Research Network on Transportation

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Research Network on Transportation

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ABSTRACTS

(A1)

SiteSelection: an open-source tool to identify complex areas for street space reallocation

R. FÉLIX[a], G. VALENÇA[a], F. MOURA[a] and A. MORAIS SÁ[b]
[a] CERIS, Instituto Superior Técnico - University of Lisbon
rosamfelix@tecnico.ulisboa.pt
[b] *CiTUA, Instituto Superior Técnico - University of Lisbon*

Keywords: Street space reallocation, Complex zones, Open-source tool, GIS, Decision support.

Subject area: Decision support tools for space reallocation

Category: Presentation of research activities (research center, topics or interests of research, etc.), by Professors or Researchers

Abstract:
In urban areas, reallocating street space may be complex due to the lack of space, dispute of uses and need to perform trade-offs. There is a potential to reallocate space dynamically over time according to fluctuations of mobility demand, to have a more efficient and just space distribution. A complex space for street reallocation is defined as facing the mobility vs access dilemma, having high connectivity, having dense and diverse land use and with high levels of traffic or/and public transport. Zones with these characteristics tend to have scarce urban space to fulfill the street's mobility and accessibility functions. These zones require a deeper understanding of urban dynamics to prioritize sustainable transportation policy.
To support the identification of such complex areas in urban environments, where diverse users and demands compete for space, we propose a site selection methodology based on GIS methods to process existing open geo-data. SiteSelection is an R full script that uses a dynamic pipeline and gathers and processes information on road network centrality measures (betweenness, closeness, degree), population density, points of interest and activities, and on-surface public transit frequency. It uses open data to identify complex areas, such as road networks, land use and points of interest (OpenStreetMaps), administrative areas and population (Census), and public transit (General Transit Feed Specification sources). The developed open-source tool [u-shift.github.io/SiteSelection] can reproduce the proposed methodology for any given area or city in Portugal in less than 2 minutes, allowing to visualize the selected areas with a score-ranking, and to export results in different formats for further analysis.
This methodology could be expanded not only to other countries (as long as required data exists), but also for other applications, such as identifying potential 30km/h areas or Low Traffic Neighborhoods.

Date: April 2023 – April 2024

AGENDA BE.NEUTRAL: BUILDING AND MOBILITY INTEGRATION, FROM STRUCTURAL TO DIGITAL

P. Baptista [a] and S. Melo, [b]

[a] *IN+ Center for Innovation, Technology and Policy Research, Department of Mechanical Engineering, Instituto Superior Técnico (University of Lisbon), Email: patricia.baptista@tecnico.ulisboa.pt*
[b] *Mobility Unit, CEiiA, Email: sandra.melo@ceiia.com*

Keywords: carbon-neutral mobility, urban sustainability, electric vehicles, emission quantification

Subject area: sustainable cities

Category: Research Projects (BE.Neutral – Agenda de Mobilidade para a neutralidade carbónica nas cidades, contract number 35, funded by the Resilience and Recovery Plan (PRR) through the European Union under the Next Generation EU)

Abstract:
The Be.Neutral initiative is a collaborative effort involving 44 entities from industry, academia, and the scientific and technological sectors, alongside eight cities in northern Portugal. This consortium is dedicated to developing and implementing innovative mobility products and services aimed at accelerating the reduction of urban carbon emissions.

The project's ambition is to position Portugal as a leading exporter of cyber-physical zero-carbon mobility solutions to cities worldwide. Central to this endeavor is the creation of new mobility products and services—including physical devices, connectivity solutions, and data science platforms—that can quantify avoided emissions in real-time, thereby expediting progress toward carbon neutrality by 2030.

This abstract focuses on a specific key component of the Agenda Be.neutral: the development of Digital Twins for cities and the associated project of BEN. The development of a Digital Twin for advanced simulations of cities and mobility systems enables detailed analysis and comprehensive energy, environmental, and economic assessments of various sustainable urban solutions, namely BEN. The BEN vehicle, a lightweight four-wheeled electric vehicle designed for shared urban mobility services. Manufactured using sustainable technologies and materials to minimize its carbon footprint, the BEN vehicle aims to set a new standard in low environmental impact transportation.

Through these comprehensive efforts, Be.Neutral aspires to create Europe's first carbon-neutral regions, setting a precedent for sustainable urban mobility and contributing significantly to global carbon reduction goals.

Date: April 2023 – December 2025

(A3)

Guilherme Ribeiro [a, b], Virgínia Infante [a], António R. Andrade [a] and Amélia Areais Carr [c]

[a] *IDMEC,*
Instituto Superior Técnico
Universidade de Lisboa
[b] *Email: guilhermefbribeiro99@tecnico.ulisboa.pt*
[c] *Instituto da Mobilidade e dos Transportes, I.P*

Keywords: Transportation System, RAMS, Human-Centric, Safety, Transportation.

Subject area: Traffic management, Maintenance and Railway Safety

Category: PhD thesis (ongoing, started in Sep. 2024)

Abstract:

RAMS (Reliability, Availability, Maintainability, and Safety) is one of the most important Key Performance Indicators in Transportation. Meanwhile, nowadays society requires increased attention to the human-centric dimension of Industry 5.0. This proposed PhD project, which was awarded an individual FCT PhD scholarship, aims to integrate these two major concepts — RAMS and Industry 5.0 — through their application in three transportation Case Studies. These case studies will focus on different issues in Portuguese transportation, each evaluated in terms of specific RAMS components.

Reliability and Availability will be investigated in multimodal transportation hubs. The impact of schedule synchronization and rescheduling on hub users will be assessed in the Ermesinde and Cais do Sodré Hubs. Maintainability will be examined in the Bike Sharing System, with the proposal of a new vehicle maintenance strategy based on Remaining Useful Life, giving increased relevance to user needs and reports. Finally, Safety will be addressed in the railway system, focusing on both workers and general citizens. An optimized method of smart fleet assignment for train-drivers will be developed. This method will be based on studies related to SPADs in the Portuguese railway system and will seek the mitigation of the risks related to this incident. Regarding regular train users, the issue of railway suicides will also be analyzed. This study, conducted in collaboration with the Portuguese National Safety Agency (IMT), will approach the topic through both historical/statistical analysis and the development of human-centric mitigation measures.

Ultimately, by evaluating these independent case studies through a common Human-Centric strategy, this research will develop tools to enhance all four dimensions of RAMS in the future of transportation systems.

Date: September 2024 – September 2028

(A4)

AN EXPLORATORY RESEARCH APPROACH TO ASSESS MOBILITY PERFORMANCE AND ITS IMPACTS IN SMALL-MEDIUM PORTS

M.C. COELHO [a,b]

[a] Department of Environment and Planning & Centre for Mechanical Technology and Automation (TEMA), University of Aveiro, Portugal
[b] LASI – Associate Laboratory of Intelligent Systems, Guimarães, Portugal
Email: margarida.coelho@ua.pt

Keywords: ports, entropy, noise, pollutant emissions

Subject area: sustainable cities

Category: Research Project funded by FCT

Abstract:
Ports serve as crucial connectors between maritime and land-based transport modes, ensuring the efficient distribution of goods and reducing road congestion. However, Port activities also contribute to noise and pollutant emissions, making it essential to address the impacts associated with these ports to achieve decarbonization targets outlined in the European Green Deal and other EU transport policy objectives.

The main objective of this FCT exploratory project is to develop a methodological platform of a multidimensional indicator of entropy and cumulative impacts assessment of mobility in Ports. This will include all modes (ships, trains, road and nonroad vehicles) as well as the prospection of the incorporation of automated, electric and new mobility services in the Ports ecosystem. Therefore, the overall concept is consolidated upon addressing the gaps around a transfer entropy approach to link mobility behavior in Ports and specific contribution of pollutants and noise emissions, contributing to the establishment of a multidimensional indicator, which could be used for establishing rigorous regulations for Green Ports in their full extent.

