S. Mavromatis, A. Ziakopoulos, J. Roussou, M. Oikonomou, E. Vlahogianni & G. Yannis
National Technical University of Athens (NTUA)

Automation and public transport

Sustainable Cities - Viewpoints of the Pioneer Alliance
IoT for Smart Cities School
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LEVITATE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824361.

Levitate project

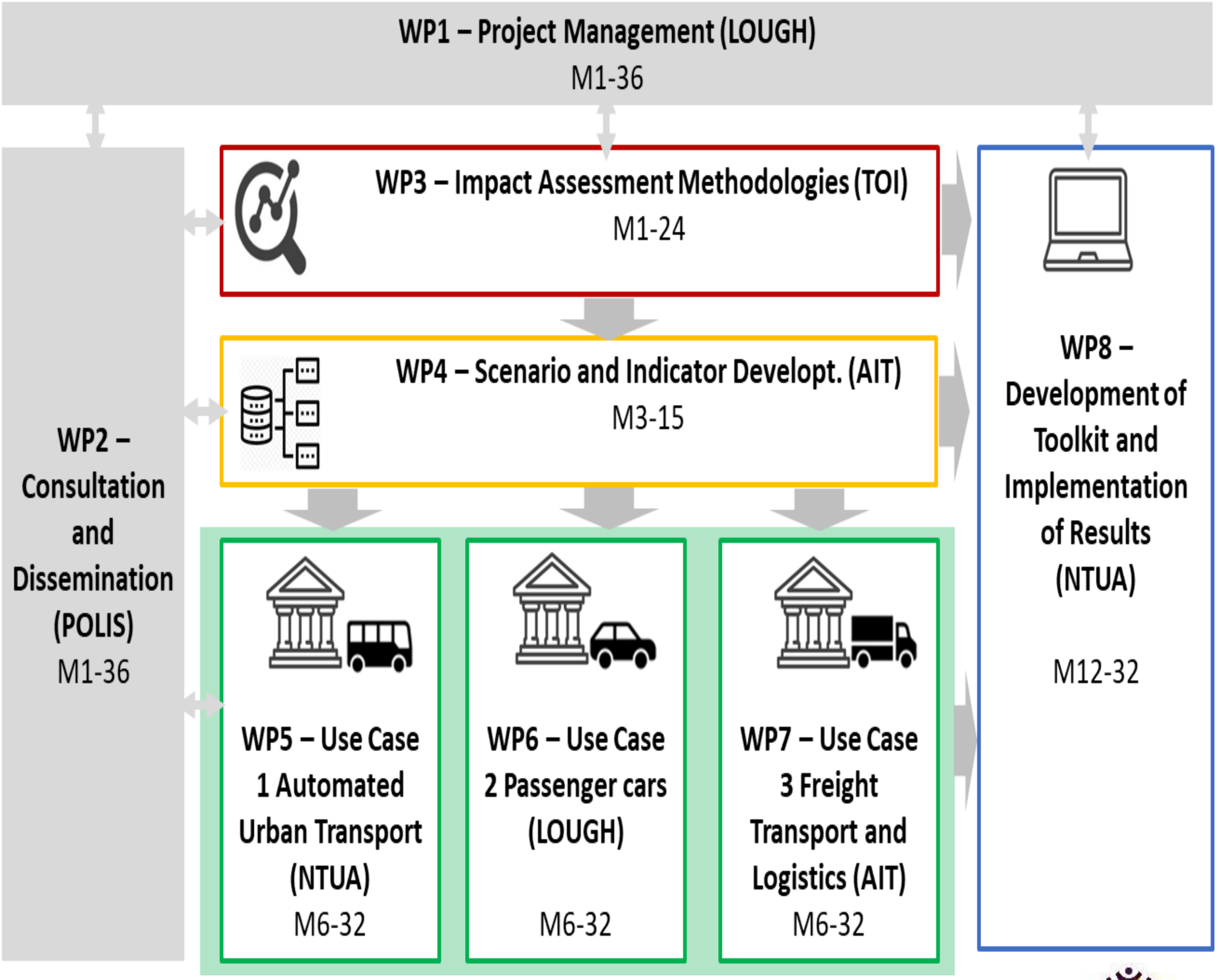
- **LEVITATE** focuses on the development of a new impact assessment framework

