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Welcome

Welcome to the 2023 edition of the INNOVATION IN TRANSPORT REVIEW by the Center for Innovation in Transport (CENIT). Since its creation in 2001 as a partnership between the Catalan Government and the Universitat Politécnica de Catalunya-BarcelonaTech, CENIT has focused on finding sustainable and innovative solutions for transport and mobility. Since 2017, CENIT has formed part of The International Center for Numerical Methods in Engineering (CIMNE).

Over the past two decades, we have witnessed huge changes in the transportation landscape, highlighting the growing demand for innovation, technology and flexibility to create a sustainable model that will help to protect the well-being of future communities and the environment.

In this issue, we present insights and findings from some of our recent research spanning topics such as the impact of technology on transportation, the environmental aspects of transportation, and the evolving field of electromobility.

Our article on Barcelona's superblocks looks at how the implementation of a superblock model within the framework of automated vehicles holds significant promise for expanding pedestrian-friendly zones.

In our piece on the Smart Mobility toolkit project for the World Bank, we see how technology can help cities assess and enhance their Smart Mobility initiatives, enabling integration with broader urban goals and technological advancements for sustainability and livability.

Meanwhile in Costa Rica, we examine the implementation of electric buses in San José with the aim of helping the country achieve its goal of making 30% of buses emissions-free by 2030.

At CENIT, we continue to work with enthusiasm, dedication, and flexibility as we tackle one of the most significant challenges of the 21st Century: bringing efficient, sustainable transportation to communities and providing policymakers with research-driven knowledge.

DR. SERGI SAURÍ MARCHÁN

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Contributors

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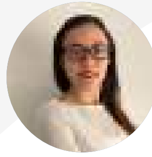
Samra Sarwar's research is focused on explaining and understanding the traffic flow impacts of automated driving, external disturbances in traffic (impacts on congestion cost, tolling strategies, etc.) and to offer solutions to mitigate the negative effects of disturbances through traffic management.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



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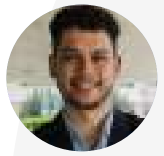

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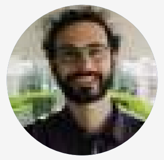

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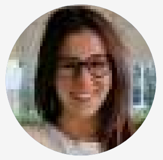
Maurici Hervas is an Industrial Engineer from the Polytechnic University of Catalonia (UPC), specialized in Nuclear Energy. He has worked in several fields including as a consultant for Naturgy, where he helped automate report generation, and in the automotive sector as a production engineer. Later he was the engineering manager of a photovoltaic self-consumption division, performing solar studies and overseeing technical projects. He has also served as general manager of an import/export company during the COVID-19 pandemic. He joined CENIT in 2022 as PhD candidate for Energy transition at the Port of Barcelona.



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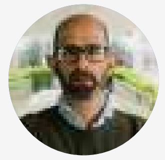
Chiara Saragani is an Industrial Engineer from Alma Mater Studiorum of Bologna. Her areas of expertise include logistics, production systems, research operation and transport. She joined CENIT in 2022 as PhD candidate for Digitalization at the Port of Barcelona. During her Bachelor's Degree, she spent a semester in Buenos Aires, Argentina and wrote her dissertation on the topic of logistics and production systems. She continued her Master's studies at Alma Mater Studiorum of Bologna and spent a semester at École Supérieure d'Ingénieurs en Électronique et Électrotechnique, ESIEE Paris, where she completed her dissertation concerning distribution logistics and research operation.



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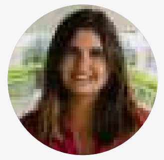
Francisco Rodero has a Bachelor of Science and Master of Science in Informatics Engineering from the Universitat Politècnica de Catalunya (UPC-BarcelonaTech) and obtained a Postgraduate in Smart Mobility: Intelligent Transport Systems from the UPC School of Professional & Executive Development. He has 20 years' experience working on projects where computer sciences are applied to mobility and transport with a strong focus on software engineering and traffic simulation.



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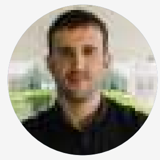

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Unlocking the Future: Barcelona's Superblocks in the Transition to Full Automation.

BY SAMRA SARWAR

The "Eixample" district of Barcelona

By incorporating Autonomous Vehicles (AVs) in the environment, the performance of the transportation network notably improves in terms of traffic flow. With 100% penetration of AVs in the network there will be a 33% increase in traffic flow at the same density.

A future vision of urban mobility planning concerns the condition of traffic and mobility in general with the integration of automated vehicles (AVs) into the road network. With an increasing trend of the global population mainly living in urban areas, approximately 70% by 2025, more cars will be on the road network as many cities are car-dependent.

The planning of vehicle-dependent cities across the world with emerging technologies like automated vehicles must be amended to make them pedestrian-friendly. Therefore, there is a need to reorganise the urban streets to create more spaces for pedestrians, even with the presence of automated vehicles (AVs). The implementation of a superblock model within the framework of automated vehicles holds significant promise for expanding pedestrian-friendly zones. In the superblock model, cut-through traffic demand is restricted, and traffic generated or attracted to a superblock can have access, allowing for more room for public spaces. The proposed model is applied to a small network in the "Eixample" district of Barcelona, as shown in Figure 1 (a), (b), and (c) during the transition phase from traditional vehicles to a fully automated environment. The considered network covers an area of 1.33 km² comprising of 13 zones, 193 nodes and 684 links. This district has a perfect grid-like street structure, which represents the perfect picture for the superblocks' network. Eixample covers 16.2% of the total area of Barcelona city, and 2115 trips/day take place in this neighbourhood which is approx. 30% of trips/day of Barcelona city (7224 trips/day), which has only 2m² urban green/hab. The aim is to utilise this relatively small network area with actual OD matrices representing the regular hourly daily traffic, to facilitate the initial execution of the proposed model and maintain simplicity in the analysis. The equilibrium assignment Bi-conjugate Frank-Wolfe network is used while adopting different penetration rates of AVs. After analysis it is evident from Figure 2 (a), (b), and (c) that the demand in the network shifted from restricted routes towards the concerned links using the shortest path method. It is observed in Figure 2 (a) that the volume difference outside the superblocks on the concerned links when there are 0% AVs in the network, with the inclusion of superblocks, reaches saturation. Similar trends are also observed in the network, with 40% AVs and 100% AVs in the presence of superblocks.

Figure 1. (a, b) Considered area of Barcelona; (c) Road network of considered area with superblocks.

(a)

(b)

(c)

As depicted in Figure 3 (a), (b), (c), and (d), we can witness that the flow capacity increases with a higher share of AVs. Human drivers have a reaction time of 1 second, while AVs have a reaction time of 0.6 sec. Thus, capacity and wave speed increase with a higher proportion of AVs, and this, in turn, affects the macroscopic fundamental diagrams (MFDs). Since traffic flow is a function of traffic speed, Figure 3 (a), (b), (c) and (d) present the Macro Fundamental Diagrams (MFDs) of the selected Barcelona network, comparing 100% traditional vehicles in the network with 40% AVs and 100% AVs in the presence of superblocks respectively. Figure 3 (a) shows an approximate 18% increase in flow at the same density with 40% AVs in the network, while Figure 3 (c) shows an approximate 33% increase in flow at the same density with 100% AVs. Therefore, the speed-density and flow-density relationship depicts that with the inclusion of AVs in the network containing superblocks, the capacity of the transport links will increase as the link flow increases accordingly. Overall, the network with superblocks and traffic in the network containing AVs have more benefits over costs.

The results from the application of the model to the Barcelona network reveal the positive impacts of superblocks in a network with a mix of AVs and traditional vehicles in the traffic flow. Various traffic parameters, including V/C, volume difference, and total travel cost, are computed. The findings indicate improved traffic network performance in terms of the level of service (LOS). The results revealed that the V/C ratio on concerned links outside superblocks without AVs is more than 1. With 40% AVs, LOS is improved, with a V/C ratio of less than 1 on the majority of links. Furthermore, with 100% AVs in the network, the LOS is significantly improved because the V/C ratio on significant links is even less than 0.7, as shown in Figure 4 (b) and (c). The cost-benefit analysis demonstrates that, despite an increase in the cost objective function after optimising the optimal location, the benefits are approximately 52% more than the cost of the system when having a demand factor (y) of 500, with 20% of the city's area covered by superblocks with 100% AVs compared to traditional vehicles. In a nutshell, we conclude that a network with superblocks with AVs in a system will reduce the generalised travel cost by reducing the costs of social externalities and travel time.

