24/03/2021
ERCI Railway Webinar

The HARMONY Model Suite

Dr. Manos Chaniotakis,
Lecturer, Deputy Director of MaaSLab, UCL
Deputy co-ordinator of the HARMONY project

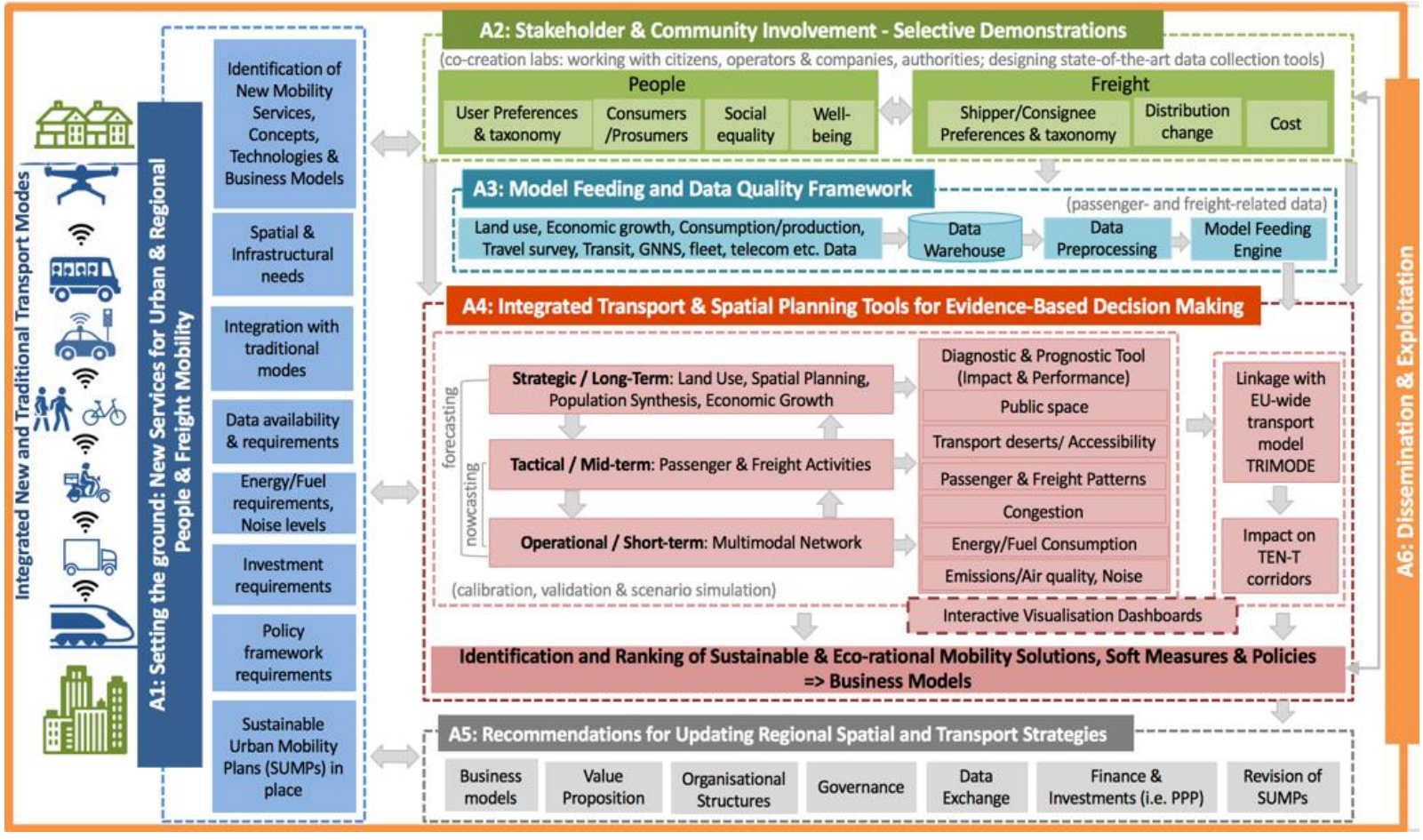
MaaS Lab | UCL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815269

HARMONY's Vision

Develop **a new generation of harmonised spatial and multimodal transport planning tools** which comprehensively **model the dynamics of the changing transport sector and spatial organisation**, enabling **metropolitan area authorities** to lead the transition to a low carbon new mobility era in a sustainable manner.

