cenit magazine
Science for Transport

Innovation in Transport Review

ISSUE# 3

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cenit Science for Transport
An Innovation Unit of CIMNE

Cenit magazine
Issue #3
November 2024
cenit.es

Welcome

Welcome to the 2024 edition of the INNOVATION IN TRANSPORT REVIEW from CIMNE's transport innovation unit CENIT. Since its creation in 2001 as a partnership between the Catalan Government and the Universitat Politécnica de Catalunya-BarcelonaTech, CENIT has been dedicated to finding sustainable and innovative solutions for transport and mobility.

Over the past two decades, the transportation landscape has undergone significant changes, emphasising the increasing need for innovation, technology and flexibility to create a sustainable model that protects the well-being of future communities and the environment.

In this issue, we present insights and findings from some of our recent research, focusing on key topics such as advanced transport simulation models for sustainable urban mobility, the potential for electrification in public transport systems, and innovative solutions to help European ports achieve climate neutrality.

Our article on CENIT's role in the Sustainable Mobility Plan for Ankara (SMART Ankara) highlights our responsibility in developing an Activity-Based Model (ABM), a transport simulation tool to support Ankara's urban mobility objectives.

In our insights from Fiji's Electric Bus Project, we explore the electrification potential of key public transport routes, supported by Green Climate Fund (GCF) Readiness funding, to promote the adoption of electric buses in the country.

CENIT's involvement in the European project PIONEERS, led by the Port of Antwerp-Bruges, is also featured. This project addresses the challenges European ports face in achieving climate neutrality by 2050, aligning with the European Green Deal's primary goals.

At CENIT, we remain enthusiastic, dedicated, and flexible as we continue to tackle one of the most significant challenges of the 21st century: delivering efficient, sustainable transportation to communities and equipping policymakers with research-driven knowledge.

DR SERGI SAURÍ MARCHÁN
Director, CENIT
Assistant Professor, UPC

Contributors

DR. SERGI SAURÍ MARCHÁN

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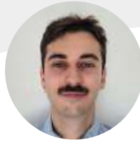
Dr. Sergi Saurí has been the Director of CENIT since 2013. He also serves as Associate Professor at the Department of Civil and Environmental Engineering of UPC-BarcelonaTech and President of the University Network RUITEM (Ibero-American University Network of Territory and Mobility). He holds a PhD in Civil Engineering from UPC-Barcelona Tech, a Master's in Shipping Business from UPC-Barcelona Tech, and a Bachelor's in Economics from the University of Barcelona. He is currently a member of the Infrastructure Committee of Infrastructure Financing of the Professional Association of Civil Engineers of Catalonia and was previously a member of the Board Committee of this association. He also served as Assistant Professor in Transportation at UPC and Director of the Master's in Supply Chain, Transportation, and Mobility at the same institution. His PhD thesis on Optimisation of Regulation for Public-Private Partnerships in Container Port Concessions was awarded the IV Abertis Transport Infrastructure Management Award and he was a Visiting Scholar at the Massachusetts Institute of Technology (MIT) in 2008. An expert in the areas of transport modelling and transport economics, he is the author of a number of scientific publications and has led multiple projects in both the public and private sector.



ALEX MUMBRÚ CAMPRUBÍ

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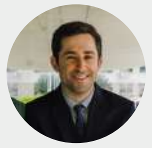
Alex Mumbrú has a degree in Industrial Engineering from UPC – Polytechnic University of Catalonia, where he is currently pursuing a Master's degree in Civil Engineering with a specialty in Transportation Engineering. Currently, as a Trainee Engineer at CENIT, his areas of focus include transport policy and economic assessments at regional, national and international levels, performing cost-benefit assessments, and participating in projects such as the Bus Network Electrification Project in Fiji and the freight demand study for the northern region of Argentina. He is also involved in the HORIZON project RAIL4CITIES, focusing on green and socially inclusive urban development around railway stations. Alex also works as a Consultant for the Generalitat de Catalunya, focusing on cost-benefit assessments and transport planning.



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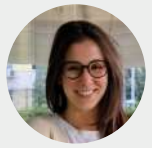
Genís Majoral is a Civil Engineer specialising in transport and urban planning from the Polytechnic University of Catalonia (UPC). He is a Researcher at the Centre for Innovation in Transport (CENIT) where his areas of specialisation are modelling, transport demand and transport economics. Currently, he is a PhD candidate in Civil Engineering at the UPC and studying for a Master's degree in Economic Research at the National University of Distance Education (UNED). He is also an Assistant Professor in Maritime Economics at the Tecnocampus of Mataró in Catalonia (UPF). In the field of transport modelling, he has contributed to updating the transport demand model for Catalonia (Department of Territory), developed mobility models for the Sustainable Urban Mobility Plan (SUMP) of Ankara, Türkiye, including an activity-based model (ABM), and updated a freight model for Argentina (CAF). In terms of transport economics, he has worked on the analysis of the financial statements and financial model of highway concessions (MITMA) and service areas, the evaluation of the impact of a tax on e-commerce deliveries (ATM) and the definition of financial aid for the digitalisation of road transport companies (passengers and goods, for MITMA). Other notable projects include a study on the potential future impact of 5G on ports and the development of the national maritime policy of Trinidad and Tobago (Government of the Republic of Trinidad and Tobago). Regarding electromobility, he has participated in the definition of business and financial models for mass implementation of e-buses in San José, Costa Rica, (The World Bank) and e-bus prioritisation for Fiji (GGGI). He is the author of the scientific articles (SCI) "Application of a Tax to e-commerce delivery in Barcelona."; "Lessons from Reality on Automated Container Terminals: What Can Be Expected from Future Technological Developments?" and co-author of "Analysis of superblocks during the transition phase from traditional vehicles to a fully automated vehicle environment: A case-study of Barcelona City".



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Chiara Saragani is an Industrial Engineer from the *Alma Mater Studiorum* – University of Bologna, specialising in logistics, production systems, operations research and transportation. In 2022, she joined the Centre for Innovation in Transport (CENIT) as a PhD candidate, focusing on the digitalisation of the Port of Barcelona. During her undergraduate studies, Chiara spent a semester at *Instituto Tecnológico de Buenos Aires* (ITBA) in Argentina, deepening her knowledge of logistics and transportation systems. She went on to pursue her Master's degree at the University of Bologna, with an exchange semester at *École Supérieure d'Ingénieurs en Électronique et Électrotechnique* (ESIEE) in Paris. There, she completed her dissertation on distribution logistics and operations research, culminating in a Master's thesis titled: *"Crowd-shipping and Autonomous Vehicles: An Optimization Model for Last-Mile Delivery."* Currently, as part of her PhD research in collaboration with the Port of Barcelona, Chiara explores cutting-edge technologies such as real-time monitoring systems, Digital Twins, and AI applications in port logistics, leveraging 5G connectivity. She is actively involved in the PIONEERS project, where she contributes to the development of several pilot initiatives. Her insights and findings are regularly shared through articles published in the *PierNext* newsletter.

FRANCISCO MIGUEL RODERO BLÁNQUEZ

ITS Manager.

Francisco Rodero has an MSc in Informatics Engineering from the *Universitat Politècnica de Catalunya* (UPC-BarcelonaTech), holds postgraduate in Smart Mobility and Intelligent Transportation Systems from the UPC School of Professional & Executive Development and supports laboratory lecturing in the field of databases for Bachelor Degrees such as Data Science and Engineering and Informatics Engineering. He joined CENIT in 2009 as a Computer Sciences Senior Engineer and became ITS Manager in 2014. He has been actively supporting research and participating in both local and International projects mainly related to traffic simulation and data processing. Prior to his arrival at CENIT, Francisco worked for 7 years at the INDRA group, developing projects related to Satellite Navigation Systems for the European Space Agency and optimisation of the operations in the Barcelona Airport Terminal. His areas of expertise include simulation, modelling and software engineering, including tasks such as database design and computer programming.

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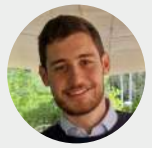
Clara Soler Bañuelos is a Civil Engineer. She obtained her Bachelor's degree from the Polytechnic University of Catalonia and obtained her Master's double degree with the Illinois Institute of Technology specialising in Transportation Engineering. Prior to starting her PhD, she worked as an Associate Project Manager in a construction project for Ferrovial in Atlanta, Georgia. She is currently developing her PhD with the *Autoritat del Transport Metropolità de Barcelona* on the topic of sustainable and resilient financing models for public transportation. Research topics include identifying key trends in future mobility and analyzing how these will affect the funding of public transport; maximising revenue by assessing new funding sources and adjusting fare policy; studying the most appropriate mix of revenue sources to ensure long-term sustainability; modelling the costs of public transport and analysing the resilience of the funding model.



MATTEO BOSCHIAN CUCH

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PhD Candidate.
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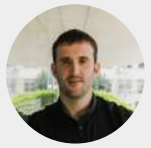
Matteo Boschian Cuch holds a Bachelor's degree in Aerospace Engineering and a Master's in Mobility Engineering from the *Politecnico di Milano*. He joined the Centre for Innovation in Transport, CENIT, in 2023 as PhD candidate in Transport and Sustainable Mobility in the port sector at the Port Authority of Barcelona. During his Bachelor's degree, he gained a foundational understanding of the aerospace sector, acquiring essential technical skills and knowledge. In his Master's program, he expanded his expertise to the mobility sector, studying various aspects such as the technical requirements of transportation systems, their environmental and social impacts, transport assignment models, and the financing of transport infrastructure. During his studies, he had the opportunity to participate in academic projects in collaboration with major companies in the Italian mobility sector. His Master's thesis focused on Cost-Benefit Analysis and transport appraisal techniques. At CENIT, Matteo specialises in the maritime sector, specifically in ports. His PhD research focuses on the sustainability of the transport sector related to ports, with two interconnected areas of study. He works on intermodal transport, contributing to the development of the Multimodal Observatory of MEDports, while also focusing on road traffic by designing and implementing a model to calculate emissions from road vehicles visiting the port. Additionally, he has participated in several CENIT projects for international clients, focusing on port management models, regulatory assessments impacting ports, and exploring alternative fuels for the maritime sector.



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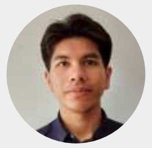
Paco Gasparín is a graduate in Statistics from the University of Barcelona (UB) and from the Polytechnic University of Catalonia (UPC). He also completed a Master's degree in Statistics and Operations Research from UPC, specialising in Operational Research, with his thesis focusing on the "Analysis of mobile phone data for modelling transport demand." His areas of expertise include data analysis, advanced statistical methods, mathematical modelling and operational research. He joined CENIT in 2018 as a Researcher in the Urban Mobility and Freight Transport department, working on mobility and freight transport projects at national and European level.



MULIA ANDREAS PASARIBU

Researcher in Transport and Urban Mobility.