Volume difference <=0 >0

Figure 2. (a, b, c)

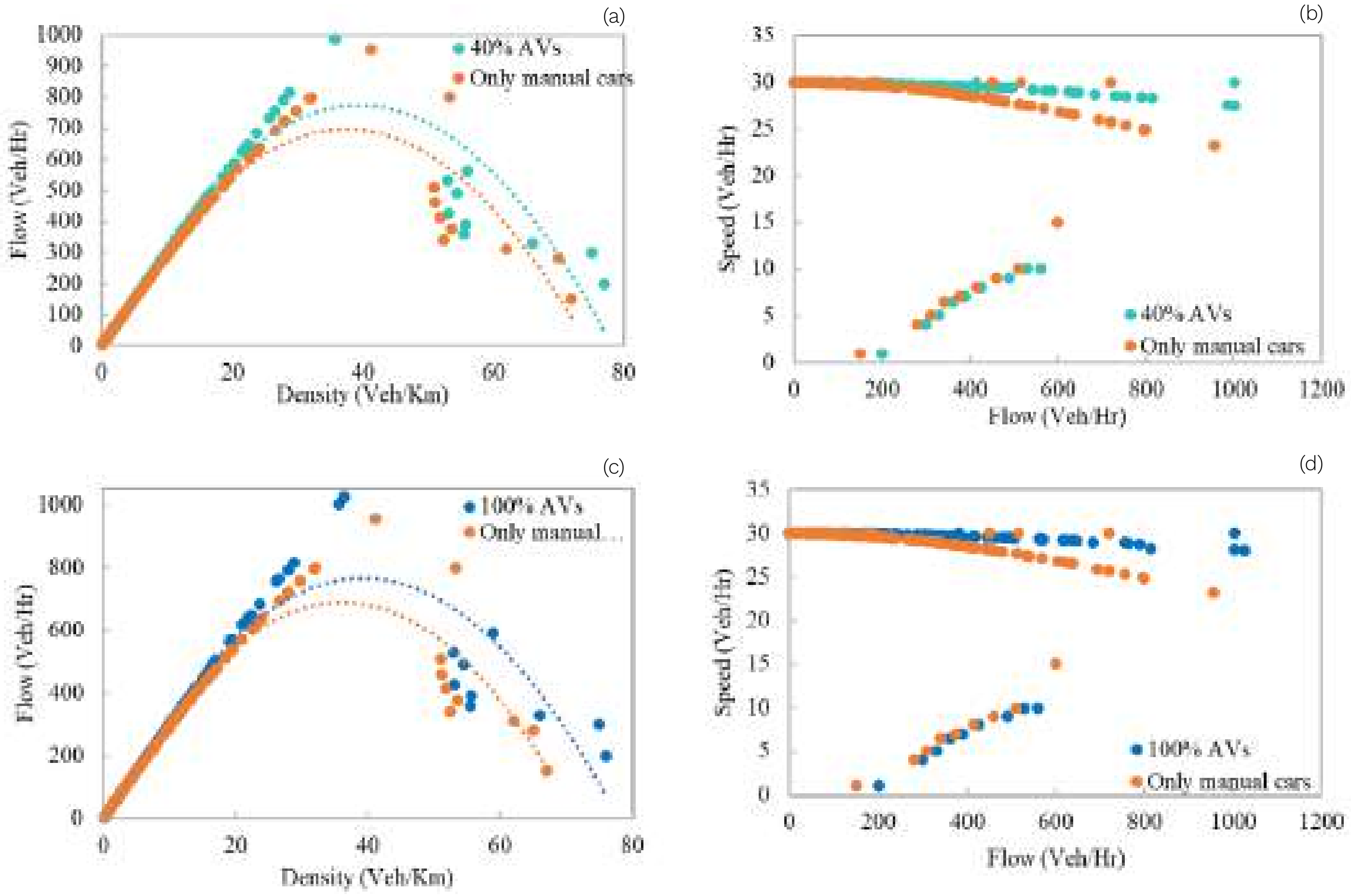


Figure 3. (a, b, c, d)

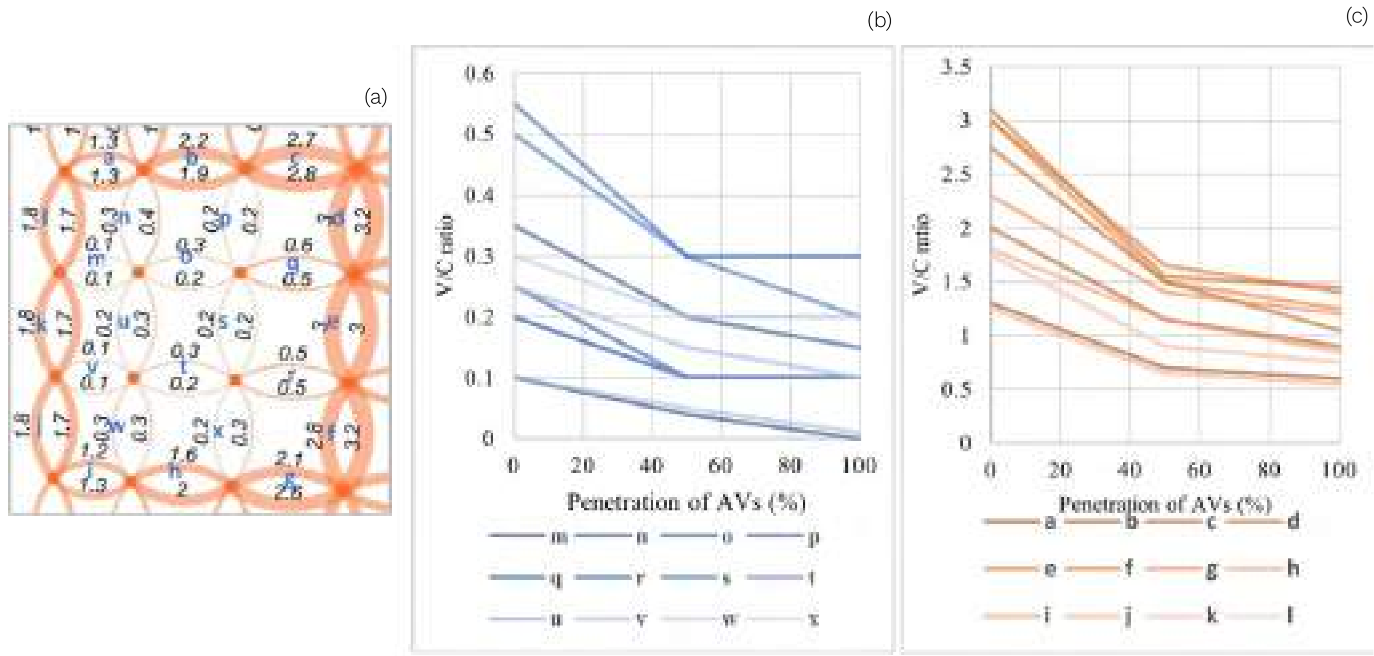


Figure 4. (a, b, c)

Smart Mobility Implementation Toolkit for World Bank Operations.

BY SERGI SAURÍ, PAOLA K. RODRÍGUEZ AND ANDRÉS REYES DIÁZ

For several decades, transport authorities around the world have relied on Intelligent Transport Systems (ITS) to make more efficient use of existing transport infrastructure with the aim of reducing traffic congestion, road crashes, and air pollution. Recently, the smart city concept has gained great popularity and the evolution of this movement has transformed ITS into Smart Mobility—a series of transport initiatives that are integrated with broader city efforts, aided by technology and digital platforms, to improve livability, competitiveness, and sustainability. Smart Mobility initiatives may constitute a new generation of traditional ITS investments powered by technological innovation and rapid penetration of new Information and Communication Technologies (ICT).

Despite several initiatives promoting Smart Mobility in urban transport systems, little is known about how these systems and their cities are performing, or if any model cities for Smart Mobility exist. Without a formal definition of Smart Mobility and related indicators to assess its progress, it is difficult to determine if a transport system is becoming "smarter", or what needs to be done to make it smarter. This Smart Mobility Implementation Toolkit intends to help assess this. The Toolkit is based on four elements described in Figure 1 below:

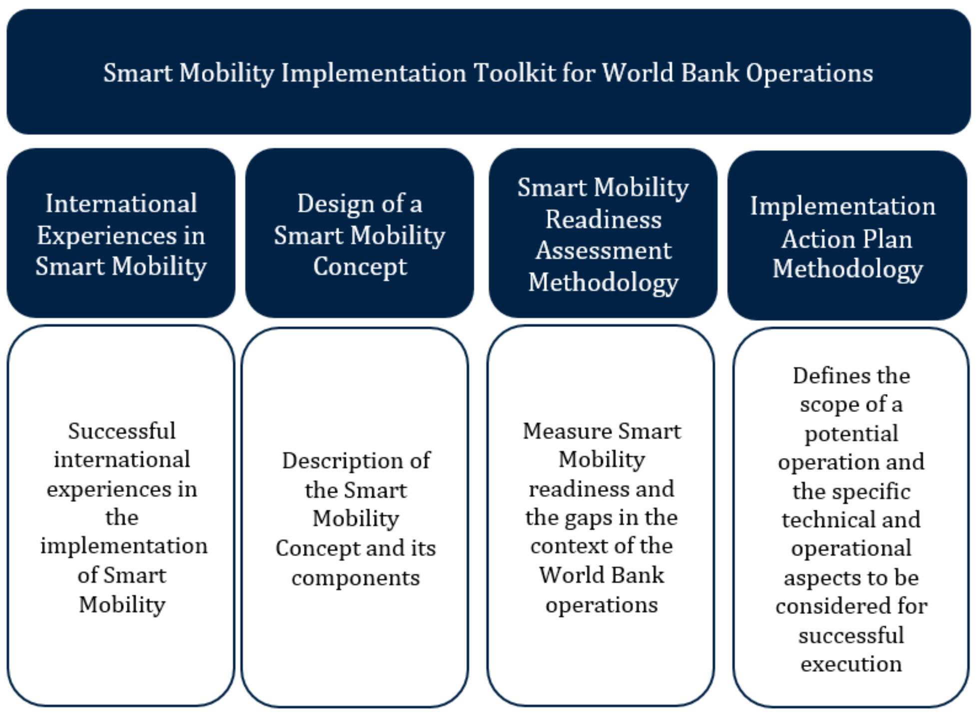


Figure 1. Smart Mobility Implementation Toolkit for World Bank operations.

