A National Multimodal Mobility Model for supporting decision-making in passenger transportation sector

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Il Centro Studi di Ferrovie dello Stato Italiane

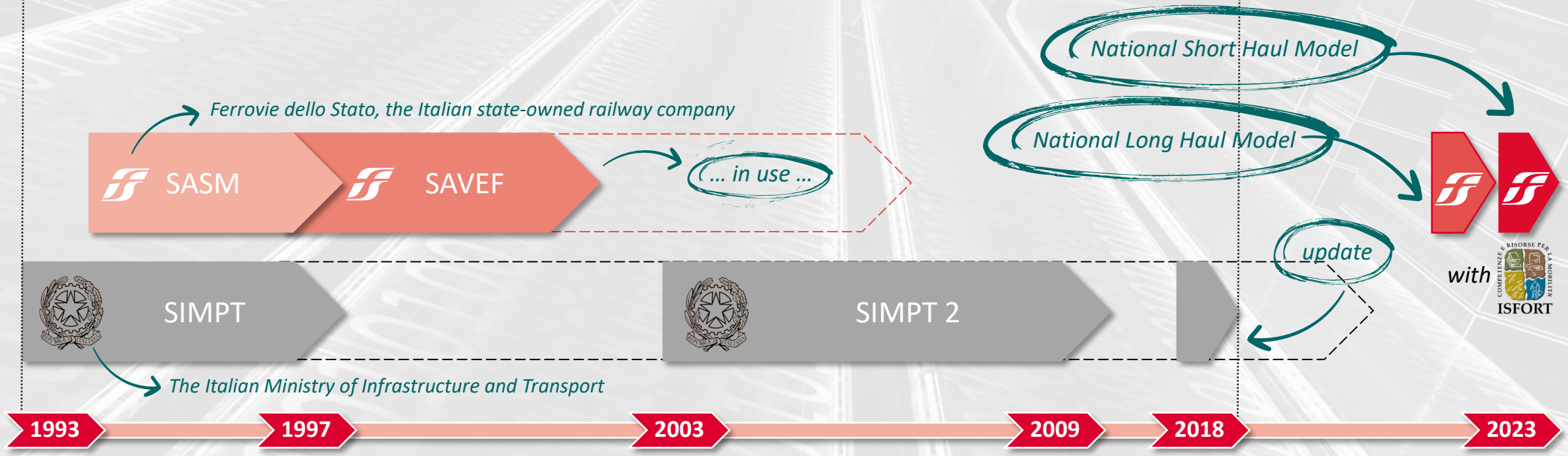
Introduction

- ✓ To overcome the limitations of stationary mobility models currently in use at the national scale, Ferrovie dello Stato Italiane has recently developed a multimodal short and long-distance passenger model aimed at assessing the economic, social, and environmental impacts of mobility in Italy.
- ✓ This presentation briefly illustrates the methodological structure of the model build with the support of ISFORT.

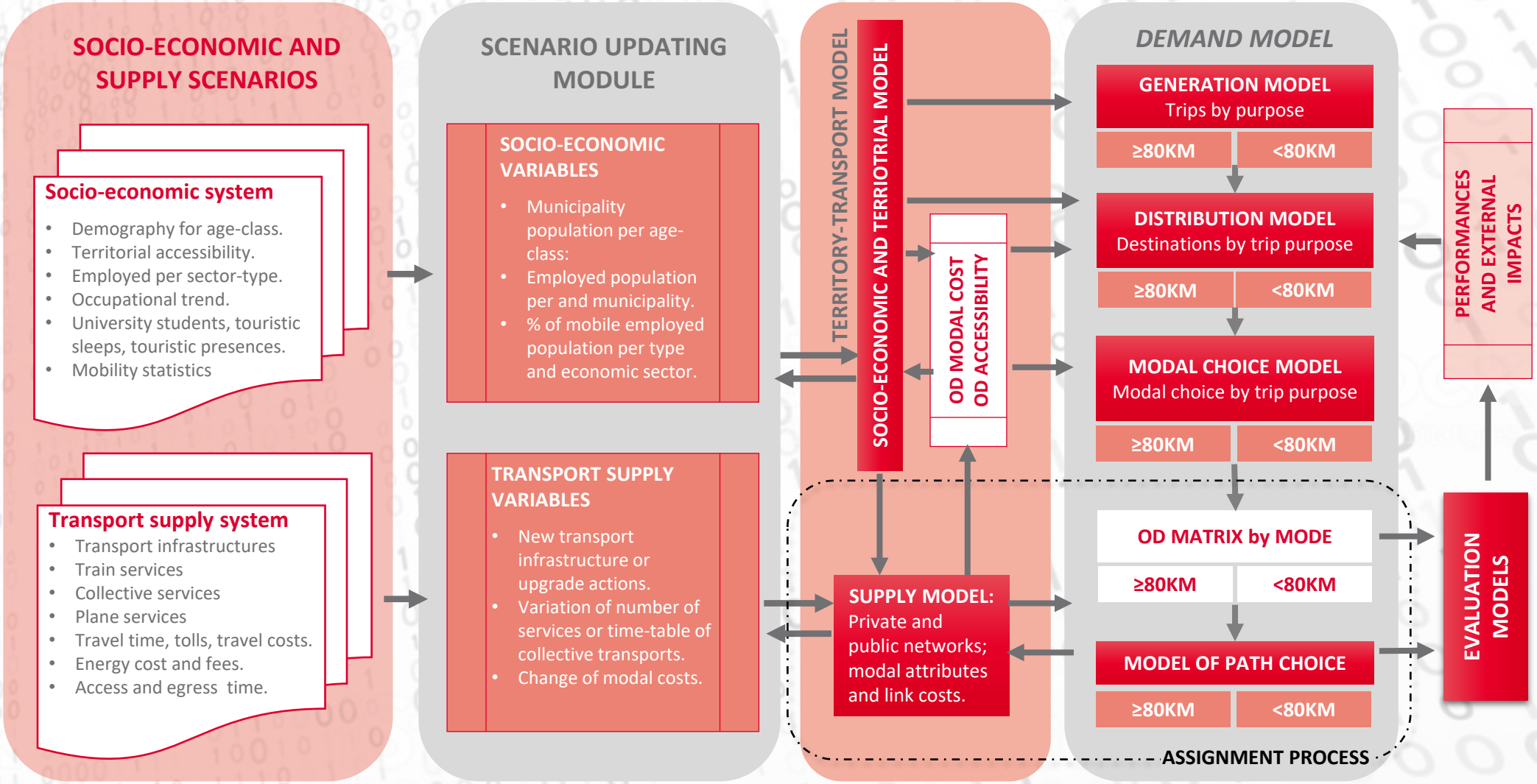
History of Italian institutional national models