Mulia Andreas Pasaribu is a Civil Engineer with two Master's degrees in Urban Mobility from the UPC – Polytechnic University of Catalonia and in Transport, Mobility, and Innovation and the KTH Royal Institute of Technology. He also holds a degree in Civil Engineering from the Bandung Institute of Technology (ITB). Currently, he is a Researcher at the Centre for Innovation in Transport (CENIT) in Barcelona, where he applies his skills in Python and GIS tools such as QGIS and VISUM to analyse and model urban transport systems. His recent project involves developing an Activity-Based Model for Ankara, Türkiye. Previously, Mulia worked at the Institute for Transportation Development and Policy (ITDP) Indonesia in Jakarta as a Transport Engineer Assistant. There, he co-wrote the Inception Report of the E-mobility Implementation Roadmap for Indonesia's Public Transit Program (UK PACT) and collaborated with ITDP China on designing transport infrastructure projects for the city of Bandung.

TOMI HENRIQUEZ

Researcher in Sustainable Transport Transitions.

Tomi Henriquez is a Computer Scientist (BSc Georgia Institute of Technology (USA)) and a Sustainable Transport Transitions Scientist (MSc *Universitat Politecnica de Catalunya* (ES), MSc Eindhoven University of Technology (NL)) working as a Researcher at the Centre for Innovation in Transport (CENIT). At CENIT, Tomi has mainly focused on the development of activity-based transport demand models (ABM) for the planning of sustainable urban mobility transitions. Most recently, Tomi has worked on the translation of an existing activity-based model from a US context to a Turkish context to support the development of a sustainable urban mobility plan (SUMP) in Ankara, Türkiye. Prior to joining CENIT, Tomi worked on and led many transport and non-transport related initiatives in European and North American contexts. Tomi worked to develop a tool to estimate the feasibility and potential savings of transitioning existing lines to or operating new lines as autonomous electric vehicle fleets and designed and programmed the UI/UX for the tool. Additionally, Tomi helped to define a strategy and policy objectives for public and road safety for the city of Atlanta and led the development of a centralisation and expansion strategy for the housing non-profit Habitat for Humanity. Tomi also led various software implementations in the public sector, including enterprise resource planning (ERP) software rollouts and cybersecurity design and management. Tomi has worked for large enterprises such as Microsoft and Accenture, taking on a variety of roles in strategy, management, and technology consulting. His focus has been and continues to be to help the public sector adapt to and get ahead of big technological and societal changes. In the latest iteration of his career, Tomi focuses on leveraging cutting-edge technologies to develop strategies and ease the burden on sustainable transportation transitions for public and private sector as they answer societal pressures and aim to mitigate transportation's impact on climate change.

SAMRA SARWAR

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PhD Candidate.
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Samra Sarwar is currently a PhD Urban Mobility Researcher at CENIT. Her research is focused on explaining and understanding the traffic flow impacts of automated driving, external disturbances in traffic (impacts on congestion cost, tolling strategies, etc.) and to offer solutions to mitigate the negative effects of disturbances through traffic management. She has completed her Master's degree in Transportation Engineering as a Stipendium Hungaricum Scholar from Budapest University of Technology and Economics, at the faculty of transportation and vehicle engineering from 2017 to 2019. Samra was also a teaching fellow at the University of Engineering and Technology, Lahore, in the faculty of civil engineering. At a professional level, she has worked as a Research Associate in Transport for The Urban Sector Planning & Management Services Unit, a public sector company.

SMART ANKARA Sustainable Urban Mobility Plan (Turkey)

BY MULIA ANDREAS, TOMI HENRIQUEZ AND GENÍS MAJORAL

Within the framework of the European funds for neighboring regions (IPA) to promote sustainable mobility under EU standards, through the study "Sustainable Mobility Plan for Ankara (SMART Ankara)", a sustainable mobility plan is being developed for which CENIT is responsible for developing an activity-based transport simulation model (Activity-Based Model). The model will support the evaluation and definition of the most appropriate sustainable mobility measures for the Turkish capital, a city of more than 5.5 million inhabitants with a historical trend of urban planning favoring private vehicles.

The Transport Sectoral Operational Programme (SOPT) is the major instrument for providing the financial assistance of the European Union to the transport sector in Turkey. The general objective of SOPT (2014-2020) is to contribute to Turkey EU integration with economic and social development by providing a competitive, accessible and sustainable transport system in accordance with EU standards. It is expected that a preparation and implementation of Sustainable Urban Mobility Plans (SUMPs) will bring a new transport planning perspective to Turkish cities in line with EU policies, among which the capital is found.

Ankara, with a surface area of 25,437 km2, as of 2019, is the second most populous province with a population of 5,639,076. The population of Ankara has increased linearly by 19% in the last decade due to internal migration and the mobility of refugees. The centre of Ankara has 25 districts where universities, technology development centres, organized industrial zones, powerful sector clusters, high- level bureaucracy, international institutions and non-governmental organizations are concentrated. Transportation policy in Ankara, in the previous years, was focused on traffic management and targeted continuous flow of traffic especially for private cars.

In this context, the objectives of the SMART Ankara project are to prepare a SUMP for Ankara in accordance with the best EU practices and standards. In addition, it aims to support development of a Smart Bike System (SBS) for the city. In this sense, the project consists of 6 differentiated components.

The project is led by DAI Europe, and completed with a technical team of international and local experts. CENIT is part of the consortium working on travel demand modeling, digital solutions and capacity building.

Figure 1. Ankara city. Source: Pixabay.

The process begins with an extensive analysis and data collection phase (Component 1) to establish the planning framework for Ankara's SUMP, involving stakeholders and citizens at every step. The current mobility situation in Ankara has been evaluated through the revision of existing socioeconomic and mobility data, as well as planning practices and legal conditions. In this component, a specific household mobility survey was conducted with a sample of more than 25,000 households interviewed, more than 100 traffic counts, and specific public transport surveys, stated preferences, parking, and other cordon surveys specifically tailored to Ankara's needs. The collected data feeds the development of an activity-based travel demand model for Ankara. These types of models have been gradually implemented in the last decade, with only a few working examples worldwide (mainly in the United States of America). Some elements of mobility that advance towards more complex models are complexity in travel patterns (assessment of 24-hour mobility patterns, teleworking, joint trips, etc.) or the growing intricacy of transport policies (pricing strategies, urban tolls, equity and gender analyses, policies for specific population segments, etc.).

The software selected to implement the activity-based model was ActivitySim integrated with PTV VISUM. The structure of the model (figure 2) consists of one ActivitySim component (1) and two PTV VISUM components (2, 3). ActivitySim, which is an open platform software from AMPO in the United States, has been used to create activity-based models internationally, though most implementations have taken place in the USA. The activity-based model starts from a donor model based in San Francisco and uses the data collected from Ankara to calculate and estimate the various sub-models for the context of Ankara, from the production of a synthetic population, to the estimation of long-term choices such as car ownership, and further to predict travel demand for the various transportation modes. The demand estimated from component 1 is then fed into PTV VISUM and assigned to the Ankara transportation network to visualize macroscopic trends for the region. Component 3, also through PTV VISUM, completes the visualization of Ankara transportation by including freight transport and through-traffic which utilizes regional rights of way.

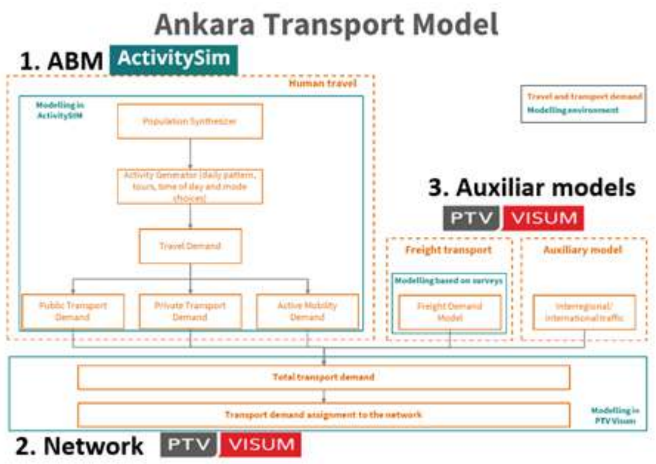

Figure 2. Transport model architecture developed for Ankara.

Figure 3. Screenshot of the private vehicle flows in Ankara's road network.

Component 1 is extended with tailor-made digital solutions based on ongoing challenges occurring in Ankara. Issues related to parking, data availability, and shared mobility management are comprehensively addressed and appropriate solutions are crafted and proposed accordingly. Leveraging CENIT's experience of knitting digital solutions together, this project performs benchmarking of solutions implemented in numerous cities backed with solid financing and governance models.By embracing the Theory of Change (ToC), a methodology that outlines how and why desired changes are expected to happen in a particular context, we have ensured that each solution has a meaningful impact and answers emerging challenges in Ankara.

Components 2 and 3 focus on the development of the SUMP strategy, where the vision, objectives, and goals are defined, as well as the measures to be implemented for the SUMP. In parallel, components 4 and 5 address training and capacity building as well as publicity and visibility, respectively.

Component 4 consists of more than 20 training sessions and workshops, whose aim is to strengthen the transport planning staff of AMM – EGO (Ankara Metropolitan Municipality and Public Transport Agency), providing the team with the skills and knowledge necessary to successfully carry out and sustain the project over time. In this area, CENIT has prepared and conducted 5 training sessions of two days each as well as two workshops, for more than 200 participants in total. The topics ranged from resilient cities and transport systems, innovative concepts in "smart cities," analytical models for SUMPs (transport models, risk prediction and assessment), intelligent transport systems, and the integration of SUMPs at the metropolitan level.

The objective of component 5, publicity and visibility, is to connect with the general public and citizens of Ankara to increase awareness of sustainable mobility practices. Finally, the project also provides support for the development of an intelligent bike-sharing system (SBS) for Ankara (Component 6).

All in all, the SMART Ankara project is poised to revolutionize sustainable mobility in Ankara by laying a comprehensive framework for eco-friendly transportation solutions and leveraging state of the art travel demand modeling developed by CENIT. Even now, it is already influencing public attitudes, fostering a greater appreciation for sustainable mobility practices among the city's residents and local government officials.

