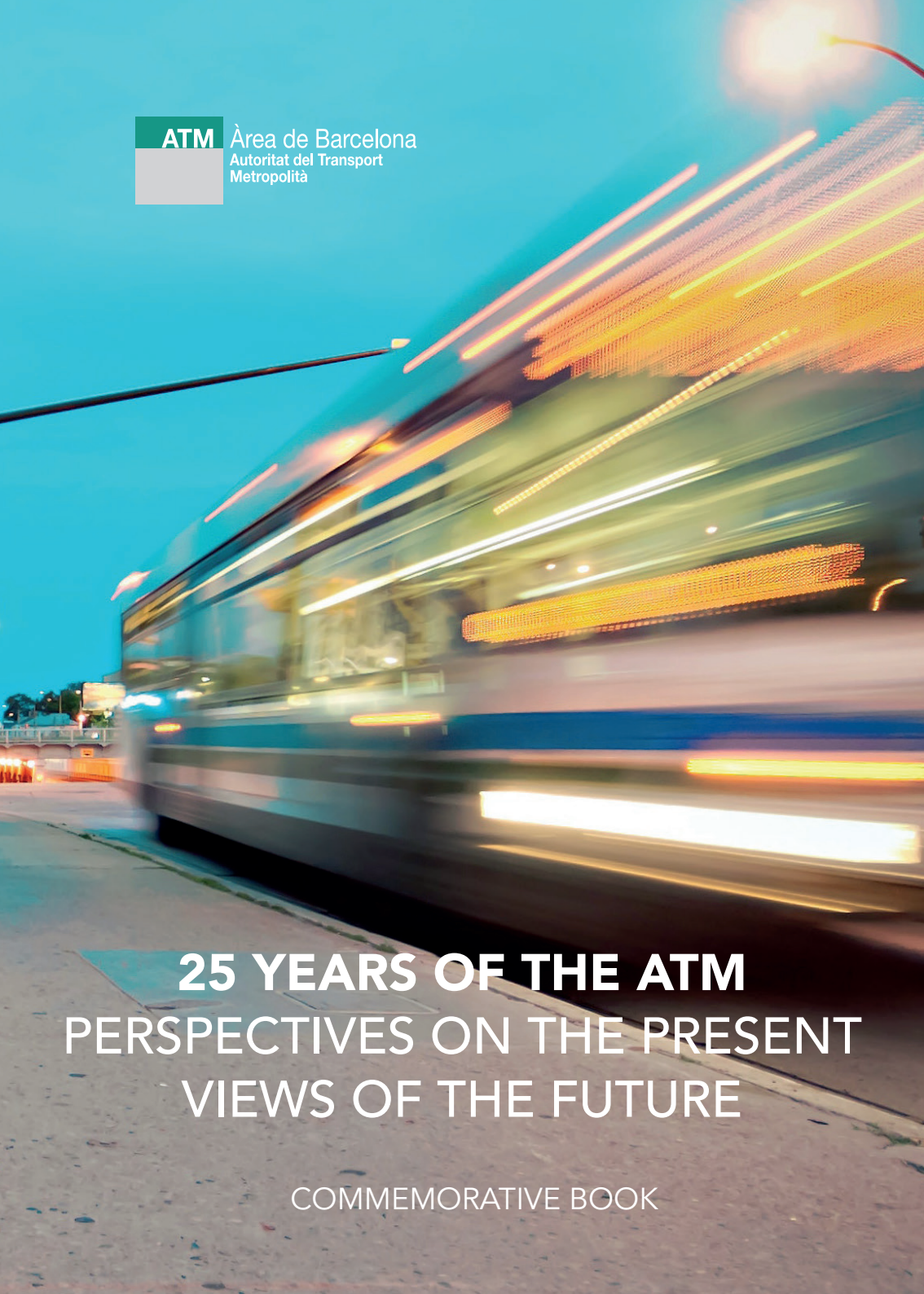

25 YEARS OF THE ATM
PERSPECTIVES ON THE PRESENT VIEWS OF THE FUTURE

COMMEMORATIVE BOOK

Contents

ATM Àrea de Barcelona
Autoritat del Transport Metropolità

Per un futur més sostenible
1997-2022

Introduction

The Barcelona Metropolitan Transport Authority turns twenty-five. It was set up on 19 March 1997 under an agreement between the Catalan Government, Barcelona City Council and the Metropolitan Transport Organisation (replaced in 2010 by the new Barcelona Metropolitan Area). The Association of Municipalities for Mobility and Urban Transport (AMTU) and the Spanish General State Administration are also represented in its management bodies.

This representation is conducive to reaching consensus and achieving teamwork between the public authorities tasked with mobility and public transport. The ongoing pursuit of this consensus has enabled the ATM to cement its role over the last quarter of a century: firstly, as the manager of the integrated fare system, a ground-breaking step worldwide when rolled out and which has turned it into the meeting and coordination point for public transport operators across a wide range of issues; secondly, as the authority for mobility in its geographical area appointed by the Parliament of Catalonia. In this role it has unlocked the planning tools which furnish a common framework for initiatives run by local councils, and; thirdly, as an agency which ensures public transport has legal and financial structures in place which help it to run more efficiently and make it possible to meet the system's financial needs and deliver ever higher-quality services.

These roles, which are performed by a team of around forty people in continuous partnership with staff at the consortium authorities and system operators, are still operational today and also geared towards the three key goals of this decade:

- Decarbonisation.

- Digitalisation.
- Decongestion.

Turning 25 is a great opportunity to think about the challenges ahead. So we asked a number of people to tell us their ideas, inevitably summarised given space constraints, about the current state of mobility. After all, the ATM has always been keen to heed studies, analyses and feedback which help it to better grasp the situation, expectations and potential.

We are sharing the thoughts in this book to show that listening and consensus-building are and will continue to be hallmarks of the ATM, an organisation steeped in 25 years of history.

ATM Àrea de Barcelona
Autoritat del Transport Metropolità

25th anniversary

Chapter 1

MOBILITY AND METROPOLIS

FlexiTransport, the platform which makes it possible to tailor public transport to the public's needs

Joan Serra i Muset, AMTU Chief Executive

One of the priority objectives of Mobility Act 9/2003 of 13 June is to deploy instruments which ensure full accessibility to transport systems under appropriate and safe mobility conditions and with the minimum possible environmental impact.

In line with this objective, the Association of Municipalities for Mobility and Urban Transport (AMTU) first chose Transport on Demand (ToD), and now flexible transport.

The AMTU has been the organisation responsible for rolling out ToD projects in Catalonia since the last Metropolitan Mobility Master Plan (PdM) (2020-2025). It is now the leader in Catalonia for implementing ToD services that make it possible to connect the most scattered areas of municipalities with their urban centres, providing people living in these areas with a connection to the main services of their town or city through a public transport service.

Each ToD project is unique and we have designed them specifically for each local council or territory. This means that each municipality has a service tailored to the specific features of its area.

However, this mode of transport is still anchored in a completely inflexible public transport model in which users have to follow pre-set timetables and predetermined routes. This is an obsolete model which is consequently not a genuine alternative to using private vehicles, especially in smaller municipalities with fewer options for delivering traditional urban transport services.

Fortunately, digitalisation of transport is already equipping us with the tools we need to move towards a new public transport model in which the user is central to the service.

New technologies enable us to work with complex algorithms which allow us to manage fleets and plan mobility in a more personalised way.

Bringing in strategic planning means coordinated with telecomputing tools and technologies working for people, the local area and the environment enables us to deliver a more flexible service tailored to its users' real needs at a reasonable and affordable cost for passengers, especially for the population segments most reliant on public transport such as the elderly, people with reduced mobility and young people.

Accordingly, the AMTU has developed the FlexiTransport Catalunya platform which allows service requests to be managed more efficiently and geared to the public's needs. This platform draws on an algorithm which manages the data of all users in real time, setting up routes and assigning vehicles derived from actual demand. In other words, flexible transport involves demand-driven, unscheduled provision and the service can be delivered by current operators on the basis of flexible routes and using small, medium or large vehicles.

This system therefore means that public bus services are tailored to existing demand whereby scheduled routes are not established beforehand but rather follow a network of stops, routes and timetables with the services actually requested.

FlexiTransport allows users to choose the start and destination of their service and arrange their pickup in advance from any computer or mobile device or by making a phone call. All requests are handled centrally by a public control office.

This more flexible mode of transport thus makes it possible to deliver completely user-oriented public transport planning where users can tell the operator their transport needs by phone and online. Furthermore, services are also not scheduled if there is no prior demand.

Flexible transport has advantages that make it a mode of public transport which is a credible alternative to the private vehicle and can be used on most existing scheduled routes. This is because it makes them more efficient, allows timetables to be matched to users and not the other way around as has been the case up to now, and gets rid of bus bunching.

Commitment to sustainable mobility

Moreover, against the background of today's climate emergency, it is more pressing than ever to provide public transport alternatives which reduce the use of private vehicles and help to enhance air quality.

One of the main benefits of flexible transport is that it cuts down on public transport vehicle under-used journeys. Flexible transport leads to fewer empty bus journeys while avoiding taxis constantly driving around without passengers. Equally, the commitment to carpooling is retained.

This mode of transport also makes it possible to set up smart ICT-based intermodal networks and upgrade public road networks in urban and rural areas alike.

In fact, an optimally implemented flexible transport system brings great direct benefits to the most rural and unspoilt areas of our region which currently do not have reliable options for getting to them by public transport. This has led to the need to plan large parking facilities to provide access the countryside around towns coupled with exceptionally heavy road traffic in some cases on roads which are not equipped to withstand this interference in their ecosystem.

Rolling out flexible transport thus envisages protecting the country's nature areas, especially tourist sites, and fosters safeguarding places and their biodiversity, including measures to alleviate problems of erosion of spaces and access roads and cutting atmospheric and noise pollution.

Flexible transport is, then, a mode of transport which was crafted at the municipal level with the goal of growing nationally.

Indeed, the AMTU is already working on a Catalan Government and Barcelona ATM commission to implement flexible transport in the Barcelona area with plans to roll it out across Catalonia at a later date.

JOAN SERRA I MUSET

General Manager of the AMTU
(Association of Municipalities For
Mobility and Urban Transport)

Joan holds a degree in Industrial Organisation Engineering, a Master's degree in Management Development Programme, a Master's degree in Occupational Health and Safety, and a degree in Mining Operation Engineering (civil engineering).

Since January 2021 he has been Chief Executive of the Association of Municipalities for Mobility and Urban Transport (AMTU). He has also been Mayor of Castellolí (Anoia) since 2011.

He is a member of the Barcelona ATM Executive Committee, and editor of the magazine MobiliCat, the leading magazine in Catalan specialising in mobility, public transport and infrastructures.

He was director of the International Mobility Congress (IMC21), the first international mobility congress to be held in Catalonia in September 2021, in Sitges. From 2015 to 2021 he was also regional officer for investment attraction for MICOD (Conca d'Òdena Municipalities Association). He was head of investment promotion for industrial estates at Igualada City Council from 2017 to 2019. From 2015 to 2019, he was CEO of the "Campus Motor Anoia", a hub which has become a benchmark in Catalonia for promoting connected and self-driving vehicles.

From 2010 to 2013, he was a member of the board and chair of the Industrial Organisation Engineers Committee of the Association of Industrial Engineers of Catalonia (COEIC).

Regional Officer of the Progea Group (Creixeda SAU), a large property developer specialising in cooperative social housing (2007-2013).

Chair of the Catalan Association of Industrial Organisation Engineers (2004-2011).

Towards the future with sound mobility planning and management

Francesc Robusté, Professor of Transport. School of Civil Engineering, UPC

The mobility of the future which is already here

In "The Future of Transport in Urban Areas" (Robusté, 2009) commissioned by the European Parliament from six university lecturers, I discussed the concepts, vehicles and modes which are likely to be prevalent in European cities in 2050. The analysis predates the disruption brought about by Uber, self-driving vehicles and technology applied to urban mobility in the form of shared vehicles based on electric engines and is still relevant today.

There I said that most of the innovation in urban mobility will come from reengineering old concepts with the help of ICT: its successful or unsuccessful implementation will depend on a package of "soft" management measures that involve understanding the behaviour of stakeholders and managing the system in an integrated, efficient and dynamic (real-time) way rather than on "hard" physical infrastructure or "new" vehicles (energy source switching is not strategic).

In fact, some concepts common to developing countries or challenging post-war situations may be ramped up under the innovative umbrella of technology: co-housing (sharing common elements in a house as when we lived with our parents or shared a student flat at the expense of a lack of privacy and having to observe "ground rules"), short-term rental of rooms and residences, vehicle hire ranging from electric scooters and bicycles to motorbikes, cars and buses, etc. The key to platforms is that they provide users with trust (magnified in blockchain transactions) and, obviously, globalisation.

In the discussion mentioned above, I suggested concepts and vehicles that would be in and out in European cities by 2050. I remember German parliamentarians asking me why I thought that trams (Light Rail Transit, LRT) would not be fashionable in 2050. I replied that what I meant was that cities which had trams running should continue to renew their rolling stock every thirty years, whereas if a city in 2050 wanted to implement a public transport system with an intermediate capacity between a bus and a metro, they would certainly put in place BRT (Bus Rapid Transit) which by then would: be electric without overhead lines (with battery, intermediate charging points or magnetic induction rail sections); deliver similar capacity performance (if the right of way or exclusive lane is guaranteed for BRT, a purely political decision); be optically guided (following markings or "guides" on the roadway); have the flexibility of a bus, and; cost a fraction of the price of the rail system.

I admit I underestimated the upsurge in electric scooters because I didn't know "where to put them" in the city. Now we know: sharing cycle lanes (or rather Personal Mobility Vehicle (PMV) lanes, encompassing conventional and electric bikes) which have to be wide enough (to maintain two speed ranges, 10-15 kph for cruising and 20-30 kph) and one-way (depending on the flow) on safety grounds.

Over the next two to three years, we will see a reshuffling of carpooling, global PMV platforms converging on similar services ignoring local regulations and number restrictions and delivery and ecommerce services. Nevertheless, the physical or functional aspects of covering a certain distance at a certain speed will still hold sway.

Comprehensive mobility planning and efficient management

I remember when the ATM was set up in 1997 and two technicians were put in charge. In spite of the gripes compared to the Madrid Regional Transport Consortium in terms of history and financial and human resources, that beginning seemed promising. Then came a period of "political planning", although now it would appear we are back on the right track.

The idea for metro line L9 was proposed in the *Intermodal Transport Plan* of 1992 which was never signed off. The proposal was purely technical and sought to remedy the planning errors of L3 and L4 (two eccentric orbital lines) and the later error of L2 (the first metro plan under democracy drawn up in 1984, which still did not use demand models). L9 initially only got as far as the residential part of Passeig de la Zona Franca (metros run through very dense urban areas, not industrial estates) and was a distributor at a level closer to Collserola (the third "transversal" after L1 and L5), providing the "upper zone" and the university area with new or improved accessibility, but also a social redistributor by connecting different neighbourhoods with different per capita incomes.

The prospect that this L9 metro line might be financed with European funds in the same way as the Madrid metro's L8 was financed (Nuevos Ministerios-Barajas, express services with few stations, as airport services should be), not only prompted the establishment of the ATM but also the preparation of the first Infrastructure Master Plan (PDI) 2001 with this twin

L9-L10 line, which is a European record in terms of driverless metro length and a *sine qua non*: it had to reach Barcelona Airport in order to be eligible for funding as a "strategic" project in a large city. This is not the right place and nor do I have the space to go into detail on the vicissitudes, cost overruns and decisions on metro L9, but I think we can all agree that the decisions have been "improvable" and that the best news is that we seem to be starting to see the light at the end of the tunnel (in this case, literally).

The new ATM PDI 2021-2030 addresses the gender perspective (basically getting projects done right: with information, light, safety, comfort, with everyone in mind), health and the environment. It includes demand studies and cost-benefit analysis and the digitalisation of mobility. We also have the T-Mobilitat operational (finally!) as a contactless transport ticket.

All that remains to be done now is to integrate mobility planning globally: all rail systems, regardless of which government operates them, but also the rest of public transport by bus... and individual mobility in the form of traffic or personal mobility vehicles... and pedestrians, of course. And also including forecasts and real-time information for efficient mobility management.

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FRANCESC ROBUSTÉ

Transport Chair. School of Civil Engineers, UPC

Professor of Transport, School of Civil Engineering of Barcelona, Polytechnic University of Catalonia - BarcelonaTech. Coordinator of the Barcelona Innovation in Transport (BIT) consolidated research group.

PhD in Civil Engineering from the UPC (1989), PhD in Engineering (1988), MSc in Operations Research (1987), and MEng in Transportation (1986) from the University of California at Berkeley.

Francesc has been director of the Abertis Chair in transport infrastructure management, chair of the Spanish Transport Engineering Forum and director of the Barcelona School of Civil Engineering. He is an expert in the scientific analysis of transport systems.

Reimagining transport

Sebastián Court Benvenuto, Secretary General of ALAMYS

When we start to think about what lies ahead, it's only natural to realise how difficult it is. To share my view of the coming years in transport and cities, I find it helpful to review some historic milestones which enable us to take stock.

We don't need to go that far back. In 1977, Ken Olsen, who was the founder of the Digital Equipment Corporation, said that "there is no reason for any individual to have a computer in his home". This most likely seemed quite reasonable to many people at the time considering the size of the computers which were then in use.

If we go back to the ATM's inception in 1997, listening to music on mini-discs with a small number of songs or watching our first movies on DVD was commonplace. Yahoo Mail came along and the domain name of a then recent browser, Google.com, was also registered.

In 2007, just 10 years later and only 15 years ago, the first iPhone came out. Since then, we haven't been able to live or work as we would expect without a smartphone on which we get emails and instant messages and that we can use to call and see whoever we want anywhere in the world. No doubt many of us have had to go back home to get our phones when we accidentally leave them behind.