The Port of Aveiro Administration is an associate partner of this project. This research is aligned with the initiative "zero-emission ports" of the Smart and Sustainable Mobility Strategy and goes in line with Horizon Europe Missions "Restore our Ocean and Waters by 2030" and "Climate-Neutral and Smart Cities by 2030".

Date: 1st of January 2025 – 30th of June 2026

DEVELOPMENT OF A METHODOLOGY FOR MODELLING FUEL CONSUMPTION AND VEHICLE EMISSIONS USING ARTIFICIAL NEURAL NETWORKS BASED ON EXPERIMENTAL DATA

MATHEUS H. R. MIRANDA [a], LUDMILA C. A. SILVA [a], TIAGO L. FARIAS [b], GONÇALO DUARTE [c,d] and MIGUEL CAMPINO [d]

[a] Integrated Systems Laboratory, School of Mechanical Engineering
University of Campinas - UNICAMP, São Paulo, Brazil
Email: m265303@dac.unicamp.br, ludmila@fem.unicamp.br
[b] IDMEC, Instituto Superior Técnico,
Universidade de Lisboa, Lisbon, Portugal
Email: tiago.farias@tecnico.ulisboa.pt
[c] Departamento de Engenharia Mecânica - Instituto Superior de Engenharia de Lisboa (ISEL),
Lisbon, Portugal
Email: goncalo.duarte@isel.pt
[d] IN+ Center for Innovation, Technology and Policy Research, Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal
Email: miguel.campino@tecnico.ulisboa.pt

Keywords: Vehicle dynamics, Power management systems, Artificial neural network, Vehicle emissions, Experimental data.

Subject area: Vehicle emissions.

Category: Presentation of research activities (research center, topics or interests of research, etc.), by Professors or Researchers.

Abstract: In order to promote the advancement of mobility technologies, it is essential to understand the dynamic behaviour of vehicles, energy consumption and pollutant emissions, as well as the propulsion system management and its components. Thus, the main objective of this research is to apply machine learning techniques, specifically the artificial neural network method, to develop a representative model focusing on exhaust emissions and fuel consumption of plug-in hybrid electric vehicles. The model will use experimental on-road data collected from different plug-in vehicles using a PEMS (Portable Emissions Measurement System). This research will allow to improve the modelling of the internal combustion engine, which is essential for developing the dynamic simulation model of a plug-in hybrid electric vehicle. To achieve this goal, it is necessary to analyse the vehicle's propulsion system behaviour during specific driving cycles. This way, it will be possible to obtain a robust and representative database, which is fundamental for training artificial neural networks, as well as validating the methodologies already developed during the doctoral research. The expected results include developing tractive power management systems for these vehicles, which will provide more accurate and robust estimates of pollutant emissions since these are based on on-road collected data. Therefore, this work aims to contribute to the development of advanced power management strategies for vehicles and present a model capable of realistically representing the tailpipe emissions profile and energy consumption, considering variables such as vehicle operation, climatic conditions, and driving style.

Date: November 2024 – May 2025

(A6)

TRANSFORMING TRUCK PLATOONING THROUGH THE DEVELOPMENT AND INTEGRATION OF EVENT-BASED USE CASES FOR DRIVING SIMULATORS

T. C. Botelho [a], S. P. Duarte [a], M. C. Ferreira [b], S. Ferreira [a], A. Lobo [a]

[a] *CITTA – Centro de Investigação do Território, Transportes e Ambiente, Faculdade de Engenharia, Universidade do Porto, Portugal*
[b] *INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Porto, Portugal*

Keywords: Truck platooning; Driving simulation; Scenarios; Requirements.

Subject area: Transportation Engineering

Category: Master thesis

Abstract: Truck platooning, synchronizing multiple trucks using automated driving and vehicle-to-vehicle communication, is a promising solution for improving road safety, efficiency, and environmental sustainability. Comprehensive testing is required in controlled environments and real-world scenarios to ensure its feasibility. This work started with a need for proper testing of truck platooning and proper scenarios and requirements for its integration into regular traffic.

This work consisted of three phases. It began with (i) a comprehensive literature review of truck platooning tests in simulators and on-road studies, aiming to gather requirements and typical configurations of the technology. The review analyzed 30 articles categorized into human-centered, technology-centered, and energy-efficiency studies. Key variables identified include the number of trucks (2–10), platoon speeds (30–105 km/h), inter-truck distances (3–44 meters), and fuel savings (2–18%). The findings enable the design of use cases and scenarios.

In the second phase, (ii) two use cases were developed for implementation on a truck simulator. The *Emergency Takeover* use case focused on safe inter-truck distances and driver responses during emergency takeovers, while *Critical Situation Response After Takeover* studied driver passive fatigue from prolonged automated platooning. A third use case, *Highway Ingress*, was designed for implementation on a light vehicle simulator to examine surrounding drivers' reactions to platoons during highway merging. The scenarios include variations where all other aspects remain constant, but the inter-platoon gap distance varies between 8, 15, and 22 meters.

The final phase, (iii), involved creating and implementing scenarios in simulators at the University of Porto's Faculty of Engineering. A dedicated tool featuring route-based and GPS-coordinate scenario generation was developed to facilitate scenario creation. Preliminary tests validated the realism and usability of these scenarios.

The principal project is ongoing, with regular drivers conducting simulations in the light vehicle simulator use case. Final refinements are also being completed on the truck simulator in preparation for trials with professional truck drivers.

THE RELEVANCE OF PUBLIC FACILITY PLANNING TOWARDS THE 15-MINUTE CITY: AN EXPLORATORY ACCESSIBILITY ANALYSIS IN MARINHA GRANDE

M. CRUZ [a] and J. F. BIGOTTE [b]
[a] University of Coimbra
CITTA - Research Centre for Territory, Transports and Environment
Department of Civil Engineering
Email: monica.cruz@phd-student.pt
[b] University of Coimbra
CITTA - Research Centre for Territory, Transports and Environment
Department of Civil Engineering
Email: jbigotte@dec.uc.pt

Abstract:
In recent years, several cities worldwide have been adopting the principles of the 15-minute city concept. This approach focuses on ensuring the proximity of the population to essential services and activities such as shopping, education, health, and entertainment, through the location of facilities within walking or cycling distance of neighborhoods. By prioritizing people, the 15-minute city seeks to restore the sense of community, improve the physical and mental health of the population, and reduce social inequalities and car dependency. As a result, it is expected to diminish urban congestion and CO_2 emissions, delivering environmental benefits and contributing to a better quality of life.

Based on the premise of accessibility by proximity, this study initially evaluates the population's access to schools, healthcare centers, and pharmacies. The analysis focuses on public facilities for two main reasons. First, they provide essential services, making proper access to schools and healthcare centers a prerequisite for a 15-minute city. Second, while the government bodies can take direct action related to the provision of educational and healthcare services through investments in new facilities, their influence on the location of private establishments such as stores and offices is rather limited, relying mainly on land-use regulations. Although pharmacies are mostly private, their creation and relocation are strictly regulated, justifying their inclusion in the analysis. Pedestrian accessibility to primary and secondary schools, healthcare centers, and pharmacies in the urban area of Marinha Grande was assessed using Geographic Information Systems to calculate contour measures for three service levels:]0-5],]5-10], and]10-15] minutes. Subsequently, the population with walking access to each type of facility, across the different service levels, was estimated by intersecting the coverage areas with census tracts population data from 2021.

The results are analyzed alongside a critical discussion of the 15-minute city concept. Overall, schools exhibit a more balanced spatial distribution compared to healthcare facilities. Considering the characteristics of each age group, secondary schools provide better coverage than primary schools. As anticipated, pharmacies are significantly more accessible than healthcare centers. These findings highlight the need for improved public facility planning to realize the vision of the 15-minute city. Future research should explore additional case studies to validate and expand upon these preliminary insights.