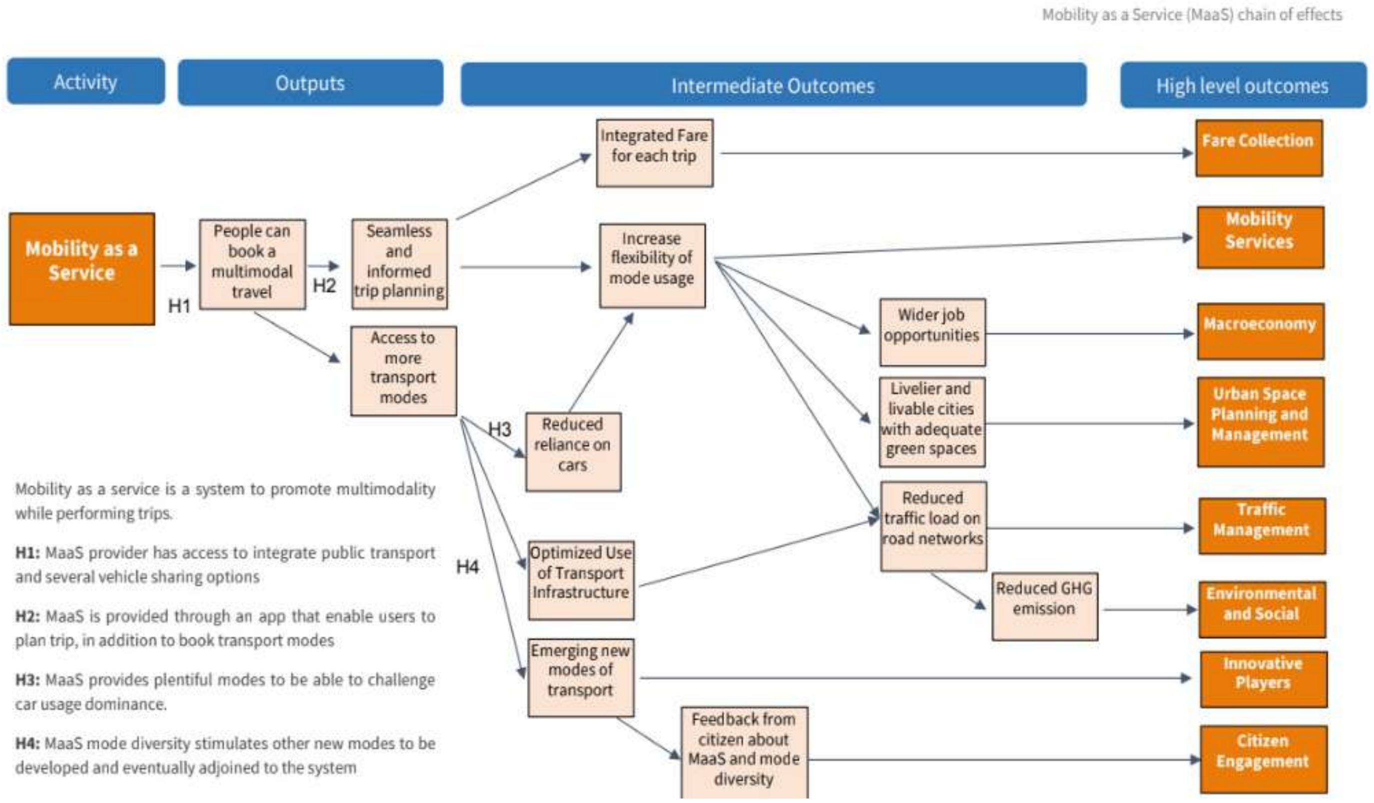

Figure 4. Theory of Change of Mobility as a Service as a smart mobility solution.

Figure 5. Workshops and capacity building training carried out by CENIT to professionals in the public administrations of Ankara.

PIONEERS (Portable Innovation Open Network for Efficiency and Emission Reduction Solutions)

BY MATTEO BOSCHIAN CUCH

PIONEERS (Portable Innovation Open Network for Efficiency and Emission Reduction Solutions) is a European project led by the Port of Antwerp-Bruges, which started in 2021 and will run for 5 years. It addresses the challenges European ports must overcome to achieve the European Green Deal's primary objective of climate neutrality by 2050.

In addition to the Port of Antwerp-Bruges, the project involves three other European ports: Barcelona, Constanța and Venlo. It consists of 19 demos, which are being tested and demonstrated for feasibility at the Port of Antwerp-Bruges, the project's lighthouse port, before being transferred to the other three ports. These ports represent an ideal mix in terms of size, location, and operations.

The project involves more than 40 partners from diverse sectors, including terminal operators, private companies, universities, and research centres, like the International **Centre for Numerical Methods in Engineering (CIMNE), though its innovation unit in transport, CENIT.**

The project has five objectives:

1) Reduce the port's total environmental footprint by introducing Clean Energy production, storage, and supply.

2) Deploy sustainable port infrastructure beyond energy supply demand.

3) Introduce eco-friendly improvements relying on digitalisation and new methods of operation.

4) Co-define and transfer PIONEERS demos to fellow ports during the project lifecycle.

5) Deliver and disseminate a **Port Master Plan** for the transition towards GHG-neutral shipping and wider multimodal mobility by 2050.

Figure 1. Port of Barcelona. Source: Unsplash.

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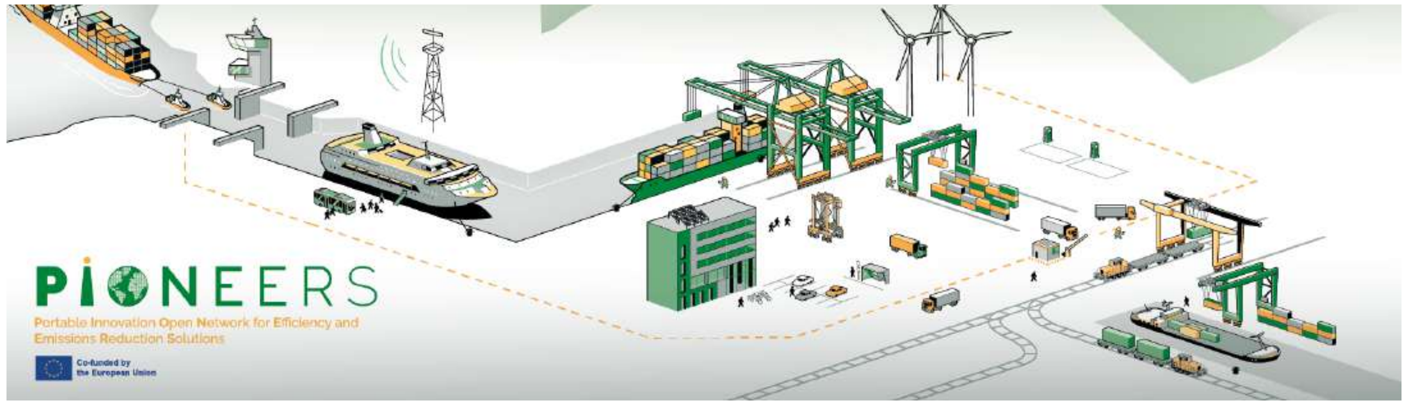


Figure 2. PIONEERS demonstrators.

PILOT CASES:

In PIONEERS, there are 19 demos involving all areas of the ports: the maritime side, inland side, terminal operations, and distribution to the hinterland. The objective of these demos is to implement the solutions and transfer selected ones to other participating ports, while assessing the barriers and challenges encountered during the project. The identification of viable innovations will be ensured by addressing not only technical, socioeconomic, safety, and sustainability challenges, barriers and opportunities, but also by engaging stakeholders. These include public and port authorities, representative bodies, terminal operators, freight forwarders, transport companies, and cruise and tour operators.

These demos can be categorised into four groups:

1) Clean Energy Production, Storage & Supply

- Energy generation from water currents
- A corridor of modular docking stations for energy containers
- Battery Storage and Smart Management of Green Energy in terminal operations
- Hydrogen refuelling infrastructure

2) Sustainable port design

- Green Straddle Carriers
- Hydrogen heating for buildings
- Local resource recovery for green, circular concrete
- Electric green last-mile for on-site logistics operations

3) Modal Shift and Flow Optimization

- Modal shift in port employee commutes
- Mobility as a service for better port-city accessibility
- Cargo flow optimization
- Cargo flow prediction
- IT Platforms for planning multimodal transport

4) Digital Transformation

- Automated shuttle solutions for port operations
- Inland automated vessel technology
- Vessel traffic optimization
- Maritime 5G for intelligent vessel location
- Container transport forecast
- Port digital twin enabling tracking of CO_2 emissions

The role of CENIT (CIMNE) in the project

CIMNE's innovation unit in transport, CENIT, plays an active role in all phases of the project, supporting the Port of Barcelona. The main task is related to the development and delivery of a Green Port Master Plan for the Port of Barcelona, which will be presented at the end of the project. Furthermore, CIMNE will play a key role in coordinating the linked actions of the pilot projects, conducting a thorough analysis of the results and providing a comparative assessment between the pilots at the lighthouse Port of Antwerp-Bruges and the Port of Barcelona. The team at CENIT is supporting the Port of Barcelona in the implementation of **two digital pilots** at the port: the implementation of the **digital twin,** which keeps track of emissions produced on the port's boundaries and the installation of the **5G network** for vessel detection within the maritime port boundaries. Moreover, as an innovation unit with previous knowledge on the local environment of the Port of Barcelona, CENIT will contribute to the innovation actions transferred from the lighthouse port, such as the **Multimodal Container Planner**, the **Modal shift** that will result from engaging employers at the Port, and the adoption of the **Digital Twin**.

Figure 3: Maritime 5G for Intelligent Vessel Location Showcase.

Finally, CENIT will be involved in the impact assessment and process evaluation, specifically focusing on evaluating the innovations implemented at the fellow ports (Barcelona, Constanța, and Venlo). This will involve determining the net benefits for each of the four pillars at the three fellow ports. Additionally, the difference between the realised net benefits and the desired future benefits will be quantified for these ports. Furthermore, the transferability and scalability of these innovations from the lighthouse port (Antwerp-Bruges) to the fellow ports will also be evaluated.

European Navigational Hazard Infrastructure: a collaborative data sharing platform supporting enhanced situation awareness to reduce the risk of collision during navigation

BY FRANCISCO MIGUEL RODERO BLANQUEZ

Around 3,000 maritime incidents occur every year in the European maritime fleet. 28% of these accidents are categorised as severe or very severe accidents.

The OCEAN project (Operator-Centred Enhancement of Awareness in Navigation) is focused on enhancing operator awareness in navigation, to reduce the frequency of severe accidents like collision and grounding, to preserve the life of marine mammals and to mitigate the risk presented by floating obstacles. This way, the Project aims to promote safer practices through enhanced instrument usability and by creating a Decision Support System for mariners.

Through human-centred design, which prioritises people's needs and behaviours in product and service design, the project will utilise cutting-edge technology, such as AI algorithms, to enable mariners to make better decisions, improving safety and protecting the marine environment.

The project aims to enhance operational efficiency and protect marine life by adopting advanced technology such as hydrophone grids, satellite imagery analysis and prediction models for both marine mammals and container drift while addressing many critical aspects including:

- Navigational accidents root cause assessment
- Enhanced Professional Standards for Situation Awareness
- Human-centred Bridge Equipment Design Methods
- Detection and tracking of Marine Mammals in high-density areas
- Tracking and Recovery of Floating Containers
- Improved Situation Awareness and Manoeuvring Planning
- Automated Anti-collision Solutions & Shipboard Infrastructure

In addition, the project aims to build the so-called European Navigational Hazard Infrastructure (ENHI), a system with the capability of receiving data concerning observations, detections and predictions from multiple data streams and able to optionally share part of this data with other components of the data ecosystem. This way, interfaces and formats to exchange data have been defined to support multiple sources. Mechanisms have also been developed to manage data in a proper way in terms of consistency, persistence and quality. Overall, from a design perspective, the ENHI can be seen as the sum of all the components depicted in the following diagram:

Figure 1. Segmentation of the ENHI from the data point of view. Source: OCEAN.