- **LEVITATE** enables policymakers to:
  1. manage the introduction of **connected and automated transport systems (CATS)**
  2. maximise the **benefits** and
  3. utilise the technologies to achieve **societal objectives**

- Development of an open access web-based **Policy Support Tool** targeting Decision makers at **all levels**:
  Municipalities, Regional Authorities & National Governments

Project Structure

- Multi-disciplinary methodology to assess short, medium and long term **impacts**
- **Case studies**: mobility, environment, safety, economic and societal indicators
- Range of **forecasting and backcasting scenarios**: automated urban transport, passenger cars, freight services
- New web-based **Policy Support Tool** – Decision Support System



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CATS within public transport (1/2)

- Extensive **Literature Review** process within LEVITATE
- **5 grades** of automation for rail-bound services (UITP, 2012)
- **5 levels** of road automation (additional to baseline) have been introduced (SAE, 2016)
- Levels are **descriptive** rather than normative and **technical** rather than legal
  - No particular **order** of market production is implied
  - Minimum **capabilities** for each Level

Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of Disruption
GoA 1	ATP with driver	Driver	Driver	Driver	Driver
GoA 2	ATP and ATO with driver	Automatic	Automatic	Driver	Driver
GoA 3	Driverless	Automatic	Automatic	Train attendant	Train attendant
GoA 4	UTO	Automatic	Automatic	Automatic	Automatic