For years now, we have been listening to our favourite music whenever we want and watching the films we like however often and wherever we want.

Over these last two years of the pandemic, we learned that we can work from home as well as in an office and that we can also celebrate birthdays and anniversaries at a distance. We also had to try new products or met a friend who sells exquisite food. My usual supermarket was perhaps a little put out by some of these discoveries.

We certainly inadvertently learned to travel less than we did before.

Everything has changed much faster than we were used to. Cities and transport are and will be no exception.

The question is what comes next. Houses are already being built using 3D printers. And not only that, as pieces of meat have already been printed on 3D printers. I can have doctor's appointments from home and even phobias are being treated using virtual reality. Of course, I can now see all the art in the world from my home because regardless of what might have been thought in 1977, many people do have a computer at home and even more have one in their pocket.

Nonetheless, as human beings something is missing. When you saw your family again after the first lockdowns, the hugs must have been

deeply moving. People saw their friends, their colleagues and that also brought them a lot of energy. This is where we still have our chance.

The great challenge for transport leaders is to reimagine mobility, connecting it to the exponentially vibrant lives of people in the city and recognising that contact with each other is irreplaceable.

I think we might all agree that most of us don't like commuting. That is why it is essential to make the journey meaningful, to find a way to personalise it, or for everyone to personalise it to suit their own preferences. Create meeting places, places for connecting, so that the journey connects you over and above the need to go from departure point to destination.

Connect us with what moves and drives us. Ensure that if a bike is my travel choice, I can also use it together with other means of public transport and continue my journey with them as we are also environmentally friendly. If art is my passion, seeing it at home on a tablet is not the same as going somewhere with my best friend, chatting and enjoying a coffee while visiting a museum or a station packed with works of art. Finally, working by video call, most likely shared, which compels us to be more transactional and means we miss those moments when we say hello to someone in the corridors or have breakfast

with a person we don't work with directly, connecting with their interests and catching up with them.

Technology is, of course, a big power-pack. Digital payment methods, seeing mobility as a fully integrated service, augmented reality, bringing in data systems which help everyone find what they are looking for and craft this unique experience, or just reminding me that my favourite café is at the next station.

However, the end is not technology but rather the way we see ourselves as systems. We need to grasp diverse identities, beliefs, entertainments and tastes to build in the services and interests which are most connected to each of us. Not for the crowd, but for the individual. We have to listen a lot to those we seek to connect with.

Over these 25 years, the ATM has grown enormously, bringing in many operators and supporting the development of the region's areas. It has been a crucial piece in enhancing the quality of life of many people. Ever since it was set up, it has seen how quickly society has evolved in terms of economics, technology and values.

My call for the coming years is to reimagine transport to ensure that the speed of change the world is delivering to us never sidelines our systems.

Reimagining transport will not only keep us connected and make us ever more a part of the city; it is also essential for cities to develop sustainably to make sure that future generations can continue to enjoy them.

Many congratulations on this 25th Anniversary!

SEBASTIÁN COURT

Secretary General of ALAMYS

Sebastián Court is a Mathematical Civil Engineering graduate from the University of Chile who has almost 15 years' experience in transport.

He is currently Corporate Planning and Development Manager at Metro de Santiago, Chile, and Secretary General of ALAMYS, the Latin American Association of Metros and Subways.

He has worked on major metro projects leading planning, design and implementation processes.

For several years he headed the operation of Santiago's integrated transport payment system where he led the project which will help towards financial inclusion through transport and its means of payment.

In the Planning and Development Department he is at present heading projects such as the Metro's strategic plan, innovation and digital transformation, seeking to co-construct the future of Metro de Santiago centred on sustainability.

The ATM's significance in transforming mobility and rolling out the goals of the Catalan Mobility Act 2003

Adrià Gomila, Director of Mobility at Barcelona City Council.

There is widespread agreement on the benefits of and the need for revamping mobility and that the 2003 Act was a key milestone on this journey. The ATM has played, and continues to play, a crucial role in the consensus-based definition and implementation of this transformation of mobility in the Barcelona area. This is no small matter, given that experience shows that it is precisely when it is time to get down to work that the main discussions, disputes, difficulties and misgivings crop up. In my view, the ATM has an essential role to play in encouraging people, businesses and government to tackle the challenges which implementing changes in mobility entail in their routine activities.

The Catalan Mobility Act, passed in June 2003 by the Catalan Parliament, established the essential link between mobility, urban planning and the environment as a prerequisite for progress and improvement in these three areas. At the time when the Act was passed, the existence of the ATM meant that an agency was on hand to drive and unlock the measures envisaged. The ATM's roles were thus enlarged over and above those strictly concerning public transport. The then "recently" founded ATM, which had already played a crucial role in public transport fare integration (another significant milestone in the makeover of mobility), was a chance to push forward with implementing the plans and goals in Act 9/2003 in the Barcelona region.

The Act's sections include numerous instruments to be put in place which are needed to ensure that the goals set are achieved by combining these instruments. The journey of the last 25 years is proof of the considerable efforts made in this respect, making it easy to draw up a list of the major aspects

pursued over the past quarter of a century. It only takes a brief review of the summary of the Act to find examples: mobility master plans, urban mobility plans, the investment programme, service plans, assessment and monitoring instruments, mobility indicators, assessment studies of the mobility generated, and management and participation bodies.

The ATM is engaged in all the stages. First of all, in the substantive discussions in the drafting stage, where goals are set and actions are outlined. This stage almost always comes to a successful conclusion.

The greatest difficulties, disputes and hurdles emerge when putting in place the mechanisms and actions included in the regulations and plans. The ATM's absolute and necessary involvement is shown by its input in the deployment and implementation stages, one of the main weaknesses of mobility laws and plans.

Just as the successes and achievements demonstrate the importance of the ATM's role, it is equally true that this significance is also evident in the shortcomings in certain aspects of the transport and mobility system due to projects where targets have not been achieved.

I think it might be useful to end this article by taking advantage of this anniversary to look to the ATM's future. The experience and learning from the successes and mistakes of 25 years provide a solid basis for partnership between tiers of government to address the "new" challenges and opportunities that lie ahead in enhancing mobility: shared-use vehicles, micro-mobility as an add-on to public transport, technological innovations, greater environmental awareness, new paradigms in social relations between people and organisations, innovation in entrepreneurship and economic activity and more.

In short, we hope that the ATM model will remain in place for the sake of all of us who are working on the transformation of mobility.

ADRIÀ GOMILA

Director for mobility at Barcelona City Hall

Industrial Engineer.

Adrià's career has always been related to mobility, mainly at Barcelona City Council where he has held various positions since 2001. He has also worked at Etra Catalunya, as an associate professor at the UPC and at Sabadell City Council.

He is currently Director of Mobility at Barcelona City Council.

Director de Mobilitat
a l'Ajuntament de Barcelona

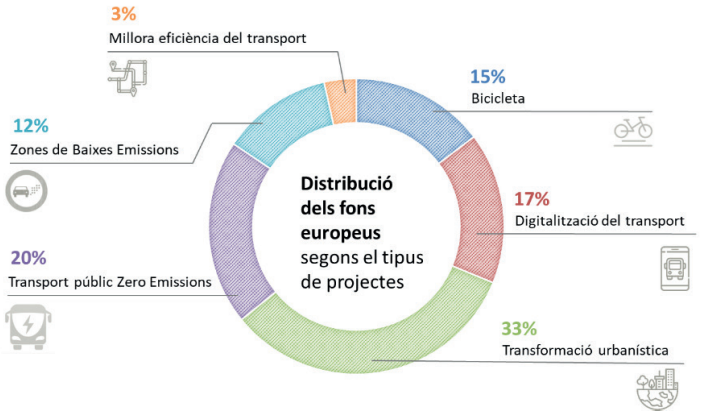
Projects to digitalise transport in the AMB

Joan M. Bigas, Director of Mobility, Transport and Sustainability at the AMB

It is self-evident that well-targeted digitalisation can significantly enhance public transport services, for instance by making the system more efficient, improving accessibility, information and a number of other benefits for public transport users and mobility in general.

The strategic measures the AMB is undertaking are digitalisation actions for smart supply and demand management, leading to greater efficiency and effectiveness in service delivery. Specifically, it is working on setting up tools for planning journeys and improving public transport in real time; measures to automate and digitally manage social pricing processes in public transport and user care; initiatives to upgrade the system for operating and displaying data on the bus and metro public transport network; demand monitoring and digitalisation of the bike infrastructure; and the recent digitalisation of the taxi business.

The AMB has of late received funding from the NextGeneration Funds as part of the first call of Spain's Ministry of Transport, Mobility and Urban Agenda. The AMB has been awarded €40 million, 100% of the total amount for which it was eligible. A decisive factor was the availability of mature projects involving the digitalisation of sustainable mobility which enabled the AMB to earn the highest rating at 84.74 points out of a hundred in its block.



Seventeen percent of these funds from European recovery and resilience mechanisms will be allocated to transport digitalisation initiatives and projects, including projects which will gain substantial impetus. They include new

on-board bus customer information systems with ultra-panoramic screens to provide more complete, dynamic and real-time service information in a multi-modal approach coupled with a video surveillance and video-analysis system tapping artificial intelligence for passenger counting and pattern interpretation, thus delivering service safety, comfort, optimisation and efficiency.

Another is the rollout in the 161 metro stations of a new user information system enabling the implementation of new train operating models (loops, skip station, switched-off signals, rerouting) to enhance frequencies at peak times and on high-demand stretches, thereby minimising the need for additional resources. It will also make it possible to provide information about carriage use, service status and other means of transport while fostering accessibility. The key components of the metro network's signalling system, track and trains will also be monitored to furnish real-time system data and existing on-demand bus systems are to be improved.

The AMB has an app for real-time metropolitan public transport planning and querying (AMB Mobilitat app) which boasts over 200,000 active users. The action consists of digitalising public transport services to enhance the service and user experience. Specifically, a new intermodal journey planning app is to be developed to improve the design and user experience and add new features anchored in the Mobility as a Service concept.

The AMB provides municipalities with a public platform for smart and sustainable controlled parking zone management. This platform includes services for managing Park & Ride zones (P&R app in eight car parks and 453 spaces), resident zones (app operational in l'Hospitalet de Llobregat), short-stay zones (an AMB parking app rolled out in 11 municipalities) and loading and unloading zones (SPRO app implemented in nine municipalities). It is also planning to design and upgrade digital tools, equipment and signage to enable municipalities to set up and manage controlled parking zones by vehicle polluting potential.

The AMB manages, processes and distributes over 500,000 social and environmental transport tickets per year in the metropolitan area. It is looking into setting up new systems for unified management of transport tickets, communication with users and creating a user space or citizen's folder which links all metropolitan apps to allow transport tickets and metropolitan mobility services to be managed using the same system.

Mobility services and activities generate a huge volume of data. Analysing, mining and displaying this data are essential to enhance service quality and

map out fresh mobility measures. Likewise, AMB Informació has a Transport Management and Information Centre (CGIT) which handles the managing and publishing of information and needs updated information about transport and services. A Mobility Data Platform is planned for managing, analysing and displaying mobility data to more flexibly and reliably add value to transport and mobility information.

Other relevant technological measures also financed with the funds include the AMB's promotion and support for the deployment of new Low Emissions Zones coupled with the extension and improvement of existing zones in metropolitan municipalities featuring technology such as control cameras, integration in the metropolitan platform, signage systems and more.

The AMB currently has a vehicle for the automatic capture of offences using on-board cameras, which provides a service for municipalities to issue penalty notices before the start of the penalty period or to control areas not covered by fixed cameras and promote the dissuasive effect of the sight of the vehicle on the road. It also plans to purchase on-board offence control systems to equip two new vehicles and to set up a metropolitan platform for managing and

processing penalty notices.

A metropolitan public bicycle system is currently being rolled out by supplying e-bikes and fitting out docking stations as secure parking facilities. It will be implemented in 15 municipalities and the planned sharing system will be arranged as a fully digitalised mode adding to public transport. European funds will help to finance a significant part of the investment.

The AMB is also committed to monitoring metropolitan BICIVIA infrastructure demand and digitalising the bike infrastructure by installing totem counters and points with supply and installation of loops in the metropolitan network. The infrastructure demand monitoring devices furnish data on the use of the infrastructure. Analysis of these data allows for better infrastructure management and planning.

Finally, the AMB is developing a new app (Picmi Taxi) designed to replace the raised hand with a digital system which puts people in contact with taxi drivers so they can find each other and make the service more efficient. This will significantly reduce the number of empty taxi journeys and help improve air quality by cutting pollutant emissions.

Improvements in information technologies and the funding provided by the AMB and the European recovery and resilience mechanisms have enabled significant progress to be made in all these projects. At the metropolitan authority we will have to closely track the new changes emerging in mobility and transport digitalisation to leverage them and tailor them to the needs of people and their right to get around safely, efficiently and sustainably.

JOAN M. BIGAS

Director for Mobility,
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Degree in Civil Engineering from the Polytechnic University of Catalonia.

Postgraduate studies in economics and business organisation and urban management.

Over 30 years of experience in the public transport and mobility industry.

Since 2015 he has been Director of Mobility, Transport and Sustainability for the Barcelona Metropolitan Area, in charge of metro, bus and taxi services in the 36 municipalities.

CEO of AMB Informació i Serveis S.A., a state-owned enterprise tasked with customer service in social pricing and transport information and in ITS technology projects.

Deputy Chair of the Organising Authorities Committee of the International Association of Public Transport (UITP) and member of the Bus Committee.

AMB representative in EIT Urban Mobility.

Digitalisation of mobility in the Barcelona metropolis

Antoni Poveda, Deputy Chair for Mobility, Transport and Sustainability at the AMB

The internet makes it possible to connect means of transport with the user and this has dramatically changed planning and management in public and private transport alike. Big data, the management of data flowing between customers and means of transport, has itself become a new sub-sector of mobility which has grown exponentially over the last few years.

The huge innovations in data management should not make us lose sight of the fact that the goal is still to deliver high-quality and efficient carriage of people and safeguard the social right to mobility.

In the Barcelona Metropolitan Area we have worked diligently on our digitalisation projects, striking a balance between the needs of the public and the

potential of technology to ensure it is the latter which adapts to the former and not the other way round.

Accordingly, the digitalisation projects in which the AMB is involved have been geared towards travel planning tools, improvements in transport information, better urban transport ticketing and payment handling processes, on-demand bus systems, and technologies to make access to transport easier for people with reduced mobility or special needs.

We have recently taken a significant step forward by securing funding in the Spanish Ministry of Transport, Mobility and Urban Agenda call for proposals for recovery and resilience mechanisms in mobility. The AMB is to earmark €7 million for mobility and transport digitalisation measures. Major projects will be funded such as improving digital information on buses and the metro, evolutionary transformation of the AMB Mobilitat app (regularly used by almost 200,000 people), expanding and enhancing apps for controlled parking and loading and unloading zones, a citizen's folder based on social pricing, and a number of integrated big data tools.

These resources will enable us to continue promoting and supporting the deployment of new Low Emissions Zones, a flagship project in which digitalisation plays a key role: control cameras, integration in the metropolitan platform, signage systems, exemptions register, etc. They will also be crucial in rolling out a metropolitan public bike system which is to be implemented in 15 municipalities, furthering the process of digitalising the bike sector which we have already kicked off with the Bicibox parking system.

Finally, there is digitalisation of the taxi sector where the AMB is developing an app to replace the raised hand with a digital system which puts people in

contact with taxi drivers so they can find each other and make the service more efficient. This will reduce the number of empty taxi journeys and help improve air quality by cutting pollutant emissions.

In my view, all of this shows that the sustainable mobility digitalisation policies pursued in recent years have positioned the AMB and its municipalities at the forefront across Spain. We still have a long way to go in terms of digitalising mobility, a field that is bound to continue to amaze us in the near future. [1]

1 Photos: sources AMB, TMB and Barcelona City Council

ANTONI POVEDA

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Journalist by profession. Senator chosen by the Parliament of Catalonia. He was Mayor of Sant Joan Despí for 15 years until 2021 and is currently Deputy Mayor for Institutional Relations.

Since 2007, he has been Deputy Chair of the Metropolitan Transport Authority (ATM) and Deputy Chair for Mobility, Transport and Sustainability at the Barcelona Metropolitan Area (AMB) where he has promoted more environmentally friendly public transport systems including renewing the fleet of buses to make them less polluting.

Since 2015, he has chaired the Cities for Bicycles Network, a nationwide organisation which champions using bikes as sustainable transport.

ATM Àrea de Barcelona
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25th anniversary

Chapter 2

ACCESSIBILITY AND INCLUSIVENESS

Mobility: accessibility and inclusiveness

Dr. Jordi Roig de Zárate – Chair and Chief Research Officer.
Faustino Cuadrado Capitán – CEO. MASS FACTORY – UAB

Mobility, accessibility and inclusiveness are terms used on countless occasions every day, but do we all understand them in the same way?

The core definition of mobility is the capacity or ability to move. However, when seen as a service that moves people and things, is that the most appropriate definition?

From our standpoint, mobility is much more than the ability to move people around by means of a transport service. Mobility is the ability to have in place a package of transport systems which ensure a full and safe life for society as a whole.

And what is accessible mobility? Even today, towards the end of the first quarter of the 21st century, when we refer to society we generally mean people who meet a preconceived standard of physical, sensory and cognitive abilities. We often forget that society includes people living with different abilities, whether congenital or acquired, permanent or temporary. Disability is not a state of people but rather a condition which restricts their mobility and hence what they can do. Mobility is therefore a universal and inalienable right which inevitably leads us to the most germane condition for public transport services: accessibility.

So we can define accessible mobility as providing equal opportunities for all by giving them access to the education, health and welfare systems, the jobs market and any other cultural, artistic, sports or social activity.

