Intelligent Transportation Systems: The @CRUiSE Project

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“Transportation Technology” Research Group - Research Lines

universidade de aveiro

1. Impacts of transportation systems

2. Intelligent Transportation Systems (ITS)

3. LCA of alternative energy vectors for road vehicles

4. Active modes (cycling & walking)

On-going Projects:

- @CRUiSE
- MobiWise
- CISMOB

BACKGROUND

Motivation

- Europe: ~33% of energy consumption from transportation sector
- ~73% of transportation-related GHG are from road transport
- Vehicle emissions → important source for air pollution (NOx, PM)
- Conventional fuels are expected to remain predominant over the next decades

⇒ **There is the need to optimize the use of the road infrastructure**

Research Challenges & Opportunities

Where are the traffic congestion and emissions hotspots?

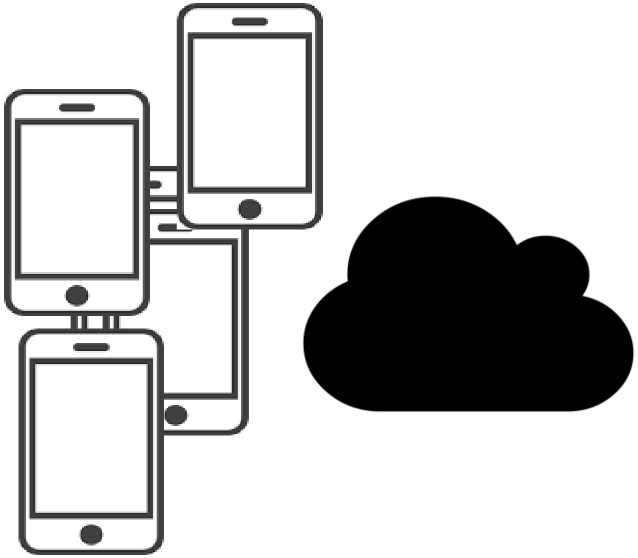
What are the most critical links in terms of congestion?

Where should we reduce pollution?

What are the most vulnerable areas?

Increasing availability of sensor technology to record large amounts of data

✓Smartphone location data
✓GPS (probe vehicle data)
✓Cell phone density
✓Traditional traffic road monitoring network



THE @CRUiSE PROJECT:

Advanced Impact Integration Platform for Cooperative Road Use

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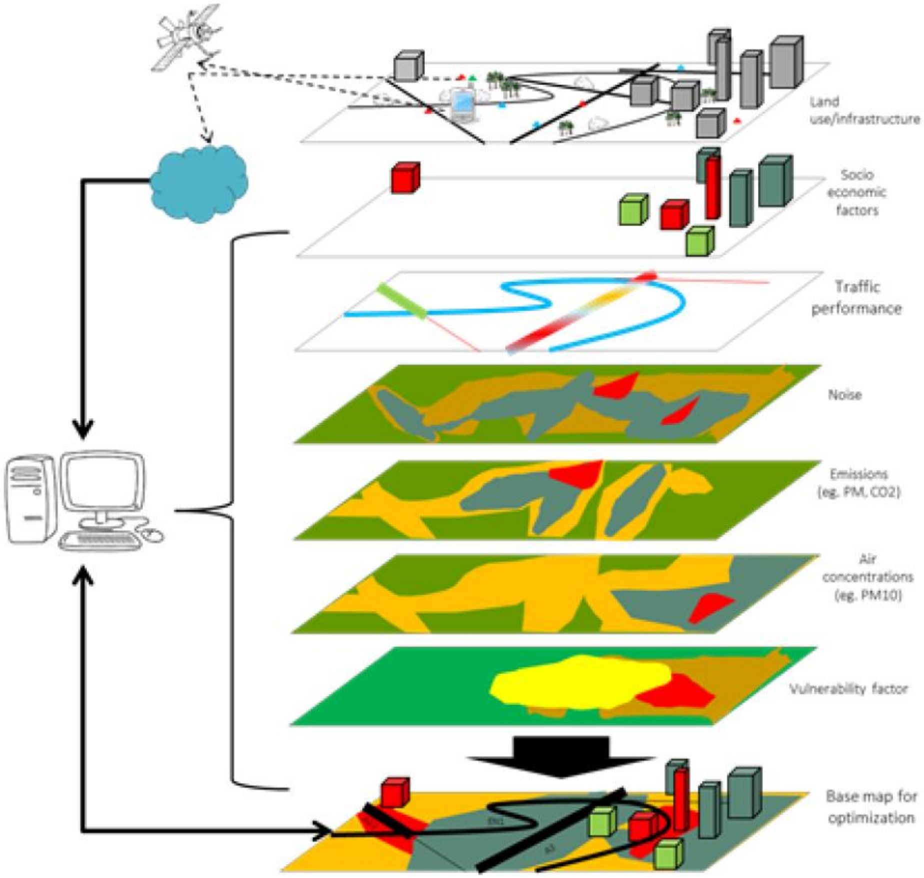
PORTUGAL 2020
COMPETE 2020

Objectives of @CRUiSE

Goal: To integrate road traffic impacts into a single analytical framework for use in advanced traffic management systems (ATMS).



3 main pillars:

a) Designing a conceptual methodology for assigning a ***link-based indicator*** that can evaluate ***different traffic-related externalities***, adjusted to ***local contexts of vulnerability***;

b) Improving the interoperability between traffic-related models and new sources of traffic information;

c) Optimizing the network operations by means of a decision support system.

http://project-cruise.weebly.com/

Consortium: *TEMA (leader), CESAM, IT*
International expertise: *North Carolina State University; University of Salerno*