ATP - Automatic Train Protection

ATO - Automatic Train Operation

Source: UITP, 2012

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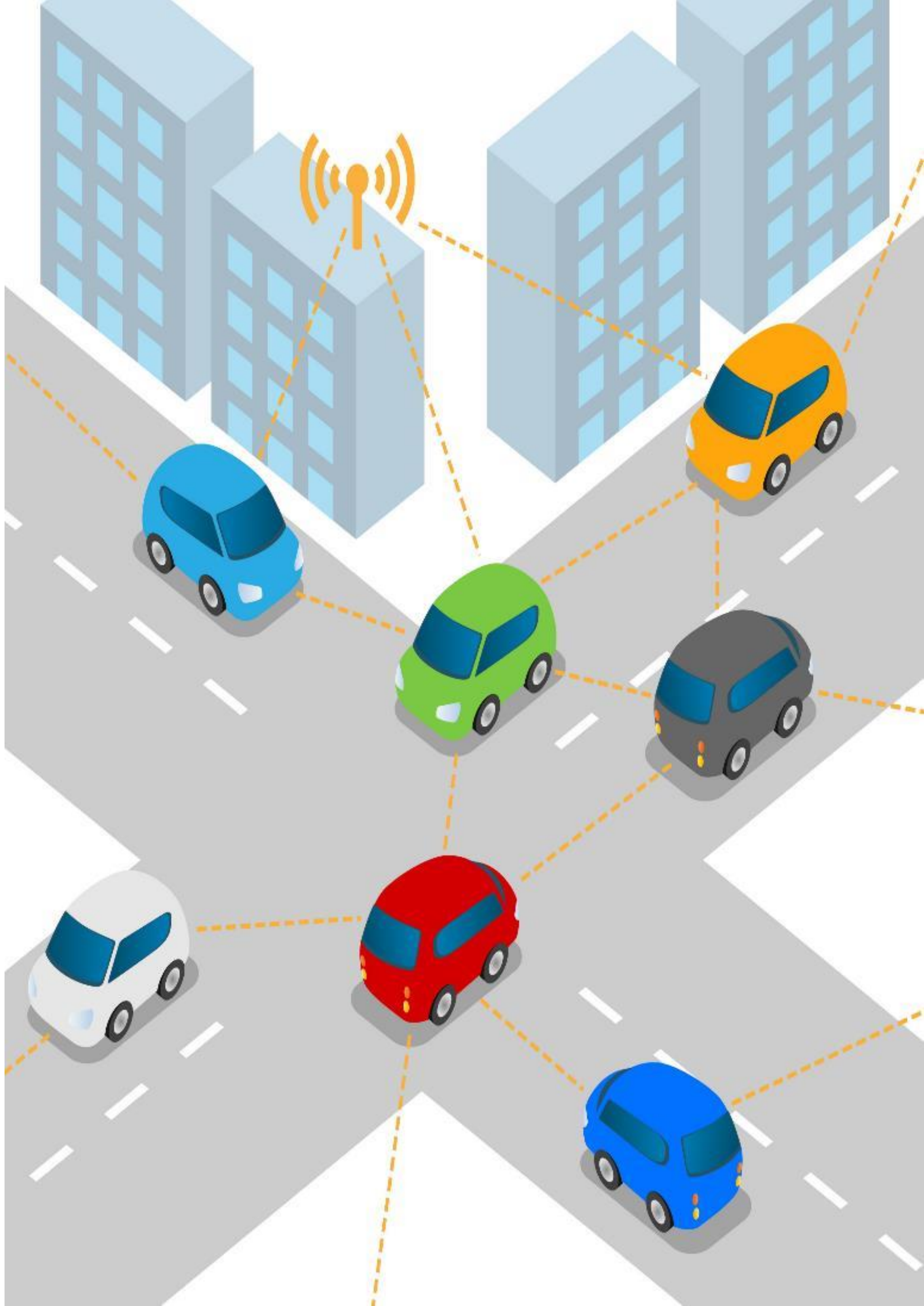
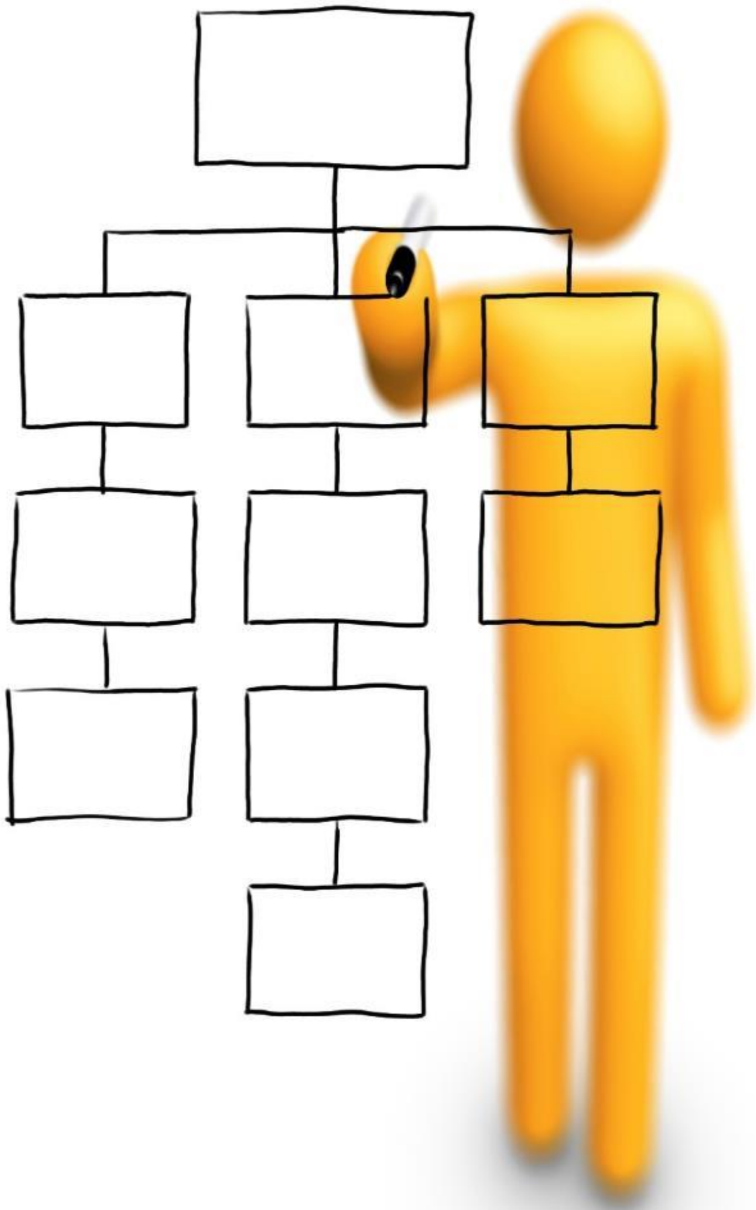
CATS within public transport (2/2)

