PHOEBE Project

Athens Use Case

Stella Roussou
Research Associate, PhD Candidate

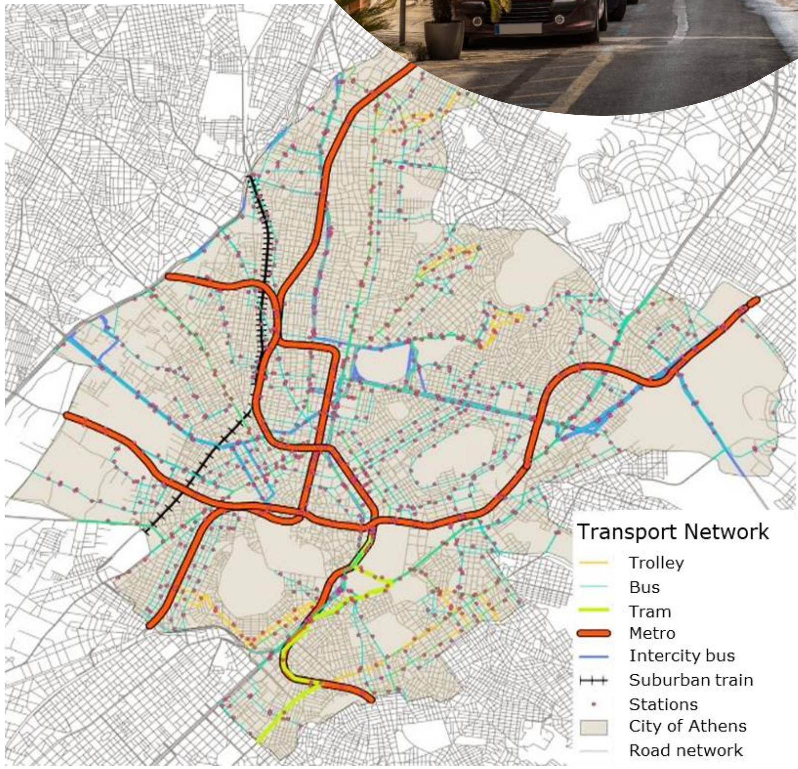
Together with:
Apostolos Ziakopoulos, Maria Oikonomou, George Yannis

Department of Transportation Planning and Engineering,
National Technical University of Athens

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Athens Characteristics



- The **City of Athens** (pop. 664,000) is in the Attica metropolitan region (pop. 3.75 million).

- **Passenger vehicles** make up 69% of the total vehicle fleet in Attica, followed by motorcycles and mopeds at 24%, trucks at 6.7% and buses at 0.3%.

- The **public transport network** of Athens consists of buses, trolleybuses, trams and metro lines for urban transport, complemented by the network of Suburban bus and train services.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

Athens Use Case

- The focus of the Athens pilot is **pedestrian road safety.**
- In order to measure it, **profiles** and example travel patterns are defined.
- The analysis place critical emphasis on **VRU KPIs**, such as speed measurements and modal share of pedestrians, cyclists and similar modes, such as e-scooters.
- The Athens use case applies the **PHOEBE predictive safety framework** to assess the safety impacts of urban mobility interventions.

Cities can move from **reactive crash analysis** to **proactive safety prediction**.

The **analysis integrates**:

- Infrastructure safety assessment (iRAP methodology)
- Traffic microsimulation models (Aimsun Next)
- Video-based monitoring of pedestrian behaviour

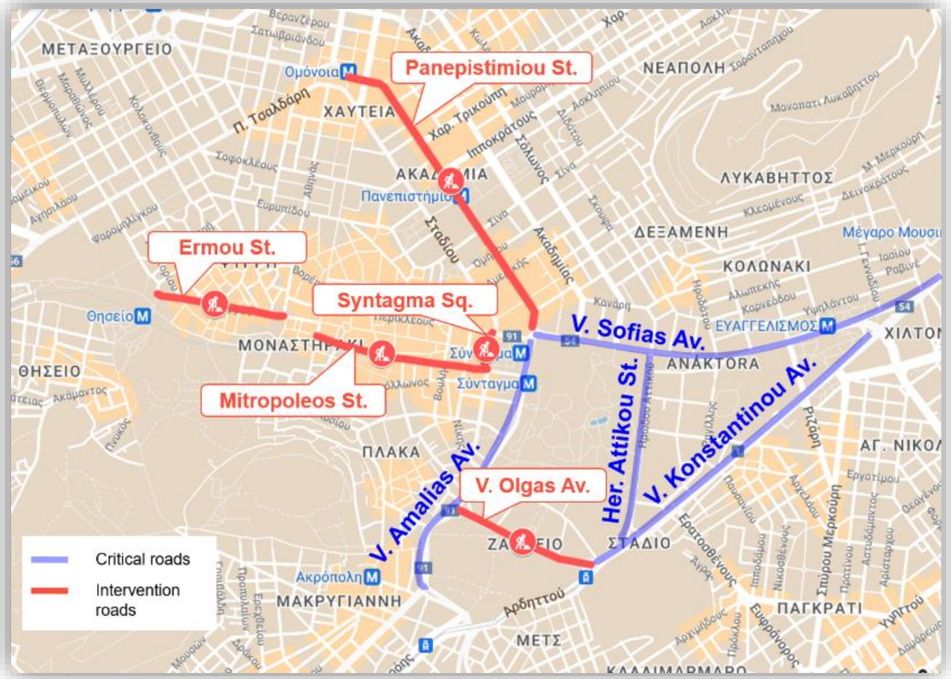
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Use case Interventions

City of Athens implemented three **major interventions** to promote safety and sustainable mobility:

- a **30 km/h speed limit** across the network through several regulatory measures, from nominal enforcement to police presence to radars and speed cameras
- the establishment of an extensive network of **bicycle routes** within the existing road network (mixed traffic, bike/bus lanes and bike lanes on road shoulders)
- the promotion of **public transport** modes.