(A8)

ACCESSIBILITY ACORDING TO THE UNIVERSAL DESIGN APPROACH. THE CASE OF INTERNATIONAL PEDESTRIAN CROSSINGS

M. ROSA [a] and M. LOKMER[b]
[a] Institute of Engineering,
University of Algarve
Email: mmrosa@ualg.pt
[b] Faculty of Civil Engineering,
University of Zagreb
Email: maja.lokmer@windowslive.com

Keywords: universal design, inclusive design, age friendly design, pedestrian crossings, layout

Subject area: age friendly and inclusive cities

Category: Presentation of research activities (research center, topics or interests of research, etc.), by Professors or Researchers

Abstract:

In last decades, the rapid ageing of the population has awakened greater interest in this population segment, from the public policies perspective, highlighting the importance of Age-friendly Cities. So, added attention must be given to pedestrian infrastructure in order to be age friendly and inclusive. The goal of this work is to present international layouts of pedestrian crossings for age friendly and inclusive society, designed according to the approaches of "Universal Design" and "Inclusive Design".

Universal design is linked with designing one-space-suits-almost-all, and inclusive design focuses on one-space-suits-one, e. g. design a space for everyone (collective perspective) versus design a space for one specific group (particular perspective). As the built environment must be understandable to and usable by all people, both are important for social sustainability. Universal design contributes to social inclusion, but added inclusive design is needed, matching the excluded users to the object or space design.

Previous research shows that tactile paving designed for blind people can be uncomfortable for some elderly people and also for wheelchair users and ambulant disabled people that may be at greater risk of tripping. From the perspective of elderly tourists, particularly older individuals (+ 80), there is a lack of interest in tactile surfaces. So, the needs of elderly people and blind individuals are divergent.

Considering pedestrian crossings, there is a tendency to considerer tactile surfaces in all the extension of dropped kerbs, to guaranty information to blind people. However, this layout is not considered age friendly or healthy for wheelchair users. In Sweden and Germany, dual crossings have been implemented where there is a flush crossing section with smooth surfaces adjacent to a section with tactile surfaces that give the correct orientation of the pedestrian crossing and a warning surface, on the edge of the sidewalk, to alert for the presence of the carriageway. Big changes in Portuguese street design are required.

Date: November 2021 – November 2023

(A9)

uRISK: UNDERSTANDING RISKY BEHAVIOURS AT THE WHEEL USING A DRIVING SIMULATOR

S. P. Duarte [a], S. Ferreira [a], C. Rodrigues [a], J.P. Tavares [a], A. Lobo [a]

[a] CITTA – Centro de Investigação do Território de Transportes e Ambiente, Faculdade de Engenharia da Universidade do Porto
Email: spduarte@fe.up.pt

Keywords: unsafe driving index, human factors, driver monitoring, driving simulator
Subject area: Road safety
Category: Research Projects (funded by FCT or other institutions)

Project abstract:

While safety is a paramount objective for the whole transport system, road safety deserves particular attention, given the disproportionate occurrence of accidents and casualties. The European Commission sets ambitious targets: eliminating road crashes caused by human error by 2050 and ensuring that the EU remains a world leader in transport safety. The "Vision Zero" strategy is heavily reliant on vehicle automation, which is expected to take the human driver "out of the loop" at its most advanced stage of development. However, as full automation is not immediately achievable, the EU Road Safety Policy Framework 2021-2030 established a range of key performance indicators (KPIs) for road safety on the way to "Vision Zero". Being the human error involved in some way in 95% of road crashes, either as the main cause or as a contributing factor, KPIs to assess progress on safe driving behaviours, such as speed and driving impairment, are naturally defined. After years of strong investments in infrastructures, law enforcement and driver training/education, in which the EU observed a steady decrease of road deaths and serious injuries, the efforts to further reduce those figures are now shifting to emerging monitoring and warning technologies. This allows to act proactively in the prevention of crashes by providing real-time feedback to the driver about his/her driving performance and physiological state, or about changing road conditions. In fact, during the transition to full automation, driver assistance and driver/road monitoring systems will continue to be developed to become more reliable and compliant with drivers' expectations.

uRisk will contribute to this endeavour by conducting an exploratory study on human errors and risky behaviours at the wheel. The project aims to deliver a generalised index to characterise unsafe driving that will combine multiple dynamic driving and driver's physiological parameters. Variations in these parameters are associated with the level of risk at the wheel, and consequently, with the occurrence of traffic incidents. The index will incorporate and hierarchize these measures in a standardised manner. Any traffic incident or accident is preceded by variations in dynamic driving parameters (e.g., trajectory, speed, acceleration, and following distance), which are not adequate to the local conditions of the road, traffic, or surrounding environment. These are accompanied by reactions in the driver's physiological signals (e.g., heart rate, heart rate variability, brain activity, and eye movement). Sudden variations in dynamic driving and biometric parameters are many times the physical consequence of human errors, which may be produced by instant or permanent risky situations. The instant risk factors include the driver's response to the road geometric and environmental features, traffic conditions, distractions, and unexpected events. The permanent risk factors are mainly related to the driver's characteristics or state (e.g., gender, age, physical conditions, and psychological conditions), and also to travel motivation. The new index can be embedded into new in-vehicle driver monitoring/warning systems, improving human-systems integration and reducing the probability of "false alerts" that affect users' trust and compliance with the systems'
recommendations.

uRisk will explore the sequential and combined cause-effect relations between risk factors, physiological signals and variations of driving parameters in traffic incidents by conducting driving experiments in a simulated environment. The research team will test a set of risk factors as comprehensive as possible with simultaneous monitoring of dynamic driving parameters and physiological signals in a driving simulator. Nonintrusive equipment, such as eye-tracking and heart-rate monitoring devices, will be used to assess the variations in the driver's physiological signals. The data obtained through the experiments will be analysed and processed through advanced statistical and machine learning techniques to predict the evolution of drivers' behaviour and/or state based on the generalised unsafe driving index.

In the end, uRisk will contribute to the state of the art by integrating information about the driver with behaviour factors and increased awareness on risky behaviours and recommendations on new solutions to improve road safety by reducing the risk and impact of human errors, aiming to support the authorities in policy-making and the industry in developing enhanced ICT solutions, automation, and Advanced Driver Assistance Systems (ADAS).

(A10)

EXPLORING MY RESEARCH IN TRANSPORTATION SYSTEMS BEYOND RAILWAYS

A. R. ANDRADE [a]
[a] IDMEC, Department of Mechanical Engineering,
University of Lisbon, Lisbon, Portugal.
Email: antonio.ramos.andrade@tecnico.ulisboa.pt
[b] Department of Computer Science,
University of XXX
Email:
[c] Center of Transportation Studies
Email:

Keywords: network design, aviation, bus, bike sharing systems, maintenance.

Subject area: maintenance and operations in transportation systems

Category: Presentation of research activities (research center, topics or interests of research, etc.), by Professors or Researchers

Abstract:

Although my research path has mainly focused in railway systems, I have been trying to expand my research contribution beyond railways. In this presentation, I will explore the main contributions in: i) transport network design in air transport and public buses, ii) bike sharing systems and iii) reliability, availability, maintenance and safety techniques applied to transportation systems. Some case studies will be discussed from work that I have been supervised throughout the years, exploring future steps and opportunities for future research.

THE EVOLUTION OF CITY-SCALE EMISSIONS INVENTORIES:
SMART SOLUTIONS TO ASSESS THE IMPACT OF ROAD TRAFFIC ON AIR EMISSIONS

J. GINJA [a], S. DE VITO [b] and M.C. COELHO [c,d]

[a] *IDAD - Institute of Environment and Development, Aveiro, Portugal*
Email: joao.ginja@ua.pt
[b] *ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy*
Email: saverio.devito@enea.it
[c] *Department of Environment and Planning & Centre for Mechanical Technology and Automation (TEMA), University of Aveiro, Portugal*
[d] *LASI – Associate Laboratory of Intelligent Systems, Guimarães, Portugal*
Email: margarida.coelho@ua.pt

Keywords: greenhouse gases, inventory, city, road transport, atmospheric emissions, machine learning.

