Book of Abstracts

Organization:

universidade de aveiro
theoria poiesis praxis

Title:

Book of abstracts of the 24th Euro Working Group on Transportation Meeting

Editors:

Margarida C. Coelho, Joaquim Macedo, Eloísa Macedo, Paulo Fernandes, Jorge Bandeira, Behnam Bahmankhah

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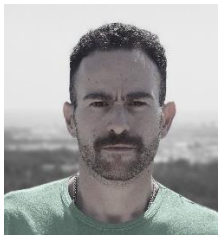

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Introductory Foreward

The 24th Edition brings the Euro Working Group in Transportation (EWGT) meeting back to Portugal. From the 8th to the 10th of September 2021, EWGT is being organized by the University of Aveiro through the Smart Mobility research team of the Department of Mechanical Engineering and the Centre for Mechanical Technology and Automation.

I clearly remember the moment when I received, in the early beggining of 2020, the challenge to submit a proposal to organize EWGT2021 in Aveiro. I was far to imagine the turnovers that the world would face with the pandemic. I had the hope that I could host you in person in Aveiro and show you the beauties of the "Portuguese Venice" (as it is often called, because of its water cannals). Nevertheless, we stand together as a strong research community and the program of EWGT2021 shows exactly that: even with the challenges that we faced in these last 18 months, the research on Mobility and Transportation is stronger and brighter than ever.

EWGT2021 has received considerable attention from the research community. We received 235 extended abstracts, with 141 complete papers being submitted, of which almost 87% were accepted. We have 25 countries represented in EWGT2021. The conference features keynote speeches by three leading researchers in multicriteria and logistics, vehicular sensing, and intelligent and sustainable transportation systems. It provides a rich technical program covering a wide range of topics in transportation research and almost 130 high quality presentations. Mobility is each time more multidisciplinary and this diversity is crucial to establish a productive dialogue that is needed to solve mobility challenges and pave to way for smarter, safer and more sustainable mobility systems. The conference topics are extremely varied: 1) transport modeling and control, 2) planning and operation, 3) transport economics and policy, 4) innovative solutions, covering all transportation modes. There are also sessions dedicated to mobility innovations (namely automated vehicles applications) as well as covering the impacts and trends and mobility trends during and after COVID-19 pandemic.

The process of organizing this conference in remote conditions (not only between you and me, but also between the organising team itself, due to the pandemic restrictions) was, as you may imagine, quite challenging. First and foremost I would like to thank my organising committee fellow members for accepting this challenge and their dedication in creating an interesting event; a special word to Mariana Vilaça, for her organization, attention and effort in the daily conference management; to each member of the support team who helped in so many details (registration, webpage, logo design, technology…). I will be always grateful. Second, a special thank you goes to the organizers of the special sessions, who were able to attract interesting papers in their particular fields. Third, an acknowledgement to the Scientific Committee members and reviewers that had such a hard job in revising so many good papers that were submitted. Fourth, I would like to thank the institutional support of the Rectory of the University of Aveiro, the Department of Mechanical Engineering and the Centre for Mechanical Technology and Automation; the Portuguese Institute of Mobility and Transportation; and CIRA-Aveiro Region. A word of appreciation to our Platinum Sponsor, PTV consultants, always in the frontline in terms of modelling mobility challenges. A special word is also given to Riccardo Rossi for trusting the organization of EWGT2021 to the Smart Mobility research team of the University of Aveiro, and for his availability to advise the organising committee with his immense experience of EWGT. And last, but not the least, I express my gratitude to each one of you: the EWGT2021 authors, keynote speakers, session chairs, whose contributions have made this conference a reality.

The Portuguese poet Fernando Pessoa (through his heteronym Álvaro de Campos) wrote:

«I bring inside my heart,
Like in a safe that cannot be closed completely,
Everywhere I've been,
All ports I've arrived at,
All the landscapes I saw through windows or portholes,
Or on decks, dreaming,
And all of this, which is so much, is too small for what I want.»

«Trago dentro do meu coração,
Como num cofre que se não pode fechar de cheio,
Todos os lugares onde estive,
Todos os portos a que cheguei,
Todas as paisagens que vi através de janelas ou vigias,
Ou de tombadilhos, sonhando,
E tudo isso, que é tanto, é pouco para o que eu quero.»

In «Passagem das horas», Álvaro de Campos

At this moment, I really want that EWGT2021 fulfill your expectations and I look forward to meet you soon.

Aveiro, September 2021

Margarida C. Coelho – General Chairwoman of EWGT2021

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Nuno Ribeiro

Corrado Rindone

Joaquin Rodriguez

Alessio Salvatore

Patrizia Serra

Pavlos Tafidis

Enza Torrisi

Paolo Ventura

Senlei Wang

Organizers of special sessions

Eloisa Macedo and Jorge Bandeira - Anticipating impacts of autonomous vehicles

Eloisa Macedo and Jorge Bandeira - Smart cities and Mobility as a Service

Anna Lina Ruscelli - Toward new railway management systems

The executive committee wants to thank the commitment of these colleagues in setting up excellent sessions on their fields of research.

The EURO Working Group In Transportation

EWGT 2021 is held under the patronage of the EURO Working Group on Transportation (EWGT) and The Association of European Operational Research Societies (EURO).

Aims and Scope

Main targets of the EWGT concern providing a forum to share information and experience of research activities, encouraging joint research and the development both of theoretical methods and applications, promoting the cooperation among different institutions and organisations, leaders at national level in the field of traffic, transportation and logistics systems.

Primary field of interest concerns operation research (OR) methods, mathematical models and computation algorithms to solve and support the solution of problems faced by public administrations, city authorities, public transport companies, service providers, logistic operators and so on.

Related areas of interest are:

- land-use and transportation planning
- traffic control and simulation models
- traffic network equilibrium models
- public transport planning and management
- applications of combinatorial optimization
- vehicle routing and scheduling
- intelligent transportation systems
- logistics and freight transportation
- environmental challenges
- impact evaluation methods.

Scientific Board

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- Markos Papageorgiou -Technical University of Crete (Greece)
- Jacek Zak - Poznan University of Technology (Poland)

Coordinator

Riccardo Rossi - University of Padova (Italy)

Plenary lectures – Bio of keynote speakers and abstract

KEYNOTE SPEECH BY JACEK ŻAK

INTELLIGENT/ SMART DECISION MAKING FOR TRANSPORTATION & LOGISTICS

Bio:

Professor Jacek Żak is a graduate of Harvard Business School and Massachussetts Institute of Technology in Boston, USA, and a double Fulbright Program Grantee.

He is a Professor at Poznan University of Technology; Faculty of Engineering Management. He is a highly recognized international expert in Multiple Criteria Decision Making/ Aiding for Transportation and Logistics.

Jacek Żak is the founder and the leader of the Operations Research Oriented Poznań Transportation – Logistics Group. He was the Head of the Department of Logistics at Poznan University of Technology between 2008 – 2016. He has acted as a business consultant at the Institute of Logistics and Warehousing and F5 Consulting Company in Poznan. He is also a co-founder of the Poznan University of Logistics.

Adittionally, Professor Jacek Żak is a member of several international organizations and an editor of the indexed Journal of Advanced Transportation. He has 180 publications, including 10 books and monographs and 100 research projects, including EU undertakings.

Title: Intelligent/ Smart Decision Making For Transportation & Logistics

Abstract: The Keynote Lecture has an instructional character. It presents basic concepts and ideas of intelligent decision making for transportation and logistics. The application of different modern technologies and methodologies to generate good and rational decisions is discussed. The State of the Art in the Methodology of Multiple Criteria Decision Making / Aiding is presented and its extension towards Intelligent Decision Making is demonstrated. The "intelligence" in different phases of the decision making process, including: problem recognition, modeling and solving is presented. Several transportation-logistics case studies show the applicability of the concept of "Intelligent Decision Making" in these areas.

KEYNOTE SPEECH BY SUSANA SARGENTO

Aveiro as a living lab for intelligent mobility and Transportation

Bio:

Susana Sargento is a Full Professor in the University of Aveiro and a senior researcher in the Institute of Telecommunications, where she is leading the Network Architectures and Protocols group. She was a visiting PhD student in Rice University (2000-2001), and a Guest Faculty in Carnegie Mellon University (2008).

Susana has been leading research projects with telecom operators and OEMs. She has organized several international conferences and workshops, such as ACM MobiCom, IEEE Globecom, and has also been a reviewer of conferences and journals, such as IEEE Networks, IEEE Communications. Susana has co-founded a vehicular networking company, Veniam (www.veniam.com), she is the winner of the 2016 EU Prize for Women Innovators. She is also the co-coordinator of the national initiative of digital competences in the research axis INCoDe.2030, belongs to the evaluation committee of the Fundo200M (www.200m.pt), and she is one of the Scientific Directors of CMU-Portugal Programme.

Her main research interests are in the areas of self-organized networks, in ad-hoc and vehicular network mechanisms and protocols, such as routing, mobility, security and delay-tolerant mechanisms, resource management, and content distribution networks. She regularly acts as an Expert for European Research Programmes.

Title: Aveiro as a living lab for intelligent mobility and Transportation

Abstract: The world we live in is constantly changing. Playing to Aveiro's strong legacy of technological innovation, the Aveiro STEAM City project is changing the way city actors perform and interact, differentiating it from its competitors at home and abroad.

Aveiro is today a living trial city for intelligent mobility and transportation, with an advanced large-scale communications infrastructure, spread throughout the city. It is composed of fibre link technology (spread across 16km), reconfigurable radio units, 5G-NR radio and 5G network services. The access infrastructure covers 44 strategic points in the urban area of Aveiro, in the form of smart lamp posts or wall boxes on building facades, with mobility sensors such as radars, lidars and video cameras. Buses and garbage collection vehicles have also been equipped with communication units and sensors, which currently record mobility and environmental data, making a complete live map of these parameters in the city, and providing the required data for traffic monitoring and safe driving systems.

This talk will address the living lab, the services it can support, with a special emphasis on mobility and transportation, and how the interaction with citizens has been achieved.

KEYNOTE SPEECH BY ASAD KHATTAK

A bumpy road to driverless cars: Challenges and opportunities

Bio:

Dr. Asad J. Khattak is Beaman Distinguished Professor of Civil & Environmental Engineering at The University of Tennessee, Knoxville. He serves as the Coordinator for the Transportation Group in the Department, and is Associate Director for the Collaborative Sciences Center for Road Safety—a National University Transportation Center, based at UNC-Chapel Hill. Dr. Khattak's research focuses on various types of innovations related to intelligent transportation technologies, transportation safety, and sustainable transportation. Dr. Khattak received his Masters and Ph.D. degrees in Civil Engineering from Northwestern University. He serves as Editor of Science Citation Indexed Journal of Intelligent Transportation Systems, with a 2-year impact factor of 4.277 (for 2020).

Title: A bumpy road to driverless cars: Challenges and opportunities

Abstract: This presentation will cover recent innovations in driverless technologies that can better meet the needs of urban living. The transportation system of the future is anticipated to integrate automation and connectivity of vehicles. Enabled by the growing computational power, ubiquity of sensors, big data, and Artificial Intelligence, cities have new opportunities to be more accessible, energy efficient, cleaner, and supportive of more diverse emerging technologies. Automation can improve traffic congestion and lower vehicle operating costs and wireless connectivity can reduce injuries and deaths in collisions. Capturing these opportunities will partly depend on overcoming the infrastructure legacy of the past and addressing the resource challenges of the present. However, through careful systems planning, we can harness new opportunities. The presentation will highlight the promise and the challenges/uncertainties inherent in transitioning to a more technologically advanced system. We will briefly introduce connected and automated vehicle technologies, their status, their prospects, and discuss relevant issues.

Conference Sponsors and Institutional Support

Platinum Sponsor:

Institutional Support:

Conference in Numbers

Number of submitted extended abstracts: 235

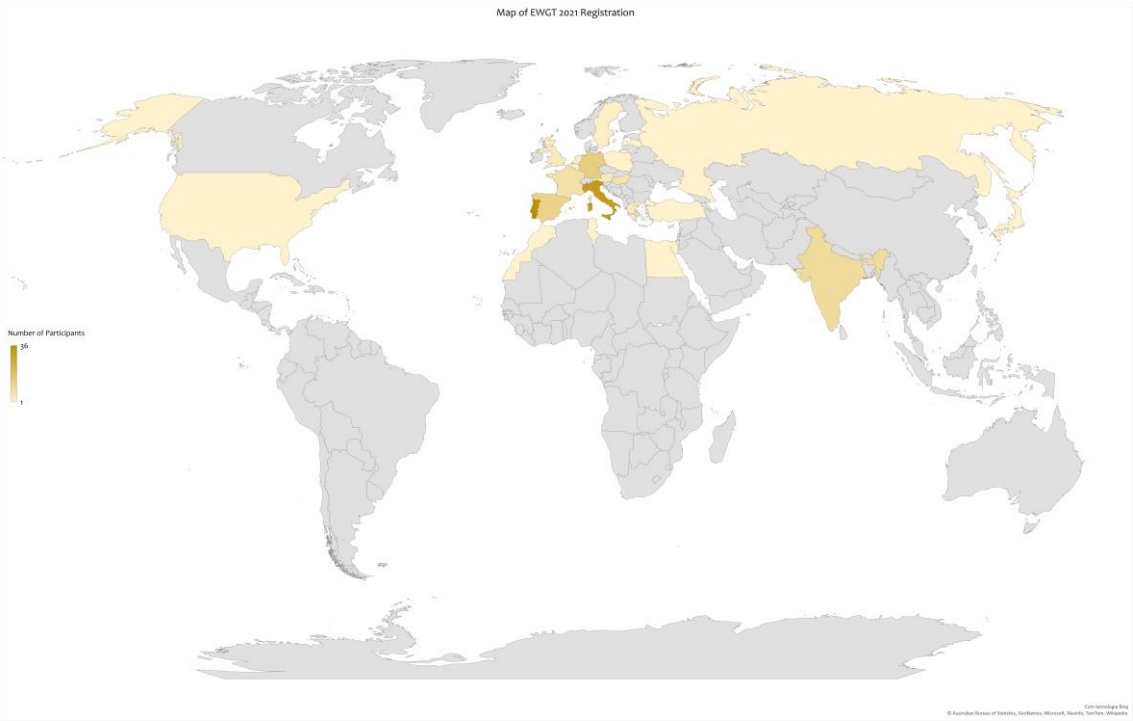
Number of submitted papers: 141

Number of accepted papers: 122

Number of registered participants: 146

Number of sessions: 37

Number of presentations: 129



Country	N.º of participants	Country	N.º of participants
Abu Dhabi	1	Portugal	36
Austria	3	Russia	1
Belgium	1	Spain	12
Egypt	1	Sweden	2
France	7	Tunisia	1
Germany	14	Turkey	1
Greece	4	United Kingdom	4
Hungary	6	United States	1
India	9		
Italy	32		
Japan	1		
Latvia	1		
Luxembourg	3	**Total**	146
Malta	1	**Number of Countries**	25
Morocco	1		
The Netherlands	2		
Poland	1		

Program Overview

CEST		WEDNESDAY, September 8 2021
10:00	OS	**Opening Session**
10:30	W1	Plenary: Jacek Zak
		Intelligent/Smart Decision Making for Transportation & Logistics
11:30		Morning Coffee Break
11:40	WA1	Urban mobility innovations
	WA2	Rail transport systems
	WA3	Active travel modes and health
	WA4	Sponsor Session PTV
13:20		Lunch
14:30	WB1	Transportation planning and traffic engineering
	WB2	The future of mobility after COVID-19 1
	WB3	Advanced modeling approaches in logistics
	WB4	SS Anticipating impacts of autonomous vehicles
16:10		Afternoon Coffee Break
16:20	WC1	Vehicle routing and route planning
	WC2	Control and management of transportation systems
	WC3	Demand and choice modeling
18:00		

CEST		THURSDAY, September 9 2021
10:00		
10:30	T1	Plenary: Susana Sargento
		Aveiro as a living lab for intelligent mobility and transportation
11:30		Morning Coffee Break
11:40	TA1	Autonomous vehicle systems applications
	TA2	Public transport planning and operation 1
	TA3	Survey applications
	TA4	Sensors and automatic data collection methods
13:20		Lunch
14:30	TB1	Big data and machine learning in transportation
	TB2	Airport and air transport operations
	TB3	Smart cities and smart mobility
	TB4	SS Toward new railway management systems
16:10		Afternoon Coffee Break
16:20	TC1	Energy consumption and emission modeling 1
	TC2	Decision support analysis and operations research
	TC3	Transportation planning and travel behaviour
	TC4	Dynamic network modeling
18:00		

CEST		FRIDAY, September 10 2021
	FA1	Public transport planning and operation 2
10:00	FA2	Shared mobility
	FA3	Impact assessments and ex-post evaluation
11:40		Morning Coffee Break
11:50	FB1	Energy consumption and emission modeling 2
	FB2	Simulation and optimization of transportation systems
	FB3	The future of mobility after COVID-19 2
13:30		Lunch
14:30	F1	Plenary: Asad Khattak
		A Bumpy Road to Driverless Cars: Challenges and Opportunities
15:30		Afternoon Coffee Break
15:40	FC1	Safety and security
	FC2	Transport Operations and Performance
	FC3	SS Smart cities and Mobility as a Service
17:20	CS	**Closing Session**

Detailed Program

Wednesday, September 8th

10:00-10:30 Session OS: Opening Session

CHAIR:

Margarida Coelho (University of Aveiro, Portugal)

10:30-11:30 Session W1: Plenary Talk by Jacek Zak

CHAIR:

Margarida Coelho (University of Aveiro, Portugal)

10:30 *Jacek Zak* (Poznan University of Technology, Poland)

Intelligent/ Smart Decision Making for Transportation & Logistics

11:30-11:40 Coffee Break

11:40-13:20 Session WA1: Urban mobility innovations

CHAIR:

Joaquim Macedo (Universidade de Aveiro | Departamento de Engenharia Civil, Portugal)

11:40 *Beatriz Mendes* (Faculty of Engineering of the University of Porto, Portugal)
Marta C. Ferreira (Faculty of Engineering of the University of Porto, Portugal)
Maria T. Galvão (Faculty of Engineering of the University of Porto, Portugal)

Tourism as a Service: Enhancing the Tourist Experience

PRESENTER: *Beatriz Mendes*

12:00 *Santhanakrishnan Narayanan* (Technical University of Munich, Germany)
Josep Maria Salanova Grau (Centre for Research and Technology - Hellas Hellenic Institute for Transport, Greece)
Rodric Frederix (Transport and Mobility Leuven, Belgium)
Athina Tympakianaki (Aimsun SLU, Spain)
Constantinos Antoniou (Technical University of Munich, Germany)

Modelling of shared mobility services - An approach in between traditional strategic models and agent-based models

PRESENTER: *Santhanakrishnan Narayanan*

12:20 *Hagen Ußler* (TU Dresden, Institute of Traffic Telematics, Chair of Transport Systems Information Technolog, Germany)
Christian Setzefand (MRK Media AG, Niederlassung Dresden, Germany)
Oliver Michler (TU Dresden, Institute of Traffic Telematics, Chair of Transport Systems Information Technology, Germany)

An empirical study on V2X radio coverage using leaky coaxial cables in road crash barriers

PRESENTER: *Hagen Ußler*

12:40 *Sérgio Pedro Duarte* (University of Porto, Portugal)
Jorge Pinho de Sousa (University of Porto, Portugal)
Jorge Freire de Sousa (University of Porto, Portugal)

Designing urban mobility policies in a socio-technical transition context

PRESENTER: *Sérgio Pedro Duarte*

11:40-13:20 Session WA2: Rail transport systems

CHAIR:

Anna Lina Ruscelli (Scuola Superiore Sant'Anna, Italy)

11:40 *Amr Wahaballa* (Aswan University, Egypt, Egypt)
Mohamed Abdelhaleem (Aswan University, Egypt, Egypt)
Khaled Saeed (Aswan University, Egypt, Egypt)
Ayman Othman (Aswan University, Egypt, Egypt)

Experimental analysis of boarding and alighting behavior in urban public transport network: A case study

PRESENTER: *Amr Wahaballa*

12:00 *Ida Kristoffersson* (VTI Swedish National Road and Transport Research Institute, Sweden)
Carl-William Palmqvist (Lund University, Sweden)

Improving commuter train punctuality using lead indicators

PRESENTER: *Ida Kristoffersson*

12:20 *Federico Naldini* (Alma Mater Studiorum - Università di Bologna, Italy)
Paola Pellegrini (Université Gustave Eiffel, France)
Joaquin Rodriguez (Université Gustave Eiffel, France)

Real-Time Optimization of Energy Consumption in Railway Networks

PRESENTER: *Federico Naldini*

12:40 *Luis Cadarso* (Rey Juan Carlos University, Spain)
Ricardo Garcia (none, Spain)
Esteve Codina (Universitat Politècnica de Catalunya, Spain)

Microscopic Disruption Management: Energy Consumption and Passenger Compensation Optimisation

PRESENTER: *Luis Cadarso*

11:40-13:20 Session WA3: Active travel modes and health

CHAIR:

Behnam Bahmankhah (University of Aveiro, Portugal)

11:40 *Marisdea Castiglione* (Roma Tre University, Italy)
Rosita De Vincentis (Università Roma Tre, Italy)
Marialisa Nigro (Università Roma Tre, Italy)
Vittorio Rega (Roma Tre University, Italy)

Bike Network Design: an approach based on micro-mobility geo-referenced data

PRESENTER: *Rosita De Vincentis*

12:00 *Christos Karolemeas* (National Technical University of Athens, Greece)
Avgi Vassi (National Technical University of Athens, Greece)
Stefanos Tsigdinos (national technical university of athens, Greece)
Efthimios Bakogiannis (ntua athens, Greece)

Measure the ability of cities to be biked via weighted parameters, using GIS tools. The case study of Zografou in Greece

PRESENTER: *Christos Karolemeas*

12:20 *Maria Grazia Bellizzi* (University of Calabria, Italy)
Laura Eboli (University of Calabria, Italy)
Carmen Forciniti (University of Calabria, Italy)
Gabriella Mazzulla (University of Calabria, Italy)

Establishing Performance Criteria for Evaluating Pedestrian Environments

PRESENTER: *Maria Grazia Bellizzi*

12:40 *Suzanne Maas* (University of Malta, Malta)
Maria Attard (University of Malta, Malta)
Mark Anthony Caruana (University of Malta, Malta)

Motivators and barriers for shared bicycle use in 'starter' cycling cities: Evidence from BSS user surveys in three Southern European island cities

PRESENTER: *Suzanne Maas*

11:40-13:20 Session WA4: SPONSOR PTV

CHAIR: *Paulo Fernandes* (University of Aveiro, Portugal)

11:40 *Cristina Vilarinho* (Public Administration/Câmara Municipal do Porto, Portugal)
Ignácio Galindo Pinto (PTV Group Iberia, Spain)

Mesoscopic Traffic Simulation with PTV tools: Options and case of Porto

13:20-14:30 Lunch Break

14:30-16:10 Session WB1: Transportation planning and traffic engineering

CHAIR: *Riccardo Rossi* (University of Padova, Italy)

14:30 *Federico Orsini* (University of Padova, Italy)
Massimiliano Gastaldi (University of Padova, Italy)
Gregorio Gecchele (Atraki s.r.l., Italy)
Riccardo Rossi (University of Padova, Italy)

Dealing with multicollinearity in real-time road safety analysis

PRESENTER: *Federico Orsini*

14:50 *Purvang M Chaudhari* (Sardar Vallabhbhai National Institute of Technology, Surat, India-395007, India)
Jaydip Goyani (Sardar Vallabhbhai National Institute of Technology, Surat, India-395007, India)
Shriniwas Arkatkar (Sardar Vallabhbhai National Institute of Technology, Surat, India-395007, India)
Gaurang Joshi (Sardar Vallabhbhai National Institute of Technology, Surat, India-395007, India)
Said M Easa (Ryerson University, Toronto, Canada, Canada)

Design Consistency Evaluation of Two-Lane Rural Highways in Hilly Terrains

PRESENTER: *Jaydip Goyani*

15:10 *Jay Mistry* (Parul University, India)
Purvang Chaudhari (SVNIT, India)
Shriniwas Arkatkar (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Constantinos Antoniou (Technical University of Munich, Germany)

Examining Traffic Operations at Multi-Legged Intersection Operating under Heterogeneous Traffic: A case Study in India

PRESENTER: *Purvang Chaudhari*

15:30 *Pasquale Carotenuto* (National Research Council of Italy - Institute for Applied Mathematics "M. Picone", Italy)
Riccardo Ceccato (University of Padova – Department of Civil, Environmental and Architectural Engineering, Italy)
Massimiliano Gastaldi (University of Padova – Department of Civil, Environmental and Architectural Engineering, Italy)
Stefano Giordani (University of Rome "Tor Vergata" – Department of Enterprise Engineering "M. Lucertini", Italy)
Riccardo Rossi (University of Padova – Department of Civil, Environmental and Architectural Engineering, Italy)
Alessio Salvatore (National Researc Council of Italy - Institute for Applied Mathematics "M. Picone", Italy)

Comparing home and parcel lockers' delivery systems: a math-heuristic approach

PRESENTER: *Alessio Salvatore*

14:30-16:10 Session WB2: The future of mobility after COVID-19 1

CHAIR:

Margarida Coelho (University of Aveiro, Portugal)

14:30 *Rodrigo Netto de Souza* (Department of Transport Technology and Economics, Budapest University of Technology and Economics, Hungary)
Tamás Mátrai (Budapest University of Technology and Economics, Hungary)

Impacts of the COVID-19 pandemic in the demand for urban transportation in Budapest

PRESENTER: *Tamás Mátrai*

14:50 *Tiziana Campisi* (Faculty of Engineering and Architecture, University of Enna KORE, Cittadella Universitaria 94100 Enna, Italy, Italy)
Socrates Basbas (School of Rural & Surveying Engineering, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece;, Greece)
Mirto Trouva (School of Rural & Surveying Engineering, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece;, Greece)
Thomas Papas (School of Rural & Surveying Engineering, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece;, Greece)
Nurten Akgün Tanbay (Faculty of Engineering and Natural Sciences, Bursa Technical University, Bursa 16330, Turkey, Turkey)
Nikiforos Stamatiadis (Department of Civil Engineering, University of Kentucky ,Lexington, KY 40506-0281, USA, United States)
Giovanni Tesoriere (aculty of Engineering and Architecture, University of Enna KORE, Cittadella Universitaria 94100 Enna, Italy, Italy)

Anxiety, fear and stress feelings of road users during daily walking in the pandemic COVID-19: Sicilian cities

PRESENTER: *Thomas Papas*

15:10 *Antonio Pascale* (University of Aveiro, Portugal)
Simona Mancini (Università degli Studi di Salerno, Italy)
Pedro M. d'Orey (University of Porto, Portugal)
Claudio Guarnaccia (Università degli Studi di Salerno, Italy)
Margarida C. Coelho (University of Aveiro, Portugal)

Correlating the Effect of Covid-19 Lockdown with Mobility Impacts: A Time Series Study Using Noise Sensors Data

PRESENTER: *Antonio Pascale*

15:30 *Raquel Fulgêncio* (Faculdade de Ciências da Universidade do Porto, Portugal)
Marta Campos Ferreira (Faculdade de Engenharia da Universidade do Porto, Portugal)
Diogo Abrantes (Faculdade de Ciências da Universidade do Porto, Portugal)
Miguel Coimbra (Faculdade de Ciências da Universidade do Porto; INESC TEC, Portugal)

Restart: A Route Planner to Encourage the Use of Public Transport Services in a Pandemic Context

PRESENTER: *Raquel Fulgêncio*

14:30-16:10 Session WB3: Advanced modeling approaches in logistics

CHAIR:

Carina Pimentel (University of Aveiro, Portugal)

14:30 *Christian Truden* (Lakeside Labs Klagenfurt, Alpen-Adria Universität Klagenfurt, Austria)
Kerstin Maier (Alpen-Adria-Universität Klagenfurt, Austria)
Philipp Armbrust (Alpen-Adria-Universität Klagenfurt, Austria)

Decomposition of the vehicle routing problem with time windows on the time dimension

PRESENTER: *Christian Truden*

14:50 *Aleksandra Colovic* (Polytechnic University of Bari, Italy)
Mario Marinelli (University of Sannio, Italy)
Michele Ottomanelli (Polytechnic University of Bari, Italy)

A multi-objective network design model for road freight transportation using the eHighway system

PRESENTER: *Aleksandra Colovic*

15:10 *Fatemeh Bagheri Khalili* (Iran University of Science and Technology, Iran)
Antonio Pais Antunes (University of Coimbra, Portugal)
Afshin Shariat Mohaymany (Iran University of Science and Technology, Iran)

How is freight distribution affected by travel time unreliability?