Principal weak points:

- ✓ No ready-to-use data
- ✓ Need for big efforts for setting up scenarios
- ✓ Unclear demand partitioning by distance class



Structure of national passenger demand model



Socio-economic and territorial data

Demography

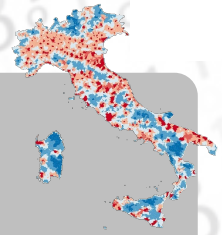
1

Population by age class from ISTAT (National Institute of Statistics)

Accessibility

2

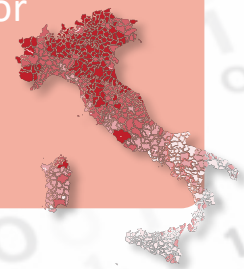
Internal areas classification (SNAI)



Workforce statistics

3

Workers by Nace Rev. 2 sector



Employment trends

4

Ministry of Finance, Bank of Italy, National Agency for Active Labour Policies (ANPAL), Audimob survey, PoliMI surveys

Education statistics

5

Ministry of Education: High-school and University students, School location and student mobility

Tourism statistics

6

Travels and Holidays, tourism accommodation (ISTAT); tourism data and expense (Bankitalia)

Mobility statistics

7

Audimob, Eurostat, Enac, ISTAT, Rail Ticketing, Road flow counts (ANAS)

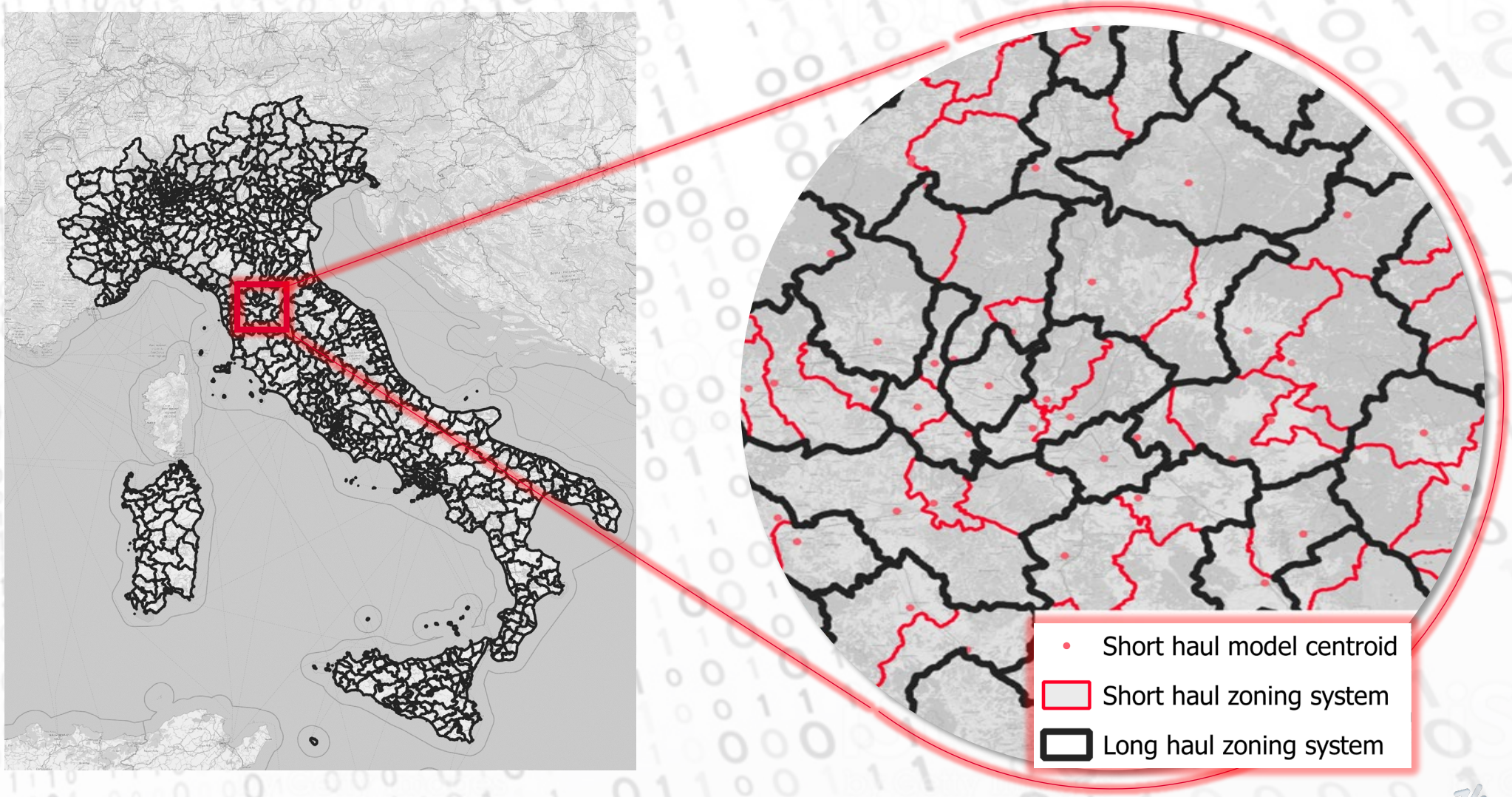
Big Data

8

vodafone

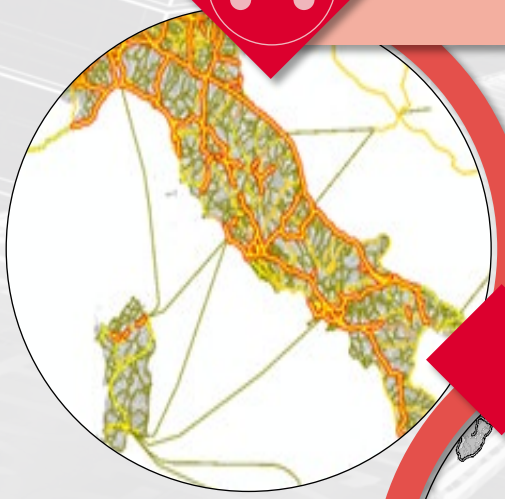
Mobile network data, plus floating car data