Key Locations:

- Panepistimiou St.: Fewer lanes, wider sidewalks and a new dedicated bus lane
- Syntagma Sq.: Wider sidewalks, reorganized bus/taxi space
- Vasilissis Olgas Ave.: Closed to cars (pedestrians & cyclists only)
- Ermou St.: Motorcycle parking management

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Simulation Scope, Scenarios & Description

The Athens use case simulation explored **the impacts of urban interventions** on traffic conditions, safety and mobility behaviour, focusing on three distinct scenarios:

- **Scenario 0 (baseline)**: Conditions before any intervention implementation
- **Scenario 1**: Conditions after interventions implementation
- **Scenario 2**: After interventions with a 30 km/h speed limit

For each scenario, **10 different replications** with random seeds were simulated.

- A traffic simulation model was developed in Aimsun Next, focusing on central Athens and **key intervention corridors**.
- The simulation model covered an area of approximately **3 km²** with a total road length of 47 km.
- The model included **five types of users**: private cars, trucks, buses, taxis and pedestrians.
- The simulation was conducted during the **morning peak hour** (08:00-09:00 a.m.).

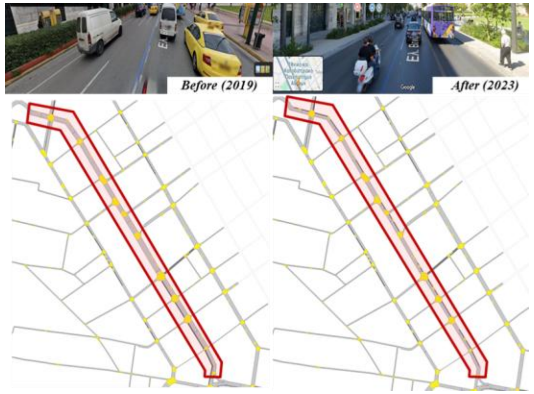
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

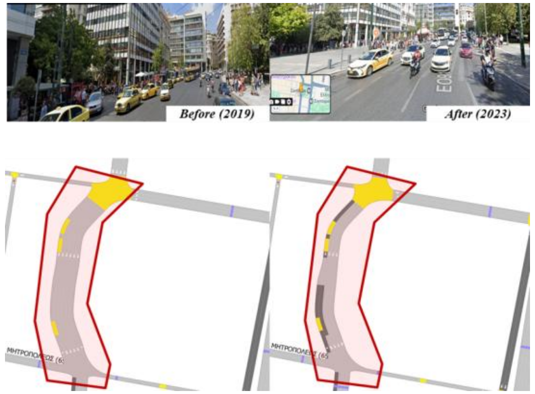
Pedestrian & Interventions Integration

- Pedestrian measurements were conducted manually by analyzing **videos from cameras**.
- A total of **6,912 pedestrians** were counted during the simulated period.
- Entrances and exits for pedestrians were established on each side of the crossings, and a corresponding **OD matrix** was developed.
- The implemented interventions were incorporated into the simulation network by modifying **road geometry, lane allocation and traffic regulations**.

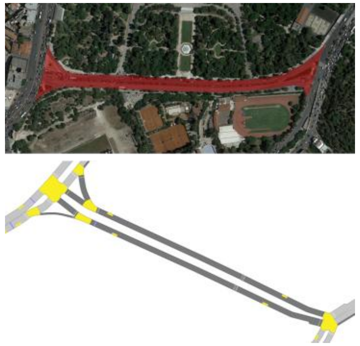
Panepistimiou Street



Syntagma Square



Vasilissis Olgas Avenue



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

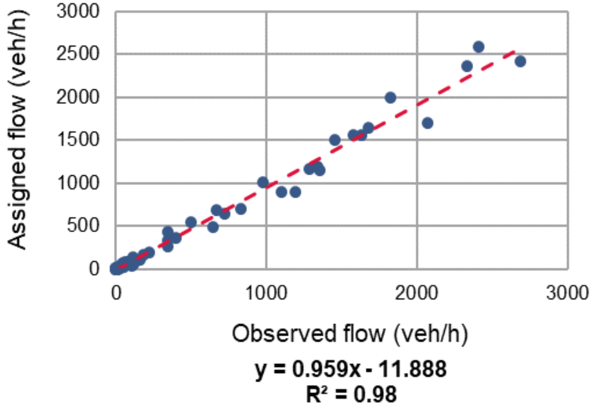
Motorized Vehicles Integration

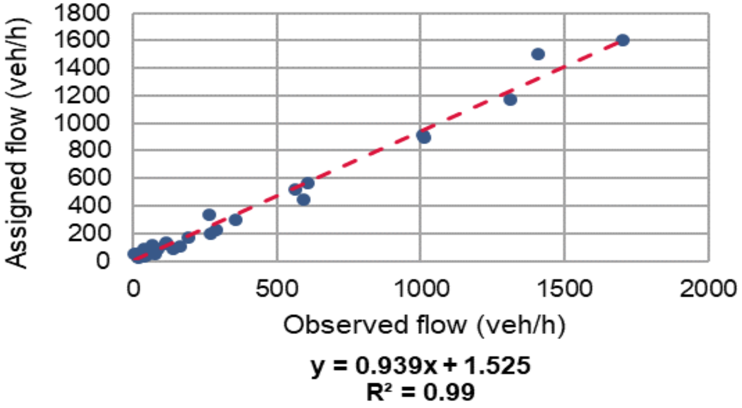
Before interventions integration

- **Traffic data** were collected from the Athens Traffic Management Centre (ATMC) using 19 detectors (traffic cameras).
- Additional **field measurements** were used to account for fleet composition.
- The model was successfully calibrated using the **GEH index** (85.2% of cases had GEH values below 5, and 100% were below 10).
- The model achieved an **R^2 value of 0.98**, indicating an excellent fit.