The following text describes the different components of the ENHI in more detail:

- I/O Interfaces: Input and output interfaces defining how data is received and sent between the components of the OCEAN ecosystem.
- Data Storage: Implements the underlying information system used to store both active data and historical information (expired data).
- Management: Includes all the rationale implementing the use cases as well as supporting features concerning the control of accuracy, consistency and uniqueness.
- Publishing: Feature used to build Navigational Warnings before they are published/delivered to the end users.

The image below illustrates the envisaged workflow in the OCEAN data ecosystem. As a general overview, reporting data is sent to the ENHI which, depending on the configuration of the system, can optionally request additional data to two on-demand components in charge of detecting containers or marine mammals through the analysis of satellite imagery or predicting the drift of a given container. The second half of the project (from April 2024 on) will address the support to the generation of Navigational Warnings (NW) to be delivered to the ships through existing communication channels as well as the incoming data product based on the *International Hydrographic Organization* S-100 framework specification.

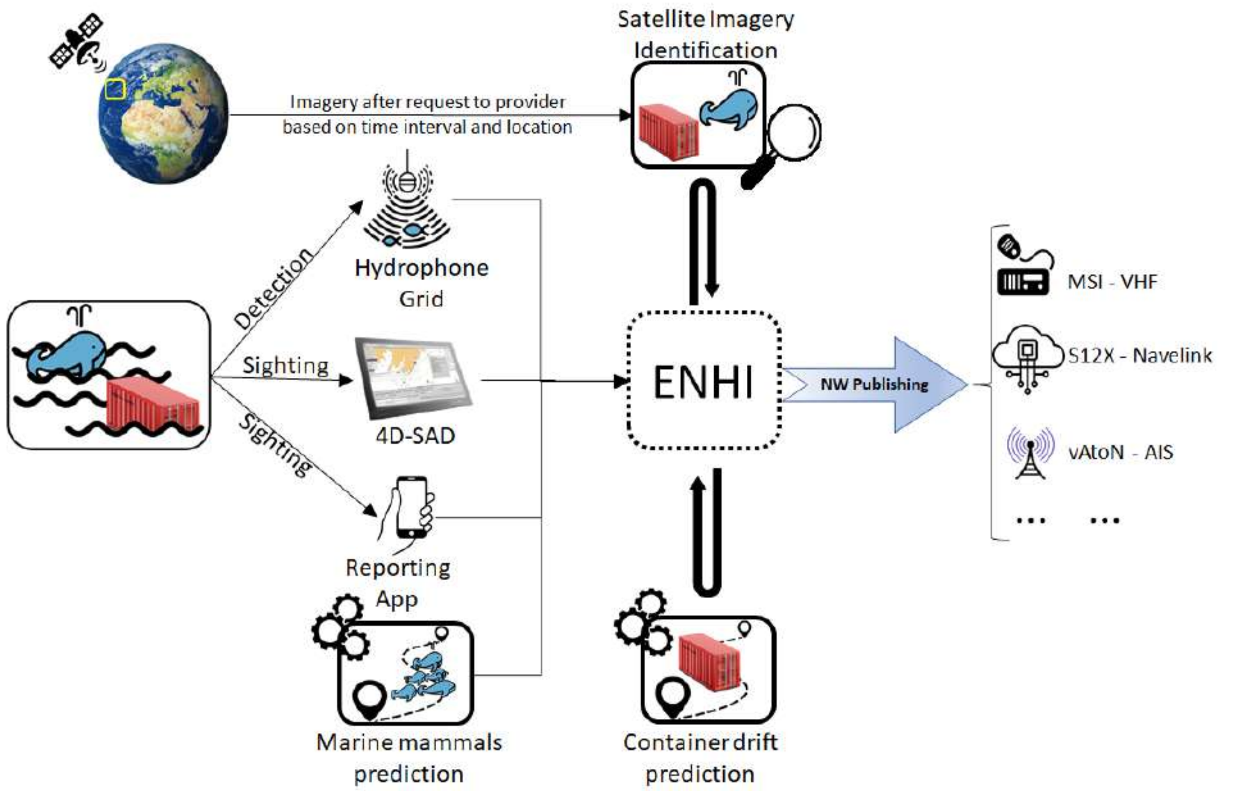
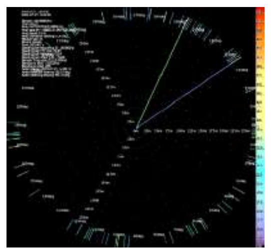


Figure 2. Overview of the European Navigational Hazard Infrastructure data ecosystem. Source: OCEAN.

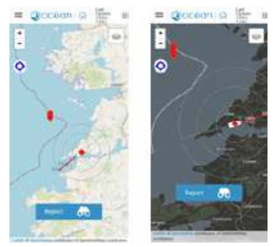
For a better understanding of the whole system, the following list briefly outlines the most relevant features of the involved components:

Passive Acoustic Monitoring (PAM)



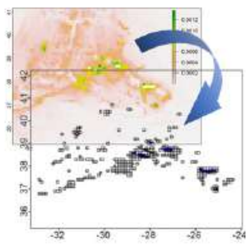
- System developed in charge of detecting and locating whale audio
- Composed of 4 hydrophones offering flat frequency receiving responses over a wide frequency range and relatively high transmitting sensitivity, making the solution very useful within many areas of underwater acoustic research, tests and measurements
- Data collected is processed (beamforming using distance between hydrophones) to create 3D representation/spheroid of the surrounding space
- Detected sounds are filtered and classified according to specific species by means of machine learning algorithms and, if necessary, sent to the ENHI

Reporting app



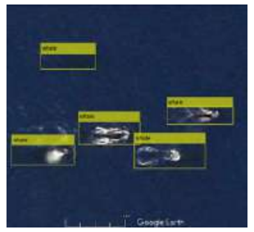
- *Progressive Web Application* (PWA) targeting small craft and leisure market (while 4D-SAD targets SOLAS ships), which allows users to report sightings of both marine mammals and containers as well as displaying Navigational Warning information
- Reporting is possible at any time and data is sent to the ENHI whenever an internet connection is available
- PWA technology allows for device-independent installation

Environmental Niche Models (ENM)



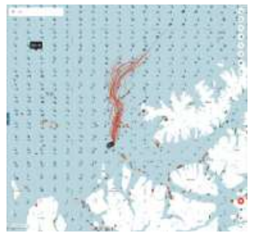
- Statistical prediction of the probability of occurrence (or habitat quality) for some marine mammal species based on variables like sea surface temperature (SST), productivity, topography or oceanographic structures such as thermal fonts, among other covariates
- The models run periodically to adapt results according to changes in the dynamic covariates of a specific geographic area
- Output is given by means of a raster file with coloured pixels representing the probability/habitat quality. Then, a threshold is used to create polygons representing areas of high probability of animal presence

Satellite Imagery Analysis



- Optionally triggered by the ENHI upon the reception of a report
- A request is sent for a given area/ time interval and both marine mammals and containers can be eventually detected after processing available imagery from the provider and sent back as additional data that complements the former report
- After the application of pre-processing steps (geometric, radiometric and atmospheric corrections, pan sharpening), species-specific machine learning models (both for classification and object detection) are used for the actual detection of marine mammals

Container Drift Model



- Regarding container losses and floating objects, this component is used to predict potential drift along a specific time interval considering the timestamp and location of the event that triggers the request and the corresponding weather and sea conditions like wind or wave height, for example
- The output, based on the results of simulated data using *OpenDrift*, is then converted to geographical areas and sent back to the ENHI in *GeoJSON* format
- In the same way as the satellite imagery analysis, it is integrated in the data ecosystem as an optional on-demand component triggered by the ENHI

The ENHI gathers near real time data concerning hazards from many different sources and provides mechanisms to generate NW that can be used to feed mariners with valuable information in order to replan the routes in advance or support manoeuvres during the voyages with the objective of avoiding collisions.

Co-funded by the European Union

The OCEAN Project is an innovation and development initiative co-funded by the European Union. UK participants are supported by UK Research and Innovation Grant Number 10038659 (Lloyd's Register) and Grant Number 10052942 (The Nautical Institute)

Source: Unsplash.

Freight Flows and Logistics Costs in Northeast Argentina: Maximizing Efficiency

BY CHIARA SARAGANI AND GENÍS MAJORAL OLLER

The East side of Argentina (NEA + ER) Includes the regions of Chaco, Corrientes, Entre Rios, Formosa and Misiones. These areas are primarily involved in producing agricultural, livestock, forestry, mining, and various other products, with a high degree of exports, both within Argentina and to the rest of the world. Of the approximately 46 million tons of products generated annually in the region, 31% are transported within the region, 55% are moved to other regions of Argentina, and 14% are exported. Moreover, the NEA + ER receives a significant amount of goods from the rest of the country, totalling about 11.8 million tons, a quantity similar to previous internal movements. In other words, Argentina imports equal 26% of the volume generated in the region.

Potential transit flows, meaning exports from the rest of Argentina to neighbouring countries, which can pass through the NEA + ER, amount to 12 million tons. A significant portion is directed towards Brazil, totalling 9.5 million tons. Flows from the rest of Argentina to Paraguay, Uruguay, and Bolivia are less significant.

The transit flow of imports from Brazil, Uruguay, Paraguay, and Bolivia totals 17.8 million tons, a quantity which is greater than the transit flow of exports.

Given this context, there is a need for an efficient transportation system for long distances. The current state of the railway system suggests a limited capacity to serve as an effective international transport mode. The Urquiza line (which connects with Paraguay, Brazil, and Uruguay) has been identified as only handling internal traffic, moving only 0.5 million tons, mostly from NEA to the south (Zárate). It follows that all international transportation relies on road or waterways.

Regarding inland navigation, the tonnage processed at the Corrientes and Entre Ríos port clusters (exclusively grains) is only 0.83 million tons, a very small share of the total generated in the region. Finally, regarding truck movements, certain infrastructure improvements are necessary. Specifically, it is important to develop safer routes that comply with regulations to accommodate the transit of heavy-cargo trucks.

In terms of product types, this region is a major producer, with forestry products accounting for the largest share at 30%, followed by mining at 25%, and agricultural products at 21%, primarily including grains such as corn and wheat, as well as oilseeds like soybeans and sunflower. The beef sector also has a notable contribution of 6% of tons generated. The remainder consists of regional products (fruits), processed products (flour), and semi-processed products (paper).

The forestry chain is based on the exploitation of two main types of forests: native forests and planted forests. The product flows from this exploitation represent a significant portion of production in the NEA + Entre Ríos region.

Figure 1. Freight vehicle transporting logs.
Source: Original photo taken by Genis Majoral on field visit to Argentina.

Between 2015 and 2020, 632.5 million tons of grains were transported in Argentina, of which 45% were soybeans, 32% corn, 17% wheat, and only 6% barley. The provinces of Buenos Aires, Córdoba, Santa Fe, Entre Ríos, and La Pampa account for 90% of the quantities transported. The most significant province in terms of grain origin, as a percentage of the total marketed, is Santa Fe. 64% of transported grains are destined for the ports of Bahía Blanca, Quequén, and Rosario.