PRESENTER: *Antonio Pais Antunes*

15:30 *Giovanni Calabrò* (University of Catania, Italy)
Michela Le Pira (University of Catania, Italy)
Nadia Giuffrida (University College Dublin, Ireland)
Martina Fazio (University of Catania, Italy)
Giuseppe Inturri (University of Catania, Italy)
Matteo Ignaccolo (University of Catania, Italy)

Modelling the dynamics of on-demand urban deliveries via an agent-based model

PRESENTER: *Giovanni Calabrò*

14:30-16:10 Session WB4: SS Anticipating impacts of autonomous vehicles

CHAIRS:

Jorge Bandeira (University of Aveiro, Portugal)
Eloisa Macedo (University of Aveiro, Portugal)

14:30 *Qiaochu Fan* (Delft University of Technology, Netherlands)
J. Theresia van Essen (Delft University of Technology, Netherlands)
Gonçalo Homem de Almeida Correia (Delft University of Technology, Netherlands)

Heterogeneous fleet sizing for on-demand transport in mixed automated and no-automated urban areas

PRESENTER: *Qiaochu Fan*

14:50 *Muhammad Tabish Bilal* (University of Genoa, Italy)
Davide Giglio (University of Genoa, Italy)

Realization of the penetration rate for autonomous vehicles in multi-vehicle assignment models

PRESENTER: *Muhammad Tabish Bilal*

15:10 *Laszlo Szoke* (Budapest University of Technology and Economics, Hungary)
Szilard Aradi (Budapest University of Technology and Economics, Hungary)
Tamas Tettamanti (Budapest University of Technology and Economics, Hungary)

Investigating Successor Features in the domain of Autonomous Vehicle Control

PRESENTER: *Laszlo Szoke*

15:30 *Clément Lemardelé* (Universitat Politécnica de Catalunya, Spain)
Miquel Estrada (Universitat Politécnica de Catalunya, Spain)
Laia Pagès (UPC Technology Center - CARNET, Spain)

Uncertainty analysis of autonomous delivery device operations

PRESENTER: *Clément Lemardelé*

16:10-16:20 Coffee Break

16:20-18:00 Session WC1: Vehicle routing and route planning

CHAIR: *Dirk Mattfeld* (TU Braunschweig, Germany)

16:20 *Soraia Felicio* (Faculdade de Engenharia da Universidade do Porto, Portugal)
Joana Hora (Faculdade de Engenharia da Universidade do Porto, Portugal)
Marta Ferreira (Faculdade de Engenharia da Universidade do Porto, Portugal)
Diogo Abrantes (Faculdade de Ciências da Universidade do Porto, Portugal)
Paulo Costa (Faculdade de Ciências da Universidade do Porto, Portugal)
Camila Dangelo (Faculdade de Engenharia da Universidade do Porto, Portugal)
Jorge Silva (Bosch Security Systems, Portugal)
Teresa Galvão (Faculdade de Engenharia da Universidade do Porto, Portugal)

Handling OpenStreetMap georeferenced data for route planning

PRESENTER: *Soraia Felicio*

16:40 *Philipp Armbrust* (Alpen-Adria-Universität Klagenfurt, Austria)
Philipp Hungerländer (Alpen-Adria-Universität Klagenfurt, Austria)
Kerstin Maier (Alpen-Adria-Universität Klagenfurt, Austria)
Veronika Pachatz (Hex GmbH, Austria)

Case study of Dial-a-Ride Problems arising in Austrian rural regions

PRESENTER: *Veronika Pachatz*

17:00 *Hazal Akova* (Technical University of Istanbul, ITS Research Lab, Turkey)
Selin Hulagu (Technical University of Istanbul, ITS Research Lab, Turkey)
Hilmi Berk Celikoglu (Technical University of Istanbul, ITS Research Lab, Turkey)

Static bike repositioning problem with heterogeneous distribution characteristics in bike sharing systems

PRESENTER: *Selin Hulagu*

17:20 *Vanessa Voelz* (Technische Universität Braunschweig, Germany)
Dirk C. Mattfeld (Technische Universität Braunschweig, Germany)
Yannick Scherr (Technische Universität Braunschweig, Germany)

Relocation planning with partly autonomous vehicles in carsharing systems

PRESENTER: *Vanessa Voelz*

16:20-18:00 Session WC2: Control and management of transportation systems

CHAIR:

Roberta Di Pace (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)

16:20 *Roxan Saleh* (Dalarna University/Swedish Transport Adminstration, Sweden)
Hasan Fleyeh (Dalarna University, Sweden)

Using Supervised Machine learning to predict the status of the road signs

PRESENTER: *Roxan Saleh*

16:40 *Radha Reddy* (CISTER Research Center, ISEP, FEUP, Portugal)
Luis Almeida (CISTER Research Center, FEUP, Portugal)
Miguel Gaitan (CISTER, ISEP, FEUP, Portugal)
Pedro M. Santos (CISTER, ISEP, FEUP, Portugal)
Eduardo Tovar (CISTER, ISEP, Portugal)

Synchronous Framework Extended for Complex Intersections

PRESENTER: *Radha Reddy*

17:00 *Louis Balzer* (Université Gustave Eiffel, France)
Ludovic Leclercq (Université Gustave Eiffel, France)

Mode shift with tradable credit scheme: a simulation study in Lyon

PRESENTER: *Louis Balzer*

17:20 *Yaroslava Shynkar* (Hunter College, CUNY, United States)
Anita Raja (Hunter College, City University of New York, United States)
Ana L. C. Bazzan (Universidade Federal do Rio Grande do Sul, Brazil)
Marin Marinov (Hunter College, CUNY, United States)

Multiagent Meta-level Control for Adaptive Traffic Systems: A Case Study

PRESENTER: *Yaroslava Shynkar*

16:20-18:00 Session WC3: Demand and choice modeling

CHAIR:

Lídia Montero (Universitat Politècnica de Catalunya, Spain)

16:20 *Harsh Vardhan* (Indian Institute of Technology, Roorkee, India)
Ishan Rai (Indian Institute of Technology, Roorkee, India)
Nidhi Kathait (Indian Institute of Technology, Roorkee, India)
Amit Agarwal (Indian Institute of Technology Roorkee, Roorkee, India, India)

Crowd-sourced web survey for household travel diaries

PRESENTER: *Nidhi Kathait*

16:40 *Ariane Scheffer* (University of Luxembourg, Luxembourg)
Richard Connors (University of Leeds, UK)
Francesco Viti (University of Luxembourg, Luxembourg)

Dynamic Modal Split Incorporating Trip Chaining: A Parsimonious Approach to Mode-Specific Demand Estimation

PRESENTER: *Ariane Scheffer*

17:00 *Paolo Delle Site* (University Niccolò Cusano, Italy)

Properties of a Markov model representing the dynamics of mode choice adaptation to radical supply changes

17:20 *Lidia Montero* (Universitat Politècnica de Catalunya (UPC), Spain)
Javier Ortigosa (Autoritat Metropolitana del Transport (AMB), Spain)
Xavier Alarcón (Autoritat Metropolitana del Transport (AMB), Spain)
María Paz Linares (Universitat Politècnica de Catalunya (UPC), Spain)
Marta Cuatrecasas (Universitat Politècnica de Catalunya (UPC), Spain)
Jordi Cluet (Universitat Politècnica de Catalunya (UPC), Spain)

Demand model estimation from smartphone data. An application to assert new urbanistic development scenarios

PRESENTER: *Lidia Montero*

Thursday, September 9th

10:30-11:30 Session T1: Plenary Talk by Susana Sargento

CHAIR: *Margarida Coelho* (University of Aveiro, Portugal)

10:30 *Susana Sargento* (University of Aveiro, Portugal)

Aveiro as a living lab for intelligent mobility and Transportation

11:30-11:40 Coffee Break

11:40-13:20 Session TA1: Autonomous vehicle systems applications

CHAIR: *Dirk Mattfeld* (TU Braunschweig, Germany)

11:40 *Dinesh Cyril Selvaraj* (Politecnico di Torino, Italy)
Shailesh Hedge (Politecnico di Torino, Italy)
Nicola Amati (Politecnico di Torino, Italy)
Carla Fabiana Chiasserini (Politecnico di Torino, Italy)
Francesco Deflorio (Politecnico di Torino, Italy)

A Reinforcement Learning Approach For Efficient, Safe and Comfortable Driving

PRESENTER: *Dinesh Cyril Selvaraj*

12:00 *Bálint Kővári* (Budapest University of Technology and Economics, Hungary)
Tamás Tettamanti (Budapest University of Technology and Economics, Hungary)
Tamás Bécsi (Budapest University of Technology and Economics, Hungary)

Deep Reinforcement Learning based approach for Traffic Signal Control

PRESENTER: *Bálint Kővári*

12:20 *Sayed Faruque* (Edinburgh Napier University, UK)
Achille Fonzone (Edinburgh Napier University, UK)
Grigorios Fountas (Edinburgh Napier University, UK)

Explaining expected non-shared and shared use of driverless cars in Edinburgh

PRESENTER: *Sayed Faruque*

12:40 *Dimitris Tsiktsiris* (Information Technologies Institute, Center for Research and Technology Hellas, Greece)
Anastasios Vafeiadis (Information Technologies Institute, Center for Research and Technology Hellas, Greece)
Antonios Lalas (Information Technologies Institute, Center for Research and Technology Hellas, Greece)
Minas Dasygenis (Department of Electrical and Computer Engineering, University of Western Macedonia, Greece)
Konstantinos Votis (Information Technologies Institute, Centre for Research and Technology Hellas, Greece)
Dimitrios Tzovaras (Information Technologies Institute, Center for Research and Technology Hellas, Greece)

A Novel Image and Audio-based Artificial Intelligence Service for Security Applications in Autonomous Vehicles

PRESENTER: *Dimitris Tsiktsiris*

11:40-13:20 Session TA2: Public transport planning and operation 1

CHAIR:

António Lobo (Faculty of Engineering University of Porto, Portugal)

11:40 *Antonio Comi* (Università di Roma "Tor Vergata", Italy)
Mario Sassano (Università di Roma "Tor Vergata", Italy)
Alessio Valentini (Università di Roma "Tor Vergata", Italy)

Monitoring and controlling real-time bus services: a reinforcement learning procedure for eliminating bus bunching

PRESENTER: *Alessio Valentini*

12:00 *Ali Mahdi* (Budapest University of Technology and Economics, Hungary)
Jamil Hamadneh (Budapest University of Technology and Economics, Hungary)
Domokos Esztergár-Kiss (Budapest University of Technology and Economics, Hungary)

Modeling of Travel Behavior in Budapest: Leisure Travelers

PRESENTER: *Ali Mahdi*

12:20 *Nandan Dawda* (Sardar Vallabhbhai National Institute of Technology, India)
Romin Italiya (The Maharaja Sayajirao University of Baroda, Vadodara, India)
Shriniwas Arkatkar (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Gaurang Joshi (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)

Comprehending Users Perception towards Integrated Multimodal Public Transport System

PRESENTER: *Nandan Dawda*

12:40 *Fiilipe Almeida* (Faculty of Engineering University of Porto, Portugal)
António Lobo (Faculty of Engineering University of Porto, Portugal)
António Couto (Faculty of Engineering University of Porto, Portugal)
José Pedro Ferreira (Câmara Municipal do Porto, Portugal)
Sara Ferreira (Faculty of Engineering University of Porto, Portugal)

Urban factors influencing the vehicle speed of public transport

PRESENTER: *António Lobo*

11:40-13:20 Session TA3: Survey applications

CHAIR:

Vincenza Torrisi (University ofCatania, Italy)

11:40 *Cristian Poliziani* (DICAM - Department of Civil, Chemical, Environmental and Materials Engineering- University of Bologna, Italy, Italy)
Federico Rupi (DICAM - Department of Civil, Chemical, Environmental and Materials Engineering- University of Bologna, Italy, Italy)
Joerg Schweizer (DICAM - Department of Civil, Chemical, Environmental and Materials Engineering- University of Bologna, Italy, Italy)
Matteo Saracco (DICAM - Department of Civil, Chemical, Environmental and Materials Engineering- University of Bologna, Italy, Italy)
Daniele Capuano (DICAM - Department of Civil, Chemical, Environmental and Materials Engineering- University of Bologna, Italy, Italy)

Cyclist's waiting time estimation at intersections, a case study with GPS traces from Bologna

PRESENTER: *Cristian Poliziani*

12:00 *Mario Binetti* (Polytechnic University of Bari, Italy)
Salvatore Gabriele Pilone (Polytechnic University of Bari, Italy)
Achille Fonzone (Edinburgh Napier University, UK)
Leonardo Caggiani (Polytechnic University of Bari, Italy)

Describing the use of informal ridesharing in Scotland

PRESENTER: *Salvatore Gabriele Pilone*

12:20 *Tiziana Campisi* (University of Enna KORE, Italy)
Dario Ticali (University of Enna KORE, Italy)
Matteo Ignaccolo (university of catania, Italy)
Giovanni Tesoriere (University of Enna KORE, Italy)
Giuseppe Inturri (University of Catania, Italy)
Vincenza Torrisi (University ofCatania, Italy)

Factors influencing the implementation and deployment of e-vehicles in small cities: a preliminary two-dimensional statistical study on user acceptance

PRESENTER: *Vincenza Torrisi*

11:40-13:20 Session TA4: Sensors and automatic data collection methods

CHAIR:

Jorge Bandeira (University of Aveiro, Portugal)

11:40 *Dmitry Pavlyuk* (Transport and Telecommunication Institute, Latvia)
Ilya Jackson (Transport and Telecommunication Institute, Latvia)

Potential of vision-enhanced floating car data for urban traffic estimation

PRESENTER: *Dmitry Pavlyuk*

12:00 *Jorge Tavares* (INESC TEC, Portugal)
Joel Ribeiro (INESC TEC, Portugal)
Tânia Fontes (INESC TEC, Portugal)

Detection of vehicle-based operations from geolocation data

PRESENTER: *Joel Ribeiro*

12:20 *Sergio Di Martino* (University of Napoli "Federico II", Italy)
Luigi Libero Lucio Starace (University of Naples Federico II, Italy)

Vehicular Crowd-Sensing on Complex Urban Road Networks: A Case Study in the City of Porto

PRESENTER: *Luigi Libero Lucio Starace*

12:40 *Anitha Jacob* (Government Polytechnic College Chelakkara, India)
Jisha Akkara (Jyothi Engineering College Thrissur, India)
Jinesh Kj (Jyothi Engineering College Cheruthuruthy, India)
Jose Therattil (Jyothi Engineering College Cheruthuruthy, India)

Effect of Non-urban Two Lane Highway Geometry on Car and Bus Drivers – A Physiological Study

PRESENTER: *Jisha Akkara*

13:20-14:30 Lunch Break

14:30-16:10 Session TB1: Big data and machine learning in transportation

CHAIR:

Dmitry Pavlyuk (Transport and Telecommunication Institute, Latvia)

14:30 *José Carlos García-García* (Universidad de Castilla-La Mancha, Spain)
Ricardo García-Ródenas (Universidad de Castilla-La Mancha, Spain)
Julio Alberto López-Gómez (Universidad de Castilla-La Mancha, Spain)
José Ángel Martín-Baos (Universidad de Castilla-La Mancha, Spain)

A comparative study of machine learning, deep neural networks and random utility maximization models for travel mode choice modelling

PRESENTER: *José Ángel Martín-Baos*

14:50 *Hekmat Dabbas* (Technische Universität Braunschweig, Germany)
Bernhard Friedrich (Technische Universität Braunschweig, Germany)

Benchmarking machine learning algorithms by inferring transportation modes from unlabeled GPS data

PRESENTER: *Hekmat Dabbas*

15:10 *Thummaporn Nimpanomprasert* (Leuphana University of Lüneburg, Germany)
Lin Xie (Leuphana Universität Lüneburg, Germany)
Natalia Kliewer (Freie Universität Berlin, Germany)

Comparing two hybrid neural network models to predict real-world bus travel time

PRESENTER: *Lin Xie*

15:30 *Marialisa Nigro* (Università Roma Tre, Italy)
Marisdea Castiglione (Roma Tre University, Italy)
Fabio Maria Colasanti (Roma Tre university, Italy)
Rosita de Vincentis (Department of Engineering, Roma Tre University, Italy)
Carlo Liberto (ENEA, Italy)
Gaetano Valenti (ENEA, Italy)
Antonio Comi (University of Rome Tor Vergata, Italy)

Investigating Potential Electric Micro Mobility Demand in the city of Rome, Italy

PRESENTER: *Marisdea Castiglione*

14:30-16:10 Session TB2: Airport and air transport operations

CHAIR: *Antonio Antunes* (University of Coimbra, Portugal)

14:30 *Chiara Gargano* (Politecnico di Milano, Italy)
Paola Astegiano (One works Spa, Italy)
Francesca Sirtori (One Works Spa, Italy)
Roberto Maja (Politecnico di Milano, Italy)

Dynamic and static analysis of Airport capacity

PRESENTER: *Chiara Gargano*

14:50 *Mattia Cattaneo* (University of Bergamo, Italy)
Sebastian Birolini (University of Bergamo, Italy)
Paolo Malighetti (University of Bergamo, Italy)

A grid-based spatial model for airline service design in multi-airport systems

PRESENTER: *Mattia Cattaneo*

15:10 *Joey van Kempen* (TU Delft, Netherlands)
Bruno Santos (TU Delft, Netherlands)
Lennart Scherp (TU Delft, Netherlands)

A Data-drive Approach for Robust Cockpit Crew Training Scheduling

PRESENTER: *Bruno Santos*

14:30-16:10 Session TB3: Smart cities and smart mobility

CHAIR:

Jorge Bandeira (University of Aveiro, Portugal)

14:30 *Francesco Russo* (Mediterranea University of Reggio Calabria, Italy)
Antonio Comi (Dept. of Enterprise Engineering - University of Rome Tor Vergata, Italy)

Providing dynamic route advice for urban goods vehicles: the learning process enhanced by the emerging technologies

PRESENTER: *Francesco Russo*

14:50 *Elija Deineko* (German Aerospace Center, Germany)
Carina Thaller (German Aerospace Center, Germany)
Gernot Liedtke (German Aerospace Center, Germany)

Assessing Long-Term Impacts of Automation on Freight Transport and Logistics Networks: Large-Scale LRP Integrated in Microscopic Transport Simulation

PRESENTER: *Elija Deineko*

15:10 *Koichi Sabashi* (Kyoto University, Japan)
Boaz Ben Moshe (Ariel University, Israel)
Jan Dirk Schmoecker (Kyoto University, Japan)
Yuval Hadas (Bar-Ilan University, Israel)
Satoshi Nakao (Kyoto University, Japan)

Understanding Tourists' wayfinding during evacuation based on a Virtual Reality approach

PRESENTER: *Jan Dirk Schmoecker*

15:30 *Eloisa Macedo* (University of Aveiro, Portugal)
Ricardo Tomás (University of Aveiro, Portugal)
Paulo Fernandes (University of Aveiro, Portugal)
Margarida Coelho (University of Aveiro, Portugal)
Jorge M. Bandeira (University of Aveiro, Portugal)

Driving behaviour impacts in a mixed road traffic environment

PRESENTER: *Eloisa Macedo*

14:30-16:10 Session TB4: SS Toward new railway management systems

CHAIR:

Anna Lina Ruscelli (Scuola Superiore Sant'Anna, Italy)

14:30 *Matteo Petris* (Centre Inria Lille - Nord Europe, France)
Paola Pellegrini (Université Gustave Eiffel, France)
Raffaele Pesenti (Università Ca' Foscari Venezia, Italy)

Dynamic Decomposition of the Real-Time Railway Traffic Management Problem

PRESENTER: *Matteo Petris*

14:50 *Ricardo Garcia-Rodenas* (Universidad de Castilla-La Mancha, Spain)
Maria Luz López-García (Universidad de Castilla-La Mancha, Spain)
Luis Cadarso (Universidad Rey Juan Carlos, Spain)
Esteve Codina (Universidad Politécnica de Cataluña, Spain)

A Mixed-integer Linear Program for Real-time Train Platforming Management

PRESENTER: *Ricardo Garcia-Rodenas*

15:10 *Sarah Frisch* (Alpen-Adria-Universität Klagenfurt, Austria)
Philipp Hungerländer (Alpen-Adria-Universität Klagenfurt, Austria)
Anna Jellen (Alpen-Adria Universität Klagenfurt, Austria)

On a Real-World Railway Crew Scheduling Problem

PRESENTER: *Sarah Frisch*

15:30 *Gabriele Cecchetti* (Scuola Superiore S. Anna, Italy)
Anna Lina Ruscelli (Scuola Superiore Sant'Anna, Italy)
Piero Castoldi (Scuola Superiore Sant'Anna, Italy)
Cristian Ulianov (Newcastle University, UK)
Paul Hyde (Newcastle University, UK)
Luca Oneto (University of Genoa, Italy)
Peter Marton (University of Žilina, Slovakia)

Communication platform concept for virtual testing of novel applications for railway traffic management systems

PRESENTER: *Anna Lina Ruscelli*

16:10-16:20 Coffee Break

16:20-18:00 Session TC1: Energy consumption and emission modeling 1

CHAIR:

Ana Miranda (University of Aveiro, Portugal)

16:20 *Elisabete Ferreira* (University of Aveiro, Portugal)
Eloísa Macedo (University of Aveiro, Portugal)
Paulo Fernandes (University of Aveiro, Portugal)
Benham Bahmankhah (University of Aveiro, Portugal)
Margarida C. Coelho (University of Aveiro, Portugal)

Biplots of kinematic variables and pollutant emissions for an intercity corridor

PRESENTER: *Elisabete Ferreira*

16:40 *Sergio Batista* (Division of Engineering, New York University Abu Dhabi, UAE)
Mostafa Ameli (University Gustave Eiffel, COSYS, GRETTIA, Paris, France, France)
Monica Menendez (Division of Engineering, New York University Abu Dhabi, UAE)

On the characterization of eco-friendly paths for regional networks

PRESENTER: *Sergio Batista*

17:00 *Micael Rebelo* (Universidade de Aveiro, Portugal)
Sandra Rafael (Universidade de Aveiro, Portugal)
Jorge Bandeira (Universidade de Aveiro, Portugal)

Could drag coefficient institute platoons as the future of sustainable highway transportation? VSP sensibility analysis

PRESENTER: *Micael Rebelo*

17:20 *Paulo Fernandes* (University of Aveiro, Portugal)
Elisabete Ferreira (University of Aveiro, Portugal)
Paulo Amorim (University of Aveiro, Portugal)
Margarida Coelho (University of Aveiro, Portugal)

Comparison of different approaches for estimating tailpipe emissions in passenger cars

PRESENTER: *Paulo Fernandes*

16:20-18:00 Session TC2: Decision support analysis and operations research

CHAIR:

Joaquim Macedo (University of Aveiro, Portugal)

16:20 *Gianfranco Fancello* (DICAAR - Department of Civil Engineering, Environment and Architecture - University of Cagliari, Italy)
Patrizia Serra (DICAAR - Department of Civil Engineering, Environment and Architecture - University of Cagliari, Italy)
Valentina Aramu (DICAAR - Department of Civil Engineering, Environment and Architecture - University of Cagliari, Italy)
Daniel Mark Vitiello (DICAAR - Department of Civil Engineering, Environment and Architecture - University of Cagliari, Italy)

The competitive factors of Container terminals in Med area: an experimental analysis using APC and DEA

PRESENTER: *Gianfranco Fancello*

16:40 *Fatima Ezzahra Achamrah* (Ecole Centrale Casablanca, Ecole CentraleSupelec-Paris Saclay University, Morocco)
Fouad Riane (Ecole Centrale Casablanca, Ecole CentraleSupelec-Paris Saclay University, Morocco)
El-Houssaine Aghezzaf (Ghent University, Faculty of Engineering and Architecture, Belgium)

Bi-level programming for modeling inventory sharing in decentralized supply chains

PRESENTER: *Fatima Ezzahra Achamrah*

17:00 *Jacek Zak* (Poznan University of Technology, Poland)
Ali Alazzawi (Poznan University Of Technology, Poland)
Monika Sznajder (Poznan University Of Technology, Poland)

Lean/ Agile Management of the Copy Paper Supply Chain through the Optimization of the Fleet Composition Problem

PRESENTER: *Ali Alazzawi*

17:20 *Bruno Oliveira* (Faculty of Engineering, University of Porto, Portugal)
António Galrão Ramos (School of Engineering, Polytechnic Institute of Porto, Portugal)
Jorge Pinho de Sousa (Faculty of Engineering, University of Porto, Portugal)

A heuristic for two-echelon urban distribution systems

PRESENTER: *Bruno Oliveira*

16:20-18:00 Session TC3: Transportation planning and travel behaviour

CHAIR:

Behnam Bahmankhah (University of Aveiro, Portugal)

16:20 *Riccardo Ceccato* (University of Padova, Italy)
Gregorio Gecchele (ATRAKI S.r.l., Italy)
Riccardo Rossi (University of Padova, Italy)
Massimiliano Gastaldi (University of Padova, Italy)

Cost-effectiveness analysis of Origin-Destination matrices estimation using Floating Car Data. Experimental results from two real cases (abstract)

PRESENTER: *Riccardo Ceccato*

16:40 *Danyang Sun* (Ecole des Ponts ParisTech(ENPC), France)
Fabien Leurent (Ecole des Ponts ParisTech(ENPC), France)
Xiaoyan Xie (Ecole des Ponts ParisTech(ENPC), France)

Exploring jobs-housing spatial relations from vehicle trajectory data: A case study of the Paris Region

PRESENTER: *Danyang Sun*

17:00 *Farhan Shakeel* (Imob, Belgium)
Muhammad Adnan (Imob, Belgium)
Tom Bellemans (Imob, Belgium)

Joint-Activities Generation among Household Members using a Latent Class Model

PRESENTER: *Farhan Shakeel*

17:20 *Riccardo Rossi* (University of Padova, Italy)
Giulia De Cet (University of Padova, Italy)
Evelyn Gianfranchi (University of Granada, Spain)
Federico Orsini (University of Padova, Italy)
Massimiliano Gastaldi (University of Padova, Italy)

How precision teaching can shape drivers' lateral control over time

PRESENTER: *Giulia De Cet*

16:20-18:00 Session TC4: Dynamic network modeling

CHAIR:

Jean-Patrick Lebacque (UGE COSYS GRETTIA, France)

16:20 *Facundo Storani* (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)
Francesca Bruno (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)
Stefano de Luca (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)
Roberta Di Pace (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)
Chiara Fiori (Dipartimento di Ingegneria Civile, Università degli Studi di Salerno, Italy)
A within day dynamic network loading framework for large scale applications
PRESENTER: *Roberta Di Pace*

16:40 *Leila Heni* (National Engineering School of Monastir-ENIM, Tunisia)
Habib Haj-Salem (Gustave Eiffel University - COSYS/GRETTIA, France)
Jean-Patrick Lebacque (Gustave Eiffel University - COSYS/GRETTIA, France)
Khalifa Slimi (Higher Institute of Transport and Logistics, Sousse University, Tunisia)
A very large-scale traffic network modeling based on the integration of the Bi-dimensional and the GSOM Traffic Flow models
PRESENTER: *Leila Heni*

17:00 *Vladimir Shepelev* (South Ural State University (national research university), Russia)
Alexandr Glushkov (South Ural State University (national research university), Russia)
Irina Makarova (Kazan Federal University, Russia)
Aleksey Boyko (Kazan Federal University, Russia)
Clustering Urban Transport Network Junctions Using Convolutional Neural Networks and Fuzzy Logic Methods
PRESENTER: *Aleksey Boyko*