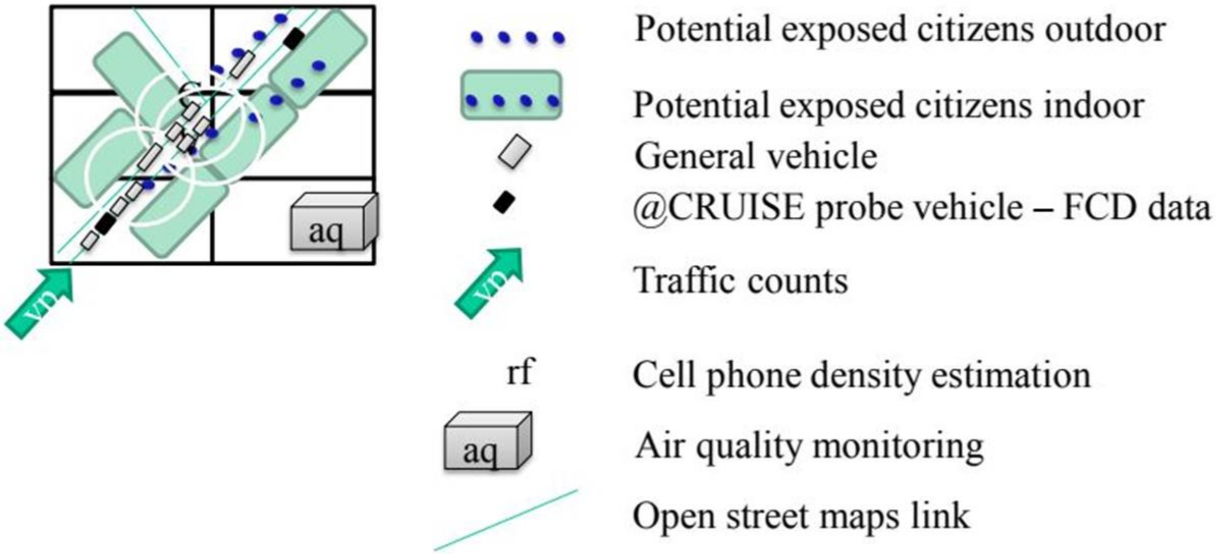
Tasks

- Task 1 • Literature review and experimental setup
- Task 2 • Experimental work - Road and environmental conditions monitoring
- Task 3 • Development, integration and validation of related-traffic models
- Task 4 • Dynamic link-based eco-indicator
- Task 5 • Data fusion and data management
- Task 6 • Network optimization and design of a decision support system
- Task 7 • Prototype / Software and applications development
- Task 8 • Dissemination and Reports

Main deliverable: Prototype of an integrated decision support system for selecting the appropriate traffic management measures.

METHODOLOGY

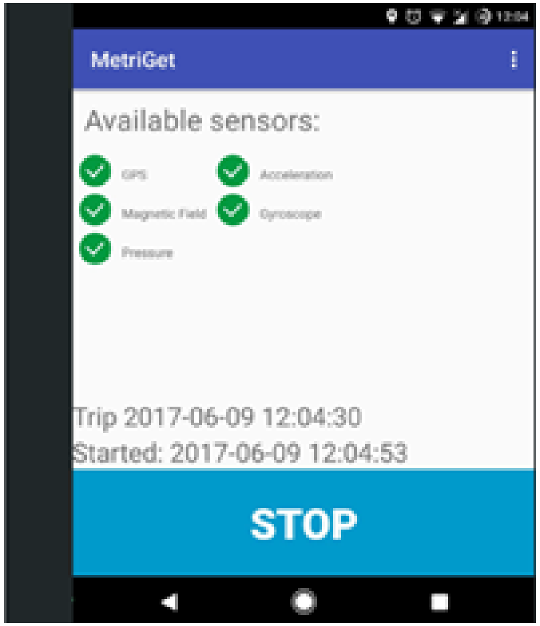
Experimental measurements



Mobile application developed to collect data from sensors and send to a server

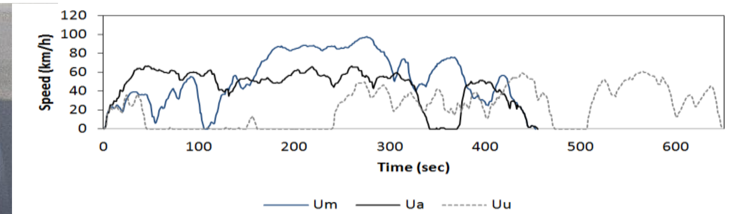
Mobile application

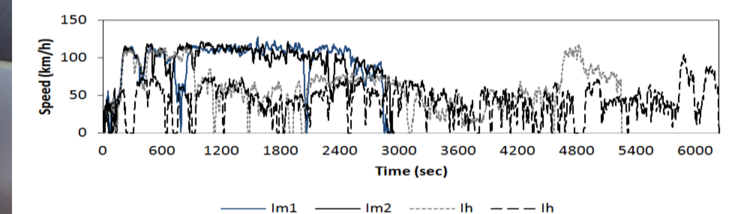
MetriGet



Ref: Daniel Silva, MSc. Thesis in Telematics, UA, 2017.