This Toolkit is based on the logic of the Theory of Change (ToC), which provides a clear picture of how change occurs. The ToC starts with the analysis of a situation and the context that needs change, and the identification of the desired change, as per the city's vision. The expected change should be obtained from the implementation of Smart Mobility Solutions and Smart Mobility Activities (SMS/SMA), through a causal pathway from the problem to be solved, to the identification of the SMS/SMA to be implemented.

In order to apply this methodology, a web-based tool (part of this Smart Mobility Implementation Toolkit) was developed for World Bank staff to carry out their own assessments and plans

The Implementation Readiness Assessment evaluates how ready a city is for the implementation of SMS/SMA based on its current situation, and by identifying general gaps in the conditions that affect their implementation, as well as the gaps of already implemented solutions that need to be addressed to improve mobility conditions.

The proposed Smart Mobility Readiness Assessment methodology was organized into categories with corresponding evaluation indicators. Three groups of categories were defined, General Characteristics, Smart Framework, and Smart Mobility Solutions. See Figure 2 for the assessment of two nonexistent cities compared with their minimum threshold, which is defined as the scenario at which the expected goals of Smart Mobility (Universal Access, Efficiency, Safety, and Green Mobility) start to be achieved, and therefore, as the basis for the deployment of Smart Mobility services.

Figure 2. Web-based tool - Smart Mobility Readiness Assessment

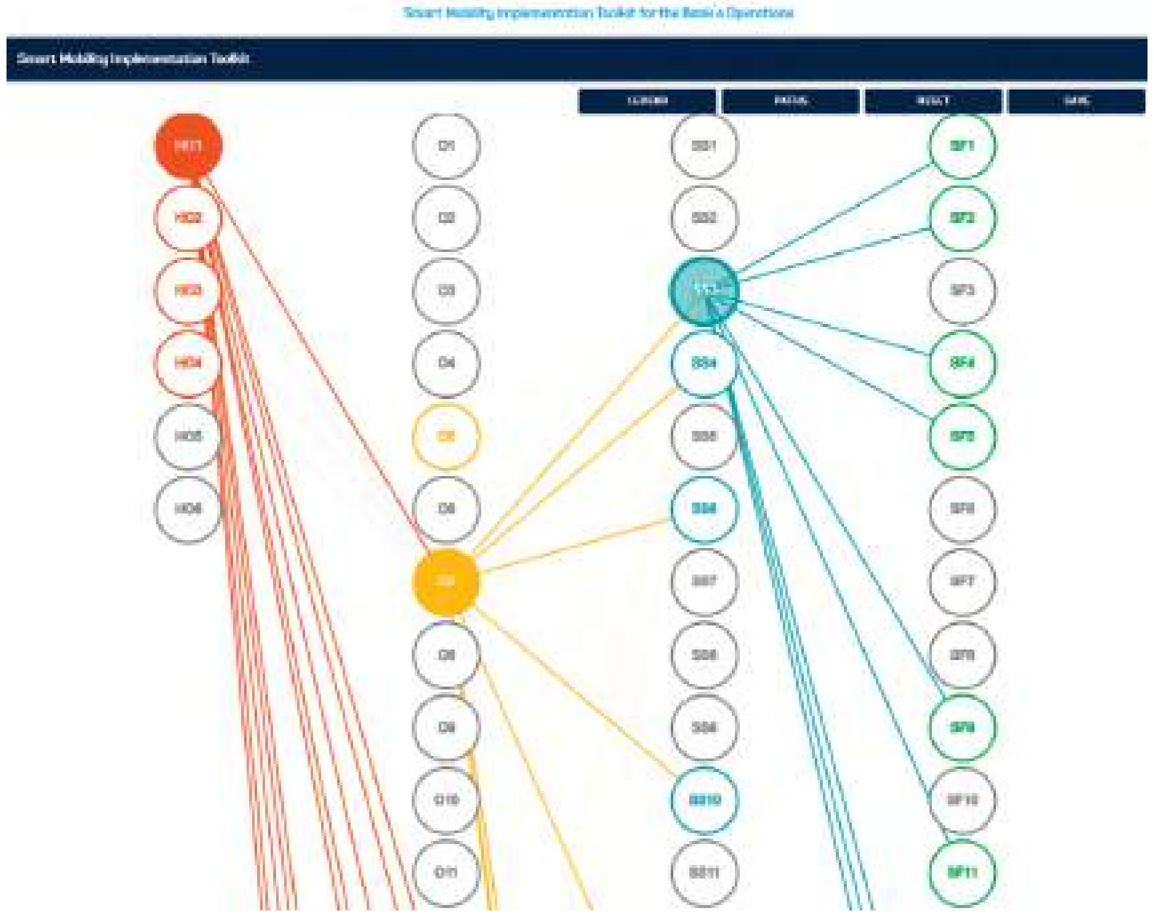


Figure 3. Web-based tool - Smart Mobility Implementation Action Plan.

The relationship between elements helps to systematize the development of the implementation plan. These relationships define a network, with nodes as the elements of the Smart Mobility Concept and links corresponding to the relation implemented by previously identified links. This network can be represented as a neuronal network with Smart Mobility Concept elements: High-level outcomes (HO), Outcomes (O), Smart Solution Activities (SS), and Smart Framework Activities (SF) – see Figure 3.

The guidelines for the development of a Smart Mobility Implementation Action Plan help define the scope of a potential operation, as well as the specific technical and operational aspects to be considered for a successful execution, considering the problem to be solved by the implementation of SMS and the gaps identified in the Readiness Assessment. Therefore, this Toolkit supports the path from the problem to the activities that should be included in an operation, as well as the conditions to consider for the development of the activities.

Sustainable Mobility in Singapore and Barcelona: CENIT and CLC Collaborate on Socio-Economic Evaluation Framework.

BY ANDRÉS REYES DÍAZ

Final workshop attendees.

Tiong Bahru pedestrian and road repurposing.

Cities with high population and density are facing challenges regarding the wellness, mobility, and economy of their inhabitants. Additionally, climate change brings new problems to the equation, requiring cities to be more resilient. Suitable mobility and liveable cities, therefore, are key solutions to be addressed to enable cities to become environmentally neutral and with people at the center of their development. That means a paradigm change in the way that cities develop, make policies and take decisions.

In that sense, CENIT and the Center of Liveable Cities (CLC) have combined their collective expertise in a research initiative aimed at furthering research in a new manner to evaluate suitable mobility projects. Titled "Evaluating the Socio-Economic Implications of Sustainable Mobility," it seeks to enable the quantification of both the advantages and drawbacks of sustainable mobility measures. To achieve this, the project aims to establish a comprehensive framework comprising key socio-economic indicators. These indicators will be instrumental in monitoring and evaluating the effectiveness of sustainable mobility interventions. The framework is focused on helping policymakers in cities such as Barcelona and Singapore, as it will provide them with invaluable tools for enhancing decision-making. Additionally, it will improve the communication of the associated costs and benefits of these policies to the citizens.

Following the different milestones of the joint research, a CENIT delegation travelled to Singapore in April 2023, while a delegation from CLC visited Barcelona in November 2022. Understanding the reality of the city was one of the main objectives of the visit. The trips enabled the experts from CENIT to better understand how Singapore is changing and the great efforts of CLC and other government entities (URA, LTA, among others) to transform the vision and the goals of the city to make Singapore a more liveable city enhancing suitable mobility.

Side visits were made at different decisive locations where suitable mobility solutions are being developed. For example, CENIT went to Tiong Bahru pedestrian and road repurposing side, where LTA has aimed to make the area more pedestrian-friendly by creating a safer walking environment and opening up spaces for community use. The team also visited the Bencoolen Street repurposing project and the Civic District, which provided an insightful overview of the efforts of the Singapore government to make the city more liveable and sustainable-oriented.

Additionally, CENIT was able to understand the process followed by the government to implement new suitable mobility initiatives. This approach is based on community engagement, involving prior pilot phases that are evaluated before they are finally implemented This sheds light on how to further develop the framework.

To conclude the visit, CENIT's delegation and the CLC team executed the second workshop included in the MOU signed in April 2022. The objectives of the workshop were to:

1. Present the draft framework architecture and understand the assessment processes for sustainable mobility initiatives in cities such as Barcelona and Singapore;
2. Discuss the operational relevance of the framework; and
3. Discuss planning and governance-related challenges faced by cities in their transition to reduced car dependency and share noteworthy strategies and solutions that we can learn from.

The session was attended by 28 representatives from relevant ministries and agencies (i.e. LTA, URA, HDB, HPB, MOF, MSE), and academia (i.e. SUTD). Their involvement and participation provided the CENIT-CLC team with insights, feedback, and different perspectives to improve the framework.