17:20 *Megan Khoshyaran* (Economics Traffic Clinic, France)
Jean-Patrick Lebacque (UGE COSYS GRETTIA, France)
A Macroscopic Model for Very Large Multimodal Networks Combining the GSOM and the Bidimensional Approach
PRESENTER: *Jean-Patrick Lebacque*

Friday, September 10th

10:00-11:40 Session FA1: Public transport planning and operation 2

CHAIR: *Bhouri Neila* (IFSTTAR, France)

10:00 *Christos Karolemeas* (National Technical University of Athens, Greece)
Stefanos Tsigdinos (National Technical University of Athens, Greece)
Efthimios Bakogiannis (National Technical University of Athens, Greece)
Alexandros Nikitas (Huddersfield Business School, University of Huddersfield, UK, UK)

Evaluating the suitability of urban road networks to facilitate autonomous buses

PRESENTER: *Stefanos Tsigdinos*

10:20 *Eloisa Macedo* (University of Aveiro, Portugal)
Joao Teixeira (Universidade de veiro, Portugal)
Matthias Gather (University of Applied Sciences Erfurt, Germany)
Claudia Hille (University of Applied Sciences Erfurt, Germany)
Marie-Luise Will (University of Applied Sciences Erfurt, Germany)
Niklas Fischer (University of Applied Sciences Erfurt, Germany)
Jorge M. Bandeira (University of Aveiro, Portugal)

Exploring relevant factors behind a MaaS scheme

PRESENTER: *Eloisa Macedo*

10:40 *Jingjing Yu* (University of Hamburg, Germany)
Stefan Voss (University of Hamburg, Germany)
Philip Cammin (University of Hamburg, Germany)

Cruise passenger-oriented evaluation system for the public transport of hinterland destinations

PRESENTER: *Jingjing Yu*

11:00 *Bruno Machado* (University of Aveiro, Portugal)
Amaro Sousa (University of Aveiro, Portugal)
Carina Pimentel (University of Aveiro, Portugal)

Operational planning of integrated urban freight logistics combining passenger and freight through mathematical programming

PRESENTER: *Bruno Machado*

10:00-11:40 Session FA2: Shared mobility

CHAIR:

Behnam Bahmankhah (University of Aveiro, Portugal)

10:00 *Sören Schleibaum* (Clausthal University of Technology, Germany)
Jörg P. Müller (Clausthal University of Technology, Germany)
Monika Sester (Leibniz University Hannover, Germany)

Enhancing Expressiveness of Models for Static Route-Free Estimation of Time of Arrival in Urban Environments

PRESENTER: *Sören Schleibaum*

10:20 *Dennis Harmann* (Institute of Transportation and Urban Engineering, TU Braunschweig, Germany)
Sefa Yilmaz-Niewerth (Institute of Transportation and Urban Engineering, TU Braunschweig, Germany)
Christina Jacob (Institute of Transportation and Urban Engineering, TU Braunschweig, Germany)

Methodological Distribution of Virtual Stops for Ridepooling

PRESENTER: *Dennis Harmann*

10:40 *Ester Lorente* (PTV Group, Spain)
Jaume Barceló (Tech. Univ. of Catalunya, Spain)
Esteve Codina (Universitat Politècnica de Catalunya, Spain)
Klaus Nökel (PTV Group, Germany)

An Intermodal Dispatcher for the Assignment of Public Transport and Ride Pooling Services

PRESENTER: *Ester Lorente*

11:00 *Andrea Chicco* (Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Italy)
Marco Diana (Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Italy)

Understanding micro-mobility usage patterns: a preliminary comparison between dockless bike sharing and e-scooters in the city of Turin (Italy)

PRESENTER: *Andrea Chicco*

10:00-11:40 Session FA3: Impact assessments and ex-post evaluation

CHAIR:

Joaquim Macedo (Universidade de Aveiro | Departamento de Engenharia Civil, Portugal)

10:00 *Gabriel Valença* (CERIS, Instituto Superior Técnico, Univeristy of Lisbon, Portugal)
Gabriel Stumpf (CERIS, Instituto Superior Técnico, University of Lisbon, Portugal)
Cláudia Soares (ISR-LARSyS, Instituto Superior Técnico, University of Lisbon, Portugal)
Filipe Moura (CERIS, Instituto Superior Técnico, University of Lisbon, Portugal)

Screening walkability violations through self-reported claims by smartphone detection: The case of Lisbon, Portugal

PRESENTER: *Gabriel Valença*

10:20 *Murli Naga* (NIT, Calicut, India)
Chintaman Bari (Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat, India)
Yogeshwar Navandar (NIT, Calicut, India)
Ashish Dhamaniya (Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat, India)
A Study on User Acceptable Road Pricing Policy for Toll Roads: A case of Eethakota, India
PRESENTER: *Murli Naga*

10:40 *Giulio Giorgione* (University of Luxembourg, Luxembourg)
Francesco Viti (University of Luxembourg, Luxembourg)
Assessing Equity in Car-sharing Systems: the case of Munich, Germany
PRESENTER: *Giulio Giorgione*

11:00 *Carlos Sampaio* (University of Aveiro, Portugal)
Margarida C. Coelho (University of Aveiro, Portugal)
Eloísa Macedo (University of Aveiro, Portugal)
Jorge M. Bandeira (University of Aveiro, Portugal)
Mapping of individual transportation traffic-related externalities in an intercity corridor
PRESENTER: *Carlos Sampaio*

11:40-11:50 Coffee Break
11:50-13:30 Session FB1: Energy consumption and emission modeling 2

CHAIR:

Eloisa Macedo (University of Aveiro, Portugal)

11:50 *Behnam Bahmankhah* (Universidade de Aveiro, Portugal)
Eloísa Macedo (Universidade de Aveiro, Portugal)
Paulo Fernandes (Universidade de Aveiro, Portugal)
Margarida Coelho (Universidade de Aveiro, Portugal)

Micro driving behavior in different roundabout layouts: Pollutant emissions, vehicular jerk and traffic conflicts analysis

PRESENTER: *Behnam Bahmankhah*

12:10 *Eloisa Macedo* (University of Aveiro, Portugal)
Antonio Pascale (University of Aveiro, Portugal)
Elisabete Ferreira (University of Aveiro, Portugal)
Claudio Guarnaccia (University of Salerno, Italy)
Margarida Coelho (University of Aveiro, Portugal)

Experimental evaluation of gear shift and internal-combustion engine variables on fuel consumption, noise and pollutant emissions

PRESENTER: *Eloisa Macedo*

12:30 *Ihab Kaddoura* (Technische Universität Berlin, Germany)
Ricardo Ewert (Technische Universität Berlin, Germany)
Kai Martins-Turner (Technische Universität Berlin, Germany)

Exhaust and non-exhaust emissions from today's and future road transport: A simulation-based quantification for Berlin

PRESENTER: *Kai Martins-Turner*

12:50 *Ana Paula Valente de Jesus* (Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT), University of Aveiro, Portugal)
Marta Ferreira Dias (Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP), DEGEIT, University of Aveiro, Portugal)
Margarida Coelho (Department of Mechanical Engineering, Centre for Mechanical Technology and Automation, University of Aveiro, Portugal)

LPG vehicles' adoption in Portugal: lessons for new AFVs diffusion

PRESENTER: *Ana Paula Valente de Jesus*

11:50-13:30 Session FB2: Simulation and optimization of transportation systems

CHAIR: *Paulo Fernandes* (University of Aveiro, Portugal)

11:50 *Thibaut Barbet* (Ecole des Ponts ParisTech, France)
Amine Nacer-Weill (Ecole des Ponts ParisTech, France)
Changtao Yang (Ecole des Ponts ParisTech, France)
Juste Raimbault (University College London, UK)

An agent-based model for modal shift in public transport

PRESENTER: *Juste Raimbault*

12:10 *Lasse Bienzeisler* (TU Braunschweig, Germany)
Torben Lelke (TU Braunschweig, Germany)
Oskar Wage (Leibniz Universität Hannover, Germany)
Lena-Marie Huck (TU Braunschweig, Germany)
Bernhard Friedrich (TU Braunschweig, Germany)

Uncertainty and Variability Analysis of Agent-Based Transport Models

PRESENTER: *Torben Lelke*

12:30 *Victoria María Orlando* (CONICET, Argentina)
Enrique Gabriel Baquela (GISOI, Argentina)
Neila Bhouri (IFSTTAR/COSYS/GRETTIA, France)
Pablo Andrés Lotito (CONICET, Argentina)

Analytical and simulation-based estimation of public transport demand

PRESENTER: *Neila Bhouri*

12:50 *Jamil Hamadneh* (Budapest University of Technology and Economics, Hungary)
Domokos Esztergár-Kiss (Budapest University of Technology and Economics, Hungary)

The Influence of Spent Time at Park-and-Ride Facility on the Travel Behavior of Workers and Shoppers

PRESENTER: *Jamil Hamadneh*

11:50-13:30 Session FB3: The future of mobility after COVID-19 2
CHAIR: *Margarida Coelho* (University of Aveiro, Portugal)

11:50 *Stefania Boglietti* (Università degli Studi di Brescia, Italy)
Andrea Ghirardi (Università degli Studi di Brescia, Italy)
Chiara Turri Zanoni (Università degli Studi di Brescia, Italy)
Roberto Ventura (Università degli Studi di Brescia, Italy)
Benedetto Barabino (Università degli Studi di Brescia, Italy)
Giulio Maternini (Università degli Studi di Brescia, Italy)
David Vetturi (Università degli Studi di Brescia, Italy)

First comparison between e-Powered Personal Mobility Vehicle's and bike's dynamics

PRESENTER: *Roberto Ventura*

12:10 *Tatiana Bruce da Silva* (IN+ Center for Innovation, Technology and Policy Research, LARSys, Instituto Superior Técnico, Universidade de Lisboa, Portugal)
Patricia Baptista (IN+ Center for Innovation, Technology and Policy Research, LARSys, Assoc. para o desenv. do IST, Universidade de Lisboa, Portugal)
Carlos Augusto Santos Silva (IN+ Center for Innovation, Technology and Policy Research, LARSys, Instituto Superior Técnico, Universidade de Lisboa, Portugal)
Luan Santos (Production Engineering Program (PEP/COPPE/UFRJ), Federal University of Rio de Janeiro, Brazil)

The use of alternative fuels to mitigate climate change impacts in the transportation sector in Rio de Janeiro, Brazil

PRESENTER: *Tatiana Bruce da Silva*

12:30 *Torran Semple* (Edinburgh Napier University, UK)
Grigorios Fountas (Edinburgh Napier University, UK)
Achille Fonzone (Edinburgh Napier University, UK)

Demographic Factors Affecting the Rate of Outdoor Exercise Trips During the COVID-19 Lockdown

PRESENTER: *Torran Semple*

12:50 *Janina Scheelhaase* (German Aerospace Center (DLR), Germany)
David Ennen (German Aerospace Center (DLR), Germany)
Benjamin Frieske (German Aerospace Center (DLR), Germany)
Klaus Lütjens (German Aerospace Center (DLR), Germany)
Sven Maertens (German Aerospace Center (DLR), Germany)
Florian Wozny (German Aerospace Center (DLR), Germany)

How to support the economic recovery of aviation after COVID-19?

PRESENTER: *Janina Scheelhaase*

13:30-14:30 Lunch Break

14:30-15:30 Session F1: Plenary Talk by Asad Khattak

CHAIR: *Margarida Coelho* (University of Aveiro, Portugal)

14:30 *Asad Khattak* (University of Tennessee, United States)

A bumpy road to driverless cars: Challenges and opportunities

15:30-15:40 Coffee Break

15:40-17:20 Session FC1: Safety and security

CHAIR: *António Lobo* (Faculty of Engineering University of Porto, Portugal)

15:40 *Aninda Bijoy Paul* (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Jaydip Goyani (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Shriniwas Arkatkar (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Gaurang Joshi (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)

Modeling the Effect of Motorized Two-Wheelers and Autorickshaws on Crossing Conflicts at Urban Unsignalized T-Intersections in India using Surrogate Safety Measures

PRESENTER: *Aninda Bijoy Paul*

16:00 *Yawar Ali* (Indian Institute of Technology, Delhi, India)
Ritvik Chauhan (Sardar Vallabhai National institute of Technology - Surat, India)
Shriniwas Arkatkar (SV NATIONAL INSTITUTE OF TECHNOLOGY, India)
Ashish Dhamaniya (SVNIT SURAT, India)

Application of Empirical & Simulated Vehicle Trajectories in Risk Assessment at Signalized Intersection

PRESENTER: *Ritvik Chauhan*

16:20 *Shawon Aziz* (School of Planning and Architecture New Delhi, India, India)
Dr. Sewa Ram (School of Planning and Architecture New Delhi, India)

A Meta-analysis of the methodologies practiced worldwide for the identification of road accident black spots

PRESENTER: *Shawon Aziz*

16:40 *Antonio Comi* (Dept. of Enterprise Engineering - University of Rome "Tor Vergata", Italy)
Antonio Polimeni (Dept. of Enterprise Engineering - University of Rome "Tor Vergata", Italy)
Chiara Balsamo (Dept. of Enterprise Engineering - University of Rome "Tor Vergata", Italy)

Road Accident Analysis with Data Mining Approach: evidence from Rome

PRESENTER: *Antonio Polimeni*

15:40-17:20 Session FC2: Transport Operations and Performance

CHAIR:

Paulo Fernandes (University of Aveiro, Portugal)

15:40 *Gonçalo Santos* (University of Coimbra, Portugal)
Sebastian Birolini (University of Bergamo, Italy)
Gonçalo Correia (Delft University of Technology, Netherlands)

A three-dimensional flow-based model to design shared autonomous vehicle system's fleet size, charging facilities, and vehicle operations

PRESENTER: *Gonçalo Santos*

15:55 *Sebastian Birolini* (Department of Management, Information and Production Engineering, University of Bergamo, Italy, Italy)
Emanuele Besana (Department of Management, Information and Production Engineering, University of Bergamo, Italy, Italy)
Mattia Cattaneo (Department of Management, Information and Production Engineering, University of Bergamo, Italy, Italy)
Renato Redondi (Department of Management, Information and Production Engineering, University of Bergamo, Italy, Italy)
Jose M Sallan (Universitat Politecnica de Catalunya, ESEIAAT, Spain, Italy)

A Tactical Integrated Connection Planning and Passenger Allocation Model for Low-Cost Carriers

PRESENTER: *Sebastian Birolini*

16:10 *Anna Ibraeva* (University of Coimbra, Portugal)
Bert van Wee (TU Delft, Netherlands)
Gonçalo Homem de Almeida Correia (TU Delft, Netherlands)
António Pais Antunes (University of Coimbra, Portugal)

Changes in car use resulting from a TOD-type project: longitudinal macro-analysis of the case of Metro do Porto (Portugal)

PRESENTER: *Anna Ibraeva*

16:25 *Bianca Pascariu* (Roma Tre University, Italy)
Marcella Samà (Roma Tre University, Italy)
Paola Pellegrini (Univ. Lille Nord de France, France)
Andrea D'Ariano (Roma Tre University, Italy)
Dario Pacciarelli (Roma Tre University, Italy)
Joaquin Rodriguez (Univ. Lille Nord de France, France)

Performance evaluation of an ant colony optimization for the train route selection problem

PRESENTER: *Bianca Pascariu*

16:40 *Diana Jorge* (Universidade de Coimbra, Portugal)
António Pais Antunes (Universidade de Coimbra, Portugal)
Tânia Rodrigues Pereira Ramos (Instituto Superior Técnico, Portugal)
Ana Paula Barbosa-Póvoa (Instituto Superior Técnico, Portugal)

Solving Large-size Smart Waste Collection Problems with Workload Constraints through a Hybrid Metaheuristic

PRESENTER: *Diana Jorge*

16:55 *Reza Mehdizadeh Anvigh* (University of Aveiro, Department of Civil Engineering, Portugal)
José Figueiredo Silva (University of Aveiro, Department of Environment and Planning, Portugal)
Joaquim Macedo (University of Aveiro, Department of Civil Engineering, Portugal)

Assessment of changing existing drainages to smart drainages by its effects' evaluation on traffic parameters in critical rainy conditions: A fuzzy-Delphi criterion prioritization.

PRESENTER: *Reza Mehdizadeh Anvigh*

15:40-17:20 Session FC3: SS Smart cities and Mobility as a Service
CHAIRS: *Jorge Bandeira* (University of Aveiro, Portugal)
Eloisa Macedo (University of Aveiro, Portugal)

15:40 *Domokos Esztergár-Kiss* (Budapest University of Technology and Economics, Hungary)
Tamás Kerényi (Budapest University of Technology and Economics, Hungary)

Definition of mobility packages by using city specific parameters and user groups: a case study

PRESENTER: *Domokos Esztergár-Kiss*

16:00 *Marc Hasselwander* (University of Coimbra, Portugal)
Joao Bigotte (University of Coimbra, Portugal)

Transport Authorities and Innovation: Understanding Barriers for MaaS Implementation in the Global South

PRESENTER: *Marc Hasselwander*

16:20 *Carolina Cisterna* (university of Luxembourg, Luxembourg)
Fiore Tinessa (university of Naples, Italy)
Francesco Viti (university of Luxembourg, Luxembourg)
Federico Bigi (university of Luxembourg, Luxembourg)

Analysis of MaaS membership attributes: an agent-based approach

PRESENTER: *Carolina Cisterna*

16:40 *Jorge Bandeira* (Centre for Mechanical Technology and Automation, Dept. of Mechanical Engineering, University of Aveiro, Portugal)
Eloísa Macedo (Centre for Mechanical Technology and Automation, Dept. of Mechanical Engineering, University of Aveiro, Portugal)
João Teixeira (Centre for Mechanical Technology and Automation, Dept. of Mechanical Engineering, University of Aveiro, Portugal)
Niklas Fischer (Institute of Transport and Spatial Planning, University of Applied Sciences Erfurt, Germany)
Gennaro Ciccarelli (TTS Italia, Italy)
Mihai Niculescu (ITS Romania, Romania)
Matthias Gather (Institute of Transport and Spatial Planning, University of Applied Sciences Erfurt, Germany)

Multidimensional Indicator of MaaS platforms performance

PRESENTER: *Jorge Bandeira*

17:20-18:00 Session CS: Closing Session

Abstracts

Defining mobility packages by using city specific parameters and user groups: a case study

Domokos Esztergár-Kiss[a,]*, Tamás Kerényi[a]

[a] *Budapest University of Technology and Economics, Faculty of Transportation Engineering and Vehicle Engineering, 1111 Budapest, Műegyetem rkp. 3., Hungary*

Abstract | Paper #1

By taking city specific parameters into account, this paper explains the definition of mobility packages for users in the Mobility as a Service framework. Therefore, a method that creates package levels for various transportation modes in cities is elaborated. The method involves urban characteristics, the aspects of city structure, environmental awareness, modal split, and financial features, as well. Mobility packages are created for public transport, bike-sharing, car-sharing, and taxi. In order to create more diverse mobility packages, the preferences of user groups are considered, and special packages are prepared for travelers. The method is tested with a short survey in Budapest, Hungary. The results show that the workers' package is similar to the basic package, while in case of students and pensioners, the service level of car-sharing and taxi is lowered based on the revealed usage requirements.

Keywords: Mobility as a Service; mobility packages; city parameters; user groups.

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Potential of vision-enhanced floating car data for urban traffic estimation

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Abstract | Paper #2

Floating car data (FCD) have recently become a popular tool of urban traffic engineering. Conventional FCD contains a series of probe cars' timestamped locations and are used to estimate traffic speeds and travel times and identify congestions. In this study, we propose the enhancement of conventional FCD with car vision information: traffic measurements, collected by video cameras or lidars, installed on the probe cars. Given the limited penetration rates of probe cars, such vision information can significantly improve the accuracy of traffic estimation. Our experimental study is based on two simulated vision-enhanced FCD data sets: sensor-based real-world traffic data set with simulated observability and a simulation model with vision-equipped probe cars. We estimate the potential of vision-enhanced FCD for urban traffic flow estimation for different probe car penetration rates. A recently proposed temporal geometric matrix completion algorithm is utilized for traffic speed estimation given incomplete spatiotemporal traffic flow information. Empirical results show that the availability of vision-enhanced FCD leads to significant improvement: the coverage of 6% of spatiotemporal slots by probe cars gives reasonable, and the coverage of 9% – nearly optimal accuracy of traffic speed estimation. Thus, obtained experimental results support our hypothesis about the utility of vision-enhanced FCD to improve traffic estimation accuracy and discover related problems and limitations.

Keywords: Data fusion; spatiotemporal models; geometric matrix completion; traffic forecasting; missing data imputation.

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First experimental comparison between e-kick scooters and e-bike's vibrational dynamics

Stefania Boglietti[a], Andrea Ghirardi[a], Chiara Turri Zanoni[b], Roberto Ventura[a,*] , Benedetto Barabino[a], Giulio Maternini[a], David Vetturi[b]

[a] *Department of Civil, Environment, Land and Architecture Engineering and Mathematics (DICATAM), University of Brescia, Via Branze 43, Brescia 25123, Italy*

[b] *Department of Mechanical and Industrial Engineering (DIMI), University of Brescia, Via Branze 30, Brescia 25123, Italy*

Abstract | Paper #3

Being the most popular among electrical-powered Personal micro Mobility Vehicles (e-PMVs), e-kick scooters have recently been equated with bikes (or e-bikes) by some European regulations. However, the similarity between e-kick scooters and bikes could be somehow questionable, due to their different characteristics. While the literature has studied the dynamic behaviour of bikes and e-kick scooters separately and has made some theoretical comparisons based on analytical models, no study has compared these two vehicles using experimental data. This paper covers this gap by evaluating the vibrational response (which can affect users' comfort during a ride) of e-kick scooters and bikes at the pavement irregularities, using real data. First, kinematic data on accelerations were collected by two Inertial Measurements Units (IMUs) and then analysed adopting the basic vibration evaluation method proposed by ISO 2631-1. Then, several Z-test between the means of the vibrational magnitudes and two multiple regression analyses were performed: the first to investigate whether significative differences exist between the vibration magnitude acting e-kick scooter and e-bike, and the second to understand which factors affects this vibrational magnitude for each vehicle. A significant difference emerged between these vehicles as the mean of the vibration magnitudes measured on the e-kick scooter was higher than that measured on the e-bike. Hence, e-kick scooters appeared to be globally less comfortable than the e-bikes. Furthermore, the vibration magnitudes acting on the e-kick scooter appeared to be more influenced by the path, user, and speed factors than those acting on the e-bike. This analysis revealed insights that could challenge the recent European regulations that equated e-kick scooters with bikes. Moreover, the results could help public administrations in regulating the circulation of e-kick scooters along city paths.

Keywords: e-kick scooters; e-bikes; comfort; vibrations; frequency response; ISO 2631-1.

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Improving commuter train punctuality using lead indicators

Ida Kristoffersson[a,*], Carl-William Palmqvist[b]

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[b] *Lund University, Lund, Sweden*

Abstract | Paper #4

Train delays are often monitored using lag indicators of achieved punctuality levels, but indicators can also be used proactively as lead indicators to help reach a certain level of punctuality. In this paper, two lead indicators – the share of delayed dwell times and the share of delayed run times – are formulated and tested on Swedish commuter train data for the years 2001-2020. Results show that in general a larger share of dwell times are delayed compared to run times, and that the differences between metropolitan areas are substantial. Furthermore, results indicate that no more than 25 % of dwell times and 3 % of run times can be delayed if operations are to reach 95 % overall punctuality. Results also show that both dwell time and run time delays have decreased substantially during 2020, at least partially due to the lower ridership during the pandemic.

Keywords: Punctuality; commuter train; delays; monitoring; indicators; key performance indicators.

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Enhancing expressiveness of models for static route-free estimation of time of arrival in urban environments

Sören Schleibaum[a,*], Jörg P. Müller [a], Monika Sester[b]

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[b] *Institute of Cartography and Geoinformatics, Leibniz University Hannover, 30167, Hannover, Germany*

Abstract | Paper #5

Scheduling of taxis can reduce cost and potentially decreases CO_2 emissions. However, with a rising number of taxis or travel requests, the time for computing schedules increases. A promising alternative is to estimate trip durations based on historical trip data without calculating routes. Based on an analysis of the state of the art, in this paper we identify and investigate two limitations of route-free Estimated Time of Arrival (ETA) models: First, the overall set of features considered by state of-the-art models is limited. For instance, some potential relevant features (such as weather-related ones) are not considered at all. Also, different models use different sets of features, such as the linear distance between pickup and dropoff location, in diverse and partly inconsistent ways. For those features generally considered, we find different representations, e.g., for trip start time. Second, while discretization of degree-based coordinates for pickup/dropoff locations via spatial binning is very common in state-of-the-art ETA models, the chosen grid cell sizes vary widely and apparently arbitrarily. The contribution of this paper is threefold: First, we propose to enhance route-free ETA models by additional features and investigate the influence of the feature representation on the prediction precision based on a benchmark dataset. Second, we compare different grid cell topologies and sizes as regards their effect on the prediction precision of ETA. Third, we construct and evaluate three types of Machine Learning (ML) models. Our findings indicate that the results outperform state-of-the-art static route-free ETA estimation models.

Keywords: Estimated time of arrival; travel time estimation; taxi fleet management; machine learning.

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Methodological distribution of virtual stops for ridepooling

Dennis Harmann[a,*], Sefa Yilmaz-Niewerth[a], Christina Jacob[a]

[a] *Technische Universität Braunschweig, Institute of Transportation and Urban Engineering, Hermann-Blenk-Str. 42, 38108 Braunschweig , Germany*

Abstract | Paper #6

In recent years, an increasing number of shared and on-demand mobility services were deployed in several cities. Most of these services utilize virtual stops as pick-up and drop-off points due to a better service efficiency compared to a door-to-door operating policy. Virtual stops do not include any physical element of a conventional bus stop. Therefore, they are only visible on a mobile device with the proper application. Emerging from the flexibility of distributing virtual stops, strategic considerations are essential to optimize the service quality and usability. This work introduces three approaches to identify locations for virtual stops, followed by methodological strategies. Different characteristics are obtained by applying these methods, assessed by a comprehensive utility analysis regarding users' and providers' perspectives. The evaluation shows that for users, virtual stops located at streetlamps are the most advantageous. In contrast, providers benefit from virtual stops at intersections, mainly due to better routing efficiency.

Keywords: Ridesharing; shared mobility; on-demand mobility; meeting-points; stop-distribution.

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Uncertainty analysis of autonomous delivery device operations

Clément Lemardelé[a,*], Miquel Estrada[a], Laia Pagès[b]

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Abstract | Paper #7

Autonomous delivery devices (ADDs) are medium-size autonomous vehicles used for urban logistics operations. They are expected to highly improve the efficiency of last-mile distribution in dense urban environments in future years. However, the magnitude of the operation cost reduction greatly depends on some operation variables of the robots. The main objective of this paper is to quantify the ADD operation cost uncertainty depending on the stochastic behavior of given input variables. First, ADD operations are modelled using the continuous approximation methodology. These mathematical formulations relate some ADD operation input parameters – mainly the volume capacity of the robot, its commercial speed, its unit operations costs, and its maximum range – and give an estimation of the carrier's last-mile operation costs. Then, an uncertainty analysis based on the Monte Carlo approach is done. To the best of our knowledge, this is completely novel in the field of ADD operations assessment. Instead of working with deterministic values, some probability distribution functions (PDFs) are assumed for the different input parameters. The ADD total operation costs consequently follow their own PDF that is obtained via the Monte Carlo process. The model uncertainty analysis indicates that ADDs would, on average, reduce last-mile operation costs by 8% for a demand density around 40 receivers/km^2.

Keywords: Last-mile logistics; autonomous delivery robot; continuous approximation; Monte Carlo; uncertainty analysis.