The zoning system

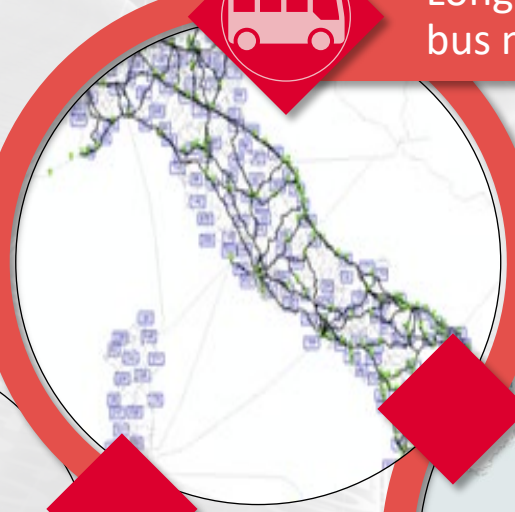


Transport supply system data

Road network



Long distance bus network



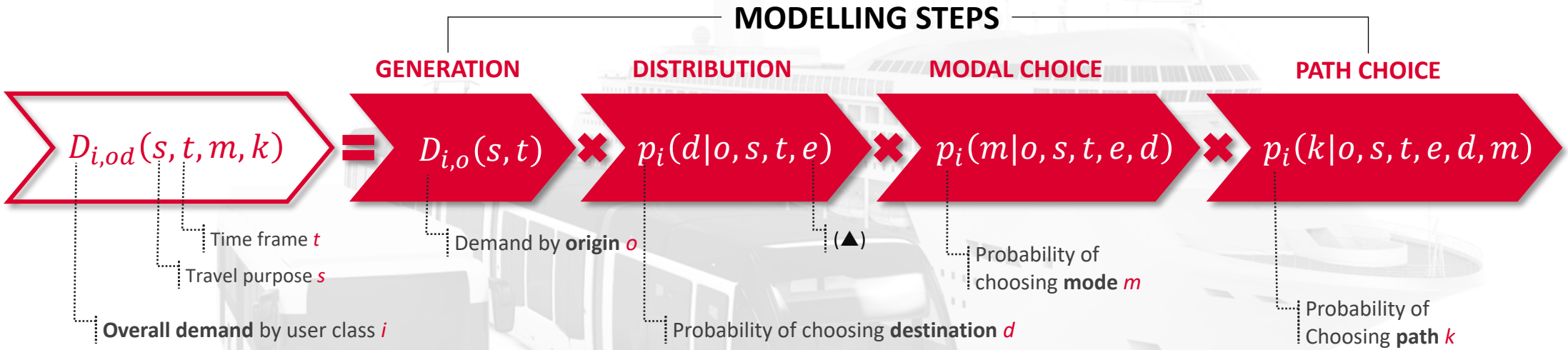
Short distance bus, Google API

Rail service graph (GTFS)

Eurostat air OD

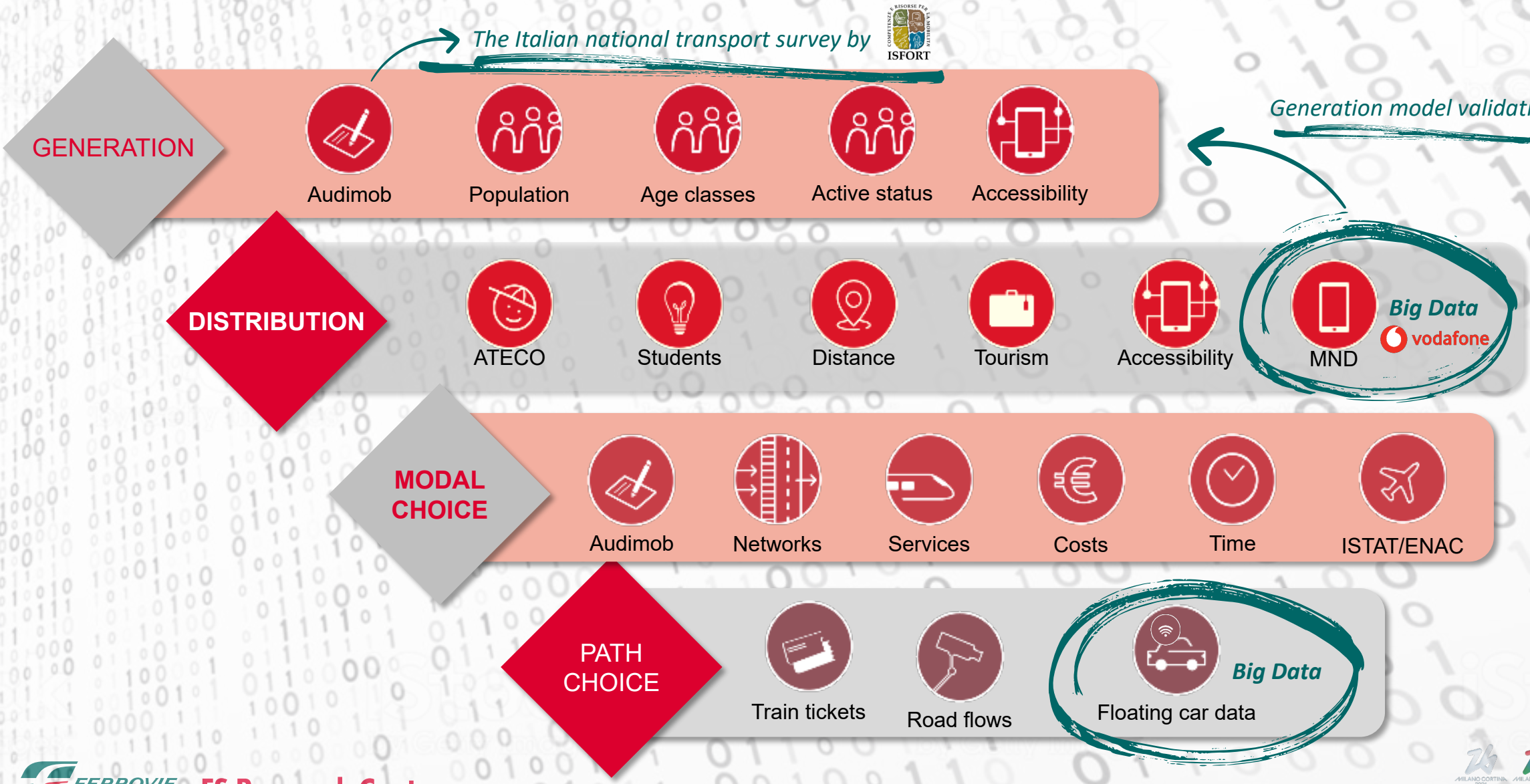
Modelling steps

- The model is **sequential** and **iterative**. The output results of each step are used for verification and validation activities, allowing to improve the formulation of the entire model with the aim of strengthening the methodological soundness of the whole process.
- The functional structure of the national passenger demand model is at **partial rates**, **disaggregated by homogeneous users and by purpose travel** with a trip-based approach. The model estimates passenger demand for an **average weekday** through the specification of four/five sub-models, of which the general formulation is as follows:



(▲) Only for short haul model (<80Km), there is an intermediate step between generation and distribution model aimed to estimate the vector of trips generated by individuals moving outside the area of residence.