- Public transport constitutes a significant element of urban mobility
- Two extreme scenarios describing the **uptake of CATS**
  - **Pessimistic scenario**: public transport will suffer due to the focus on autonomous private cars
  - **Optimistic scenario**: shared autonomous cars will be fully integrated into public transport and **provide great coverage** for all regions of the city, thus rendering private cars superfluous



Impact taxonomy

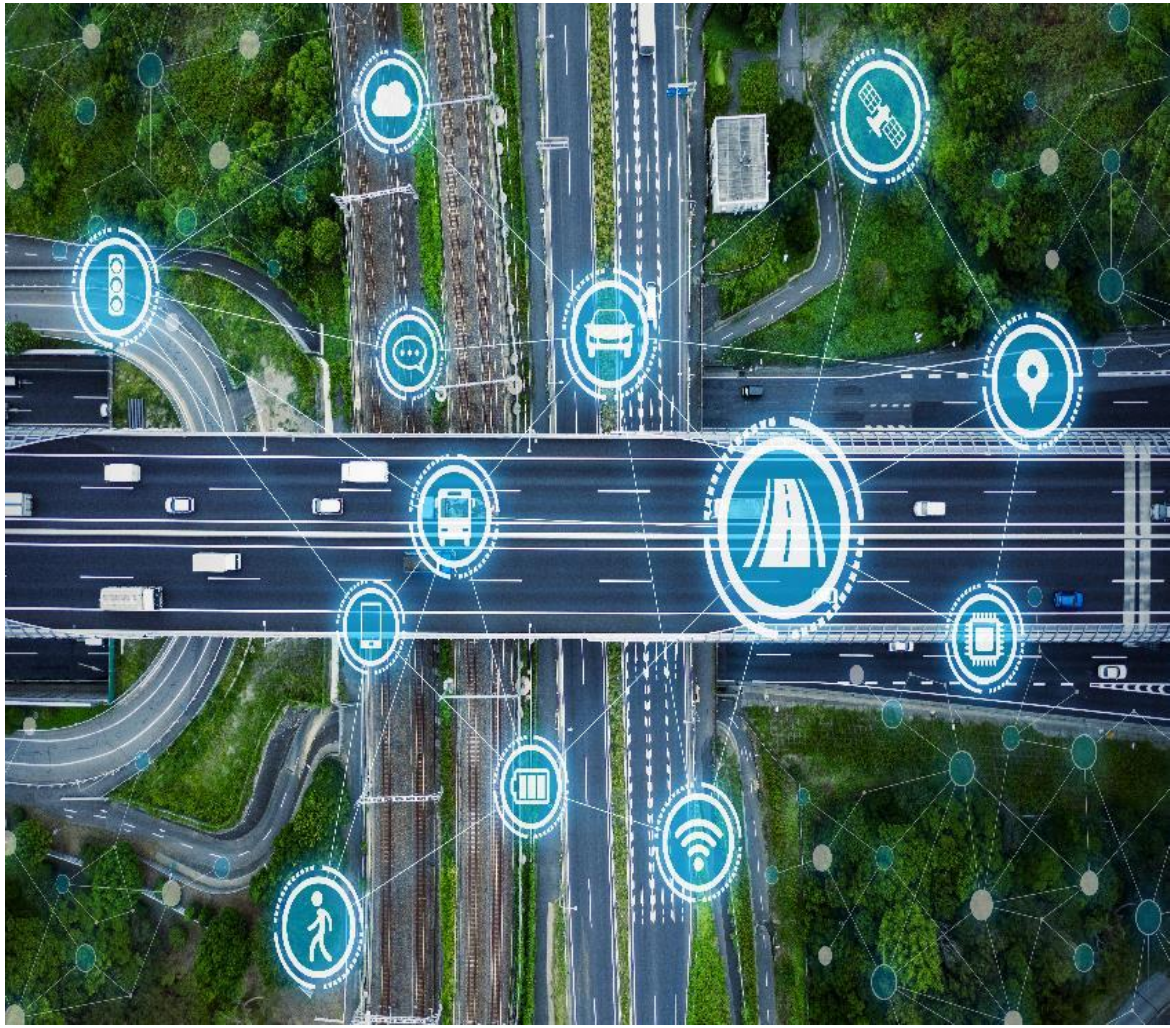
- **Direct impacts**: Noticed by each road user on each trip
  - Travel time, vehicle operating cost, freight operating cost, access to travel
- **Systemic impacts**: System-wide impacts occurring in the transport system
  - Amount of travel, congestion, modal split of travel, shared mobility rate, vehicle utilization rate, vehicle occupancy
- **Wider impacts**: Wider societal impacts occurring outside the transport system
  - Parking space, road safety, energy efficiency, vehicle emissions, public health, inequality in transport, commuting distances