In conclusion, the NEA + ER region of Argentina has the potential to become a critical logistics and transport hub for both domestic and international trade. However, unlocking this potential will require targeted investments in infrastructure, particularly in upgrading its railway systems and developing more efficient transport routes. By implementing strategic improvements, the region can enhance its connectivity, accommodate increasing freight volumes, and establish itself as a competitive player in the global market.

Regarding the analysis conducted in the project, several considerations were made concerning the NEA + ER region. These are as follows:

- NEA is a region that produces raw materials (with little industry), which are mainly processed in Rosario and Buenos Aires and then subsequently exported.
- Transversally, the flows move from Cuyo-Córdoba-Santa Fe-Brazil and from NOA-Buenos Aires or NOA-Brazil.
- Vertically, NEA + ER is part of the Paraguay-Paraná Waterway corridor to Rosario and Buenos Aires, and the Mercosur corridor from Buenos Aires to Brazil.
- It is a transit point between Argentina and Paraguay or Brazil.
- The Paraná Waterway runs through the NEA, accompanied by the Urquiza and General Belgrano railway lines, as well as the network of roads that connect to neighboring territories.

Figure 2: Port of Posadas.
Source: Original photo taken by Genis Majoral on field visit to Argentina.

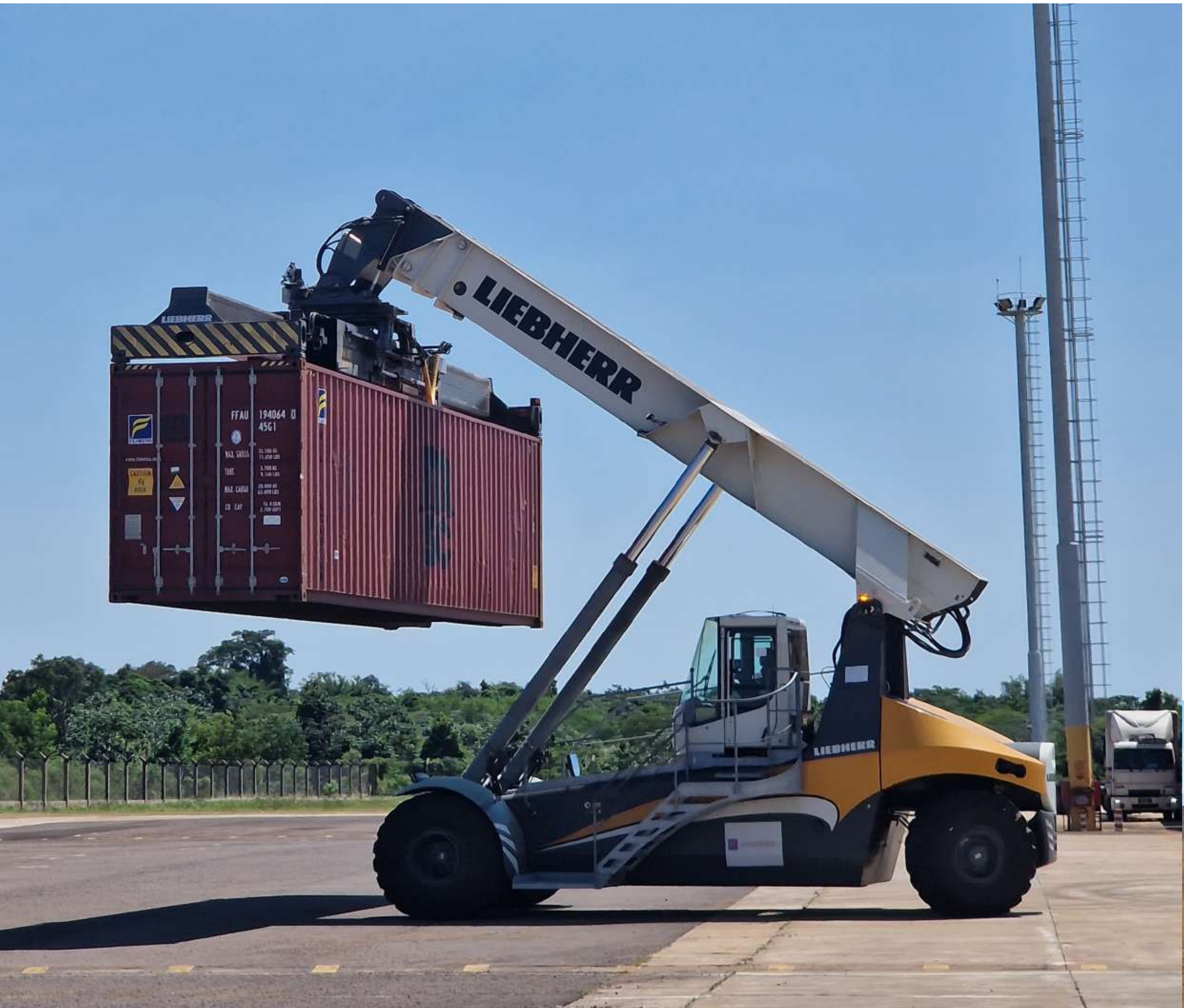


Figure 3: On Route 14. Source: photo by Genís Majoral.

In light of the previous considerations, two potential scenarios were explored to improve the current logistics system. The first scenario, called "Business as Usual," is more conservative and focuses on optimising the existing environment. The second scenario aims to position NEA + ER more competitively by addressing not only internal flows but also external ones, with the goal of enhancing the region's overall connectivity and efficiency.

In conclusion, the NEA (Northeast Argentina) and Entre Ríos regions are vital for Argentina's agricultural, livestock, and forestry production. With 55% of their output destined for domestic regions and 14% exported, primarily to Brazil. The significant trade with Brazil underscores a strong commercial interdependence within Mercosur, where these regions serve as a key corridor for exports.

Road transport is the dominant mode of moving goods, highlighting the critical importance of infrastructure investment. Improvements in the road network are essential to avoid bottlenecks and maintain the flow of goods efficiently. Despite its role, the current rail infrastructure, particularly the Belgrano and Urquiza lines, is insufficient to meet demand. Thus, a significant opportunity exists to enhance rail capacity, improve service reliability, and encourage a modal shift from road to rail, which could improve both cost efficiency and environmental sustainability.

Two development scenarios are proposed for the NEA region. The first focuses on optimising the current logistics system, enhancing infrastructure and efficiency, while maintaining Buenos Aires as the central hub. The second, more ambitious scenario, aims to transform the NEA into a strategic international logistics hub, connecting Atlantic and Pacific markets through bioceanic corridors. This plan requires significant infrastructure investments, including ports and railways, and emphasises climate adaptation to ensure long-term sustainability. While the first scenario offers incremental improvements, the second envisions a transformative role for the region in global trade.

Figure 4: Provincial Road 73, Argentina. Source: Wikimedia Commons.

Decarbonising Public Transport: Insights from Fiji's Electric Bus Project

BY ALEX MUMBRÚ CAMPRUBÍ AND GENÍS MAJORAL OLLER

Figure 1: An electrically-powered bus. Source: Wikimedia Commons.

Road transport in Fiji is highly dependent on petroleum fuels and accounts for 60% of the total petroleum consumption in the country. As a Small Island Developing State (SID) with around 900,000 inhabitants Fiji is committed to reducing its fossil fuel consumption as noted in its Nationally Determined Contributions (NDC) to GHG reductions and the Fiji 2018 LEDS (Low Emission Development Strategy). Several studies, such as the Greater Suva Transportation Strategy (GSTS), have focused on greening Fiji's land transport. Decarbonizing buses, the most widely used form of public transportation in the islands, would mark a significant step forward in this effort.

Fiji's Enhanced 2020 NDC (Nationally Determined Contributions) aims for a 30% emission reduction and net-zero emissions by 2050, with electric vehicles playing a key role in achieving this goal. The NDC Investment Plan, developed by the Climate Change Division of Fiji's government, highlights Electric Vehicle Network Development as a priority, and the Fiji NDC Implementation Roadmap 2017-2030 targets a reduction of 137,000 tCO_2 per year in the transportation sector. This includes vehicle replacement programmes for various types of vehicles, which is expected to significantly contribute to CO_2 mitigation.

CENIT's role in the green transition

In line with the above, the study on Route Prioritization for Phasing in of Electric Buses in Fiji (Global Green Growth Institute, GGGI), carried out by CIMNE's transport innovation unit CENIT, aims to support the adoption of electric buses by evaluating the electrification potential of main public transport routes through Green Climate Fund (GCF) Readiness funding.

This project has aimed to identify the most suitable routes for implementing electric buses, laying the groundwork for future studies and efforts in Fiji's transition to electric public transport.

Methodological Approach: Examining and assessing Fijian bus routes

The project comprised three phases: first, data collection and preprocessing; second, bus route prioritisation through a Multi-Criteria Analysis (MCA); and finally, the development of an implementation roadmap, a strategic plan detailing the necessary steps and actions to successfully introduce and integrate electric buses into Fiji's existing public transport system.

During the first phase, which involved data collection and preprocessing, it was essential to gather information about Fiji's bus routes. The necessary data, including bus routing and timetables, was collected from multiple stakeholders, such as official bodies and bus operators, by local consultant Dr. Joeli Varo, a GIS specialist. Dr. Varo also assisted in the subsequent digitisation of the routes. Due to the variety of sources, one of the main challenges of the study was the heterogeneity of the available data and the required preparation and preprocessing.

The physical characterisation of the current bus system involved the digitalisation of the mapping of the routes and obtaining the operational parameters of velocity, slope, and energy requirements for each route. The operational characterisation of the system involved the digitalisation of the timetables (which often takes the form of scanned timetables), matching timetables with GIS routes, the estimation of the necessary fleet, expeditions per day and week, and frequencies. Viti Levu island, the region of the electrification study, consisted of more than 320 routes.

In order to conclude the data preprocessing phase, a preliminary assessment of the feasible routes was conducted taking into account battery range constraints and the challenges posed by rural routes, such as sealed or unsealed conditions, which complicate bus electrification due to mechanical issues and performance on sloped terrains.

To tackle the challenges with rural lines and the implementation of new electric buses, an alternative solution was proposed: retrofitting the current buses operating in rural conditions. This option has both pros and cons. On the one hand, it reduces the initial investment cost; however, it also decreases the electric battery range, which, as mentioned earlier, is a limiting factor in the electrification of buses.

Once the first phase was completed, the second phase, MCA prioritisation of the bus routes was carried out. The input to the multicriteria analysis was the bus routes as alternatives, each evaluated based on different criteria. In light of the available data, the final criteria used were based on the following groups:

- Operational dimension
- Social, environmental and economic factors
- CAPEX and OPEX costs

The criteria governing the evaluation and appraisal of bus line electrification were based on the World Bank reference on the Economics of Electric Mobility. This framework evaluates changes in the economic landscape when introducing electromobility according to the following dimensions using the following formula:

$$\Delta NSC = \Delta PV(Capital\ Costs) + \Delta PV(Operating\ Costs) + \Delta PV(Charging\ Infrastructure) + \Delta PV(Externalities) + \Delta PV(User\ Costs)$$

To evaluate the cost variations for each scenario (e-Bus vs. Business as Usual), the following MCA criteria were selected to compare the differences for each route in both scenarios: costs (purchase, maintenance and recharging infrastructure), externality savings, operational criteria (demand served, frequency of operation, line type), and other criteria (fleet age and operator readiness).

