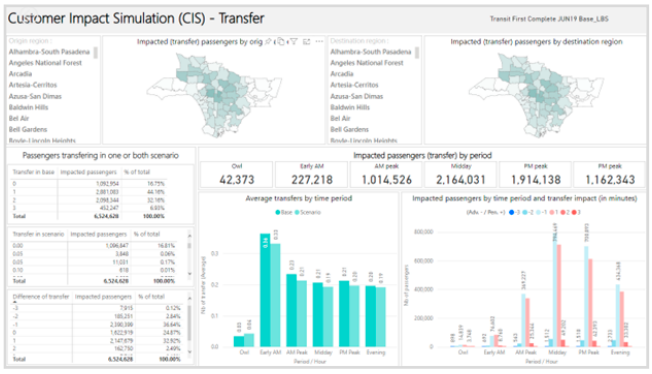
Being part of the Hastus scheduling software allows NetPlan and the CIS to use actual Metro routes and timetables, along with imported General Transit Feet Specification (GTFS) of surrounding transit agency; this saves time and generates more accurate results. Through NetPlan, LA Metro planners can quickly model various scenarios and create easy-to-understand, interactive dashboards using Microsoft Power BI, which can be shared quickly with external stakeholders and decision makers to give them an overview of the key CIS results, while also facilitating the process for input on proposed changes. Then, we can also easily transfer the selected scenario to schedulers for it to be put in operation.

Another feature of the NetPlan module, one which proved tremendously important in reviewing, making, and presenting the proposal to the public, is the Reach Map Web. This tool allows Metro users (or the wider public) to compare how far they can travel in 10-60 minutes using the current and proposed networks, along with relevant statistics such as reachable jobs by type.

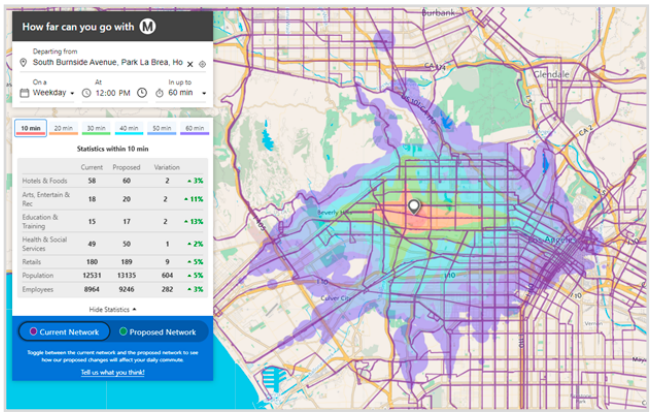
Reach Map is also used by planners at LA Metro to compare the travel times between the as-it-is and proposed scenarios allowing them to finetune their proposal.



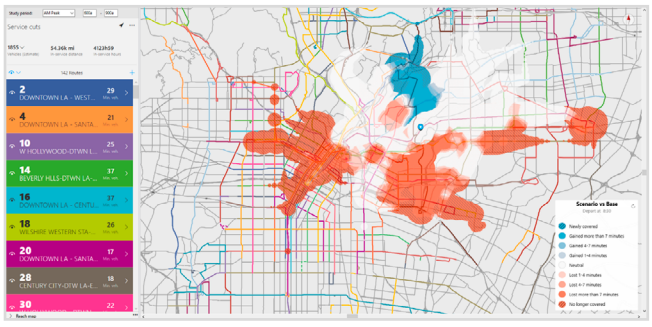

*Interactive CIS dashboard to show the impact on ridership, travel time, or transfers between the as-it-is network and the proposed one. © LA Metro*




*CIS dashboard featuring the impact on transfers. © LA Metro*




*Accessibility analysis. © LA Metro*



*Travel time analysis. © LA Metro*

## CITIZEN ENGAGEMENT

Citizen engagement prior to a major bus network redesign and operations monitoring is an essential step nowadays. Irrespective of the fact that public consultation is a legal requirement in some geographical contexts, meaningful exchanges should be sought at all times. Daily public transport users and (as yet) non-users will enrich technical proposals and encourage daily users and key stakeholders to take ownership and support the bus network implementation and operations better. Key stakeholders are shortlisted below.