After interventions integration

- **Traffic data were** collected from the ATMC using 6 detectors (traffic cameras).
- Additional **field measurements** were used to account for fleet composition.
- The model was successfully calibrated using the **GEH index** (85% of cases had GEH values below 5, and 100% were below 10).
- The model achieved an **R^2 value of 0.99**, indicating an excellent fit.





This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Non-Compliant Behaviour Modelling

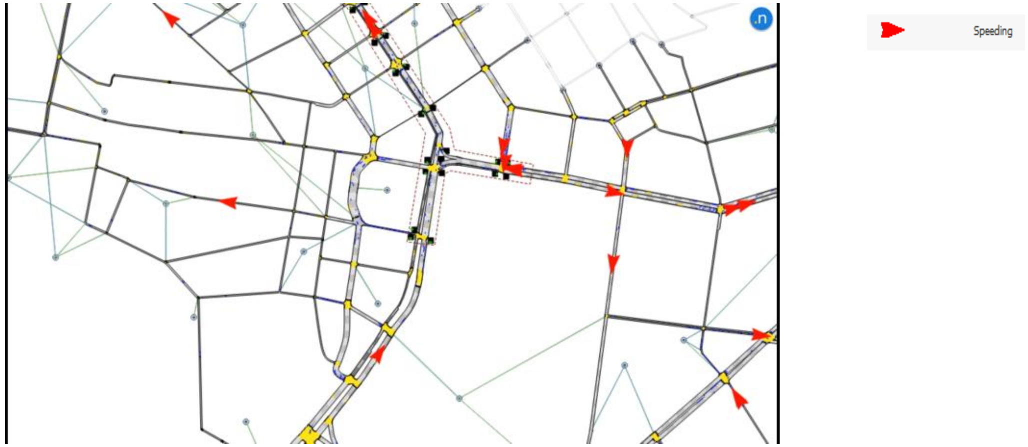
- To enable realistic safety critical interactions, some **non-compliant behaviours** have been added to the traffic simulation software:
  - **Speeding**
  - **Pedestrian red light violation**
- Behaviours are triggered dynamically **via an API** using observed data inputs.
- Behaviour is activated at each **simulation time step**.

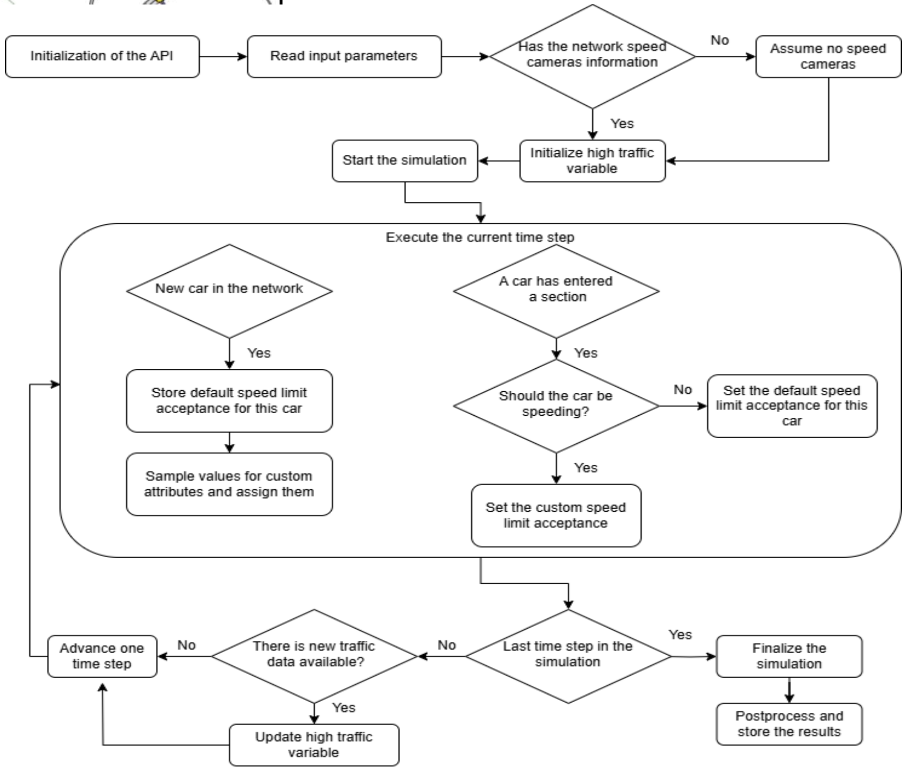
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Speeding

- Speeding is implemented through the **speed limit acceptance parameter** in Aimsun.
- The probability of speeding depends on **traffic and human-related factors**.
- Traffic-related variables are derived from the **simulation**.
- Human-related variables (e.g., behaviour, demographics) are **externally provided**.