Nevertheless, accessible mobility is not the same as inclusive mobility. There are special transport services designed specifically for people with disabilities or other groups of passengers who cannot access transport independently. Their cost means that these services are limited, unsustainable and do not foster the inclusion

of users in society. Consequently, the first recommendation of the World Report on Disability (WHO, 2011) says that it is essential to enable access to all mainstream policies, systems and services for everyone. Hence mobility accessibility needs to ensure the inclusion of as many people as possible in each part of a journey.

Three types of barriers which restrict the use of public transport have to be addressed to make it accessible:

1) Architectural: physical access to transport infrastructure.
2) Communication: providing comprehensible information on how to use the transport network and infrastructure.
3) Wayfinding: the user's ability to find their way around with all the information available.

How these three barriers impact vulnerable people:

The measures taken in Barcelona to improve accessibility to public transport are:

1) Architectural: accesses to transport and its infrastructures adapted to groups with physical disabilities and the elderly such as:
   - Raised stops and low-floor buses.
   - Lifts and ramps.
   - Special wheelchair areas.
2) Communication: information systems adapted to different abilities.
   - Signage: maps, lines, stations, estimated time of arrival and guidance directions.
   - Public address: announcements for next stop, interchanges and incidents or relevant information.
   - Fitting induction loops for hearing impaired users.
   - Braille in lifts and on ticket vending machines for visually impaired users.

3) Wayfinding:
   - Tactile paving for the visually impaired.

- Mobile mobility apps which also provide information.
- QR codes to identify stops and points of interest which can also provide information through mobile apps.
- Bluetooth beacons to identify transport.

There has been a huge improvement in accessibility in public transport in "Greater Barcelona" over the last few years. The efforts of institutions, transport operators, disabled people's organisations and the public have not been for nothing. However, there are still challenges we have to address in order to achieve accessible and inclusive mobility:

- Transport network integration cannot be restricted to the fare system; infrastructures need to be fully and uniformly accessible.
- Information for users should be properly standardised, adapted, signposted and updated. If the user's understanding of the information they perceive depends on their abilities, then there is no communication, and without communication there is confusion and ultimately rejection of public transport.

To further the inclusion of people with disabilities, the elderly and people with mental or memory impairments, the Barcelona ATM has launched a pilot test of the App&Town Compagnon system, an innovative "door-to-door" navigation system designed to break down all accessibility barriers by drawing on existing infrastructures:

1) Architectural: with a journey planner which factors in the needs of each user based on their individual abilities, physically accessible routes, favourite lines and interchanges, safe routes, etc.
2) Communication: with a mobile app which interacts with the user featuring a customised interface and providing understandable information at the most appropriate time for the user via audio, text, images, pictograms and vibration.
3) Wayfinding: with a navigation algorithm which taps geolocation techniques to give precise directions from departure to destination, quickly identifying when the user errs from the set route and triggering support actions to ensure the journey is successfully completed.

App&Town Compagnon is not an isolated system but rather integrates all existing accessibility infrastructures in the network and enhances them. App&-Town Compagnon is a solution which improves mobility, personal autonomy, social inclusion and quality of life for all.

DR. JORDI ROIG DE ZÁRATE

Chairman and Chief Research Officer at Mass Factory – UAB

PhD in Computer Engineering from the UAB. Director of the Sabadell School of Engineering (UAB) from its establishment in 1988 until 2000.

Since 1993, he has worked proactively with ONCE and has extensive experience in domestic and international projects concerning accessibility for people with disabilities.

He led the OnTheBus Project and is co-founder of the company.

FAUSTINO CUADRADO CAPITÁN

Delegate Board Member at Mass Factory – UAB

Degree in Computer Engineering from the Autonomous University of Barcelona and General Management Programme at IESE Business School. He has over 25 years of experience leading multicultural teams in businesses in the ICT sector such as Nokia, Red Eléctrica Telecoms, Jazztel, BuyVIP and ADP ÉS.

He has an extensive and successful track record in various start-ups including BuyVIP and App&Town. Faustino is an entrepreneurial professional, enthusiastic, ethical, goal-oriented and tenacious, leading teams and businesses with continuous and sustainable growth.

Tailoring transport networks to people's diversity expectations

Francesc Aragall, Chair of Design for All International

Catalonia has made considerable progress towards enhancing accessibility for people with difficulties in their daily mobility.

At the ATM and alongside removing barriers, this has been driven by urban planning strategies which have been internationally recognised as role models, such as ensuring appropriate density, decentralising services in large cities, non-specialisation of neighbourhoods, promoting the use of public transport and, more recently, increasing pedestrian space.

This trend has not only had a constructive impact on the quality of life of local people but has also made an exceptionally effective contribution to Catalonia's popularity as a tourist destination.

However, further innovation is needed to improve the adaptation of public transport to the needs of diverse users.

Over and above the significant efforts made by the public transport network to enhance physical, sensory and cognitive accessibility, future improvements also have to factor in the need to upgrade transport-related services for other aspects of diversity such as gender, age, sexual orientation, cultural background, IT literacy and sensitivity to weather conditions and pollution.

To achieve this, best practices in countries and regions which have already started to address these issues ought to be examined while users, who are not sufficiently heard, should be engaged in designing new products and services.

I would like to mention some of these needs as examples by sharing best practice benchmarks we have identified in the course of our work on projects in various places.

Provision of public toilets on the transport network

The elderly and children need to use public toilets more frequently than other people, and while some trains and stations do have this service in place, provision is noticeably poor in other parts of the transport network and public space. This shortcoming was most evident in the pandemic when toilets in bars, restaurants and public facilities could no longer be used.

In Japan, for instance, the entire transport network has public toilets with a number of features to note:

- In individual stalls there is a folding seat for a baby to sit on while the adult uses the toilet.
- Every metro and railway station has family toilets which, in addition to being accessible and gender-neutral, also have a number of accessories that allow adults and children to use them at the same time, and even a folding bunk bed for a person who is unwell to lie down or to change an adult's nappies.

Baby seat. Photo: Imma Bonet

Public family toilet. Photo: Imma Bonet

Wayfinding for pedestrians

Another area for improvement is the interface between the transport network and the public space, particularly in terms of wayfinding.

While information on how to get around in transport networks is generally quite satisfactory, information on how to get to them and find your way around the streets is

far from sufficient, and this affects decision-making when it comes to choosing a mode of transport.

Cities such as London or Madrid are significantly upgrading information in the public pedestrian space.

Presentation of the Madrid signage master plan. Photo: @Avanti-Avanti Studio

Transport on the outskirts of cities

Although Barcelona and its nearby municipalities have ample public transport services, the further away you get from the metropolis, the less public transport is available and in some cases there is none at all.

Whereas it is true that delays in infrastructure improvement investment and budgetary constraints are a major stumbling block, in some regions they have met this challenge creatively.

For example, in Florida in the United States and also on the island of Tenerife, taxis offer shared trips during off-peak hours to fill in for buses.

The evolution of driverless vehicles and technologies associated with 5G will also need to be closely tracked to explore their role in contributing to transport services available for people living in more isolated areas.

Language diversity

In a territory with such language diversity and which welcomes migrants and tourists from all over the world, the transport network and its services need to be understandable to people from different cultures. This can be achieved by increasing the use of globally understandable communication codes and icons and also including more languages and machine translation systems in apps and websites.

It is also in Japan where the wayfinding system in the metro means it can be used even if you don't understand either Japanese or English. Indeed, as a result of the Olympic Games several companies have developed translator tablets and other devices which enable transport network customer care staff to provide information in the user's language.

Protection against weather conditions and pollution

Using suitcases and trolleys on uneven pavements leads to unnecessary noise pollution while climate change is increasingly impacting transport infrastructure and passenger comfort.

In Singapore, where torrential rain and strong solar radiation are common, they have looked into how to encourage people to walk, concluding that journeys need to be useful, safe, comfortable and attractive while also setting up bus exchanges which connect offices and homes to the transport network.

Many cities such as Seoul are also investing in new silent, dirt-resistant and, more recently, bacteriostatic paving.

Having outlined the need to tailor networks to human diversity, I am convinced that, just as it has done so far, the ATM will continue to address the challenges of delivering a transport network which is increasingly fit for all.

Silent bacteriostatic paving. Photo: Access Safety

FRANCESC ARAGALL

Chair of Design for All International

Design for All consultant who started out in this field in 1990.

Founder and chair of Design for All International and director of ProAsolutions, a company based in Spain and Portugal which applies Design for All in urban planning, architecture, transport, tourism, services and products, cultural facilities, safety and waste management.

Francesc has mainstreamed Universal Design and Active Mobility in over 300 urban plans in various European countries and has been involved in several projects and standards development for CEN and CENELEC, AENOR, Singapore, Catalonia, the UAE and Turkey.

MaaS: technology working for more sustainable, inclusive and accessible mobility

Laia Garriga Mas, Business Development Manager, Rail Industry & Logistics at the EURECAT FOUNDATION

Mobility as a Service (MaaS) is a new, service-minded transport paradigm which advocates sustainable, flexible, continuous and more cost-effective mobility with the goal of replacing private vehicles and fostering multimodal transport while emphasising user needs.

Mobility as a Service calls for integration of and access to public and private mobility services via a single platform enabling on-demand, fair and inclusive multimodal mobility.

The maturity of digital technologies such as artificial intelligence, data governance, virtual reality, 5G and cybersecurity and their convergence and integration are having an exponential impact on unlocking interrelationships between the physical and virtual worlds, enhancing the free flow of data, fostering smart automation and context adaptation, linking domains and fast-tracking the development of new services and business models, and of course also helping to improve decision-making.

Yet notwithstanding the maturity of the technologies which can bring MaaS platforms to fruition, there are still many barriers to the uptake of the technologies in the mobility industry and no agreement on the definition of governance structures. This calls for a number of initiatives, which include: unpacking the legal and public liability risks associated with the impact of these platforms on mobility, which is often unknown, imprecise, or even not yet adapted to change; getting hold of quality data; building public-private partnership mechanisms; enhancing the narrow ecosystem of local technology providers, most of which are currently small, and seeking to lessen the significant reliance on large multinational organisations in terms of the availability of mobility data generated by users.

Why should we continue to work towards building MaaS platforms in spite of the challenges?

Sustainability

Pollution, traffic and noise in cities are a growing and seemingly worsening problem. This is one of the reasons why Mobility as a Service has emerged in recent years.

Unleashing Mobility as a Service encourages people to use new forms of public, private and shared transport, making us less reliant on private cars, cutting pollution and crafting more green areas which deliver quality of life and health for the public at large.

Ease of use and flexibility

The development of mobile apps turns MaaS into a fast, user-centric system. Using a mobile app to check out all the ways of getting around a city makes it a convenient and multimodal system without needing to have a different platform for each means of transport. Apps need to be able to adapt to the needs of each person and hence enable transport for any user profile in the city and isolated areas alike.

Connectivity and safety

Mobile devices are equipped with features such as speed, real-time data availability, cameras, satnavs, etc. All this makes it possible to build customised apps. It has also been shown that using mobile devices for these shared mobility services is a secure and effective system for both users and enterprises, whether state-owned or private.

Saving money

Most of these kinds of platforms which support collaborative mobility offer to pay only for the miles travelled, as is the case of car sharing services, and this type of service also saves money on parking and helps to combine routes, with additional saving in time.

Unlocking smart cities and digitalisation

One of the plans for the future of cities is for them to become smarter, more sustainable and with services accessible to all. Solutions which drive MaaS allow cities to evolve towards more digital and accessible places with the help of the technologies we use in our daily lives.

Technology should continue to be our partner in creating a better, more accessible and digitalised world which caters for our needs.

LAIA GARRIGA

Business Development Manager;
Rail Industry & Logistics
a Fundació Eurecat

Laia is a facilitator of new business projects and collaborative project development. She holds an Industrial Engineering degree from the Barcelona School of Industrial Engineering (ETSEIB). Her career has always been related to value-added technologies and business development in a number of industrial, health and insurance sectors.

She is head of rail and logistics business development at Eurecat and deputy chair of innovation at the IN-Move by Railgrup cluster. She has over nine years of experience in the railway and transport industry, where she has driven collaborative projects with several businesses including Assets4Rail, a European project featuring 19 partners, and Diamond, a European project to develop tools to shape means of transport by mainstreaming a gender perspective. She has also been involved in projects with the Metropolitan Transport Authority including the definition of origin-destination (OD) matrixes with differentiation by means of transport and projects to enhance transport accessibility.

The pre-conditions for MaaS to deliver sustainable and equitable mobility outcomes and the role of public authorities in the MaaS ecosyste

Suzanne Hoadley, Senior Manager, Polis

MaaS has been the subject of much research and discussion in recent years, leading to a substantial body of knowledge about different aspects, not least the business models and technical requirements such as data sharing. One area that has received less attention is travel behaviour, specifically the influence of MaaS on people's travel choices.

The MaaS discourse is dominated by the promise that MaaS will encourage the shift to more sustainable modes, among car drivers particularly. This assumption appears naïve as it ignores the triggers inducing travel behaviour change, which are mainly driven by changes in personal circumstances (new job, moving house, growing family, etc) and by public policy rendering private car use less convenient, notably through road space repurposing and the introduction of traffic and parking restrictions and road pricing.

This latter point is supported by recent research on the most successful measures for reducing car usage and promoting sustainable mobility, carried out by Lund university. Of the 12 groups of measures studied, traffic and parking restrictions appear in the top 3 whereas apps are in 12th place (https://www.theguardian.com/environment/2022/apr/16/12-most-effective-ways-cars-cities-europe)

If MaaS is not the silver bullet for achieving sustainable mobility outcomes, it does nonetheless offer an unparalleled opportunity to improve the integration of existing transport services and to enable more seamless trips for users.

For public authorities, MaaS also creates an impetus for modernising IT systems and provides an additional distribution channel for their services. However, this does not come without a cost - in terms of information technology development, operations and maintenance - nor without risk, notably from the creation of a new market of independent MaaS platforms.

The arrival of independent MaaS platforms represents a paradigm shift in the urban/metropolitan transport landscape, unlike the long distance transport sector in which big players such as Amadeus and Trainline have been operating for a long time.

The risks are largely hypothetical today because MaaS has not been deployed at scale; however, they build on the trends and impacts seen in other digital transport services, such as ride-hailing, and in other digital platform sectors, such as eCommerce or hospitality (accommodation booking). While these platforms deliver much valued services to their users, they create undesired effects on the ground, which must then be addressed through public policy.

With respect to the goals of sustainability and equity set by public authorities, there is concern that independent MaaS platforms may prioritise those modes that generate the highest revenue, assuming their income is derived from commission. Since there is little to zero revenue value from walking, cycling and public transport, this may lead to car-based trips being promoted. There is also a risk that a small number of dominant players will emerge (not unheard of in the volatile mobility market), able to exert a disproportionate influence on operators in terms of setting pricing conditions for instance. Another risk relates to data asymmetry whereby independent MaaS platforms hold better travel data than the public authorities and operators themselves. These risks and the measures to avoid them are explained in greater detail in a paper co-drafted by Polis and the two public transport associations EMTA and UITP. (https://www.polisnetwork.eu/wp-content/uploads/2021/02/UITP-EMTA-POLIS-Joint-opinion-on-EU-wide-integrated-ticketing.pdf)

How can these adverse effects be avoided? Public authorities (transport authorities, municipalities) must play a role in shaping and steering the local MaaS ecosystem. They should make use of existing powers to set the conditions for (i) access to public space and infrastructure for transport services, and

(ii) the resale of public transport and other publicly produced or compensated transport services. Against a backdrop of recent national legislation (Finland and France) and future EU legislation enabling the creation of digital resale channels for transport services, it is imperative that the strong role of public authorities in MaaS is recognised and that the powers vested in them today are not diminished.

SUZANNE HOADLEY

Senior Manager at Polis

Suzanne is Senior Manager at Polis with responsibility for activities related to ITS, data, digitalisation, automation and connectivity. Polis is the network of city and regional authorities promoting innovation for sustainable mobility. She has worked at Polis since 2001.

Her main task involves facilitating knowledge transfer and debate among Polis members on topical issues and emerging themes including data sharing, MaaS, digitalisation of transport in local government, multi-modal network management, C-ITS and CCAM. Suzanne has edited policy papers on several of these themes, with the aim of bringing forward the views of Polis member cities and regions to the European institutions and other stakeholders.

Common data spaces for accessible and sustainable mobility

Julià Vicens, Research Scientist at the EURECAT FOUNDATION

The traces we humans leave behind help us grasp how we experience space. They range from the archaeological data which have enabled us to unpack how humans have spread across the earth over millions of years and thousands of miles to the big data which give us access to very precise information that describes -at multiple temporal and spatial scales- how we move and with what and with whom we interact. Digitalisation and massive data gathering pave the way for analysing how humans move in a metro station, on city streets, between regions or even over long distances between countries. These data have significant potential for understanding not only people's behaviour with respect to mobility but also how they live in urban and rural space. Armed with this knowledge, we can enhance the experience of mobility and design better, healthier and more sustainable spaces. Nevertheless, we may also reproduce the inherent biases in the data and the under-representation of systematically invisible groups. Furthermore, data privacy and governance are still a challenge when devising data-driven decision-making systems.

Mobility is a complex system which is shaped by numerous factors at the same time. Mobility interacts with urban, biological and economic systems. Traffic calming in a street, extending public transport in a certain area or setting up a new bike lane have impacts which reach beyond changes in travel flows or means of transport; they are social, economic or environmental impacts which directly impinge on quality of life and even social cohesion. Some of these impacts have become apparent and evident during the Covid-19 pandemic, and not just the significance of mobility in spreading a disease but also its cascading effects. The most obvious impacts are probably environmental on the improvement of air quality (Venter *et al.*, 2021) and the lowering of noise levels (Bonet-Solà, D., 2021). Understanding the dynamics and emergence of mobility patterns which have a direct impact on the liveability of cities, regions

and communities is crucial for designing more efficient transport services and more accessible and safer spaces.