Data sources according to modelling steps



Long haul model: insights

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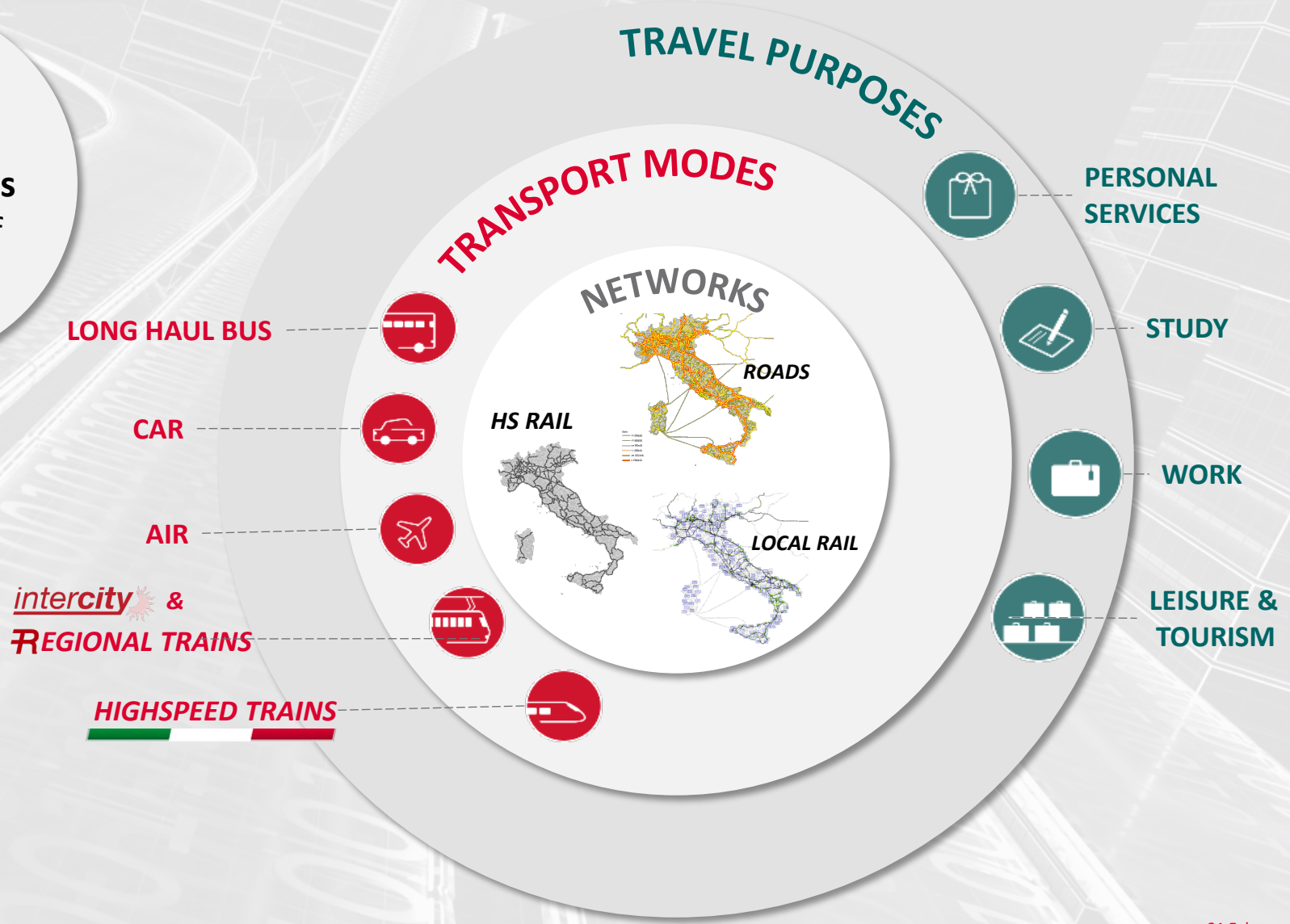
Long haul module dimensions

The model investigates many **purposes** and **modes** of transport

The model performs demand assignment on the **whole railway service network** and on a **road network** including all the Country's **principal** roads

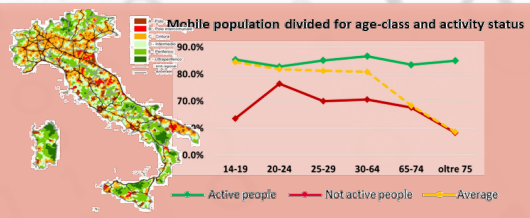


National Long Haul Passengers Model

Generation model

INPUT

- Accessibility class k (SNAI definition) of municipalities contained in zone O
- Segmentation of pop. for 6 age-class → $n^i[O]$
- Segmentation of population For socio-economic aspects → $p^{i\ active/not\_active}$
- Smart workers



MODEL

$$d_s[o_k] = \sum_i n^i[o_k] p^{i_{active}}[o_k] \cdot x_s^{i\_active\_k} + n^i[o_k] p^{i_{not\_active}}[o_k] \cdot x_s^{i\_not\_active\_k}$$

$$d[o_k] = \sum_s d_s[o_k]$$

Trip generation rate *x*

Calibration with Audimob interview data, trips>80km

OUTPUT

- **Total number of trips** within 80 km generated by the population per national traffic zone;
- Number of trips splitted by **reason s** generated by the entire resident population (commuting to work, study, etc.)
- Number of trips splitted by **age-class i** (active or not active population) per traffic zone
- Number of trips splitted by **reason s produced by age-class i** distinguished per active/not active population.