- local and national elected representatives
- local authorities, such as town planning departments
- other public transport operators (bus, rail, metro...)
- representatives of public transport users
- emergency and security services
- grid and energy providers should be invited to ensure the system design is compliant with imminent or future fleet electrification, particularly if opportunity-charging strategies for battery electric buses are being considered.
- other public services (education, health department...)
- local amenity and residents' groups
- business Improvement districts

In addition, comments should also be invited from individuals.

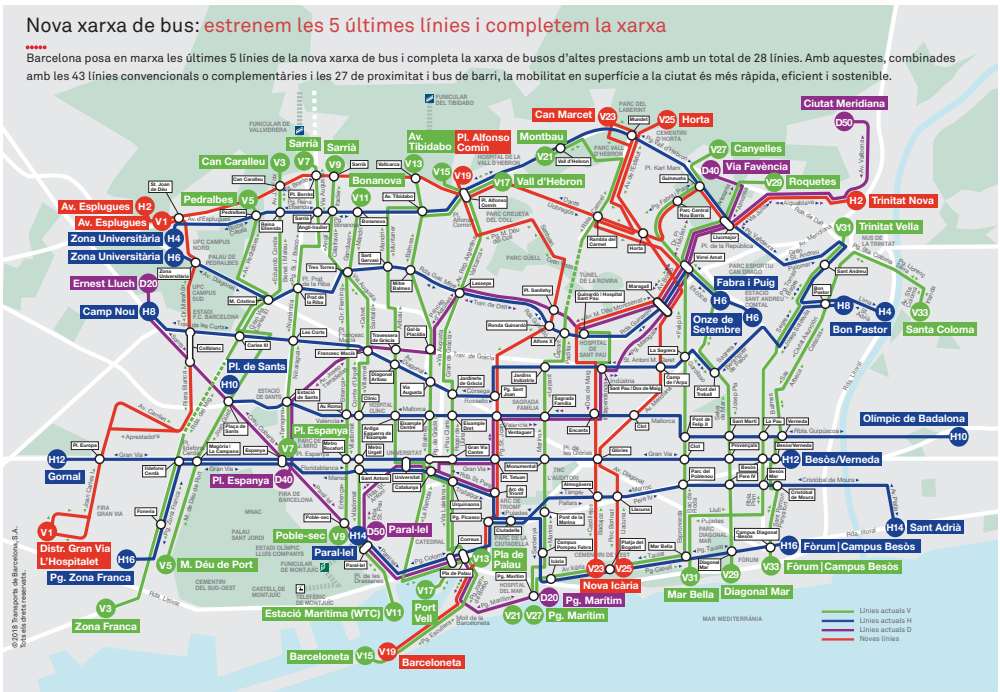
## INSIGHTS OF BARCELONA'S BUS NETWORK REDESIGN PUBLIC ENGAGEMENT ACTIVITIES

Barcelona's new bus network project started in October 2012, and was completed in November 2018. During this six-year period, the existing bus network was transformed into a more efficient, easier to understand and more reliable and competitive transport system for the future.

In the period between 2012 and 2018, Transports Metropolitans de Barcelona (TMB) and the Barcelona City Council joined forces to restructure the city's bus network. A new, more hierarchical network with high-level of service, conventional , and local routes network was designed and implemented that followed the particular city's grid (one-way streets in the sea-mountain and parallel to the sea direction) and the people's requests from the periodic customer satisfaction surveys. The implementation of the new schemes was gradual, at a rate of four to five premium routes each year, with the corresponding changes to the conventional routes. The whole process was completed by the end of 2018.

Both TMB and the Barcelona City Council carried out comprehensive information, participation, and consultation process to explain to local people, organisations, and stakeholders the impacts, benefits and changes associated with the roll-out of the consecutive phases of the new bus network. For this purpose, multiple meetings with politicians, people in charge of mobility, technicians and citizens were held in different formats at the City Council and TMB premises.