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Heterogeneous fleet sizing for on-demand transport in mixed automated and non-automated urban areas

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Abstract | Paper #8

The era of intelligent transportation with automated vehicles (AVs) is coming. Nonetheless, the transition to this system will be a gradual process. On the one hand, some zones in the city may be dedicated to AVs with a fully intelligent traffic management system geared toward high performance. On the other hand, automated and conventional vehicles may have to be allowed to drive in the remaining zones of the urban network in a transition stage. In this paper, we consider a situation where AVs are deployed by a taxi operating company to serve door-to-door travel requests. Facing this transition period, a strategic flow-based vehicle routing model is developed to determine the optimal fleet size of automated and conventional taxis as a function of the gradually increasing coverage of the AVs-only dedicated area. Traffic congestion is considered through flow-dependent travel times. Two taxi company service regimes are tested: the User Preference Mode (UPM) and the System Profit Mode (SPM). In the UPM, passengers can choose their preferred vehicle type according to their preference. In the SPM, the taxi company will take charge of the vehicle assignment to maximize the system profit. The developed model formulations are applied to a case study of a large toy network. The results give insight into the performance of the heterogeneous taxi system on a hybrid network. Strategies are presented on how to adjust the fleet size of automated and conventional taxis to get the best system profit while satisfying the mobility demand. The SPM can bring more profit to the operating company by reducing the detour and relocation cost of taxis, reducing the salaries for drivers through a bigger fleet size of AVs, and reducing the delay penalty, compared to the UPM.

Keywords: Vehicle routing problem; automated vehicles; mixed-driving environment; on-demand mobility service; traffic congestion; AVs-only zone.

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Decomposition of the vehicle routing problem with time windows on the time dimension

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Abstract | Paper #10

The *Vehicle Routing Problem with Time Windows* (VRPTW) asks for the optimal set of routes to be performed by a fleet of vehicles to serve a set of customers within their assigned time windows. In this work, we propose a matheuristic for the VRPTW which utilizes the sub-problem constituted by optimizing only a selected time window of the VRPTW whereas the tours outside of this time window are regarded as fixed. We call this problem the *Single Time Window Vehicle Routing Problem* (STWVRP). For applying the STWVRP, we must assume that several customers are assigned to the same time window, i.e., the number of time windows is much smaller than the number of customers. An exact problem description of the STWVRP is given in the form of a Mixed-Integer Linear Programming formulation. We apply this exact formulation within a matheuristic for the VRPTW. The paper concludes with extensive computational experiments.

Keywords: Vehicle routing problem with time windows; mixed-integer linear programming; matheuristic.

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Using supervised machine learning to predict the status of road signs

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Abstract | Paper #12

There is no data collected and saved about road signs in Sweden and the status for these signs is unknown. Furthermore, the status of the sign colors, the quality of the sign, the type of the retroreflection material, and age of the road signs are unknown. Therefore, it is difficult to know the status (approved or not) of any road sign without performing a costly inspection. The aim of this study is to predict the status of the road signs mounted on the Swedish roads by using supervised machine learning. This study investigates the effect of using principal component analysis (PCA) and data scaling on the accuracy of the prediction. The data were prepared before using then scaled using two methods which are the normalization and the standardization. The three algorithms that tested in this study are Random Forest, Artificial Neural Network (ANN), and Support Vector Machines (SVM). They are invoked to predict the status of the road signs. The algorithms exhibited overall high predicting accuracy (98%), high precision (98%), high recall (98%), and high F1 scores (98%). Random forest showed the best performance with 4 PC components on the normalized data with a highest accuracy of 98%. Using PCA showed different impacts on the performance of different techniques. In the case of ANN, invoking PCA improves the accuracy, while for SVM the accuracy decreases when PCA is used. On other hand, PCA has no effect on the accuracy of the random forest model when scaling is invoked. The effect of the data scaling using normalization and standardization is also investigated in this study, and it is noticed that scaling of the data increases the accuracy of the prediction for all the three models (ANN, SVM and Random Forest). Furthermore, better accuracy is achieved when the standardization is invoked compared with normalization.

Keywords: Road signs; supervised machine learning, principal component analysis, prediction.

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A reinforcement learning approach for efficient, safe and comfortable driving

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Abstract | Paper #14

The remarkable advancements in their sensing, computing and communication capabilities make vehicles and road infrastructures able to generate and collect an enormous amount of information, which fosters the development of data-driven models for context-aware decision making. In this work, we leverage Deep Reinforcement Learning (DRL) and develop an adaptive cruise control (ACC) application that aims at ensuring a safe, comfortable, and efficient driving experience. Our DRL framework accounts for, and properly weights, the different environmental conditions playing a role in adaptive cruise control, including vehicle stability. We evaluate and compare the performance of the proposed framework against standard ACC, by integrating it in the CoMoVe framework, which realistically represents vehicle communication, mobility, and vehicle dynamics. The results show that our solution provides very good performance in terms of safety, comfort and vehicle stability, under different traffic scenarios. Furthermore, they highlight the important role of vehicle connectivity in gathering additional data on the surrounding environment, hence improving the performance of the DRL scheme.

Keywords: Machine learning-based applications for autonomous vehicles; connected vehicles; vehicle dynamics; adaptive cruise control.

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Bi-level programming for modeling inventory sharing in decentralized supply chains

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Abstract | Paper #15

This paper deals with inventory sharing and routing in the context of decentralized supply chains. The supply chain considered in this paper consists of a single manufacturer distributing its products through a network of independents Points of Sale (POS). The problem is modeled as a 1-leader - n-followers Stackelberg game. A new mixed-integer bi-level program is developed, in which the manufacturer decides first on inventory levels and the distribution routes, considering each follower's (POS) response function that minimizes the follower's own cost. A trade-off solution to manage conflict of interests between the parties involved in the supply chain is also proposed. To solve the mixed-integer bi-level program an original hybrid Genetic Algorithm coupled with deep reinforcement learning is developed and used to solve a set of large-size instances. The gap analysis shows that the proposed hybrid algorithm performs quite well and that inventory sharing allows the network to improve its service level.

Keywords: Transshipment; vehicle routing problem; decentralized supply chain, bi-level optimization; metaheuristic ; deep reinforcement learning.

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The use of alternative fuels to mitigate climate change impacts in the transportation sector in Rio de Janeiro, Brazil

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Abstract | Paper #16

This paper assesses how increased use of alternative fuels (ethanol and electricity) contributes to reduce carbon dioxide (CO_2) emissions of light-duty vehicles in Rio Janeiro state (RJ), Brazil, a region of a developing country – most such analysis focus at the aggregate country level. Using an energy systems model (OSeMOSYS), we analyze scenarios that consider an improvement in the quality of the ethanol (in gCO_2eq/MJ) consumed in RJ due to the development of the RenovaBio program, greater uptake of electric vehicles, carbon pricing, and a combination of these policies. We also analyze a scenario with the new RenovaBio targets, which the Brazilian government scaled down because of the COVID-19 pandemic. We find that electric vehicles are the most cost-effective policy to reduce CO_2 emissions (by 1.9%) when no carbon pricing is considered. When it is, however, CO_2 emissions are reduced the most (between 47% and 56%), regardless of the vehicle technology being used, but it is the costlier policy (between 5.4% and 15.3%). In scenarios with carbon pricing, flex-fuel vehicles switch to ethanol, an important result for a region where this technology already dominates the vehicle fleet. Greater uptake of electric vehicles leads to lower overall transportation costs (by 2.5%), but when a CO_2 price is considered, because the electricity system still relies on fossil fuels, the reduction in CO_2 emissions is compromised. In such a setting, increased ethanol quality reduces carbon emissions more than electric vehicle adoption (by 16%). The RenovaBio targets' reduction due to the COVID-19 pandemic, however, jeopardizes this result. Such findings convey important evidence to policymakers and the research community: decarbonization of transportation in a region of a developing country, where economic resources are scarcer, can start before electric vehicles become affordable by increasing and maintaining continued access to lower-carbon fuels.

Keywords: Alternative fuels; ethanol; electric vehicles; climate change mitigation; COVID-19; Rio de Janeiro state.

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A comparative study of machine learning, deep neural networks and random utility maximization models for travel mode choice modelling

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Abstract | Paper #18

Traditionally, Random Utility Maximization (RUM) models have been widely applied to travel mode choice modelling. Currently, Machine Learning (ML) models are being applied as an alternative to RUM models, since they provide better results in terms of prediction capability and they can manage large volumes of data. In this paper, a comprehensive comparison between classic RUM models and ML models, including single and ensemble classifiers as well as Deep Neural Networks (DNNs), is provided in order to assess systematically the performance of different models over two different datasets which have different sizes and nature of data. Numerical experiments show Random Forest (RF) is the best classifier in terms of accuracy index and the computational cost to train the model.

Keywords: Random Utility Maximization (RUM) models; Deep Neural Networks (DNN); Machine Learning (ML) models; travel behaviour.

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Sociodemographic factors affecting outdoor exercise trips during the COVID-19 lockdown

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Abstract | Paper #19

We employ a state-of-the-art modelling framework to determine the significant factors affecting rates of outdoor exercise trips during Scotland's COVID-19 lockdown, using data from public surveys conducted by Transport Scotland. The random parameters ordered probit modelling approach is used for its ability to account for the potential effect of unobserved heterogeneity stemming from explanatory variables. The framework is extended further to also allow for detection of heterogeneity among the means of random parameters. We show that various sociodemographic factors (relating mainly to household social grade, employment status and disability) significantly influenced the frequency at which outdoor exercise trips were made during lockdown. Specifically, those who are self-employed, those from a social DE household (the household's main income earner is employed in a manual occupation or is unemployed) and those with a health problem or disability, were shown to be significantly more likely to complete no outdoor exercise during lockdown, and therefore, these groups are at greater risk of the associated mental and physical illnesses. Model results are linked to issues surrounding transport equity, as personal vehicle ownership was found to significantly affect the rate of outdoor exercise trips made by disabled individuals. Policy implications are discussed with regards to mitigating the effects of the pandemic on the future health state of groups exhibiting low exercise levels.

Keywords: COVID-19; exercise; public health; random parameters ordered probit; unobserved heterogeneity.

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Comparing different approaches for estimating tailpipe emissions in passenger cars

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Abstract | Paper #21

Vehicles with Internal Combustion Engines (ICE) still represent the most prevalent form of road transport in Europe, being an important source of both greenhouse gases and air pollutants. In response to these concerns, Portable Emission Measurement Systems (PEMS) have been widely used by researchers to measure tailpipe emissions and to detect cheating of emissions regulations by manufacturers. This paper introduces four different approaches to estimate carbon dioxide (CO_2) and nitrogen oxides (NOx) emissions for these vehicles. These approaches were based on: i) speed intervals (≤50 km.h^{-1}, 50-90 km.h^{-1}, ≥ 90 km.h^{-1}); ii) internally observable variables (IOVs); iii) vehicle specific power (VSP); and iv) driving volatility indicators. The development of IOVs models was made by testing the most significant parameters on CO_2 and NOx emission rates, which included the engine speed (RPM), manifold absolute pressure (MAP), and intake air temperate (IAT). VSP-modal approach centred on binning emission rates in 14 models that reflects deceleration, idling, cruise, and acceleration states. Driver volatility was characterized by means of vehicular jerk (i.e., first derivate of acceleration) using nine combinations of vehicular jerk types. To obtain real world emissions, data were collected from one petrol and one diesel passenger cars using an integrated PEMS. IOVs and jerk models based on the product of MAP and RPM presented similar CO_2 emission compared to measured values for both vehicles, but they resulted in higher overestimation of NOx than a VSP-modal approach. The proposed methodology can be extended to other individual ICE or alternative fuel vehicles for which it may be expensive to get emissions, engine, and dynamic data.

Keywords: Vehicle emissions; predictive models; speed, internally observable variables; vehicle specific power; driving volatility.

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Bike Network Design: an approach based on micro-mobility geo-referenced data

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Abstract | Paper #24

Cycling and micro-mobility, in general, have been long promoted as sustainable and suitable modes of transport due to emission mitigation, congestion reduction and improvements to users' health and lifestyle. However, as most cities in the world have followed a car-centric development, their bicycle network is often highly fragmented, constituting the biggest barrier for attracting new users. This paper introduces a data-driven procedure based on micro-mobility geo-referenced data collected in the city of Rome (Italy). The aim is to identify corridors of high-density micro-mobility demand through an iterative clustering procedure and to evaluate potential growth scenarios of the bicycle network by locating the strategic missing links in the existing infrastructure to achieve a fully connected bicycle network that maximizes the overall usage of deployed bike lanes. The procedure has been applied to the city of Rome (Italy) adopting point data of the e-scooter sharing operator *Dott*.

Keywords: Bike network design; micro-mobility; clustering techniques; e-scooters.

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Cost-effectiveness analysis of Origin-Destination matrices estimation using Floating Car Data. Experimental results from two real cases

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Abstract | Paper #26

The aim of this paper is to estimate static Origin-Destination (OD) matrices combining traditional data sources and Floating Car Data (FCD), testing several scenarios with different penetration rates and representativeness of probe vehicles. For each scenario, the accuracy of results is related to the cost of the data acquisition. To the best of the authors' knowledge, this paper represents the first attempt to define a relationship among FCD penetration rate and representativeness, traditional data sources, OD matrices accuracy and cost of estimation, thus contributing to the literature on the subject and providing useful considerations for practical applications. The procedure was applied to two real cases for which ground-truth matrices were available, in order to calculate goodness of fit indicators for the estimated matrices. In this way, it was possible to define optimal solutions, which can maximize the reliability of results and minimize their cost. Results highlighted that the representativeness of probe vehicles is the main factor affecting the difference between estimated and real matrices. Moreover, when heterogeneity of penetration rates among OD pairs occurs, estimation errors can be reduced by the availability of traffic counts from on-site observations, although increasing costs. For this reason, optimal solutions were identified among scenarios balancing economic effort and estimation performance. In addition, the use of FCD was found to be competitive with procedures exclusively based on traditional on-field activities, both in terms of obtained OD matrix accuracy and costs.

Keywords: Floating Car Data; OD matrix estimation; big data; cost-effectiveness analysis; multi-objective optimization.

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How to support the economic recovery of aviation after COVID-19?

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Abstract | Paper #29

The still ongoing COVID-19 pandemic lead to the most significant decrease in global air transport passenger traffic in aviation history. This decrease has been caused by a combination of demand and supply shocks. Main reasons for these shocks were the global travel restrictions, border closures, the rules and regulations for physical distancing as well as income losses of both private companies and private households even though financial support has been provided by many governments. As a consequence, airlines worldwide had to cut down the number of operated routes and flights significantly. Since February 2020, both the number of global passengers and passenger flight kilometers decreased by 80 per cent and more). These developments have caused large financial losses both for airlines and airports worldwide, critically threatening the existence of a large number of these companies. This paper investigates whether and how the economic recovery of the aviation sector should be supported by governments. Our main results indicate that government loans or government secured loans are enabling a well-balanced trade-off between governmental influence, public debt and distortion of competition if the lending criteria are transparent and nondiscriminatory. However, in the course of time, over-indebtedness will become a critical issue for most companies. At this point, non-refundable state grants offer a relatively simple but costly solution since these subsidies will directly increase public debt.

Keywords: Aviation; COVID-19 pandemic; policy measures.

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Evaluating the suitability of urban road networks to facilitate autonomous buses

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Abstract | Paper #30

The present paper intends to develop a method for evaluating the suitability of urban road networks to accommodate the movement of autonomous buses (ABs). The output of this process is the production of a detailed map indicating the score of each road segment in the network. To this end we follow a five-step methodological approach. The first step includes the examination of the current street classification, in order to identify functionality of the road network. The next step deals with investigating specific road network features such as slope, angle degrees in intersections, road surface width (excluding sidewalk) and existence or absence of medians in two-direction roads. After that we map the critical urban spaces or clusters in the study area and calculate their 250m isodistance zones, in order to detect clusters with high urban significance. The final step includes the process of evaluation. More specifically, the road network segments are evaluated through a simple formula, which is the suitability indicator that displays the appropriateness of the segments. The method is applied to the municipality of Kallithea which is a densely populated suburb in the southern part of Athens, therefore a favourable area for enhancing public transport. The suggested method describes a planning tool that can be utilised by policy makers and planners in order to promote sustainable mobility and the use of public transport in particular, improve travel conditions, enhance social equity and augment smartness in a long-term period. Lastly, the method can provide an adequate background for the potential integration of autonomous shuttle buses into the street classification system. This fact will facilitate their movement in the complex urban transport systems and will be a driver for shifting from conventional to smart cities.

Keywords: Autonomous Buses (ABs); suitability index; spatial analysis; GIS tools.

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Measure the ability of cities to be biked via weighted parameters, using GIS tools. The case study of Zografou in Greece

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Abstract | Paper #31

During the past decades, unlike other countries of the European community, Greek society excluded bicycle from its everyday life, both as a solution for sports and recreation, as well as a transport mode. However, in the last few years, maybe due to the economic crisis, people in Greece began to consider cycling, again, in their daily routine. In this context, the present paper endeavours to examine and evaluate the ability to cycle in the complex urban environment of Greek cities. Therefore, this study develops a method for assessing bikeability, based on international literature and related walkability evaluation methods. Initially, a literature review was conducted to identify those parameters that positively affect the suitability of a cycling route. Afterwards, we developed linear scales to transform the quantitative data into scores ranging from 0 to 10, in order to be comparable. In the next step we used participative Analytic Hierarchy Process (AHP) in order to weight each parameter and identify its significance. Lastly, we formulated the final bikeability index. The chosen case study is the Municipality of Zografou, which constitutes one of the most significant municipalities in Athens, combining all aspects of a modern city: a liveable central area, university campuses, high residential density and traffic congestion problems. The results indicate that the overall bikeabilty index of Zografou is quite low, specifically it equals to 3,7/10 meaning that most of the road sections are not suitable or attractive for cycling. This paper provides fruitful insights about the issue of bikeability in urban areas and mostly its spatial dimension and it could be used as decision making tool for stakeholders and planners.

Keywords: Bikeability, cycling, AHP. GIS, spatial data.

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Dealing with multicollinearity in real-time road safety analysis

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Abstract | Paper #32

Multicollinearity is a statistical phenomenon in which predictor variables of a multiple regression model are highly correlated; this may affect model reliability and interpretability. It is a common problem for models with a large number of predictors, as it often is the case in real-time road safety analysis models. This work introduces the principal component logistic regression (PCLR) model to this field, in order to deal with the issue of multicollinearity. A real-time conflict prediction model to predict rear-end conflicts was calibrated with both a classic logistic regression (LR) and PCLR. Data were collected on an Italian motorway for one year, with radar sensor on multiple cross-sections. According to our findings, LR coefficient estimates were not reliable, as several of them were not coherent with observed descriptive statistic values and with literature findings. Conversely, PCLR provided significant improvements in terms of model interpretability, leading to a model which is able to predict unsafe situations with a satisfactory precision, and to suggest on which variables to intervene in order to avoid such situations.

Keywords: Real-time conflict prediction; logistic regression; principal component analysis; multicollinearity; traffic conflict technique.

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Vehicular crowd-sensing on complex urban road networks: A case study in the city of Porto

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Abstract | Paper #34

The viability of high-mileage vehicles, like taxis, in acting as potential probes for Vehicular Crowd-Sensing (VCS) has been largely confirmed in many experimental studies. However, these studies have been mostly carried out considering data from cities with regular, grid-based, road networks, or by abstracting the road network to a grid of cells. In this paper, we investigate the potential suitability of taxis as probe vehicles, by evaluating the achievable spatio-temporal sensing coverage, computed over real trajectories from a swarm of 100 taxis in the city of Porto (PT). Our results confirm that as few as 100 taxis have the potential to effectively sense complex urban road networks, for many VCS-based use cases. On the other hand, we found that the probing frequency might be inadequate to support use cases requiring higher sampling rates. As a consequence, recruiting more vehicles and/or devising specialized routing/incentitivazion mechanisms might be necessary.

Keywords: Vehicular Crowd-Sensing; Probe Vehicles; Intelligent Transportation Systems.

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Dynamic decomposition of the real-time railway traffic management problem

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Abstract | Paper #36

In a railway network, traffic is often perturbed and trains must be rerouted and rescheduled. Doing so in large networks is a challenging task, which has been tackled through various decomposition approaches in the literature. In this paper, we propose an algorithm for managing traffic considering dynamic problem decompositions. It is an asynchronous algorithm based on the decomposition of the problem considering at each time step the smallest possible portion of the network and subset of trains. We prove that this algorithm guarantees to find an overall feasible solution if it exists, for single track networks with passing loops.

Keywords: Railway traffic management; Real-time scheduling; Problem decomposition.

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Demand model estimation from smartphone data. An application to assert new urbanistic development scenarios

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Abstract | Paper #37

The pervasive use of mobile devices has brought a valuable new source of data. The work presented here has a twofold objective: firstly, to demonstrate the capability of mobile phone records to feed traditional trip-based demand models and, secondly, to assert the possibilities of using developed models to estimate the effects of new urbanistic development scenarios. Detailed trip data for the metropolitan area of Barcelona are reconstructed from mobile phone records. This information is then employed as input for building a set of demand trip-based models and to apply these daily-based models to the appraisal of new development scenarios in a VISUM model of the city. The model calibration and validation process proves the quality of the models obtained. Our results show the way in which the generated trips are distributed into the study area and modal share is modified in the considered scenarios.

Keywords: Demand models, smartphone data, appraisal of new urbanistic scenarios.

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Realization of the penetration rate for autonomous vehicles in multi-vehicle assignment models

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Abstract | Paper #38

Growing development in technologies that can lead to fully automated driving is at pace. This can result in an enormous change in traffic operations and network properties. However, there are uncertainties about the full deployment time of these autonomous vehicles on road networks. The transition period from vehicles with drivers to driverless will result in a mutual environment with an interaction between traditional (that is, manual) vehicles, automated vehicles and infrastructure. In this context, this research attempts to focus on the various factors of land use, user demographics and road network affecting the percentage of autonomous vehicles into the multi-vehicle assignment models and their subsequent impacts on the traffic network properties. This research aims to use a realistic approach to evaluate the percentage of autonomous vehicles to be injected into the traffic models via an indicator matrix and seven decision indices. A macroscopic traffic model is formulated for mixed traffic flow to which demand is assigned following a stochastic user equilibrium approach using the Frank Wolfe algorithm. The formulated model is applied to a real-world city network for a small part of the Italian city of Genoa. Results showed an effective improvement in traffic network properties with increment in capacities and flow speeds against the saturation grade for the given network.

Keywords: Autonomous vehicles; penetration rate; traffic model; multi-vehicle assignment; indicators.

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Investigating successor features in the domain of autonomous vehicle control

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Abstract | Paper #39

In this article, the basic Reinforcement Learning (RL) concepts are discussed, continued with a brief explanation of Markov Decision Processes (MDPs). Reasoning for the application of RL in the autonomous vehicle control domain is accompanied with a developed basic environment for simulation-based training of agents. Furthermore, we look at the available literature of successor features, and the recent achievements of its utilization. Our motivation is to tackle the problem of credit assignment with reward decomposition by using successor features, because the complex tasks while driving can cause unsuccessful training and can be challenging. After explaining the applied methodology and showing how it works, state-of-the-art ideas are investigated and infused into the vehicle control realm. Moreover, the paper details how these features can be tailored to the highway driving scenarios and what is the secret behind its capability to boost the performance of the RL agent. In order to investigate the proposed problems in a credible way we applied a high-fidelity traffic simulator (SUMO) as our environment, and concluded different trainings based on various scenarios. We present successor features applied to an autonomous vehicle control setting, such as highway commute. Our results imply that learned skills can help with the multi-objective rewarding problem, and agents applied to changing reward systems can adapt quickly to the new tasks. The only thing to find is the correct decomposition and selection of successor features.

Keywords: Reinforcement learning; autonomous vehicle motion control; highway assist; successor features; general policy improvement; general policy evaluation.

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The influence of spent time at park-and-ride facility on the travel behavior of workers and shoppers

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Abstract | Paper #40

In this paper, the Park-and-Ride (P&R) facilities are considered as short time activities in the daily activity plans of travelers. The purpose of integrating the P&R system into the daily activity plans is its benefits of reducing the undesirable effects of using private vehicles, such as pollution and traffic congestion, in the city center. Previous works did not extensively study the influence of the P&R operational strategy on the travel behavior of workers and shoppers; while this study not only covers this underexamined area of research but focuses on the impact of extending the duration of the P&R facility on traveler mobility. The study is conducted by integrating 13 P&R facilities in Budapest, Hungary into the daily activity plans belonging to the traveler groups of workers and shoppers. The study points out the changes in the travel pattern when P&R is enforced to be used by travelers to hinder travelers from entering the city center or park their cars on street. Besides, a comparison is made with a previously published work to study the impact of changing the P&R activity time and the existing condition where no P&R is provided. The multi-agent transport simulation (MATSim) software is used to conduct the simulation. The results support that using the P&R system increases the total travel time, decreases the number of Vehicle-Miles-Traveled (VMT), and changes the travel pattern. Moreover, the results reveal 5.75 minutes increments in the average trip time, when the P&R duration is increased from 4.5 minutes to 10 minutes. The result led to the conclusion that the operational strategy of the P&R facilities impacts the mobility of travelers, and the P&R system changes the travel pattern, such as the duration of peak periods and the number of vehicles en route.

Keywords: Travel time; MATSim; optimization; park and ride; utility function.

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Dynamic and static analysis of Airport capacity

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Abstract | Paper #41

The objective of this paper is to compare two methods of airport capacity analysis: Static Analysis and Dynamic Analysis. For this purpose, the two methods have been evaluated in two different scenarios, the first one related to normal operations and the other to an exceptional event. In the context of the coronavirus COVID-19 pandemic, they can be considered as coinciding with a "Pre-Covid" and a "Covid" scenario. Currently, the calculation of airport capacity is mostly linked to static analysis, a solid historical method, based on empirical formulas dictated by the International Air Transport Association (IATA). The dynamic analysis is a state-of-the-art method that uses software packages to simulate a great variety of non-ordinary situations by incorporating a wide range of information related to the specific case study such as airport layout, entry/exit routes, etc. Nevertheless, since it does not currently have specific guidelines, is still little used. The following study evaluates the two methods, highlighting their strengths and weaknesses.

Keywords: Dynamic analysis; static analysis; airport capacity; Covid-19; PTV Viswalk.

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A mixed-integer linear program for real-time train platforming management

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Abstract | Paper #42

Unexpected events may perturb operations and generate conflicts that must be addressed promptly to limit delay propagation and other negative impacts on the network. The real-time railway traffic management problem deals with disruptions in railway networks, including tracks, junctions and stations. When they happen in station areas, new decisions involving train platforming, rerouting, ordering and timing must be made in real time. This paper explores a mesoscopic approach to deal with disruptions at rail stations. A mathematical programming-based model is proposed to determine re-routing and re-scheduling decisions for railway traffic in a station area. The key steps of the approach, which simulate what happens in real-time traffic management, are: i) an initial on-line preprocessing stage of the set of feasible routes originally planned, ii) a second preprocessing stage which analyses the disruption and sets the necessary parameters for the last step iii), which consists of an integer programming model that seeks solutions which minimise deviations from planned train schedules and assigns new and appropriate platforms (if necessary). Computational experiments show that realistic instances can be solved near to optimality using CPLEX in very short times. This allows to consider this methodology for solving real time traffic management problems.

Keywords: Railway traffic; train platforming problem; real-time re-scheduling; real-time re-routing.

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Relocation planning with partly autonomous vehicles in car sharing systems

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Abstract | Paper #43

Allowing one-way trips in car sharing systems to extend the system's flexibility causes vehicle imbalances across stations. This unfavorable car distribution can be tackled with car relocation. Various research has been conducted on relocation tour planning, both for conventional and autonomous vehicles. We analyze a novel relocation approach that is intended for partly autonomous vehicles, based on the upcoming technology of platooning. We use an integer program to solve several instances to depict advantages and limitations of the platoon approach. We analyze different infrastructure settings and demand types and their effect on the relocation effciency. We further compare the new approach to conventional relocation in terms of saving costs and realizing more customer trips.

Keywords: Car sharing systems; relocation; autonomous vehicles; platoon.

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Real-time optimization of energy consumption in railway networks

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Abstract | Paper #44

In railway traffic, perturbations may give rise to conflicts, causing delays. As a countermeasure, effective re-scheduling and rerouting decisions can be taken by addressing the real-time Rail Traffic Management Problem (rtRTMP). One of its subproblems is the real-time Energy Consumption Minimization Problem (rtECMP). The latter enforces the train routing and precedences computed by a rtRTMP solver and defines train timings and speed profiles. The objective is to minimize the weighted sum of train energy consumption and total delay. In this paper, we propose an Ant Colony Optimization algorithm for the rtECMP and we test it on the French Pierrefitte-Gonesse control area with dense mixed traffic. The results show that, in a very short computing time, a remarkable exploration of the search space is performed before convergence.