Subject area: sustainable cities

Category: PhD thesis (ongoing)

Abstract:
Despite the climate and energy policies, GHG emissions from transport have increased by more than 33% between 1990 and 2019. This trend is expected to reverse, but not sufficiently to meet the EU's climate neutrality targets. Vehicle emissions are still a significant source of air pollution, impacting air quality and human health. Measuring and communicating emissions is a fundamental action for mitigating climate change, improving air quality, and formulating policies. In this context, cities play an important role in reducing GHG emissions.

The present work reviews the evolution of city-scale methods for GHG and air pollutants inventories, for road transport emissions. Additionally, discusses the most relevant applications of artificial intelligence methodologies allowing the prediction of emissions trends and the assessment of mitigation measures. The evaluation carried out allowed the identification of different existing limitations in developing city-wide GHG inventories, particularly due to the complexity of implementing existing protocols, or the existence of gaps, and lack of precise information.

The emergence of artificial intelligence (AI) and Machine Learning (ML) tools has made it possible to more effectively explore different information and the relationships between different data, for instance for microscopic approach to modelling emissions with a regional traffic model (Tu et al., 2019), or assessment of mitigation strategies (Franco et al., 2022, 2023).

This work proposes the development of a method, including Machine Learning, to assess emissions from road transport. The model to be developed considers the use of indirect data, and results from inventories already reported, to estimate emissions, minimizing the uncertainties of the estimates, with application in cities, both in a developing country and in the European Union.

Date: October 2023 – October 2026

HOW DO PEDESTRIANS PERCEIVE THE CHANGES IN THE URBAN ENVIRONMENT AT DIFFERENT TIMES OF THE DAY?

B. BOIANI [a], G. VALENÇA [b], M. HUMBERTO [a] and F. MOURA [b]
[a] Department of Transport Engineering,
Escola Politécnica (University of São Paulo)
Email: brenobcosta@usp.br (B. Boiani), mateushumberto@usp.br (M. Humberto)
[b] Civil Engineering Research and Innovation for Sustainability (CERIS)
Department of Civil Engineering, Architecture and Environment,
Instituto Superior Técnico (University of Lisbon)
Email: gabrielvalenca@tecnico.usliboa.pt (G. Valença), fmoura@tecnico.ulisboa.pt (F. Moura)

Keywords: walkability, urban space, perceptions, pedestrians, dynamic allocation

Subject area: Sustainable cities

Category: Research Projects (funded by FCT or other institutions)

Abstract:
This study aims to identify barriers in the urban environment faced by pedestrians at different times of the day. It also explores whether variations in travel patterns throughout the day influence pedestrians' perceptions and motivation to walk or use urban spaces. Using a seven-dimension framework for evaluating walkability (7Cs), a survey was conducted in Lisbon, Portugal, in June 2024. Respondents were asked to identify attributes they considered barriers to walking. To capture differences in perceptions, the survey was administered between 8 a.m. and 8 p.m., enabling comparisons across different time periods. The Rasch model was used to analyse the sample ($n = 1031$), which ranks the difficulty of identified barriers and estimates the probability of pedestrians overcoming them based on a single latent trait. Overall, the most challenging barriers to overcome included litter on the ground, parked vehicles (both legally and illegally parked), traffic volume, air and noise pollution, and poor sidewalk conditions.
When the data was segmented into three time periods, namely peak hours, off-peak hours, and lunch time) variations in perceptions emerged. For instance, sidewalk conditions and crowding were perceived as more challenging during peak hours, while air and noise pollution, as well as illegally parked vehicles, were reported as greater obstacles during off-peak and lunchtime periods. Similarly, compared to peak hours, the percentage of respondents that have at least 50% of chance of overcoming the hardest barriers almost doubles at off-peak hours and doubles at lunch time. These findings suggest that public policies can be tailored to address specific barriers during critical times of the day, enhancing walkability and pedestrian satisfaction.

Date: January 2024 – September 2024

EVALUATION OF ENVIRONMENTAL AND HEALTH IMPACTS OF DYNAMIC ROAD SPACE ALLOCATION

C. MATAJS [a], P. BAPTISTA[b] , G. VALENÇA[c], R. FELIX[d], F. MOURA[e]
*[a] Department of Hydraulic and Environmental Engineering, University of São Paulo,
Department of Civil Engineering, Architecture and Environment,
Instituto Superior Técnico (University of Lisbon), Email: crmatajs@gmail.com*
*[b] IN+ Center for Innovation, Technology and Policy Research, Department of Mechanical Engineering,
Instituto Superior Técnico (University of Lisbon), Email: patricia.baptista@tecnico.ulisboa.pt*
*[c] Civil Engineering Research and Innovation for Sustainability (CERIS), Department of Civil Engineering,
Architecture and Environment, Instituto Superior Técnico (University of Lisbon), Email:
gabrielvalenca@tecnico.ulisboa.pt*
*[d] Civil Engineering Research and Innovation for Sustainability (CERIS), Department of Civil Engineering,
Architecture and Environment, Instituto Superior Técnico (University of Lisbon), Email:
rosamfelix@tecnico.ulisboa.pt*
[e] Civil Engineering Research and Innovation for Sustainability (CERIS), Email: fmoura@tecnico.ulisboa.pt

Keywords: urban space; dynamic allocation; walking; cycling; environmental impact assessment
Subject area: sustainable cities, urban planning
Category: Research Projects (funded by FCT)

Abstract:
Road spaces in urban areas are often highly contested, as they must accommodate a wide range of activities and functions. Addressing the challenges posed by the competition and complexity of these environments calls for innovative solutions, such as dynamic road space allocation. Traditional static allocation strategies often struggle to meet the changing demands of urban environments. Dynamic allocation, which adjusts over time based on traffic and pedestrian activity, offers a promising solution to optimize limited urban space.

Beyond influencing transportation systems, urban planning also plays a critical role in shaping environmental outcomes. The transportation sector, for instance, stands as a significant contributor to environmental pollution, exerting substantial pressure on both local and global ecosystems. Throughout Europe and Portugal, the transportation sector predominantly relies on petroleum fuels, a practice that significantly contributes to the emission of carbon dioxide, a key greenhouse gas. New urban solutions are being proposed, but without an analysis of their environmental impacts in terms of pollutants.

This study develops a replicable methodology for impact assessment to support cities in evaluating static and dynamic road space allocation solutions, in environmental and health terms. The environmental impacts are estimated by calculating the emission of pollutants (CO_2, CO, HC, NO_x, $PM2.5$, $PM10$, $PM\,TSP$ and VOC) and energy consumption in a week. The health impacts, in turn, are calculated as avoided premature deaths per year, based on the impacts of physical activity and exposure of air pollution in active modes of transport (walking, regular cycling and e-biking).

The methodology was applied to a case study in Lisbon, Portugal, known for its significant conflicts of use and urban mobility challenges. For that purpose, traffic and pedestrian count data were processed to quantify the environmental impacts associated with the current situation. Subsequently, different scenarios applying different static and dynamic solutions are analyzed and compared. The methodology builds upon two reference methodologies: 1) Health Economic Assessment Tool (HEAT) for quantifying the health and economic benefits associated with increased levels of physical activity; and 2) COPERT for quantifying vehicle emissions factors in different driving conditions.

Among the scenarios analyzed, the implementation of a bike lane has the most positive environmental effects in terms of reducing pollutant emissions, followed by the introduction of a bus lane and, finally, closing the street to vehicles on weekends. Dynamic solutions demonstrated the potential to achieve

environmental benefits comparable to those of static approaches. This is particularly advantageous in complex urban spaces, as dynamic solutions optimize underutilized areas through more flexible and adaptive planning strategies

Overall, this study contributes to the growing body of research on sustainable urban development and underscores the importance of considering environmental impacts in the design and implementation of urban planning strategies.

