Agenda

• The LEVITATE project

• Urban transport sub-use cases
  - Point to point automated urban shuttle connecting two modes of transport
  - Point to point automated urban shuttle in a large scale network
  - Autonomous mobility on demand shuttle service (AMoD)

• Policy Support Tool

• Conclusions and Future steps
Societal Level Impact of Connected and Automated Vehicles

€6.4 million project funded by the European Commission under the Horizon 2020 research framework programme

Project coordinator: Loughborough University
Start date: 1/12/2018 – 30/11/2021
Partners: 12 – from 10 countries
The LEVITATE project

Project partners:

- **LOUGH** (UK), **AIT** (AT), **AIMSUN** (ES), **NTUA** (EL), **POLIS** (BE), **SWOV** (NL), **TOI** (NO), **TfGM** (UK), **City of Vienna** (AT), **QUT** (AU), **TJU** (CN), **UMTRI** (US)

Duration of the project:

- 36 months (December 2018 – December 2021)

Operation Program:

- European Union’s “Horizon 2020” research and innovation program
Why LEVITATE

High expectations about CATS in terms of **safety, mobility, environment and prosperity**

The need to measure the impact of existing systems as well as forecasting the impact of future systems represents a **major challenge**

The **dimensions for assessment** are wide including safety, mobility and environment, with many sub-divisions adding to the complexity of future mobility forecasts
LEVITATE...

is building tools to help **European cities, regions and national governments** prepare for a future with increasing levels of automated vehicles in passenger cars, urban transport services and urban logistics.

The aim is to develop an **impact assessment framework** to enable policymakers to manage the introduction of CATS, maximise the benefits and generally harness the technology to achieve societal objective.
Challenges

Research questions

- How will autonomous vehicles improve safety, congestion, economy and the environment?
- What are the key policy decisions to maximize these benefits?

→ Focus on cities

Challenges

- Provide rigorous forecasts of impacts for many years ahead
- Wide range of impacts
- Wide range of forecasting methods
- Wide range of city types
Levitate overview

Impact Assessment Methodologies

Forecasting and Backcasting Scenario and Indicator Development

Development of web-based Policy Support Tool

Formulation of policy recommendations

Use Case 1 Automated Urban Transport

Use Case 2 Passenger cars

Use Case 3 Freight Transport and Logistics

Structured exchange with users, administrations and experts
Use Cases in Levitate

<table>
<thead>
<tr>
<th>Passenger cars</th>
<th>Urban transport</th>
<th>Freight Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road use pricing</strong></td>
<td>Automated shuttles</td>
<td>Automated urban delivery</td>
</tr>
<tr>
<td>- Empty km pricing</td>
<td>- Point to point shuttle connecting two modes of transport</td>
<td>- Semi-automated delivery</td>
</tr>
<tr>
<td>- Static toll on non-AVs</td>
<td>- Point to point shuttle in a large scale network</td>
<td>- Fully-automated delivery</td>
</tr>
<tr>
<td>- Static toll on all vehicles</td>
<td>- Autonomous mobility on demand shuttle service (AMoD)</td>
<td>Local freight consolidation</td>
</tr>
<tr>
<td>- Dynamic toll on non-AVs</td>
<td></td>
<td>- Automated delivery via white label city-hubs</td>
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<tr>
<td>- Dynamic toll on all vehicles</td>
<td></td>
<td>Hub to hub automated transfer</td>
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<tr>
<td><strong>Automated ride sharing</strong></td>
<td></td>
<td><strong>Highway platooning</strong></td>
</tr>
<tr>
<td><strong>Parking space regulation</strong></td>
<td></td>
<td>- Platooning on city highways</td>
</tr>
<tr>
<td>- Parking price</td>
<td></td>
<td>- Access control for bridges on city highways</td>
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<tr>
<td>- Replace long-term parking</td>
<td></td>
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<tr>
<td><strong>Dedicated lanes for AVs</strong></td>
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</table>
Urban transport sub-use cases

1. Point to Point Automated Urban Shuttle Service (AUSS) connecting two modes

2. Point to Point AUSS in a large-scale network
   - Shuttle service connecting urban zone and the suburbs (not served by standard bus service)
   - Anywhere to anywhere urban shuttle service
   - Last-mile shuttle service
   - E-hailing