Keywords: Energy consumption; multiple trains; ant colony optimization; traffic management; rail transport.

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Investigating potential electric micromobility demand in the city of Rome, Italy

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Abstract | Paper #45

Recent electric micromobility solutions can represent a sustainable transport alternative in urban environments. Indeed, these can be adopted as a substitute of car, especially for specific distance classes, as well as they can increase accessibility to transit services. Aiming to investigate the potential demand that can be moved from private cars to environment-friendly micromobility modes (e.g., e-scooters and e-bikes), a methodology based on exploiting data by probe vehicles is presented. To test its goodness, it is applied to the city of Rome (Italy) with challenging results.

Keywords: Micromobility; probe vehicles; Floating Car Data; e-bikes; e-scooters.

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Monitoring and controlling real-time bus services: a reinforcement learning procedure for eliminating bus bunching

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Abstract | Paper #48

Bus bunching is one of the main issues encountered in bus service operations. The headway (i.e., time between two successive buses) of high-frequency services operating on congested routes can be subject to significant variability with two or more buses arriving at the same bus stop and at the same time (bus bunching). This affects the reliability of bus services and causes user frustration with the travel experience. Although public transport is encouraged as the most environment-friendly mass transit solution, bus bunching is undesirable given that it creates inefficiencies and can push passengers to use private transport. The advances in information communication technologies (ICTs) offer new opportunities for transit operators to limit this effect, ensuring a more reliable service. The paper, taking advantage of the innovations in ICTs, proposes a machine learning-based procedure addressing the issues causing bus bunching. The procedure is applied to a real test case with encouraging results. It opens the possibility that it may be incorporated in a decision support system to assist operators (drivers) in taking corrective actions throughout the day, improving bus service operations.

Keywords: Machine learning; bus bunching; bus services operations; transit services; automated vehicle monitoring; intelligent transport system; service reliability; operations control.

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Exploring jobs-housing spatial relations from vehicle trajectory data: A case study of the Paris Region

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Abstract | Paper #50

This study explores the spatial relations between job and housing locations by mining trajectory data. The objective is to establish a data-driven method to recognize employment core areas and identify their residential catchment areas. More specifically, mobility traces are firstly mined to detect the home and work places of each vehicle according to temporal patterns of the day and repetition patterns over distinct days. A spatial density distribution analysis is then conducted to identify the employment cores and sub-cores. The core-periphery patterns between the cores and other areas are further investigated by building a connection graph based on the home and work locations over spatial zones. The graph-based clustering algorithm is employed to partition the graph so as to identify bonded zones as communities and interpret the catchment areas pertaining to different employment cores. A case study has been applied with the field-collected Floating Car Data in the Paris Region to showcase the method applicability. Overall, this study offers a referential framework for capturing urban spatial dynamics by digital traces, with the advantages of being data-driven, scalable for large-scale, and less dependent on prior expertise. The results may contribute to the planning guidance corresponding to up-to-date changes.

Keywords: Trajectory data mining; home-work commuting; employment cores; catchment areas; community detection.

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How precision teaching can shape drivers' lateral control over time

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Abstract | Paper #51

The present work describes a driving simulator experiment aimed at verifying if different feedback systems may have a positive effect on the participants' driving behaviour in terms of lateral vehicle control over time. Participants performed the same track 4 times: the first time (baseline) no feedback was delivered, whereas the next three times either an auditory or multimodal (that is, visual and auditory) feedback was presented in case of error. About 25% of the participants in the initial sample were tested again after a month without any feedback. The results showed that the positive effect of the feedback with respect to the baseline track in terms of lower standard deviation of lateral position (SDLP), lower mean lateral speed (LS) and lower standard deviation of steering angle (SDSTEER) was maintained over time. Thanks to the precision teaching technique, drivers improved the investigated driving parameters while maintaining a correct position inside the lane.

Keywords: Driving simulator; precision teaching; lateral control; feedback systems.

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Modeling of travel behavior in budapest: Leisure travelers

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Abstract | Paper #53

People usually travel with different preferences to reach the location of their leisure activities, where transport mode is a decisive factor. Previous studies focus on developing discrete choice models for people where a trip purpose is considered as an explanatory variable. In this paper, discrete choice modeling is applied to model the behavior of leisure travelers, to understand the impact of several factors on the transport mode choice, such as sociodemographic variables. A sample of 1100 travelers from a household survey in Budapest is used in the analysis. The sample includes the daily activity plans of leisure travelers and their sociodemographic as well as economic characteristics. A Multinomial Logit (MNL) model is applied, where the data are examined across travel time variables and travel characteristics, such as travel time, travel cost, age, gender, income, and car ownership. The developed models are used to predict the probability of using the different transport modes based on the characteristics of the travelers and their trips. The model indicates that time and the cost impact travel negatively. While other variables show varied impacts on the transport mode selection. The output of this study is important for decision-makers to understand the patterns of leisure tips in a city.

Keywords: Travel behavior; leisure trip; multinomial logit model; discrete choice modeling.

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LPG vehicles' adoption in Portugal: lessons for new AFV diffusion

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Abstract | Paper #57

Nonetheless the efforts of the different players, namely oil companies and fuelling stations owners, the liquid petroleum gas (LPG) does not play the role of an alternative to traditional fossil fuels yet. So far, LPG vehicles (LPGV) have failed in being widely accepted by users. Currently, LPGVs' sales are already being surpassed by the "pro-electrification" group of vehicles formed by hybrids (HEV) and battery-electric vehicles (BEV). So, while establishing a parallel with LPGVs and natural gas vehicles (NGV) diffusion and adoption lessons learned, this paper explores alternative fuel vehicles (AFV) purchase's intentions determinants and the eventual influence of socio-demographic characteristics. The results of a survey carried out to 189 individuals show fundamental differences within gender as well as between education level groups. HEVs are on top of women purchase intention ranking while men express preferences towards BEVs. NGVs and fuel cell electric vehicles (FCEV) are newcomers in this ranking. Meanwhile, LPGVs confirm a declining trend. Among AFV's purchase intention determinants, low emissions, clean energy sources, affordable energy, and environmental concerns are the most frequently stated. The results also reveal significant differences in perceived AFV's features between educational level groups, highlighting post-graduates' answers, which leads us to conclude that qualification plays an essential role in how potential buyers perceive the vehicles and influences the purchase decision-making process. Finally, in this study, we also give implications for improving users' knowledge and perception of AFVs and suggestions for future research.

Keywords: Vehicles adoption; purchase intentions; purchase decision determinants; alternative fuel vehicles.

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Deep Reinforcement Learning based approach for Traffic Signal Control

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Abstract | Paper #61

The paper introduces a novel approach to the classical adaptive traffic signal control (TSC) problem. Instead of the traditional optimization or simple rule-based approach, Artificial Intelligence is applied. Reinforcement Learning is a spectacularly evolving realm of Machine Learning which owns the key features such as generalization, scalability, real-time applicability for solving the traffic signal control problem. Nevertheless, the researchers' responsibilities become more serious regarding the formulation of state representation and the rewarding system. These Reinforcement Learning features are also the most fascinating and controversial virtues since the utilized abstractions decide whether the algorithm solves the problem or not. This paper proposes a new interpretation for the feature-based state representation and rewarding concept that makes the TSC problem highly generalizable and has scaling potential. The proposed method's feasibility is demonstrated via a simulation study using a high-fidelity microscopic traffic simulator. The results justify that the Deep Reinforcement Learning based approach is a real candidate for real-time traffic light control.

Keywords: Deep reinforcement learning; traffic light; traffic signal control; policy gradient algorithm; SUMO; traffic simulation.

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Exploring relevant factors behind a MaaS scheme

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Abstract | Paper #62

Mobility as a service (MaaS) is a newly emerging concept that is mainly focused on user mobility needs. MaaS is expected to reshape the way people travel and improve future urban mobility. However, research shows that there is neither a consensus on an unequivocal MaaS definition nor a universal best way to evaluate and compare MaaS schemes. Thus, given the large differences between MaaS packages, this research provides new insights into what is offered in a variety of MaaS platforms with special concerns related to functionalities and information types, customisation, and possible integration of specific societal goals. For that purpose, various European MaaS providers/platforms were explored under the PriMaaS partnership, composed of heterogeneous regions. Data were aggregated and analysed applying cross-tabulation and clustering techniques. The proposed approach led to relevant factors, such as Payment, Customisation, and Trip Planning. Relationships between platform characteristics and societal goals suggest these can be used as a conceptual foundation. Our study provides a baseline for establishing a conceptual framework to develop sustainable MaaS indicators, which would help citizens using MaaS more efficiently and support MaaS providers and operators in developing sustainable business models.

Keywords: Mobility as a service (MaaS); platform characteristics; societal goals; sustainable mobility.

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Screening walkability violations through self-reported claims by smartphone detection: The case of Lisbon, Portugal

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Abstract | Paper #63

A smartphone app was developed for the citizens to self-report incidents in the city of Lisbon and to supervise its process of resolving the problem. There are many areas that people can report on, however, this article focuses on exploring data related to "sidewalk and accessibility". The aim of this paper is to elaborate a methodology for simplifying large datasets and guide policymakers in resolving the problems reported. An example of the proposed methodology is used in "sidewalk and accessibility" occurrences to evaluate where and what are the main concerns of citizens regarding this aspect in the city. The methodology proposed in this paper provides insight for local authorities to elaborate urban strategies and policies in favor of resolving the claims and ensuring in this case, a more walkable city.

Keywords: Active transportation; walkability; urban mobility; big data; policy; data.

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A Tactical Integrated Connection Planning and Passenger Allocation Model for Low-Cost Carriers

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Abstract | Paper #64

Historically, the aviation industry has been characterized by a clear dichotomy between Low Cost (LCC) and Full Service (FSC) carriers. In recent years, however, airlines have undergone a profound hybridization process, blurring the traditional boundary between these two business models. On the one hand, full service carriers took on some practices of LCCs, such as service unbundling, more competitive pricing strategies and streamlined services, in an effort to become more cost-effective and thus properly cope with the increasing and fierce competition exerted by LCCs, especially on short- and medium-haul routes (Jarach et al., 2009; Bitzan and Peoples, 2016). On the other hand, LCCs have mimicked some archetypal features associated with the FSC business model and focused on new ways to enhancing passenger experience and attracting new market segments; examples include a renewed approach of fare bundling and seat differential pricing (Klophaus et al., 2012), as well as the establishment of operations at primary airports (Dobruszkes et al., 2017). One of the key differences that traditionally distinguished LCCs and FSCs relates to their network structure. While LCCs mostly relied on a pure point-to-point network, FSCs rather used a hub-and-spoke network. In recent years, however, some major LCCs, such as Vueling, Norwegian, Eurowings, and Ryanair, have begun selling connecting itineraries by combining their existing flights and providing integrated ticketing and baggage handling. Consequently, several studies have investigated the rationale behind this initiative, motivated either as part of an integrated feeding strategy with FSC partners (e.g., in the case of Eurowings and Vueling) or to long-haul flights (e.g., Norvegian), or simply to take advantage of the feasible connections (connecting alternatives) that originate from the highly connected and dense network of existing flights (e.g., Ryanair). (Fageda et al., 2015; Fichert and Klophaus, 2016; Maertens et al., 2016; Klophaus and Fichert, 2019; Morlotti et al., 2020). A number of early contributions have focused on quantifying the degree of ”indirect” connectivity and self-hubbing potential provided by the current network of LCCs, founding that these account for more than two-third of the fastest indirect connection in Europe (Malighetti et al., 2008; Maertens et al., 2016; Cattaneo et al., 2017). The more recent works by Klophaus and Fichert (2019) and Morlotti et al. (2020) have instead empirically examined and reported on a given carrier (Ryanair)’s connecting strategy. These latter studies emphasized that Ryanair still mostly relies on its stand-alone nonstop routes, but it has taken first steps to provide connecting services through its large and dense network with the aim to increase passenger volumes and revenues. Yet, its connecting strategy appears immature and experimental: flight schedules are not optimized to facilitate short connecting times on the provided connecting itineraries, and, more importantly, pricing on these itineraries follows a simple additive rule—the price is roughly given by the sum of the two flight legs’ prices plus an additional amount (about 10 Euro). While this avoids the problem of revenue cannibalization, it also denotes minimal (if not totally absent) revenue optimization and exacerbates the challenges related to managing this highly complex and potentially multi-hub situation. Although the presented literature has extensively shown the potential opportunities that may be obtained by leveraging connecting itineraries in LCCs’ networks, these studies provide a rather descriptive than prescriptive approach. By contrast, this work aims to contribute to both literature and practice by developing an integrated optimization framework to assist LCCs’ connection planning. The proposed Integrated Connection Planning and Passenger Allocation Model (ICPPAM) represents itinerary demand based on a discrete choice model, estimated using historical data and considering key itinerary attributes. The derived demand function is explicitly incorporated in the optimization model, thus yielding an explicit treatment of supply-demand interactions. Subject to the current provision of flights, the model aims at maximizing airline’s profits by simultaneously selecting through which airports to enable connections (hub selection) and which specific connections to activate. To illustrate the benefits that can be derived by the application of the ICPPAM, a real-world case study was conducted considering the network of the largest European low-cost carrier, Ryanair, in 2019. Two distinct analyses were conducted to appraise the potential profit increase and business implications of introducing connecting itineraries via a single airport (single-hub scenario) or multiple airports (multi-hub scenario). Additionally, we considered two alternative pricing strategies: an additive pricing approach, which replicates the approach currently used by Ryanair and defines the price of Ryanair’s connecting itineraries as the sum of the prices of the two flight legs, and what we call market-aligned pricing, according to which Ryanair’s itineraries are given an average price that is aligned to the price of itineraries with similar characteristics serving the same market. Through comparison with a baseline network, which reflects the current situation—absent connecting itineraries and consisting of only local nonstop traffic— our preliminary results highlight substantial business opportunities that Ryanair could exploit by optimizing its connection strategy over its existing network of flights. Under a market-aligned pricing strategy, revenue increase is estimated to be as high as 7% (with 10 activated hub airports). On the other hand, much smaller revenue improvements (1.2%) are observed when an additive pricing strategy is used. These improvements follow from two main reasons: first, the capturing of passengers from new markets served through connecting itineraries, and, second, the optimization of passenger mix on each flight. Additionally, these results highlight how the target airline should be able to implement a sophisticated and market-aligned pricing strategy to fully exploit the benefits related to the introduction of connecting flights. This, in practice, requires substantial investment in revenue management and inventory systems. In this respect, the proposed model can be useful to carefully evaluate the adoption and implementation of these systems. At the same time, the endogenization of pricing decisions in the ICPPAM represents with no doubt an interesting (and challenging) avenue for future research efforts.

Keywords: Low-Cost; self-hubbing; flight connection strategy; mixed-integer programming; discrete choice modeling.

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Uncertainty and variability analysis of agent-based transport models

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Abstract | Paper #67

This paper presents an analysis of the output variability of agent-based transport models. We simulated a MATSim model of the city of Hanover multiple times with identical input and evaluated the resulting travel times on different level of aggregation. On a global level, we observed minor variations of travel times. However, the results show an increased variation when examining the output on the level of districts or for individual agents. A recommendation for estimating the required number of simulation runs for a stable output of travel time for the purposed aggregation level is derived from our case study.

Keywords: MATSim; output variation; agent-based transport simulation.

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Assessing long-term impacts of automation on freight transport and logistics networks: Large-scale LRP integrated in microscopic transport simulation

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Abstract | Paper #68

Up to now, bulk transports have been carried out via a hub-and-spoke network in the general cargo sector. However, it is expected that the use of autonomous vehicles will enable a more flexible delivery. Such developments may, economically, make sense for shippers. From an ecological point of view, also negative effects can be expected due to enhanced transport performance. In the framework of this research, we investigate the impacts of automation on general cargo transport at the logistics network level. For assessing the impacts of autonomous vehicles on logistics network structures and on freight transport routes ex-ante, an instrument for strategic transport and logistics network planning is needed. We develop an effective heuristic to find new facilities and adjust the network, while thereby considering the routing characteristics by tackling the large-scale location routing problem (LRP). By the linked approach, we can optimize the logistics network and also measure exact transport distances, driving transport lead times and number of necessary vehicles on the infrastructure network. We operationalize this approach in the framework of a case study focusing on the food retail distribution in Germany. In fact, this research reveals that the utilization of autonomous vehicles significantly enhances transportation ranges and the number of tours, while reducing the number of operating facilities.

Keywords: Freight transport; Location Routing Problem; logistics network optimization; tour optimization; microscopic agent-based transport simulation; food retail distribution.

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A grid-based evolutionary spatial algorithm for airline service design in multi-airport systems

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Abstract | Paper #71

This paper proposes an integrated modeling framework to support airline frequency planning in a multi-airport system. First, a grid-based spatial model is developed to estimate passenger demand as a function of air-service characteristics (such as flight frequency and airfare) and ground accessibility. Second, an evolutionary algorithm is proposed to provide decision support for the allocation of flights to airports belonging to the multi-airport system, subject to fleet availability, flow balance and operational requirements. We apply the proposed approach to model frequent flyer passengers departing from one of the major multi-airport systems in Europe. Our results show that the degree of diversification of a multi-airport system—i.e., the presence of alternative airports—plays a significant role on both the demand and supply sides, providing passengers with more diversified and accessible services and providing airlines with higher operational flexibility and resilience in case of disruptions. Our modeling framework can be extended to capture additional managerial objectives or practical requirements.

Keywords: Multi-airport systems, air travel demand, frequency planning, genetic algorithm, frequent flyer passengers.

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Effect of non-urban two lane highway geometry on car and bus drivers – A physiological study

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Abstract | Paper #74

Life is a complex phenomenon, so is the task of driving. Mostly human performance is controlled by sympathetic and parasympathetic systems functioning in human body. It is quite dynamic in response to numerous stimuli the driver acquires from the human-vehicle-environmental ensemble. Geometry is one of the fundamental stimulus for a driver, driving on a non-urban highway, especially when there is minimal interference from other vehicles. Consequently, it is quite natural that drivers adopt higher speeds. His/her mental workload will be based on the input he/she gets from the above system and the rate of reception of input will be more with speed. Any inability to cope with the workload may lead to occurrence of crashes. Hence, it is very important to take into account the influence of geometry on driver workload while designing highways. One way to assess the workload is to capture the physiological responses of a driver like heart rate, galvanic skin resistance and rate of eye blinking, during driving. The study included driving experiments done on 114 horizontal curves of gradient less than 2 percentage, each curve being driven over by 30 car and bus drivers. The effect of geometry on workload of car and bus drivers were further analysed. It was found that driver physical characteristics like, age, driving experience, depth perception, vision acuity and reaction time were not found to significantly influence the workload. But workloads of car and bus drivers are significantly different. Sight distance and width of shoulder affect the workload of car drivers. Sight distance was the significant variable affecting bus driver workload. Workload of a driver is found to increase with increase in visibility as increased visual sensations actuates more physiological responses on a human body.

Keywords: Driver workload; heart rate; galvanic skin resistance; rate of eye blink; highway geometry; horizontal curves.

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Microscopic disruption management: Energy consumption and passenger compensation optimisation

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Abstract | Paper #78

Rail operations are often disrupted by accidents that cause traffic to diverge from the scheduled operations, rendering it difficult to run the schedule as planned. In such a case, the operator must change the schedule to return to the original schedule. If passengers are delayed, a train operator may have a policy of economically compensating them (e.g., refunding ticket fare). Compensation amounts are usually determined by the length of the delay. As a result, it is critical to have a smart way of determining whether to accelerate trains to absorb delays, thus increasing energy usage, or to compensate passengers. This paper presents a mathematical model for determining the speed profile while taking passenger usage into account. The model determines the best sequence of operating regimes and switching points between them for a variety of different situations and train types, all while accounting for delays and passenger compensation policies. The aim is to reduce both the amount of energy consumed and the amount of compensation paid to passengers. There are constraints on traction and braking forces, train velocity, forces induced by vertical and horizontal track profile, and passenger compensation policy. The results of computational tests performed on practical problem instances of the Spanish rail operator RENFE are showed. The suggested approach is capable of producing strategies that strike an excellent balance between different managerial objectives.

Keywords: Train re-scheduling; passenger compensation; delays; optimal control.

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A three-dimensional flow-based model to design shared autonomous vehicle system's fleet size, charging facilities, and vehicle operations

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Abstract | Paper #83

Self-driving vehicles, also known as automated vehicles, are expected to be part of daily transportation systems in the next decades. This technology has several advantages, namely improving non-drivers' mobility and enhancing road safety. Services providing on-demand rides through the use of self-driving vehicles are denominated shared autonomous vehicle (SAV) systems. SAV systems are cheaper to run than traditional on-demand services, since the use of self-driving vehicles lowers driving costs (when compared to ridesourcing), relocation costs (when compared to carsharing), and insurance rates (absence of human error). This has the potential to reduce the service price, and, as a consequence, generate additional demand. It is expected that traditional on-demand services converge into SAV services, and it is highly likely that public transportation will follow. In addition, the market penetration of battery electric vehicles (BEVs) is increasing. Electric powered engines are more efficient than combustion engines, although the use of batteries still has limitations in terms of vehicle range (influenced by battery capacity, charging speeds, driving conditions and weather), and ecological footprint. There are good chances that SAV systems will use BEV technology at the moment self-driving technology becomes available. If this is the case, assuming that charging and battery limitations remain at that time, battery capacity and charging speed will affect the operation of shared autonomous and electric vehicle (SAEV) systems, influencing their planning and operations. Managing the vehicles' time according to the transportation of clients, charging and relocation needs is a challenge for SAEV upcoming systems. This management is highly dependent on the fleet size, as well as on the number of charging points (sockets) and respective charging speeds. The design of these main parameters of the SAEV system can be done by two processes: optimization or simulation. In optimization a model is defined for a specific problem by using mathematical equations, while in simulation a system is modeled by defining an environment, the agents, and the interactions between them. Only a few studies deal with the design of SAEV systems. On the optimization side, Zhang et al. (2016) used vehicle routing with model predictive control (MPC) to optimize movements with charging constraints. This approach was later updated by Iacobucci et al. (2019) to incorporate electricity price information for optimizing vehicle charging. On the simulation side, Chen et al. (2016) used an agent-based model to simulate the operations of a fleet of SAEVs and showed that the fleet size is highly dependent on charging infrastructure and vehicle range. This model was later updated by Farhan & Chen (2018) to consider ridesharing with an integrated optimization and discrete event simulation framework. Iacobucci et al. (2018) developed a simulation methodology using a heuristic-based charging strategy to evaluate a SAEV system interacting with demand. All these contributions lack a complete view of the problem parameters (reactive actions in simulation, and rolling horizons in optimization using MPC) leading to near-optimal solutions. Flow-based optimization can be used to produce a tool that allows to obtain global optimal values of the main variables involved in a SAEV system. The flow-based optimization approach already used in the assessment of SAV systems (Liang et al., 2016; Tsao et al., 2018; Iglesias et al., 2018), aggregates vehicle movements into flows reducing the number of decision variables (when compared to vehicle routing). This work presents an integer programming (IP) model to design a SAEV system's fleet size, charging facilities, and vehicle operations. It uses profit maximization as an objective and considers vehicle flows in a time-space-energy network. The aggregation of vehicle movements in flows decreases the computational time, enabling the application of the model to realistic-sized problems (when compared to vehicle routing). The considered approach is possible due to the less detail needed in an early design stage of the system, the planning stage. The model is tested using real mobility data from a region in the center of Portugal.

Keywords: Integer programming; flow-based; shared autonomous vehicles; charging; optimization.

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Cruise passenger-oriented evaluation system for the public transport of hinterland destinations

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Abstract | Paper #87

The cruise ship industry has become the fastest-growing sector of leisure and tourist business. In terms of the daily cruise service, a key part lies in the accessibility to attractive hinterland destinations. From the viewpoints of safety, efficiency, and environmental protection, public transport is considered to be a good option to access hinterland destinations. It requires the design and selection of public transport routes for cruise passengers by evaluating service quality. The existing studies focus on the evaluation of transport service quality incorporating the passenger perspective while there is a lack of studies oriented towards the cruise passengers. In this paper, we aim at setting up a four-layer cruise passenger-oriented evaluation system. Two cruise centers located in Hamburg, Germany, and Qingdao, China are focused. The proposed evaluation system identifies the weights of 21 criteria and the ranking of the transport routes for cruise passengers in different age groups. Considering the berthing time of cruise ships and the commuting time of local residents, the proposed evaluation system also provides suggestions for the one-day tour itinerary of cruise passengers in the hinterland. Moreover, the preferences on transport routes of different-age cruise passengers are disclosed to promote the relevant improvement in public transport infrastructure in specific transport routes. In doing so, this paper aims at supporting the smart city development for port cities.

Keywords: Cruise passenger; public transport; TOPSIS; fuzzy AHP; service quality.

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Cyclist's waiting time estimation at intersections, a case study with GPS traces from Bologna

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Abstract | Paper #89

Waiting time plays an important role in the cyclists' route choice, most likely because cyclists, after a stop, need to pedal harder to regain their previous speed. Literature review highlights that cyclists generally overestimate waiting time approximately three to five times higher than their actual waiting time. The aim of this paper is to quantify cyclists' waiting time in function of specific intersection characteristics and person attributes. This aim is achieved in two steps: (1) a recent algorithm that estimates cyclists' waiting time from GPS traces is validated, using data from a manual survey, (2) a second manual survey has been conducted to test the representativeness of a big data set of 270,000 GPS traces recorded in the city of Bologna, Italy; the same survey also showed how many cyclists pass with the red signal for different maneuvers; and finally (3) the mentioned algorithm is applied to the big data set in order to estimate the waiting time for different intersection types and cyclist attributes. Such estimations have not been addressed in literature due to the difficulty of associating the cyclists' waiting times with infrastructure elements based using GPS traces. Results show that waiting time represents a not-negligible share of the bike trip (11% of total trip duration). On average, particularly large waiting times have been found (1) at complex intersections by (2) for cyclists younger than 25 years old, (3) for infrequent cyclists and (4) for women. During rush hour, cyclists have recorded waiting times only 6% above the daily average, demonstrating that traffic congestion has a limited effect on waiting times. Furthermore, approximately 14% of all cyclists have crossed the red traffic light, especially when the opposite traffic volume is not high and there is good visibility. The study contributes to provide a novel and validated tool to evaluate waiting times of cyclists from GPS traces, which can support the calibration of cyclists route choice models.

Keywords: Waiting time; big data; cyclist; GPS trace; manual survey; map matching.

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Experimental analysis of boarding and alighting behavior in urban public transport network: A case study

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Abstract | Paper #90

This paper investigates the characteristics of passengers' behavior and its effect on the metro stopping time at stations. A field survey was conducted on two mega stations in Cairo metro by video cameras photographing and a stated preference survey was performed based on design of experiments approach. The level of passenger non-compliance behavior, defined as the passengers start boarding the metro while others alighting is analyzed and its relationship with deferent affecting factors is fitted by a two-factor interaction model with a determination coefficient of 0.9234. It is found that some factors have a significant impact on passenger's non-compliance behavior such as the number of alighting and boarding passengers, applying a penalty when not comply with the rules and the door opening shift (i.e. the train stop away from the place designated for it on the platform). Factor interactions show that alighting process does not affect passenger behavior in case of door opening shift. This may be because the alighting passengers are ready to alight from their position inside the train and have nothing to do. Delay from work is the most influential factor and has interaction with all affecting factors. Results may help for verifying passenger behavior simulation to improve the operational capacity of the metro network.

Keywords: Boarding; alighting; non-compliance; behavior.