Date: February 2024 – November 2024

(A11)

MULTI-OBJECTIVE OPTIMISATION OF ROAD NETWORKS

P. SOUTINHO [a]
[a] Doctoral Program in Spatial Planning (PDPT FEUP)
Email: up202204101@up.pt

Keywords: planning, transport, networks, modularity

Subject area: Territorial Planning
Category: PhD thesis (ongoing)
Date: September 2023 – September 2025

Abstract:
Why are so many biological networks organized in modular structures? While modularity is often associated with evolvability—the capacity to adapt quickly to new environments—recent research suggests it may also be a by-product of selection processes aimed at reducing connection costs, serving as a survival mechanism. This study identifies similar patterns in ancient road networks, which exhibit modular structures across various geographies. These resilient, durable human-made networks appear to have developed organically, with modularity playing a pivotal role in their longevity.
Analysis reveals a consistent pattern in the spacing of waystations, specifically at intervals of 8, 10, and 12 miles, most likely related to the average walking distance before having to take a rest (about 3 hours walking). Case studies from Spain, Portugal, Egypt, and the UK demonstrate the widespread and intentional use of modularity in these networks, highlighting its effectiveness as a design principle rather than a regional anomaly. Moreover, these routes were build under very specific criteria, always trying to maintain a straight path where feasible but adapting smoothly to terrain challenges, following the ridges of the landscape to minimize slope changes, river crossings and erosion risks, while preserving the overall network modularity.
Building on these insights, this research proposes an Organic Road Model (ORM) for designing efficient and resilient road networks. The ORM employs three building blocks, of 6, 8, and 10 miles, and evolutionary algorithms to optimize networks using a multi-objective approach that includes: (1) shortest path, (2) minimal slope variation, and (3) modular structure. The ORM integrates these criteria in a human-centered modular framework, enhancing sustainability and scalability of modern transport networks, particularly those supporting soft mobility.

(A12)

SAFETY AND EMISSIONS ALGORITHMS FOR THE INTERACTION BETWEEN MOTOR VEHICLES AND VULNERABLE ROAD

E. FERREIRA [a, b], E. MACEDO [a, b] and M.C. COELHO [b, c]

[a] Department of Mechanical Engineering/ Centre for Mechanical Technology and Automation (TEMA), University of Aveiro
Email: {elisabetedsf, macedo}@ua.pt
[b] LASI - Intelligent Systems Associate Laboratory, Guimarães, Portugal
[c] Department of Environment and Planning/ Centre for Mechanical Technology and Automation (TEMA), University of Aveiro
Email: margarida.coelho@ua.pt

Keywords: Integrated Driving Indicator; Safety; Volatility; Operational Performance; Emissions.

Subject area: Sustainable cities

Category: PhD thesis (ongoing)

Abstract: Road transport, particularly passenger vehicles, significantly contributes to urban environmental and safety challenges through CO_2 and NOx emissions and traffic-related casualties, especially in Portuguese urban areas. While existing research typically addresses safety or emissions separately, integrated approaches examining safety-emissions hotspots remain scarce, particularly regarding Vulnerable Road Users (VRU). This doctoral thesis develops a comprehensive framework by analysing microscopic driving behaviour on intercity corridors in the Aveiro region, incorporating real-world emissions data and volatility metrics. The work investigates how vehicular jerk acceleration thresholds can classify driving styles and relate CO_2 and NOx emissions in light vehicles, comparing these relationships across urban, rural, and highway routes under naturalistic driving conditions against established metrics like relative positive acceleration, mean positive acceleration, and power demand. This research introduces novel integrated driving indicators encompassing safety, volatility, operating mode, or emissions variables. The Integrated Driving Indicator (iDI) validation emphasizes operational performance components through statistical methods for driving behaviour classification. Moreover, the Markov Decision Process was implemented to support driver performance evaluation decision support system. The approach was validated using simulated traffic data from two highway sites, correlating iDI-identified failures with potential traffic conflicts detected by the Surrogate Safety Assessment Model (SSAM). We also intend to test the emissions-based iDI formulation at the urban level in the next step, including vehicle-VRU interactions.

Date: April 2021 – August 2025

(A13)

PERCEPTIONS IN SOCIAL MEDIA REGARDING THE 15 MINUTE CITY

G. Valença [a] and H. Hook [b]

[a] *Civil Engineering Research and Innovation for Sustainability (CERIS)*
Department of Civil Engineering, Architecture and Environment,
Instituto Superior Técnico (University of Lisbon), Portugal
Email: gabrielvalenca@tecnico.ulisboa.pt

[b] *Social and Economic Geography Group,*
Department of Geography,
Ghent University, Belgium
Email: hannah.hook@ugent.be

Keywords: Accessibility equity; 15-minute city; text mining; conspiracy theory; mobility narrative

Subject area: Mobility Narratives

Category: Research activities (Paper currently under review in TR-Part D)

Abstract:
Despite the largely positive reaction to the 15-minute city concept as a model for sustainable, healthy, and inclusive urban living, substantial resistance has emerged within various communities citing concerns regarding, for instance, loss of personal freedom or economic consequences, to the point of the development of conspiracy theories. Using a textual social media dataset obtained from Reddit, this research analyses the public discussion on 16 and 17 February 2024 surrounding the question, "Why do some Americans fear the 15-minute city?", with a mixed-methods approach. Text mining, topic modeling, and bigram networking categorize 2,346 eligible responses to the question into five main topics: Choice and opportunity (38.29%), urban transition (21.41%), apprehension and misinformation (16.65%), explanation (13.43%), and freedom of movement (10.22%). Qualitative thematic analysis validates these topics and identifies nuanced public perceptions about the 15-minute city, including lifestyle preferences, socioeconomic factors, car-centric urban planning, practical challenges, government control conspiracies, cultural resistance, conceptualization, feasibility, polarization, and social concerns. Results indicate that the 15-minute city concept, though popular, has sparked controversy and conspiracy theories, particularly due to its branding, the political alignment of supporting parties, and misunderstandings about its aims. This research highlights the importance of presenting mobility policies in tangible, relatable terms – focusing on practical benefits for daily life rather than broad sustainability goals – to bridge polarized views and address public concerns effectively.

Date: January 2024 – November 2024

(A14)

A PRELIMINARY STUDY ON THE APPLICABILITY OF THE 15-MINUTE CITY CONCEPT TO AFRICAN CONTEXT

J. L. TXIFUNGA [a], J. F. BIGOTTE [b]

[a]

University of Coimbra
CITTA – Research Centre for Territory, Transports and Environment
Department of Civil Engineering,
Email: lourenco.txifunga@phd-student.uc.pt
[b] University of Coimbra
CITTA – Research Centre for Territory, Transports and Environment
Department of Civil Engineering
Email: jbigotte@dec.uc.pt

Abstract:

Due to growing urbanization, it is expected that, in Africa, about 60% of the population will live in cities by 2050. Therefore, African cities need to adopt sustainable urban planning policies, such as the "15-minute city". This emergent concept promises to mitigate the impacts of growing motorization and climate change by promoting accessibility to essential goods and services through short trips on foot or by bicycle.

The "15-minute city" emphasizes proximity to public facilities and amenities, such as schools, healthcare centers, and local markets. Although it originated and has been widely applied in countries of the global north, its suitability for other contexts, such as Africa, has yet to be demonstrated.

This research work explores the assessment of accessibility to public facilities, namely schools, healthcare centers, and local markets, in Moçâmedes (Angola). Facilities were mapped through both open data sources and questionnaires to local stakeholders. The accessibility analysis is based on a series of isochrones from the facility location.