We don't all experience public space, and public transport in particular, in the same way. Women's mobility patterns differ from men's (Gauvin *et al.*, 2020), and in some instances women may even have to adopt strategies to feel safe in public space by amending their behavioural patterns to adapt to these spaces. So aspects such as gender or socioeconomic status mean the experience of mobility is very different. As we have seen in projects such as Diamond, which taps knowledge from data to manage gender-specific needs in the use of transport systems, it is essential to tailor methodologies and infrastructures to ensure that everyone can enjoy public space and mobility on an equal basis.

Vulnerable people and groups have traditionally been excluded from decision-making, and working with large volumes of data does not ensure that they are represented. Indeed, sometimes the opposite is true as the same dynamics are perpetuated and they are either not represented or their representation is biased. An assessment of biases in both the data and the models under development is essential to identify and, where feasible, mitigate the potential impacts. It is also imperative in this situation to work with the public and generate participatory schemes whereby everyone is involved in the decisions shaping public space together with public and shared transport. These participatory strategies have been instrumental in public space interventions targeting the recovery of public space (Zografos *et a*l., 2020) and in a shared understanding of the impact of mobility on air quality (Perelló *et al.*, 2021), for example in the EU Mission: Climate neutral and smart cities advocating a participatory and inclusive approach to decision-making processes.

Engaging the public not just as data providers but also as key stakeholders in rethinking public spaces and the way we get around is paramount. Integrating stakeholders and civil society in decision-making allows for a better understanding of concerns and needs when mapping out the transport and cities of the future and putting in place mechanisms to reclaim and enable the evolution of public space. Setting up mobility data spaces – and satellite systems – with open data is a core component that allows the public and private research community to effectively engage in the process of rethinking transport services and infrastructures. Processes can be shaped around them

to broaden the vision of the use of transport and public space to craft safer environments.

The inherent complexity of mobility has to be addressed holistically by building in a range of expertise which allows us to address cross-cutting impacts. Shaping the future hinges on open participation in decision-making and in the design of transport services and infrastructure coupled with the settings in which it takes place, be it the city or the train carriage, the cycle lane or the carpool. And this has to be done by including vulnerable and under-represented groups which are usually the ones with the greatest accessibility problems. Finally, a mobility data pool needs to be put in place bringing together data from private organisations, government and people openly and with robust processes which ensure data governance by the public while safeguarding their individual and collective rights.

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Julià Vicens is a research scientist in social computational science in the Data Science and Big Data unit at Eurecat.

His research encompasses areas such as complex systems and citizen science, seeking to understand social phenomena including behavioural patterns, information propagation and human mobility with a special interest in uncovering the inequalities of social systems.

He has been involved in numerous domestic and international research and innovation projects whose findings have been published in high-impact journals.

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Chapter 3

SUSTAINABILITY AND HEALTH

Urban Vehicular Access Regulations (UVARs), and how they help the move to sustainable transportation in Europe

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Lucy Sadler, Director Sadler Consultants Europe GmbH

Cities sometimes restrict - permanently or temporarily - the access to an area, road, or a portion of the road to all vehicular traffic; or to specific vehicle categories. These are implemented for to improve issues such as safety, health, environmental or mobility (such as congestion or the move to sustainable mobility).

When such restrictions are implemented in urban and metropolitan areas, we can refer in general terms to **Urban Vehicle Access Regulations or UVARs.**

There are generally 5 main UVAR typologies:

1. Pedestrian Zone (pedestrians (and perhaps cyclists) only).
2. Limited Traffic Zone (only certain vehicles).
3. Low / Zero Emissions Zone (access according to emissions).
4. Congestion Charge Zone (entry on payment).
5. Pedestrian Priority Zone (shared road space, where pedestrians have priority).

There are over 700 UVARs in around 500 cities in Europe, shown on the map below taken from www.urbanaccessregulations.eu, which gives full information on all European UVARs.

And why UVARs?

- **Pollution kills** over 7 million people each year (WHO figures)– especially the vulnerable, elderly, those with pre-existing health conditions, or even

COVID-19 – and causes lung disorders such as asthma in our children. It also costs our society 4.8% of global GDP (World Bank).

- **Congestion** in cities requires delivery companies to send out additional vehicles (to also sit in the traffic jams), and makes journeys and deliveries less reliable. In Europe congestion costs 1% of GDP (European Commission).
- **Urban quality of life** can be improved by converting road space into recreation or commercial space. In the 1970s the central squares of many European cities were filled with parked cars. Now the space is used for outside dining and recreation. Few would want to return to the town square filled with cars. More recently it has been used for recreation, outside dining and shops.
- **Urban space is a valuable resource**, often given 'free' or for low cost.
- **Fairness**: those cycling, walking or using public transport are not only more sustainable, but using up much less road space. The poorer in urban society are often those without a car. Why should they/society subsidise the greater road space and other costs from car drivers?
- **And because sometimes, carrots simply aren't enough** to get the change needed.

The need to reduce climate emissions towards the Paris Agreement is an increasing driver of UVARs. While national policies can often improve the general conditions for lower emitting options, UVARs can help facilitate faster speed the change in urban areas.

Centre of Ravensburg, Germany (photos, Lucy Sadler)

Shared space in Bristol, UK (photos, Lucy Sadler)

The sections below explain the main different types of UVAR in more detail.

Pedestrian Zone

A **Pedestrian Area** or **Pedestrian Zone,** typically a square, a road or a group of contiguous roads where no motorised vehicles are allowed and the whole space is reserved only to pedestrians, sometimes also allowing bicycles as equal or 'tolerated' status.

Sometimes, and only if signposted as such, pedestrian areas might admit just a very few vehicle/user categories such as emergency/police, people with reduced mobility with proof (eg a blue badge), residents who needs to reach their garage, delivery vehicles (usually in one short and off-peak time window) or micro-buses. Parking is never allowed and admitted vehicles should proceed at walking speed.

The overall objectives are to make these areas more liveable and safer by prioritising walking, social interaction and to protect visually and physically sensitive sites such as monuments and landscapes.

Space taken by on-road parking in Freiburg, Germany (photo, Lucy Sadler).

Quite often such zones cover small and fragmented city portions even if there are examples of large and long corridors connecting squares like in Varna (Bulgaria), neighbourhoods like in Paris and fully pedestrianised city cores like in Ljubljana (Slovenia) and Pontevedra (Spain). However, cities are increasingly implementing pedestrian zones over large parts of the city centre, to ensure that it is attractive to visitors.

Pedestrian areas usually use changes to the road layout to make it obvious that cars are not allowed, for example cobblestones, physical interventions, the presence of monuments in squares, street furniture transforms roads into public spaces, and reinforce the message that no motor traffic allowed and facilitate the improved ambience of the area.

Limited Traffic Zone (LTZ)

In line with the objectives of pedestrianisation (liveability, road safety, cultural and natural heritage protection, climate change) and in order to reduce congestion, **Limited Traffic Zones (LTZ)** restrict access to only those motorised trips that are considered necessary for the functioning and daily life of the area. Residents, garage owners/tenants, caregivers, people of reduced mobility, freight carriers, maintenance and servicing companies are commonly authorised and pre-registered user categories plus of course public transport, taxis, emergency/police vehicles.

Usually covering wider areas such as historical centres, LTZs always work with **Permits**, These authorisations must be requested and approved in advance to permit access. Some permits can have a longer validity (e.g. for the categories indicated above) others may allow occasional access from other user types such as residents visitors or hotel guests[2]. LTZ might also restrict access (in addition or exclusively) to specific vehicle categories (quite common are the restrictions for lorries and coaches) or vehicle characteristics such as type, weight, size or pollution levels (noise, air quality). The EU UVAR project ReVeAL Guidance on Exemptions and Permits gives more details on this.

The city of Varna in Bulgaria has a 1.5 km pedestrian corridor linking the entrance of its famous Sea Garden, the church of St Nicholas, the Theatre and the Clock Tower. Photos: TRT

Parking is also often allowed and time windows are largely used to regulate freight transport and loading/unloading operations.

The overall principle is to reduce motor traffic; to reduce motor traffic to the very essential level, or to significantly reduce, depending on the number/ categories of permits granted. the policy objective to prioritise walking, cycling and public transport..

LTZs are widespread in Italy (the very first European Limited Traffic Zone

was introduced in Siena already in 1965 and there are now over 350 camera-controlled LTZs in Italy), but also exist in other countries, as shown in the map above.

The permanent "car free" area of the city centre of Ghent in Belgium is made of 4 different LTZs (plus some pedestrianised streets) surrounded by its famous Circulation Plan (ie where through traffic is not possible due to the road layout / one-way streets / road blocks).

The permits for an LTZ scheme might also refer to specific vehicle categories (quite common are the restrictions for lorries and coaches) or vehicle characteristics such as type, weight, size or pollution levels (noise, air quality), as explained in the ReVeAL Guidance document.

Low Emission Zone (LEZ)

The focus on pollution levels and meeting the EU health-based air quality objectives has led in more recent years to the introduction of many **Low Emission Zones (LEZ)**, also called "Environmental Zones" in some countries (e.g. Germany, the Netherlands, Sweden, Denmark).

LEZs restrict vehicular access to those vehicle categories that meet set minimum air quality emissions standards;. Usually through the European vehicle emission standards for exhaust emission (NO_X, PM, CO, VOC, HC, NMHC) and the respective "Euro Standards" (see eg Dieselnet for further explanations)

Different from an LTZ, the primary objective of a Low Emission Zone is to reduce air pollution from, rather than reduce traffic. Generally, pure LEZs rarely reduce traffic levels, their immediate effect is to accelerate the renewal of the fleet – although this can be different where a very strict standard is used, for example the London Ultra LEZ with a Euro 6 diesel standard (vehicles post 2013-15) introduced in 2019). The founding principle is to discriminate by air pollution contribution and not by transport mode, and generally vehicle owners exchange their older polluting vehicle for a newer less polluting one, or retrofit with, for example, a diesel particulate filter to meet the emissions standard.

LEZs are usually phased in, becoming increasingly strict standards over time. Sometimes stricter rules applied in different and usually concentric areas may lead, for the sake of communication and comprehension by road users, to different sub-type names such as Ultra Low Emission Zone (ULEZ) in London.

Some LEZs (e.g. London) use a charging mechanism, so vehicles meeting the standard are free, those not meeting it are subject to a high fee (equivalent to a penalty fine).

When only zero emission vehicles are allowed, the LEZ becomes a **Zero Emission Zone (ZEZ)**; usually implemented to reduce climate change emissions, as well as air pollution. There are a number of mechanisms / routes to a ZEZ. Sometimes by strengthening an LEZ, other times by putting a Zero Emission Vehicle (ZEV) requirement on a LTZ or Pedestrian Area delivery window access. A good practice ZEZ will also look to reduce traffic, perhaps with an LTZ or Spatial Interventions (changes in the road layout, perhaps pedestrianisation or bus lanes) in the road network to remove road space.

Congestion Charge Zone

Vehicular traffic might not be restricted according to certain vehicle/user category or emission standard but require payment to permit entry.

Again, a combination is possible between the two scopes of pollution and congestion reduction: a Pollution Charge Zone is a UVAR scheme where only vehicles not meeting a set emissions standardhave to pay (eg London's LEZs) whereas in a Congestion Charge Zone all motor vehicles are charged irrespective of their emission standard. Sometimes there are differential charges for different vehicle types, for example higher charges for lorries than cars, polluting vs less polluting (eg Oslo).

The formerIn 2008, Milan's implemented the Ecopass pollution charging scheme, (2008-2011)which accelerated fleet renewal at the start, but as the standard was not tightened, itwhile progressively losting its initial congestion

reduction effect as the emissions standard was not tightened asnd more and more vehicles could access the zone. It was therefore converted into a Congestion Charge, now called "Area C", in 2011 where pre-Euro 4 vehicles are not permitted to access and all vehicles entering pay a fee (so it has an LEZ character incorporated into the main charging scheme). Other cities with congestion charges include London, Stockholm and Valetta.

Charging systems and regulations, also known as urban road tolls, usually work with ANPR or transponders (to check payments) and exemptions for some vehicle categories. Such scheme can cover both small and wider areas.

Residential Area, Encounter Zone, Superblock, Woonerf

In all UVARs discussed so far, vehicle access regulations or charges are applied: access is regulated through legal regulations. However, there are also other types of scheme that can sometimes be considered UVARs, where motor traffic is regulated through a changes in the spatial road layout and/or reducing speeds

Two typical examples are **Residential Areas/Home Zones** and **Encounter Zones/Superblocks**. Users must adapt their driving/walking style while going in/out, moving and use such areas.

The art. 27 bis of the 1968 UN Convention on Road Traffic (European Appendix) clearly states which behaviours and uses are allowed in **Residential Areas** signposted as such, however these are often also used outside residential settings:

- Pedestrians may make use of the road over its entire width. Games are allowed.
- Drivers shall proceed at very low speed, as specified by national legislation and which in no case should exceed 20 km (12 miles) per hour.

- Drivers shall not put pedestrians at risks nor behave in an obstructive manner. If necessary, they shall stop.
- Pedestrian shall not impede vehicular traffic unnecessarily.
- Parking is forbidden except where allowed by parking signs;
- At intersection, road users emerging from a residential area shall give way to other road users, except when otherwise provided in domestic legislation.

The shared character of the road is the most relevant element, but typically the physical configuration of the area also reinforces such coexistence. Traffic calming interventions and opposing one-way streets/modal filters are used to avoid through traffic. The success of the **Woonerf** concept developed in the Netherlands ("woon" literally translates as residential and "erf" as yard) is due to a strict combination of law and road design elements.

The concept has been extended to other parts of the city: the "erf" can have other primary uses like crafts, trade, tourism, education and recreation. In France, Switzerland, Austria and Belgium these are named "**Encounter Zones"** or "**Superblocks"** that simply use traffic filters to remove traffic rather than banning it. The COVID-19 pandemic has also promoted this approach, for both temporary and permanent schemes.

A 30 km/h limit is usual in such sones, and similarly, but with less emphasis on road use and design, **30 km/h (20 mph) Zones** can also support these aims, particularly where the legislation does not allow other UVAR types. Of course, traffic calming elements remains fundamental and should be present in addition to the prescribed speed limit for drivers.

A German Residential Area road sign (Spielstraße), used more widely than just residential areas. Photo credit, Lucy Sadler

These areas can be referred as "Pedestrian Priority Zones" even if the original definitions are more appropriate to distinguish the context and the characteristics of each scheme.

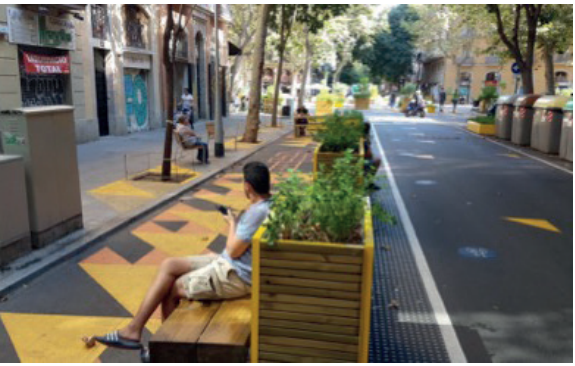
It should be noted that these types of UVARs are not always defined as UVARs, and can be implemented on a smaller scale than many 'traditional' regulatory UVARs.

Are Parking schemes considered UVARs?

This is a question with a variable answer, depending on the definition of UVARs chosen.

Parking is an essential part of restricting vehicular access, as if there is no parking, there will (eventually) be much less traffic travelling there. So, in a broader sense, parking can be considered an UVAR – as in the EU UVARBox project to digitise UVARs to support their use in navigation tools.

However, in discussions of UVAR strategies or policies, such as this, parking is included as an often essential supporting measure, not as an UVAR. This is



Traffic calming and filtering interventions at Barcelona's Saint Antoni Superblock.
Photos: Barcelona Municipality

because parking is a huge already well developed field with its own guidance, expertise, and that including it 'under' UVARs would not do it justice.

Many of the UVARs that restrict traffic work closely with parking rules, as supporting measures that are crucial for the functioning of the scheme. If vehicular access is restricted, then the parking spaces can have other uses, as well as more parking spaces perhaps being required on the edge of the UVAR. Within the UVAR, parking can in fact be: allowed/not allowed, allowed only in signed on-street spots, open to the public or reserved to some user categories (e.g. disabled, residents), allowed in specific time windows, paid/free. It can also happen that UVAR-related permits, exemptions and charges embed also parking options or fees.

UVARs can often regulate kerbside management – eg permits for loading/unloading of goods (or luggage), passengers' pick-up/drop-off and street cleaning, often indicating time windows to limit the time needed for such operations.

Zonal vs. punctual access regulations

In describing UVARs, we mostly refer to a zonal application covering areas that includes more streets or an entire neighbourhood and this is particularly relevant from a driver perspective: access and/or driving style (but also allowed uses of the road space such as loading/unloading operations and parking) refer to a portion of the city bordered by proper UVAR signage at entry/exit gates with rules that are valid to all the roads inside the area. This area may also have specific road space allocation such as loading/unloading operations and parking spaces within the zone.

Of course, as already described, for Pedestrian Areas, traffic restrictions road closures or traffic calming UVARs interventions may also be applied also punctually (a single square, road or a portion of the road) and so we can have, for example, single roads closed to vehicles of a specified maximum length/height/weight, temporary closures for weekly street markets but also other punctual implementations of other UVAR sub-types such as School streets, Spielstraße (Play streets) or Living streets.

How UVARs works in practice?

As shown above, the different types of schemes are often implemented together and schemes increasingly combine the different aspects – for example regulating deliveries in a pedestrian zone, paying for permits or exemptions, or the road toll depending on the emissions level. The schemes can also complement each other – the space that is freed from the traffic reduction of a LTZ or a road charging scheme can be used for spatial interventions to make the area more attractive.

Exemptions can be an important part of an UVAR, to minimise potential unintended consequences – especially for the more vulnerable in society and sometimes to make it politically acceptable.