Societal level impacts (1/3)

- **Fully automated public transport** is projected to lead to:
  - reduced crash rates,
  - increased punctuality,
  - shorter headways,
  - greater vehicle availability
  - greater modal splits for public transport

- **First and last mile AV services** can boost the use of other transport systems, affecting modal split and increasing congestion.



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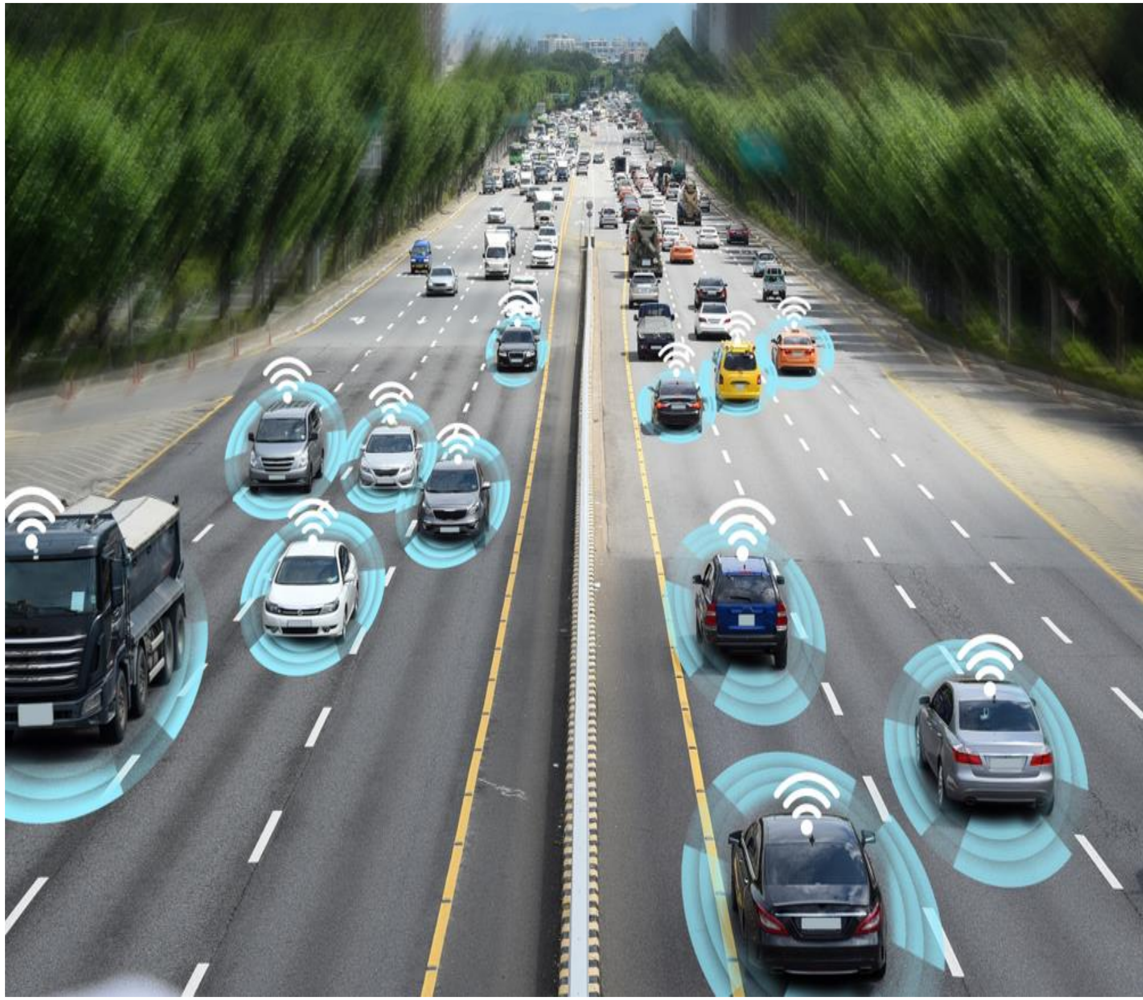
Societal level impacts (2/3)