Numerous meetings were held during the implementation phases, including visits to the depots and the bus control centre and a preview of the coming new itineraries, with




*Bus network redesign citizen information sample. © TMB*

slots dedicated to passengers over 60 years old. During these sessions, in addition to explaining everything about the new services and the model itself, many proposals and suggestions for improvement were gathered from the attendees and followed a feasibility analysis.

As the new bus network grew, the participatory process not only focused on explaining the new model but also the wider coverage the new routes would provide and how to use the web. Here, users could harness the increasing number of premium routes with excellent headways and transfer areas, where they could switch from one route to another.

Strictly speaking, each phase starts once planners have completed the new layout. This encompasses new route designs, operating issues, infrastructure and bus priority measures along with urban furniture. A kick-off meeting and several follow-ups (one per month) at a high level were taking place. In parallel, technical level rollout meetings were held weekly. Meanwhile, a communication plan was prepared, and multiple gatherings at municipal level were scheduled.


*Public engagement activities poster. © TMB*

A notable event was the presentation of a new phase to the Mobility Pact's Public Transport Group. This is a space for participation and dialogue made up of city associations and entities and local and supramunicipal administrations and institutions, which acts as a participatory forum and area for consensus around Barcelona's mobility model, good quality public space and a healthy city.

The goal of the municipal sessions was to share future developments for the new bus network, in order to understand it fully, discuss it and make it easier for people to use. In addition, proposals for improvement based on people's everyday knowledge were collected and analysed before changes were implemented.

The final, and most complex, phase of the process was complemented by the digital platform 'Decidim.Barcelona', which ensured participation in the process. There, announcements for in-person events (to encourage attendance by interested parties), all the documents worked on (such as maps and presentations) and the minutes and proposals from sessions were published. In parallel, the public submitted many proposals online.

Some 1,750 people participated in this participatory process and 384 proposals were received. Of these, 259 arose from the in-person meetings, and the remaining 125 were proposed directly by the public through this platform. Some 60% of all contributions were granted, either as improvements to the project (41 requests were incorporated) or because they enhanced several aspects.

The new bus network results from a wide-reaching political and social consensus. It has included specific working groups (including Mobility Pact and Council for the Elderly) and open information and debate sessions in all city districts. Since 2017, this has been incorporated into the digital participation platform https://www.decidim.barcelona/processes/xarxabus.

*Network redesign public consultation activies in Barcelona. © TMB*


*Elizabeth line station. © Manel Rivera, 2022*

## HOW LONDON´S BUS NETWORK EMBRACED THE ELIZABETH LINE

The Elizabeth line is a new urban railway system running east-west under central London. It joins two existing commuter lines to each other via a new central London tunnel, along with a new branch into southeast London. It also links Heathrow Airport directly with the West End shopping and leisure district and the two main financial hubs of the City of London and Canary Wharf.

It is comparable to an RER or S-Bahn type system. Whilst the central area stations were new, the stations on the existing lines have been upgraded with more frequent services and improved accessibility.

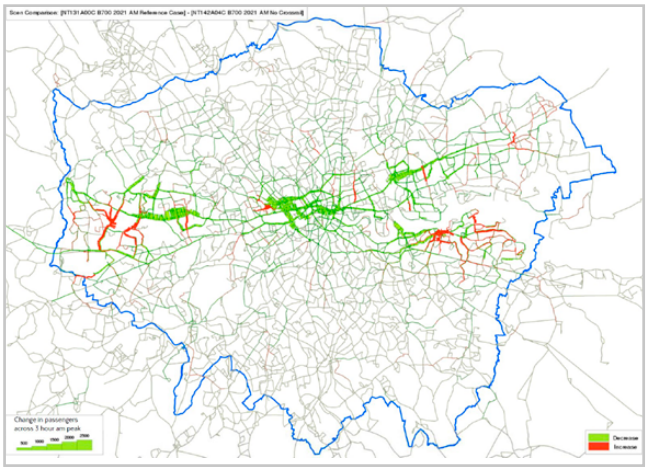
Originally planned as Crossrail in the 1990s, detailed planning began in 2001. As part of that, the impact of the bus network was studied in TfL's strategic Railplan model. The main work on potential changes to the bus network was undertaken in 2016–2017.