Enforcement is a key issue; a scheme that is not enforced, or has too many exemptions, becomes a 'non-scheme', on paper only. Cameras with Automatic Number Plate Recognition (ANPR), manual with enforcement officers and police, or with movable or permanent physical barriers such as bollards.There are a number of resources on UVARs available to support transport professionals considering them. They include:

- The CLARS website: https://urbanaccessregulations.eu/ information on all European UVARs
- Free CIVITAS UVAR online training program: https://civitas-learningcentre.talentlms.com/index
- ReVeAL UVAR tools: The EU project ReVeAL is developing tools to support cities implementing UVARs. Some are already available, full toolkit available in November 2022: https://urbanaccessregulations.eu/

LUCY SADLER

Director at Sadler Consultants Europe, GmbH

Lucy Sadler was the head of air quality for the Mayor of London, working on the Central London Congestion Charge and Low Emission Zone, and has run the European Access Regulation Platform since 2007.

The CLARS Platform supports cities implementing access regulations and runs the website urbanaccessregulations.eu giving comprehensive UVAR information.

Lucy is also part of the Horizon 2020 ReVeAL project, (***Re***gulating ***Ve***hicle ***A***ccess for Improved ***L***iveability) providing support on developing UVARs, UVARBox on digitising UVARs and UVARExchange.

Climate-neutral cities, the driving force behind sustainable mobility

Laia Bonet Rull, Deputy Mayor for 2030 Agenda, Digital Transition and Sports and Cabinet Officer for Mobility, Barcelona City Council

As we bounce back after two years of an unprecedented pandemic, the far-reaching social, economic and environmental changes which were already underway have become more apparent than ever and have been further hastened by digitalisation and the social and climate emergency.

One of the areas where these changes are most evident is in the mobility model in our cities. For example, in terms of private vehicles the percentage of people using cars has halved over the last thirty years. Back then, almost seventy percent of Barcelona's households owned a car, and now we are at almost half of that. Today, there are 135,000 fewer cars registered than twenty years ago, a twenty percent drop. Fewer young people are getting their driving licences every year, and instead they are choosing to get around the city by bike, carpooling or public transport. Then there is a forty percent growth of ecommerce in Barcelona as a result of the pandemic, which has added an "extra mile" to the urban freight distribution chain.

So revamping mobility is one of the key tools we have available to make the energy transition happen as we have been phasing out the most polluting combustion engine vehicles and steadily putting in place new, much cleaner means of transport and energy. However, we have also added complexity and pressure in metropolises and cities, the immediate scenario of these major changes, which puts them in a strategic position to lead the fight against climate change, enhance social welfare and generate economic opportunities. This means we have to think of them as a whole in order to tackle these challenges with environmentally effective and socially fair solutions.

Local authorities have been addressing these changes in order to organise mobility, ensure the different modes of transport can run alongside each oth-

er and forge ahead towards this new, more efficient, flexible and sustainable model of urban mobility which people are asking us for. Yet we also have to keep striving to rise to challenges such as the recent choice of Barcelona to join the European "100 Climate-Neutral and Smart Cities by 2030" mission from among the nearly 400 candidates. This programme will turn the city into an innovation and experimentation hub which helps make all European cities climate-neutral and also positions Barcelona as an international touchstone in the battle against climate change and in moving towards a fairer and healthier city and unlocking shared progress.

To do this, first and foremost we need to stay firmly committed to public transport. Experience backs us up as we can confidently claim that the Barcelona of the metro works: it is the only city in Spain where public transport is more efficient than private transport for journeys taking less than 30 minutes. Nonetheless, we need to take a global view and unlock intermodality between means of transport. This calls for extending the model outside the Metropolitan Area to deliver mobility alternatives and reduce traffic with measures such as Park & Ride and bus lanes on high-capacity roads. Yet we also need to cut emissions from the vehicles we use to get around if we are to improve the quality of the air we breathe, which is one of the great collective challenges we face. This was Barcelona's vision when it started up its "Bicing" public bicycle service 15 years ago and it has remained so in recent years, including a commitment to more than doubling the number of cycle lanes, enhancing the city's entire cycling infrastructure and extending using bikes as a personal mobility vehicle.

So we need to continue to step up our commitment to public transport while ensuring that this investment spearheads the shift towards a sustainable vehicle fleet. Several studies show that the most efficient way to cut pollution is not by reducing the number of vehicles in a city, be they cars, buses or vans, but rather by replacing vehicles which run on fossil fuels with others powered by electricity or hydrogen.

We are thus getting the city ready for electric mobility by rolling out a network of electric vehicle charging stations and devising a strategy which is designed to evolve and adapt to social, economic and energy market changes. This is to ensure that leveraging electricity in mobility enhances sustainability

and environmental friendliness and allows us to shift towards the healthy city we want.

Meanwhile, Barcelona Metropolitan Transport (TMB) has pioneered the introduction of a hydrogen-powered bus which will be supplied by the new green hydrogen production plant in the Zona Franca. It is also overhauling its bus fleet with more than two hundred new hybrid and electric buses and already has one fully electrified route and two more on the way.

From a metropolitan standpoint, other measures include the Low Emission Zones which have made it possible to reduce journeys in the most polluting vehicles by 609,000 and achieved the target of cutting NO_2 levels by eleven percent.

People want and expect businesses and institutions to strive to combat climate change and improve the health and air quality of cities. This is our commitment now and for the coming 25 years.

LAIA BONET RULL

Deputy Mayor for 2030 Agenda, Digital Transition, Sports and Territorial and Metropolitan Coordination and Cabinet Officer for Mobility. Barcelona City Council

Laia Bonet Rull (Valls, 2 January 1972) is Deputy Mayor for 2030 Agenda, Digital Transition, Sports and Territorial and Metropolitan Coordination at Barcelona City Council.

She is a lawyer by training and a lecturer in Administrative Law (Pompeu Fabra University) and Communication Law (Blanquerna-Ramon Llull University). She was Secretary of the Government of Catalonia from 2007 to 2010 and a member of the Catalan Parliament from 2010 to 2012, during which time she was deputy spokesperson for the Socialist parliamentary group in the Catalan Parliament.

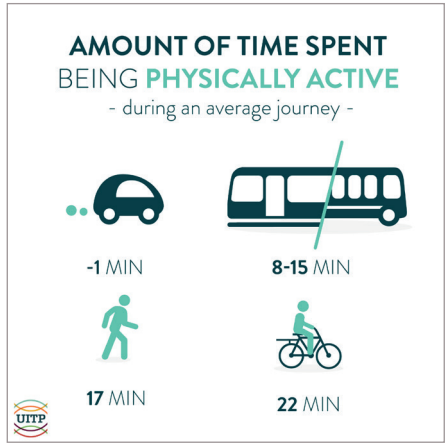
One step at a time advancing public transport for healthy and active cities and citizens

Mohamed Mezghani, Secretary General at International Association of Public Transport (UITP)

As we go to school, to work, to sports clubs, and cafe's, public transport is always there for us. And whether we travel by rail, road or on water, public transport makes our journeys active, safe and clean. Yes, our sector provides essential mobility, but the benefit we bring to society goes so much further.

Some months ago I took part in an active mobility challenge. The goal was simply to walk 10,000 steps per day. Of course, I spent time in nature. But trying to maximise the steps of daily life, made a lasting and healthy change to my commuting habits.

Normally, I travelled from UITP's offices in Brussels to the Gare du Midi train station by metro. That took me 10 to 15 minutes. But instead, to reach those 10,000 steps, I walked. The 30 minute stroll took me along the Brussels canal and some of the most vibrant areas of the city. Walking to my train added a couple of thousand steps to my daily count, benefited my health and cleared my head.



Source: UITP Urban Mobility Playbook

As we described in our Better Urban Mobility Playbook, getting people to walk to the

bus stop or bike to a train station, might be the simplest way to encourage an active and healthy lifestyle. A journey by bus for example, means people spend an average of 8 to 15 minutes being physically active. Over an entire day, train commuters walk 30% more than car commuters.

And the health issues linked to our sedentary lifestyles are becoming more prevalent. In fast growing cities, one in six children is overweight or obese. For adults, this number is one in two. To combat obesity and associated health issues, the WHO recommends 30 minutes of daily physical activity. This drastically decreases the risk of diseases such as Type 2 Diabetes, Depression, and Alzheimer's.

Less noise, better sleep

But the health benefits of public transport go much further. According to the WHO, 360 million people worldwide suffer from disabling hearing loss due to constant and excessive noise exposure, much of it caused by traffic. In the European Union 30% of people are exposed to such high noise levels, that it disturbs their sleep. That percentage is even higher in developing countries.

Studies have shown that the top five quietest cities in the world are Zurich, Vienna, Oslo, Munich and Stockholm. All of them have highly efficient public transport systems and actively disincentivise the use of cars in their urban areas. Public transport moves hundreds of people in just a couple of vehicles, driving through a city mostly without noise. Imagine the sound pollution if those people travelled in their private cars.

Cleaner Air

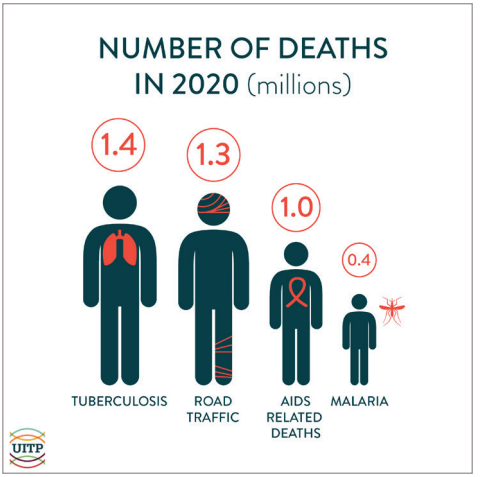
The same equation counts for air pollution. Air pollution causes premature deaths from non-communicable diseases such as strokes, lung cancer and heart attacks. The WHO recognises it as the single biggest environmental threat to human health causing eight million premature deaths per year globally.

In developing countries, 90% of air pollution is attributed to vehicle emissions. And also here, public transport offers the solution, as it produces far fewer quantities of air pollutant per passenger kilometre than individual private motorised mobility.

Drastically reducing Road deaths

Finally, there is road safety. Danger on the road is a direct consequence of our choice to allow cars to dominate the urban landscape. Each year, over 50 million people are injured worldwide on roads. 1.3 million people die, with road traffic being the leading cause of death for children and young adults across the globe.

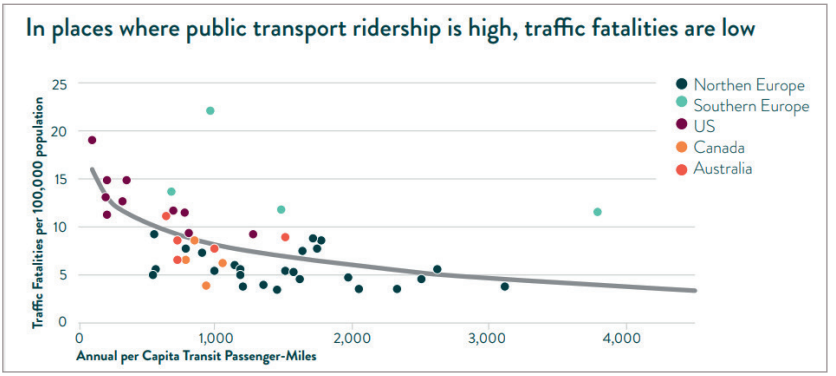
In places where public transport ridership is high, traffic fatalities are low. There is a direct corelation between the number of people killed on the roads in towns and the number of journeys made by car. In towns where there are well developed public transport systems, the number of deaths is half as many as in towns where almost all journeys are made by car.



Source: UITP Urban Mobility Playbook

Public transport provides mobility for life

The Brazilian city of Salvador is a good example of how a well planned healthy mobility strategy can stimulate both the use of public transport and ac-



Source: UITP Urban Mobility Playbook

tive mobility. Developments like 15 elevated bridges, bike and jogging tracks and 6,000 new trees, created a quality environment for active mobility.

But by connecting this infrastructure with 17 bike-sharing stations along metro stations, multimodal travel, combining active mobility and public transport, rose drastically.

Put simply, if we want people to adopt an active and healthy lifestyle, we should start simple. Design our cities around public transport and active mobility. Convince people to leave their cars at home and walk, bike, use public transport, and mix those modes. That is where healthy mobility starts.

MOHAMED MEZGHANI

Secretary General
Entity: International Association
of Public Transport (UITP)

Mohamed Mezghani has been working for more than 30 years in public transport and all related fields. He has been the Secretary General of the International Association of Public Transport (UITP) since January 2018 and is a passionate advocate for urban mobility worldwide.

Local authorities and the great challenge of sustainable mobility

Aurora Carbonell i Abella, AMTU Chair. and ***José Maria Chavarría***, FECAV Chair

The AMTU, which as you know is the Association of Municipalities for Mobility and Urban Transport, has been working with you for years in this complex and thrilling endeavour to make our country a people-friendly and environmentally efficient place in terms of sustainable mobility. We represent the views and efforts of the municipalities which are striving for public transport that meets the planet's challenges by following the great mantra of "act locally to have a global impact".

We need to live up to our responsibilities and take action by constantly improving our essential mobility plans, making sure that low-emission zones are set up, cutting down on our carbon footprint, investing in energy-efficient and sustainable public vehicles and delivering personal and public mobility which brings us ever closer to European green standards.

This is why we are committed to models such as Transport on Demand (ToD) and Flexible Transport. And in this we have always had the backing and partnership of the Barcelona ATM, which is essential in our way of thinking to continue working and battling to enhance air quality and, in short, the quality of life of people across Catalonia.

Let's keep working together for our people and area.

Sustainable mobility needs to include a public transport network which is fair in its modes and these in turn have to pool resources to cover the entire area and thus enhance the quality of life of the people who use public transport. Digitalisation plays a key role here because it shapes other factors such as accessibility and the health of transport users. Furthermore, connectivity fosters new transport services such as on-demand buses. This sustainable and inclusive mobility model is evidence of the changes in users' consumer hab-

its. Likewise, digital transformation has a significant impact on urban transport infrastructures by fashioning a scenario of opportunities for efficient management and occupation of public spaces through multifunctional, automated and resilient systems. In short, the main targets of this cross-cutting approach to mobility and which are aligned with the ATM's values are the fight against climate change to curb the emission of polluting gases, the flexibility and safety of public transport modes and the coordination of authorities, associations and organisations to plan sustainable mobility.

Many congratulations on your 25th anniversary.

ATM Àrea de Barcelona
Autoritat del Transport Metropolità

25th anniversary

Chapter 4

INNOVATION

Artificial intelligence; a tool working for safe mobility

Joan L. Mas, Director of CIDAI

Safety is an essential aspect of mobility, whether in towns and cities or between them, and this means it has to be ensured as far as possible in all circumstances. It hinges on a number of factors which may be objective, such as the quality of road infrastructure, weather and the condition of the vehicles used in transport; or subjective, including driver skill, distractions and others which play a crucial role in the number of accidents. Then there is the constant rise in road usage, the emergence of various forms of urban micro-mobility, last-mile traffic and in general the increasingly challenging relationship between pedestrians and vehicles in an urban environment.

Harnessing artificial intelligence (AI)-based technologies is a potential solution to address safety challenges and cut accident rates on roads inside and outside built-up areas. It is also an essential ingredient for reaching the target of halving road traffic fatalities by 2030 as set out in the UN Sustainable Development Goals (SDGs), specifically SDG 11 on inclusive, safe, resilient and sustainable cities.

AI can assist in achieving this goal in a number of ways. For example, by gathering and analysing accident data, it can help to identify locations with a higher risk of accidents, understand why this is the case and put forward mitigation measures. In turn, the knowledge gained from this process can be leveraged for safer urban planning by reducing or eliminating these risks.

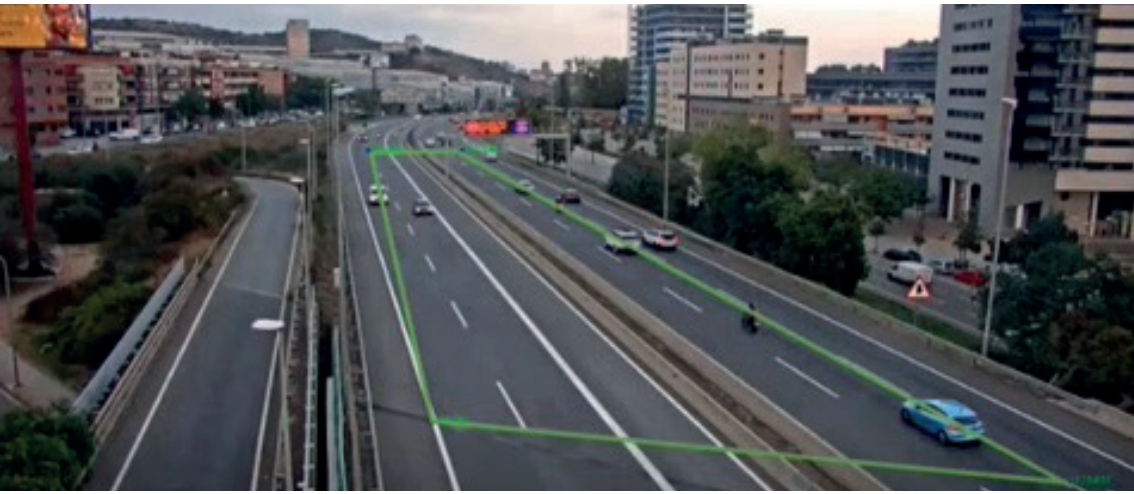
AI also plays an essential role in self-driving cars. This is because in a scenario of full autonomy which we have not yet reached, it is technology which will enable the vehicle to make its own decisions based on the inputs it receives from the array of sensors replacing the driver. Once again, there are many ethical, regulatory and legal implications in terms of safety.