Overall, the participants expressed that there was interest and relevance for the socio-economic cost-benefit assessment framework to support cities' transition Finally, the joint research team is working hard to keep developing the framework. Combining the CBA methodology with MCA by applying AHP enhances the decision-making process. The framework will be integrated into an Excel-based tool to facilitate the analysis and the retrieval of results and key parameters. Furthermore, the team is preparing a scientific publication, which will help the community to understand the scientific basis of the new framework, along with other publications to engage citizens on our approach to the process. towards sustainable mobility. Particularly in relation to the holistic representation of benefits, ease of securing funding for small-scale mobility projects, comparison between alternative proposals, safeguarding of foundational first principles through the implementation of an initiative, encouragement of post-implementation evaluation, and communication of impacts to stakeholders.

The turbulent future for European maritime transport with the announced extension of the EU ETS.

BY JAVIER GARRIDO, MAURICI HERVAS AND CHIARA SARAGANI

Port de Barcelona

This article is a contribution from CENIT for the Innovation blog of the Port of Barcelona.

The extension of the EU ETS to maritime transport aims to reduce the sector's GHG emissions. It is going to be an important step for the decarbonization of transport, but is there any collateral damage?

European ports are sailing towards carbon neutral.

In 2015, the Paris Agreement (COP21) pushed the European Union towards creating its own strategy concerning the achievement of the 2050 sustainable objectives, and thus, the Green Deal. It aims to lead EU members towards green transition and climate neutrality through a series of initiatives.

Within the Green Deal, the maritime transport sector plays an important role, despite the fact that it only represents between 3% to 4% of the total CO_2 emissions produced by the EU.

To reduce greenhouse emissions, the EU decided to create a package of policies, named "Fit for 55", in which the maritime sector is heavily involved. Specifically, one of these sanctions appears to be particularly delicate: the EU Emissions Trading System (EU ETS).

EU ETS extension: a measure with a rocky progression:

The European Union estimates that the EU ETS represents a fundamental step for the abatement of greenhouse gas emissions, targeting at least a 43% reduction by 2030 compared to 2005.

The decision-making process of this measure has not been smooth. Indeed, the text has already seen several modifications even though it is not approved yet.

After a review by the Council and the Parliament, the directive will include the maritime sector in the EU emissions market earlier, from 2024, with a phase-in period. The scope is limited to 50% of emissions for routes between EU and non-EU ports, and 100% of emissions produced for routes inside the EU.

Not only is the maritime transport sector affected by the EU ETS, but other sectors are also included. The emission rights payments received are allocated to diverse funds, one of them being the Social Climate Fund, which helps EU citizens and micro-companies to invest in sustainable energy measures. Moreover, the Modernization Fund and the Innovation Fund were also created. The first one supports ten EU members during their climate neutrality transition, while the second one promotes innovative low-carbon technologies.

The following table shows the development of the measure:

EU ETS evolution process: three different changes

I – proposal for a revised EU ETS, 14th July 2021	II – new agreement after European Parliament rejection, 22nd June 2022	III – new EU ETS provisional agreement, 29th November 2022
Extend EU ETS for maritime sector. From 2023	EU ETS for maritime sector. From 2024	
EU ETS for ships over 5000GT		EU ETS for all cargo vessels and passenger ships over 5000GT
100% emissions paid for routes inside EU. 50% emissions paid for route between EU and non-EU waters	From 2027, 100% of emissions for all trips will be paid	100% emissions for intra-European routes. 50% emissions for extra-European routes will be covered
Gradual EU ETS implementation between 2023 and 2026. Emissions to be paid each year: 20% in 2023;45% in 2024;70% in 2025;100% from 2026.	No gradual EU ETS implementation	Gradual EU ETS implementation between 2024 and 2026. Emissions to be paid each year: 40% in 2024;70% in 2025;100% in 2026.
EU ETS includes just CO2 emissions	EU ETS extended also for methane (CH4) and nitrous oxides (N2O)	EU ETS extended also for methane (CH4) and nitrous oxides (N2O) from 2026
The responsible entity is the shipping company	The responsible entity is the shipping company, but costs should be passed on to charterers	
	From 2027, EU ETS will be extended for ships over 400GT	General cargo vessels and offshore vessels of over 400GT inclusion in EU ETS will be reviewed in 2026
	Where the distance of the port is less than 300 nautical miles from EU, 100% of emissions will be included	
	Creation of an Ocean Fund to support energy efficient transition	
		Offshore services vessels from 5000GT also included from 2027

Source: an elaboration based on [illegible] study

The extension of the EU ETS to maritime transport will help to decarbonize the economy and accelerate the implementation of more sustainable technologies. At the same time, some adverse effects could appear since the policy is not going to be applied on a global scale. Although, maritime transport is an international business subject to external factors.

Therefore, "Puertos del Estado", a public entity which is responsible for Spanish ports, decided to investigate the impact this measure would have on ports such as Barcelona, Algeciras and Valencia and its knock-on effect on the Spanish economy.

A first study was developed by each of these ports, and a second in-depth study was conducted in order to consolidate the results and then perform an analysis of the possible evasive mechanisms. This last study was conducted by the Center for Innovation in Transport (CENIT), an investigation center in Barcelona specialized in logistics and transport challenges.

CENIT investigates possible negative impacts of the EU ETS on the Spanish maritime sector

The research study considers the main container routes which connect Spanish Mediterranean trade, in particular, products handled by Algeciras, Valencia and Barcelona ports. The study takes into account 8 routes between America and Europe and 6 routes between Asia and Europe.

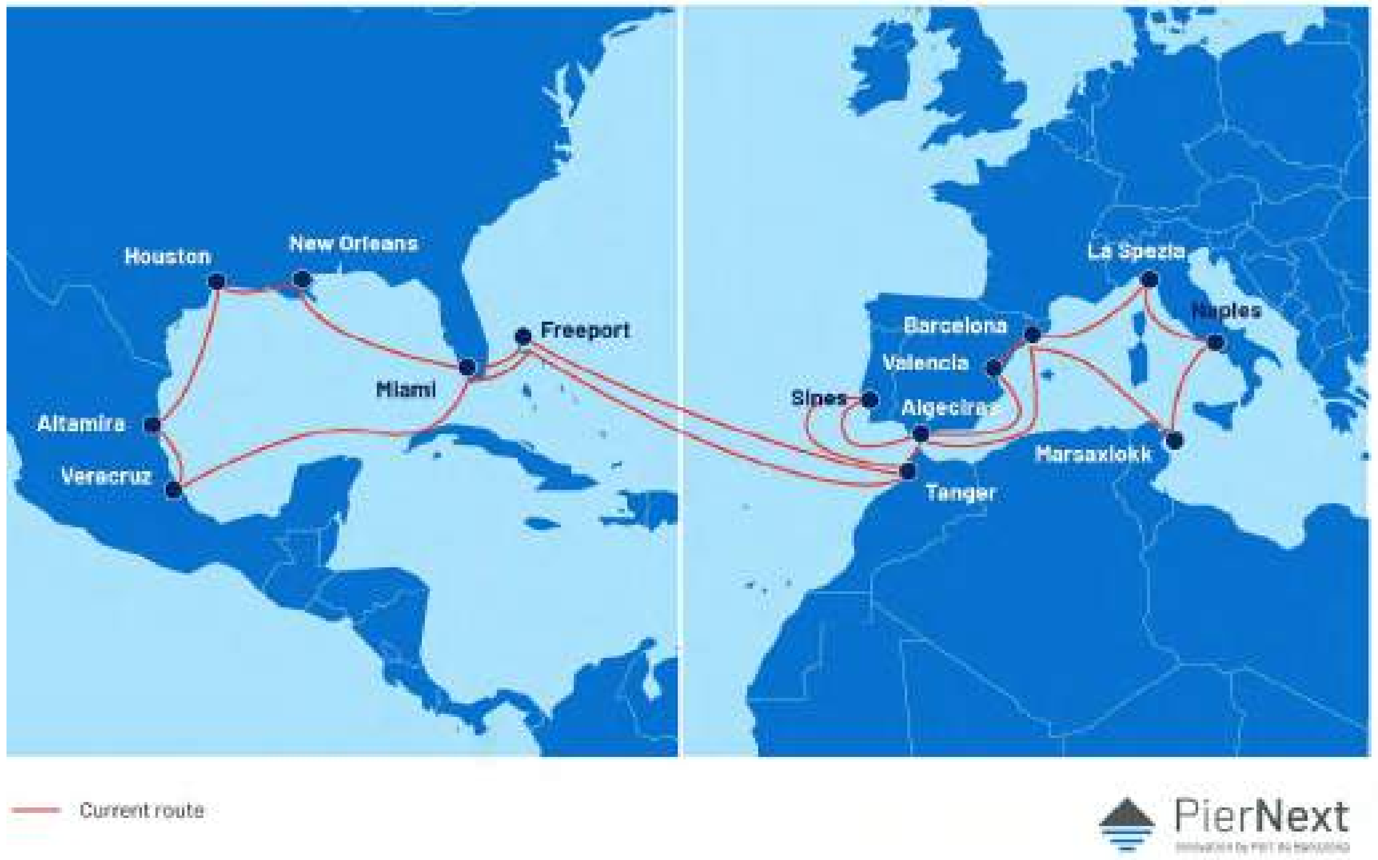
These routes have a regular frequency, and they are considered relevant enough, given that they cover a significant percentage of the total maritime traffic for the ports studied.