The main forecasts from the model were, as expected, a reduction in bus usage where faster rail alternatives were available, and an increase in those bus routes feeding into rail heading stations on the line. The forecasts were then translated into service planning proposals. These were grouped around the main interchange stations in the suburbs of west, north-east and south-east London, where the main passenger usages changes were expected.

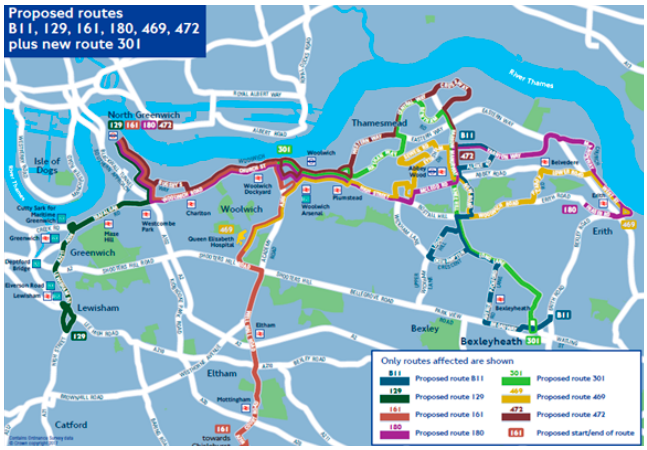
A total of 40 bus route changes were proposed for the reasons briefly presented above. The schemes seek to achieve a number of objectives, including:

- Supporting the opening of the Elizabeth line by providing sufficient capacity to meet predicted future demand.
- Supporting the opening of the Elizabeth line through providing new or quicker connections where demand is expected to be sufficient to justify the additional cost.
- Supporting regeneration and housing by improving bus routes that serve new development.
- Addressing operational issues on bus routes to improve the passenger experience
- Rebalancing bus provision in line with changes in demand to ensure resources are being used efficiently.

Central London changes were dealt with in a separate study, as usage was already falling due to a switch to already-upgraded rail lines and also because of falling traffic speeds. All proposals were the subject of TfL's standard public consultation process, where stakeholders and the public have their say on any proposed changes to the structure of a TfL bus route. A standard TfL business



*Forecast change in bus passenger flows as a direct result of the Elizabeth line (modelled year 2021). © Transport for London*




*Southeast London route changes plan. © Transport for London*

case was carried out for all changes. Some proved to be extremely worthwhile and thus were implemented in advance of the opening of the line. In all, around 30 routes were affected by the proposals.

As an example, in southeast London the changes were a combination of new routes feeding the line (route 301) and parallel routes altered to reflect changes in rail heading (route 472). It was forecast that demand at North Greenwich – a railhead on the Jubilee tube line - would have a reduced catchment area and the changes reflected that.

In west London, the opportunity was taken to introduce a new limited-stop route along a busy orbital corridor linking Heathrow Airport to the Elizabeth line at Hayes and the popular suburbs of Harrow and Northolt. The existing route 140 was restructured into an express route - X140 - and stopping routes 140 and 278. The latter also gave new links to the suburbs of Hillingdon and Ruislip. Again, this route was introduced early, as positive outcomes and success was foreseen even before the launch of the Elizabeth Line service. Nevertheless, most changes to the bus network were introduced when the main section of the Elizabeth line opened in May 2022. Whilst most of the changes were implemented, a few have been delayed or were changed following a public consultation.


*Electric Bus in London featuring Elizabeth line promotional livery . © Transport for London*

It is worth checking the 2017 technical note detailing the bus service changes for further information. https://content.tfl.gov.uk/changes-to-suburban-bus-services-to-support-the-elizabeth-line.pdf

## CONCLUSIONS

*The bus network planning is a core activity within bus operators, key to guaranteeing citizens' access to public transport and ensuring and efficient use of available resources.*

*Many tasks and focus areas are regarded in bus system planning, a profession needing trained and dedicated staff, with a high sensitivity to customers' experience and great interest in continuously improving the bus service supply. Bus planners have a deep understanding of the network performance, local context, and public transport requirements to actively contribute in the urban space design and collectively achieve greener, more liveable, and efficient cities.*