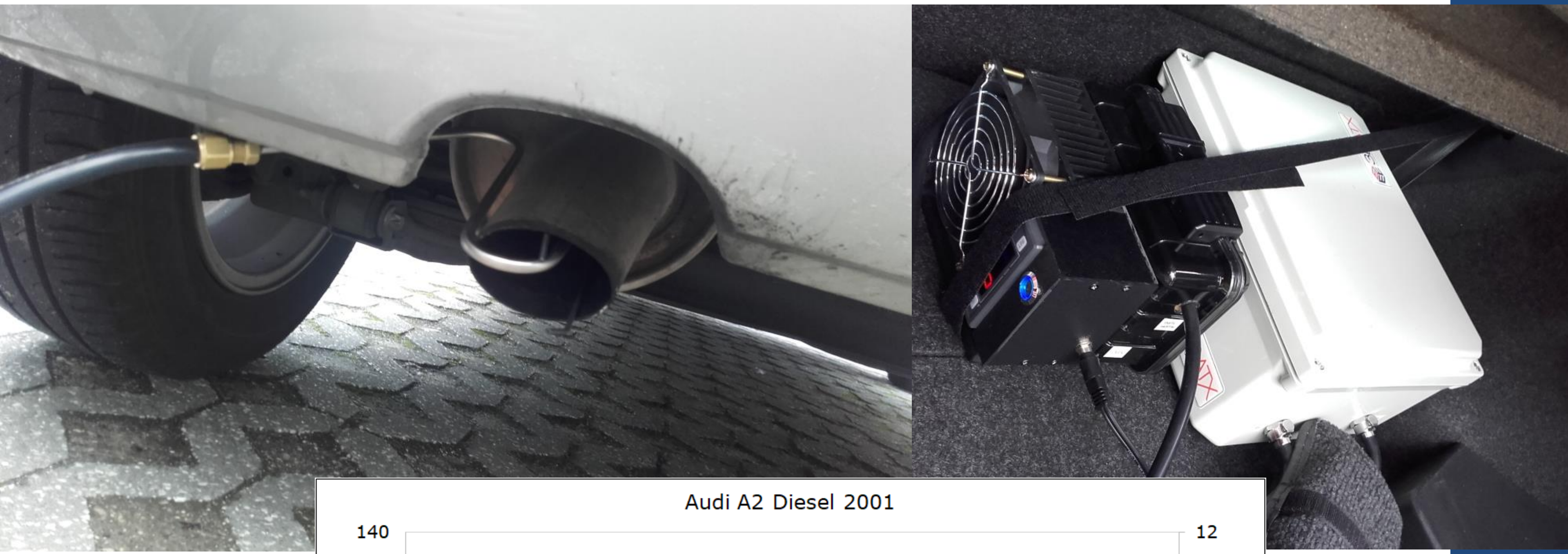
Experimental measurements

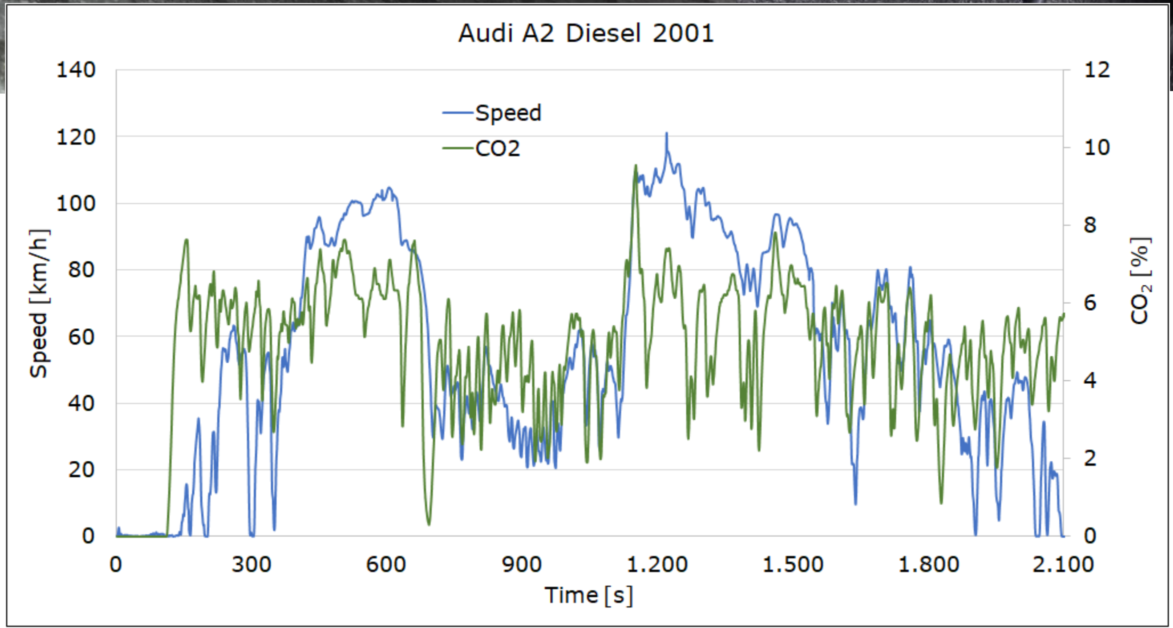




Experimental measurements

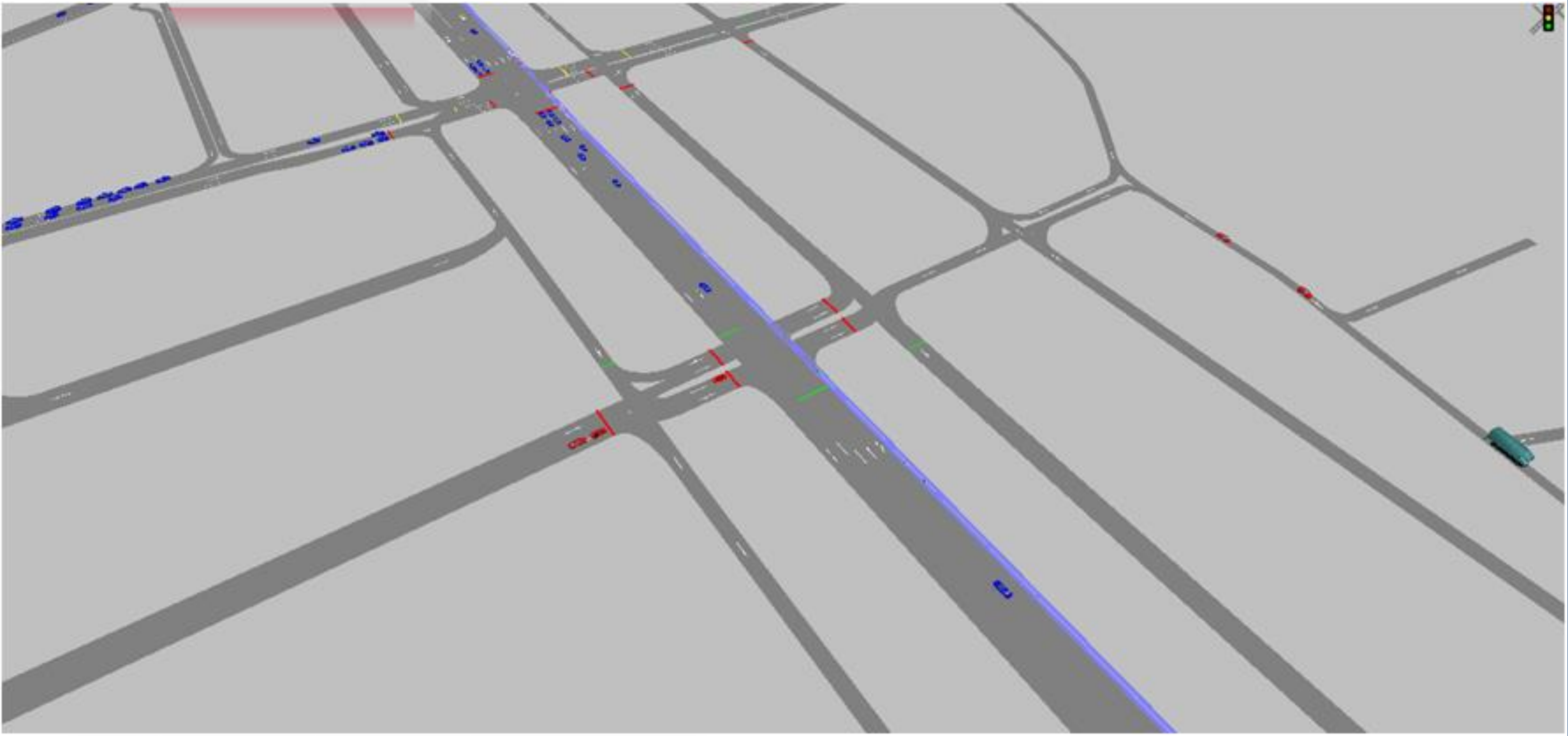
Portable Emissions Monitoring System (PEMS)