(A18)

INCORPORATION OF PLASTIC WASTE INTO ROAD PAVEMENTS: PERFORMANCE EVALUATION OF SMA-11 MIXTURE CONTAINING FLAKES OF WASTE LOW-DENSITY POLYETHYLENE (LDPE) FROM A RECYCLING FACILITY

Josué Cardoso [a], Arminda Almeida [a], João Santos [b], Adelino Ferreira [a]

[a] *Research Center for Territory, Transports and Environment (CITTA), Department of Civil Engineering, University of Coimbra, Coimbra, Portugal*
[b] *Department of Construction Management and Engineering (CME), Faculty of Engineering Technology, University of Twente, Enschede, The Netherlands*

Keywords: Road pavements, asphalt mixtures, plastic waste, rutting performance, fatigue performance

Subject area: Sustainable cities and Infrastructure

Category: Submitted Papers along 2024

Abstract: Plastic has revolutionized the world because of its numerous applications; however, plastic pollution became a difficult challenge to deal with. The European Union Plastics Strategy stimulates sustainable practices to improve circularity for plastics. Following this direction, the scientific community have been investigating the incorporation of plastic waste into asphalt mixtures over the last years. The aim of this article is to produce a stone mastic asphalt (SMA) mixture incorporating flakes of waste LDPE and using conventional bitumen, instead of using a polymer modified bitumen (PMB) that is common for this type of mixture. The results of Marshall tests and volumetric properties were analysed to define the most suitable mixtures to be further studied. Performances of a reference mixture and a plastic modified mixture were evaluated in terms of water sensitivity (indirect tensile strength ratio), workability, rutting (wheel-tracking Test), stiffness and fatigue (four-point bending test). Both reference and plastic modified mixtures presented good performances in all aspects. In comparison with reference mixture, the mixture with LDPE presented excellent performance against rutting with almost no deformation accumulated, and a slightly reduced behaviour against fatigue. Additionally, a mechanistic-empirical analysis was proceeded and found that using plastic modified mixture can enhance the structural behaviour of a pavement. Finally, it is possible to produce a stone mastic asphalt (SMA) using conventional bitumen and incorporating waste LDPE, which can contribute to a circular economy for plastics and help mitigate the problem related to its disposal.

A PRELIMINARY STUDY ON THE EVOLUTION OF THE BRAZILIAN AIR TRANSPORT NETWORK

Alberto Blaite, António Pais Antunes and João Bigotte
University of Coimbra
CITTA – Research Centre for Territory, Transports and Environment
Department of Civil Engineering
Emails:
alberto.blaite@student.uc.pt
antunes@dec.uc.pt
jbigotte@dec.uc.pt

Keywords: aviation, air transport network, network evolution, network dynamics, Brazil

Subject area: air transport

Category: PhD thesis (ongoing)

Abstract:

The evolution of air transport networks (ATNs) has been a growing field of research, especially after the deregulation of the aviation sector that took place from the late 1970s onwards. Understanding how ATNs have evolved at local, regional, and global levels is important not only to understand their dynamics and influencing factors, but also to try to predict future behaviors to design public policies and management tools, and to prevent eventual disruptions.

This work presents a preliminary study on the evolution of the Brazilian air transport network, focusing on the southern states, from 2000 to 2024. During these 25 years, the aviation industry had to deal with the effects of deregulation, a period of domestic economic growth, a global financial crisis, and a global pandemic. Legacy companies closed operations and new low-cost airlines entered the market. Based on a large database from official sources, we explore the changes in the network in terms of connectivity using a set of measures from Complex Network Theory (density, centrality, clustering, etc.).

The results highlight the significant changes that occurred in the network during that 25-year period. In general, it evolved from a denser and more connected network to a hub-and-spoke network. To validate these initial findings, the analysis is being extended to the entire domestic Brazilian ATN. Further research (in the context of the PhD) will focus on the evolution of the international ATN and the individual network of the three major Brazilian airlines operating commercial flights.

Date: June 2024 – present

TOWARDS A MODELING APPROACH TO TRANSIT-ORIENTED DEVELOPMENT (TOD) PLANNING

J. CRUZ [a], J. F. BIGOTTE [a], A. P. ANTUNES [a]
[a] University of Coimbra
CITTA - Research Center for Territory, Transports and Environment
Department of Civil Engineering
Emails:
uc2013168639@uc.pt
jbigotte@dec.uc.pt
antunes@dec.uc.pt

Keywords: Transit-oriented development, integrated land-use transport planning, optimization, facility location, network design.

Subject area: urban planning, transport planning, sustainable cities

Category: PhD thesis (ongoing)

Abstract:
Transit-oriented development (TOD) is a planning concept that aims to reduce car dependence, improve accessibility, and promote sustainable and livable communities. It is based on the integrated development of land-use and transport systems by creating high-density, mixed-use, walkable neighborhoods around main transport hubs.

Although there is already a large body of literature on TOD, quantitative tools for strategic planning are still scarce. This research presents a preliminary modeling approach towards TOD planning. Specifically, it presents an optimization model that simultaneously selects which urban nodes and transport links should be developed to maximize accessibility within a given metropolitan area. The model is illustrated through randomly generated toy networks. The preliminary results confirm the suitability of employing optimization techniques for TOD planning and call for further research towards an effective tool for decision support.

Date: May 2024 – present

(A21)

BUS AND BRT LINEAR NETWORK PLANNING AND FREQUENCY SETTING WITH ELASTIC DEMAND

J. ALBUQUERQUE [a], A. R. ANDRADE [b] and M. GOMES [b]
[a] Department of Mechanical Engineering,
Instituto Superior Técnico - University of Lisbon
Email: joao.albuquerque.23@tecnico.ulisboa.pt
[b] Department of Mechanical Engineering,
Instituto Superior Técnico - University of Lisbon
Email: antonio.ramos.andrade@tecnico.ulisboa.pt
[c] Department of Civil Engineering, Architecture and Environment,
Instituto Superior Técnico - University of Lisbon
Email: marta.gomes@tecnico.ulisboa.pt

Keywords: Mixed-Integer Linear Problem, Transit Network Design Problem, Elastic Demand, Discrete Choice Models

Subject area: Network Design, Public Transit

Category: Master thesis

Abstract: There is a research gap in mixed-integer linear solvers applied to transit network design and frequency setting problems with variable demand. This work presents a new formulation that linearly integrates discrete choice models in an optimization model at the cost of discretizing the routes' frequencies. Each possible itinerary within the network is pre-computed using graph's theory and is compared against each of the best itineraries of the competing modes of transport, which are obtained using Google Maps. Each itinerary in the network is assigned its probability of being chosen based on their utility, using a multinomial logit, taking into consideration the itinerary's access, waiting and travel time, cost and number of transfers. Its coefficients were calibrated using a Stated Preferences Survey. The solver aims to maximize the total network demand by tuning its active routes and frequencies, activating the itineraries with the highest probability of being chosen, constrained by the buses' capacities and number. The demand for each origin-destination pair is estimated assuming all users travel in the highest utility active itinerary, but not all may. This work is applied to a case study in the Barcelona Metropolitan Area, consisting of 8 bus lines and one Bus Rapid Transit. Its formulation is versatile, allowing for different assumptions on passenger assignment and coverage. The best formulation was able to increase the network's ridership in 44% compared to the available real network demand statistics, with an average modal share of 7.91%.

Date: March 2023 – October 2024

(A22)

MARIA BEIRÃO[a], ADELINO FERREIRA[a] and ANABELA RIBEIRO[a]
[a] Department of Civil Engineering,
University of Coimbra
Email: uc2010130764@student.uc.pt

Keywords: Cycling Networks; Bikeability; Artificial Intelligence; Active Urban Mobility

Subject area: Urban Mobility

Category: PhD thesis (ongoing)

Abstract:

The consequences of the massive use of pollutant and space-consuming vehicles and the growing demand for sustainable urban mobility solutions is accelerating the need for innovative methods for the planning and optimisation of cycling networks. This need is particularly felt, particularly in cities that are in the early stages of a more pronounced cycling mobility and, therefore, do need to build and/or develop infrastructure dedicated to active mobility. This study proposes an integrated approach that combines artificial intelligence (AI), urban data analysis, and simulation to improve the efficiency of cycling networks, promoting bicycle adoption and contributing to the mitigation of urban mobility environmental impacts. The research begins with constructing an aggregated bikeability index, which integrates indicators such as infrastructure, safety, and accessibility, to assess the cycling potential of urban areas and identify zones with the greatest need for intervention. Next, the study explores the potential demand for cycling mobility, applying a hybrid methodology that combines revealed preference and stated preference methods to estimate travel patterns and identify preferred routes. This provides a solid foundation for planning networks tailored to users' real needs.