At CIDAI, the Centre of Innovation for Data tech and Artificial Intelligence which is the hub for the Innovation strand in the CATALONIA.AI strategy, we have prioritised activities connecting mobility and AI. Specifically, in 2021 we drew up our White Paper on AI and Mobility in Catalonia and in lockstep we ran an innovation project to show how AI technologies can be harnessed to identify risk scenarios in urban traffic.

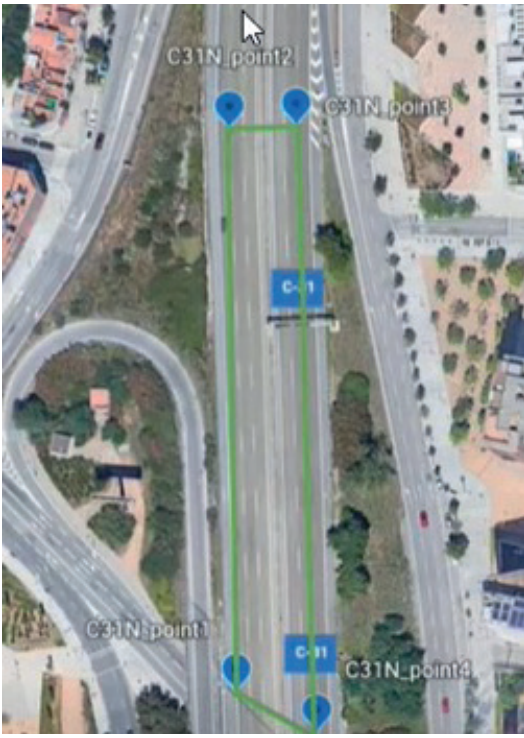
Writing the White Paper furnished the opportunity to bring together the main players in mobility in Catalonia from government, business, technology and academia in a committee of experts, including the ATM represented by Mr Ll. Alegre, its Mobility director. As a result of this interaction, the White Paper pinpoints challenges and opportunities in the uptake of AI in the mobility industry coupled with recommendations and proposals to move forward more than twenty specific projects undertaken in Catalonia in this area which exemplify a variety of use cases of AI and mobility applications.

CIDAI has also conducted a demonstration project about using AI as a support tool for assessing risk scenarios in urban traffic. The project has been run by some of CIDAI's partner organisations, specifically BSC, i2CAT, Eurecat and Microsoft, and has been supported by the Catalan Traffic Service, the Mossos d'Esquadra Catalan police force and Barcelona City Council.

The project has developed computer vision-based solutions and examines various risk situations including traffic detection at intersections and identification of pedestrians jaywalking. It also includes a dashboard to display the results of the underlying data analytics.



In short, drawing on artificial intelligence to improve road safety is one more example which reflects the AI for Good concept, i.e. harnessing AI technology to enhance the wellbeing of people, and is a priority work strand for CIDAI and its partners.



JOAN L. MAS

Director of CIDAI
(Centre of Innovation for Data Tech
and Artificial Intelligence)

Enginyer de Telecomunicacions (UPC) i MBA (Webster University). Va treballar durant 10 anys al centre de recerca de l'Agència Espacial Europea als Països Baixos, en els projectes ENVISAT i METOP, satèl·lits d'observació de la Terra. Del 2000 al 2008 va desenvolupar a NTE S.A. equipament per a l'Estació Espacial Internacional i sistemes de suport a la vida per a missions espacials tripulades. A Eurecat, és el director de la Divisió de Tecnologies Digitals, impulsant desenvolupaments en àmbits com Data Analytics i Big Data, Intel·ligència Artificial, Ciberseguretat, etc., per a aplicacions multisectorials com Salut Digital, Indústria 4.0 o Recursos, entre d'altres, i és director del CIDAI des del gener de 2021.

Geographic information systems and their benefits in urban transport infrastructures

Toni Alpuente, Director of Operations at Tramvia Metropolità, S.A. (TRAM)

Recently implemented urban transport infrastructures, such as the TRAM network, have been built on the basis of initial construction plan documentation. Discrepancies between what was planned and what actually happened were resolved during the construction process. The reconsiderations and alterations meant that a considerable number of aspects varied, including, for example, changes in the new infrastructure layout. This was compounded by the fact that the project had to be implemented in phases (in current projects, even in lots). Finally, the changes were recorded in as-built documentation intended to reflect what was actually implemented.

Furthermore, over the years an urban infrastructure undergoes internal and external alterations which change the "picture" of the as-built construction documentation. These changes are often not properly recorded as part of the operation of the system or are saved in a format which is not the same as the available documentation.

This means that when a technical query on the infrastructure is launched, a mobility practitioner may run into problems in finding out about the real situation of its assets and this calls for a process of "digestion", filtering and absorption of part of the knowledge which is not consolidated in the available documentation, largely due to:

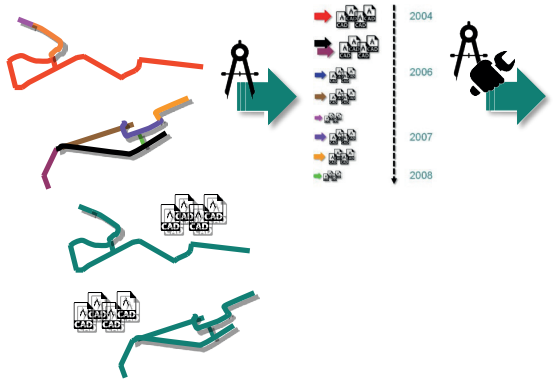
- Diversity in technical documentation (mainly graphical)
- Technical information not aggregated (lists, specifications, handbooks)
- Poor traceability of changes to date

This can make the efficiency of daily work contingent on historical knowledge and the ability to remember everything that has gone on over the years. Another consequence is the amount of time spent on compiling and analysing data.

Organisations can turn this situation around by rolling out a geographic information system (GIS) which contains some of the information about their assets. A GIS is an agile and dynamic tool which provides critical thinking about data and what they can bring to the table. It is an extremely helpful gizmo for setting out complex ideas and therefore also opens up the possibility of making information available to other "not so technical" audiences in the organisation who may benefit from it in their routine work or future projects.

GIS implementation phases

The process of implementing a GIS in an existing infrastructure starts with a **first phase** in which the documentation is standardised with emphasis on graphic material (drawings) and consolidating a version which reflects the final position of the construction process as a whole. This may uncover documentary "gaps" or conflicts which need to be resolved by checking what has actually been done.

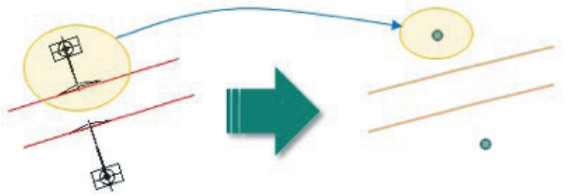


This phase is the cornerstone of the whole process. It is essential that it is led by a person in the organisation who has sufficient historical knowledge of the infrastructure to ensure that no critical aspects of the documentation are "lost". Equally important is the help of all members of the organisation working on day-to-day operations.

The **next phase** is a strategic turning point: the definition of the future GIS's data structure (also called an asset tree). The infrastructure's assets have to be integrated into geo-referenced information layers which will contain graphical and alphanumeric information on these assets. So it has to be decided what is to be included and how, i.e. the asset layers and their attributes (as well as the coding strategy).

From then on, there is a paradigm shift in the way of recording the infrastructure's specifications as very detailed information which is hard to use (drawings, lists, documents, etc.) has to be converted into less detailed information that can be easily exploited. This is when things get a bit hairy with a false sense of danger due to the potential loss of information. Subsequent results will show how good synthesis and simplification make it possible to exploit the consolidated information agilely while always retaining the option of detailed queries for specific and one-off situations.

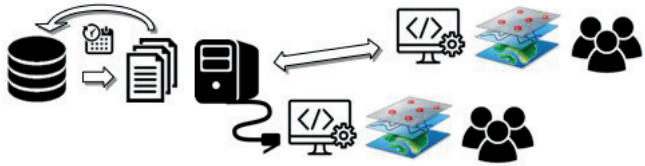
A GIS cannot directly import most graphical information, such as CAD drawings, because it only supports simple geometric elements (points, lines and polygons). A projection needs to be made by assigning each element (or set) a simple geometric shape and encoding the layers with the relevant information.



At this point it is crucial to bear in mind all the possible recipients of the information and their needs when defining the geometries of the layers and their attributes. Needless to say, this won't be straightforward when at least the basic agreement of all the parties involved is sought and it can also be a hazardous phase due to the high likelihood of deadlock in the process.

The **third phase** involves uploading graphic and alphanumeric information. Specialist companies are of great help here as they have tools which make the job a whole lot easier. The involvement and participation of appropriate members of the organisation is also essential in order to ensure the timely inclusion of any discrepancies between the available documentation and the infrastructure's actual situation. This task will generate an iterative process with the previous phase as improvements or shortcomings with respect to what has been defined are often spotted.

Once the uploading is complete, the GIS would become a static tool again unless there is a **final phase** in which a procedure for updating the asset information is defined by putting in place an operational model. Successful GIS consolidation is heavily reliant on the organisation's uptake of all its dimensions, and information maintenance is one of the most important of them. Continuous application of this process makes it possible to pinpoint improvements or shortcomings in terms of the layers and their attributes.



The upshot of the process is a multidisciplinary, dynamic and scalable tool which dovetails with the organisation's general and particular needs throughout its lifecycle.

TONI ALPUENTE

Operations Manager at Tramvia Metropolità, S.A. (TRAM)

Toni Alpuente holds degrees in Industrial Electronics Engineering (UPC) and Industrial Organisation Engineering (UPV) and has spent over 20 years in the mobility sector. He began his career in the traffic light industry before moving into rail transport.

He has held leadership positions in projects, facilities, operations and maintenance.

One of his specialities is managing technical knowledge and its application in improving project planning along with operation and maintenance management.

Using exponential technologies in the evolution of vehicle and transport infrastructure maintenance

Alberto Fonseca, Director of the Technology Unit at the TMBB

Introduction

Vehicle and infrastructure maintenance is a critical process in the operational performance of any transport undertaking. Its significance stems from the impact it has on the quality of service to passengers and in service delivery costs.

This has meant that historically there has been an ongoing concern to enhance the approach to this process by evolving it using the tools available at any given time.

In this article, I will give a brief description of how new technologies can enable new maintenance strategies and the benefits that this brings.

The evolution of maintenance

In the beginning, maintenance was strictly corrective: when something broke down, it was repaired or replaced. This is a highly reactive approach where the impact of failure cannot be averted and puts a lot of pressure on maintenance staff to get the situation sorted out as quickly as possible.

Later on, preventive maintenance strategies were devised: yardsticks are set, such as operating hours, and when this point is reached action is taken to

lessen the likelihood of the failure occurring. The problem here is that there may be significant inefficiencies because the decision for preventive action is based on statistical behaviour, and sometimes actions are taken or components are replaced when this would not have been strictly necessary in many cases.

The most efficient approach would be predictive maintenance, which would further fine-tune conventional preventive maintenance. It consists of monitoring components and identifying patterns which make it possible to infer the failure before it happens. It has the advantage of anticipating failure and preventing its impact while avoiding unnecessary actions on components which do not need them.

Using exponential technologies

The disruptive technologies which have been converging and developing quickly over the last few years are game changers and have the potential to make the predictive maintenance approach viable. They are basically algorithmic technologies leveraging artificial intelligence (AI) and sensorisation (IoT) which will be joined in the near future by lag-free hyperconnectivity through 5G services.

The most significant is probably artificial intelligence. Although this is not a new technology, it has matured swiftly as a result of the upsurge in computing power and techniques for handling big data.

Artificial intelligence enables machines to identify patterns and future failure situations by drawing on big data in an adaptive process which improves over time as the results are fed back into the system. This is essentially diagnostic automation to which the automation of other parts of the process such as autonomous generation of work orders can later be added.

Yet all this only works when big data are available and they can only be acquired on the back of smart operational monitoring. This is now feasible on the back of the development of IoT technology which has delivered accurate

and reliable energy-autonomous sensors which are able to connect directly to communications networks using standard protocols.

Without data, or with very sparse data, diagnostic systems can't possibly perform properly. To give a simile, it's like trying to predict a person's heart failure from their annual medical check-up; it simply can't be done. You can only reach this conclusion by constantly monitoring the heart's operation. Data are the key piece in the jigsaw.

Although in the first stage all this analysis can be done online, 5G technology's maturation affords fresh possibilities such as real-time processing, thereby adding the benefit of immediacy to those mentioned above.

A few final thoughts

Notwithstanding its importance, the evolution of maintenance cannot be a stand-alone project but rather should be baked into the company's digital transformation strategy portfolio as it needs to be equipped with the required capabilities.

As in any approach to digital transformation, the real challenge is not rolling out the technology but rather reformulating processes and most of all changing people's mindset.

The future is not about replacing maintenance staff but instead overhauling their role by adding automation to their tasks and where the key factor is human-machine collaboration.

This is just one more example of how ever-accelerating technological change can help us make things work better, and so technology should be seen as an ally, not an enemy; as an opportunity, not a threat.

In any event, technology is part of the journey we need to undertake to build an increasingly efficient and sustainable public transport system which accomplishes its service goals for society.

ALBERTO FONSECA

Director of Technology TMB

Alberto Fonseca is a telecommunications engineer and holds a Master's degree in information technology management. He has also completed the Public Transport Manager's Certificate Programme.

Since 1994, he has been at Barcelona Metropolitan Transport (TMB) which operates Barcelona's metro and bus networks. He is currently its Director of Technology.

The Technology Unit's mission is to develop and deploy technological solutions for the TMB's business and corporate areas: conventional IT solutions and specific OT systems to support metro and bus operations (SCADA systems, video surveillance and security, ticket sales and validation, passenger information systems, public address systems, fleet tracking, people location, control centres, on-board technology in trains and buses, etc.).

Since joining the TMB, he has specialised in technological solutions applied to public transport. Initially he was a consultant for several cities in Spain and abroad. Since then he has successively been leader of a number of projects, head of various systems (telephony, radio, OAS), Head of the Bus Technology Unit, Director of Telecommunications, Director of Business Technology and Head of Innovation and Technology.

He also occasionally gives presentations, writes articles for journals and takes part in symposiums.

Innovation and technology as levers of change for new mobility

Daniel Marco, Director General of Innovation and Digital Economy, Government of Catalonia

People and freight mobility has always been one of humankind's main concerns. Applying technology in this field has generated significant economic and social impacts such as building cities, the emergence of trade and the spread of tourism.

However, just as the advent of the automobile generated wealth and social progress, it has also had unwanted effects. There are currently 1.2 billion cars in the world which account for 22% of CO^2 emissions, and it is estimated that this will grow to 4 billion cars by 2050 and make up more than 30% of CO^2 emissions. Furthermore, every minute two people die in traffic accidents worldwide and pollution is the leading cause of heart attacks and respiratory diseases.

So we need to ensure we retain the benefits of mobility while mitigating the downsides and it is to this end that digital technology innovation and application is a lever of change for the new mobility.

The mobility industry is undergoing far-reaching transformation brought about by technological progress, innovation in business models and social changes. This sector is directly influenced by the impact of digitalisation, spurred on by the pandemic, and also by how people are behaving as they embrace working from home, ecommerce and telemedicine in their daily lives.

Our goal is crystal clear: we have to shift towards digitalised, decarbonised, shared and multimodal mobility which is first and foremost tailored to the needs of each person, i.e. mobility which is as bespoke as possible, and technology is the only feasible way forward to achieve this. Cutting-edge digital technologies such as 5G, artificial intelligence and blockchain furnish us with the innovations we require for this new mobility.

5G will provide a new environment of smart connectivity, vehicle-to-vehicle connectivity, vehicle-to-infrastructure connectivity, and vehicle-to-citizen connectivity. This connectivity will enable new fully orchestrated state-of-the-art and increasingly autonomous digital services.

Artificial intelligence, meanwhile, enables us to build up our capacity to analyse the large amount of data generated by stakeholders and draw on algorithms to automate processes for better management, safety and security and an enhanced citizen experience. This is a shared data environment featuring data-driven operators making data-driven decisions and fully customised service propositions.

Finally, blockchain or distributed ledger technologies will provide us with new governance of the digital realm, a decentralised model which will allow us to empower the role of the citizen, control of their data and the generation of value derived from their behaviour. The citizen is no longer a passive user but rather an active participant in the new mobility model.

Digital and mobility policies are currently in the same Ministry under the Deputy First Minister in the Government of Catalonia, evidence of the relevance of these two areas for our society. Physical and digital connectivity structure the territory and generate equal opportunities for all in Catalonia wherever they live. So we need to work on together, anchored in innovation to cater to society's needs.

Mobility is one of the priority transformation areas in Catalan Government-driven strategies for frontier digital technologies such as 5G, artificial intelligence and blockchain and they deliver an instrument to build venues for public-private partnership to shift towards this new digitalised, decarbonised, shared and above all person-centred multimodal mobility.

It is absolutely crucial to forge ties between these two realms and jointly unleash the solutions needed for this new digital mobility. In Catalonia we have a world-leading digital ecosystem and a mobility industry which has been one of the mainstays of our economy, so we have the right ingredients to excel in the new mobility models of the future too.

DANIEL MARCO

Director General for Innovation and Digital Economy, Government of Catalonia

Born in Barcelona in 1974, Daniel is a graduate in Electronics Engineering from the School of Telecommunications Engineering at the Polytechnic University of Catalonia (UPC) and in Industrial Engineering from the School of Industrial Engineering at the UPC. He also holds an MBA from Esade Business School.

He started his career as a communications manager in an R&D group at the Philips Consumer Electronics ASA-Lab in Eindhoven in the Netherlands.

In 2000, he came back to Barcelona and joined the Doxa Consulting Group where he held a number of strategic and business consultancy posts in the telecommunications, media and technology sector.

In 2007, he moved on to the Catalan Government as head of the ICT digitalisation and industrial development programmes run by the Directorate General for the Information Society and in 2012 he was appointed director of the Digital Agenda for Catalonia 2020.