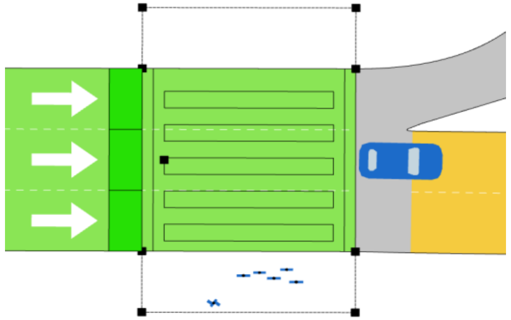
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

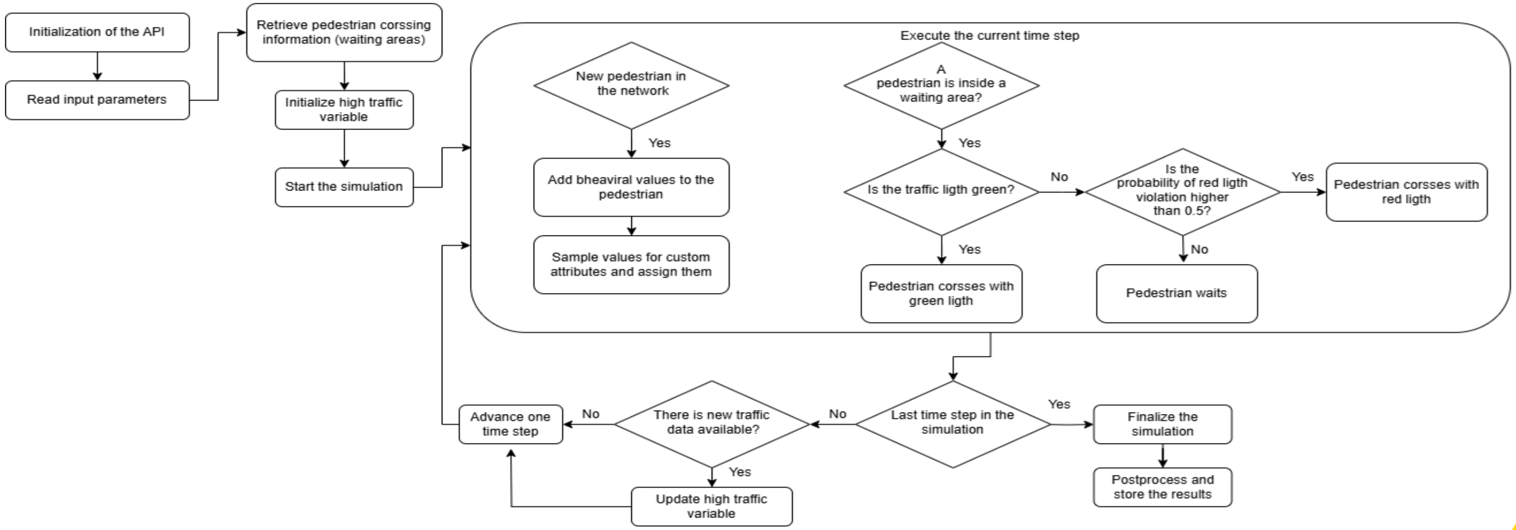
UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Pedestrian Red-light Violation

- Pedestrians are evaluated when they are in crossing **waiting areas**.
- If the signal is not green, a **probability of violation** is calculated.
- If the probability exceeds a **threshold**, the pedestrian crosses against the red light.
- **Social attributes** (e.g., age, urgency) are assigned to pedestrians.

Detail of a pedestrian crossing with the waiting areas in the simulation





This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Key Results & Conclusion

Road Safety

- High traffic volumes and infrastructure design **reduced speeding behaviour**.
- Pedestrian violations were more likely under **low traffic** and time pressure conditions.

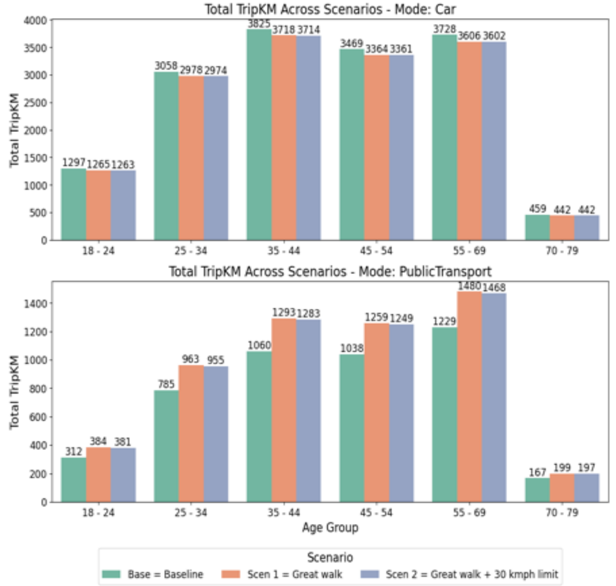
Mode Shift

- Use of private cars and motorcycles **decreased**.
- Public transport usage, walking and micromobility **increased**.

➢ Overall, the interventions **improved safety and shifted mobility** towards more sustainable and people-oriented transport.