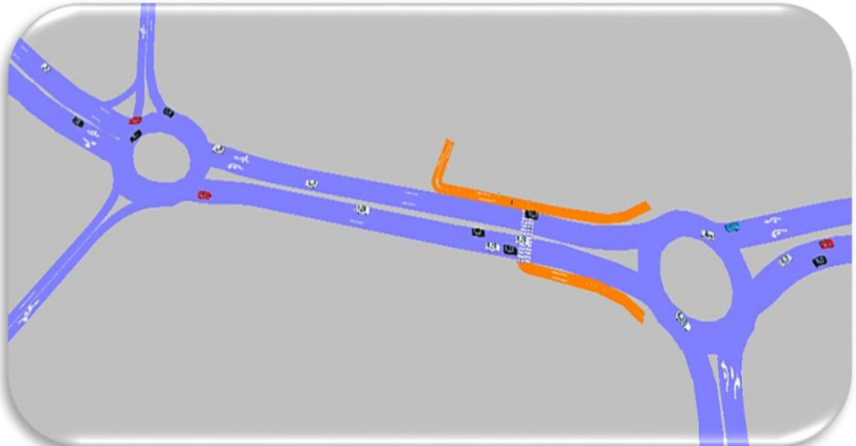




VISSIM

Traffic modeling





Emissions, air quality, noise and safety modeling

Emissions → Vehicle Specific Power (VSP)

$$VSP = v \times \left[1.1 \times a + 9.81 \times \sin\left(\arctan\left(grade\right)\right) + 0.132\right] + 0.000302 \times v^3$$

Noise → Semi-dynamic Model

Quartieri, Guarnaccia et al.

UNIVERSITÀ DEGLI STUDI DI SALERNO

Air quality

VADIS

Safety

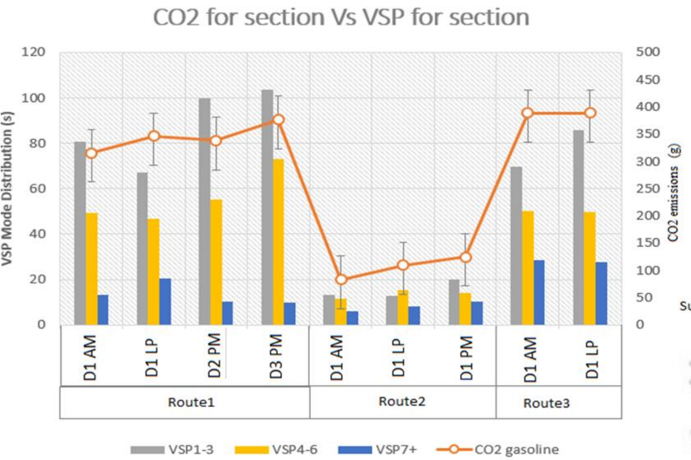
SSAM model

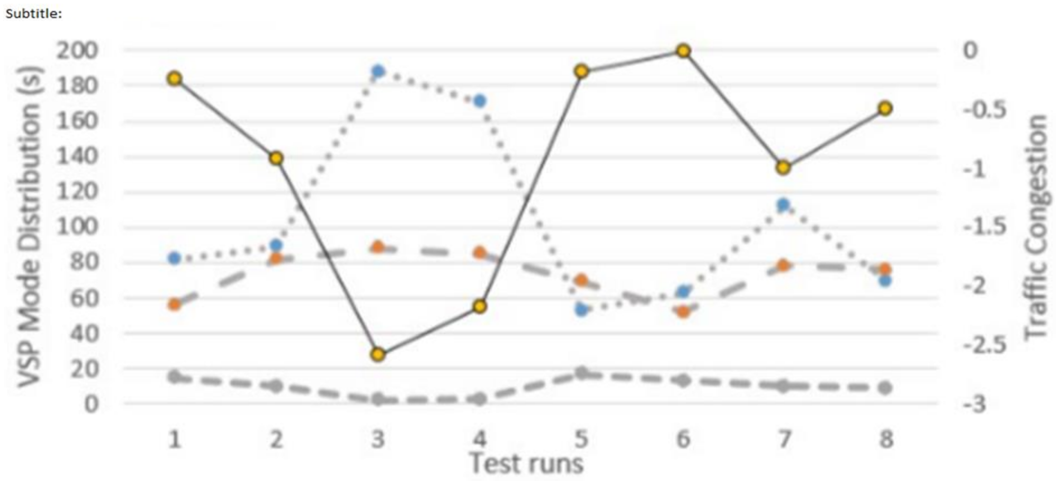
Multi-objective criteria

Fast Non-Dominated Sorting Genetic Algorithm – NSGA-II

RESULTS

Correlation between traffic variables and emissions





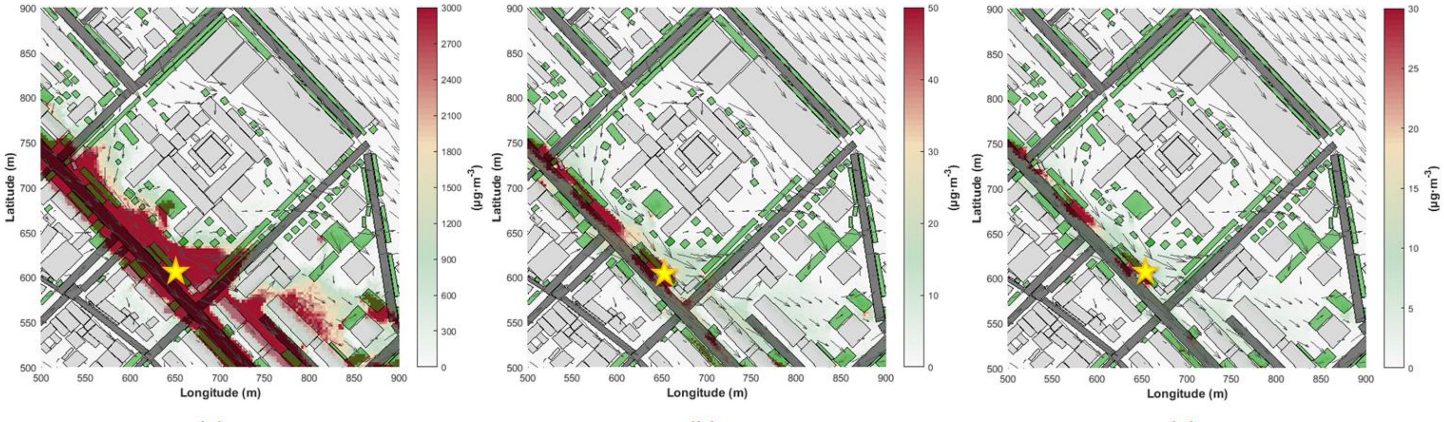
- **Urban** links: knowledge on **travel time** helps to **anticipate emissions**
- Correlation of aggregated VSP Modes with congestion algorithms + CO_2 emissions, enables the understanding of driving behavior and emissions impacts
- **Driving behavior:** the most important factor on characterizing arterial routes

Ref: João Teixeira, Paulo Fernandes, Jorge M. Bandeira & Margarida C. Coelho, Information Management for Smart and Sustainable Mobility, 96th Transportation Research Board Annual Meeting, Washington D.C., January 2017