National Long Haul Passengers Model

Modules for updating exogenous input variables

1.Demographic variable forecast	Estimates the variations of the municipal population **by age groups** based on **ISTAT regional demographic forecasts**
2.Active/not active people forecast	Official estimates of percentage changes in **GDP** **Employment forecast (ANPAL)** per occupational type-sector (**ATECO),** projection at municipality level. Variation of students based on demographic projections and Agnelli Foundation university enrolment rates
3.Smart workers	Forecast of **Smart Working** percentage per occupational type-sector ATECO using: Observed phenomenon (MIT, Isfort,…) Official forecasts of smart workers by Bank of Italy, POLIMI

GENERATION MODEL

National Long Haul Passengers Model

Distribution model

INPUT

- Number of trips from generation model
- **Actrativeness features** for zones A_d; separation cost between zones C_{od}
- **Hierarchical classification** of zonal attraction capacities by trip reason (S,A,B,C,D)
- Matrix of time and territorial distances among zones

MODEL

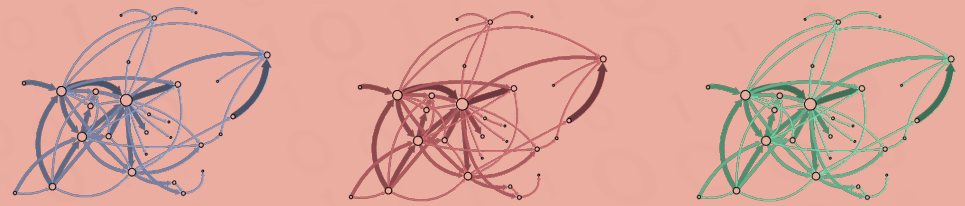
$$p[d/osh] = \frac{A_d^{\beta_1} \cdot C_{od}^{-\beta_2}}{\sum_d A_d^{\beta_1} \cdot C_{od}^{-\beta_2}}$$

β_1 and β_2 are defined for each reason and attraction class

Calibration with Mobile Network Data

OUTPUT

- National origin-destination matrix splitted by purpose s



National Long Haul Passengers Model

Actractiveness features of distribution model

STUDY

- number of students enrolled in university

WORK

- number of employees divided in ATECO categories

PERSONAL SERVICES

number of employees related to
- activities providing services to households and individuals such as manufacturing activities;
- wholesale and retail trade, repair of motor vehicles and motorcycles;
- professional, scientific and technical activities;
- health and social care;
- other service activities.

TOURISM

number of employees related to:
- accommodation and catering services;
- rental, travel agencies, business support services;
- artistic, sports, entertainment, and amusement activities.
- Beds of the accommodation establishments.

Actrativeness features for zones A_d

Classification of zonal attraction capacities (S,A,B,C,D) by trip reason

National long haul passenger modal choice model

THE MODEL

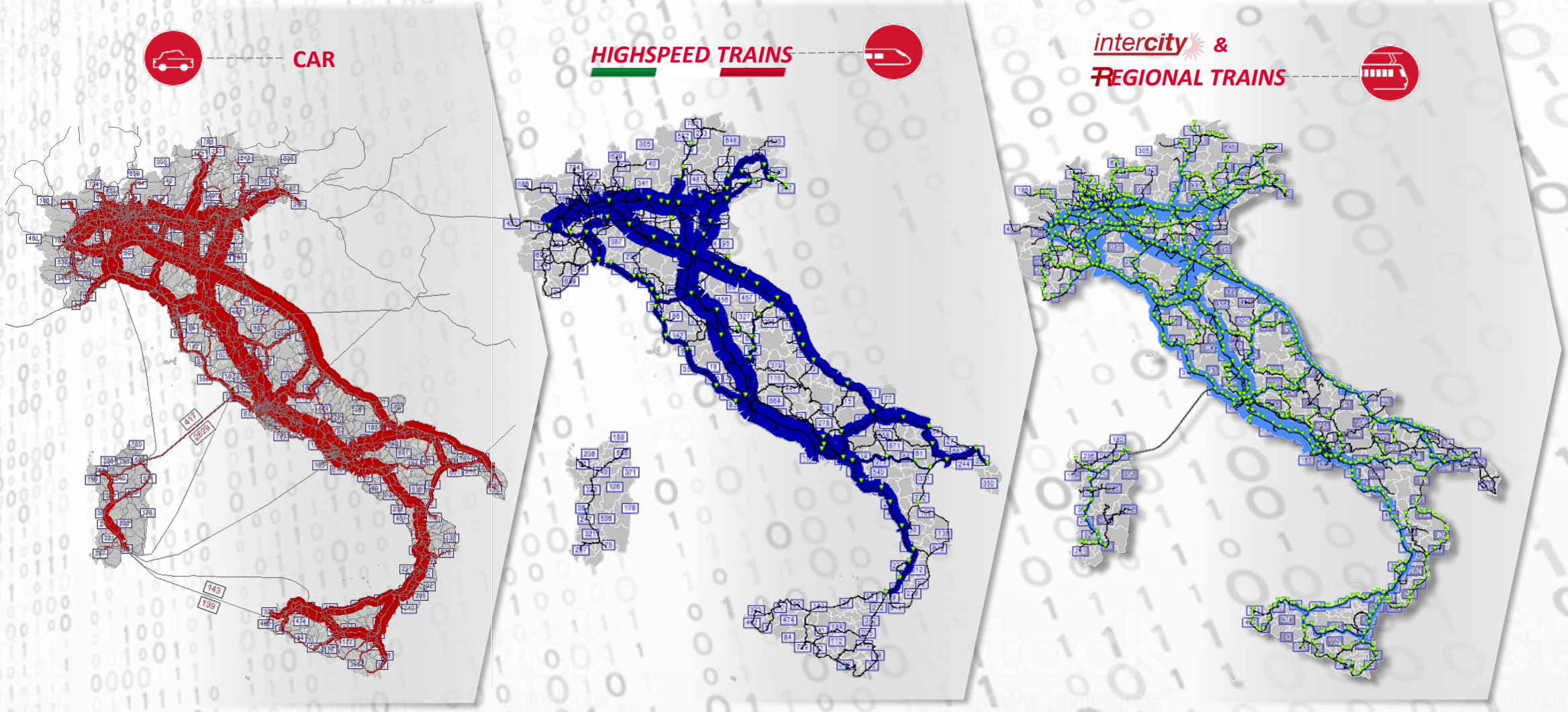
Utility of mode *m*

$$p[m/ods] = \frac{\exp(V_{m/ods})}{\sum_{m'} \exp(V_{m'/ods})}$$

Probability of choosing **mode** *m* for each given origin *o*, destination *d*, and purpose *s*

MODE	ATTRIBUTES
CAR	• travel time, including access and egress times within the zone; • *cross-zonal average cost, estimated on the basis of average consumption of private vehicles and motorway tolls.*
HIGHSPEED TRAINS	• On board time (GTFS) + access/exit time HS station + waiting time • Tariff cost+ access/exit cost • Frequency of HSR services
intercity & REGIONAL TRAINS	• On board time (GTFS) + access/exit time HS station + waiting time • Tariff cost + access/exit cost • Frequency of HSR services
LONG HAUL BUS	• Travel time by scheduled services + access/exit time • Average cost by consulting the website of the main operators
AIR	• Flight time + access/exit time + time spent in the airport • Tariff cost of flight + cost of access/exit to the airport