HARMONY conceptual architecture



Main outcomes

- **The HARMONY Model Suite (software)**
- Training material and activities for using the HARMONY MS
- Recommendations for SUMPs update (AVs & drones included)

HARMONY consortium

21 partners from 9 European countries

www.harmony-h2020.eu

Harmony-H2020

Harmony_H2020

HARMONY

HARMONY MS

The HARMONY Model Suite (MS)

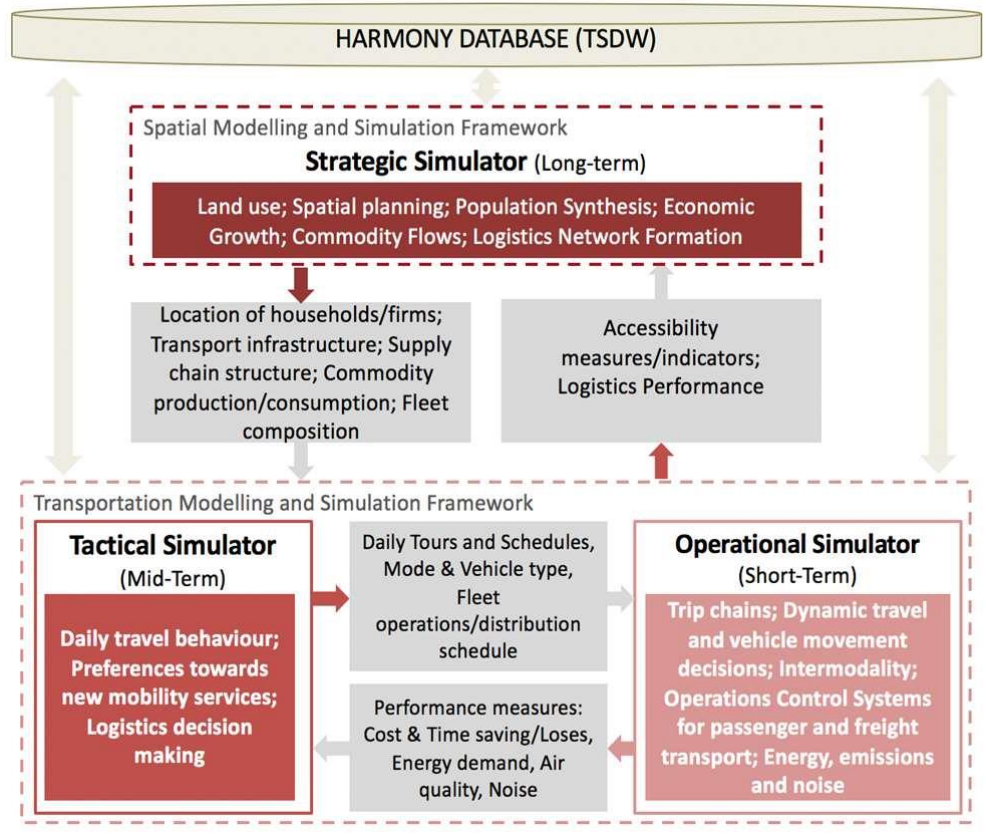
Multi-scale, software-agnostic, integrated activity-based model system.

Integration of new and existing sub-models, including:

- land-use models (strategic/long-term),
- people and freight activity-based models (tactical/mid-term), and
- multimodal network models (operational/short-term).

Enables end-users to couple/link independent models and analyse a portfolio of regional and urban interventions for both passenger and freight mobility:

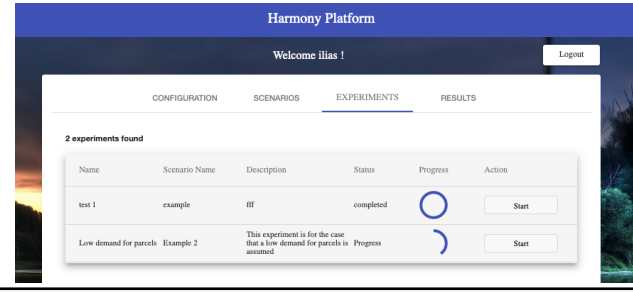
- policies and capital investments,
- land-use configurations,
- economic and sociodemographic assumptions,
- travel demand management strategies
- new mobility service concepts.



Overall architecture

Web-based interface

User can choose which transport interventions to compare on a concrete setting (supply, demand)