Impacts Modeling

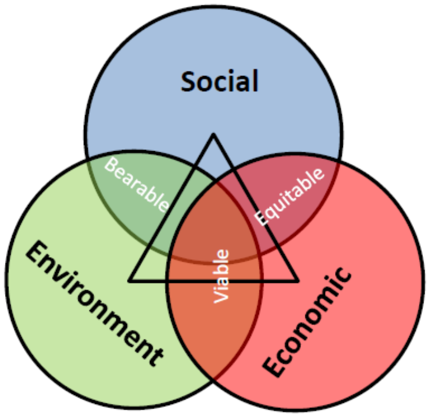
GIS-based modelling structure with data on noise levels, CO_2 emission factors and costs

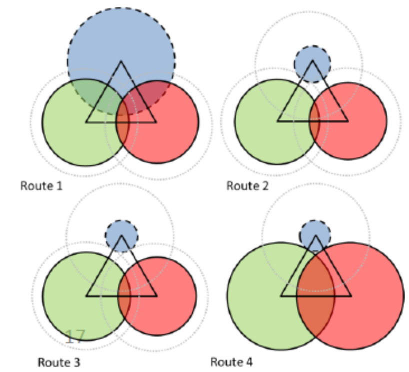
Concentrations fields (µg·m^{-3})



Route choice impacts on pedestrians/residents

	Indicator	Unit	R1	R2	R3	R4
Individual (driver)	Distance	(m)	1.00	0.98	0.65	0.69
	Travel time costs	(EUR)	0.88	0.99	1.00	0.69
	Fuel Use costs	(IEUR	1.00	0.98	0.92	0.76
	Travel costs	**(EUR)**	**0.94**	**1.00**	**0.99**	**0.72**
	Conflicts	number	0.25	0.89	0.12	1.00
	CO	(g)	1.00	0.52	0.47	0.72
	NOX	(g)	0.87	1.00	1.00	0.87
	HC	(g)	0.97	1.00	0.95	0.72
	CO2	(g)	1.00	0.98	0.92	0.76
	Noise	(db)	1.00	0.96	0.92	0.96
	Local Env. costs	**(EUR)**	0.91	1.00	0.98	0.81
	Global Env. Costs	(EUR)	1.00	0.98	0.92	0.76
	Total Env. Costs	(EUR)	0.97	1.00	0.96	0.79
Other-road users	CO	(%)	0.65	0.54	1.00	0.51
	NOX	(%)	0.58	0.40	1.00	0.43
	HC	(%)	0.87	0.35	1.00	0.48
	CO2	(%)	0.61	0.37	1.00	0.43
	Travel time	(%)	1.00	0.28	0.96	0.52
NRU	Pedestrians	number	0.10	0.26	1.00	0.49
	Exposed Façade	(ha)	0.20	0.67	1.00	0.52



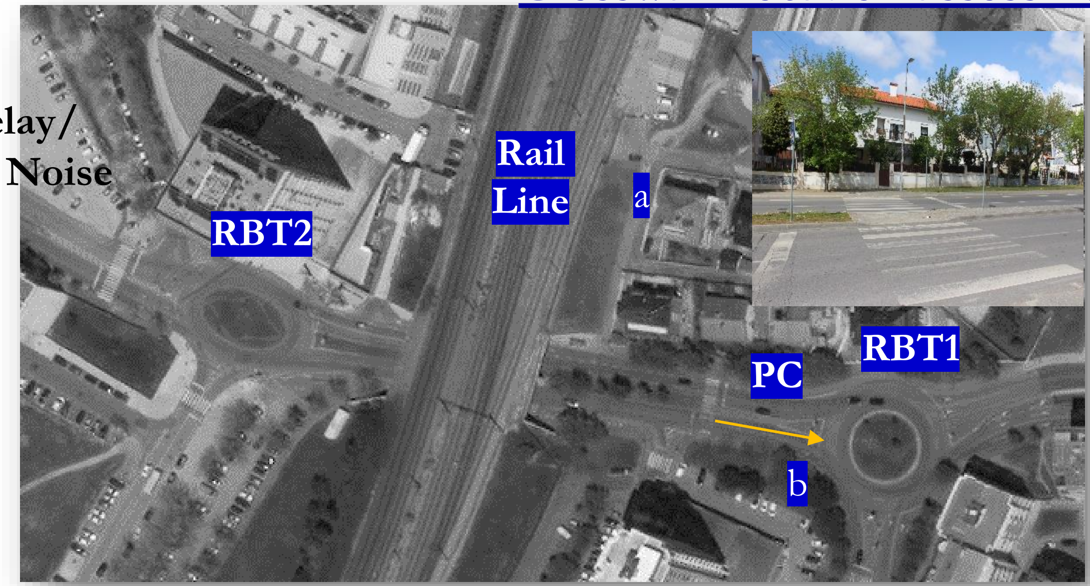


- Trade-offs identified in the minimization of environmental indicators
- The most obvious conflict: between the minimization of environmental costs and the exposed population to local traffic externalities

Ref: Jorge M. Bandeira, Claudio Guarnaccia, Paulo Fernandes, Margarida C. Coelho, Advanced impact integration platform for cooperative road use, International Journal of Intelligent Transportation Systems Research, 2016.