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Explaining expected non-shared and shared use of driverless cars in Edinburgh

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Abstract | Paper #91

The rollout of driverless cars (DC) may reshape human mobility drastically. Urban roads may face a surge of car traffic if DC technologies continue to enhance the use of private cars. Shared DC use can remedy this by reducing the number of urban trips that non-shared-use DC could otherwise make. While recent research has proven the importance of socioeconomic factors on shared DC use, the influence of present sharing behaviour, personality traits, and social norms on shared DC use has not been extensively explored to date. To address this gap in this study, we employed a panel of 500 Edinburgh-based respondents through an online survey to examine the likelihood of accepting the non-shared-use and shared-use DC options for regular urban trips. We have collected data on respondents' present carsharing and ridesharing behaviour, personality traits, social norms, and sociodemographic characteristics. To elicit the impact of these factors on the likelihood of accepting non-shared-use and shared-used DC options, ordered probit models were estimated. The model findings imply that frequent household car users and those influenced by social expectations to preserve the environment are willing to use non-shared-use DC. In contrast, city centre dwellers, cooperative and younger adults with sharing attitudes show a higher tendency towards shared DC. High-earning, working-aged and young respondents are more inclined to use a driverless taxi, whereas city-centre dwellers and those influenced by social expectations to share personal resources are more favourable towards ridesharing with a stranger in DC. These results can assist the policymakers and transport planners shape policies for promoting shared DC use and transport service providers to deliver and operate shared DC fleets efficiently.

Keywords: Driverless car; shared use; ordered probit models.

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Synchronous framework extended for complex intersections

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Abstract | Paper #92

Current trends towards smart mobility aim at mitigating traffic congestion and providing intelligent and sustainable transportation. Intelligent intersection management systems are an integral part of this trend and profoundly impact urban traffic management. To this purpose, we proposed in prior work a specific Intelligent Intersection Management Architecture (IIMA) for single-lane isolated intersections with an associated Synchronous Intersection Management Protocol (SIMP). The IIMA/SIMP framework targeted autonomous and human-driven vehicles and outperformed competitors in several metrics, notably intersection throughput, time loss, fuel efficiency, and polluting emissions. This paper is the first step to extend such a framework to the more complex scenario of multi-lane intersections, particularly for dedicated left-turn lanes and shared lanes. Using SUMO, we compare IIMA/SIMP performance against competing traditional and intelligent intersection management approaches. Simulation results under varying vehicle arrival rates confirm the advantages of IIMA/SIMP even in complex intersections, improving intersection throughput and reducing average trip time loss.

Keywords: Smart Cities; Smart Mobility; Intersection Management; IIMA; SIMP; Complex Intersections.

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Benchmarking machine learning algorithms by inferring transportation modes from unlabeled GPS data

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Abstract | Paper #95

Many traffic-related applications, e.g. traffic demand modeling, rely on conventional data collection methods such as travel surveys. These methods can be demanding in terms of cost and time, which results in low network coverage and limited representativeness. On-motion sensors, e.g. smartphones, offer the opportunity to replace such methods and compensate for the aforementioned drawbacks by collecting positioning data automatically. GPS data consist of positioning records each of which has geographical coordinates and a timestamp associated. These data, however, require cleansing and processing before being put into use. Information about the used transportation mode is missing from this kind of data unless travelers were specifically asked to report it. In the literature, supervised machine learning (ML) algorithms were successful in inferring transportation modes from GPS data. However, these algorithms, unlike unsupervised ML algorithms, require training data that are not always available. This paper aims to investigate the capability of unsupervised ML algorithms to infer transportation modes from real GPS data extracted from smartphones. Therefore, we used two datasets to benchmark different unsupervised ML algorithms with different input attributes. The paper also investigates the feasibility of using a pre-trained model for unlabeled real data. Finally, we compared the best performing unsupervised setup to the supervised ML algorithms recommended in the literature. The results suggest that the recommended unsupervised setups can reach an overall inferring accuracy of 93%.

Keywords: Floating smartphone data; recognition; identification; supervised learning; unsupervised learning.

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A multi-objective network design model for road freight transportation using the eHighway system

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Abstract | Paper #96

New technological innovations of eco-friendly vehicles for freight transport combined with the usage of renewable energy sources showed significant results in mitigating transport-related carbon footprint. Therefore, in this paper, we present a multi-objective network design model considering a novel technology, the eHighway system, based on electrified roads to supply new Overhead Catenary (OC) hybrid trucks. This work investigates the opportunities of adopting eHighways and evaluates its environmental benefits considering limited budget resources for infrastructure electrification. We propose an optimization problem formulation including three objectives: the minimization of infrastructure and environmental costs, and the maximization of the total number of OC hybrid trucks served on electrified arcs. The Pareto optimization approach is considered for a comprehensive analysis of all possible solutions according to different criteria weights. The proposed model has been evaluated on a test network and the numerical results of Pareto optimization show the environmental improvement we can obtain by using the eHighway system up to about 99% according to the assumed available budget and assigned criteria weights. As a result, the model can be considered as a useful tool for decision-makers in the eHighway network design.

Keywords: eHighway system; environmental impact; network design; freight transport; Pareto optimisation.

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Road accident analysis with data mining approach: Evidence from Rome

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Abstract | Paper #98

Nowadays, road accident is one of the main causes of mortality worldwide. Then, measures are required to reduce or mitigate the accident impacts. The identification of the most effective measures requires an effective analysis of accidents able to identify and classify the causes that can trigger an accident. This study uses data mining as well as clustering approaches to analyze accident data of the 15 districts of Rome Municipality, collected from 2016 to 2019. The aim is to find out which data mining techniques are more suitable to analyze road accidents, to identify the most significant causes and the most recurrent patterns of road accidents by means of a descriptive analysis. Besides, a model to foresee road accidents is proposed. Results show that such analyses can be a powerful tool to plan suitable measures to reduce accidents as well as to forecast in advance the areas to be pointed out.

Keywords: Road accidents; road safety; accident analysis; cluster analysis; data mining.

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A data-drive approach for robust cockpit crew training scheduling

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Abstract | Paper #99

This work addresses the cockpit crew training scheduling problem. The objective is to produce a robust cockpit crew training schedule, including the assignment of trainees, instructors and simulators. To attain this objective, we propose a scheduling framework composed of four modules: a Training Scheduling & Assignment Model (TS&AM), a Disruption Generator (DG), a Rule-Based Recovery (RBR) algorithm, and a Neural Network (NN). The TS&AM is an integer programming model that integrates scheduling of courses and assignment of resources. The output roster serves as input for a data-driven DG based on Monte-Carlo Simulation. The disruptions are then solved using the RBR algorithm. Finally, The NN feedback algorithm learns the recovery costs experienced in the disruption impact simulator and updates these costs in the TS&AM to generate more robust rosters. The proposed modelling framework was calibrated, tested, and demonstrated in a simulation environment developed using four years of historical crew training data from a major European airline. The experiment showed that our approach outperformed the roster produced by the airline. The approach proposed produces rosters that reduce recovery costs by 21 percent, while still decreasing total training costs by 3 percent.

Keywords: Crew training schedule; integer linear programming; neural network; robust scheduling.

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Detection of vehicle-based operations from geolocation data

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Abstract | Paper #100

Geolocation data identifies the geographic location of people or objects, which may unveil the performance of some activity or operation. A good example is, if a vehicle is in a gas station then one may assume that the vehicle is being refuelled. This work aims to obtain vehicle-based operations from geolocation data by analysing the stationary states of vehicles, which may identify some motionless event (e.g. bus line stops and traffic incidents). Ultimately, these operations may be analysed with Process Mining techniques in order to discover the most significant ones and extract process related information. In this work, we studied the application of diverse approaches for detecting vehicle-based operations and identified different operations related to the bus services. The operations were also characterized according the distribution of their events, allowing to identify specific operations characteristics. The public transport network of Rio de Janeiro is used as a case study, which is supported by a real-time data stream of buses geolocations.

Keywords: Vehicle geolocation; transport operations; process discovery.

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How is freight distribution affected by travel time unreliability?

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Abstract | Paper #102

The impact of travel time unreliability on freight transport has been extensively investigated in the last 20 years with the main focus being placed on mode and route choice (and using mostly stated preference data). In contrast, freight distribution has been very rarely examined in the literature. In this paper, we describe a study on how travel time unreliability affects interregional freight distribution using (revealed preference) data from the last national transport survey carried out in Iran (2015). Through this study, conducted using spatial interaction models and linear and geographically-weighted regression approaches, we found that, globally, travel time reliability is approximately as important as average travel time in determining freight distribution flows, but this importance varies widely across regions. We also found that tardy trip reliability measures describe freight distribution patterns more accurately than statistical range measures (coefficient of variation of travel time).

Keywords: Freight distribution; road transport; travel time reliability; spatial interaction models; geographically-weighted regression.

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Impacts of the COVID-19 pandemic in the demand for urban transportation in Budapest

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Abstract | Paper #103

Social distancing guidelines established amid the COVID-19 pandemic have decreased the number of trips in urban transportation networks; furthermore, travelers have shifted away from high occupancy modes due to the fear of contagion. This scenario has led to reduced public transportation ridership and increased shares of private cars, cycling and walking in urban areas. In the international literature, predictive models for this scenario of changed travel behavior and imminent needs for operations and planning adjustments, however, are still scarce or limited in scope. Holt-Winter's multiplicative method was used to extrapolate pre-pandemic datasets as a means to evaluate the impacts of the pandemic in transportation activities in Budapest. Data from March 2020 indicate that stay-at-home orders have resulted in intra-city and commuter traffic reductions of about 35%, while public transportation ticket sales decreased by 90%. Bicycle traffic, on the other hand, increased by about 13% in the same period. These observations suggest that the COVID-19 pandemic has driven significant changes in trip generation and mode choice in Budapest. This study proposes the adjustment of a pre-existing four-step transportation model of Budapest based on the introduction of contextual explanatory variables and on the recalibration of model parameters in order to reflect pandemic-related trends in trip generation and trip distribution. The recalibration and validation of the model were based on data from the first wave of the pandemic in Hungary. Validation results, although limited, suggest that the traditional four-step models are able to capture the impacts on transportation of the atypical scenario of a pandemic with relatively simple adjustments and few data requirements.

Keywords: COVID-19; macroscopic model; lockdown; mobility demand; Budapest.

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Dynamic modal split incorporating trip chaining: A parsimonious approach to mode-specific demand estimation

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Abstract | Paper #105

Dynamic mode choice is essential to understand the potential effectiveness of policies aiming to achieve desirable modal split targets or to manage the demand for resource-limited systems such as shared mobility services. In this paper, we propose an estimation of dynamic modal split for work-related trips, including mode- and time-specific costs, with activity participation based on utility maximization. In order to obtain an accurate profile while remaining at an aggregate level, three types of work activities are described (full time, morning and afternoon shift). The estimated modal split concerns motorized vehicles, soft modes but also train and urban public transport. Based on utility maximization principles, the accumulated utility is formulated within a departure time choice model. A Markov Chain Monte Carlo procedure is used to evaluate the marginal utility function parameters which are used in a joint departure time and mode choice evaluation. Mode specific travel speed for each time of the day is used to estimate also travelled distance distribution per mode. The methodology is applied and tested, using data collected in Ghent in 2008. 16.749 work-related trips have been considered in a simplified estimation where two successive trips are constrained to be done with the same mode. This methodology is characterized by low data requirements and the model is shown to be flexible to include all available type of information in order to refine or accelerate the estimation. The proposed method is easy to implement using only dynamic trip counts, without the need for simulation or traffic assignment.

Keywords: Mobility, mode choice dynamics, travel demand, work trips, Markov Chain Monte Carlo.

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An intermodal dispatcher for the assignment of public transport and ride pooling services

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Abstract | Paper #106

This paper describes the components of an intermodal dispatcher of ride pooling requests to integrate these urban mobility systems with the public transport network in an urban area, thus making possible a new intermodal system. The intermodal dispatcher makes use of a prior dispatcher, developed exclusively for conventional ride pooling systems and a method that filters out the requests that have few possibilities of being served using the public transport system, leaving them to be served directly by ride pooling vehicles. The assignments of customers to vehicles of the ride pooling system are finally determined by an integer programming model of reduced dimensions, so that it can be solved efficiently by conventional solvers as shown in the preliminary computational results included in the paper.

Keywords: Intermodal dispatching; ride pooling; public transport.

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Solving large-size smart waste collection problems with workload constraints through a hybrid metaheuristic

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Abstract | Paper #107

The emergence of the Internet-of-things (IoT) has created opportunities in companies to access real data to support their decision making process. Waste systems are not an exception, and real data availability on waste bins fill levels leads to the so called smart waste collection problem. This work explores this problem and proposes a hybrid metaheuristic to solve it considering workload constraints. This methodology consists of: (i) a look-ahead heuristic to decide the days in which collection is necessary and the bins that need to be collected (must-go) according to the present bin fill levels and future bin fill level predictions; and (ii) a simulated annealing/neighborhood search algorithm to choose the bins that can result in more profitable route(s) if visited and the best route(s) to visit these bins. The proposed hybrid metaheuristic is applied to test instances of different sizes and to a real case study with useful and satisfactory results.

Keywords: Smart waste collection; workload constraints; hybrid metaheuristic; simulated annealing; neighborhood search.

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Experimental evaluation of gear-shift and internal-combustion engine variables on fuel consumption, noise and pollutant emissions

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Abstract | Paper #108

Although variability of noise and pollutant emissions are usually associated with vehicular speed and acceleration, driving style, mainly related to gear-shift and internal engine variables such as revolutions per minute (RPM) or engine load (EL), can also play a key role. Moreover, the contribution of each variable for fuel consumption, noise and pollutant emissions can vary for different vehicle-motorization types. However, the effect of such internal variables on noise and pollutant emissions is not fully exploited in the literature. Thus, this work aims to assess the impact of the gear selection, RPM, and EL on fuel consumption, and carbon dioxide (CO_2), nitrogen oxides (NOx), and noise in terms of sound power level (L_w) emissions for a diesel passenger vehicle. This is focused on a speed and gear-based controlled on-road environment. Internal observable (fuel consumption, RPM, and EL) and kinematic (speed and acceleration) variables were recorded on a second-by-second time basis using an On-Board Diagnostic System, and noise data were recorded with a Sound Level Meter. Pollutant emissions were estimated using the Vehicle Specific Power (VSP) methodology with a 1Hz frequency. In this study, Clustering and Disjoint Principal Component Analysis is applied to find patterns hidden in data. An Ordered Logit model to predict the gear based on exploring kinetic and internal engine variables, that are influenced by driver's driving style, is developed. Preliminary results highlight the potential of the developed model and show the potential influence of gear selection for minimizing fuel consumption, noise and pollutant emissions. These findings establish a foundation for developing a sustainability gear-shift indicator that not only is focused on minimizing fuel consumption, but also noise and pollutant emissions. These are relevant for a driver to understand vehicle performance and alleviate the relative impacts of the driving style if integrated into vehicle engine control units.

Keywords: Gear-shift indicator; internal observable variables; kinematic variables; pollutant emissions; noise.

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Biplots of kinematic variables and pollutant emissions for an intercity corridor

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Abstract | Paper #109

A thorough understanding of driver behavior is an important step to improve the environmental performance of road traffic. Accurate data analysis tools can be valuable to identify these concerns. The present study explores relationships between driving patterns, tailpipe emissions, and road differentiation by using Principal Component Analysis Biplot. This statistical methodology is suitable to identify patterns hidden in data and can be used as a visualization tool. In this study, the key variables included were: speed, engine speed (RPM), acceleration, and vehicular jerk (first derivative of acceleration), as kinematic variables, and carbon dioxide (CO_2), nitrogen oxides (NOx), and VSP (Vehicle Specific Power) mode, as pollutant emission variables. For this purpose, second-by-second vehicle dynamics and tailpipe emissions data were collected in three passenger cars with different powertrains (gasoline, diesel, and hybrid) along with different types of routes (one partly urban/rural and two motorways with variations in traffic volumes) in Aveiro Region (Portugal). Results revealed that Biplots allowed to distinguish different driving behaviors, separate route types (urban/rural from motorways), establish some remarks about emissions, and also present the correlated variables in a single plot. Therefore, this technique can be considered as a useful visualization tool to explore real traffic-related data.

Keywords: Biplots; principal component analysis; tailpipe emissions; kinematic variables.

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Comparing two hybrid neural network models to predict real-world bus travel time

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Abstract | Paper #110

In order to enhance the efficiency and reliability of bus transportation systems, it is important to predict travel time precisely in the planning phase. With the precise prediction of bus travel times, the cost can be reduced for bus companies, such as from planning fixed buffer times between trips, while a better service can be provided for passengers. In this study, historical bus travel data from a bus line of the HOCHBAHN bus company in Germany in 2019 are used for the analysis.We develop two neural network models, namely multilayer perceptrons and a long short-term memory neural network, for predicting the bus travel time between timepoints for a trip occurring at a given time of day, on a given day of the week, and in given weather conditions. Both neural networks are combined with a genetic algorithm and a Kalman filter to improve accuracy. The genetic algorithm is implemented to tune the neural network parameters, such as the number of hidden layers and neurons in a hidden layer, while the Kalman filter algorithm is used to adjust the travel time prediction for the next trip using the latest bus operation information. In the experiment, we test our models month by month and split data for each month into three parts: the data of the first two weeks for training, one week for validation and the last week for prediction. The experiment results show that the hybrid model is powerful for predicting the bus travel time. In particular, the combination of the multilayer perceptrons with the genetic algorithm and Kalman filter provides the best travel time prediction (with an improvement of 56.2% compared with the planned bus travel time from the bus company). In order to make a recommendation for bus companies to plan vehicles with more accurate bus travel times, we test our hybrid models with larger training sets to predict the travel times e.g. in August. However, due to the structure of the planning problem, the plan for buses should be estimated before a new month begins. We cannot consider the real information during the planning, therefore we apply our hybrid models without the Kalman filter and they provide on average about 26% improvement compared with the planned travel time.

Keywords: Bus travel time predication; multilayer perceptrons; long short-term memory neural network; genetic algorithm; Kalman filter.

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A study on user acceptable road pricing policy for toll roads: A case of Eethakota, India

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Abstract | Paper #111

User's acceptability and perceptions are the important issues for the successful implementation of road pricing schemes. In a developing country like India, the toll collection is switching from Manual Toll Collection (MTC) to the Electronic Toll Collection (ETC) and Open Road Tolling. A better understanding of perceptions and acceptability on different road pricing schemes can help transport planners and decision makers to know the public support for road pricing schemes before and after implementation. A questionnaire based survey has been used to explore perceptions and acceptability of road pricing schemes such as High Occupancy toll (HOT), Dynamic Toll Pricing (DTP), Distance based pricing etc. For the present study, the sample of 550 respondents has been taken with the help of an online platform and face to face interview. The results show that about 41.18 percent of the users are willing to use the distance-based pricing scheme. The study developed multinomial logit model to analyse the acceptability of different pricing schemes. The results show that there are significant differences in user acceptability by the type of charging scheme proposed. HOT was most acceptable by users who perceive less travel time savings for using toll roads. The acceptability of DTP decreases for users who felt tolls are not an appropriate mechanism to fund roads. Number of toll booth passed is a significant parameter affecting acceptability of distance based pricing. In addition; socioeconomic variables also affect each of the pricing schemes. The signs of estimated parameters fit prior knowledge and are statically significant.The outcome of the present study will provide a reference for providing a users' acceptable pricing scheme in India.

Keywords: Road pricing scheme; acceptability; multinomial logit model.

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Analytical and simulation-based estimation of public transport demand

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Abstract | Paper #112

We consider the problem of public transport demand estimation. For the practical use of many models of transit assignment in any planning study, the knowledge of the transport demand systematized as an origin-destination matrix is required. Generally, this matrix is very expensive and difficult to obtain. In (1) we proposed to estimate the OD-matrix through the numerical solution of a bilevel optimization problem. One disadvantage of this formulation is the difficulty of obtaining descent directions; therefore, we proposed a derivative-free method for the resolution of the optimization problem. Our goal in this work is to extend the study to larger networks, combining analytical modeling and simulation-optimization methodology. We use both approaches to perform the demand estimation over a section of a real network, and compare the obtained results for different scenarios and parameters.

Keywords: Public transport demand; transit assignment; bi-level optimization; simulation; equilibrium model.

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Properties of a Markov model representing the dynamics of mode choice adaptation to radical supply changes

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Abstract | Paper #115

Day-to-day dynamics of mode choice adaptation to a radical supply change, such as the introduction of a new metro line, is considered. A model based on a stochastic process of choice is proposed. The variables of the dynamical system are choice probabilities. The model considers inertia, i.e. state dependence, and shocks, i.e. serially uncorrelated random terms, and is Markov. The system evolves according to time-homogeneous transition probabilities. A comprehensive review of the properties related to convergence to the stationary state and speed of convergence is provided. The problem of estimating the entries of the matrix of transition probabilities when these are logit with inertia is addressed. The insights are illustrated by the analysis of the dynamics, from a stationary state to a new stationary state, in a two-alternative numerical example based on simulated data. In particular, the application investigates the sensitivity of the dynamics to the inertia variable, and provides an assessment of the ability of the maximum likelihood estimators to recover the true coefficients.

Keywords: Dynamics; inertia; Markov process; mode choice.

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A very large-scale traffic network modeling based on the integration of the Bi-dimensional and the GSOM Traffic Flow models

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Abstract | Paper #116

A continuum traffic modeling is proposed to be applicable in very large and dense networks, requiring a large volume of information difficult to recover and process. The aim of this paper is to merge both macroscopic models: bi-dimensional model (BIDIM) with the GSOM (Generic Second Order) model in order to overcome the missing data for large networks and to benefit from the advantages of each model. As well, the major advantage of the proposed approach is to reproduce a detailed description of traffic dynamics for the main arteries using the GSOM model. Indeed, the bi-dimensional model allows the simulation of areas where the measurements are missing or incomplete. The method consists in proposing an interface node model ensures the exchange between the BIDIM and the GSOM traffic models. The exchange between arteries of the GSOM model and cells edges of the bi-dimensional is assumed through the supply and demand concept. Moreover, the simulation is carried out using Godunov scheme and finite volume method. The dynamic of the developed simulation model reproduces the propagation of the congestion between both models. Applied to a synthetic network, the output results are very promising.

Keywords: Large networks modeling; macroscopic model; Bi-dimensional model; GSOM model; traffic flow; Godunov scheme.

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Case study of Dial-a-Ride Problems arising in Austrian rural regions

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Abstract | Paper #117

The Dial-a-Ride Problem (DARP) aims to find an optimal schedule for a set of customer requests served by a heterogeneous fleet of vehicles. Further restrictions, namely time windows, pick-up, and drop-off locations, and capacity constraints are generally customary. A common example arises in door-to-door transportation of elderly people or people with impaired mobility. In this work, we consider a dynamic-deterministic variant of the DARP for two Austrian mobility providers. The focus of these operators lies on rural regions served by a heterogeneous fleet of vehicles. As additional conditions, we take the transportation of people with impaired mobility, break times, and the capacity of wheelchairs into account. We consider a heuristic and an exact solution approach for the DARP, namely a Large Neighborhood Search and a Mixed-Integer Linear Programming approach. In a computational study, we show different operator scenarios (minimizing overall driven kilometers, number of used vehicles, and number of unscheduled requests) with up to 500 requests per day and 50 vehicles.

Keywords: Dial-a-Ride Problem; large neighborhood search; vehicle routing.

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Establishing performance criteria for evaluating pedestrian environments

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Abstract | Paper #118

Promoting pedestrian mobility represents a strategy to achieve a sustainable transportation system, where problems such as traffic congestion, air and noise pollution are minimized. For this aim, it becomes fundamental to identify pedestrian environments that can facilitate and encourage to make trips by walking. The objective of this paper is to provide a practical methodology that can assist the analyst to identify the best alternative among some pedestrian paths with different characteristics. To this aim, subjective, objective and mixed indicators were proposed to measure the performance criteria adopted for evaluating the alternatives. A Multi-criteria analysis was applied as a tool of evaluation. The findings of the work suggest that pedestrians seem to appreciate the tree-lined paths, and prefer to keep bike lines separated from pedestrian paths. Number of crosswalk is relevant in the evaluation of pedestrian path, especially when there are shops along the path. Aspects related to the conditions of the pavement and to comfort and environment are less relevant.

Keywords: Pedestrian mobility; objective indicators; subjective indicators; MCDA.

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On a real-world railway crew scheduling problem

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Abstract | Paper #119

A railway company has to deal with many interrelated planning tasks. In this work we consider the Railway Crew Scheduling Problem (RCSP) for the Rail Cargo Austria (RCA), which is the largest railway company for freight transportation in Austria and one of the largest in Europe. The RCSP aims for determining the most efficient combination of shifts. For RCA's purposes these are shifts for engine drivers. A shift consists of a sequence of consecutive scheduled trips of locomotives and tasks over a given period of time. Each trip must be covered by exactly one shift while operational, legal and labor constraints are satisfied. The RCSP is known to be difficult to solve and there exists a wide range of solution approaches resulting from many research activities. We present and investigate a matheuristic to tackle the RCSP. We use a breadth-first search construction heuristic and formulate a Set Partitioning Problem with the aim of minimizing the overall paid working time, while all RCA specific constraints are incorporated. Although schedule efficiency and employee satisfaction are in general conflicting, a cost-efficient schedule will not be implemented if it does not reach acceptance of the crew. In a computational study we evaluate the proposed approach on it's practical applicability on real-world data provided by RCA, based on the Austrian railway network. The focus is on analyzing the effects of different conditions on crew schedules. In the course of this evaluation we make use of algorithms from previous work on the Locomotive Scheduling Problem (LSP), tailored to RCA's demands. The LSP is concerned with assigning locomotives to a train schedule while costs are minimized, and the obtained optimal locomotive schedule forms the input for the RCSP. This work provides the basis for a succeeding planning tool, as soon as the locomotive schedule was determined.

Keywords: Railway crew scheduling problem; matheuristic; real-world application.

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Assessing equity in carsharing systems: the case of Munich, Germany

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Abstract | Paper #122

This paper shows an application of a multi-agent transport simulation to evaluate equity effects of the introduction of a carsharing system. Using vehicles, members, and planning data of Oply, a carsharing service that operated in Munich until March 2020, we analyze the evolution of the distribution of costs and benefits among the inhabitants of this city. By explicitly introducing the income as an active part of the utility calculation we evaluate how offering a new mode of transport impacts the score of the agents. Two scenarios are employed to assess equity in economic terms and accessibility terms. Two different outcomes are expected: firstly, as a high pricing service, carsharing will favor high-income agents, thus skewing benefits towards them; secondly, we show that the granularity of this agent-based simulator makes it a handy tool when conducting policy evaluations on the introduction of a carsharing system.

Keywords: Carsharing; MATSim; agent-based modelling; equity.

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Transport authorities and innovation: Understanding barriers for MaaS implementation in the Global South

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Abstract | Paper #124

Mobility-as-a-Service (MaaS) is a recent concept that is seeing increasing interest across the world. First studies and field trials in developed cities suggest that MaaS can influence people's mobility behavior and create more sustainable transport systems. However, many findings are not transferable to the Global South context, considering that in terms of transport infrastructure, institutional setups, and citizens' preferences, most developing cities present significantly different characteristics. Thus, many critical questions remain unanswered, e.g., 'How to implement MaaS in a developing context?', 'What are the main challenges?', and 'Who should lead this development?'. This research work considers a public-pushed development and aims to shed light on barriers that transport authorities might face. First, barriers are identified through a literature review at the intersection of transport research and public sector innovation. Second, the barriers are analyzed based on the technology, organization, and environment (TOE) framework. Third, Global South relevance is determined through a two-round expert survey. Data related issues (e.g., standardized open data) have been identified as the most critical barrier. Also, multimodal transport planning and coordinating intermodal trips seem to be crucial challenges, considering highly fragmented operator landscapes and the lack of integrated transport planning approaches. In addition, auto-centric developments, current institutional setups, and transport authorities' organizational structures could hamper a MaaS transition in the Global South. This article contributes to the emerging literature on MaaS governance and provides insights on the capabilities of developing cities to establish MaaS and other transport innovations.

Keywords: Mobility as a Service (MaaS); public sector innovation; organizational adoption; implementation barriers; developing countries; TOE framework.