3. Autonomous mobility on demand shuttle service (AMoD)
1. Point to point AUSS connecting two modes

Route:

• 3.4 km length
• Signalized arterial and Secondary streets

Characteristics:

• Cautious AV - connected
• 5.00 m length
• 2.50 m width
• 10 passengers total capacity
• 40.0 km/h max operating speed
• 25.0 km/h mean speed
• 15 min service frequency
Scenarios Specifications

A. Scenarios on the shuttle bus route level:
   - Included or not the shuttle bus service in 2021
   - During peak and off peak hour

B. Scenarios on network level:
   - During peak and off peak hour
   - For different mobility scenarios
   - At the emergence of an incident on the shuttle route
   - Operating on a dedicated lane or with the rest of the traffic
On the shuttle bus route level results

<table>
<thead>
<tr>
<th>Traffic condition</th>
<th>Street type</th>
<th>Speed variance (km/h)</th>
<th>Delay Time (sec/km)</th>
<th>CO2 Emission (kg)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Shuttle service</td>
<td>Shuttle service</td>
</tr>
<tr>
<td>Peak hour</td>
<td>Signalized Arterial</td>
<td>34</td>
<td>130</td>
<td>130</td>
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<tr>
<td></td>
<td>Secondary Street</td>
<td>13</td>
<td>246</td>
<td>252</td>
</tr>
<tr>
<td>Off Peak hour</td>
<td>Signalized Arterial</td>
<td>45</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Secondary Street</td>
<td>26</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

- The **speed variance** of the Shuttle bus gets higher values during off peak hour than peak hour.
- The shuttle bus leads to **increased delay times** on its route, especially on the signalized arterials.
- Shuttle bus service **affects traffic only during off peak hour**, when the traffic is much lower and stochastic.
Preliminary results (1/3)

- Delay time gets lower values when more automated vehicles exist in the network.
- In mixed traffic automation decreases CO2 emissions during peak hour conditions, while no change in CO2 levels is observed during off peak hour.
### Preliminary results (2/3)

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Scenarios</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
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<tr>
<td><strong>Delay Time (sec/km)</strong></td>
<td>Peak hour</td>
<td>63</td>
<td>62</td>
<td>56</td>
<td>56</td>
<td>56</td>
<td>50</td>
<td>48</td>
<td>43</td>
<td>45</td>
<td>38</td>
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<tr>
<td></td>
<td>Dedicated lane</td>
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<td>78</td>
<td>67</td>
<td>65</td>
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<td>51</td>
<td>63</td>
<td>46</td>
<td>46</td>
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<tr>
<td></td>
<td>Incident</td>
<td>64</td>
<td>62</td>
<td>56</td>
<td>54</td>
<td>52</td>
<td>44</td>
<td>47</td>
<td>44</td>
<td>43</td>
<td>36</td>
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<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
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<tr>
<td></td>
<td>Off Peak hour</td>
<td>5.078</td>
<td>5.346</td>
<td>5.477</td>
<td>5.366</td>
<td>5.571</td>
<td>5.221</td>
<td>5.644</td>
<td>5.419</td>
<td>5.323</td>
<td>5.335</td>
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<tr>
<td><strong>Total conflict change (%)</strong></td>
<td>Peak hour</td>
<td>-</td>
<td>11%</td>
<td>9%</td>
<td>19%</td>
<td>21%</td>
<td>21%</td>
<td>20%</td>
<td>22%</td>
<td>23%</td>
<td>17%</td>
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<td>-</td>
<td>18%</td>
<td>16%</td>
<td>28%</td>
<td>27%</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
<td>24%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Incident</td>
<td>-</td>
<td>14%</td>
<td>12%</td>
<td>23%</td>
<td>15%</td>
<td>7%</td>
<td>23%</td>
<td>14%</td>
<td>25%</td>
<td>16%</td>
<td>19%</td>
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<tr>
<td></td>
<td>Off Peak hour</td>
<td>-</td>
<td>6%</td>
<td>7%</td>
<td>1%</td>
<td>12%</td>
<td>14%</td>
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<td>18%</td>
<td>22%</td>
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<tr>
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<td>Dedicated lane</td>
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<td>-54%</td>
<td>-50%</td>
<td>-66%</td>
<td>-49%</td>
<td>-3%</td>
<td>8%</td>
<td>-53%</td>
<td>-32%</td>
<td>3%</td>
<td>-53%</td>
</tr>
</tbody>
</table>