Pedestrians Red Light Running Behaviour

Variables		Estimates	z value	Pr(>|z|)	95% CI	
					L	U
Intercept		2.833	5.914	0.000	1.894	3.772
High traffic		-1.098	-22.642	0.000	-1.193	-1.003
Wide crossing width		-0.682	-14.383	0.000	-0.774	-0.589
Being in a rush		0.497	10.534	0.000	0.404	0.589
Age		-0.024	-2.950	0.003	-0.040	-0.008
Past behaviour	Red light violation	0.777	6.378	0.000	0.538	1.015
	Not looking when in hurry	0.483	2.923	0.003	0.159	0.808



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Locations Spots for Video recordings

	Road Axes	Observed Metric
Spot 1	Leof. Vasileos Konstantinou	Speeding, Illegal Crossing
Spot 2	Leof. Vasilissis Amalias	Speeding, Illegal Crossing, (Jaywalking)
Spot 3	Leof. Vasilissis Amalias (Syntagma)	Speeding, Illegal Crossing, (Jaywalking)
Spot 4	Leof. Vasilissis Sofias	Speeding, Illegal Crossing, Jaywalking
Spot 5	Leof. Vasilissis Sofias-Panepistimiou	Illegal Crossing, Jaywalking
Spot 6	Panepistimiou-Korai	Illegal Crossing, Jaywalking
Spot 7	Panepistimiou-Santaroza	Illegal Crossing, (Jaywalking, Speeding)
Spot 8	Panepistimiou-Plateia Omonoias	Illegal Crossing, Jaywalking

The video recordings were conducted:

- in **8 locations**
- for **1-hour peak time**
- for **1-hour off-peak time**
- for **2 working days of a week (Tuesday and Thursday)**
- for **2 weeks of a month**

In total **64 hours of video** were collected, 8 hours for each location.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Video data

Spot 3: Leof. Vasilissis Amalias -> Speeding, Illegal Crossing, (Jaywalking)

Spot 5: Leof. Vasilissis Sofias-Panepistimiou -> Illegal Crossing, Jaywalking

Spot 1: Leof. Vasileos Konstantinou -> Speeding, Illegal Crossing

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

Tracking Logic (1)

The system uses a **multi-step tracking logic** that includes:

1. Object detection and YOLOv8 detector

- a neural network-based object detection framework, detecting objects **including pedestrians and vehicles**,
- in each frame of the video, **outputting bounding boxes** and confidence scores for each detected object.

2. Kalman filter-based prediction

- A recursive predictive algorithm that **estimates the position and velocity of objects** based on noisy observations.
- Kalman filter tracks continuous movement, objects can become occluded or temporarily disappear from the scene (e.g., a pedestrian walks behind a vehicle).

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Tracking Logic (2)

3. Hungarian Algorithm

Detected objects are **matched with tracked ones**, which is crucial for maintaining consistent identities.

4. Apply Savitzky-Golay Filter for Unmatched Objects

Is applied to **smooth the trajectory of tracked pedestrians** and vehicles that have temporarily gone unmatched

5. Re-identification

When they reappear, the Re-ID network helps **associate them with the correct history** by comparing their visual appearance (ResNet-50 features) and the Re-ID feature vectors.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Homography and Ground Plane Projection

- Project points from the **2D image space** (the video frames) **into a real-world 2D plane** (the ground plane).

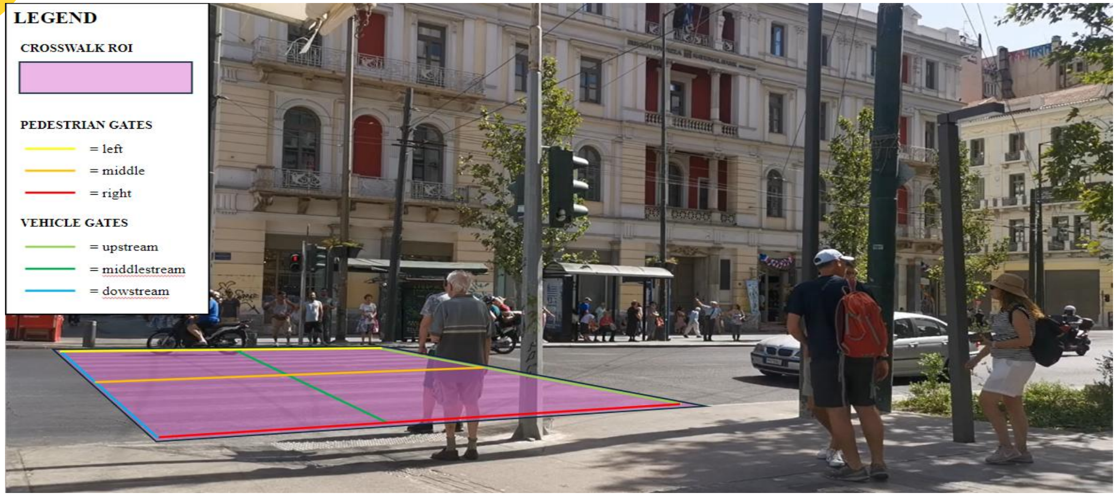
- This projection is necessary for **accurately determining whether pedestrians or vehicles** are inside certain regions, like crosswalks, which are defined in real-world coordinates.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