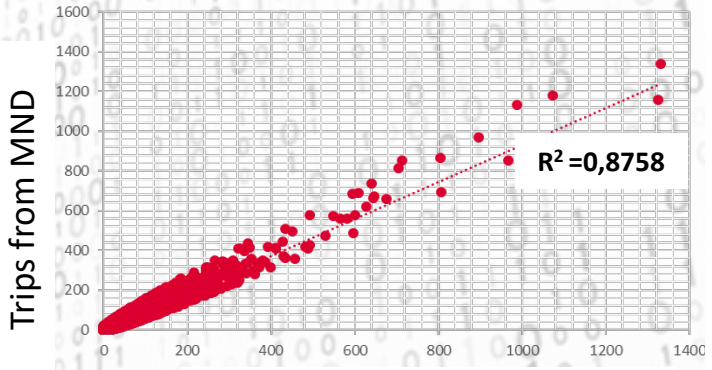
National Long-Haul flows

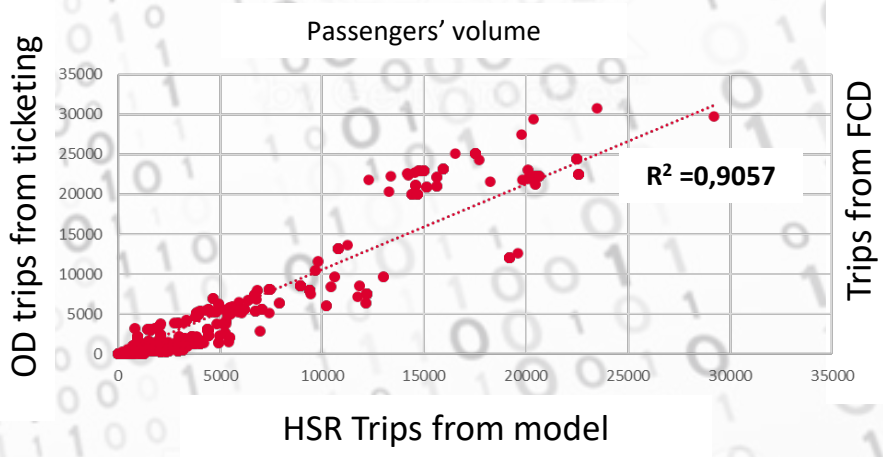


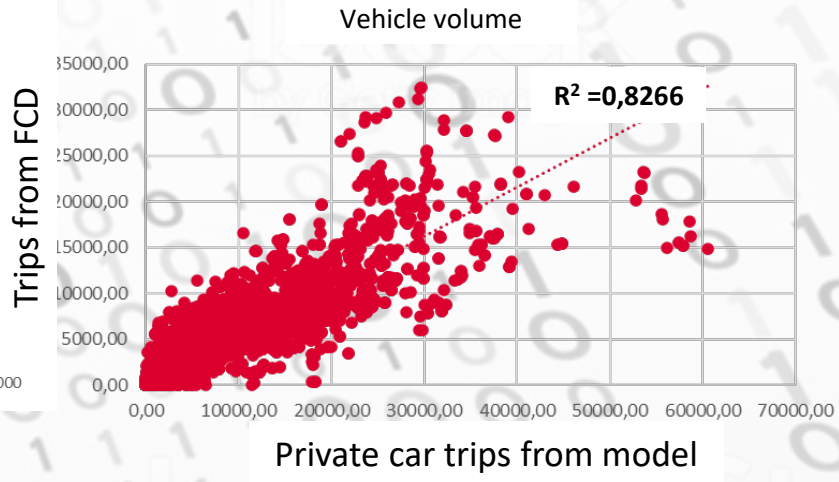
National long haul passengers model validation

The national Long-Haul Model showed a high ability to reproduce the mobility phenomena in the current scenario without the need to use origin-destination matrices correction procedures.

Generation/Distribution	Public assignment	Private assignment
OD Mobile Network Data vodafone	Passenger comparison: High Speed Rail trains('Frecce') ticketing	Road flows comparison: Floating Car Data OD matrix