Since 2014, he has been director of the Catalan Government's Smart-Catalonia strategy, the programme to turn Catalonia into a world-class smart country, and in June 2019 he was appointed Director General of Innovation and Digital Economy.

He also teaches on several postgraduate and master's degrees at the UPC and the University of Barcelona, is a speaker at domestic and international conferences and discussion forums about digital transformation and a mentor on technological entrepreneurship programmes.

Wake-Up it's 2022!

Simon Reed, Head of Technology & Data, Surface Transport, Transport for London

Before starting to write any article on current transport technology projects we need a grounding in the reality that is 2022. Prior to the pandemic, Transport for London (TfL) was already facing many challenges

- Population: 8.9 million today; 10.5 million by 2040
- Changing travel behaviour: reversing declining trip rates
- Changing city demographics: particularly age profile
- Road safety: delivering Vision Zero
- Air quality: a health crisis
- Accessibility: making public transport and active travel for all

None of these challenges have gone away and yet, as the world comes back to a new reality after two years of pandemic-disruption in public transport most public transport networks are operating with passenger volumes far less than before Covid-19 disrupted our schedules.

The UK Government policy, at the peak of the pandemic, during the first UK "lockdown", discouraged pubic-transport usage owing to the risks of contamination in confined spaces. People who had to travel reverted to private transport or sustainable modes like walking and cycling.

Date	2019	2020
July	206,371	230,235
August	134,489	128,671
September	414,027	412,742
Quarter 3: July to september	754,887	771,648

Fig. 1: New Car Registrations Jul-Sep for years 2019 and 2020. Source: UK GOV National Statistics

Many of the passengers who have left our public transport network will never return. The Decision Maker Panel (UK advisory group) surveyed its members and showed that in 2019 88% of full-time workers were based in the office and rarely or never worked at home. This figure had fallen to 53% in the first quarter of 2021 and was expected to be 64% in 2022 and beyond (post-pandemic) according to senior executives.

The accepted national view is that the workforce will be working from home two or three days a week in the 'new normal'.

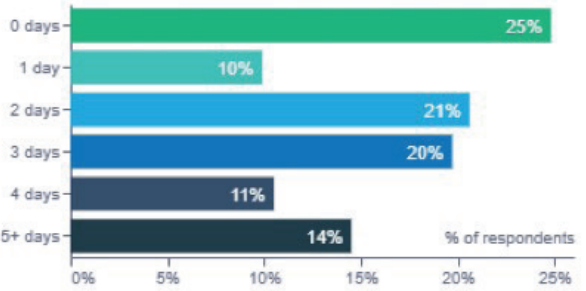


Fig. 2: "in 2022, how often would you like to commute to work after Covid-19 or have paid workdays at home?" Source: UK Economics Observatory

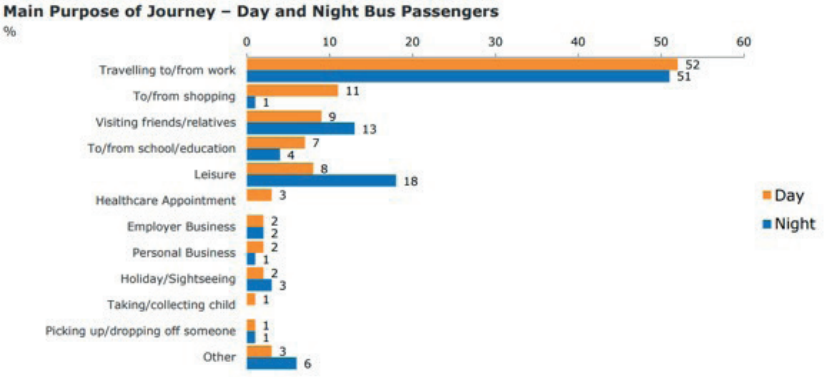


Fig. 3. London Bus Users survey – Main Purpose of Journey (pre-pandemic) Source: Transport for London (TfL)

Nightmare scenario

In 2022, it is clear that paying passengers will be travelling less than before the pandemic, they know that they have a choice of transport modes and, unless public transport can provide the service they want, they will use an alternative.

How does public transport compete?

When asked what makes passengers come back to a transport service, any group in any urban area comes up with the same set of values: Punctuality, Crowding and factors that give the feelings of Safety.

Fig. 4. Top 9 influencers of (rail) Passenger Satisfaction. Source Transport Focus – May 2022

How does Information Technology help?

The real issue is how can we make public transport as friendly as possible to the urban traveller. It's not about the technology alone: the tech can help, but it cannot do more than inform and assist.

The travelling public have had information systems for public transport for over thirty years now and every traveller will expect to have live arrival information for every mode within the scope of their journey delivered on multiple

channels at the stop and available on mobile devices. But is real-time information enough to attract passengers back to your network?

I would suggest not. Live arrival information is just a basic, a hygiene factor, an expected minimum. What is needed is a suite of services that allows the public transport service user to be as informed as (say) the Uber/Ola/Private Hire user.

So here are four areas where Information technology can help address the demands of an increasingly demanding passenger:

1. Dynamic Planning & Scheduling

The basic service offered by transport providers has to be correctly described to passengers.

The bedrock of all passenger information systems is the basic route layout and operating schedule. Covid-19 showed, with successive lock-downs and re-openings, that our transport networks needed to change more dynamically than ever before. In the case of TfL's bus network, changes to the route layout and operation pre-pandemic, were issued once a fortnight. During the first three months of the pandemic in 2020 the number of service changes quadrupled from 780 to well over 3000 as route frequencies were changed to reflect demand and new services were introduced to serve 'key workers' on a weekly basis.

The 'operating schedule' has traditionally consisted of a model of routes/vehicles/drivers and with many services is changed perhaps two- or three-times year. Yet most operators will also freely admit that the schedule is little more than a guide as there are so many special and one-off events that seem to happen with increasing regularity.

In today's environment the *published* service should always reflect the "known" operations of the service and as such all events that could affect the service should be incorporated into the published 'operating schedule,'

In the case of TfL, the service is known to be affected by over 12,000 'known-events' every year. These are events that that have been notified to the transport authority *before* they take place. These include everything from road works, road closures, temporary diversions, temporary frequency changes.

TfL is currently implementing a new Routes and Schedules system with the project name of Adiona, an implementation of Trapeze's Novus application that will become the repository for over 650 routes plus all 'known events' and will allow incremental rapid releases of new schedules into the bus network operation with new schedules and new feeds to our downstream systems.

This will allow timetables to be more accurate, with planned disruptions visible (and for the larger ones) worked into a revised timetable, allowing Journey Planning to be more informed and confidence to be maintained through a "no surprises' network.

2. Passenger Information

The basic "when is my service coming" indicator boards and services have been the staple offering for passenger information services for over twenty years. Algorithms for the calculation of accuracy vary from 'timetable + offset' through systems that use real-time and historic data to predict arrival times (as used by TfL's iBus system) right through to systems that simply show where your service currently is in real-time (usually on a map) to let the consumer determine when the service will arrive. This live-location approach has been adopted in England and Wales by the UK Department of Transport, with syndicated live bus location data for all operators (including TfL services) being supplied to developers of mobility services.

This 'syndication' has probably been the biggest break-through in the last decade of data as 'open-data' where live service arrival information produced by the operator or authority is syndicated to third-parties or independent service providers.

While the industry may congratulate itself on better algorithms and increased access channels, knowing when the service arrives only satisfies one

passenger need-state. In a post-Covid environment, passengers will want to know more, a lot more:

- Where do I catch my connection?
- How long will it take to reach the destination?
- How full is the service?

And in the event of disruption

- What is the cause of the disruption?
- What is the effect on my journey?
- What are the alternatives?

All of the above states are already provided by the private-hire mobility service providers. Investing in answering these questions simply brings the service up to the level of the (private hire) competition.

TfL have responded to the Passenger Information challenge with the TfL_Go app. This harvests the complete range of TfL, and many third party service provider's data sources, and gives an individual journey plan for the user that uses real-time sources to keep it up to date and therefore provide dynamic updates, just for you!

Information provided is only as good as the source systems that provide it and TfL is committed to refreshing its ageing iBus system within the next three years to not only provide accurate information, but also to automatically describe disruptions and provide alternatives to operators and passengers for any disruption experienced.

3. Ticketing

The trend for a reducing use of cash accelerated during the pandemic with many outlets removing cash altogether. TfL removed cash from the bus network in 2014 with the introduction of contactless payment and cash acceptance at stations was restricted further during 2020/21. Across the UK, cash payments fell by 35% (by value) in 2020. Although cash is still the second most

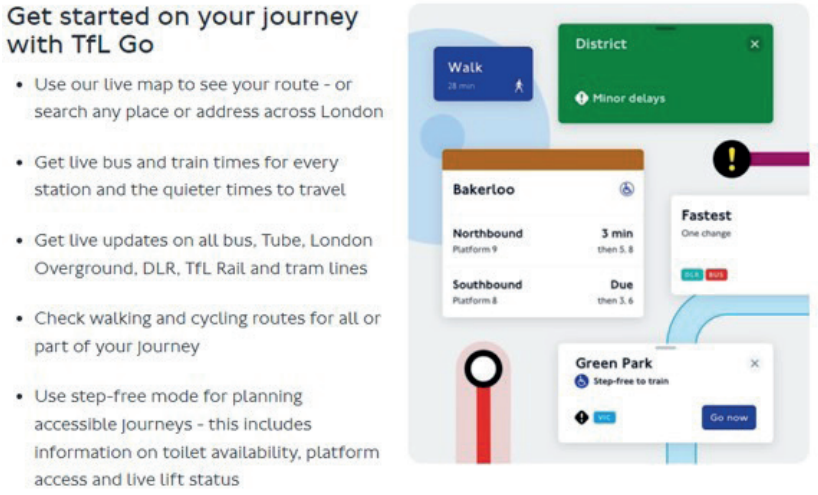


Fig. 5: TfL_go Source: https://tfl.gov.uk/maps_/tfl-go

popular payment method, it is less popular than cards in the UK and TfL has led the way with contactless transportation in the capital.

The next step from contactless adoption is the move to account-based ticketing. According to the SmartCard alliance this is "The transit fare collection system architecture that uses the back-office system to apply relevant business rules, determine the fare, and settle the transaction." In London, TfL uses this approach to apply daily and weekly "capping" so that passengers are always given the cheapest fare for their usage of the service with the discount being applied at the back-office before payment.

4. Reduce Costss

With reduced passenger journeys and relatively fixed overheads, most transport networks are making a loss and the search is on for technologies that could make a contribution to overhead reduction.

TfL have been looking at and trialling a number of initiatives that could help change the overheads of operation:

- Demand analysis, route and schedule optimisation
- Dynamic scheduling – changing the schedule in real-time

While there are clearly cases where artificial intelligence and other automation tools can make cost reductions, any analysis of Public Transport costs shows that staffing costs are the largest component of most operational expenses.

Fig. 6: TFL Demand Response Transport Trial

For this reason, TfL has also trialled Demand Responsive Transport services, but it also follows that for Information Technology to make real step-changes in costs, vehicle autonomy must be on the horizon.

Conclusion

2022 sees the start of a new paradigm for public transport services and it simply makes no sense to assume that the services provided in 2019 are still applicable to passengers in 2022. Demand has changed, expectations have changed and public transport services need to change to reflect this.

SIMON REED

Director for Technology and Data,
Land Transport, Transport for London

Simon is accountable for the delivery of technology solutions to address the transport needs 'above ground' of one of the largest cities in Europe.

He joined TfL 2006 as iBus Project Director for iBus; the world's largest (£300m contract value) Automatic Vehicle Location system. He is currently working on the replacement of London buses back-office systems, the scheduled and on-demand bus service systems (iBus2 and dial-a-ride), together with new systems for the Taxi/Private Hire licensing operation, the network control centre, Victoria Coach Station and the new Surface Intelligent Transport System that manages and controls London's traffic lights.

Managing travel demand of a Tube line closure at a time of unprecedent variability in demand

Emily Herreras-Griffiths, Head of Travel Demand Management at Transport for London

Introduction

With 120 million passengers in a normal year, Bank and Monument stations are the third busiest interchange on the London Underground network. This has made their upgrade and capacity improvement critical.

A major milestone of this capacity work was the excavation of tunnels to connect newly built infrastructure into the existing network in early 2022. To do this safely, Northern line trains could not run through the station for 17-weeks. This meant a part-line closure between Moorgate and Kennington.

Modelling outputs predicted that during the closure there would be an excess of demand on the network above 2019 pre-pandemic levels at certain times and places. It was estimated that 155,000 journeys would be displaced each weekday morning and would require redistributing across the Tube, rail, bus and active travel networks. Using a worst-case scenario, it was expected that 45,000 (29 per cent) of these journeys would need to be influenced to prevent exceeding 2019 levels of crowding.

To support the closure changes to operating plans at impacted stations and adjustments to the Charing Cross branch of the Northern line, timetables were made, alongside the introduction of a new temporary bus route, Santander Cycle Hire and e-scooters hubs. However, the operational options available were limited and so significant emphasis was placed on Travel De-

mand Management (TDM) to influence behaviour change and customer travel decisions

Furthermore, the arrival of the coronavirus pandemic created great uncertainty and required many changes. The start date of the closure moved from the summer of 2020 to the beginning of 2022. However, the greatest challenge wasn't necessarily that of timing, but stemmed from the wider socio-economic changes surrounding the pandemic that changed the dynamics of the project from when it was first planned. From consistent high ridership levels before the pandemic, to the uncertain and variable ridership, service level challenges and public health restrictions that were all still very much in flux when the closure started on 16 January 2022.

Developing and delivering TDM

Alongside modelling, customer and operational insights were used to report our strategy and provide a detailed understanding of the scale and scope of the challenge.

Outputs from station operating plans were considered and created through tabletop exercises with station staff.

Outputs from all elements of the modelling exercise were used to develop simple and tailored customer travel advice to support rerouting, retiming and remoding to mitigate the predicted impacts of the closure.

Closer to the start of the closure. on-street customer intercept surveys were used to check how the strategy was resonating with customers and to gauge the degree of customer awareness and preparation. This intelligence was used to inform and make last-minute changes to our communications.

To help overcome confidence issues and enable customer journeys, network-wide reassurance messages were reinforced, including providing real time information on crowding levels at Tube stations and encouraging customers to plan ahead.

Social media and digital channels were very important given that there were fewer customers on the network being exposed to TfL's on-network channels and following the results from the on-street customer intercept surveys, and the use of social media and the media was increased in the weeks leading up to the closure. On-network channels were still used to capture customers when they were travelling for leisure, as demand at weekends has been consistently high since all restrictions were lifted.

The closure benefited from positive active travel at a time when walking and cycling demand is usually suppressed, but this wasn't pushed further in relation to the closure until spring, when the weather usually improves, and as public transport demand continued to increase.

The TDM communications timeline was broken down into the 'four A' stages: Awareness, Advice, Activation and Achievements. These four A's were delivered chronologically, with communications beginning approximately six months before the start of the closure.

Reflections, results and conclusions

From planning to the delivery stage, this project saw dramatic changes in demand and behaviour. While demand was significantly lower than expected, modelling showed a need for a large-scale TDM campaign. Though our objectives remained the same, the unprecedented variability of demand meant we had to pivot our tactics and remain agile in our monitoring to enable changes to our response.

In short, while the scale of the task shifted, the nature of the challenge - to influence customer behaviours to ensure customer safety and a good customer experience - remained the same.

Analysis has shown that we were successful in changing travel behaviours despite the unprecedented variability in demand that was experienced in the lead up and during the closure. Remoding and rerouting messages appeared to be more successful than retiming messages in their uptake during the morn-

ing peak. This is unsurprising given the commuting purpose of journeys made at that time and backed up by a sectoral breakdown of travel options captured in the on-street customer intercepts we carried out before and during the closure.

The legacy of this project is significant for London, our customers and TDM; the closure enabled this critical new infrastructure to be completed and the TDM techniques we've explored, particularly those related to monitoring and evaluation, have been invaluable in helping us further understand the value of managing travel demand and gain a greater understanding of the dynamics of the behaviour change process for different customer groups.

EMILY HERRERAS-GRIFFITHS

Directress for Travel Demand Management at Transport for London

Emily is responsible for Transport for London's Travel Demand Management (TDM) team - one of a handful in the world dedicated to this rising speciality.

Since 2012, Emily has been instrumental in organising TfL's operations to successfully deliver pan-partner and transport industry TDM strategies including for the London Olympic & Paralympic Games, the Tour de France Grand Depart, the Rugby World Cup, and major Tube, rail and road closures in London and most recently the pandemic.

Emily is from Mallorca, Spain, is bilingual in English and Spanish, proficient in Italian and is a graduate of the University of Nottingham Trent.

IN-MOVE, DE RAILGROUP

Dr. Eng. Ignasi Gómez-Belinchón, Cluster Manager at IN-MOVE by RAILGRUP

We might say that nowadays we live in an era of technological upsurge, of "datification" of everyday life, endless connectivity, embracing and accepting a new dimension blending a fusion of the physical world and cutting-edge digital technologies such as artificial intelligence, big data analytics, the Internet of Things, blockchain and so on.

Its growing importance and maturity brings opportunities for people and economies, yet like any disruptive technology it also poses risks and challenges to be addressed, especially when we do not make technology work for people. In mobility, in (now) door-to-door mobility, we need to refocus the range of services currently available. Many of these services were designed and planned in a very different technological time. It's most likely essential to determine the (new) statistical significance of service groupings established by clustering data instead of predetermining them, e.g. in MaaS platforms.

This is the field of data science: a concept to unify statistics, data analytics, machine learning and their related methods for the purpose of understanding and analysing real phenomena by leveraging techniques and theories drawn from many fields in mathematics, statistics, information science and computing; "everything about science is changing because of the impact of information technology and the data deluge" (Tansley, Stewart; Tolle, Kristin Michele. *The Fourth Paradigm: Data-intensive Scientific Discovery*. Research. ISBN 9780982544204).