ROI and Traffic Light Detection

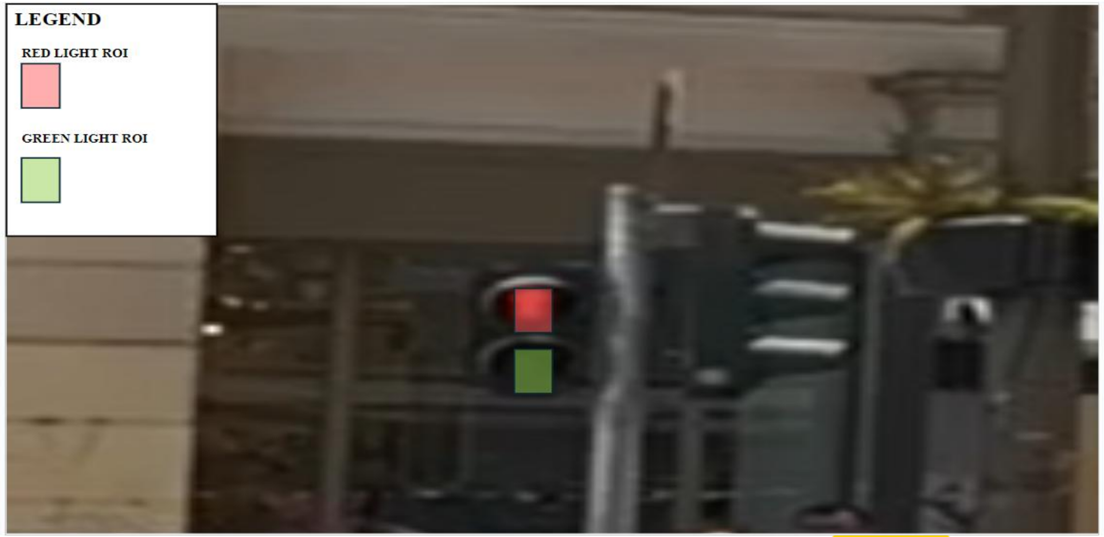


Projected Object Behavior Analysis

- The algorithm checks their positions relative to Regions of Interest (ROI), which define critical areas such as crosswalks or traffic light positions.
- If a **pedestrian** is found inside the crosswalk during a pedestrian red traffic light, their behavior is **flagged as illegal**.
- Similarly, vehicles entering the crossing area during a pedestrian green traffic light are flagged as illegal.

Traffic Light Detection

- The traffic light detection component isolates the regions corresponding to the traffic lights using Regions of Interest (ROIs) and **applies color segmentation** to determine whether the light is red or green.

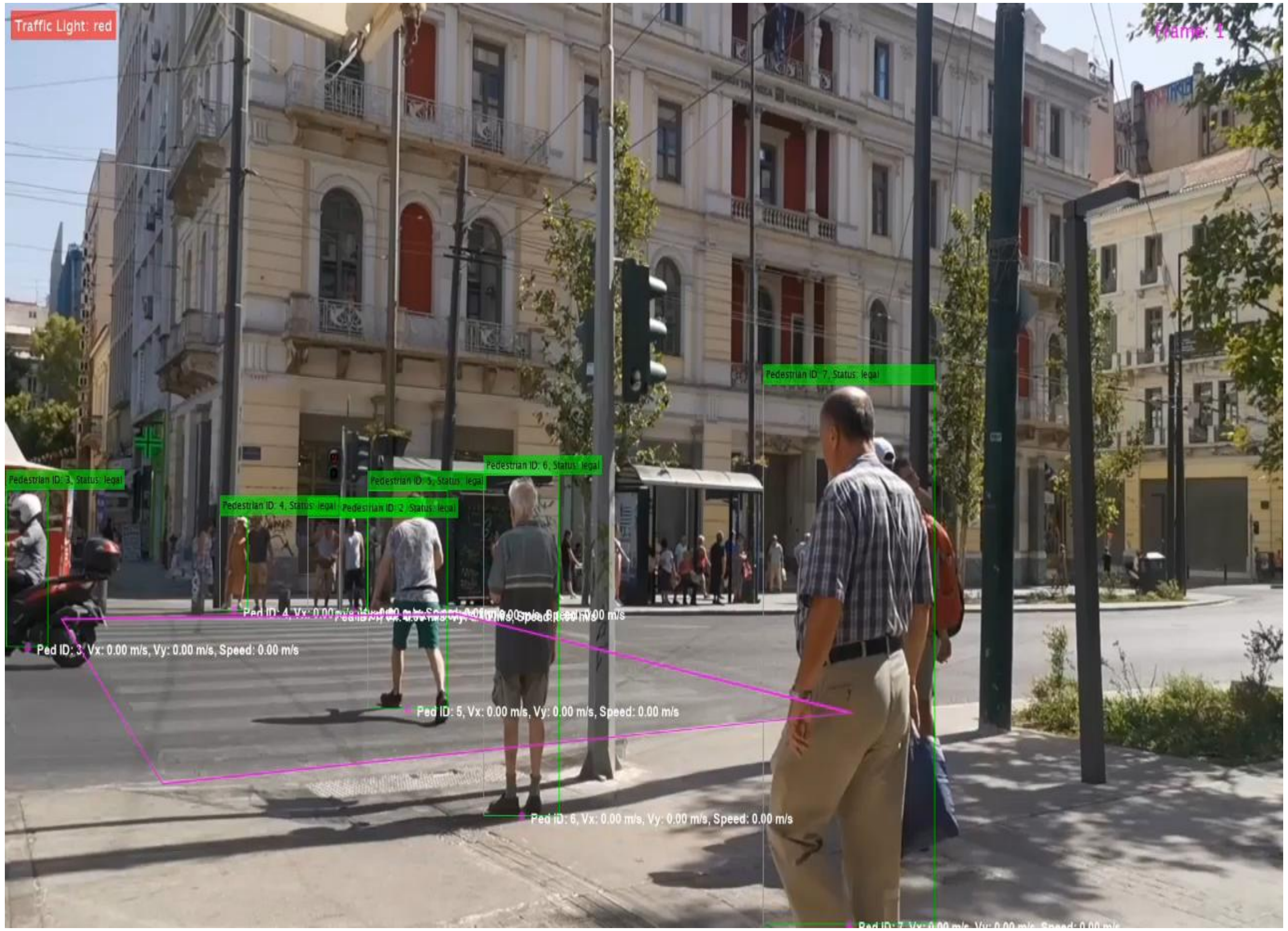


This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

Results (1) –
Legal and Illegal Behavior Detection



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Results (2) – Static Map

A satellite map image is used as the underlying reference frame to provide a real-world spatial context.