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Anxiety, fear and stress feelings of road users during daily walking in COVID-19 pandemic: Sicilian cities

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Abstract | Paper #125

The COVID-19 pandemic has significantly influenced people's lifestyles including their travel choices. The pandemic resulted in placing restrictions in travelling throughout Italy due to the obligatory need for social distancing and changes in public transport services. City residents changed their mobility patterns and started using their private vehicles more often instead of public transport, while choosing to walk or cycle for short distance trips. Governments and local authorities encouraged citizens to use sustainable travel modes, particularly walking, during the pandemic period. However, the high number of infections and deaths, especially in Italy, has strongly influenced the propensity of walking due to the emotional aspects of travelling. This paper presents a statistical analysis based on data gathered through a questionnaire in urban areas of Sicily focusing on travel by walking for either leisure or work. The evaluation of negative emotions that people who habitually walk for short distances in the study areas is the main focus of the present work. The data indicated a variation between three emotions: anxiety, stress, and fear. These emotions had a potential to influence people's daily life and, as a result, their travel habits.

Keywords: Walking; COVID-19; pedestrian feelings; sustainable mobility; road users.

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Tourists' wayfinding during evacuation based on a virtual reality experiment and simulation

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Abstract | Paper #126

Tourists are often more vulnerable than residents in sudden disaster situations due to lack of knowledge regarding evacuation routes and safe areas. To establish protocols and the schemes for tourist evacuation to safe areas, it is necessary to gather their likely behavior during an evacuation. Since there are few actual data available we conducted a VR (Virtual Reality) experiment assuming a sudden disaster situation and estimated tourists' route choice based on the experiment. The experiment was conducted with a newly developed application. In the experiment pictures of intersection in the touristic Higashiyama area of Kyoto, Japan, where shown to participants and they could choose the direction they want to proceed until reaching an open space or designated shelter. As a result, we could quantify the impact of road width and, to some degree, network structure. The results reveal the tendency to select wide roads and to proceed straight. If the participants were put under time pressure these tendencies are intensified. Utilizing these results we constructed an evacuation simulation. We conducted the simulation with various guidance situations and compared those results. The results illustrate potential capacity bottlenecks of designated shelter locations and the importance to provide route guidance and certain points in the network.

Keywords: Tourists' evacuation planning; wayfinding; virtual reality; evacuation simulation.

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Exhaust and non-exhaust emissions from today's and future road transport: A simulation-based quantification for Berlin

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Abstract | Paper #127

The full decarbonization of the transport sector is one of the greatest challenges of the coming decades. In this study, both greenhouse gases and local air pollutant emissions are quantified for the today's situation (reference case), a full decarbonization scenario and a transition scenario. The quantification uses the Handbook Emission factors for road transport (HBEFA, version 4.1) and the simulation framework MATSim (Multi-Agent Transport simulation). In the today's situation, for an average car user who lives in Berlin, the CO_2 footprint amounts to 3.3 tons per year. In contrast, for an average car user who lives in the Greater Berlin area, including Berlin, the CO_2 footprint amounts to 4.9 tons per year. In the full decarbonization scenario, greenhouse gases are eliminated. Nevertheless, non-exhaust emissions are still present. In the full decarbonization case, PM10 is found to decrease by 13-15%, PM2.5 by 26-31% and Black Carbon by 63-68% compared to the reference case (year 2020). The applied simulation approach allows for a detailed investigation of further transition scenarios towards full decarbonization.

Keywords: Decarbonization; emissions; electric vehicles; air pollution; agent-based simulation; non-exhaust emissions.

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Comparing home and parcel lockers' delivery systems: A math-heuristic approach

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Abstract | Paper #129

E-commerce is a continuously growing sector worldwide, with important repercussions on the delivery system in urban areas and especially in the Business to Consumer (B2C) sector. The delivery of a package to a consumer's address involves not only high costs for couriers (greater number of kilometres travelled), but also increased congestion and greater environmental pollution (greater volume of pollutants released into the air). To rationalize deliveries in urban areas the use of collection points, equipped with lockers, to store the goods that users have ordered has been considered in literature. This work compares two alternative delivery options: deliveries to the consumer's home versus to Lockers. To make this comparison we used a cluster first route second math-heuristic approach. In the clustering phase, we experimented a new clustering function, while the routing phase consists in solving an instance of the Traveling Salesman Problem for each generated cluster. Finally, we applied the math-heuristic to a real case (the Italian municipality of Dolo near Venice) and compared the two delivery alternatives. We evaluate the performance considering two different fleets of vehicles, with small and medium capacity. In addition, since additional trips might be performed by consumers to pick up parcels at Lockers, a sensitivity analysis was carried out to analyse the sustainability of the proposed city logistics scheme.

Keywords: City logistics, freight urban distribution, vehicle routing, math-heuristics.

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Mode shift with tradable credit scheme: a simulation study in Lyon

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Abstract | Paper #132

Several tradable credit schemes have been proposed over the last decade to restrict the use of personal cars and reduce negative traffic externalities such as congestion and pollution. Two of the main arguments of this approach compared to congestion pricing are that it is revenue-neutral and that the market could self-regulate the credit price. The trip-based MFD (Macroscopic Fundamental Diagram) framework is an efficient tool to simulate traffic dynamics at a large-urban scale considering multimodal options. It is very convenient to test demand management strategies targeting all travelers. In this paper, we propose to use such a simulation framework to investigate a tradable credit scheme, which aims to foster mode shift by regulating access to the road network. Credits are allocated to the users and are required for using their car. They can save their credits for another day or trade them using a marketplace. The credit scheme impacts are illustrated through a numerical implementation with a demand typical of a peak hour (7:00 to 8:00) in Lyon with 115 628 trips. The main result of the simulation is the potential for such a tradable credit scheme to increase public transportation share and thus reduce total travel costs.

Keywords: Tradable credits; trip-based MFD; reservoir; agent-based simulation.

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Mapping of individual transportation traffic-related externalities in an intercity corridor

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Abstract | Paper #133

There has been an increasing trend in private vehicle ownership. Despite the flexibility, convenience, and comfort-related advantages of individual transportation, it also represents some negative impacts. This paper proposes a methodology to map the individual transportation traffic-related externalities in an intercity corridor. For that purpose, PTV VISUM is used to develop a transport model. The externalities under study are CO_2 and NO_x emissions, noise, safety, and congestion. After the estimation of each externality, the information is displayed in a GIS database for analysis. The mapping of such externalities allows to support regional planning policy strategies since it can be applied as an analysis tool that can be used to estimate the impacts of specific scenarios, identify blackspots and provide insights regarding future traffic flow optimization. Using this methodology, it was possible to find the largest blackspot in terms of external costs per VKM (Vehicle-kilometer), road segments that are characterized by high volumes with low road capacity. The findings highlight that the peak-hour period entails 8% higher External Costs per VKM, in particular in the national road, but for the motorway, the value is similar. The total external costs per VKM are 8% higher in the national road during peak hour, while the value is 6% higher for the motorway in the off-peak hour period. Depending on the level of congestion, the weight of each externality differs. For a V/C ratio higher than 1.2, the congestion-related externality weights 80% of the total of externalities, while for a V/C ratio lower than 0.8, the crashes-related externality (80%) is the most prevalent, followed by the CO_2-related externality (16%).

Keywords: Mapping; intercity corridors; externalities; individual transportation.

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Multidimensional indicator of MaaS systems performance

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Abstract | Paper #136

The concept of MaaS has been described as a new way of managing urban and regional Mobility and facilitating the reduction of dependence on the individual vehicle. MaaS systems have been characterized through a single indicator so far, just providing information about the services available to the users or the level of technology used. However, to facilitate the comparison between various platforms by the potential users and facilitate the discussion between stakeholders, it is essential to provide a broader set of measures to evaluate each platform. In this work, we propose a multidimensional system based on three dimensions (coverage, functionality, and sustainability) based on pairs of indicators (geographical coverage and multimodality level; services and technology; contribution to social cohesion and the environment). The analysis of a dozen of mobility services in several European countries confirmed the notion that the MaaS is still in the preliminary development phase, and there is still a considerable margin of progress given the effective penetration in the market of large-scale systems, with advanced integration levels and effective demonstration of societal impacts.

Keywords: Mobility as a Service (MaaS); multidimensional indicator; multimodality; sustainability; policy.

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Analysis of MaaS membership attributes: An agent-based approach

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Abstract | Paper #139

Mobility-as-a-service (MaaS) provides a bundle of mobility services under one plan subscription, allowing its customers to travel on a seamless multimodal system. It is envisioned that MaaS will foster more sustainable mobility, but its expected impact is still unknown, since no MaaS system has been deployed in practice, if not in few pilots. This study aims to identify potential MaaS members attributes applying an agent-based modelling approach including MaaS as alternative for the agents. In particular, we simulate a MaaS system configuration in the city of Berlin, giving accessibility to a basic MaaS plan characterized by a daily subscription fee payment. We evaluate 5 different ranges of MaaS plan price scenarios. For comparison, we simulate a Pay-as-you-go configuration, considering specific trip-based costs per each mobility service and considering the total cost of car ownership in the daily agents' score function. Results generally show a general modal shift from walk, bike and car to MaaS services. Expectedly, the number of MaaS customers decreases as the MaaS price rises. Former public transport and free-floating car-sharing users represent the main potential MaaS customers, as they are the users who employ MaaS services for the longest time during the day. Moreover, car trips have been substituted more than 40% by public transport in MaaS scenarios suggesting that MaaS could have an overall positive impact on the environment.

Keywords: Mobility-as-a-Service; MATSim; utility maximisation; mode choice; MaaS membership.

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Multiagent meta-level control for adaptive traffic systems: A case study

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Abstract | Paper #141

As cities across the globe continue to grow, traffic congestion has become globally ubiquitous with great economic and environmental costs associated with it. The increasing prevalence of self-driving vehicles creates an opportunity to build smart, responsive traffic infrastructure of the future. Such an infrastructure consisting of connected and autonomous vehicles and smart traffic lights would have the potential to cope with congestion, weather phenomena and accidents, while maintaining safety and ensuring privacy of information. This paper introduces an approach to address the challenge of dynamically adjusting traffic to the changes in the environment. We argue that multiagent meta-level control (MMLC) is an effective way to non-myopically determine how and when this adaptation should be done. The approach highlights the role of dynamic meta-reasoning in a platooning scenario, in which collaboration contributes to improved travel time for vehicles in the network as well as a positive environmental impact as related to fuel consumption and emissions. Specifically, for the case study described in the paper, our MMLC-based approach leads to approximately 44% decrease in travel time, 7% increase in average speed, a 32% decrease in fuel consumption and a 35% drop in emissions. We also see performance advantages for a scaled-up mixed traffic simulation environment.

Keywords: Intelligent transportation systems; smart cities; multiagent systems; meta-level reasoning.

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Clustering urban transport network junctions using convolutional neural networks and fuzzy logic methods

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Abstract | Paper #147

The article develops methods to improve the accuracy of modeling and predicting the traffic capacity of intersections based on the fuzzy factors of intensity of pedestrian flow and flow discontinuity. Initial data was collected and analyzed using convolutional neural networks (YOLOv3). The article justifies the need for clustering signal-controlled junctions of the transport network to form a limited number of generic management algorithms for them. We analyzed the differences between clusters by the average values of independent factors. Regression modeling was completed for each cluster. Statistical analysis showed a significant improvement in the quality of the models within each cluster compared to the complete model of transport junctions, exceeding the maximum permissible quality thresholds. We built a model using fuzzy logic methods which reflect the distribution field of the influence of the most important factors to visually represent the influence of the fuzzy factors on the operation of a signal-controlled junction of the transport network.

Keywords: Signal-controlled transport network; right turn; clustering of intersections; statistical significance of differences; regression analysis; fuzzy logic.

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Providing dynamic route advice for urban goods vehicles: the learning process enhanced by the emerging technologies

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Abstract | Paper #148

This paper investigates the contribution of emerging technologies (i.e., internet of things and big data) for providing route advice to goods vehicles driving within cities. More precisely, the implementation and application issues related to the introduction of opportunities offered by emerging technologies in gathering real-time data, in obtaining knowledge and support for providing route suggestions will be pointed out. The main results concern the formalization of the trade-off that it is necessary to activate between the different emerging technologies (starting from internet of things and big data) to improve the learning process of path utility. This process is formalized within the general theory of dynamic transport systems. Thus, the possibility of using multiple technologies in an integrated way is pointed out, identifying the road ahead for researchers and technicians both for specializing the general technologies related to the transport systems, and for improving the current systems that provide the user with real-time and personalized information on the route.

Keywords: Emerging technologies; city logistics; path choice; path utility; path disutility; route advice; goods vehicles; last mile delivering.

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Urban factors influencing the vehicle speed of public transport

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Abstract | Paper #149

A smart and sustainable city views public transport as a policy priority. Tools to support decision-making of municipalities and bus operators are needed. Most of past studies focused on the effect of a single variable on bus travel time, being the most common studied variables the presence of bus lane and traffic signals at intersections. The analysis of the joint impact of several variables are promising, particularly using data that is commonly available to the bus operators. In this view, the present study applied a generalized linear model using bus speed as dependent variable to assess the effects of factors related to time and urban space. Data from four bus lines in the city of Porto operated by STCP (main bus operator) was considered, showing that all the analysed variables have impact on speed. The study findings confirm the relevance of bus lanes and traffic signals as spatial priority schemes. Future developments can be considering to include more variables in the model. Overall, the present study leads to relevant conclusions that can support the decisions of transit agencies and public transport operators. Additionally, the speeds obtained by the model can be used for calibrating simulation models.

Keywords: Public transport; bus speed; bus lane; urban factors; space variables; time variables.

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Static bike repositioning problem with heterogeneous distribution characteristics in bike sharing systems

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Abstract | Paper #151

Bike sharing is one of the recent trends in urban areas as a solution for the mobility problem, where it is seen as a significant component of local transportation due to the need to ensure last-mile transportation. Bike sharing systems enable bicycles to be rented at a station for a ride and be dropped off at another station which provides flexibility to users. However, incorporating a bike sharing system into the transportation network of a city involves its own challenges including balancing the supply and demand within stations, and scheduling bikes' repositioning. The bike repositioning scheduling problem arises due to the variable demand for various types of bicycles that can be rented from and left to any station. In order to ensure sustainability in bike sharing operations, bikes should be redistributed to the stations considering the demand, during for example a day or night. In this context, with the ultimate motivation of proposing a bike sharing system to meet within-day demand dynamics in a metropolitan city, we address the Static Bike sharing Rebalancing Problem (SBRP) with multiple capacitated vehicles for redistribution of bicycles. On purpose, we formulate a mixed-integer linear program in which the objective is minimizing the total cost subject to a set of constraints including truck capacity, demand satisfaction, inventory balance, and flow preservation. We have obtained the results from solutions to the SBRP through a real case study discussing the tendency on bike sharing systems before and during Covid-19 pandemic, in which total distance traveled according to the repositioning schemes for different months in a year, repositioning, and the truck type requirements for different days in a week, and the unsatisfied demand concerning the actual demands are analyzed. Computational experiments have shown that the distance traveled by trucks varies for the days of the week in different months of the year depending on the change in demand.

Keywords: Bike sharing; micro-mobility; routing, heterogeneous fleet.

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Modelling the dynamics of fragmented vs. consolidated last-mile e-commerce deliveries via an agent-based model

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Abstract | Paper #156

This paper proposes a new agent-based model (ABM) to explore different scenarios of e-commerce urban deliveries, comparing door-to-door deliveries with consolidation-based strategies. The ABM reproduces operation under different demand patterns and include the possible matching of customer systematic trips and collection/delivery points with small detour from the scheduled trip. Several variables of the model can be changed in a parametric simulation environment, allowing to infer the level of convenience of consolidation strategies for the different actors involved. The model provides indicators able to take into account customer and logistics operator perspectives, and the impact of the service on the community. Results can give useful information to understand how to manage growing on-demand urban deliveries and to measure the impact of freight transport on city sustainability.

Keywords: Parcel deliveries; e-commerce; consolidation; parcel lockers; city logistics.

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A heuristic for two-echelon urban distribution systems

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Abstract | Paper #158

The negative impacts of urban freight transport have fostered the design of new distribution systems for inner city deliveries. One of the proposed city logistics solutions is the establishment of two-echelon distribution systems, where freight originating from the periphery of the city is transferred at intermediate locations (satellites) from larger vehicles (urban freighters) to smaller more environmentally friendly vehicles (city freighters), deemed more suited to operate in the city centre. In this paper, we address a variant of the two-echelon (capacitated) vehicle routing problem (2E-CVRP) arising in the context of city logistics encompassing characteristics such as a heterogeneous fleet of city freighters, time windows, vehicles synchronisation at satellites, direct deliveries, the possibility of freight transfers at customers, and multiple trips by city freighters. We propose a heuristic solution method for this problem based on a Variable Neighbourhood Search (VNS) heuristic, as well as a set of auxiliary evaluation metrics designed to support the decision making process. Preliminary results show the flexibility of the proposed heuristic to account for different problem characteristics, as well as the impacts of considering different best insertion criteria for the initial solution construction. Additionally, the proposed evaluation metrics have allowed for an improved assessment of the trade-offs between different city logistic solutions, and may be considered when developing decision support systems.

Keywords: City logistics; two-echelon CVRP; synchronization; multi-trips; heuristic.

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Application of empirical & simulated vehicle trajectories in risk assessment at signalized intersection

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Abstract | Paper #163

Increasing road traffic accidents and fatalities, road traffic safety has become a major health concern all over the world. Over the years several studies have been carried out to enhance the road traffic safety aspects. However, majority of the studies are focused lane disciplined homogeneous studies. The lack of studies concerning safety in heterogenous traffic environment with weak lane-based movements motivated this study. Safety assessment is usually done using the crash data (reactive approach) or using TCT employing surrogate measures (pro-active approach). In this study, vehicle trajectories at signalized intersection with weak lane disciplined mixed traffic conditions have been extracted and used to estimate various SSMs for safety assessment. The extracted empirical traffic data is further used to develop a microsimulation model for acquiring vehicular trajectories in various traffic scenarios. The data generated from simulation is then analyzed for rear-end conflict and crash risk probabilities. Based on results probable measure to mitigate rear-end conflicts at signalized intersection with weak lane disciplined mixed traffic are studied. Also Based on the results from variation in number of conflicts, SSM of DRAC is observed to be suitable for weak lane disciplined mixed traffic conditions.

Keywords: Safety surrogate measures; microsimulation; vehicle trajectory; crash risk probability; signalized intersection.

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Examining traffic operations at multi-legged intersection operating under heterogeneous traffic: A case study in India

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Abstract | Paper #165

An intersection is a critical component of any road network, where traffic from different approaches merges and diverges. These merging and diverging traffic movements affect traffic operations and safety significantly. Different traffic management measures and control strategies and necessary geometric improvements are suggested to optimize traffic operations at a given intersection. It is also more prudent to assess the effectiveness of potential strategies towards improvement using simulation at first before certain appropriate strategies/alternatives are finally selected for on-field implementation. Kamrej intersection, a multi-legged junction in Surat, located in the western part of India, is taken as a case study. Traffic data such as traffic volume counts and spot speeds are used to generate and calibrate the present field condition (base model) using PTV-VISSIM software. The calibrated model is then validated using vehicle-class-wise average travel time for each traffic movement (straight and turning) and traffic flow during peak hours. Average delay is used as a measure to assess the effectiveness of selected potential traffic management alternatives. When different demand management scenarios are assessed, it is found that delays for straight and right movements can be reduced substantially, contributing towards improvement in efficiency and traffic operations at selected intersections. The current approach holds promise, thereby contributes to improving traffic operations at selected multi-legged intersections.

Keywords: Traffic simulation; intersection improvement; heterogeneous traffic.

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Design consistency evaluation of two-lane rural highways in hilly terrains

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Abstract | Paper #168

The main objective of the geometric design consistency is to minimize the emergence of unforeseen events when road users drive along a road segment. A consistent highway design ensures that successive geometric elements act in a coordinated way. In India, vehicles with diverse static and dynamic characteristics interact with each other leading to a significant difference in traffic flow operations compared to highways in developed countries. Due to the heterogeneity in traffic flow, geometric consistency would vary significantly by vehicle category for similar curve characteristics. The present study analyzes geometric design consistency by vehicle and develops vehicle category-based design consistency models for mixed traffic environments on two-lane rural highways in hilly terrain in India. A total of 30 curves with varying geometric characteristics located along the National Highway (NH-953) connecting Netrang and Rajpipla, Gujarat, India, were selected. Speed data were collected using radar gun for three vehicles category: motorized two-wheelers (MTW), cars, and heavy commercial vehicles (HCV). Geometric design consistency was evaluated using operating speed as a surrogate safety measure. The results showed that 38% and 10% of the curves (for cars), 51% and 20% of the curves (for MTW), and 32% and 51% of the curves (for HCV) have ratings of fair and poor consistency, respectively. Design consistency models for different vehicle categories were developed using the generalized linear regression modelling (GzLM) technique. The results showed that the deflection angle is positively correlated, whereas curve and tangent lengths are negatively correlated with highway alignment design consistency.

Keywords: Two-lane rural highways; hilly terrain; operating speed; geometric design consistency; vehicle categories; generalized linear regression modelling (GzLM).

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Correlating the effect of Covid-19 lockdown with mobility impacts: A time series study using noise sensors data

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Abstract | Paper #169

The Covid-19 crisis forced governments around the world to rapidly enact several restrictions to face the associated health emergency. The Portuguese government was no exception and, following the example of other countries, established various limitations to flat the contagions curve. This led to inevitable repercussions on mobility and environmental indicators including noise. This research aims to assess the impact of the lockdown due to Covid-19 disease on the noise levels recorded in the city of Porto, Portugal. Data from four noise sensors located in strategic spots of the city were used to calibrate and validate Time Series Models, allowing to impute the missing values in the datasets and rebuild them. The trend and the cyclic information were extracted from the reconstructed datasets using decomposition techniques. Finally, a Spearman correlation analysis between noise levels values and traffic volumes (extracted from five inductive loop detectors, located nearby the noise sensors) was performed. Results show that the noise levels series present a daily seasonal pattern and the trends values decreased from 6.7 to 7.5 dBA during the first lockdown period (March-May 2020). Moreover, the noise levels tend to gradually rise after the removal of restrictions. Finally, there is a monotonic relationship between noise levels and traffic volumes values, as confirmed by the positive moderate-to-high correlation coefficients found, and the sharp drop of the former during March-May 2020 can be attributed to the strong reduction of road traffic flows in the city.

Keywords: Traffic noise; time series models; Covid-19; inductive loops.

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Changes in car use resulting from a TOD-type project: Longitudinal macro-analysis of the case of Metro do Porto (Portugal)

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Abstract | Paper #170

Transit-oriented development, a concept integrating land use and public transport planning, has been widely studied in recent years as a means to reduce car trips and promote sustainable transport modes. However, longitudinal studies on the matter are still rare. Our paper explores Transit-Oriented Development (TOD) effects on travel behavior by analyzing the evolution of the number of car trips after the implementation of a light-rail metro system in the Porto region (Portugal). As Metro do Porto is a large infrastructure project (metro network of 67 km), a macro-analysis at the civil parish level is performed. Changes in the number of car trips are evaluated using a difference-in-differences model, extended to a spatial model to account for metro's spillover effects. These effects became obvious as metro ridership is reported not only in the directly metro-served parishes, but also in adjacent non-served parishes. Furthermore, we compare the performance of parishes predominantly served with TOD stations to those with transit-adjacent (TAD) stations (located in proximity to urban settlements but not properly articulated with them). We conclude that both station types can reduce the number of car trips, yet only TOD parishes generate significant spillover effects. The importance of other potentially influential factors like building density or socio-economic characteristics, is also discussed.

Keywords: Transit-oriented development; metro systems; travel behavior; panel data; difference-in-differences models..

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Joint-activities generation among household members using a latent class model

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Abstract | Paper #172

Individuals' decision to include an activity in their daily agendas is based on their needs. They take decisions of activity participation, considering the activities and schedules of other household members. This results in activities that involve the joint participation of household members. Limited modelling research is available on the notion of the generation process of joint activities of household members. Besides, the time span for most of the operational models is a single day. The current paper's focus is on modelling joint-activity generation where the time span is based on multiple days (one week). We used a latent class model (LCM) and estimated it using the data from the National Travel Survey (NTS (UK)) for the years 2013-14. On a given day, it is assumed that the individual includes an activity (that may be joint activity) in his agenda based on his need. The model predicts the probability of alternatives for an individual. Each alternative represents a series of binary outcomes (i.e. 1 or 0) in relation to the generation of a specific type of joint activity for every single day of the week. Four latent classes are identified based on model-fit parameters: frequent joint-activity performer, weekdays joint-activity performer, non-frequent joint-activity performer, and weekend joint-activity performer. The results show that both household and individual attributes impact the individual's weekly joint activities generation. The individual's economic status (i.e. full-time worker, part-time worker, etc.), available time window after mandatory activities, number of household members and life cycle stage (structure of the household, i.e. single-parent family etc.) affect which latent class the individual belongs to. Future research is focused on estimating the number of tours, and travel parties involve in joint activity models. It also focuses on integrating the model in some functional activity-based model.

Keywords: Joint-activity generation; weekly-activity diary; Latent Class Model (LCM).

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On the characterization of eco-friendly paths for regional networks

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Abstract | Paper #174

The aggregated traffic models based on the Macroscopic Fundamental Diagram represent a promising tool to design strategies for ecological routing and mitigate network-wide emissions. To this end, we must first characterize the relationship between path emissions and distance traveled on aggregated networks, i.e. a regional network. In this paper, we investigate this relationship on a 1-region and 4-regions networks. We utilize an accumulation-based MFD model to mimic the traffic dynamics in the network and utilize the COPERT IV model to estimate the travel emissions, focusing on the carbon dioxide CO_2. We show that in some cases there is a linear relationship between the total emissions of CO_2 and the average travel distance or travel time of paths on regional networks. However, this is not always true as the traffic dynamics play an important role in the drivers' path choices, i.e. on the network loading, and therefore on the total path emissions.

Keywords: Eco-friendly paths; regional networks; macroscopic fundamental diagram; sustainability.

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A novel image and audio-based artificial intelligence service for security applications in autonomous vehicles

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Abstract | Paper #177

Autonomous Vehicles (AVs) can potentially reduce the accident risk while a human is driving. They can also improve the public transportation by connecting city centers with main mass transit systems. Creating a system that can provide a sense of security to the passenger, when the driver is missing, remains a challenging task. In this work, an image and audio-based approach, supported by novel Artificial Intelligence (AI) algorithms, is proposed as a service to increase the security and trust inside an autonomous shuttle. The two modalities, running in real-time, can detect petty crimes scenarios such as screaming, bag snatching, people fighting and vandalism and enable notifications to authorized personnel for proper actions. The proposed solution is deployed on a Jetson AGX Xavier to favor power efficiency and seamless integration and achieves up to 96% accuracy. Thus, the envisioned system exhibits high potential for transforming security and safety in emerging autonomous public transportation infrastructure.

Keywords: Autonomous vehicles; public transportation; neural networks; image processing; audio processing.

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Describing the use of informal ridesharing in Scotland

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Abstract | Paper #178

Ridesharing, being part of shared mobility, is rapidly improving its diffusion, due to the use of apps and smartphones, increasing the sustainability of transportation systems. However, informal ridesharing continues to be an alternative solution for users, to reduce the total travel costs, despite it is not managed by platforms. To investigate people's behavior about shared mobility, we consider the 2017 Scottish Household Survey. Selecting users' aspects usually relevant concerning such travel modes, and setting binary logistic regressions, the strongest bond emerged involves the non-possession of private vehicles and the usage of informal ridesharing (odds ratio equal to 16.504). This result indirectly confirms the important effect of ridesharing in the reduction of car ownership, underlining the interest to better understand the impact on mobility of such habitude.

Keywords: Shared mobility; informal ridesharing; user's choice behaviour; logistic regressive model.

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Restart: A route planner to encourage the use of public transport services in a pandemic context

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Abstract | Paper #179

Public transport services play an important role in the mobility of the population in urban centers, allowing a decrease in the number of private vehicles in circulation and contributing to a more sustainable mobility. However, the emergence of the COVID-19 pandemic had a serious impact on the mobility habits of the population, with a substantial reduction in the number of public transport passengers due to the fear of contagion, which raises questions about the future sustainability of cities. Thus, it is essential to restore the confidence of travelers to feel safe and comfortable using public transport services. Taking advantage of the widespread use of mobile technologies, this article intends to propose a route planning system for public transport that meets the needs of passengers in terms of safety and comfort. After a systematic review of the existing literature and a series of focus group sessions, a prototype of the system was developed, and subsequently evaluated by potential users through usability tests. The results obtained are a good indicator of the system's functionality and ease of use. This assessment allowed us to corroborate the potential that the proposed route planning system has in promoting the use of public transport services as a means of mobility.