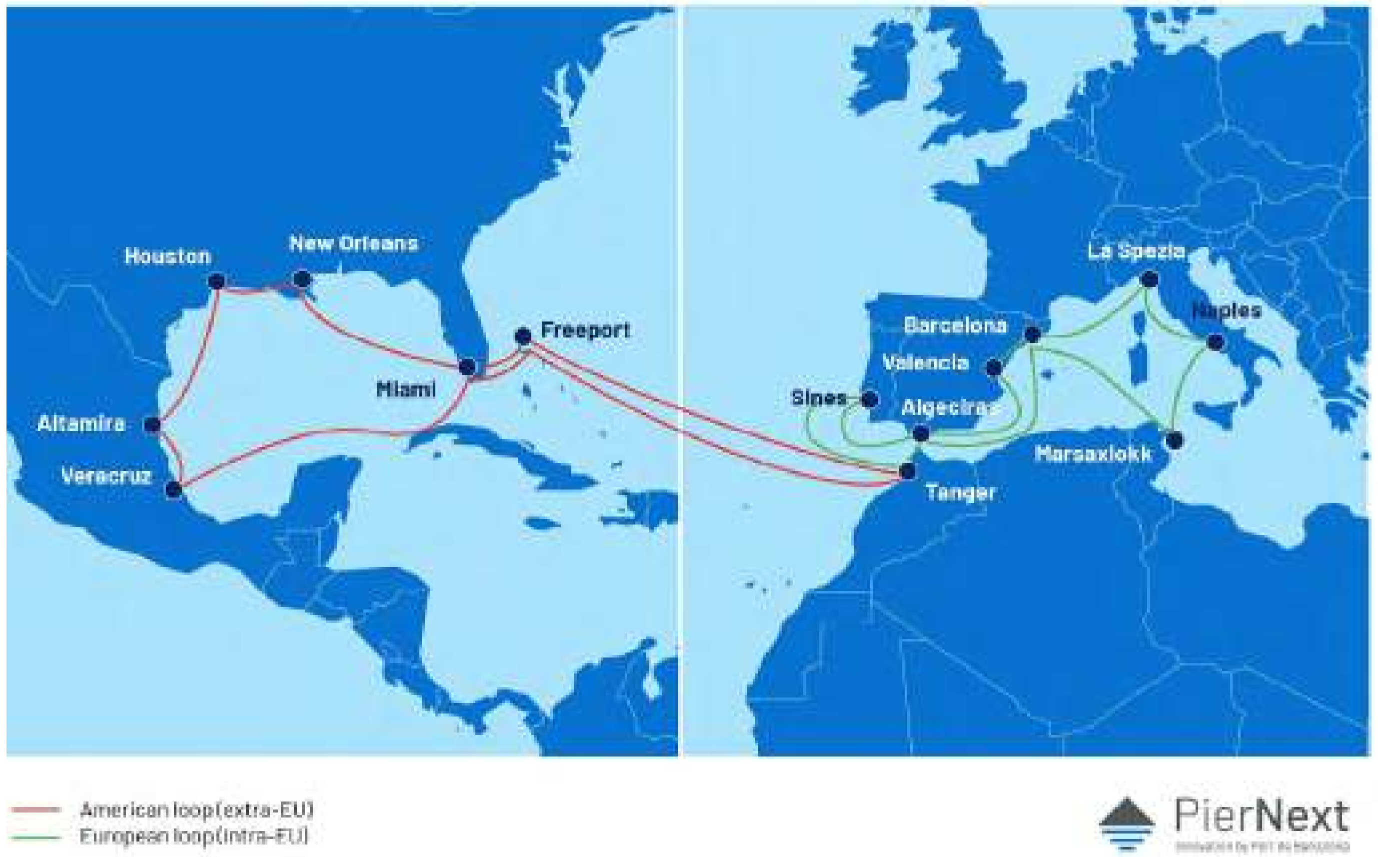
Currently, the routes perform a loop between America and Europe or between Asia and Europe.

Due to the EU ETS implementation, shipping companies could decide to split this loop in two.

To be more precise, they would first leave the containers in a North-African port, then they would move the goods to Europe with a second loop. In this way, the first route would not fall under the scope of the EU ETS, effectively minimizing the carbon emission costs of the route.

The following images show an example of this choice.





But firstly, do African ports have the capacity to manage this huge amount of containers?

The EU ETS could help speed up the expansion plans of North-African ports.

CENIT's study includes an analysis of the effective possibility of separating in two the container loop coming from America or Asia. This study showed that North Africa already has some ports exchanging goods with the European market. Moreover, it was noticed that some of these ports are very close to each other, and they could decide in the future to collaborate, in order to better manage the flow of goods.

Relevant examples of this possibility could be the port of Tangier together with the port of Nador, or Port-Said and Damietta – they are separated by 70 km – together with the port of Alexandria.

Finally, Algeria and Tunisia intend to expand their strategic maritime connections and they are also planning the development of deep-water ports close to their main cities.

These North African ports could become transshipment hubs in the future, and some of the most important shipping companies are already investing and are willing to contribute to their development. In this way they would reduce their exposure to the ETS and thus maintain a competitive advantage in the European market.

Hence, shipping company funding could speed up the ambition of North African countries to become an important reference point for the maritime transport system.

Opportunities and threats to the reconfiguration of lines

OPPORTUNITIES	THREATS
Economic growth of African countries is expected + natural resources	Trade risk of North African countries, loss of cargo control, due to unstable port policies
Alliances with African ports and logistic operators	Large investments in infrastructure without a stable regulatory framework (constantly evolving regulatory framework)
Container ships capable of making the Mediterraean loop with Africa-Europe routes already in operation	IMO regulation uncertainty
Laxer environment than in Europe	Loss of efficiency (lower team productivity)
Ability to reduce the cost of transport €/TEU	Possible dissatisfaction of European users due to the increase in lead time
The experience of shipping companies in African ports can favour their entry and expansion into new markets and African countries	Being seen as an unsustainable brand by the users, risking final user rejection

The implementation of the EU ETS could lead to shipping lines making a first stop in North Africa, the Adriatic Sea, the UK or the Eastern Mediterranean.

What would the consequences for Europe be?

Quantifying the negative impacts for the reconfiguration of maritime routes.

Taking a closer look at the CENIT research study, an analysis was conducted in terms of costs, time, emissions produced and carbon leakage.

The study examines three different scenarios, with three different time periods – short-term (2025), medium-term (2030) and long-term (2040) - and these scenarios were compared with the current situation. The study chose to focus on container shipping, as this represents around 90% of the total number of transported products. Nevertheless, negative implications would also appear for other modes of transport, such as the roll-on/roll-off market, liquid and solid bulk and short sea shipping.

In order to quantify the impact of these new transport routes, CENIT analyzed the main cost variations compared to the baseline scenario.

The main costs considered are as follows:

- Navigation costs: fuel, capital, operational;
- Emissions costs: costs to be paid in order to comply with the EU ETS;
- Container operation costs: costs related to containers loading and unloading;
- Port call taxes: taxes to pay to enter a specific port;
- Crew costs: costs related to the crew on a ship.

The considered values are the result of accurate research in order to reproduce the closest approximation to reality, investigating real information coming from the interested routes.

The EU ETS could move shipping companies towards more economic but less sustainable logistics.

Results coming from the study show that route reconfiguration would generate cost savings for shipping companies. However, emissions could increase, and a significant amount of tax evasion would occur, for both transatlantic and eastern routes.

Concerning transatlantic routes, 6 out of 8 of them would save money with the reconfiguration. This reconfiguration would result in an increase in emissions of between 0.5% and 24% in the long-term, compared to the baseline scenario.

Eastern routes show the same results, emissions would be raised by between 1% and 5% compared to the current situation.

Finally, carbon leakage would be significant for all routes. Carbon leakage is the transfer of emissions from a specific country to other regions with the aim of avoiding rigid climate policies.

The following table shows the short, medium and long-term results for both transatlantic and eastern itineraries:

	TRANSATLANTIC ROUTES			EAST ROUTES		
	Short-term (2025)	Medium-term (2030)	Long-term (2040)	Short-term (2025)	Medium-term (2030)	Long-term (2040)
Cost savings	3.8 – 19M € / year	3-38M € / year	14-60M € / year	1.4 – 28 M€ /year	6 – 58M€ / year	9-80 M€/ year
Emissions increase	4/8 routes 2%-7%	4/8 routes 3%-8%	All routes 0.5% - 24%	3/6 routes 0-5%	3/6 routes 0-5%	3/6 routes 1%-5%
Carbon leakage	1 MtnCO2/year	0.9 MtnCO2/year	0.7 MtnCO2/year	1.1 MtnCO2/year	1 MtnCO2/year	0.8 MtnCO2/year
EU ETS tax evasion	103 M€/year	145 M€/year	180 M€/year	111 M€/year	164 M€/year	205 M€/year

Maritime route reconfiguration could make the European supply chain fragile.

The EU ETS could lead shipping companies towards the reconfiguration of maritime routes connecting Europe. Indeed, companies could decide to split routes into two phases: one from the origin to an African hub and the second one from Africa to Europe. In this way, companies will pay just the emissions costs for the second trip, since the EU ETS is only applied in European maritime boundaries.

The route reconfiguration could speed up the process of African hubs expansion, resulting in the loss of transshipment traffic. Even though the majority of the lost traffic would be transshipment, the I/E activity would also suffer due to lead time increases.