Additionally to the MCA criteria and results, two other aspects were considered for the final bus route prioritisation: on the one hand, the readiness level or capacity of bus route operators to implement electromobility solutions (evaluated qualitatively), and on the other hand, the synergies among operators. Synergies can reduce the burden of charging infrastructure through shared resources.

Two options to generate synergies include:

1. Number of lines at the same depot: Having multiple lines originating or terminating at the same depot reduces infrastructure costs. If schedules allow, once one bus is charged, another can use the same charging station.

2. Total number of lines: Economies of scale mean that the more lines an operator has available for electrification, the lower the costs per unit will be for acquisition and maintenance.

Both aspects were addressed and considered in the third and final phase of electrification roadmap implementation.

Additionally, in order to ensure that the project aligned properly with the interests and priorities of local stakeholders, a complementary data collection effort was conducted to gather insights from stakeholders for developing the multicriteria analysis and understanding the nuances of the bus sector in Fiji. An online questionnaire was prepared and sent to local stakeholders (local transport agency, operators, ministers, etc.), and a meeting was held. The online survey results provided the weights for the MCA, while the meeting allowed for a more qualitative evaluation of the operators' readiness and feasibility as well as synergies.

Key Findings from MCA prioritization

The following picture (Figure 2) illustrates the assessment results. It shows how new electrified routes (Cluster 1) are concentrated in the Suva region and are mainly urban. In contrast, retrofitted lines (Cluster 2) expand into the hinterland from Suva and Nausori, starting at Navua, the main cities in the south coast region of Fiji.

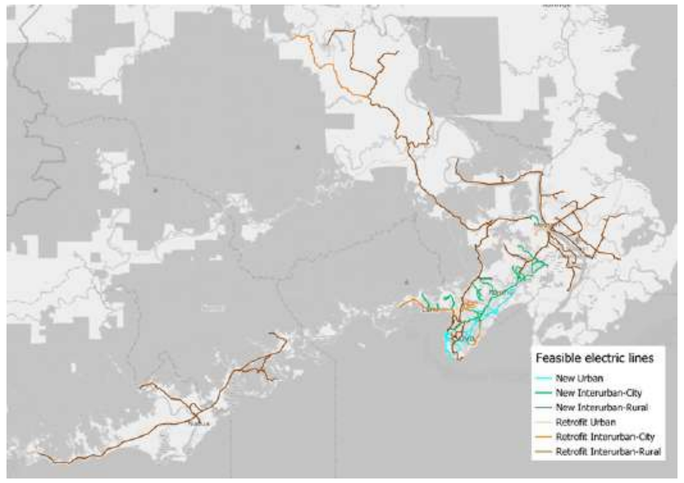


Figure 2. Mapping of the feasible cluster 1 (lot 1) and cluster 2 routes analysed.

Furthermore, due to the close scores, the final selection of routes for electrification within this cluster will depend on a qualitative analysis, considering additional constraints or parameters. These include synergies, readiness, size, the predisposition of bus companies to electrification, and alignment between operators, technology providers, and the public sector and decision-makers. This qualitative analysis forms part of Fiji's Bus Route Electrification Roadmap.

Additionally, retrofitted lines demonstrated comparable performance to new electric buses for the analyzed routes, underscoring their effectiveness. This approach is crucial for addressing challenges in rural areas where deploying new electric buses may be more complex.

Moreover, the MCA results revealed a positive correlation between investment costs or total costs and emission savings, justifying investment in electrification for lines with higher initial or fleet costs.

Furthermore, considering the variables of total costs and emission savings in relation to line typology (Figure 3), it becomes evident that the greatest savings in externalities are concentrated in urban lines. Lower electric consumption at lower speeds contributes to reduced CO_2 emissions associated with the electric grid. Although electric buses do not generate combustion emissions, the production of electric energy does, which was considered in this analysis. Routes with higher average speeds, such as long-distance and high-velocity lines, were found to potentially increase net CO_2 emissions post-electrification due to faster battery consumption, making them less competitive compared to diesel buses, when considering the current CO_2 emission factor of the electric grid.

Despite this, Figure 3 shows that even for these lines, the overall savings in total emissions (CO_2, NOX, VOC, and PM) are positive, not just CO_2.

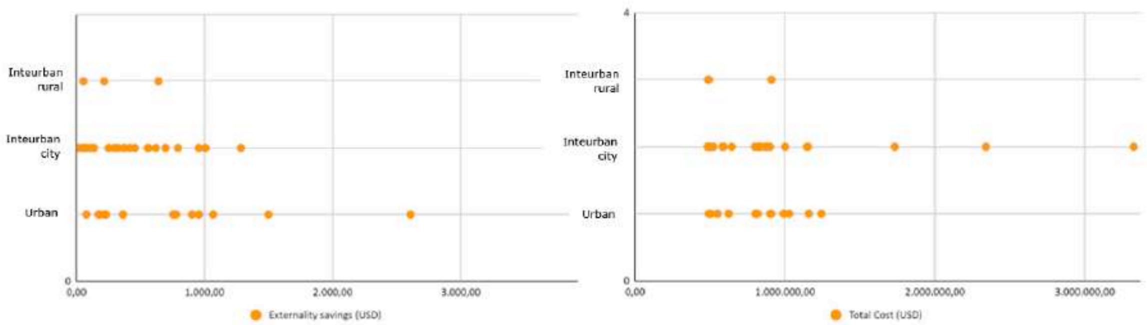


Figure 3. Line type analysis: externality savings (USD) left and Total Costs (USD) right for feasible routes to electrify.

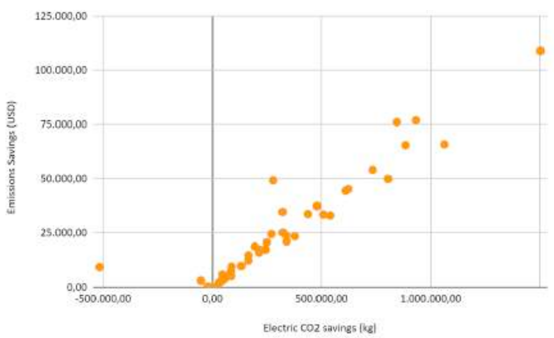


Figure 4. Line type analysis: externality savings (USD) left and Total Costs (USD) right for feasible routes to electrify.

Fiji's Bus Route Electrification Roadmap

In the multicriteria analysis, quantifying operator synergies posed challenges due to the difficulty in correlating these synergies with economic impacts. The close scores suggested that final route prioritization should rely more on qualitative analysis. Thus, a qualitative approach was adopted. Integrating the multicriteria analysis results with sensitivity and robustness assessments, as well as evaluating sector readiness (including synergies within operators and bus depots), enabled the development of comprehensive guidelines and recommendations for Fiji's electric bus implementation roadmap.

Figure 5 outlines the study's recommendations based on clusters and lots identified during the multicriteria analysis, sensitivity, and robustness assessments. Lot 1, consisting of the most feasible lines under stringent battery and road condition assumptions within Cluster 1, was recommended for initial electrification using commercially available electric buses. Among these, the top three lines identified by the MCA as robust under the robustness analysis were recommended as pilot studies.

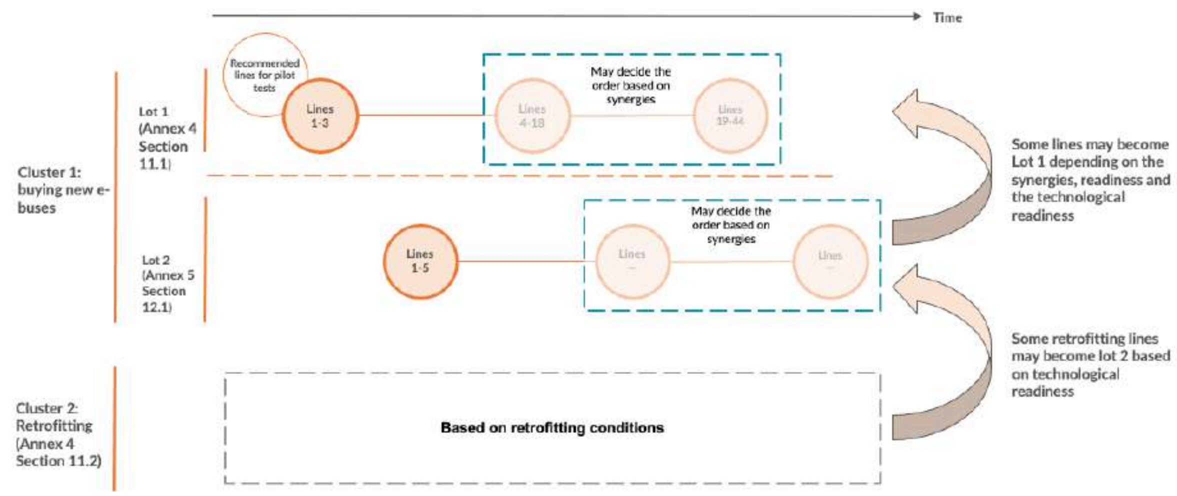


Figure 5. Implementation roadmap workflow.

Over time, subsequent electrification efforts were suggested to focus on the remaining lines in Lot 1. The exact implementation sequence thereafter depends on sector conditions and technological advancements at the time of electric bus deployment, as indicated within the dashed blue square in Figure 5.

Lot 2, comprising routes feasible under more relaxed battery and road condition assumptions within Cluster 1, was highlighted in the sensitivity analysis. Additional routes identified depend on the potential relaxation of constraints used, with their feasibility contingent on technological readiness and sector dynamics.

Cluster 2 includes routes deemed potentially electrifiable. Further implementation guidelines were not advised due to dependencies on Fiji's retrofitting capabilities. Nonetheless, exploring their feasibility is strongly recommended, as this could overcome a significant barrier posed by Fiji's challenging road conditions.

Strategic Insights and Future Directions

The study on route prioritization for the introduction of electric buses in Fiji has provided essential insights and groundwork for sustainable public transport initiatives. By evaluating and prioritizing bus routes through a rigorous Multi Criteria Analysis (MCA), the project has identified viable paths toward reducing CO_2 emissions and enhancing transport efficiency. The findings underscore the importance of considering factors such as operational feasibility, environmental impact, and economic viability in electrification decisions. This research serves as a critical stepping stone for GGGI for future studies aiming to fund the introduction of electric buses in the country. The prefeasibility study also highlighted both the challenges and opportunities inherent in transitioning to electric mobility in the Fijian context. This led to the implementation of retrofitted buses to address challenges in rural areas where deploying new electric buses may be more complex. This approach is crucial for reducing economic costs, which is particularly beneficial for developing countries, and when considering the entire lifecycle, may result in lower emissions.