Keywords: Safety; comfort; public transport; route planner; Covid-19 pandemic.

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Understanding micro-mobility usage patterns: a preliminary comparison between dockless bike sharing and e-scooters in the city of Turin (Italy)

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Abstract | Paper #180

Urban areas around the world are experiencing a sharp growth of shared micro-mobility services mainly because of the introduction of shared dockless bikes and, more recently, of e-scooters. Besides understanding who uses these services and why, more studies are needed to understand when and where these services are used and whether their usage patterns differ. This study aims to expand the current state of knowledge about the usage of micro-mobility services by comparing the spatiotemporal usage patterns of a dockless bike sharing (BS) service and an e-scooter service both operating in the city of Turin (Italy). Both visual and statistical approaches are used to analyze and contrast the temporal usage patterns of such services. Usage hotspots are detected by using spatial analysis and contextualized by considering the land use destination. Results indicate that both micro-mobility services are used to perform short trips, which are mainly occurring on weekdays in the afternoon. Usage peaks suggest that both services primarily fulfill the demand for non-commute related travel, in line with previous studies in other countries. Nevertheless, morning usage peaks of dockless BS service show that the service might also be used for commuting trips to and from university. Usage hotspot detected near to a university district only during weekdays supports this finding. On the other hand, e-scooter trips are mainly concentrated in the city center and in proximity of railway and metro stations, suggesting that, among other purposes, the service is used as a first and last-mile connection to public transport.

Keywords: Micro-mobility; bike sharing; electric kick scooter; usage patterns; KDE.

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Operational planning of integrated urban freight logistics combining passenger and freight flows through mathematical programming

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Abstract | Paper #181

This research addresses the operational planning of an urban logistics problem where an existing bus passenger transportation network is integrated with the urban freight process, and with a last mile delivery service, to send freight to city centres. The aim is to reduce the number of fossil combustion powered commercial vehicles traveling within city boundaries, solely for goods transportation, thus contributing to reduce negative effects of urban logistics activities, namely pollution, noise, and traffic congestion. An integer linear programming model is proposed to support the planning of the distribution process aiming to minimize the delivery time of the last mile operator. Results considering instances based on a real bus network of Porto city, Portugal, show the efficiency of the proposed model.

Keywords: City logistics; urban logistics; integrated urban logistics; mathematical model.

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Comprehending users perception towards integrated multimodal public transport system

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Abstract | Paper #185

Travel using public transportation offers financial benefits to the people. However, reaching a destination by using a single mode of public transport seems difficult in metropolitan cities and results in transfer at an interchange. As a result, the transfer facilities and their characteristics affect city dwellers' perception of traveling using public modes of transport. An individual's decision to ride a multi-modal public transport system is also governed by socio-demographic, travel, and public transport characteristics. With this background, the present study aims to understand the factors influencing people's behavior to use public transport, including transfer for Surat city in India. Based on 752 non-transit users' responses, the Structural Equation Model was developed using AMOS software. The results revealed that factors like 'monthly income,' 'in-vehicle time,' 'seat availability, 'out-vehicle time' and ‘punctuality of time transfer' play a crucial role in willingness to use multi-modal public transport system.

Keywords: Integrated multi-modal public transport system, structural equation modelling, willingness to use.

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Crowd-sourced web survey for household travel diaries

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Abstract | Paper #186

This study presents an open-source, web-based, self-completion and/ or personal-interview survey platform, namely Travel Survey as a Service (TSaaS), which currently hosts three different survey types. This study proposes to use the TSaaS platform as the crowd-sourced data collection approach for household travel diaries. The TSaaS provides flexibility to conduct multiple surveys for different purposes/ locations simultaneously using a web survey format. For better control of the data collection process, multiple survey links for household travel diaries (or any other survey) in a region can be created. Eventually, collected data can be processed jointly or separately as per the requirements. The data is recorded in an efficient data structure. Personal information and location are neither asked nor tracked using devices or otherwise. To assist in recalling the activity locations, a location-search field is provided and integrated with a map. The permanent address, trip origin, and destination are recorded as the nearest landmark on the map, and the location is shown as a marker on the map. The marker on the map can be adjusted to correct the location if required. A pilot study was conducted in Jaipur, and three different data collection approaches are attempted. The approaches are compared in terms of survey completion rate, survey completion time, and time-cost of each approach. The crowd-sourced web survey turns out to be the most efficient in terms of the time-cost per completed survey record and most suitable to collect a large number of survey records in an urban agglomeration.

Keywords: Travel survey; household survey; trip diaries; activity-trip chain; person trip survey; data collection.

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Lean/ Agile Management of the copy paper supply chain through the optimization of the fleet composition problem

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Abstract | Paper #190

The paper presents the analysis, mathematical formulation and solution procedure for a Fleet Composition Problem (FCP) in the Copy Paper industry. We define certain fleet composition scenarios for a three echelon supply chain and analyse how they match the incoming demand, what kind of customer service can be offered through their application and what level of logistics costs they generate. The decision problem concerning fleet composition is formulated as a multiple criteria ranking problem. Ten fleet composition scenarios – variants are evaluated by a consistent family of seven criteria. We solve the FCP along the concept of Lean/ Agile Management. In the computational phase we apply the ELECTRE III/IV method. We model the decision maker's (DM's) preferences and aggregate the variants' evaluations with the application of an outranking relation. As a result we produce a final ranking of solutions – fleet composition scenarios. This allows us to recommend the most desired solution.

Keywords: Fleet composition problem; lean/ agile supply chain; multiple criteria analysis.

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Motivators and barriers for shared bicycle use in 'starter' cycling cities: Evidence from BSS user surveys in three Southern European island cities

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Abstract | Paper #192

Bicycle sharing systems (BSS) have the potential to contribute to the creation of a cycling culture, by normalizing cycling and providing access to bicycles. This research looks at the use of BSS in 'starter' cycling cities, where modal share of cycling thus far is low and there is only limited cycling infrastructure. Surveys with users of the BSS in Limassol, Las Palmas de Gran Canaria and Malta shed light on "who" uses the BSS and "why". Through descriptive statistics and correlation analysis, the influence of individual, social environment and physical environment factors on shared bicycle use is analysed, looking at differences between frequent and infrequent BSS users, to get a better understanding of the motivators and barriers that influence BSS use. Frequent BSS use is positively associated with frequent use of other 'alternative' transport modes, such as public transport use, as well as with shorter distances from respondents' residence and most frequent destinations to the nearest BSS station. Higher perceived safety of cycling was also associated with more frequent BSS use, as did a positive social norm, including support from friends and family, respect from other road users, and feeling that cycling is an accepted form of transport, confirming the importance of such factors in building a cycling culture.

Keywords: Bicycle sharing; cycling; shared mobility; travel behaviour; correlation analysis; islands.

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Modeling the effect of motorized two-wheelers and autorickshaws on crossing conflicts at urban unsignalized T-intersections in India using surrogate safety measures

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Abstract | Paper #194

Motorized Two-wheelers (M2W) and Autorickshaws (M3W) users are vulnerable to frequent road crashes in India, and most of these crashes occur at un-signalized T-intersections. The study aims to model the effect of M2W and M3W conflicts on crossing conflicts. Crossing conflicts are identified using post encroachment time (PET) data extracted from traffic video data collected from 8 urban un-signalized T-intersections in India. The crossing conflicts are characterized as critical conflicts (-1 to 1 s) and non-critical conflicts (≥ 1 and ≤ -1 s) based on PET values. The effect of M2W and M3W on critical and non-critical crossing conflicts is quantified by developing crossing conflict models using Truncated Negative Binomial regression. Results revealed that the proportion of M2W and M3W in the conflicting and offending stream, presence of central traffic island, total conflicting volume significantly influences the number of critical and non-critical conflicts at the unsignalized T-intersections. The study promises to add valuable insights towards modeling conflicts occurring due to small-size motorized vehicles at un-siganlized intersections operating under weak-lane mixed traffic conditions.

Keywords: Safety surrogate measures; motorized two-wheelers; autorickshaws; post encroachment time; truncated negative binomial model; unsignalized T-intersection.

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A Meta-analysis of the methodologies practiced worldwide for the identification of Road Accident Black Spots

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Abstract | Paper #195

An accident Black spot (often synonymously known as a crash hotspot) is a section of road where the frequency of occurrence of several types of road accidents or a particular type of road accident is comparatively higher than other similar sections on the road. Accidents may occur on such sections of a road due to several factors such as faults in engineering design, failures in traffic rule enforcement, rash driving etc. but road accidents repeatedly occur at a location due to faults and inconsistencies in design which lead creation of an ambiguous road environment that fails to provide a positive guidance to road users. For rectifying of such road sections, it is important to identify such locations based on likelihood of occurrence of road accidents and past accident history. This paper intends to conduct a critical appraisal of the various methodologies practiced worldwide for the identification of road accident black spots and discusses their merits and demerits. The paper summarizes the key elements in the definitions of road accident Black spots and black road sections of different countries that are a part of protocol of their respective government policies. The paper at last discusses a meta-analysis of the inferences drawn out from these definitions for road accidents.

Keywords: Road; Black spot; accident; fatalities; safety.

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Factors influencing the implementation and deployment of e-vehicles in small cities: a preliminary two-dimensional statistical study on user acceptance

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Abstract | Paper #196

Recent sustainable mobility scenarios, aimed at the decarbonization in urban and non-urban contexts, seek to promote an increasing use of electric vehicles (EVs) or plug-in hybrid electric vehicles (PHEVs) by 2030, considering their attractiveness not only for private use but also as shared mobility alternatives by different categories of users. It is significant to investigate the binomial formed by users' characteristics and travel habits as influencing factors of the spread associated to these innovative services. This paper presents a descriptive and two-dimensional statistical analysis to assess the acceptance of shared e-mobility linked to the user's profile. The variables have been investigated via an on-line questionnaire, in applying the Likert scale and a single and multiple bivariate analysis have been performed. The case study of Enna city is presented, characterized by a size typical of Italian small urban centers, with critical issues in terms of the transport services supply. A large sample of under 40 years has been selected assuming their greater propensity to use this innovative transport modes. The results highlight the correlations between the socio-demographic data, the choice of the vehicle power supply and the influence of the characteristics of the service. These factors, along with the mobility patterns, must be taken into consideration for the improvement and promotion of the service.

Keywords: e-mobility; bidimensional statistical analysis; sustainable mobility; Likert scale.

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Modelling of shared mobility services - An approach in between traditional strategic models and agent-based models

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Abstract | Paper #198

Shared mobility services are slowly penetrating European cities. Hence, transport models that are capable of modelling them are a necessity, to support the policy-makers for making informed decisions. Given that many European cities, especially small and medium sized ones, continue to use the traditional four step modelling approach and such an approach does not have the necessary capacity to model the shared mobility services, there is a need to extend them. Hence, this research proposes an extended framework, by the addition of modules for synthetic population generation and fleet management. Furthermore, modules are suggested for estimation of emissions, car-ownership and induced demand, as such measures are increasingly expected by cities. Multiple equilibrium checks between the aforementioned modules are avoided in the design of this development, to reduce model complexity and convergence issues. This extended framework provides an opportunity to cities to evaluate and integrate shared mobility systems, and form long term planning strategies.

Keywords: Sharing mobility; extended four step model; travel demand modelling; transportation planning; car-sharing; bike-sharing.

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Designing urban mobility policies in a socio-technical transition context

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Abstract | Paper #202

The fast-changing behaviour of people in metropolitan areas is creating several challenges to local authorities in managing the urban space. These changes are strongly related to the evolution of technology and its adoption by companies and citizens. Current regulations need, therefore, to be rapidly updated to respond to the new urban dynamics. However, the gap between local authorities and citizens and the communication difficulties are increasing as urban centres grow, creating obstacles to innovation and hindering the deployment of new mobility solutions. The low levels of participation in public consultation actions decrease the quality of new policies, as well as their acceptance by the community. Not only do cities need to be reinvented, but local authorities also need to rethink how to interact with citizens, competing for attention in a digital world. Although digital tools are easily accessible, they are not available to everyone, and municipalities need to consider both digital and non-digital interactions to ensure that all citizens can participate. In this work, we analyse and compare a set of measures that municipalities have been adopting to increase citizens' engagement, and we develop a methodology to help local authorities increase public participation and improve citizens' commitment towards the city.

Keywords: Urban mobility; urban regulations; participation; collaboration; stakeholders' involvement; digitalization.

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Could drag coefficient institute platoons as the future of sustainable highway transportation? VSP sensibility analysis

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Abstract | Paper #204

Mobility is vital to the economic development of cities by promoting accessibility for goods and commuters. At the same time, transport systems generate negative external effects. Within the transport sector, road transport accounts for 35% of nitrogen oxides (NOx) emissions, making it the most contributing mean of transport. One way to combat some of the problems associated with the transport sector is platooning. Platooning can be described as a group of vehicles that drive close together, acting as one. This convoy or platoon also has the advantage of reducing the fuel consumption of all the vehicles within. Optimising platooning formations that encompass light and heavy-duty vehicles that travel the highways will be a requirement for the future of transportation. This optimisation can be performed by mixing vehicle type order, intervehicle distance, number of vehicles and speed of the vehicles. In addition, it is already recognized that drag coefficient plays a major role in platoons' fuel consumption at highway speeds. In this context, the main goal of this work is to analyse the influence of drag coefficient (C_d) as its portraited on the modelling approach of vehicle-specific power (VSP) and consequent vehicle emissions of NOx, carbon dioxide (CO_2) and carbon monoxide (CO). Different platooning scenarios were defined and tested through the OpenFOAM and VSP models and were compared in terms of their impact on fuel consumption and pollutant emission. Savings of 25% are achieved for cars driving in mixed platoons with trucks, making platooning the future of more efficient transport systems.

Keywords: VSP methodology; OpenFOAM model; drag coefficient; platoons; atmospheric emissions; sensibility analysis.

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Micro driving behaviour in different roundabout layouts: Pollutant emissions, vehicular jerk, and traffic conflicts analysis

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Abstract | Paper #205

Driving behaviour affects both road safety and the environment, either positively or negatively. An unsafe driving behaviour characterized by hard acceleration/braking (also called driving volatility) can lead to an increase in emissions. Driving volatility can occur due to driving style, traffic, or road conditions. Although roundabouts present better safety performance than other traffic-control treatments, different layouts may lead to different levels of traffic-related impacts. This paper aims to evaluate vehicle movements through three types of roundabouts (Single-lane (SL), Compact two-lane (CTL), and Multi-lane (ML)) focusing on assessing the impact of driving volatility on traffic conflicts and pollutant emissions. A micro driving behaviour analysis of emissions, driving volatility, and conflicts were conducted for the links of the entry, circulating, and exit areas of the studied roundabouts. Speed was used as a variable parameter directly related to the driver while vehicular jerk and traffic conflicts, as well as global (carbon dioxide – CO_2) and local (nitrogen oxides – NOx) pollutants were used to evaluate the traffic safety and emissions performance, respectively. Field measurements obtained from a light-duty probe vehicle equipped with an on-board diagnostic reader on three different layout roundabouts located in suburban environments were used to develop a microscopic traffic simulation for the baseline. Simulations were conducted using VISSIM, emissions were estimated using the Vehicle Specific Power (VSP) methodology, and the Surrogate Safety Assessment Model (SSAM) was applied for estimating the traffic conflicts between motor vehicles. Four speed-distribution scenarios were considered, and associated impacts were evaluated for each roundabout. In general, speed variation and subsequently vehicular jerk had more impact on traffic conflicts than pollutant emissions. The number of conflicts in the exit area was less than entry and circulating in all roundabout designs but ML presented more traffic conflicts.

Keywords: Roundabout; vehicular jerk; safety; emissions; conflicts; micro driving behaviour.

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An agent-based model for modal shift in public transport

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Abstract | Paper #207

Modal shift in public transport as a consequence of a disruption on a line has in some cases unforeseen consequences such as an increase in congestion in the rest of the network. How information is provided to users and their behavior plays a central role in such configurations. We introduce here a simple and stylised agent-based model aimed at understanding the impact of behavioural parameters on modal shift. The model is applied on a case study based on a stated preference survey for a segment of Paris suburban train network. We systematically explore the parameter space and show non-trivial patterns of congestion for some values of discrete choice parameters linked to perceived wait time and congestion. We also apply a genetic optimisation algorithm to the model to search for optimal compromises between congestion in different modes.

Keywords: Modal shift; public transport disruption; agent-based modeling; model exploration.

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Driving behaviour impacts in a mixed road traffic environment

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Abstract | Paper #209

The increasing levels in automated functions in vehicles are expected to reshape the future of road transport. Soon, connected, automated and conventional vehicles will share the roads, and it is essential to understand the impacts of such new road environment under several components such as traffic performance, climate change, air quality. This paper is devoted to present a study focusing on a multi-criteria traffic assignment model based on minimizing travel time, distance travelled and pollutant emissions considering various automated vehicles (AVs) with different driving behaviours scenarios in a road network of conventional vehicles (CVs). For that purpose, a case-study of an intercity corridor was used considering current traffic demand. Results show AVs introduction can in fact significantly contribute to reducing emissions provided their behaviour is a combination in its majority of cautious AV. Results suggest replacing 20% of AV aggressive fleet by cautious yields worst results regarding emissions, even when compared to 100% aggressive AVs. The proposed approach is relevant for decision making, particularly for strategic policy making and planning, and can help authorities achieving their sustainable mobility goals, specially to anticipate the impacts of AVs introduction in the near future.

Keywords: Network impacts; automated vehicles; pollutant emissions; dynamic traffic assignment.

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Tourism as a Service: Enhancing the tourist experience

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Abstract | Paper #213

The tourism sector has been facing continuous growth. It plays a vital role in countries' economic development, highlighting the need to keep nurturing it by making it easier and more attractive. This paper presents Tourism as a Service - an innovative concept that aims to ease a day in the life of a tourist by integrating services that might be found spread out through separate tools and services, including ticketing in public transport and touristic attractions, route planning, information, among others. First, focus groups were done in order to understand the users' needs regarding the use of a mobile ticketing solution in tourism. The findings from the literature reviewed and the previous step were then prioritized by relevance in a questionnaire sent to potential users, allowing the creation of a medium-fidelity prototype. The validation through usability testing confirmed an interest in the proposed solution. The critical design choices surrounding the proposed solution were discussed along with improvements and further work to be done.

Keywords: Tourism; smartphone; e-tourism; mobile ticketing; public transport.

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A within day dynamic network loading framework for large scale applications

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Abstract | Paper #214

The main field of investigation of the paper is the dynamic traffic assignment. In particular, in this context different models can be applied concerning the dynamic network loading itself and in particular the (within-day dynamic) traffic flow propagation on links. Due to the advances in technological application, more recently different traffic flow models and new enhanced strategies have been proposed and applied in the era of the Intelligent Transportation Systems and in particular in presence of cooperative and connected communications (V2V, Vehicle to Vehicle communication; and V2I, vehicle to infrastructure communication). In more detail, the paper aims at investigating the application of a new proposed traffic flow model that has been formalised to support the application of traffic control strategies (also including the procedure of speed optimisation) in presence of connected and automated vehicles (CAV). In terms of traffic flow modelling, the literature identifies three main modelling approaches: macroscopic, mesoscopic and microscopic modelling. A further approach has been recently investigated, called hybrid traffic flow modelling, which is also suitable for applications at different scales (multi-scale). This paper discusses the results achieved through the application of a new hybrid traffic flow model based on the combination of two sub-models: a space-time discrete model based on aggregate macroscopic variables representation (the Cell Transmission Model), and a space-time discrete model based on a disaggregate model (the Cellular Automata model). In particular, the main focus of the paper is on the application of the model at a large scale network considering the implicit path choice based on the Logit and C-logit behaviour models. The achieved results are also compared with respect to the application of an explicit path enumeration. The analyses are carried out in terms of travel time spent, network total delay, queue lengths and degree of saturation. Results highlight the suitability of the proposed approach and the implicit path choice modelling slightly outperforms the case of explicit path choice enumeration in terms of performance indicators.

Keywords: Traffic flow model; Cell Transmission Model; Cellular Automata; hybrid; implicit path choice modelling; larger scale.

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Handling OpenStreetMap georeferenced data for route planning

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Abstract | Paper #215

This work proposes an architecture to treat georeferenced data from the OpenStreetMap to plan routes. The methodology considers the following steps: collecting data, incorporating data into a data manager, importing data into a data model, executing routing algorithms, and visualizing routes. Our proposal incorporates the following features characterizing each street segment: safety & security, comfort, accessibility, air quality, time, and distance. Routes can be calculated considering any specified weighting system of these features. The outcome of the application of this architecture allows to calculate and visualize routes from georeferenced data, which can support researchers in the study of multi-criteria routes. Furthermore, this framework enhances the OSM data model adding a multi-criteria dimension for route planning.

Keywords: Georeferenced data; route planning.

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An empirical study on V2X radio coverage using leaky coaxial cables in road crash barriers

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Abstract | Paper #219

For current and future automated driving functions, the radio availability of broadband hybrid networking services (e.g. digital broadcasting, mobile radio, dedicated short range communication) is a prerequisite for continuous V2X information exchange. The supply focus for this is explicitly the road route with its lanes. The application of antenna-based solutions for such longitudinal radio cells with hybrid telematics services is expensive from the installation point of view and can only be adapted to new future telematics standards with great effort. A more suitable solution for such longitudinally shaped radio cells for road routes are leaky coaxial cables (LCX), which are already successfully used for tunnel solutions, for example. The paper discusses the installation and radio implementation of broadband LCX solutions (up to 6 GHz) in terms of simulation and surveying. The integration of the LCX into the crash barrier is favored due to low installation effort and easy upgradeability. An installation was realized on an automotive test fields, where preliminary empirical results for radio simulation and coverage were obtained. Based on the simulations and evaluation measurements, it can be shown that the propagated coverage approach is sustainable over all radiated services. Further solution approaches such as the direct insertion of LCX into the roadway and the derivation of vehicle location information are discussed in the outlook of the paper.

Keywords: V2X; leaky coaxial cable; LCX; traffic telematics; radio coverage planning; road crash barrier.

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Macroscopic model for very large multimodal networks combining the GSOM and the bidimensional approach

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Abstract | Paper #222

The GSOM model (Generic second order model) is a macroscopic traffic model designed to take into account the dynamics of vehicle and driver attributes. It has recently been extended to the multimodal case. One prominent feature of the resulting multimodal GSOM model is that it distinguishes two flows: vehicular (car or public transportation) and passenger. The flow of pasengers is subordinated to the flow of vehicles. On the other hand, traffic on regional sized networks cannot be modelled with any great precision over very dense surface subnetworks of the regional network. Thus various approximate methods are being developped to address this difficulty, notably the MFD (macroscopic fundamental diagram) approach and bidimensional methods. The paper concentrates on the latter and aims first to develop a multimodal bidimensional model. In a second step the paper investigates how to interface the multimodal GSOM and the bidimensional models. At a regional scale the resulting model describes the structuring network (main roads, motorways, train tram metro lines...) following the GSOM methodology, and describes the flow on dense networks of small to medium capacity streets and lines as a bidimensional flow over a bidimensional medium.

Keywords: GSOM model; bidimensional model; intersection model; macro-cell; dynamic traffic assignment; multimodal regional transportation model.

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Performance evaluation of an ant colony optimization for the train route selection problem

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Abstract | Paper #229

The real-time Railway Traffic Management Problem (rtRTMP) consists of detecting and solving time-overlapping conflicting request done by multiple trains on the same track resources. It typically involves taking retiming, reordering or rerouting train actions in such a way that the propagation of disturbances in the railway network is minimized. The rtRTMP is an NP-Hard problem and finding good strategy to simplifying its solution process is paramount to obtain good quality solutions in a short computation. Solving the Train Routing Selection Problem (TRSP) aims to do so, by limiting the number of routing variables through a pre-processing that selects the most promising routing alternatives among the available ones for each train in order to reduce the size of rtRTMP instances. This work studies the performance of an Ant Colony Optimization (ACO) algorithm for the same problem. An integer linear programming formulation for the TRSP is presented and solved using a commercial software, and it is considered as a benchmark. Computational experiments are performed on two case studies of the French railway infrastructure. ACO and the commercial solver perform comparably only on small instances and both are able to find optimal solutions. However, on larger instances, the ACO algorithm outperforms the commercial software, both in terms of computation time and solution quality.

Keywords: Rail transportation; public transportation; scheduling and optimization of transportation systems; intelligent transportation systems.

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Investigating the competitive factors of container ports in the Mediterranean area: an experimental analysis using DEA and PCA

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Abstract | Paper #230

In the maritime world scenario, various challenges are affecting Mediterranean container ports, which are trying to keep high their efficiency and their competitiveness through infrastructural and managerial improvements. The identification of the priority actions requires the analysis of the productivity of each port in relation to the use of its resources. This study applies Data Envelopment Analysis (DEA) and Principal Component Analysis (PCA) in order to investigate the potential factors that can affect the efficiency of Mediterranean container ports. These methods use six input variables (yard area, berth depth, number of quay cranes, equipment, berth length and distance of the port from the Suez-Gibraltar axis) and one output variable (port throughput expressed in TEUs). The results can help to highlight the potential factors of success for Mediterranean container ports and to identify future policies and management strategies aimed towards the strengthening of the analyzed context.

Keywords: Data Envelopment Analysis; Principal Component Analysis; benchmarking; container port; Mediterranean Sea.

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Communication platform concept for virtual testing of novel applications for railway traffic management systems

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Abstract | Paper #233

In recent years, the railway system has been facing the various challenges of the "digital age". To increase its attractiveness, capacity, sustainability, and security, it needs to improve its' everyday operational and planning process. This can be enabled using new generation digitised and automated Traffic Management Systems (TMS). Nowadays, railway dispatchers need a TMS that offers precise and real-time traffic information as fundamental condition for effective traffic management, and whose performance can be further improved by increasing availability and diversity of sources and data, for which an effective data management platform is required. The EU-funded OPTIMA project is designing and developing a communication platform to manage the connection between several services supporting TMS applications, also enabling their testing. It represents one of the steps required for the development and implementation of a new generation of TMS. This paper describes the concept for the OPTIMA platform which will link TMS applications used by railway dispatchers with infrastructure systems such as signalling and interlocking systems, maintenance, and energy management, as well as with data services (such a weather information) with the aim of providing standardised interfaces and common data structures as basis of a common and standardised communication.

Keywords: Railway; railway traffic management systems; communication platform; conceptual data model.

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Assessment of changing existing drainages to smart drainages by its effects' evaluation on traffic parameters in critical rainy conditions: A fuzzy-Delphi criterion prioritization.

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Abstract | Paper #234

Rapid growth of world population and the consequent increased demand for motor vehicles, while making no reformations in transportation infrastructure in urban areas, raise more concerns in terms of pollution and traffic problem, particularly during heavy rainfall. One key parameter that affects traffic during heavy rainfall is drainage, which is a major cause of prolonged and heavy traffic jams arising from inability to timely collect and direct surface runoff. On the other hand, it leads to higher likelihood of road accidents and traffic-related issues that impact urban life. Therefore, changing and developing the existing drainage system can have a great impact on traffic management in rainy conditions. Use of smart drainage systems can be an effective measure to deal with the issue in the short run. This demands manipulation of existing drainage systems to be smarter and adaptable to heavy rain conditions. Hence, in this study, the Fuzzy Delphi method (FDM) was used to evaluate and rank the impact of smart drainage on traffic parameters from various aspects. SPSS 26.0 software (Cronbach's alpha test) were also used to assess reliability the proposed model. For this purpose, a professional questionnaire was prepared and disseminated between those working in transportation field, mainly including traffic and urban designers. The results show that the greatest effects of smart drainages were on Speed with 0.722 points, Flow with 0.713 points, Peak Hour Factor (PHF) with 0.710 points, and Clearance with 0.701 points, respectively.

Keywords: Traffic management, critical rainfall conditions, fuzzy-Delphi, smart drainage.

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