Legend: Model | Observed data

Short haul model: insight

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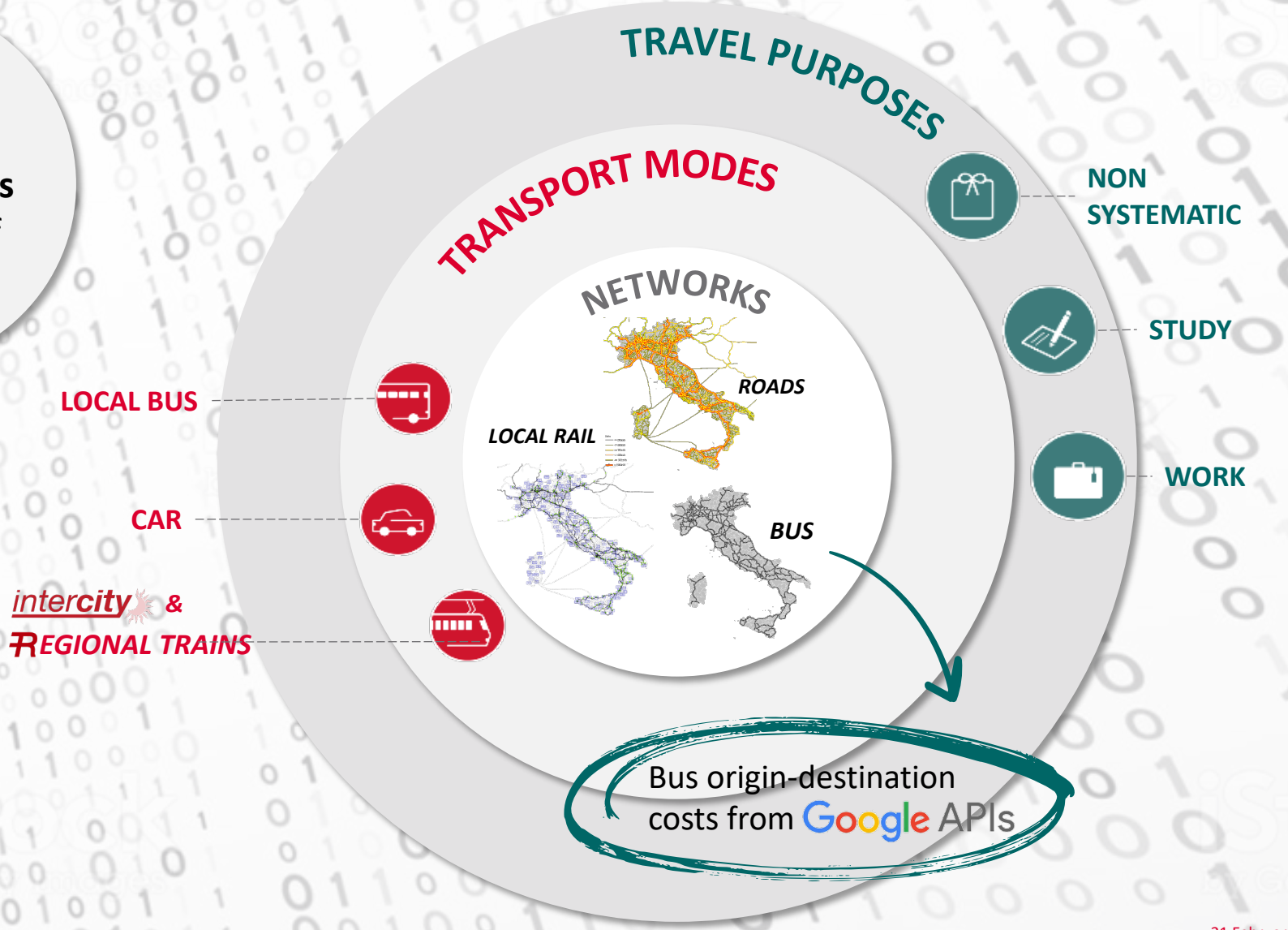
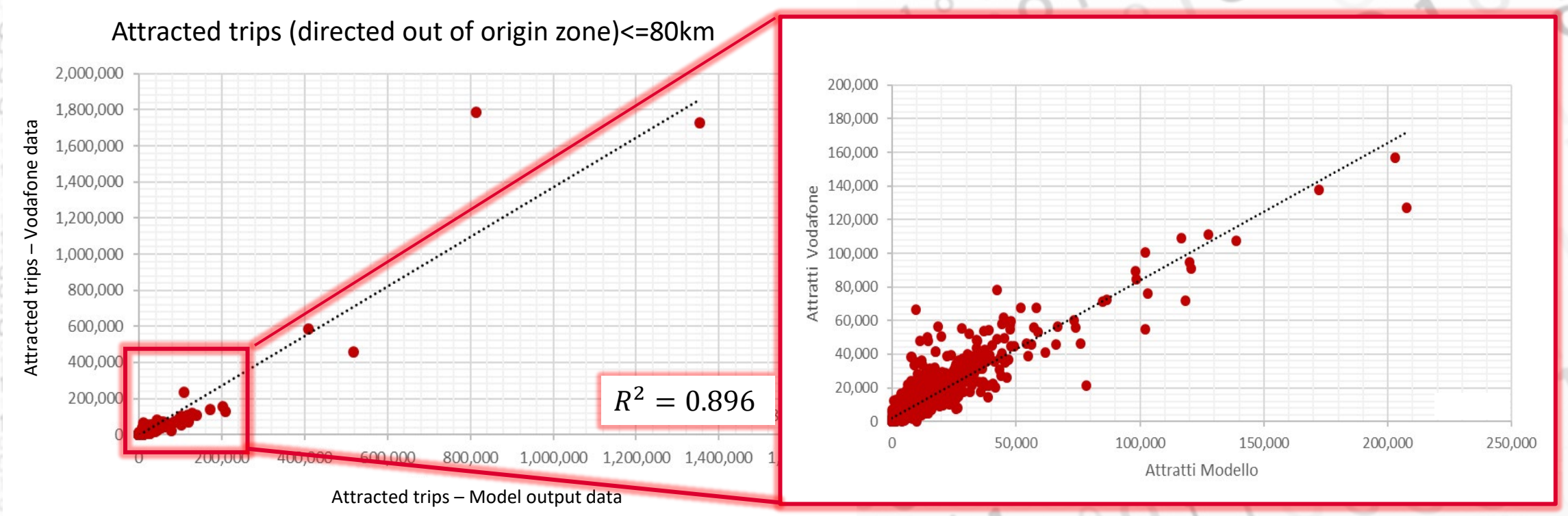


National Short Haul Model: distribution model

Model validation by comparison with Mobile Network Data (MND)

Comparison of total OD trips generated with Vodafone overall mobile phone data, trip distance less than 80 km, without come back trips.



Blending Long and Short Haul Models

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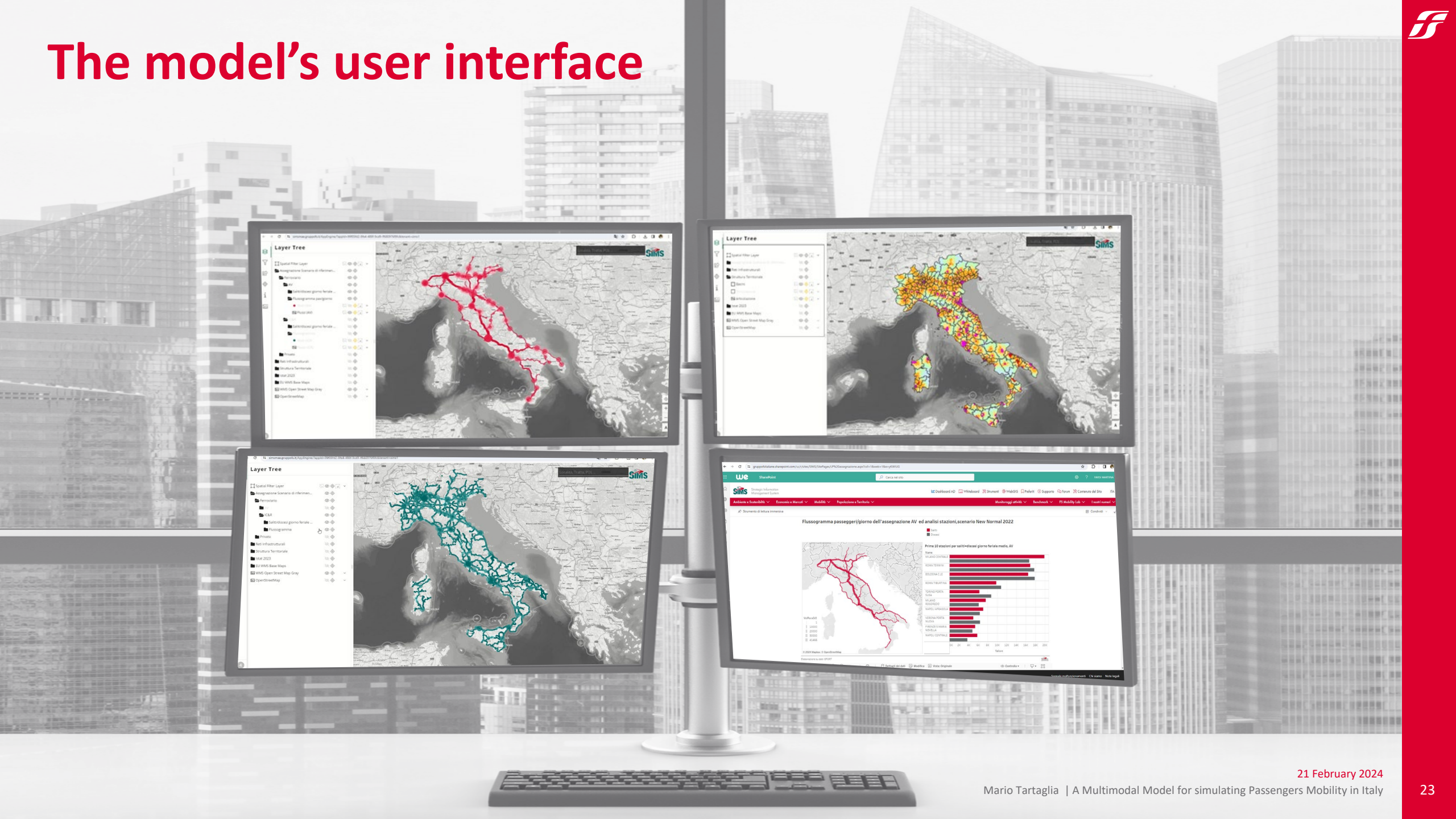
The model’s user interface