The products' time growth would make the European supply chain more uncertain due to the intermediate stop, resulting in further expenses. Moreover, the reconfiguration would lead to an increase in GHG emissions in the long-term, which is entirely counterproductive to the EU ETS's objectives.

Finally, it is possible to state that the reconfiguration would produce negative impacts not only for Spanish trade, but also the entire European one.

Indeed, similar effects could be produced in the North-European maritime routes. Shipping companies could decide to split the loop in a port of the United Kingdom, since the UK ETS will not include international shipping, instead relying on the IMO efforts.

Moreover, other reconfigurations could emerge in the Adriatic traffic and Eastern Mediterranean, moving the original paths towards Turkish and Egyptian ports.

Summary outline of impacts of the inclusion of maritime transportation in the EU ETS for the Mediterranean region.

Decarbonization will only be achieved by working together.

The study from CENIT shows how the EU ETS would negatively impact the European maritime system. The main reason is that the measure would only be applied for journeys inside European boundaries, giving the shipping companies the possibility to evade EU ETS costs, by introducing intermediate transshipment hubs in non-EU countries.

The pre-agreement contemplates the possibility of evasive maneuvers and requires that the Commission monitors these trends in order to detect them at an early stage and propose measures to address them.

Nonetheless, this mechanism relies on an active observatory. Conversely, the implementation of measures for the reduction of GHG emissions would be more efficient if all countries were involved. This choice would avoid tax evasion and shipping companies would start to focus their resources on more sustainable solutions instead of new strategic logistics hubs.

In 2015, the International Maritime Organization (IMO) started some initiatives aiming to reduce maritime emissions gradually, but the reality is that little practical action has been taken.

The European Union should take a more insistent approach with the IMO and try to put more pressure to extend the EU ETS to all countries.

Moreover, a strategic plan for funding allocation could be proposed.

The EU and the IMO could use the ETS to invest in those countries where the economy is unstable, helping them towards energy transition and a better administration of their strategic hubs.

They could also promote the research of innovative solutions which could help to speed up the clean energy implementation process.

One example could be the funding for the renewal of the fleets with more sustainable ships, generating in this manner benefits for both the environment and the shipping business. Thus, reducing the reluctance of the involved companies to assume the carbon tax.

Finally, another option would be the implementation of "Contracts for Difference". It is a program aiming to incentivize private investments for the production and use of scalable zero-emissions fuels (SZEFs), due to the high costs these technologies still have. Hence, the main objective of this program is to reduce the gap between old and promising new technologies as soon as possible.

This article analyzes the impacts for container traffic, but what about the motorways of the sea, cars, liquid bulk, cruises and others? CENIT will carry out further research to explore the impacts for different maritime sectors.

Download CENIT's study:

This article is a contribution from CENIT for the Innovation blog of the Port of Barcelona.

Fire hazard reduction in ro-ro spaces by means of a cargo distribution algorithm that accounts for fire risk management during the stowage process.

BY FRANCISCO RODERO BLÁNQUEZ AND ÁFRICA MARRERO DEL ROSARIO

Nowadays, during the stowage process, cargo units are distributed along a ship's decks mainly based on the available space, their size and, optionally, their weight. However, only cargo classified as dangerous goods is managed according to International Maritime Organization (IMO) regulations.

The LASH FIRE project addresses challenges at every stage of a fire by means of the development and demonstration of technical solutions. This paper focuses on the ignition prevention stage and describes the development of the Stowage Planning Tool (SPT), a software that incorporates fire hazard management, to support the loading process. The prototype implements risk assessment of the units based on historical data and, optionally, suggests appropriate placement of the cargo, with the aim of reducing the overall risk.

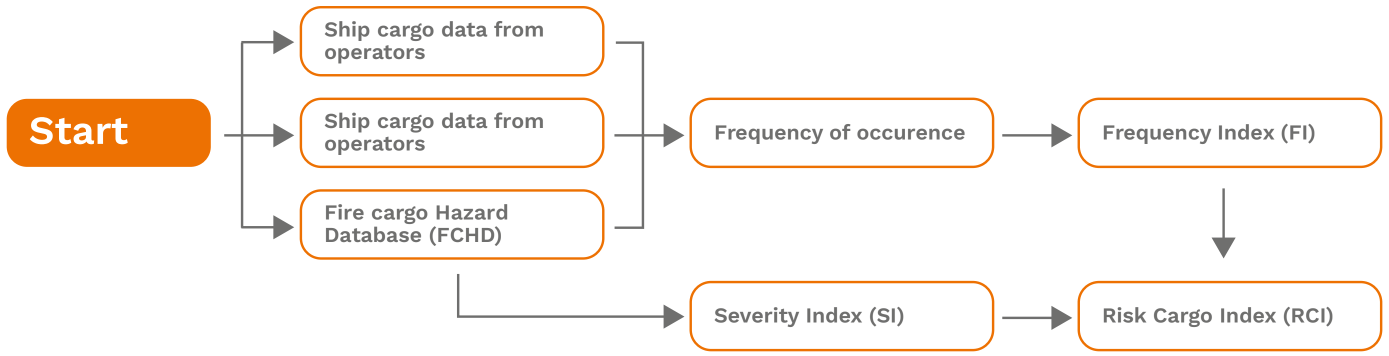


Figure 1 – Overview of the risk assessment calculation

Historical data analysis was carried out to identify patterns and to establish a knowledge baseline of the problem, with the aim of providing future solutions for preventing cargo fires on ro-ro spaces. The results were compiled in the Fire Cargo Hazard Database, including the date and location of the incident, its severity, what goods the vehicle was transporting (if any), what goods were transported by nearby vehicles and many other relevant parameters. Finally, a score value was assigned to every cargo type, and also a set of rules was defined to change the score depending on the nearby units, not only on the same deck but also on upper and/or lower decks. This way, the score value became the indicator used to measure the global risk of a certain cargo distribution.

Therefore, the idea behind the software is to find the ideal combination of placements for the cargo units that would reduce the risk in terms of the above-mentioned score indicator.

As shown in the picture on the right, the prototype interfaces with other LASH FIRE components, like the Vehicle Hot-Spot Detector (VHD) which is responsible for inspecting (by means of LiDAR sensors and thermal cameras) every single unit before it is loaded onto the ship and, optionally, trigger a high-temperature alarm. This information can be used to modify initial scores and to make informed decisions, during the loading stage about whether the suggested placement for a given unit should be changed based on the new hazard information or discarded altogether.

Since the SPT is designed to entirely support the stowage process, it contains updated information about the accurate location and information of units, which can be shared with Autonomous Guided Vehicles that patrol the ship during a voyage for path planning purposes or even to provide valuable information to fire-fighters through the Management Center from the bridge.

In conclusion, the Stowage Planning Tool as well as other solutions developed in the LASH FIRE project can help to provide a technical basis for future revisions of IMO regulations aimed at reducing fires in ro-ro spaces.

The research presented has been financed as part of the LASH FIRE project (Legislative Assessment for Safety Hazards of Fire and Innovations in Ro-Ro Ship Environment)

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 814975. Please visit the website http://lashfire.eu for further information.

Transforming Public Transportation: Financing Electric Buses for a Greener Future in Costa Rica.

BY PAOLA K. RODRÍGUEZ

Costa Rica boasts an ambitious climate policy framework in which the transportation sector, responsible for 50% of the country's total CO_2 emissions, stands as a pivotal area for achieving economic decarbonization. The objective is to ensure that 30% of the nation's buses are emissions-free by 2030, with a further increase to 85% by 2050. As a result of this initiative, Costa Rica is on the path towards an expanded electric mobility landscape in the San José Metropolitan Area (AMSJ).

To assess the implementation of electric buses in the AMSJ, a consultancy titled "Evaluation of the Implementation of Electric Mobility in Public Transportation in San José, Costa Rica" was undertaken for the World Bank, in collaboration with the Ministry of Public Works and Transportation (MOTP) and the Public Transportation Council (CTP). This consultancy was undertaken in close collaboration with CENIT's strategic partner, Hinicio, along with local consultants possessing expertise in Costa Rica and its political and transportation landscape.

The consultancy encompassed a number of studies including market surveys, an examination of market potential, and market readiness for electric buses, as well as an assessment of potential regulations for retrofitting, technical discussions leadership with counterparts in electric mobility, and an in-depth analysis of the commercial and financial model for electric buses in the AMSJ.

CENIT's main focus in the consultancy was the development of the financial model. Business models within the electric vehicle ecosystem continue to undergo evolution. Concerning electric vehicles, these models vary from full ownership to vehicle and battery aggregation versus disaggregation, lease agreements, green bonds, operational leasing, financial leasing, battery-only rental, and more. The electric bus (e-bus) ecosystem is characterized by two prominent aspects: (i) technological uncertainty with ongoing innovations in vehicle design, battery efficiency, charging systems, and more; and (ii) high initial costs, as well as the total cost of ownership (TCO). Therefore, the expansion of electric mobility necessitates a comprehensive understanding of the rapidly evolving interplay between these factors.

Moreover, many countries, such as Costa Rica, and public transportation agencies have been severely impacted financially by the COVID-19 pandemic, requiring innovative financial solutions for the implementation of electric vehicles. The development of business models resulting from this project was based on estimating the Total Cost of Ownership (TCO) of electric vehicles in comparison to conventional buses (gasoline, diesel, or natural gas). A particular focus was placed on the private sector, including public-private partnership (PPP) schemes with a proper allocation of risks between public agencies and private enterprises in the deployment and operation of electric vehicles.