- **Combination** of AVs with the urban bus system is expected to:
  - Increase travel comfort, by reducing crowdedness and enhancing privacy
  - Reduce travel costs
  - Increase availability, timeliness and reliability of transportation service

- **Autonomous taxis or car sharing** could be considered as part of the public transport as with suitable business models they can promote **sustainability**, reducing the number of private cars and congestion accordingly.



Societal level impacts (3/3)

- Automation can also **facilitate** a transition to Mobility as a Service (**MaaS**) that could **limit** the **negative effects** of road transport, as long as it promotes car sharing, ride sharing or sourcing and not private mobility solutions.

- Possibility of **increased urban sprawl** due to increased mobility opportunities (**MaaS**)

- **Fewer vehicles** that operate more efficiently would reduce car traffic and **advance public transport choice**

Market penetration

- **3 scenarios** regarding the global uptake of CATS: progressive, neutral and obstructed.
- Global sales penetration of automation **levels 3-5 by 2035** will be **85%, 25% and 10%** for the three scenarios respectively
- **Bus, van and HGV markets** are assumed to occur at the same rate as for cars and all scenarios assume that the sales will increase over time
- It is **difficult and speculative** to define CATS penetration rate regarding public transport

Scenario	LDVs (cars & vans)			HGVs			Buses		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
Total (including CAVs)	110,000	120,000	130,000	4,000	4,300	4,600	900	1,400	2,200
L3-L5 CAV sales									
Progressive	11,940	44,600	108,930	470	1,680	4,050	90	470	1,740
Central	11,880	25,200	32,240	429	900	1,150	90	290	560
Obstructed	220	3,840	10,400	8	140	370	2	40	180

Source: Babbar & Lyons, 2017

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LEVITATE WP5 results (1/3): Methodology

- Identification of relevant **specific sub-use cases (SUCs)** based on:
  - Targeted review of recent **literature**
  - Knowledge gained through **existing research** at European level
  - A dedicated **stakeholder consultation**, through a workshop conducted using a "Future Enquiry"

- Identification of **methods** needed to quantify impacts relevant to sub-use cases

- Obtain first sub-use case **simulation modelling results**

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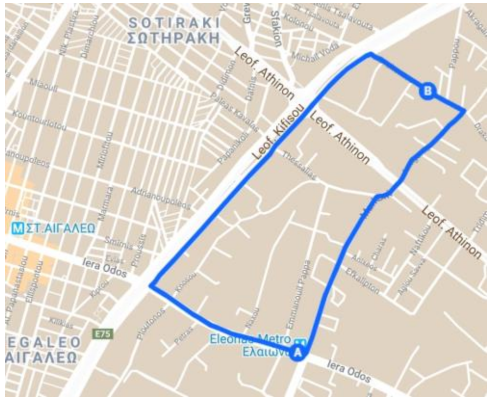
LEVITATE WP5 results (2/3):
Point-to-point automated urban shuttle service SUC