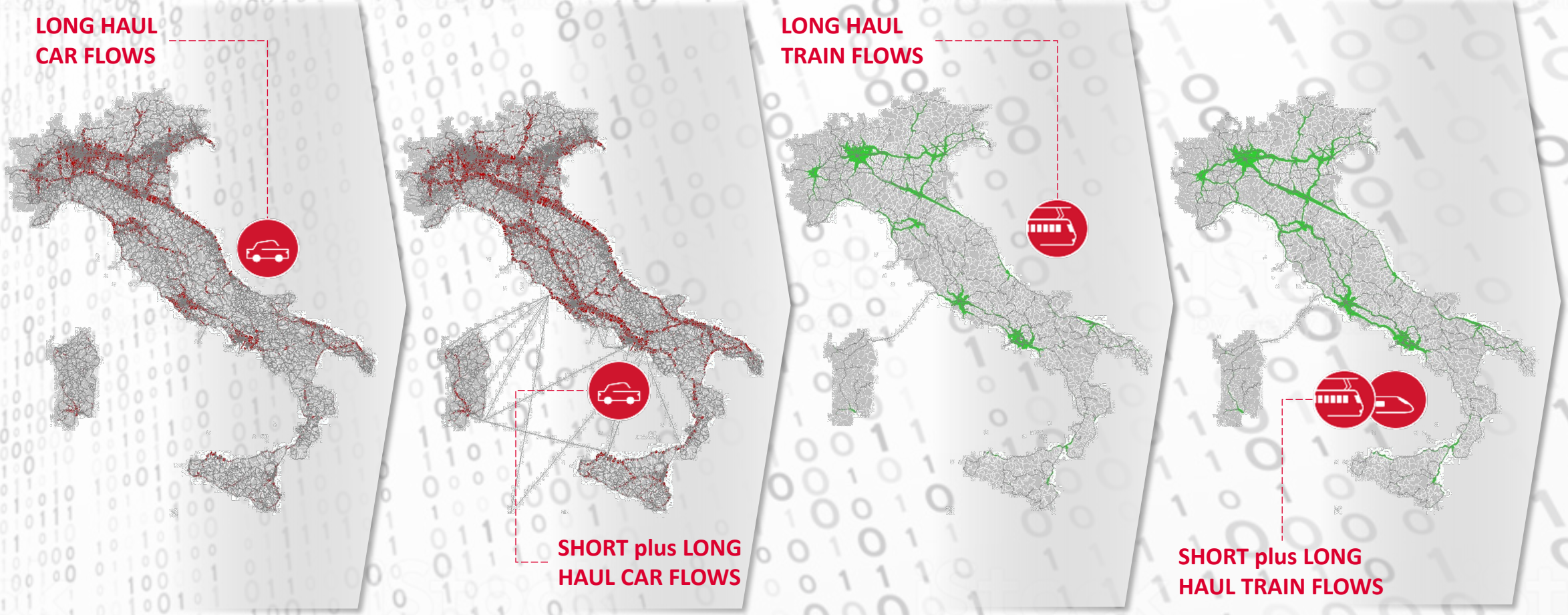


Comparison of Long-Haul and Short-Haul modules

Feature	Long-Haul	Short-Haul
Distances	Trip distances **>80 km**	Trip distances **<80 km**
Zoning system	**2815** zones	**911** zones
Purposes	4 travel purposes(no more tourism/leisure and personal services)	Only **3 travel purposes** (work, study, not systematic) instead of
Generation model		Additional multiplier: $p_m[o_k]^{i_{active/not\_active}}$: incidence of the mobile population, population that leaves the house daily, by class of i active resident in a municipality or sub-municipality of accessibility k;
Distribution model		Additional phase **Macro-distribution** to extract extra-zonal trips. **Distribution calibration** based on ISTAT OD matrix for study and work purposes, by Mobile Network Data for non-systematic matrix and purposes.
Modal choice model	5 modes: private car, long-haul bus, IC&Regional rail, Highspeed rail	Only **3 modes:** private car, local bus, IC&R services
Assignment	Principal road graph	Detailed road network graph

Overall passengers national demand modelling

Flow maps in pre-Covid scenario (2019)



National demand scenario analysis

MODEL

The National Demand Model is a **powerful, flexible and unique** tool in the national panorama for the analysis of **current and potential passenger demand**.

The model is:

- fitted at the national scale;
- made up of short and long haul sub-models;
- easy data and scenario updating;
- designed to be fed with ready-to-use official data sources.

SCENARIOS

SOCIO ECONOMIC VARIABLES

OCCUPATION E SMART WORKING

TRANSPORT SERVICES

TRANSPORT INFRASTRUCTURES

OUTPUT

- ✓ **Modal share** among modes inserted in the model and modal matrix.
- ✓ **Travel time/distance by OD**, by rail and road.
- ✓ **OD flows, passengers/vehicle** on rail/road network simulated by the model.
- ✓ **Passengers boarding and alighting** at stations divided by demand category (short/long distance).
- ✓ Estimate of **passenger-km** divided by type of service at national level.
- ✓ **Graphic output** in shapefile format customizable according to needs.

Thanks for your attention!

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