Multi-Criteria Assessment on a Corridor with Roundabouts

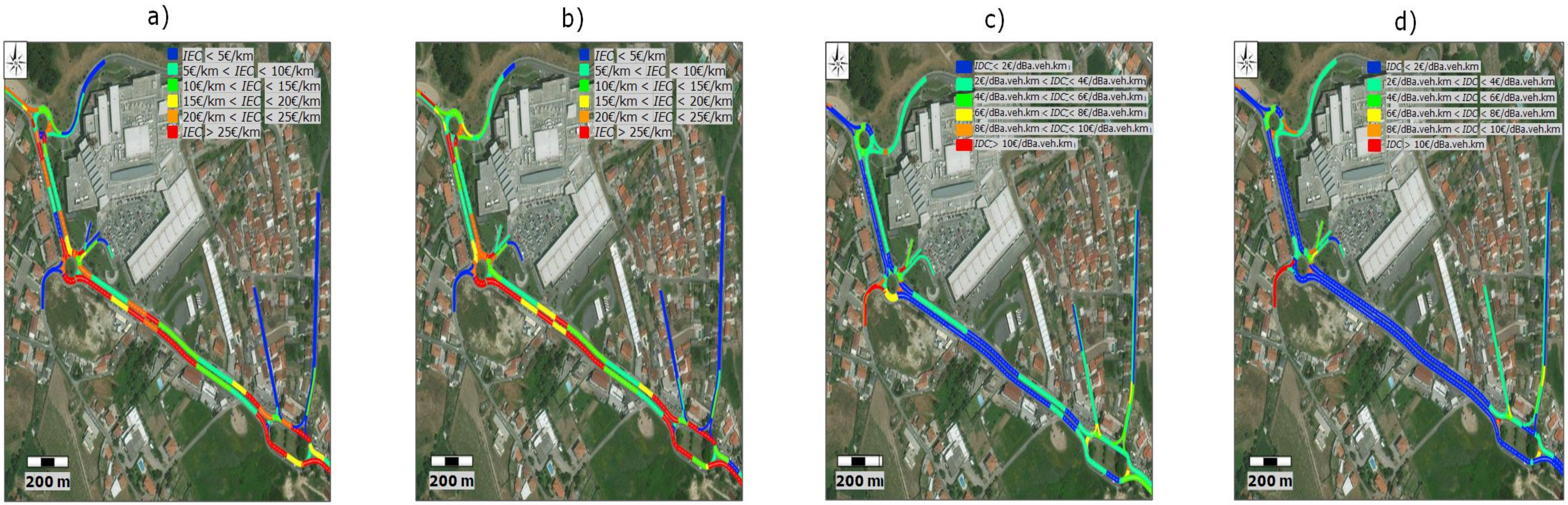
Crosswalk location assessment



- Crosswalk near the present location (PC = 33 m) achieved a good balance among traffic and pedestrian performances, CO_2 and NO_X emissions, and noise
- Noise criteria dictated some optimal locations near roundabout exit section (between 13-23 m)

Ref: P. Fernandes, J. Teixeira, A. Sousa, C. Guarnaccia, M.C. Coelho, Multi-Criteria Assessment of Crosswalk Location in Corridors with Roundabouts or Traffic Lights: The Importance of Noise Levels Estimation, 20th Euro Working Group on Transportation - EWGT 2017, Budapest.

Multi-Criteria Assessment on a Corridor with Roundabouts



- Specific objectives:

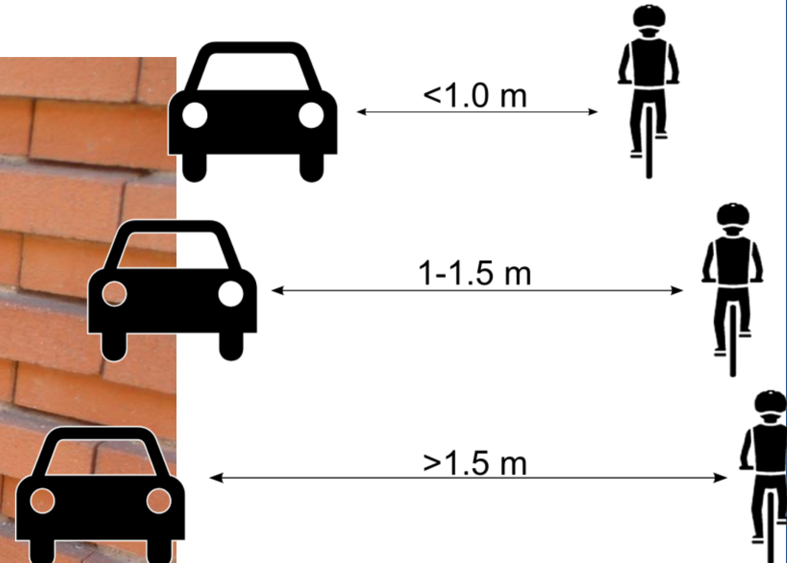
- To evaluate corridor operations in an **integrated** way: link-specific travel time, fuel use, CO_2, NO_X, and noise costs.

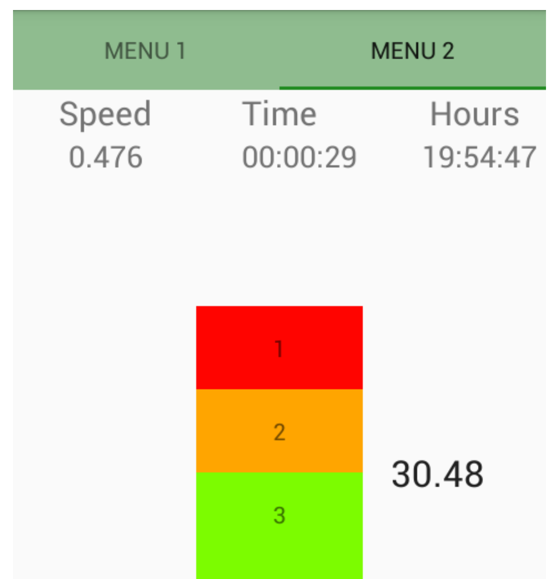
-To propose an optimization model for partial metering based-strategy.

- Using the metering system, overall costs could decrease up to 11% compared to the unmetered condition.

Ref: P. Fernandes, J. Teixeira, C. Guarnaccia, J. Bandeira, E. Macedo, M.C. Coelho, The Potential of Metering Roundabouts: Influence in Transportation Externalities, Proceedings of 97th Transportation Research Board Annual Meeting, Washington D.C., 2018.