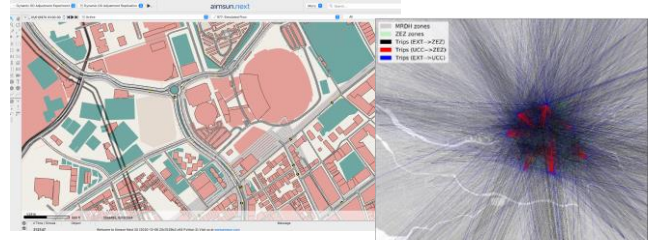


Platform core

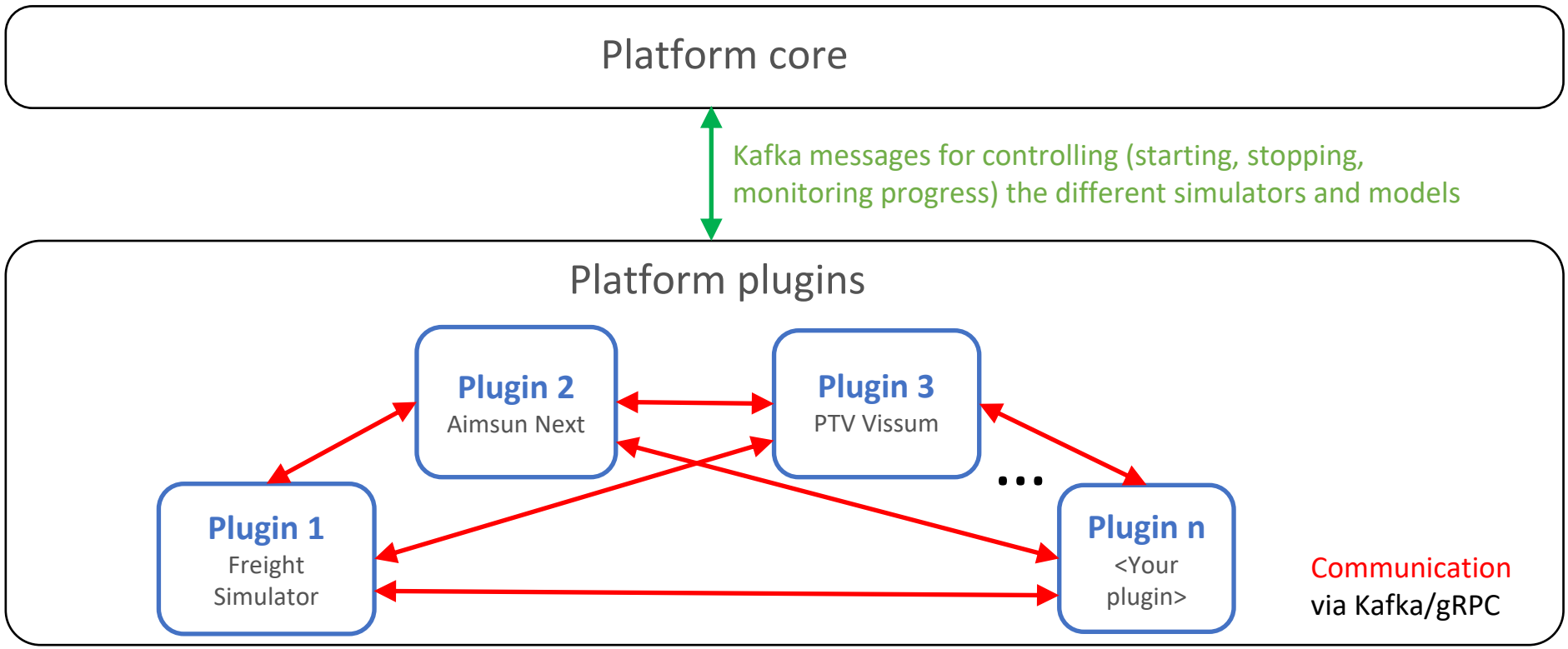
Upon a user's request, runs a specific workflow that consists of one or more simulators/models

Platform plugins

Simulators and models that can be plugged in to the platform and used in workflows



Communication between core and plugins



Each plugin:

- needs to be able to communicate with the platform core via a number of messages
- can be written in **any programming language**/environment
- can be and be **open** or **closed source**

Innovation

Flexible integration of new simulators and models	Users can leverage already integrated simulators, plug in their models + extend the capabilities of the platform
Management of data, algorithms, and tools for policy making	Users can use a single platform for running their experiments, compare results and store analysis data for further analysis
Efficient, reproducible experiments and what-if analyses	Users can browse though the results of similar experiments in other cities, reproduce results, and perform several what-if analyses

HARMONY MS: STRATEGIC SIMULATOR

The strategic simulator architecture

The Strategic Simulator is the most upstream component of HARMONY Model Suite, the one with the highest level of abstraction and the longest time-frame.