Finally, the research investigates advanced methods of optimisation and simulation for cycling networks, using artificial intelligence (AI) algorithms, particularly machine learning algorithms. These algorithms are applied within dynamic and scalable approaches to identify the most efficient solutions for the configuration of cycling networks, considering not only bikeability data and route preferences, but also contextual factors such as traffic flow and population density. AI allows for the optimisation of resource allocation and maximisation of the impact of cycling infrastructure.

By adopting a multidimensional, data-driven approach, the study aims to optimise existing cycling infrastructure and contribute to the design of smarter, more sustainable cities, promoting active mobility and reducing dependence on motorised transport modes.

Date: November 2024

ANALYSIS OF TRENDS AND FREQUENCY OF ELECTRIC SCOOTER ACCIDENTS IN PORTUGAL

BELZÉNIA A. B. MATSIMBE [a], BRUNO CARDOSO [a,b], SARA FERREIRA [a], LUCIANO MOREIRA [b]

[a] *CITTA, Faculdade de Engenharia da Universidade do Porto*
[b] *CETAPS, CIQUP, Faculdade de Letras da Universidade do Porto*
Emails: up2408583@up.pt; brunocardoso@fe.up.pt; sara@fe.up.pt; lucianomoreira@letras.up.pt

Keywords: road safety; electric scooters; traffic victims

Subject area: road safety

Category: PhD Thesis

Abstract:
The use of electric scooters in Portugal has grown substantially, driven by the demand for alternative mobility solutions in urban areas. However, this increase in the number of users has raised concerns related to road safety, as the number of accidents and victims involving these transportation mode also grew. This study aims to analyze the trends and frequency of accidents and their victims involving electric scooters in Portugal, identifying risk factors and the main causes of these incidents. To achieve this, a quantitative approach based on statistical models such as ordered logit model to analyse victims' severity was employed on traffic accident data provided by the official authority in Portugal (Autoridade Nacional de Segurança Rodoviária). The research covered variables such as the location of accidents, weather conditions, types of urban infrastructure, and the profile of those involved (age and gender).
Preliminary results indicate a higher incidence of accidents in densely trafficked urban areas, with a lack of dedicated infrastructure as a critical factor.
This ongoing work aims to discuss the implications of the study findings for the regulation of electric scooter use and to understand the impacts of electric scooters on safety.

Date: September 2024 – March 2025

(P1)

P2P CAR SHARING: OPPORTUNITIES AND BARRIERS FROM AN OPERATIONAL PERSPECTIVE

ALÍCIA FRANGO [a], AMÍLCAR ARANTES [b] and SANDRA MELO [c]

[a] Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa
Email: alicia.frango@tecnico.ulisboa.pt
[b] CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa,
Portugal Email: amilcar.arantes@tecnico.ulisboa.pt
[c] CEiiA, Center of Engineering and Development, Av. D. Afonso Henriques, Matosinhos, 4450-017,
Portugal
Email: sandra.melo@ceiia.com

Keywords: P2P Car-sharing, ISM, MICMAC, urban transportation

Subject area: Peer-to-peer car-sharing

Category: Master Thesis (OnGoing)

Abstract:

P2P Car-sharing is a transportation model that enables users to rent vehicles for short periods, supporting a shared economy and reducing the need for personal car ownership. In recent years, car-sharing models have evolved significantly, adapting to the diverse needs of users and the dynamics of urban mobility. This paper explores the obstacles peer-to-peer (P2P) car-sharing faces in its potential to address urban transportation challenges, particularly in suburban areas. The proposed methodology combines Interpretative Structural Modelling (ISM) with Matrix Cross Impact Matrix Multiplication (MICMAC) analysis, drawing on insights from car-sharing experts obtained through Focus Group Interviews (FGI). First, the primary barriers to car-sharing are identified from the literature. Then, the ISM model is developed to illustrate the relationships between these barriers and their respective hierarchical levels. Subsequently, the MICMAC analysis reveals each barrier's driving and dependence powers. Ultimately, with the help of the experts, strategies are formulated to mitigate the root barriers. This iterative process provides a comprehensive understanding of the intricate dynamics within the P2P car-sharing ecosystem, enabling the formulation of targeted interventions that promote service adoption and sustainability.

Date: September 2024 – June 2025

(P2)

HOW TRANSMISSION TYPE AFFECTS VEHICLE OPERATIONAL AND ENVIRONMENTAL IMPACT: A DATA-DRIVEN STUDY

E. MACEDO [a], R. MADAIL [a] and J. M. BANDEIRA [a]
*[a] Department of Mechanical Engineering,
University of Aveiro*
Email: macedo@ua.pt, ritalmadail@live.ua.pt, jorgebandeira@ua.pt

Keywords: driving behaviour, vehicle operational impacts, emissions

Subject area: Driving behaviour, Traffic management, Sustainable cities

Category: Master thesis (POSTER)

Abstract:
Road safety can be improved and vehicle emissions can be decreased by a deep understanding of the patterns in driving behaviour. This research focuses on the operational, safety and environmental effects of operating both manual and automatic transmission vehicles, involving a data-driven evaluation of driver behaviour in a controlled simulation experiment. The chosen scenario was an urban route and the experiment was carried out with 30 volunteers, each one performing runs either in automatic or manual transmission. The study gathered several variables, including speed, acceleration, pedal position, distance to the intersection, and other variables were computed, such as the vehicle-specific power (VSP). The estimation of the emissions was based on the VSP methodology. Initial results suggest that while driving with automatic transmissions can reduce overall pollutant emissions, it is also associated with more frequent sharp accelerations, particularly at lower speeds. This was evident during specific simulation events, such as speed bumps, pedestrian crossings, and surprise obstacles. Drivers on automatic transmissions tended to reach higher speeds and accelerations, leading to a greater proportion of time spent in high VSP modes (8 or higher), which has implications for both emissions and safety. Interestingly, drivers with more experience and male drivers generally exhibited higher speed and acceleration values, regardless of transmission type. However, the automatic transmission experiments consistently reached higher speeds and engaged in more aggressive acceleration patterns. Despite these tendencies, a general overview of a route, the automatic transmission scenario produced lower emissions than manual transmissions.
The study brings findings that can be relevant regarding the growing market penetration of electric vehicles (EVs), most of which are equipped with automatic transmissions. The data suggest that automatic transmissions may contribute to higher speeds and delayed braking responses, potentially increasing crash risks. These findings highlight the need to address driver behaviour as it pertains to both environmental impact and road safety, especially in the context of EV adoption. While the study is limited by its controlled conditions, such as the absence of varied road types, traffic, or weather conditions, the results reflect the importance of optimising driving behaviour to improve vehicle performance and environmental sustainability. This ongoing research will also focus on a microscopic analysis of driving aggressiveness and comfort, with potential applications in developing awareness tools to improve safety and reduce emissions.

Date: September 2024

(P3)

UNDERSTANDING PREFERENCES ON DIFFERENT URBAN INTERVENTIONS TO BETTER INFORM URBAN PLANNING

M. I. LOPES [a], G. VALENÇA [b] and F. MOURA [c]

[a] *Civil Engineering Research and Innovation for Sustainability (CERIS) - Department of Civil Engineering, Architecture and Environment, Instituto Superior Técnico (University of Lisbon)*
Email: maria.ines.duarte.lopes@tecnico.ulisboa.pt
[b] *Civil Engineering Research and Innovation for Sustainability (CERIS) - Department of Civil Engineering, Architecture and Environment, Instituto Superior Técnico (University of Lisbon)*
Email: gabrielvalenca@tecnico.ulisboa.pt
[c] *Civil Engineering Research and Innovation for Sustainability (CERIS) - Department of Civil Engineering, Architecture and Environment, Instituto Superior Técnico (University of Lisbon)*
Email: fmoura@tecnico.ulisboa.pt

Keywords: urban planning; public perception; urban interventions; design preferences