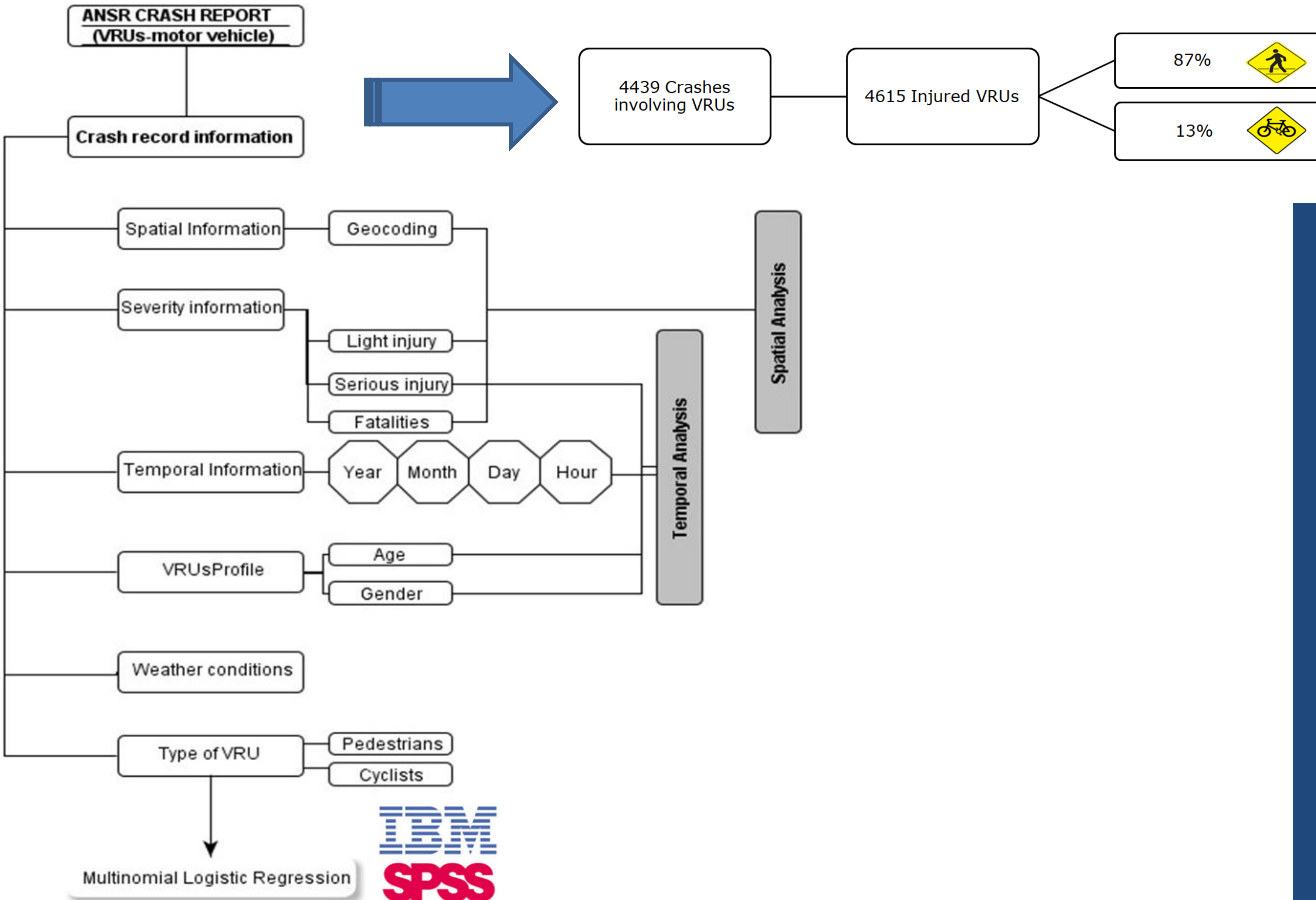
VRUs Safety: On-Board Platform of Sensors on Bicycles





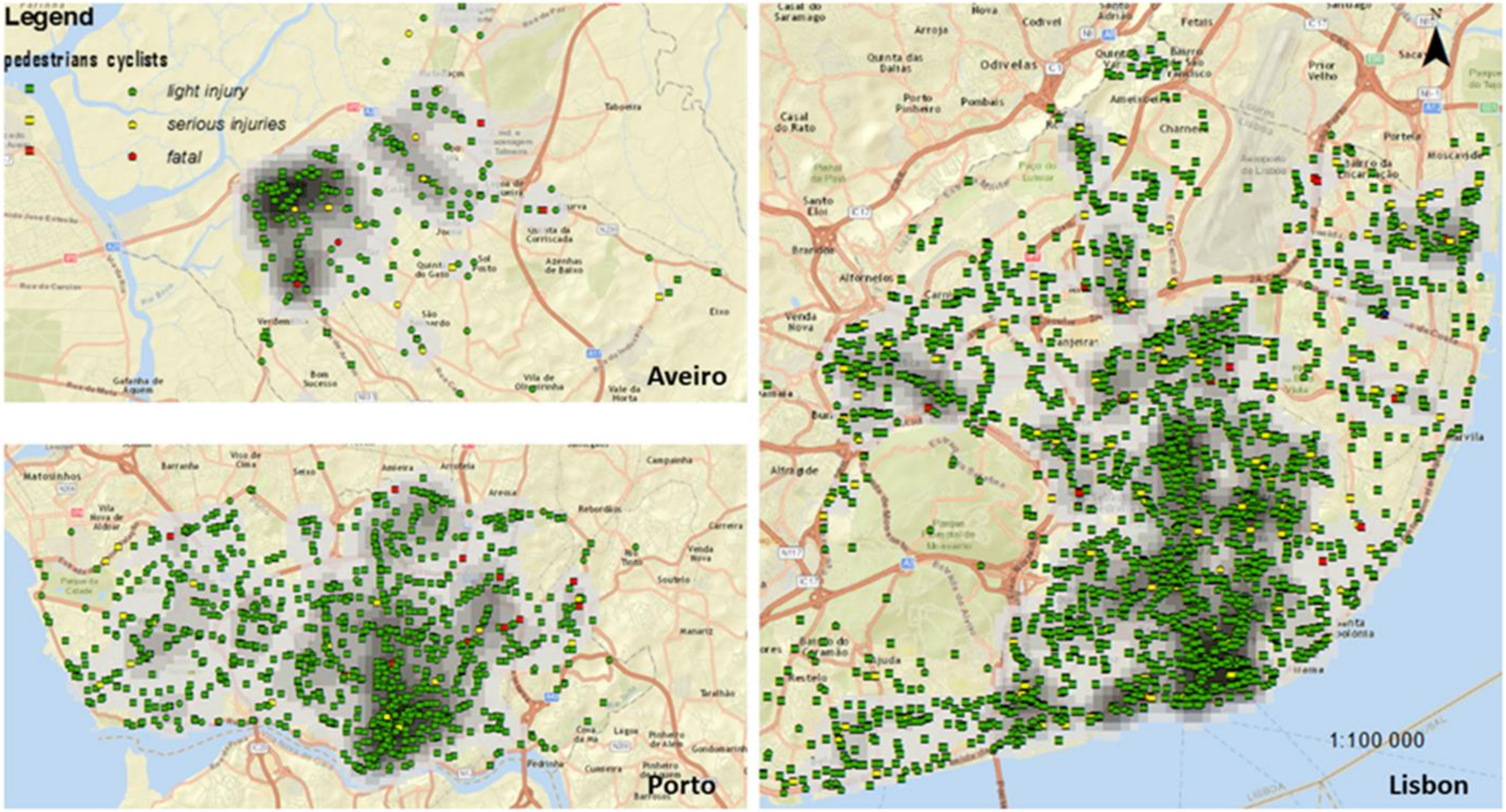
Ref: José Fajardo, José Paulo Santos, Margarida C. Coelho, An On-Board Platform of Sensors for Enhancing Safety of Cyclists, Scientists for Cycling, UA, 2016.

VRUs Crashes Predictive Modeling



Ref: Mariana Vilaça, Eloisa Macedo, Pavlos Tafidis, Margarida C. Coelho, Frequency and severity of crashes involving vulnerable road users – An integrated spatial and temporal analysis, 97th Transportation Research Board Annual Meeting, Washington D.C., 2018.