Strategic simulator subcomponents

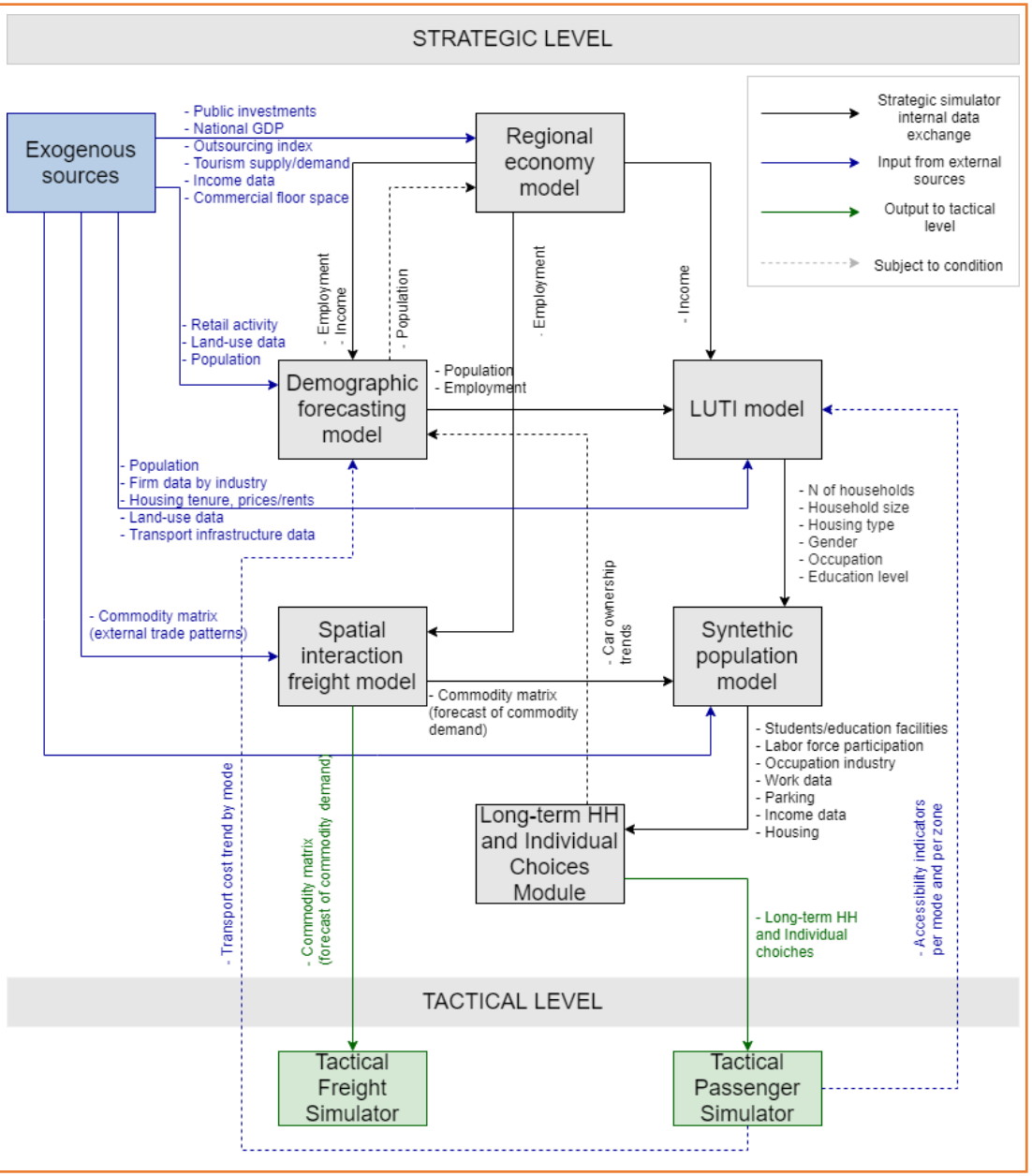
- Regional Economy model
- Demographic Forecasting model
- Land-Use Transport-Interaction model
- Spatial Freight interaction model
- Firm Synthesis model
- Synthetic population model
- Long-term Mobility Choice models

Strategic simulator outputs

- Horizon of multiple years
- Main outcomes are:
  - aggregated and disaggregated spatially-referenced household and firm populations,
  - the demand and supply of retail, work, educational and health activities, aggregate commodity flows between employment sectors.

Strategic simulator components and data flow

The strategic simulator is composed by six sub-models. They receive input data from both exogenous sources and other sub-models. The outputs of the strategic simulator feed HARMONY Model Suite's Tactical level.



Data

Given the different nature of the various components of HARMONY's Strategic Simulator, a series of different input parameters are required for the functioning and the calibration of the models.

Economic data

Public investments, national GDPs, outsourcing index, tourism supply and demand.

Network data

Transportation networks, OD matrices, travel times, public transport time tables.

Population and employment data

Population distribution, employment distribution, income data.

Land use and activity data

Land uses, retail activity, commercial floor space, commodity matrices (external trade patterns).