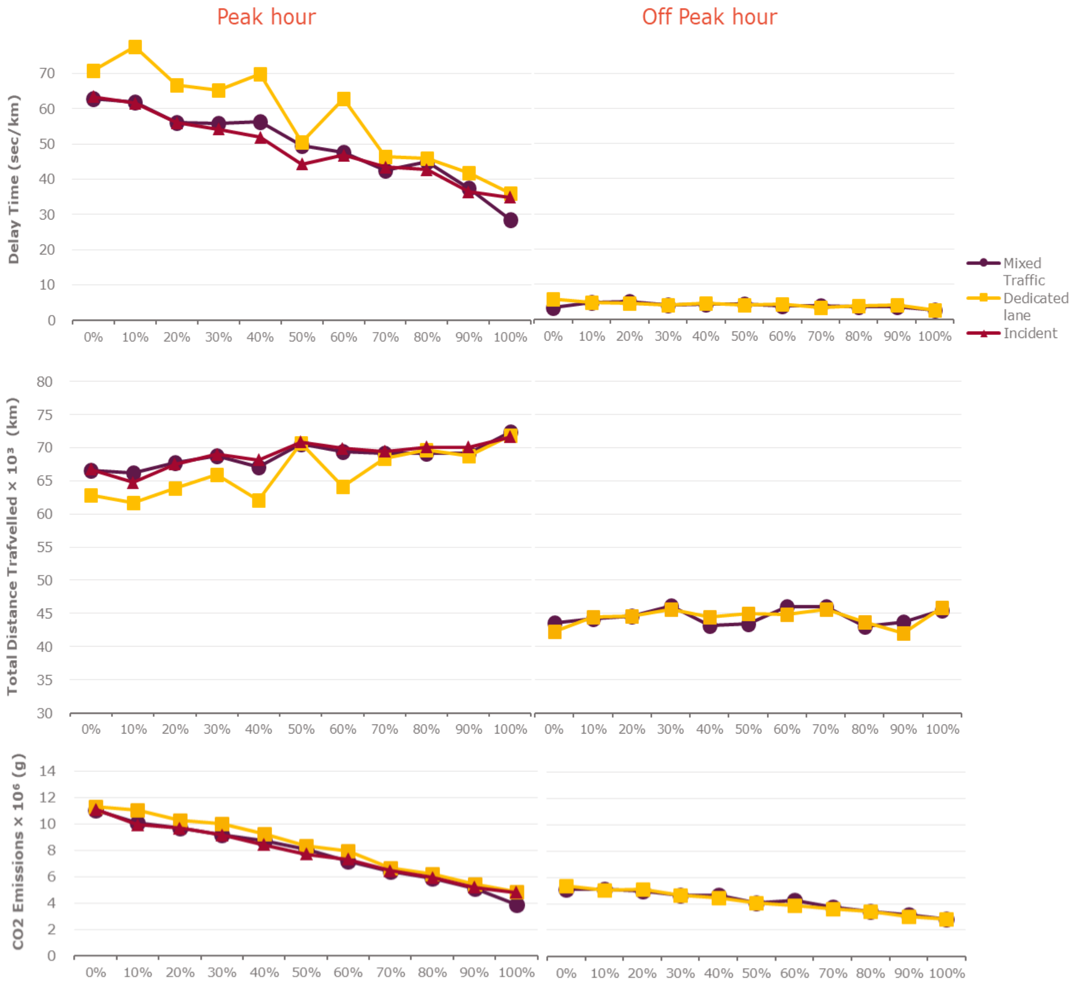
Description

- Urban automated shuttle bus service **connected two modes of transport** in Athens Network.
- The shuttle service **scenarios** include peak and off peak hour traffic conditions, the use of a dedicated lane and an incident condition.



Simulation modelling results

- **Delay time is reduced** with the increase in the penetration rate of AVs during peak hour, while it is rather stable during off peak hour.
- Total **distance travelled is increased** with the increase in the penetration rate of AVs during peak hour, while small oscillations are observed.
- Automation **decreases CO_2 emissions** during both peak and off peak hour.