1. Satellite Image as a Base:

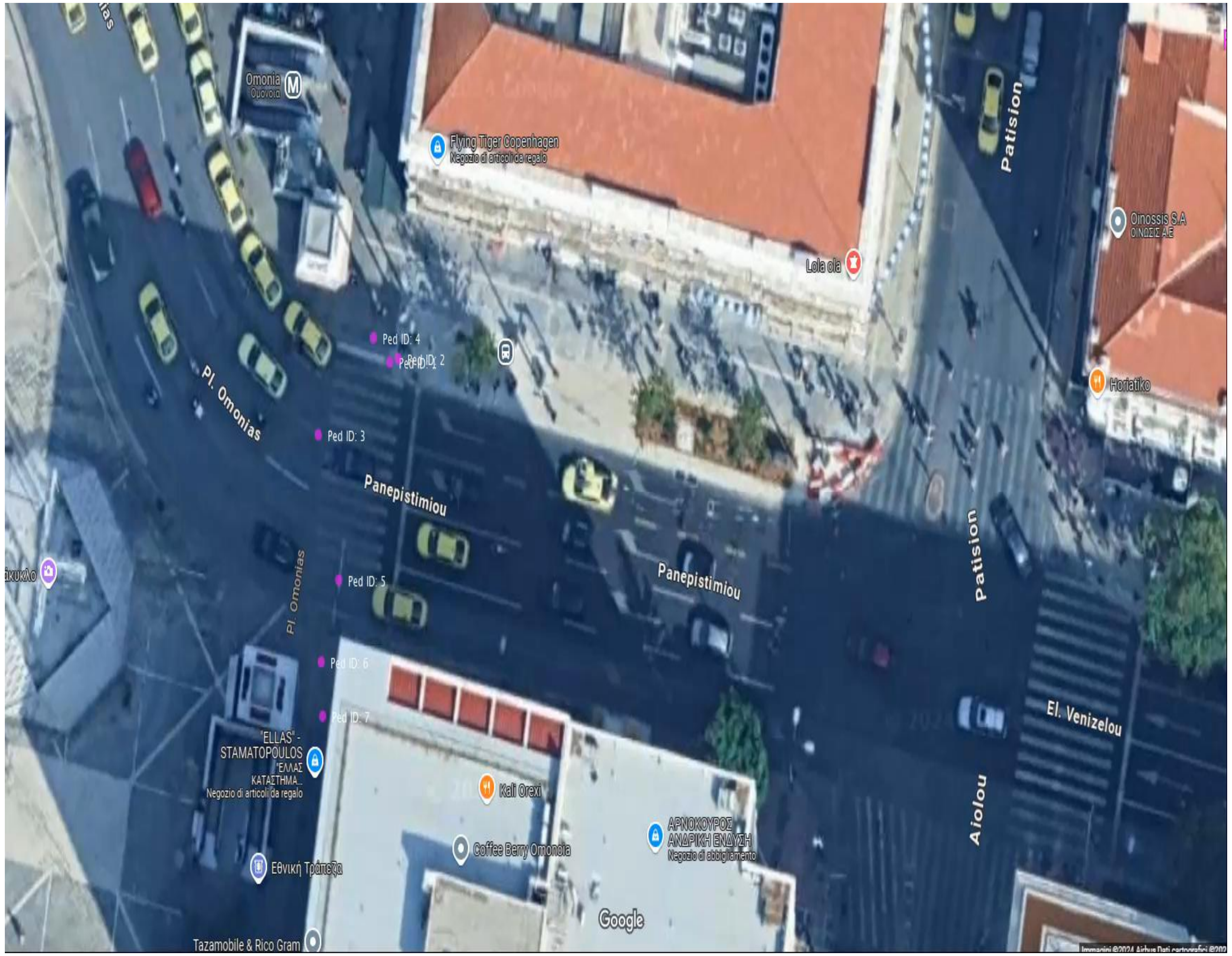
- The ground video utilizes a static Google Maps image of the observed area, offering an overhead view.
- This map serves as the real-world reference for visualizing object movements.

2. Position Projection via Homography:

- The real-time positions of pedestrians and vehicles, detected from the on-street video, are projected onto the Google Maps image using homography transformation.
- This allows objects detected in the video frames to be accurately placed on the ground plane of the map, reflecting their actual locations in the real-world coordinates.

3. Dynamic Object Overlay:

- As pedestrians and vehicles are tracked in the street video, their positions are updated and shown as moving points or icons on the static Google Maps image.
- This provides an overhead view of the area, illustrating the paths of the objects over time.



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

Speed, TTC & PET Calculation

Speed

- Speed is calculated by measuring the displacement of the object over time. For each tracked pedestrian or vehicle, the **algorithm estimates their velocity based on their change in position** (world coordinates) across frames.
- To ensure realistic speeds, the algorithm imposes a maximum plausible speed: **10 m/s for pedestrians and 40 m/s for vehicles**.
- Speeds exceeding these thresholds are discarded to avoid inaccuracies caused by noise or sudden false detections.
- The algorithm uses Median Absolute Deviation (MAD) to remove outliers in the speed calculations.

Time to Collision (TTC) & Post Encroachment Time (PET)

- For each pair of tracked pedestrians and vehicles, the algorithm computes the relative position and velocity vectors. The relative velocity between a pedestrian and a vehicle is calculated as the difference between their velocity vectors.
- If the pedestrian and vehicle are moving toward each other, the **TTC/PET is positive, indicating a potential collision**. If they are **moving apart, the TTC/PET is infinite**.
- It calculates and stores the TTC/PET for every pedestrian vehicle pair and highlights the pair with the minimum TTC/PET for each frame. This value determines which pairs are at the highest risk of collision and can be used for safety warnings or interventions.

