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

National Long Haul Model

National Short Haul Model

Ferrovie dello Stato, the Italian state-owned railway company

The Italian Ministry of Infrastructure and Transport
Structure of national passenger demand model

**SOCIO-ECONOMIC AND SUPPLY SCENARIOS**

- Socio-economic system
  - Demography for age-class.
  - Territorial accessibility.
  - Employed per sector-type.
  - Occupational trend.
  - University students, touristic sleeps, touristic presences.
  - Mobility statistics

- Transport supply system
  - Transport infrastructures
  - Train services
  - Collective services
  - Plane services
  - Travel time, tolls, travel costs.
  - Energy cost and fees.
  - Access and egress time.

**SCENARIO UPDATING MODULE**

**SOCIO-ECONOMIC VARIABLES**
- Municipality population per age-class.
- Employed population per and municipality.
- % of mobile employed population per type and economic sector.

**TRANSPORT SUPPLY VARIABLES**
- New transport infrastructure or upgrade actions.
- Variation of number of services or time-table of collective transports.
- Change of modal costs.

**TERRITORY-TRANSPORT MODEL**

**SUPPLY MODEL:**
- Private and public networks;
- Modal attributes and link costs.

**DEMAND MODEL**

**GENERATION MODEL**
- Trips by purpose
  - ≥80KM
  - <80KM

**DISTRIBUTION MODEL**
- Destinations by trip purpose
  - ≥80KM
  - <80KM

**MODAL CHOICE MODEL**
- Modal choice by trip purpose
  - ≥80KM
  - <80KM

**OD MATRIX by MODE**
- ≥80KM
- <80KM

**MODEL OF PATH CHOICE**
- ≥80KM
- <80KM

**ASSIGNMENT PROCESS**

**PERFORMANCES AND EXTERNAL IMPACTS**

**EVALUATION MODELS**

Mario Tartaglia | A Multimodal Model for simulating Passengers Mobility in Italy
Socio-economic and territorial data

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

Accessibility
- Internal areas classification (SNAI)

Workforce statistics
- Workers by Nace Rev. 2 sector

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

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

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

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

Big Data
- Mobile network data, plus floating car data
The zoning system
Transport supply system data

- Road network
- Rail service graph (GTFS)
- Long distance bus network
- Short distance bus, Google API
- 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:

\[
D_{i,o,d}(s, t, m, k)
\]

**GENERATION**

\[
D_{i,o}(s, t)
\]

**DISTRIBUTION**

\[
p_i(d | o, s, t, e)
\]

\[
p_i(m | o, s, t, e, d)
\]

**MODAL CHOICE**

\[
p_i(k | o, s, t, e, d, m)
\]

**PATH CHOICE**

\[
D_{i,o}(s, t)
\]

\[
p_i(d | o, s, t, e)
\]

\[
p_i(m | o, s, t, e, d)
\]

\[
p_i(k | o, s, t, e, d, m)
\]

(▲) 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

**GENERATION**
- Audimob
- Population
- Age classes
- Active status
- Accessibility

**DISTRIBUTION**
- ATECO
- Students
- Distance
- Tourism
- Accessibility
- MND
- Big Data

**MODAL CHOICE**
- Audimob
- Networks
- Services
- Costs
- Time
- ISTAT/ENAC

**PATH CHOICE**
- Train tickets
- Road flows
- Floating car data

*The Italian national transport survey by*

*Generation model validation*
Long haul model: insights
The model performs demand assignment on the whole railway service network and on a road network including all the Country’s principal roads. The model investigates many purposes and modes of transport.
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**

\[
\begin{align*}
    d_s [o_k] &= \sum_i n_i^{[o_k]} p_i^{active}[o_k] \cdot x_s^{active,k} + n_i^{[o_k]} p_i^{not\_active}[o_k] \cdot x_s^{not\_active,k} \\
    d [o_k] &= \sum_s d_s [o_k]
\end{align*}
\]

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
National Long Haul Passengers Model

Distribution model

**INPUT**
- Number of trips from generation model
- **Attractiveness 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**

$$p[d/osh] = \frac{A_d^{\beta_1} \cdot C_{od}^{\beta_2}}{\sum_d A_d^{\beta_1} \cdot C_{od}^{\beta_2}} \quad \beta_1 \text{ and } \beta_2 \text{ are defined for each reason and attraction class}$$

**OUTPUT**
- National origin-destination matrix splitted by purpose $s$

Calibration with Mobile Network Data
# National Long Haul Passengers Model

## Attractiveness features of distribution model

<table>
<thead>
<tr>
<th>Category</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STUDY</strong></td>
<td>• number of students enrolled in university</td>
</tr>
<tr>
<td><strong>WORK</strong></td>
<td>• number of employees divided in ATECO categories</td>
</tr>
<tr>
<td><strong>PERSONAL SERVICES</strong></td>
<td>number of employees related to:</td>
</tr>
<tr>
<td></td>
<td>• activities providing services to households and individuals such as manufacturing activities;</td>
</tr>
<tr>
<td></td>
<td>• wholesale and retail trade, repair of motor vehicles and motorcycles;</td>
</tr>
<tr>
<td></td>
<td>• professional, scientific and technical activities;</td>
</tr>
<tr>
<td></td>
<td>• health and social care;</td>
</tr>
<tr>
<td></td>
<td>• other service activities.</td>
</tr>
<tr>
<td><strong>TOURISM</strong></td>
<td>number of employees related to:</td>
</tr>
<tr>
<td></td>
<td>• accommodation and catering services;</td>
</tr>
<tr>
<td></td>
<td>• rental, travel agencies, business support services;</td>
</tr>
<tr>
<td></td>
<td>• artistic, sports, entertainment, and amusement activities.</td>
</tr>
<tr>
<td></td>
<td>• Beds of the accommodation establishments.</td>
</tr>
</tbody>
</table>

## Actraticiveness 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** \( m \) for each given origin \( o \), destination \( d \), and purpose \( s \)

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

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

### Attributes

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

Mario Tartaglia | A Multimodal Model for simulating Passengers Mobility in Italy

FS Research Centre
Il Centro Studi di Ferrovie della Stata Italiane

Ferrovie Italiane
21 February 2024

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National Long-Haul flows
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.
Short haul model: insight
The model performs demand assignment on the whole railway service network and on a comprehensive road network including all the Country’s local roads.

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

\[ R^2 = 0.896 \]
Blending Long and Short Haul Models
The model’s user interface
## Comparison of Long-Haul and Short-Haul modules

<table>
<thead>
<tr>
<th>Feature</th>
<th>Long-Haul</th>
<th>Short-Haul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distances</td>
<td>Trip distances &gt;80 km</td>
<td>Trip distances &lt;80 km</td>
</tr>
<tr>
<td>Zoning system</td>
<td>2815 zones</td>
<td>911 zones</td>
</tr>
<tr>
<td>Purposes</td>
<td>4 travel purposes (no more tourism/leisure and personal services)</td>
<td>Only 3 travel purposes (work, study, not systematic) instead of</td>
</tr>
<tr>
<td>Generation model</td>
<td></td>
<td>Additional multiplier: $p_m[\alpha_k]^{active/not\ active}$: 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;</td>
</tr>
<tr>
<td>Distribution model</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>Modal choice model</td>
<td>5 modes: private car, long-haul bus, IC&amp;Regional rail, Highspeed rail</td>
<td>Only 3 modes: private car, local bus, IC&amp;R services</td>
</tr>
<tr>
<td>Assignment</td>
<td>Principal road graph</td>
<td>Detailed road network graph</td>
</tr>
</tbody>
</table>
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!