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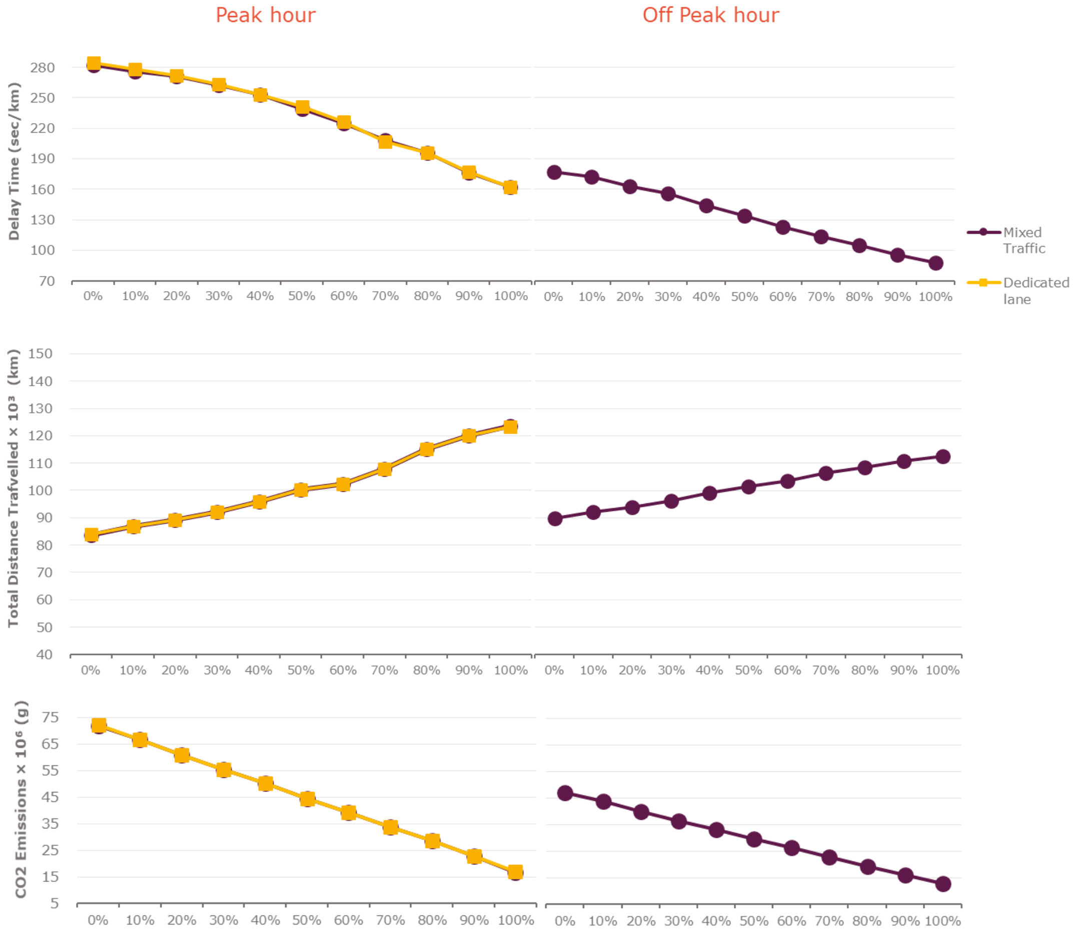
LEVITATE WP5 results (3/3): Automated urban shuttle service in a large-scale network SUC

Description

- Urban automated shuttle bus service **complementing public transport** in the city of Athens.
- The shuttle service **scenarios** include peak and off peak hour traffic conditions and the use of a dedicated lane.



Simulation modelling results

- Automation **decreases delay time** during both peak hour and off peak hour.
- **Total distance travelled gets significantly higher values** when the number of autonomous vehicles is increased.
- **CO_2 emissions are decreased** during both peak and off peak hour, when more automated vehicles exist in the network.

Planning for the future

- According to ERTRAC Connected Automated Driving Roadmap (2019), **two development paths** related to high levels of automation in the urban environment:
  - **Personal Rapid Transit (PRT):** smaller vehicles mostly utilised for transportation of people (e.g. urban shuttles for first and last mile use or even longer distances). Operation in both in a **collective or individual mode** on restricted, specific or open roads
  - **City-buses and coaches:** incorporate numerous **automated functionalities:** traffic jam and driver assistance, bus-platooning, bus-stop automation and other tasks on restricted, dedicated or open roads

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Université Gustave Eiffel
LAUREA
Technology Arts Sciences TH Köln