Subject area: Environmental Preference

Category: Master Thesis

Abstract: Urban spaces are constantly changing. Many cities are transitioning towards sustainable urban planning by prioritizing active modes, public transit, and human-oriented design, counteracting decades of car-oriented development. However, public opinion diverges on these changes. Some strong opponents may resist and even push for the reversal of already implemented measures, continuing to favor car-centric design. Given this, it becomes necessary to include the public's opinion in the urban planning process, considering their preferences, perceptions, and motives behind their resistance. This work attempts to identify patterns of public preferences on different urban interventions, specifically oriented to active modes, transit, and cars. A visual preference survey was conducted, presenting participants with eight different urban interventions. Each intervention included the "before" and "after" images, asking participants to select their preferred option. This before-and-after approach enables the study of preferences on the urban change itself, by confronting each citizen with change rather than with a single urban environment with already implemented measures. With this dataset, this study evaluates the preference rates for each intervention type, identifies common elements in the preferred images, and examines the trade-offs across seven factors influencing decisions: safety, security, stress, comfort, livability, order, and usefulness. Additionally, it explores how familiarity with the selected locations—whether participants have prior knowledge of the areas—influences their preferences. The current results show an overall positive preference for active modes (e.g., expanding pedestrian space) and transit-oriented interventions (e.g., implementing exclusive bus lanes), with acceptance rates of 90% and 80%, respectively. In contrast, car-oriented interventions (e.g., increasing parking space) are less favored but still have a 42% acceptance rate. Car owners, non-experts, and citizens with children tend to support car-oriented interventions. Residents of large urban areas demonstrate only a 38% acceptance rate for these interventions, compared to 46% among suburban (or outskirts) dwellers and an impressive 68% among citizens who reside in smaller towns. The factors that most positively influence preferences are *order*, for car- and transit-oriented interventions, and *liveability* for active-modes interventions.

Date: February 2024 – February 2025

(P4)

TRANSFORMING TRUCK PLATOONING THROUGH THE DEVELOPMENT AND INTEGRATION OF EVENT-BASED USE CASES FOR DRIVING SIMULATORS

T. C. Botelho [a], S. P. Duarte [a], M. C. Ferreira [b], S. Ferreira [a], A. Lobo [a]

[a] *CITTA – Centro de Investigação do Território, Transportes e Ambiente, Faculdade de Engenharia, Universidade do Porto, Portugal*

[b] *INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Porto, Portugal*

Keywords: Truck platooning; Driving simulation; Scenarios; Requirements.

Subject area: Transportation Engineering

Category: Master thesis

Abstract: Truck platooning, synchronizing multiple trucks using automated driving and vehicle-to-vehicle communication, is a promising solution for improving road safety, efficiency, and environmental sustainability. Comprehensive testing is required in controlled environments and real-world scenarios to ensure its feasibility. This work started with a need for proper testing of truck platooning and proper scenarios and requirements for its integration into regular traffic.

This work consisted of three phases. It began with (i) a comprehensive literature review of truck platooning tests in simulators and on-road studies, aiming to gather requirements and typical configurations of the technology. The review analyzed 30 articles categorized into human-centered, technology-centered, and energy-efficiency studies. Key variables identified include the number of trucks (2–10), platoon speeds (30–105 km/h), inter-truck distances (3–44 meters), and fuel savings (2–18%). The findings enable the design of use cases and scenarios.

In the second phase, (ii) two use cases were developed for implementation on a truck simulator. The *Emergency Takeover* use case focused on safe inter-truck distances and driver responses during emergency takeovers, while *Critical Situation Response After Takeover* studied driver passive fatigue from prolonged automated platooning. A third use case, *Highway Ingress*, was designed for implementation on a light vehicle simulator to examine surrounding drivers' reactions to platoons during highway merging. The scenarios include variations where all other aspects remain constant, but the inter-platoon gap distance varies between 8, 15, and 22 meters.

The final phase, (iii), involved creating and implementing scenarios in simulators at the University of Porto's Faculty of Engineering. A dedicated tool featuring route-based and GPS-coordinate scenario generation was developed to facilitate scenario creation. Preliminary tests validated the realism and usability of these scenarios.

The principal project is ongoing, with regular drivers conducting simulations in the light vehicle simulator use case. Final refinements are also being completed on the truck simulator in preparation for trials with professional truck drivers.

(P5)

DYNAMICS OF TELECOUPLINGS IN THE SUPPLY CHAIN FOR FOOD LOGISTICS AND TRANSPORTATION AT CEASA IN CURITIBA, PR

A. SCHMITZ [a], T. GADDA [b] and S. FERREIRA [c]

[a] *Postgraduate Program in Civil Engineering (PPGEC-CT), and Sandwich Doctorate Program at the Faculty of Engineering of the University of Porto (FEUP),*
Federal Technological University of Paraná (UTFPR),
Email: anelise.schmitz@gmail.com
[b] *Postgraduate Program in Civil Engineering (PPGEC-CT),*
Federal Technological University of Paraná (UTFPR),
Email: tatianagadda@utfpr.edu.br
[c] *Centre for Territory, Transports and Environment (CITTA),*
Faculty of Engineering of University of Porto,
Email: sara@fe.up.pt

Keywords: Telecoupling, Greenhouse Gases, Environmental Footprints, Sustainability, Food Security

Subject area: Logistics and Sustainability.

Category: PhD thesis (ongoing or recently concluded)

Abstract:

This research investigates the dynamics of telecouplings within the supply chain for fruits, vegetables, and greens (FLV) at CEASA Curitiba/PR. Telecoupling refers to the interactions among production, consumption, and flow within natural and human systems, creating economic, social, and environmental impacts across significant distances. In today's context, a rising demand for food is linked to major environmental impacts, including soil degradation and greenhouse gas (GHG) emissions, primarily driven by transportation. While existing studies tend to focus on international flows, this research addresses dynamics of subnational and urban telecouplings in Brazil. The main objective is to assess the urban telecoupling impacts on the FLV supply chain for CEASA Curitiba/PR by examining product origins and destinations and calculating environmental indicators such as carbon and energy footprints. Methodologically, the study employs both qualitative and quantitative approaches, using a case study and logistics simulations. Data are gathered from documentary and digital sources, with support from transportation and mapping software. The study aims to propose sustainable scenarios, identify strategies to reduce environmental impacts, and enhance supply chain management practices. This research aligns with the United Nations Sustainable Development Goals, especially in terms of promoting sustainable cities, responsible consumption, and combating climate change. It contributes by providing strategic insights for decision-making in food security and sustainable transport management, offering recommendations to reduce the environmental impact of urban food logistics.

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BELZÉNIA A. B. MATSIMBE [a] and SARA FERREIRA [b]
[a] CITTA, Faculdade de Engenharia da Universidade do Porto
Email: up2408583@up.pt
[b] CITTA, Faculdade de Engenharia da Universidade do Porto
Email: sara@fe.up.pt

Keywords: road safety; climate change; traffic accidents; extreme weather events; systematic review

Subject area: road safety

Category: PhD thesis

Abstract:
Climate change is expected to intensify extreme weather events, which could significantly affect road safety. Nevertheless, there remains a limited understanding of how evolving weather patterns influence the frequency and severity of road traffic accidents.

This systematic review aims to synthesize the existing literature on the relationship between climate change-induced weather events (e.g., storms, heatwaves, floods) and road traffic accidents. Specifically, it will assess how these factors affect accident rates and road user safety across different regions and road types.

A comprehensive search for relevant studies published between 2000 and 2024 is being conducted using electronic databases such as Scopus, Web of Science, ScienceDirect, Springer Link, JSTOR, TRID, Google Scholar, and PubMed. This review follows the PRISMA guidelines, focusing on empirical studies exploring the impact of climate-related factors on road traffic accidents.

As the review process continues, the initial screening results indicate that extreme weather events, including increased rainfall and heatwaves, are significantly correlated with higher rates and severity of road traffic accidents. However, the long-term effects of climate change and its broader implications for road safety remain underexplored.

This review will provide valuable insights into the ways in which climate change may affect road safety. It aims to inform future research and guide policy recommendations and strategies to improve road safety in the context of climate change.

Date: September 2024 – September 2027