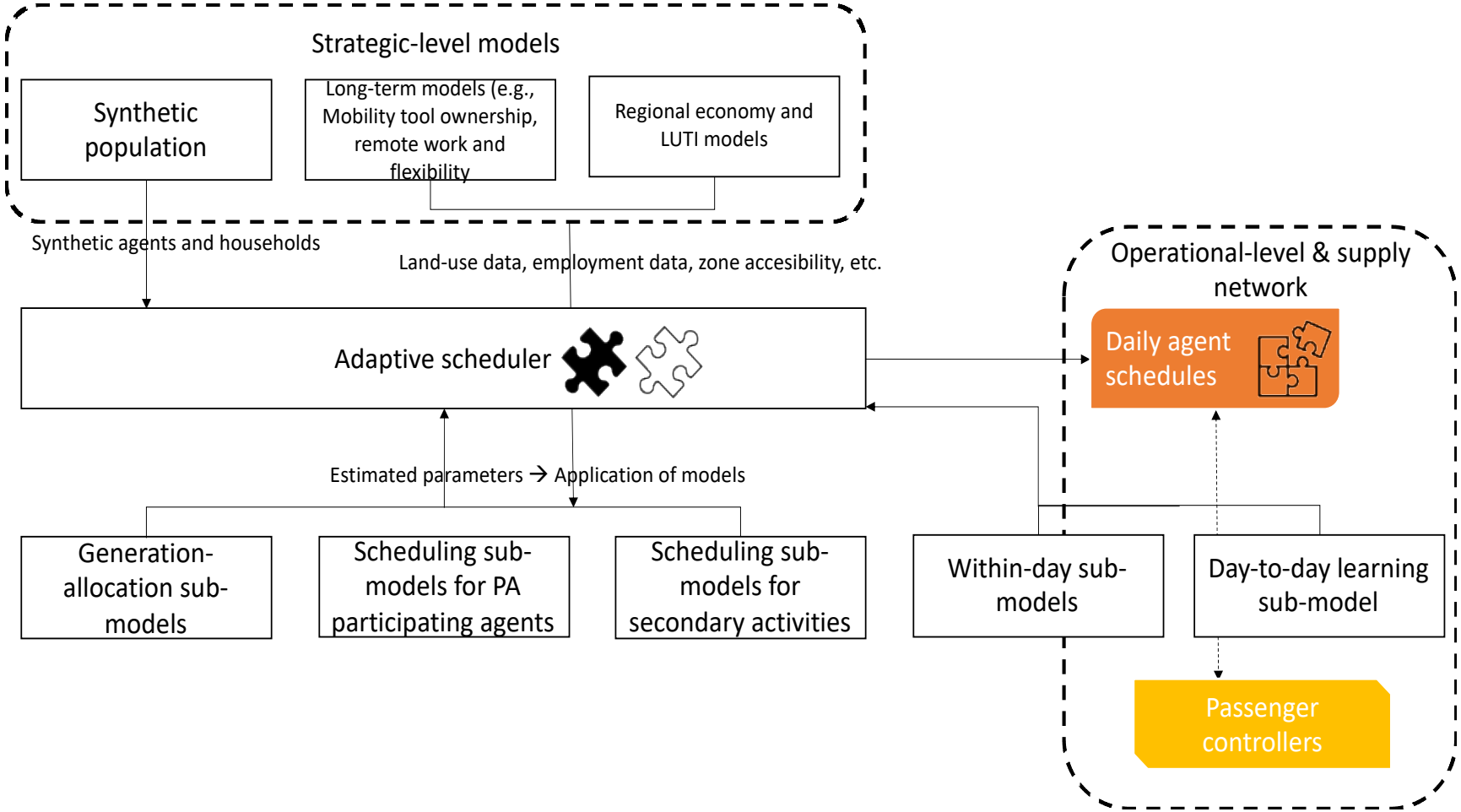
Scenarios

HARMONY's strategic simulator model will be applied to four case studies, each involving different scenarios:

Oxfordshire	Turin	Athens	Rotterdam
• New housing development scenario	• New public transport infrastructures • Land use development • Remote working	• Land use development • Remote working	• Logistic sector future trends and developments

HARMONY MS: TACTICAL PASSENGER SIMULATOR

HARMONY Tactical Passenger Simulator (TPS) architectural overview



Scenarios and KPIs

The HARMONY TPS can be utilized to evaluate and assess different scenarios and KPIs

Example of KPIs and scenarios to be evaluated

1. Impact of presence of new mobility services such as AVs in the transport system
2. Effect of long-term choice or disruptive events (such as rise of remote work in the pandemic era)
3. Effect of policy interventions (such as a zero-emission zone) in the transport system
4. Intra-household dynamics impact on daily travel and activity decisions in future scenario settings with variable population dynamics and trends
5. Effect of attitudes and perceptions in mode choice and activity participation (e.g., environmental consciousness effect on more sustainable mode choice)
6. Effect of dynamic information and network performance in within-day rescheduling and long-term passenger choices evolution

Data requirements for the Tactical Passenger Simulator

As the Tactical Passenger Simulator can be applied as a whole or in a modular setting, data requirements may vary. This slide covers the whole extent of required data

Activity diaries or activity and travel data from mobile sources

Detailed activity and travel diaries or schedules of a selected, representative sample of individuals in the study area

Accessibility indicators and zone attractions

1. Land-use and presence of attractors in zones (workplaces, schools, leisure, commercial, other attractors
2. Network and supply side data

Stated-preference experiments

SP experiments especially focusing on:

1. Long-term individual and household choices such as remote work and residential choice
2. Vehicle and mobility ownership
3. Willingness-to-use or willingness-to-adopt new forms of mobility such as AVs or MaaS
4. Mode choice experiments and within-day schedule re-evaluation

HARMONY MS: TACTICAL FREIGHT SIMULATOR

Scope and objective

Simulation of shipment-based logistic decision making behind urban freight transport demand.

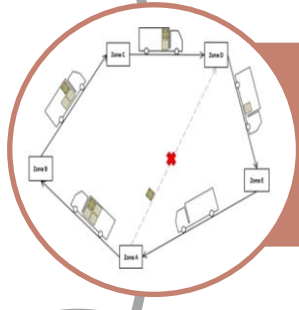
Shipment module: simulates long-term decisions such as Sourcing/Producer choice, Distribution channel choice or Shipment size & vehicle type (simultaneous).