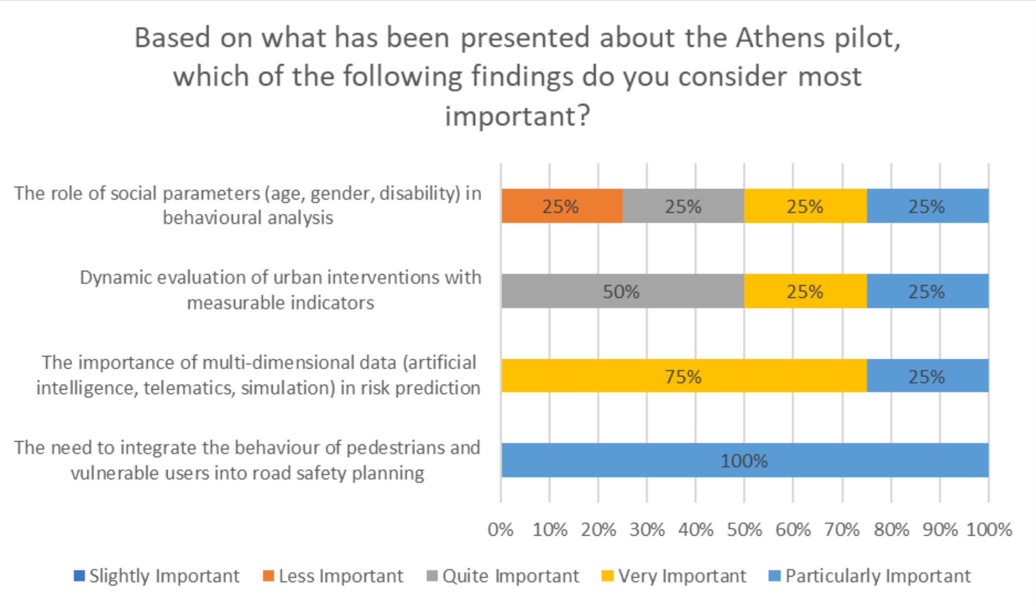
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

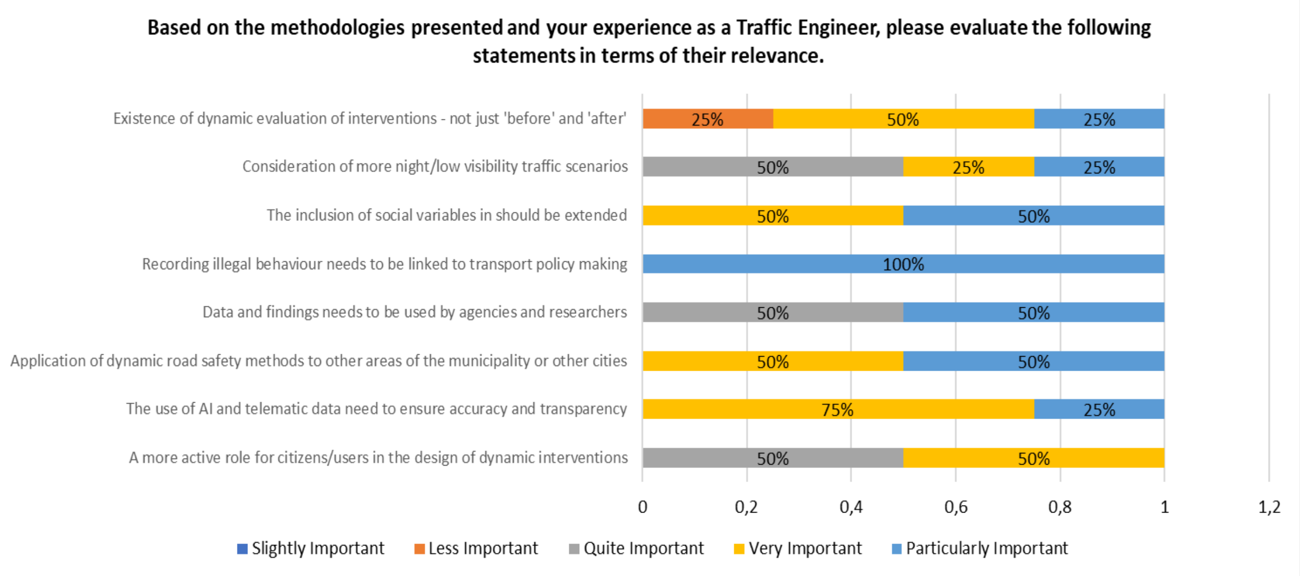
UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE

Involvement of Local Stakeholders

- The City of Athens participated and engaged through the organization responsible for all infrastructure interventions, **Athens Anaplasis**.
- The Athens stakeholders provided insights **on the implementation process** of the designed interventions, and regarding the measurements of their impacts.
- They incorporate the project outcomes as part of the **strategic planning for the City of Athens** and exploit the quantitative outcomes to reach informed decisions in order to prioritize future interventions.





This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE-PROJECT.EU

THANK YOU!

Research Associate, PhD Candidate

Stella Roussou

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)

PHOEBE Project

Athens Use Case

Stella Roussou
Research Associate, PhD Candidate

Together with:
Apostolos Ziakopoulos, Maria Oikonomou, George Yannis

Department of Transportation Planning and Engineering,
National Technical University of Athens

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101076963

UK participants in Horizon Europe Project PHOEBE are supported by UKRI grant numbers 10038897 (The International Road Assessment Programme – iRAP) and 10056912 (The Floow)