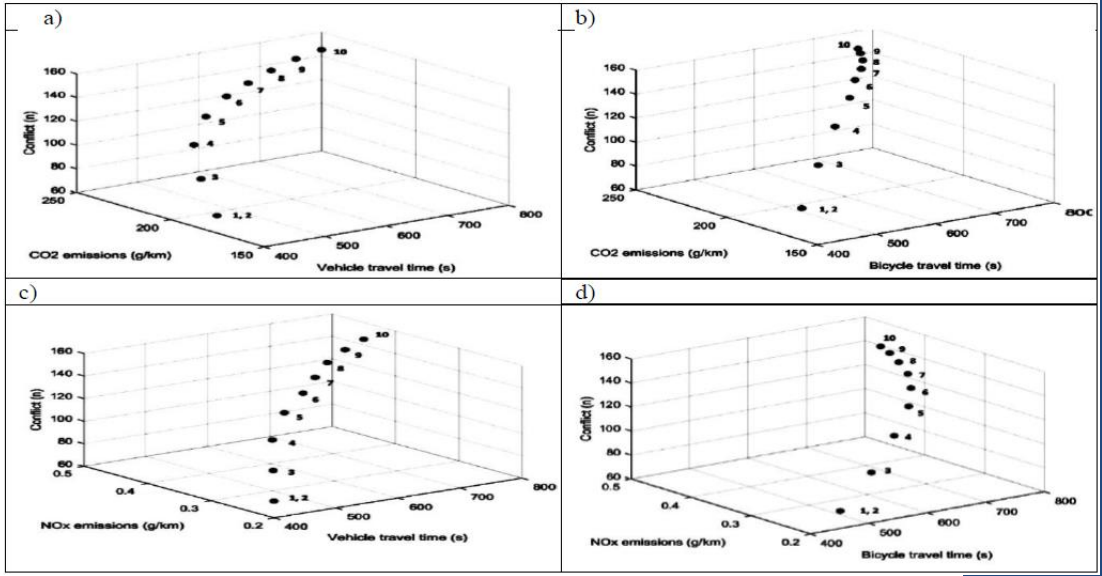
VRUs Crashes Spatial and Temporal Analysis



- Most crashes occur near high attraction places, with speed limits under 50km/h
- VRU gender and age, weather conditions ⇒ statistically significant predictor variables

Ref: Mariana Vilaça, Eloisa Macedo, Pavlos Tafidis, Margarida C. Coelho, Frequency and severity of crashes involving vulnerable road users – An integrated spatial and temporal analysis, 97th Transportation Research Board Annual Meeting, Washington D.C., 2018.

VRUs: Impacts Modeling on Different Routes



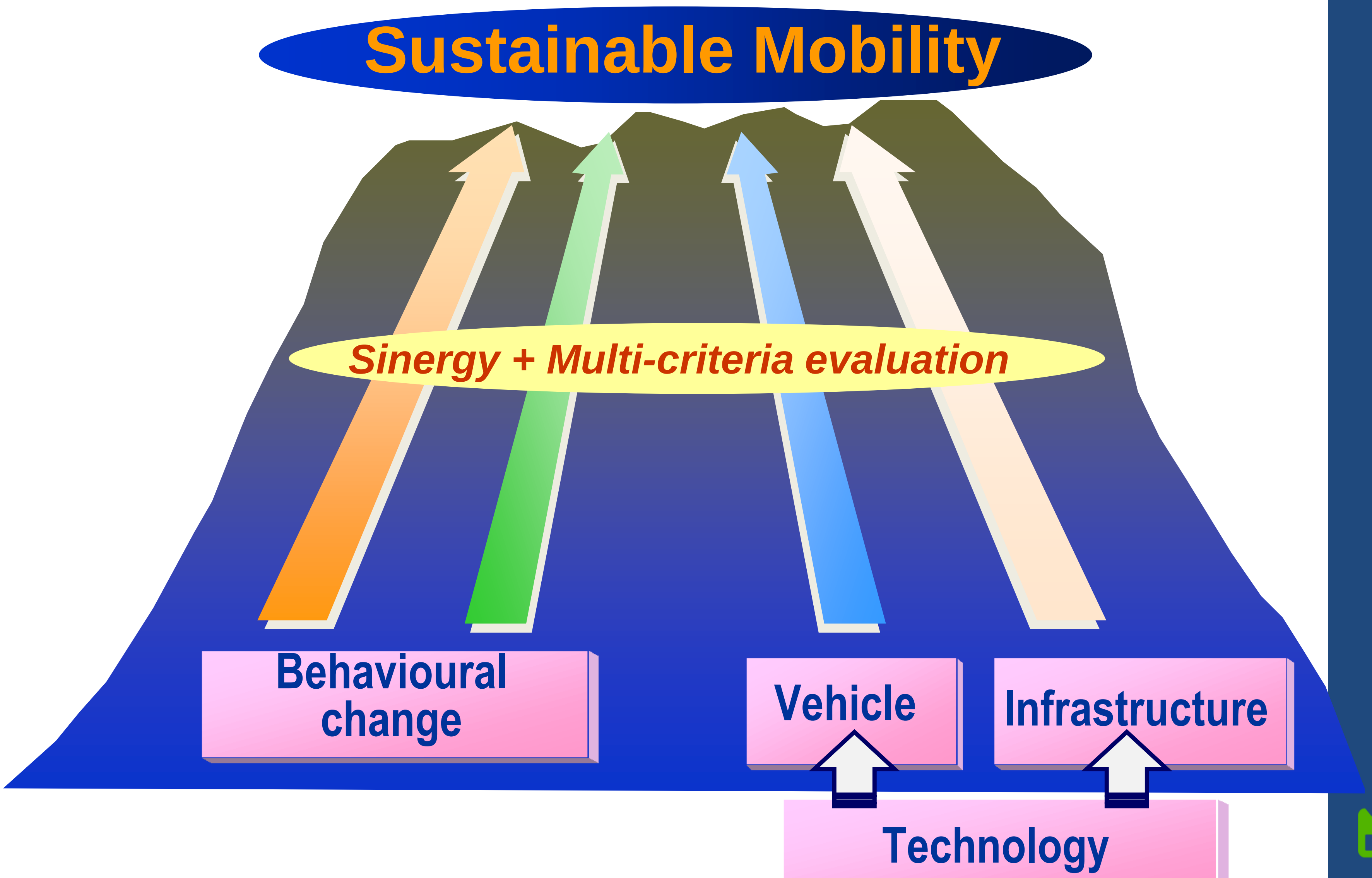
- Multi-objective model based on user's criteria

- Pareto fronts: Travel time, CO_2 and Conflicts for motor vehicle and bicycle users; Travel time, NOx and Conflicts for motor vehicle and bicycle users

Ref: Behnam Bahmankhah, Margarida C. Coelho, Multi-objective optimization for short distance trips in an urban area: choosing between motor vehicle or cycling mobility for a safe, smooth and less polluted route, Transportation Research Procedia, 2017.

CONCLUSIONS

ITS as a strategical choice to help decarbonising the transportation sector



Thank you for your attention!

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