*Innovative planning tools and new technologies are taking the bus planner profession a step further, with a strong presence of data collection and analysis activities. Current state-of-the-art planning tools are boosting the quality of network-redesign proposals by better incorporating the citizens' perspective through improved data visualization and multiple what-if scenarios evaluations.*

*This report has succinctly covered some of the many angles of the bus network and system planning from the operators' perspective, and paves the road for further exchanges and activities around bus planning within the UITP Bus Committee.*

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## / REPORT CONTRIBUTORS

Antonio GARCÍA PASTOR | AVANZA Mobility Ado, working stream leader • Bob BLITZ | Transport for London, working stream co-leader • Henk Jan JANSEN MANENSCHIJN | GVB Amsterdam, working stream co-leader • Joan Maria BIGAS SERRALLONGA | AMB Barcelona, working stream co-leader • Josep MENSION CAMPS | TMB Barcelona, chapter co-leader • Stéphane BIS | SEMITAN Nantes, chapter co-leader

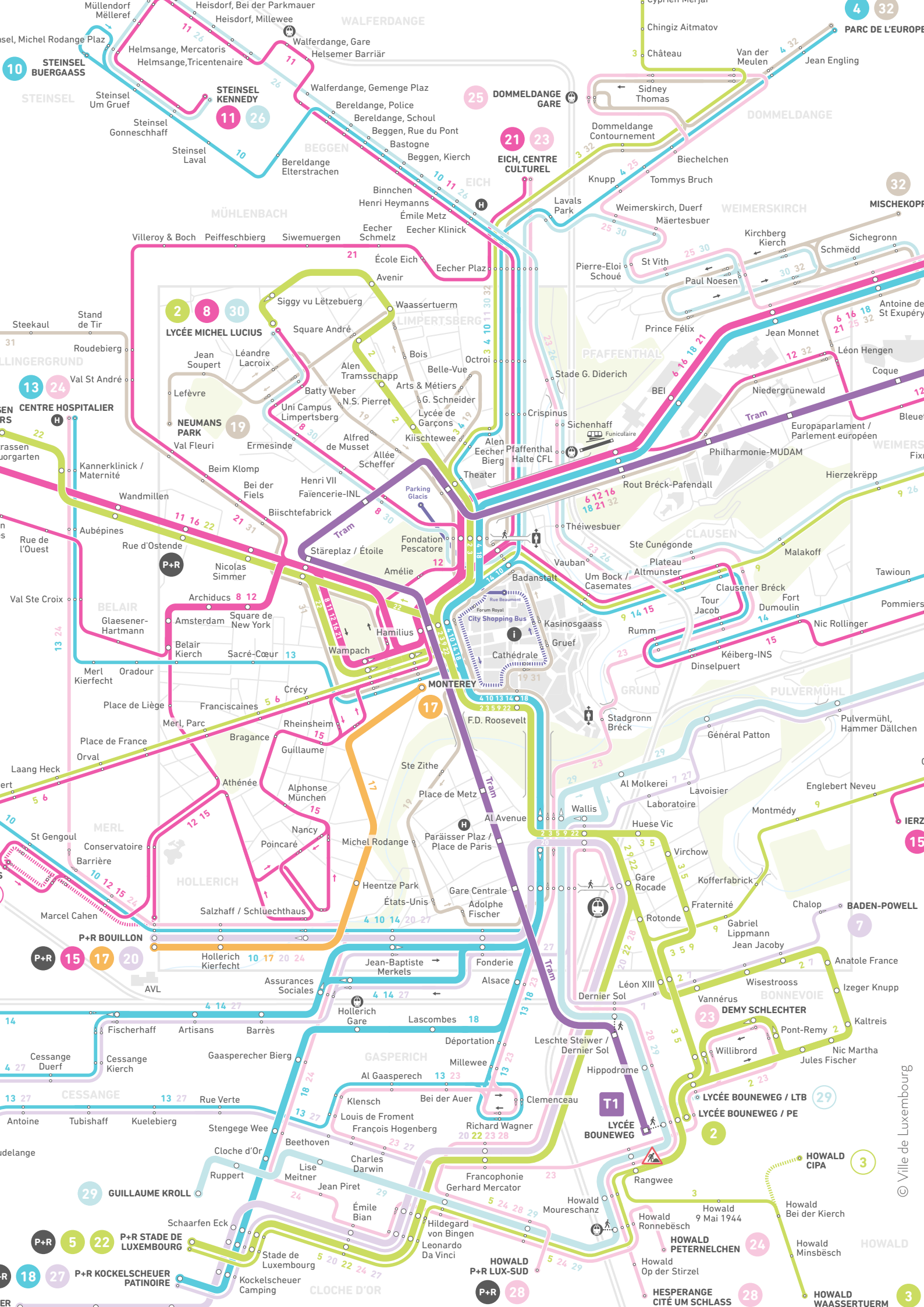
Alok Jain | as reviewer • Bonnie GUO | Shenzhen Bus Group, as chapter contribution • Dan NGUYEN | LA Metro, as chapter contributor • David CAÑABATE | Remix by Via, as chapter contributor • Denis AGAR | TransLink Vancouver, as chapter contributor • Guido BRUGGEMAN | as reviewer • Richele CABRAL | FETRANSPOR Rio de Janeiro, as reviewer • Sarah WYSS | MTA NYCT, as chapter contributor • Sonia KANDOLA | TransLink Vancouver, as chapter contributor • Stephen NEWHOUSE | TransLink Vancouver, as chapter contributor • Uli Wessling | AMB Barcelona, as chapter contributor • Zeynel ALBAS | IETT Istanbul, as chapter contributor