Scheduling module: simulates daily decisions: Tour formation and Time-of-day choice.

Network module: Simulates route choice of each vehicle, and emission calculation.

Shipment & parcel demand

- Producer/supplier choice
- Shipment size & vehicle type



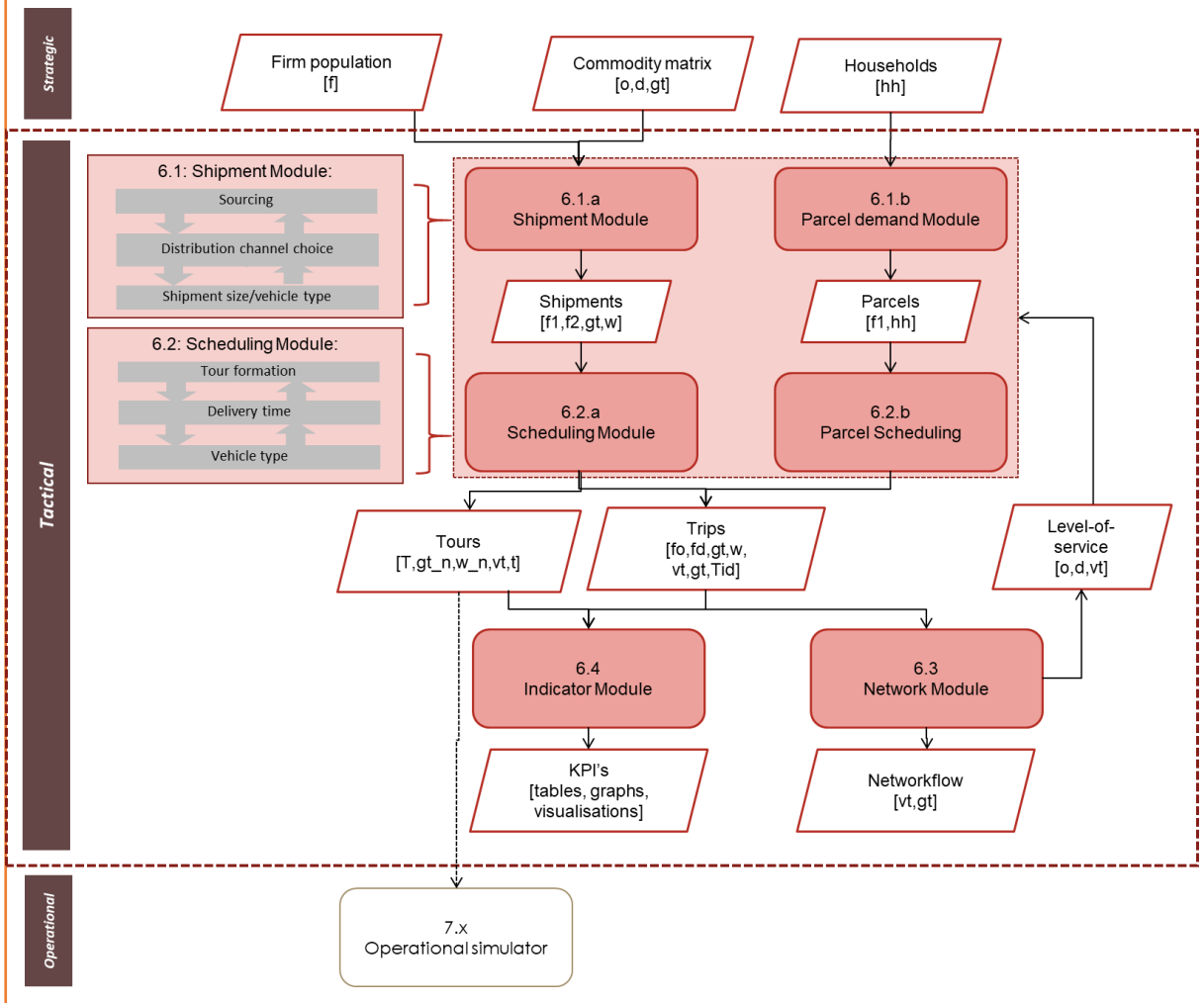
Scheduling

- Tourformation
- Time-of-delivery choice

Networkmodule

- Routechoice
- Emissions

Technical architecture



MASS-GT prototype v3

Shipment module: simulates long-term decisions:

- ❑ Sourcing/Producer choice
- ❑ Distribution channel choice
- ❑ Shipment size & vehicle type (simultaneous)

Scheduling module: simulates daily decisions:

- ❑ Tourformation
- ❑ Time-of-day

Two auxiliary modules:

- ❑ Network Module (skim & routechoice)
- ❑ Indicator Module

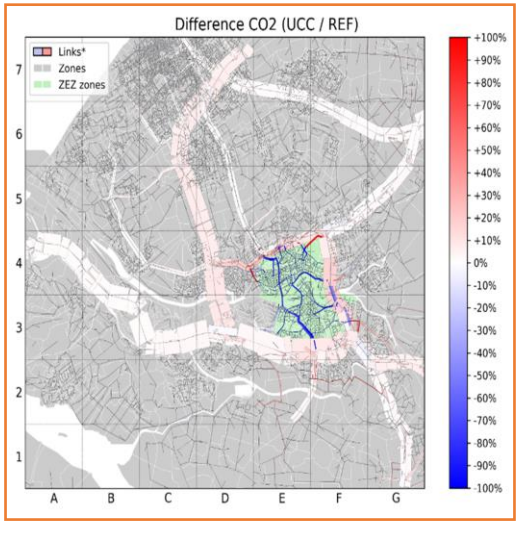
Use cases

The TFS is aimed at city logistic analysis in general. In HARMONY several relevant use cases are developed and tested during the project:

- ❑ Zero –emission zone
- ❑ Crowd-shipping
- ❑ Micro-hubs and cargo bikes
- ❑ Autonomous services

City logistic outlook

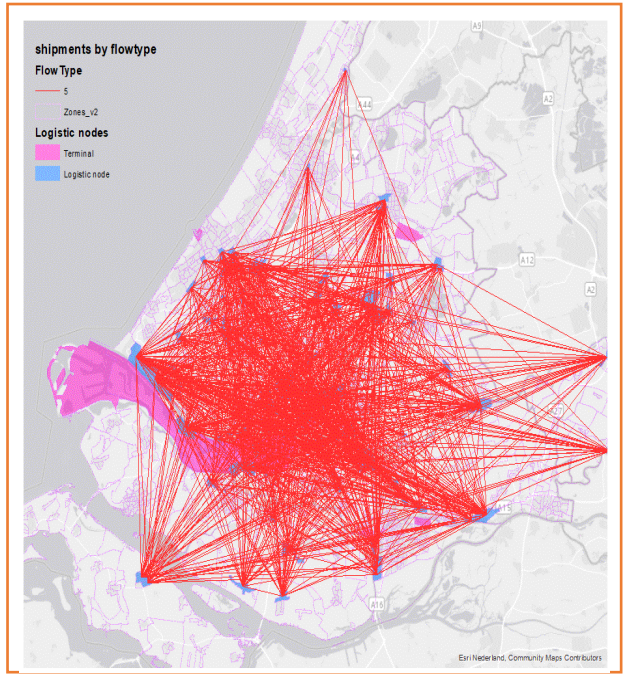
New logistic services



Impact assessment

Data requirements

The TFS has been designed in such a way that it uses generally available transport modelling data and statistics as primary inputs. Behavioural parameters can be calibrated, either validated, depending on local available data.



Summary of basis input data:

- ❑ Local transport model (networks, zones with socio economic data)
- ❑ Location of logistic nodes (distribution centers/transshipment terminals)
- ❑ Global firm statistics (size distribution)
- ❑ Aggregate commodity demand

Optional data:

- ❑ Detailed freight trip diaries
- ❑ Establishment surveys
- ❑ Truck counts

HARMONY MS: OPERATIONAL SIMULATOR

Operational simulator: main components

HARMONY's operational simulator is an integrated dynamic demand and supply simulator, operating on a short-term horizon (with-in day simulations). Its main purpose is the evaluation of the transport network's performance, under different loading conditions (demand) and variable infrastructure and mobility services configurations (supply).