Based on the lessons learned, the analysis revealed that electrifying certain bus routes, particularly those with high-speed and long-distance characteristics, could lead to increased CO_2 emissions due to the carbon footprint associated with electricity production. This underscores the need for deeper research into these factors to determine under which circumstances electrifying the bus network is justified based on the carbon footprint of electricity production. In light of these results, CENIT aims to carry out further research that may help determine which regions, particularly small island states or nations most vulnerable to climate change, yield the most effective results for decarbonization. An example of this could be the development of retrofitting electric buses, which, when considering the entire lifecycle, may provide lower emissions and significantly reduce implementation costs, especially in developing states.

Key trends shaping urban mobility - and future funding requirements

BY CLARA SOLER I BAÑUELOS

In the coming years, public transport authorities will need to deal with increased financing needs in the context of breakthrough changes in urban mobility. These new trends include urban growth and an ageing population, evolving demand patterns, digitalization, emerging urban mobility services, new environmental standards and sustainable finance. Regarding demographic patterns, the increase in urban population will likely require more funding for urban public transport since the resources needed to finance urban public transport grow at a higher rate than the city size. In terms of new environmental standards, the European Commission set out two targets for CO_2 emissions in its White Paper on Transport: a 20% reduction from 2008 levels by 2030 and a 60% reduction from 1990 levels by 2050.

The European Commission estimates that there will be a significant increase in funding gap requirements in urban public transport for the period 2010-2040. According to their estimates, the total yearly operating expenditure for this period will increase by 84% on average. Even though the operating expenditure will grow faster in EU-12 cities (at 2.8% per annum) than in EU-15 cities (at 1.5% per annum), EU-15 cities will still require a higher amount of funding per inhabitant. The expected capital expenditure requirement is estimated to increase by 105% on average during this period. In this case, EU-15 cities will also contribute to a higher proportion of this funding gap in absolute terms.

Figure 1. Electric car charging. Source: Pexels.

This article aims to assess how the most relevant trends (directly and indirectly linked to mobility) will affect the financing of urban public transport and, from there, to establish policy recommendations for the financing of public transport. To this end, the main trends affecting urban public transport will be identified, differentiating both those that are typical of urban mobility and those that are exogenous but have an impact on mobility.

Regarding the endogenous tendencies to urban mobility, in recent years a series of changes and technologies have emerged that are beginning to shape future possibilities for the coming years. Those are:

• Autonomous and connected vehicles. This is a technology that is being developed in strength in recent years. In the United States, for example, it is estimated that between 20% and 95% of kilometres travelled on American roads will be done with automatic vehicles in 2030. This will mainly make it possible to make better use of road capacity, improve traffic and reduce accidents. However, studies show that as long as current vehicles and autonomous vehicles coexist, there may be an increase in accidents. A reduction in accidents will only be effective when there are more autonomous vehicles on the roads.

Another effect of this technology is related to the value of time. If travel time is a cost and directly proportional to the value of time, with autonomous vehicles people will be able to perform other activities while driving, which will reduce the value of time. The effects that this can have in the long term are relevant. The main effect is an increase in the population living outside cities but working there, which translates into greater mobility in terms of vehicle kilometres.

• Zero emission vehicles. Sales of electric vehicles have increased in recent years, but still remain at a modest rate. For example, in 2015 electric passenger vehicles represented only 1.2% of the new vehicle fleet in the EU. This positively and directly affects GHV emission reductions per private vehicle and bus. However, it should be noted that at present the acquisition costs of this technology are much more expensive than conventional vehicles. Also, because of various issues including increased use, significant investment will be needed to extend and expand the electric vehicle supply network. In many countries there is an active policy to promote this type of mobility, as is the case in Europe.

• Shared mobility (car-sharing and bike-sharing). There is a general inclination to classify them as new services, but shared mobility is a concept that is several decades old. The possibilities afforded by new communication and information technologies (ICTs), together with the growth of the collaborative economy, have given a great boost to this form of mobility in recent years.

However, this type of mobility has to be seen as a complement to mass transport systems. Although their current volumes are not large compared to overall mobility, they are a good complement to overcome the weaknesses of current public transport services, so that the integration of these two forms of mobility can constitute a competitive offer to the private vehicle.

The different forms of shared mobility make it possible to improve three of the main weaknesses of public transport from the point of view of the quality perceived by the user: availability, reliability and comfort.

Some of the studies carried out to analyse shared mobility on the transport system indicate that there is a trend towards less vehicle ownership and a reduction in spending on transport among users of shared mobility, as well as encouraging the use of public transport.

• Another trend in demand is the concept of mobility as a service, defined as: a system in which a company offers a wide range of mobility services to customers from the existing supply. In fact, it is a natural evolution of the current service of different public transport operators to offer an integrated fare and/or an integrated payment system, as is the case in most major European cities. The next step is to integrate mobility services provided by private operators into the existing system and to complement the supply of public transport by offering last-mile services, thus providing a complete and seamless mobility service.

• New communication and information technologies (ICTs). In general terms, we can differentiate between effects that could be classified in the short and medium term with those of long term.

Figure 2: Oyster Card notice at Harringay railway station, London. Source: Wikimedia Commons.

At the first stage, new ICT services allow us to process a greater volume of data, of higher quality and in real time, which will enable more effective decisions and adaptability to the changing needs of mobility. While planning will continue to be based on a static, long-term time horizon, especially for transport systems linked to major investments, the new data available will allow better short-term adaptability of supply to variable demand. This improvement to service operations will have a direct impact on the quality of service as perceived by the user.

Another of the implications of new ICTs for urban public transport in the short and long term is the emergence of possible additional services to users. With the processing of data from customers it will be possible to articulate other services in addition to those traditionally associated with public transport and that will represent not only an additional source of income to the urban public transport but also improvements in the quality perceived by the customer.

• Finally, a third element in the short and medium term is the pricing of the urban public transport (UTP). With electronic payment systems that provide traveller data, it will be possible to define second-order price discrimination tariff systems, reducing consumer surplus and increasing income for UTP, thereby improving the system's financing. For example, mobile payment systems can enable fare structures based on the number of trips each user takes per month and the distance travelled within the public transport system, from entry to exit stations.

However, one of the most important and profound aspects of mobility linked to ICTs will have a long-term effect. Different fields of study linked to sociology and epistemology warn "of the importance of the implications of new technologies on the structures and mental processes of individuals" (M. Castells, 1997). These changes significantly influence how individuals conceive of and approach mobility, allowing them to accept and conceive of travel as a combination of different modes of transport or to make shared use of the vehicle, to mention two examples. Especially in urban areas, we are moving from a modal mobility where a service provider or a mode has to compete with the others to a multimodal and shared mobility.. This means sharing both the use of the vehicle and the integration of public and private transport. The concept of mobility as a service must be placed in this context.

This change in approach to mobility is likely to have two effects: reduced private vehicle ownership and planning for an integrated supply of transport modes, including public and private, especially in densely populated urban environments.

Finally, we cannot ignore the role that mobility is playing in the generation of new business segments in the technology sector, either in the creation of new start-ups or within already established companies.

- On demand service. New technologies are making it possible to develop on-demand public transport services (buses and cabs). This type of service will be especially relevant in low-density areas with low demand, where having a transport system with pre-established schedules means excessive costs. This will lead to a greater attractiveness of public transport.

- Multimodality. Travel from one point to another is becoming increasingly multi-modal. This is due to the convergence of several factors: the application of technology to the operation of public transport systems, which facilitates more effective modal changes; and the determination, on the basis of mobility policies, to encourage multimodality in order to make more effective use, according to each stage of a journey, of each mode of transport. This last aspect is promoted by intermodal stations and the definition of complementary public transport networks.

Among the trends, we should also include mobility policies, which are increasingly active in reducing the negative impacts derived from the mass use of private vehicles. In practice, this takes the form of measures: on the one hand, by limiting or penalising the use of private vehicles, as is the case with urban tolls, low emission zones (LEZs), restrictions on street parking, etc. And, on the other hand, by promoting the use of the most sustainable modes of transport: cycling, walking and public transport, especially by improving the offer. In the end, the objective is to reduce the urban space dedicated to private vehicles and give it back to citizens. For mobility purposes, this means thinking of all modes of transport in terms of the network and seeking synergies between them.

Figure 3. Bicycle-sharing systems. Source: Wikimedia Commons.

INNOVATION IN TRANSPORT - REVIEW #3 CIMNE

RAIL4CITIES: Transforming railway stations for green and socially-inclusive cities

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Railway stations hold a unique position in the urban landscape: they not only act as complex nodes of mobility and transport, but also as public places that can be seen as integral elements of the city. Consequently, stations have a decisive impact on their urban surroundings as places of everyday life, affecting all stakeholders including citizens and the environment.

Project Objectives

The central ambition of RAIL4CITIES is to develop a new operational, readily available and highly applicable model of stations as sustainable city promoters (SCP model), combined with a common European methodology and tool for its effective implementation. The project takes inter-dependent impediments (profit-orientated business model, complex web of agents and stakeholders, policy gaps) into account and provides decision makers with the tools to transform stations into promoters of sustainable cities.

We aim to create a novel operational model for stations to promote sustainable cities, alongside a shared European approach and tool for effective implementation.

Source: Rail4Cities Consortium (rail4cities.eu).

Implementation approach

The model will be applied to 5 living labs addressing the stations' transformation into hubs of green and active mobility in France (FR), energy hubs in Italy (IT), towards transit-oriented development in Germany (DE), into a socially-inclusive services hub using Nature Based Solutions, Poland (PL) and service hubs enabling the 15-minute city and circular economy, Belgium (BE).

In this project CIMNE's transport innovation unit CENIT developed the methodology for the impact analysis of a new model of stations in cities. The goal of the methodology we developed is to compute the Sustainable Return on Investment (S-ROI), which accounts for environmental and social factors, in addition to the economic costs and benefits (CBA). As a result, this methodology will assess not only the effects on the stations' bottom line (cost-benefit analysis of integrating, for example, new services and solutions), but also the effects on the urban ecosystem (on people, the environment, transportation planning, and urban planning), particularly those that are not "directly tangible."

In this deliverable, we have used three interrelated methodologies— the Theory of Change (ToC), a Sustainable Return on Investment (S-ROI), and a Multicriteria Analysis (MCA)— to assess the impact of the new station model on the urban context and the mobility system. The methodological framework of impact assessment is described in Figure 1.