Additionally, the model takes into account Costa Rica's objective to maximize Private Capital Mobilization (PCM) given the country's limited fiscal space and lack of public resources. It envisions a centralized structure (in the form of a trust) that would procure buses in batches, along with the charging infrastructure, and subsequently lease them to private bus operators (see the basic structure of separating ownership and operation of electric buses through financial leasing - Figure 1 and Figure 2). The cost would be lower due to economies of scale and a special rate agreement with the ICE (electric utility).

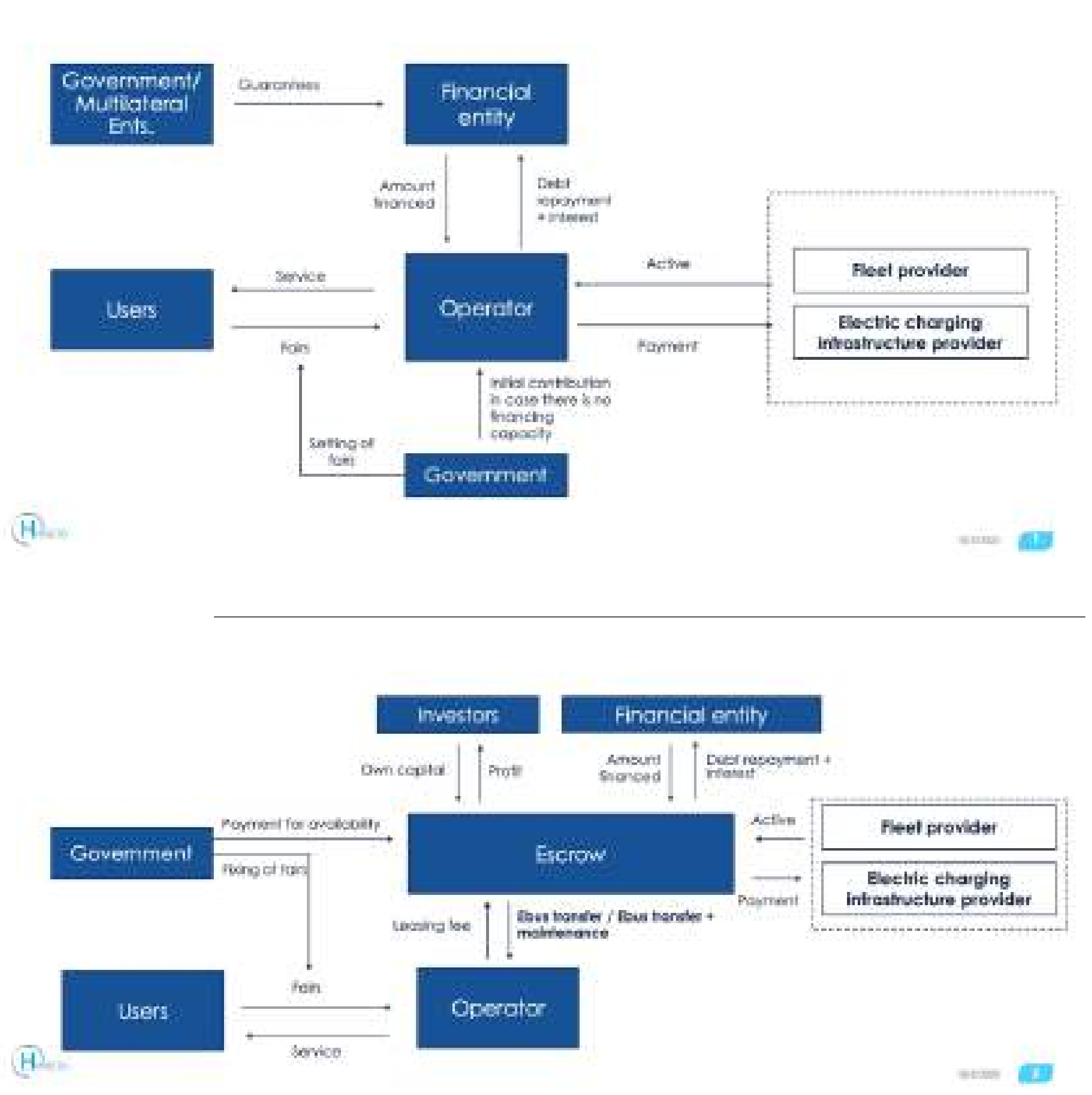


Figure 1. Theoretical Explanation of Business Models (BAU and Ownership and Operation Separation)

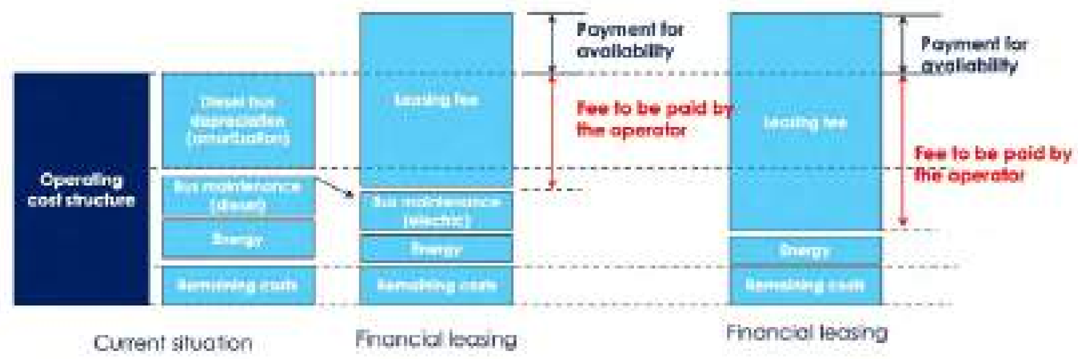
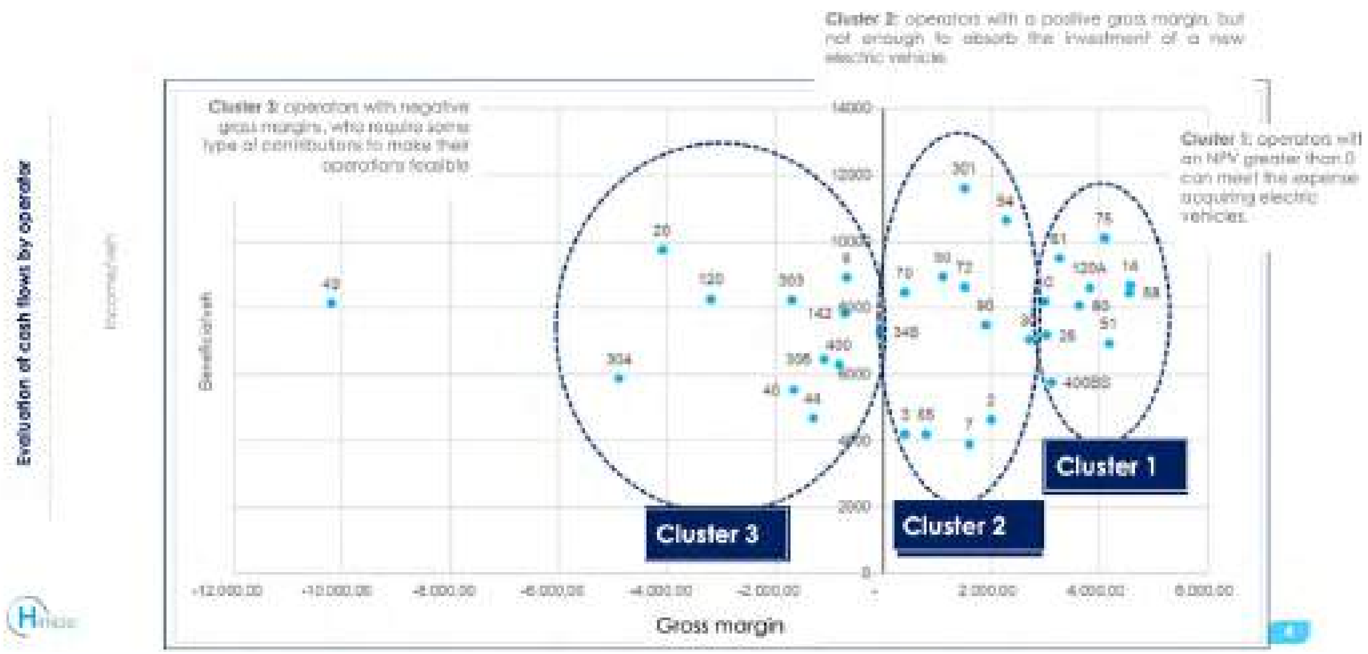


Figure 2. Theoretical explanation of the proposed financing structure

It is worth noting that there is significant variability among operators in terms of their financing capacity. Therefore, three major groups (or clusters) can be considered, which impact the implementation timelines of electric buses:



In conclusion, the proposed model would establish a trust with a minimum term of 14 years (equivalent to asset amortization). This trust would acquire the assets and be funded by investors' equity and debt. These investors can be structured debt or strategic investors. Payments would come from operators' fees and a contribution from the government in the form of availability payments (amounting to 75% of the leasing fee, with the remaining 25% assumed by the operator). Government availability payments would be made directly to the trust.