## / SURVEY RESPONDENTS

Amsterdam | Gemeente Vervoerbedrijf Amsterdam • Barcelona | Area Metropolitana De Barcelona • Barcelona | Transports Metropolitans De Barcelona • Beijing | Beijing Public Transport Corporation • Belgrade | GSP Belgrade • Bern | Städtische Verkehrsbetriebe Bern • Birmingham | Transport For West Midlands • Crawley | Go-Ahead Group • Curitiba | Urbanizaçao De Curitiba S.A. • Hitachi | Ibaraki Transportation. Inc. - Michinori Group • Istanbul | İstanbul Elektrik Tramvay ve Tünel İşletmeleri • Lisbon | Carris • London | Transport For London • Los Angeles | L.A. Metro • Madrid | Empresa Municipal de Transportes de Madrid • Marrakesh | Société De Développement Local Bus City Motajadida • Milan | Azienda Trasporti Milanesi • Montevideo | Compañía Uruguaya de Transportes Colectivos S.A. • Montreal | Société de Transport de Montréal • Multiple cities in France | Keolis • Multiple cities in Saudi Arabia | Saudi Public Transport Company • Munich | Münchner Verkehrsgesellschaft mbh • Nantes | Société D'économie Mixte`des Transports en Commun de l'agglomération Nantaise • Naples | Azienda Napoletana Mobilità Spa • New York City | Metropolitan Transport Authority - New York City Transit • Paris | Régie Autonome des Transports Parisiens • Prague | Dopravní Podnik hl. m. Prahy • Rio de Janeiro | Federaçao das Empresas de Transportes de Passageiros do Estado do Rio De Janeiro • Shenzhen | Shenzhen Bus Group Co. Ltd. • Toronto | Toronto Transit Commission

## / UITP STAFF

Andrew BATA | Head of North America Regional Office • Anne MORDRET | K&I Senior Manager • Arno KERKHOF | Head of K&I Bus Transport Unit • Efe USANMAZ | K&I Manager • Eleonora PAZOS | Head of Latin America Regional Office • Lidia SIGNOR | K&I Combined Mobility Manager • Lottie STAINER | Communications Manager • Manel RIVERA BENNASSAR | K&I Bus Manager • Sarah LANGENAKENS | K&I Officer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This Report was prepared by UITP's Bus Committee Bus Network Planning and BRT Working Group.
For more information, you can contact Manel Rivera Bennassar (manel.rivera@uitp.org).



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UITP ADVANCING PUBLIC TRANSPORT

Rue Sainte-Marie 6, B-1080 Brussels, Belgium | Tel +32 (0)2 673 61 00 | Fax +32 (0)2 660 10 72 | info@uitp.org | www.uitp.org