- If the shuttle bus uses a dedicated lane, both delay time and CO2 emissions are increased during off peak and peak hour.
- An incident occurrence on the shuttle service route was not observed to affect traffic delays and CO2 emissions.
- If the shuttle bus uses a dedicated lane, the number of conflicts is reduced during off peak hour and for other occasions it seems to be increased.
Preliminary results (3/3)

- Automation seems to lead to decreased numbers of crossing conflicts.
- If the shuttle bus uses a dedicated lane, the number of lane change conflicts is higher.
- The number of rear end conflicts is increased if an incident occurs on the shuttle bus route.
2. Point to Point AUSS in a large-scale network

Aim:
Impacts of automated urban shuttle buses complementing public transport in the city of Athens

Service Characteristics:
• Parallel operation with the existing transit service
• Intermediate stations
• Connecting various destinations
• Connecting areas with low transit coverage
2. Point to Point AUSS in a large-scale network

The city of Athens in AIMSUN

- 290×290 OD Matrices
- 2,580 Sections
- 1,137 Nodes
2. Point to Point AUSS in a large-scale network

**Athens transport network**

- 170 public transport lines
  - 95 bus lines
  - 14 trolley lines
  - 4 metro lines
  - 2 tram lines
  - 5 suburban lines
  - 50 intercity bus lines
- 1,030 public transport stations
Proposed Shuttle bus lines

**Line 1:**
Connecting the metro station “Viktoria” (A) with the metro station “Panormou” (B)

**Line 2:**
Connecting the National Garden (A) and Greek Parliament with the National Archeological Museum (B)

**Line 3:**
Connecting Omonoia Square (A) with Acropolis - Parthenon (B)

**Line 4:**
Connecting metro station “Rouf” (A) with metro station “Neos Kosmos” (B)
2. Point to Point AUSS in a large-scale network

Other Specifications
• Provision for dedicated lane
• Extreme conditions (e.g. incident)
• Frequency of service, with intermediate stops

Methodologies:
• Macro-simulation: Traffic impacts - Travel time, Distance, Trips, etc.
• Meso-simulation: Environment impacts – CO2, NOx Emissions
• Micro-simulation: Road safety impacts
• Meta-analysis
• Delphi
3. AMoD shuttle service

Service Specifications

• Fixed routes → completely free routing

• Fixed timetables → on-demand real-time requests

• Physical stops → stop anywhere

• Fleet type: small shuttles

• Rides offered disconnected from existing public transport service
3. AMoD shuttle service

Assumptions

• Part of the demand will be assigned to the new mode. The demand shift will be estimated based on the new mode choice model of Athens.

or

• Demand is generated dynamically during the simulation period ...

How this demand will be served from the new mode?

• Identify the trips
• Optimization algorithm to assign vehicles to demand
• Monitor the impact to the network
PST Overview

PARAMETERS → SUB-USE CASES → IMPACTS

RELATIONSHIPS

FORECASTING → BACK-CASTING
Policy Support Tool (PST)

Knowledge Module
- Bibliography
- Levitate results
  - use case results
  - predefined impact assessment scenarios
- Tools Documentation
- Guidelines

Estimator Module
Forecasting sub-system (per use case)

- Sub-use cases
  - Shuttle / e-hailing / MaaS
  - Road use pricing
  - Parking space interventions
  - Urban delivery (freight)
  - Local freight consolidation
  - ... etc.

- Parameters
  - GDP per capita
  - City population
  - AV penetration rate (per SAE Level)
  - Automation type
  - Vehicle ownership rate
  - Share of electric vehicles
  - Fuel / electricity cost
  - Fuel / electricity consumption

Backcasting sub-system
Employment of forecasting in an iterative process ("goal seek"), testing alternative policy interventions until the desired impact - policy goal is obtained.

TO BE DEFINED
Conclusions and Future Steps

Point to point shuttle
- Delay time gets lower values when more automated vehicles exist in the network.
- Under our assumptions, CAV introduction will decrease emissions and conflicts during peak hours.

Future sub-use cases in urban transport
- Which challenges will arise for on-demand shuttle service?
- What will be the economic benefits of introducing these sub-use cases in urban environment?
Urban Transport Services

Webinar

For more information: www.levitate-project.eu

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