The trust's debt would be wholly or partially guaranteed by a multilateral entity, which would help reduce the financial cost. This system would enable the government to make changes in operator allocation in case of non-compliance, including failure to make lease payments to the trust. The financing formula that generates fewer payments for availability is debt structured with multilateral guarantees. Given the current uncertainty caused by high interest rates, it is also advisable, at the time of structuring the debt, to evaluate the option of thematic (green) bonds with multilateral guarantees.

Two submodels have been considered: including maintenance (operational leasing) or only the financing part of the asset (financial leasing). The latter scheme is recommended due to the operators' know-how and the trust's lack of technical capacity. However, in this case, a guarantee should be established to ensure the proper maintenance of the assets by the trust.

Location and proposed deployment of electric, gas and hydrogen recharging points for overland goods distribution vehicles.

BY PACO GASPARÍN CASAJUST

One of the main challenges currently facing the road freight transport sector is the reduction of GHG (greenhouse gas) emissions, while one of the main strategies to address it comes from technological advances in alternative energies, such as electric power and compressed natural gas. Though these solutions are technically feasible, they often face practical implementation problems, one of the most pertinent of which is the lack of supply infrastructure.

The objective of this study was to identify the number and appropriate location of recharging points in Catalan territory needed for electric, gas and hydrogen powered goods vehicles and how these should be implemented over time.

The study includes an analysis of the current state of alternative technologies to fuel oil and the current state of recharging points. As an operational premise in the calculation of recharging points, an origin-destination sub-matrix of heavy vehicles was constructed by selecting the roads to be analyzed. Finally, the mathematical optimization model was constructed and the locations of the recharging points were obtained according to the proposed time scenarios.

For the construction of the sub-matrix, the intensities and charging infrastructure in the main corridors of the Catalan territory were analyzed. Based on the volume of heavy vehicles at peak times, the main axes to be studied were defined (see Figure 1). Once all this information had been obtained, a sub-matrix of distances between recharging points (by technology) was obtained for each corridor.

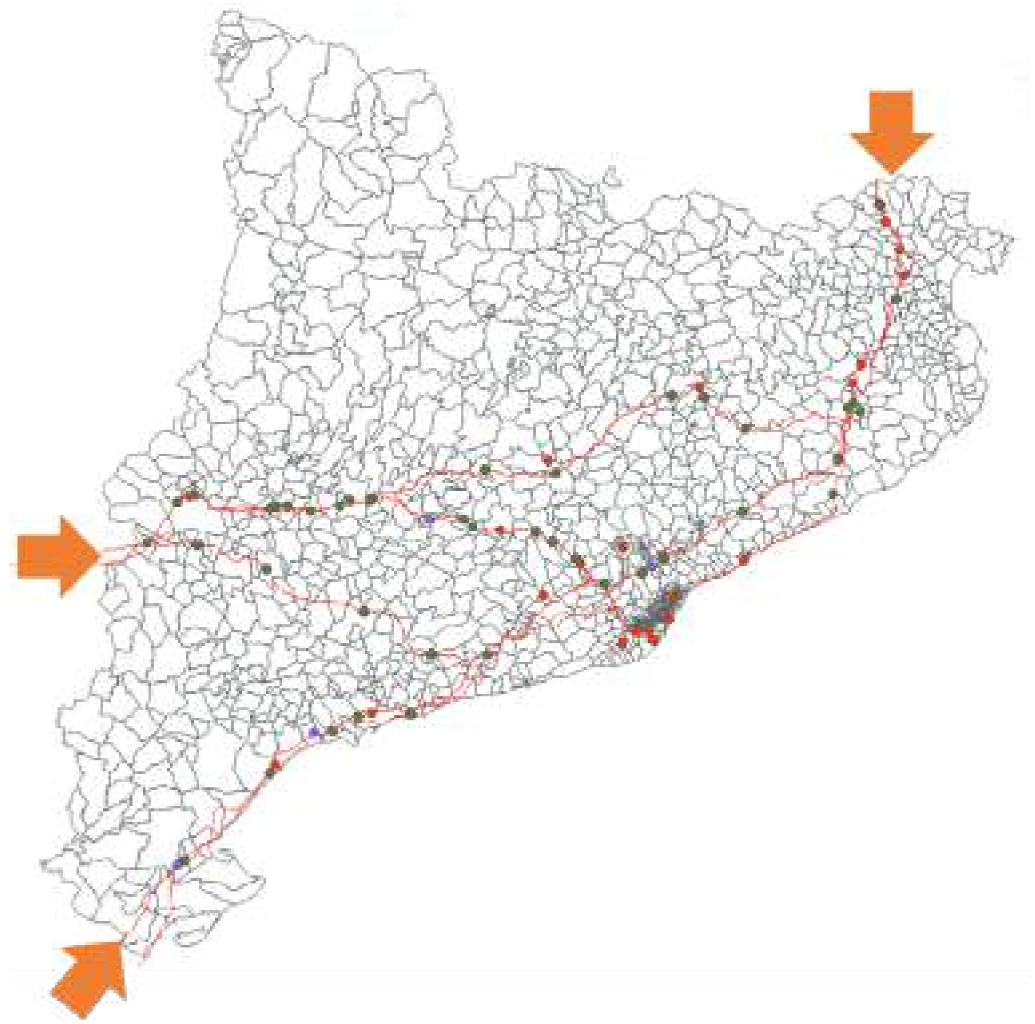


Figure 1: Main origins of interest, main road axes of interest (red graph) and transport areas. In green petrol stations, in red gas stations and in purple electric recharging points.

From the distance matrices, the optimization problem is carried out, which results in the distance at which a new recharging point should be installed. Once identified, the new theoretical points are projected onto the road network together with the gas station layer. In this way, the result is adjusted to the existing reusable infrastructure. Finally, the constraints of autonomy and distance between points are validated and the location is returned.

The objective of the optimization problem is to minimize the number of recharging points (objective function) in order to be able to provide services to goods vehicles on the main arterial roads in Catalonia.

In the following, the problem is explained mathematically.

Objective function:

$$min \sum_{v \in V} \sum_{(i,j) \in A} X_{ij}^{v}$$

Constraints:

(1) $X_{ij}^{v} \leq 1, \;\; k \in K, (i,j) \in A$

(2) $X_{ij}^{v}\left(M_{j(j+1)}^{v} - M_{ij}^{v}\right) < A, (i,j) \in A, v \in V$

(3) $X_{ij}^{v}\left(M_{i(j+1)}^{v} - M_{ij}^{v}\right) < A, (i,j) \in A, v \in V$

The meaning of each of the restrictions is as follows:

(1) At most one charging infrastructure must be installed in arc (i,j).

(2) Installation of a charging infrastructure when the distance between the current and the next charging point is greater than the vehicle's range.

(3) A driver can choose whether to charge at the current point or to go to the next point. In other words, from any infrastructure you can choose whether to stay at the current one or go to the next one.

Once the minimum critical infrastructure had been analyzed during Phase I implementation, a second phase (Phase II) involved a process of densification in order to guarantee the accessibility of goods vehicles with alternative energies throughout the territory. At this point, the maximum distances marked between electric stations (60 km) by the current regulations were considered. In order to achieve this, we began by analyzing the electric recharging infrastructure, hydrogen stations and gas stations.

A final element necessary to define the deployment of the infrastructure is to establish how many charging points are necessary for each charging infrastructure. Therefore, the calculation methodology will be based on the application of queuing theory.

The aim of this study has been to analyze the current charging infrastructure and to make a proposal for the deployment of the network in two distinct phases. In summary:

Phase I will involve the installation of 19 charging stations and two new hydrogen stations. While the gas stations are sufficient.

Phase II will require 16 new charging stations and two more hydrogen stations. For gas, however, biogas will have to be incorporated into the existing infrastructure.

	Considerations	Affected areas	Results
Phase I Deployment of critical infrastructure	Minimum infrastructure according to autonomy constraints (immediate deployment)	Corridors (AP-7, A2, C-25)	**Charging stations:** Installation of 19 electric stations **Gas stations:** Sufficiency with existing gas network **Hydrogen stations:** Installation of 2 new points
Phase II Network densification	Minimum infrastructure according to regulatory constraints. Charging station: Horizon 2026 Gas stations: Horizon 3030 Hydrogen station: Horizon 3030	10 areas covering the whole territory (Olot, Costa Brava, C-17, C-16, C-55, Penedès, Alt Camp, Pirineus, C-31, Ebre)	**Charging stations:** Installation of 16 electric stations **Gas stations:** Retrofitting existing infrastructure to accept biogas. **Hydrogen stations:** Installation of 2 new points

Figure 2: Summary of proposed deployment

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 analyze transport elements relating to service, behavior, perception, functionality, sustainability, management, quality, reliability, risk and safety. CENIT is highly dedicated to analyzing 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.

CENIT has developed a lot of research, organising a multitude of courses and scientific seminars related to research on transportation, along with the publication of books, papers in journals SCI (Science Citation Index) and congress papers. Main areas:

_Transport Economics

_Sustainable Mobility and Travel Behavior

_Public urban transport

_Traffic Modelling

_Port Logistics and Maritime Transport

_Logistics and Urban Freight Distribution

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