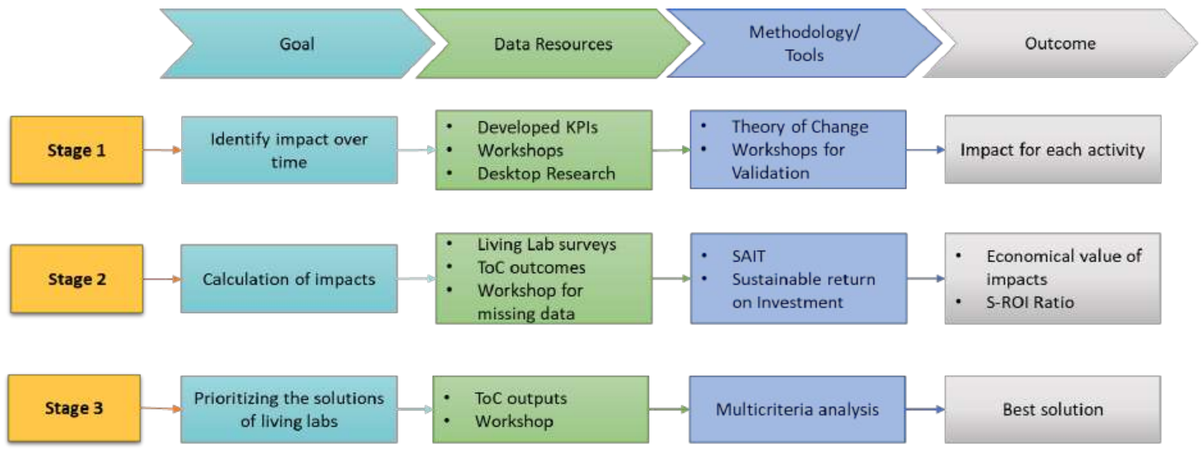

Figure 1. Methodological (c.a.) framework of impact assessment.

The ToC outlines the activities, solutions, and impacts (or KPIs) of each of the seven fields of action while also considering the boundaries and how to overcome them. The ToC serves as the foundation for both the S-ROI and the MCA.

The objective of the S-ROI methodology is to obtain an objective indicator of the net contribution or overall benefit of each of the outputs to subsequently choose the optimal solution. Figure 2 explains the proposed workflow for implementing the S-ROI evaluation of the activities proposed in the living labs.

The selection of optimal solutions is made in conjunction with the results of the multicriteria analysis (MCA). This method starts with the identification of the main objective and the determination of the criteria and sub-criteria, applied to the alternatives. The hierarchy represents the relationships between the following elements (see Figure 3):

- Level 1: Primary Objective. The aim would be to select the solutions with the greatest potential in each of the actions.
- Level 2: Criteria and sub-criteria. The first ones could be Infrastructure, Environmental, Social, Financial, Accessibility, Technology and Safety; while the sub-criteria would be specific KPIs within each criterion.
- Level 3: The different alternatives or viable solutions would be proposed for each action.

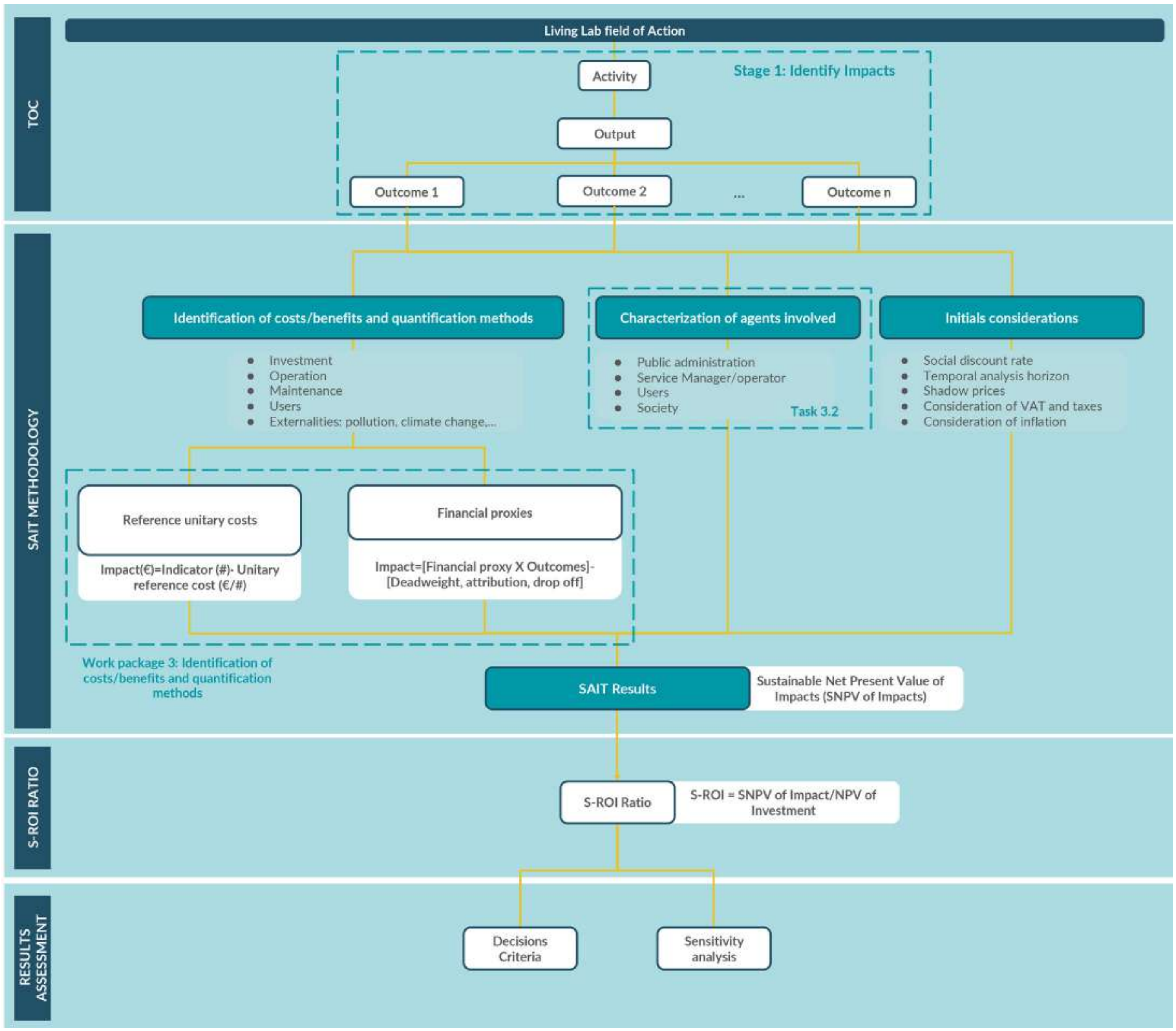

Figure 2. Workflow for implementing the S-ROI evaluation of the activities.

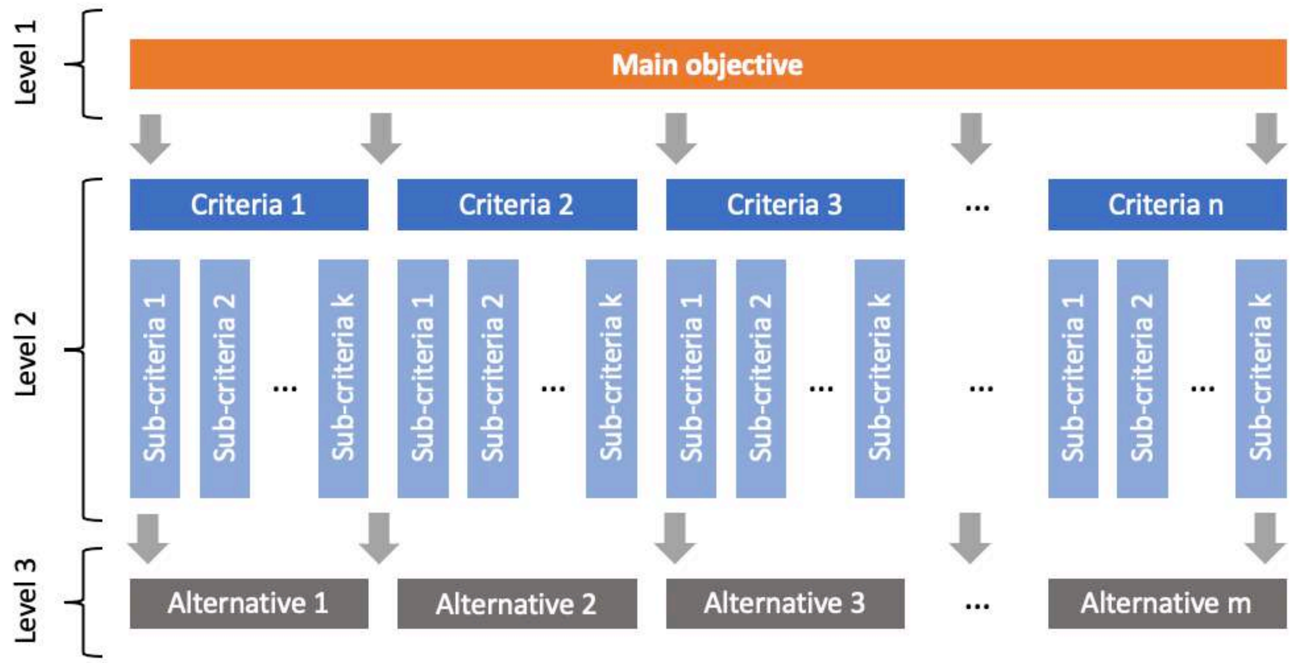

Figure 3. Conceptual diagram or hierarchical model of the Hierarchical Analytical Process (AHP).

The central idea of this methodology is to develop a tool that provides the key solutions for each action to address economic, environmental, and social aspects. The impact analysis tool will allow for the construction of creative services and solutions that address social, environmental, and economic factors by integrating S-ROI and MCA. As outcomes, the integration of a S-ROI calculation in the cost-benefit analysis aims at:

- Better understanding of how sustainability and the financial area relate.
- Greater awareness of sustainability issues as an integral part of the business operation.
- Company participants to feel better prepared for upcoming sustainability standards and regulations.
- Railway companies to start to integrate S-ROI methodologies in their internal CBA for their future projects, as they will see the benefits of such a calculation and will also have an impact on their collaboration with local institutions.

Conclusion

The RAIL4CITIES project adopts a unique approach to rethinking railway stations as catalysts for sustainable and socially inclusive urban development. By creating and executing the SCP model, the project not only solves the existing limits of traditional station models but also provides a comprehensive framework for their transformation into hubs of green mobility, social inclusion, and economic resilience. RAIL4CITIES provides a sophisticated tool for analyzing the multiple implications of station modifications by using connected approaches such as the Theory of Change (ToC), Sustainable Return on Investment (S-ROI), and Multicriteria Analysis (MCA). This strategy ensures that decision-makers have the knowledge they need to maximize station functions while combining economic viability with environmental and social advantages. The project's achievements will encourage the adoption of sustainable practices, thereby fostering the development of greener and more livable railway stations throughout Europe. As railway stations and municipal governments begin to incorporate this methodology into their planning and operations, the potential for widespread positive impact on urban ecosystems becomes more tangible, ushering in a new era of sustainable urban transportation.

CENIT is dedicated to generating knowledge in transport, logistics and mobility, and its transmission to society through research, education and technology transfer, encompassing different areas of economy and transport engineering. Our multidisciplinary, scientific, and systematic approach allows us to quantitatively analyse transport elements relating to service, behaviour, perception, functionality, sustainability, management, quality, reliability, risk and safety. CENIT is highly dedicated to analysing the problems affecting day-to-day transportation systems, logistics chains and nodes and mobility from a scientific perspective. This provides added value for innovative solutions and technical support to advise public bodies and companies.

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NOVEMBER 2024

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