This concept leads us to a huge arena for exploration and innovation through technology. It can enable us to analyse and classify opportunities to deliver value to certain groups of people in order to facilitate and tailor their mobility on the basis of the specific needs which have been identified, structured and segmented and also in a broader way than ever before. There is no doubt that the growing significance and maturity of this field, artificial intelligence, as the sum of technological "sensors" plus interpretation and

meaning-making capacity (data science) brings opportunities for people and economies. Nonetheless, like any domain involving disruptive technologies it also poses risks and challenges to existing markets. It even entails changes in regulatory paradigms and models towards a tendency for mixed public-private governance models. The difficulty or attraction is that since this is an innovation stage, there are no established projects but rather only projects to be established and to unlock capacity to learn, adapt, imitate and provide creativity and accomplish their purpose by upgrading existing processes. I think that using these new frontiers in AI

and data science can help to push new frontiers in innovation and adaptation of new mobility services suitable for the "new" lives, brought to the fore especially after the Covid-19 pandemic and further inspired by the growing awareness of environmental and territorial sustainability and healthy habits. In particular, I think it can assist in assessing innovation related to delivering a better "travel" experience, a better customer experience, getting value back from the overwhelming volume of data available – note that I do not even say getting information but rather value – and finally concentrating power in cities with a greater role of public transport, a smart mobility approach which makes living in them meaningful.

We have been overtaken by circumstances. We are unwittingly exposed to the convenience of AI every day in digital assistants, smartphones, (personalised) online shopping, smart recommendation engines, facial recognition for social media, digital payment and so on. Commuting is a major part of the city and so it is ineluctable that we should require the getting around aspect of our lives to be on a par with these other services we already use and there should be no disruption to these creature comforts during our trips and journeys. Public transport service providers need to acknowledge rising customer expectations.

The citizen-centric approach can bring innovation in real-time operations management, customer analytics, smart ticketing systems (variable pricing based on more than just the number of journeys to be made), predictive condition-based maintenance, multi-modal journey planners, service disruption management, fraud detection, security management, network planning and route design, mass customisation services, individualised customer care

(WhatsApp is already used in this way by some ground-breaking operators), back-office administrative tasks, rolling out digital assistants to enhance customer service efficiency and quality, using AI in low value tasks and insecure work environments, tapping AI to enhance our quality of life in cities and in territories, improving suitability for mobility use and more on the way towards "Liveable Mobility": transport is no longer just a service but rather something which needs to dovetail with the lives of people, with new patterns of movement, with new generations and new needs (referring to the 'Wise Cities' concept put forward by Prof Jaume Barceló - Emeritus Professor of the UPC https://smartlogistics-ib.webnode.es/_files/200000290-0401604fa7/Jaume%20Barcel%C3%B3.pdf).

DR. ENG. IGNASI GÓMEZ-BELINCHÓN

Cluster Manager a IN-MOVE, by RAILGRUP

Ignasi has extensive experience in strategic management and technological innovation. Scientific background: 1987-1990 Spanish National Research Council (CSIC).

Environmental research and technological development: more than 20 scientific articles published including in Nature and Environmental Science & Technology. Management background: over 20 years of experience in general management and design and implementing numerous technology projects for products, processes and strategies.

Some of them are connected to making the sector more competitive and rolling out the Local Government Industrial Policy Model through Intercluster Activities and specific projects. Over the last 10 years he has been managing and facilitating EU projects for cluster members in rail mobility as Railgrup Cluster Manager. Member of the European Railway Cluster Initiative (ERCI). Chair of the ERCI Task Force on Multimodal Logistics. Education: PhD in Chemical Engineering. 1987 IQS-Ramón Llull University. Barcelona. SMP Operations. Esade. Barcelona. 1994. Marketing Programme. ASHRIDGE. Berkhamsted. UK 1995. Fluent in English, French, Italian, Catalan and Spanish.

Expanding the ATM

Jordi Montero Garcia, Technology Project Manager at inLab FIB UPC

Abstract: This article outlines how digital transformation and technology are at an ideal point for public transport travellers to understand, use and have a better user experience (UX) enabled by the development of information and communication technology (ICT) solutions.

Digital transformation, users and mobility

Digital transformation is an integral part of our management and usage of every process and action around us every day. Ever since the advent of the first computers, we have sought to innovate and better leverage the resources associated with each of our processes by harnessing the potential inherent in new technology. Sadly, this yearning for improvement has on numerous occasions run up against the drawback of insufficiently mature or financially unviable technology, turning our needs into a science-fiction pipe dream.

We are at a unique time when the synergy of technologies and new ICT solutions coupled with the affordability of the resources needed to operate them are properly aligned to enable science fiction to be embraced by its users and become a flawless accessory geared towards enhancing the user experience in their everyday processes.

User experience on public transport

The term user experience (UX) is closely tied to software engineering and design and refers to the need to meet the user's expectations without hassle or inconvenience while adding value to every interaction the user has with the system.

This concept, which might be seen as tightly bound up with ICT, can be shared with other processes and is a key factor in grasping a new model for service operation in public transport use.

The Metropolitan Transport Authority (ATM) is committed to developing new solutions to enhance users' everyday lives by means of new information services which facilitate and make their journey easier and more convenient, as described below.

Intermodality: Accessibility and Augmented Reality

The ATM strives to provide the public with an accessible, sustainable and safe mobility system while keeping them informed about the mobility services it supplies. To this end it coordinates with tiers of government and pools resources with the transport operators involved.

The growing number of new operators and new transport route services entails an increase in intermodality and consequently a rise in the number of journeys associated with transfers made by users between transport systems. These routes, which might otherwise be considered static over time, may no longer be unalterable due to the inherent change found in any dynamic system.

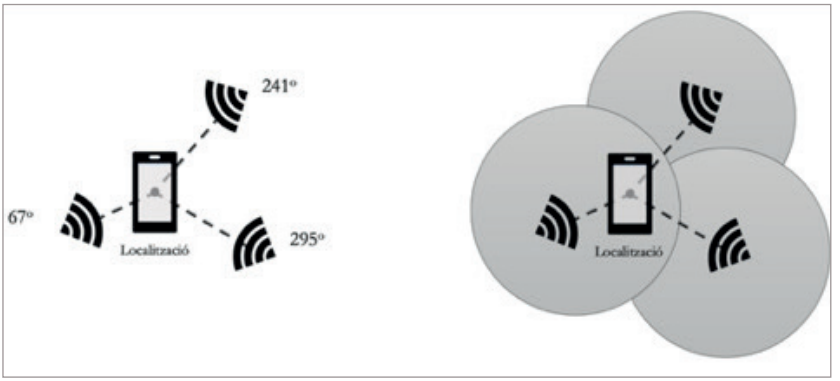
Communication measures are needed in these cases of infrastructure or route changes which are helpful for the end user and involve putting in place special signage to assist them with the change.

An augmented reality (AR)-based guidance solution is presented below which the ATM, in conjunction with the UPC's inLab FIB, is developing to address the cases mentioned above while also improving information on accessible routes for people with reduced mobility.

The navigation system we have developed makes it possible to deliver virtual signage using augmented reality technologies and also addresses the

problem intrinsic to indoor navigation systems which do not allow for position triangulation based on signals from satellite navigation systems.

Conventional indoor location systems involve the deployment of infrastructures that make them overly expensive and are mostly based on algorithms for triangulating the signal emitted by devices sited throughout the indoor space where the user is to be positioned. This triangulation process, which may use various calculation methods such as reception time, signal strength, reception angle, etc., entails maintenance which further drives up the system's cost.

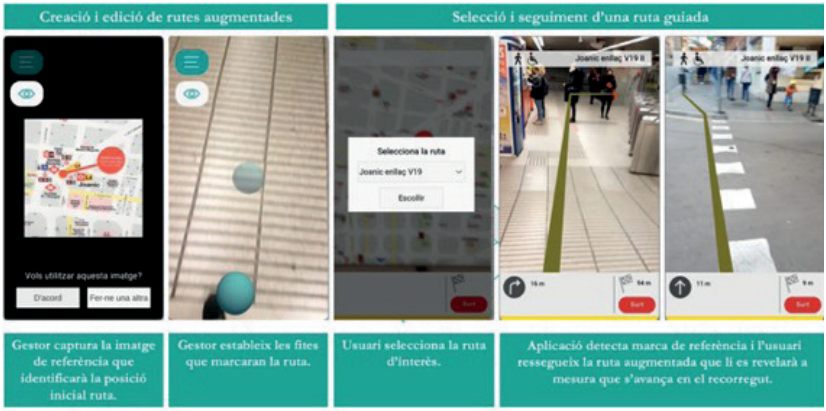


Source: inLab FIB - Signal triangularisation based on angles and intensity

As an alternative, the ATM and inLab FIB have developed an indoor/outdoor route navigation system which harnesses augmented reality techniques and processing of the image captured by the user's mobile device, whether phone or tablet, to locate the user on a route predefined by the system manager.

These kinds of indoor localisation systems draw on scene-based localisation. The system defines a number of waypoints in a virtual world which will be discovered and displayed as the user progresses through it, just as they would on a real excursion, thereby enabling the mobile app to synthesise reality and convey it to the virtual world and thus locate the user in the augmented reality scenario. The system we have developed meets the main requirements expected of an indoor localisation system: accuracy, scalability and affordability.

The diagram below shows the basic workflow associated with the system which is currently being tested and calibrated.



Source: inLab FIB – Basic workflow of augmented reality route guidance

Once the system has been fully defined and calibrated, users accessing the app will be able to follow pre-set routes which will help to enhance their experience by displaying static and dynamic information which may be useful to them on their journey. This information includes estimated walking time, estimated time to reach the next means of transport, remaining distance to the destination or next change of direction and/or route to lifts and stairs along with other static and dynamic components which may be helpful and have been specified along the route.

Turning to the technology, the solution features a pyramidal architecture with the infrastructure which supports the entire system, the API which enables communication with components at higher levels and the database that stores the routes hosted in the system, at its base. The intermediate level houses the technologies which support the augmented reality techniques and above this are the apps for iOS and Android devices that the traveller will use.

The indoor navigation system presented is enhanced by an augmented reality information system, currently under development, which will provide the user with dynamic and static information based on the transport operators' signage and/or information maps that they encounter on their journey.

In my view, this system might well be a turning point in how users interact with the metropolitan transport system. This shift will be further heightened with the addition of immersive devices such as Microsoft® Holo Lens 2 which will turn augmented reality into mixed reality and furnish a range of options which have yet to be explored.

Source: inLab FIB – Pyramidal architecture of the AR system for ATM

JORDI MONTERO GARCIA

Technology Project Manager
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Jordi Montero has a degree in computer engineering from the UPC and is a technology project manager at inLab FIB UPC, an innovation and research laboratory at the UPC's Faculty of Computer Science in Barcelona specialising in applications and services harnessing frontier technologies and accredited as a TECNIO centre by ACCIÓ.

Jordi also teaches Simulation in the Faculty and on the Master's in Industry 4.0 and has worked on a range of process simulation studies over the past 25 years. He additionally runs ICT projects for people with reduced mobility.

Transport services Act - Finland

Maria Rautavirta, Director of Unit Data Business Unit Data Department, Ministry of Transport and Communications of Finland

Finland has been recognised as the home country of Mobility as a Service - MaaS. As a civil servant at the Finnish Ministry of Transport and Communications I have been privileged to be part of its development ever since we began our journey of rethinking mobility by bringing users to its centre in the early 2010s.

Although smartphones had enabled internet in the pockets of every citizen since 2007, it took another 11 years and three governmental terms to get us Finns to the point where the legislation, administrative processes or technological choices don't prevent but enable smooth travel chains and mobility services that meet people's needs. And although this development is still in its infancy, and massive implementation work and further investments in our digital capabilities are still needed, it is clear that without regulatory push and reform, it will not be possible to move towards a green and digital future of mobility.

In short, the Finnish Transport Services Act, which came into force in 2018, meant obligations to fully bring the digital means of mobility into use: connectivity by mobile networks –real time data and backend interoperability – and account-based ticketing systems. It also meant huge restructuring of the public sector data assets into one piece of regulations act to accommodate its secondary use as well as streamlining the licensing practices of market operators to enable flexible fleet use to meet user needs. By forcing essential data and ticketing systems to be made available through API's from their source of origin, we created a transport system in which each commercial passenger vehicle, more than 11 000 operators in the transport system and an enormous amount of data points, were tied together into a virtual cobweb. As a result, the user, the spider, can utilise all the parts of the mobility system in the way they prefer.

After almost five years of implementation, several million euros of investments in digital interoperability as well as a huge amount of people cooperat-

ing to create the contractual basis and design for the services, we can finally witness the results. On the demand side we see an increase in the use of public transport and mobility services in urban areas and a number of successful mobility service pilot and development projects in rural areas. On the supply side we see providers of bundled multimodal trip offerings, route apps able to purchase tickets as well as an increased offering of on-demand services, micro mobility and city bike operators and third party parking and taxi apps. From the backend, we witness more accurate data for transport system management and statistics as well as real time receipt and accounting data for business users to support their automated bookkeeping and travel invoicing.

However mobility is not limited to our borders and much wider shoulders are needed through wider scaling and geographical coverage in order to increase investment security and to incentivise a better service level that meets the demand of the citizens. To this end, we need enabling legislation for the EU to better support market interoperability and access. We need fair access to data and ticketing as well as the possibility of third party service offering, and we need user empowerment to make more sustainable choices, meeting their personal needs and abilities.

I have made no trip on which I would not have wanted the ticket machine (in Cologne) or guidance service (in Luxembourg) to have spoken to me in my native language or not make me log into a separate service (in Brussels) or download a separate app (in Barcelona) to get me a ticket or a trip of my choice. There is still work to be done in the EU to create a common mobility market and to provide the means for all of us to exercise our right to move freely and seamlessly within Europe in an inclusive, accessible and sustainable way. The Finnish experiences with Transport Services Act show that we as legislators have a job to do. The future of mobility builds itself – if we allow it to do so!

- Història de la MaaS | Future Mobility Finland
- Replantejar la mobilitat - Revolució del transport - Perspectives internacionals - Valto (valtioneuvosto.fi)
- Obligacions previstes a la llei de serveis de transports: Pràctiques d'interfície | Liikkumisen rajapinnat

MARIA RAUTAVIRTA

Directress of Data Business Unit at the Ministry of Transport and Communications of Finland

Ms Maria Rautavirta is Director of Data Business Unit at the Ministry of Transport and Communications of Finland. Maria is responsible for the strategic development of horizontal data economy initiatives, also covering solutions for personal data management and regulative framework.

Furthermore, Maria looks after data utilisation in the field of transport and logistics. Maria has been drafting the regulations to open mobility data in Finland to promote markets and access for digitalised mobility services. Maria believes that through data we can empower citizens and enable new innovations and technologies for the benefit of people and societies.

Mobility: uncertain scenarios brimming with innovation challenges and opportunities

Xavier López Luján, Chief Operating and Corporate Officer at the Eurecat Technology Centre

People and freight mobility is changing dramatically and quickly. Two key factors in understanding this revolution are the emergence, swift development and uptake of many innovative digital and other non-digital enabling technologies and the much-needed and pressing decarbonisation of the economy. Nevertheless, other aspects also play a key role such as the steady build-up of a large part of the world's population in urban environments, the social, transport and consumer changes derived from all of the above, and the lack of strategic, technological, energy and industrial self-sufficiency in some regions around the world.

To give a local example, last mile logistics in Barcelona has grown exponentially on the back of the new consumer habits brought about by ecommerce and spurred on by the pandemic, and this poses major management, environmental and social challenges.

All in all, these are new, multivariable and uncertain scenarios whose full consequences are difficult to foretell.

What does seem clear, however, is that over the next few years we will see and experience diversification and hence segmentation of technologies, products, processes, services and business models associated with mobility and that this segmentation will bring great challenges yet also opportunities for businesses and public institutions.

This concerns not only vehicle propulsion technologies, where the speed at which electrification takes hold will be influenced by factors including technological breakthroughs in batteries and new materials and also the rollout of

the infrastructure needed and the greater or lesser scope of public policies supporting this electrification.

It is also the case, and perhaps even more so in the medium term, that renewable hydrogen may play a significant role in the decarbonisation of industry and public and freight transport and this, for instance, is one of the European Commission's staunchest commitments under the Green Deal.

As for other aspects, we will have to see the extent to which autonomous or assisted driving technologies are introduced together with the new business models for vehicle usage, which will encompass traditional ownership, shared ownership or use, rental in much more flexible formats than now, subscription, combinations of the above and so on. Where we are on the adoption curve for many of these technologies and models is not yet clear, and which ones will be the "winners" in generating certain standards for the future is equally uncertain.

It is also unsure how today's mobility industry will cope with all these changes. There will be winners and losers here as well. Notwithstanding all this, we do know that another consequence of all the above changes is the reconfiguration of the value chains of all mobility-related activities: new technology developers, new product and component manufacturers and service providers, production relocation, sweeping changes in supply chains, fast-tracked transition to the circular economy, etc.

In view of this uncertain and ambiguous yet fascinating scenario, a few final thoughts: firstly, the public sector's role in regulating but also spearheading and promoting certain transformations will be crucial. Many of the changes outlined above cannot be steered solely by business rationale or economic efficiency, albeit business co-leadership will be essential. Secondly, the public sector needs to take decisions rooted in a holistic and long-term vision of everything to do with mobility yet it also has to be much more flexible and agile than it is at present. Public policies should include putting people, especially the most disadvantaged, at the centre and fostering the utmost technological and industrial self-sufficiency or sovereignty as priority strategic vectors.

Of course, technology operators such as Eurecat will strive to help as much as possible by bringing innovation and technology to businesses, people and institutions to ensure that these accelerated transformations have a constructive impact on our enterprises, institutions and people's quality of life.

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