Main components

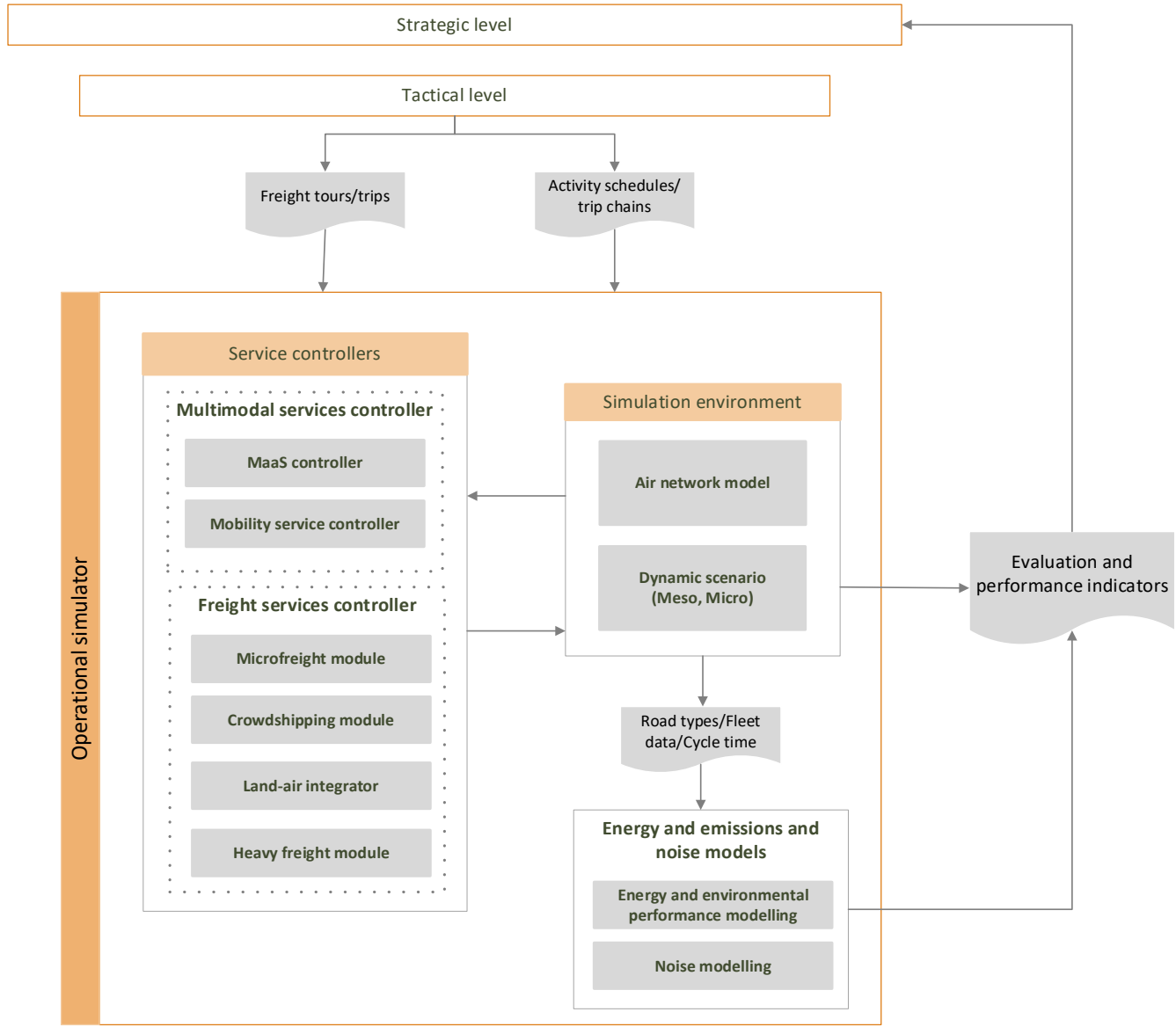
It will contain modules that will emulate the daily operations performed by mobility and logistics operators, as well as energy noise and emissions that will generate scenario performance data.

Multimodal services controller: Emulate daily operations of on-demand, shared services, AVs and Maas

Freight services controller: Emulate daily operations of city logistics, crowdshipping, and deliveries with drones

Energy and emissions model: Quantify the lifecycle energy and emissions impact from passenger and freight movements

Operational simulator - High level architecture



Operational simulator: inputs

In order to create a realistic simulation environment, the operational simulator requires the following inputs:

- Network geometry: Data describing various geometrical aspects of the area (e.g. road widths, shapes, slopes, number of lanes, intersections, air corridors, location of vertiports).
- Demand: Zoning system, demand data expressed in trips or tours, activity schedules for passengers.
- Traffic control: Data defining the operation of traffic signals and ramp meters.
- Transit operation: Data defining the operation of public transport (e.g. transit routes, stop locations, service schedule).
- Network traffic state and performance: Data defining the behaviour of road elements (e.g. volumes, speeds, travel times).
- Traffic monitoring data: Traffic flow, speed and occupancy data from road detectors.
- Fleet characteristic: Vehicle composition for public transport vehicles, freight and drones.

Operational simulator: Scenarios and KPIs

The operational simulator integrates the operation of innovative passenger and freight services, indicatively Autonomous Mobility on Demand, MaaS and crowdshipping. Results from modelling these services allow to evaluate the environmental and operational impacts on the modelled area. Table 1 outlines possible scenarios and their respective KPIs.

Scenarios	KPIs
Autonomous mobility on demand (Electric vehicles, demand responsive services)	• Energy and emissions performance • Network travel times • Kilometres travelled per vehicle type • Vehicle occupancy
Integration of new city logistics concepts (Automated delivery vans, e-cargo bikes, drones)	• Number of deliveries per unit time • Total cost of delivery • Energy and emissions performance
Crowdshipping for parcel delivery	• Kilometres travelled per vehicle type • Total cost of delivery • Energy and emissions performance

HARMONY MS Applications

Rotterdam
- HARMONY MS - Freight

Oxfordshire
- HARMONY MS - Passenger

Trailblazing

Athens
- HARMONY MS - Passenger

Turin
- HARMONY MS - Passenger

Aspiring

The HARMONY MS will be available to the market in mid-2023.

info@harmony-h2020.eu https://harmony-h2020.eu/

UCL Contact Details:
Maria Kamargianni: m.Kamargianni@ucl.ac.uk
Manos Chaniotakis: m.Chaniotakis@ucl.ac.uk

www.harmony-h2020.eu Harmony-H2020 Harmony_H2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815269