CLASS

A City Logistics Analysis and Simulation support System
What CLASS can do

Class supports City Logistics Managers to:

- identify the main characteristics and the critical stages of the actual City Logistics System (CLS)
- assess and verify the new scenarios

through a set of indicators related to:

- land-use
- freight demand and supply
- logistic profile
- road network performances and impacts
CLASS: main components

Database

Simulation models and procedures

GIS

GUI
CLASS: application example

CLS of inner area of Rome:
• 9 km² – 50,000 inhabitants – 24,000 employees related to trade;
• 15,000 tons per day with more than 66% destined to retail or food-and-drink outlets;
The application was supported by 600 interviews of truck riders, 500 interviews of retailers.
CLASS: Application example

Land use indicator examples

- number and ratio between employees and residents
- number and density of retailer outlets
- number and density of retail employees also disaggregated for freight type
### Freight demand indicator examples

<table>
<thead>
<tr>
<th>Zone</th>
<th>Logisite profile</th>
<th>Surface (km²)</th>
<th>Density of daily attracted quantity (tons/km²)</th>
<th>Density of daily attracted deliveries (deliveries/km²)</th>
<th>Average quantity delivered (tons/del)</th>
<th>Daily morning deliveries</th>
<th>Daily afternoon deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONTI</td>
<td>B</td>
<td>1.77</td>
<td>911</td>
<td>2,090</td>
<td>0.44</td>
<td>3,388</td>
<td>320</td>
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<td>Trevi</td>
<td>B</td>
<td>0.79</td>
<td>2,252</td>
<td>5,489</td>
<td>0.41</td>
<td>3,939</td>
<td>410</td>
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<td>Colonna</td>
<td>B</td>
<td>0.44</td>
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<td>11,447</td>
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<td>4,530</td>
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<td>4,876</td>
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<tr>
<td>Ponte</td>
<td>E</td>
<td>0.33</td>
<td>682</td>
<td>1,402</td>
<td>0.49</td>
<td>430</td>
<td>38</td>
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<tr>
<td>Parione</td>
<td>B</td>
<td>0.29</td>
<td>5,137</td>
<td>13,086</td>
<td>0.39</td>
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<td>665</td>
<td>1,278</td>
<td>0.52</td>
<td>403</td>
<td>54</td>
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<td>S. Eustachio</td>
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<td>2,821</td>
<td>6,053</td>
<td>0.47</td>
<td>1,687</td>
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<td>Campitelli</td>
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<td>98</td>
<td>194</td>
<td>0.50</td>
<td>157</td>
<td>15</td>
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<td>S. Angelo</td>
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<td>2,413</td>
<td>0.55</td>
<td>355</td>
<td>65</td>
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<tr>
<td>Ripa</td>
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<td>155</td>
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<td>118</td>
<td>15</td>
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<tr>
<td>Esquilino</td>
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<td>0.82</td>
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<td>1,335</td>
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<tr>
<td>Ludovisi</td>
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<td>1,142</td>
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<tr>
<td>Sallustiano</td>
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<tr>
<td>Castro Pretorio</td>
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<td>8,703</td>
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<td>3,077</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>9.22</strong></td>
<td><strong>1,554</strong></td>
<td><strong>3,704</strong></td>
<td><strong>0.42</strong></td>
<td><strong>30,873</strong></td>
<td><strong>3,294</strong></td>
</tr>
</tbody>
</table>
**CLASS: Application example**

*Freight transport supply indicator examples:*

- the services for transport quantity and deliveries offered by the different types of transport services (i.e. on own account and third party);
- the vehicles fleet used for freight restocking characterized in terms of vehicle types (e.g. light or medium or heavy), equipment (e.g. refrigerator), emission standards (e.g. Euro I, Euro II) or type of fuel (e.g. gasoline, diesel).
CLASS: Application example

*Logistic profile indicators* allow to identify areas homogeneous respect to some specific logistics needs:

- commercial density and homogeneity
- logistic accessibility
- product characteristics destined to retail outlets, like fragility, perishability or cooling needs
- actor (e.g. retailers, wholesalers, carriers) needs related to particular requirements
Logistic profile examples

- **Profile A**, cluster of shops specialized in one specific type of service/product characterized for high commercial density and homogeneity and low logistic accessibility;

- **Profile B**, hotels, restaurants, small grocery stores, small neighborhood markets mainly characterized by the perishability of the products (ho.re.ca);

- **Profile C**, business center characterized for high commercial density and low homogeneity with a low logistic accessibility;

- **Profile D**, large commercial stores mainly characterized by a good logistic accessibility and a big amount of freight to be delivered;

- **Profile E**, residential areas with local trade characterized for low commercial density and homogeneity with a low logistic accessibility;
Road network performance indicator examples:

- for light (less than 1.5 ton), medium (between 1.5 and 3.5 tons) and heavy (more than 3.5 tons) vehicles and for transport service type (i.e. on own transport and 3p):
  - Link flows
  - Veic-km
  - Average speed
  - Traffic pollutant emissions characterized for pollutant type (e.g. CO, No_{x})

- Road accidents characterized for type of vehicles and location.
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Road network performance indicator examples
Freight vehicle link flows
### CLASS: Application example

#### Road network performance indicator examples

**Performances and pollution**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>3p</th>
<th>Own account</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>light vehicles</td>
<td>medium vehicles</td>
<td>total</td>
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<tr>
<td>Veic-km/day</td>
<td>79,081</td>
<td>39,826</td>
<td>118,907</td>
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<tr>
<td>Veic-h/day</td>
<td>2,139</td>
<td>1,048</td>
<td>3,187</td>
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<tr>
<td>Average speed [km/h]</td>
<td>36.97</td>
<td>38</td>
<td>37.31</td>
</tr>
<tr>
<td>CO (kg/day)</td>
<td>75.68</td>
<td>23.00</td>
<td>98.68</td>
</tr>
<tr>
<td>NOx (kg/day)</td>
<td>82.36</td>
<td>95.84</td>
<td>178.20</td>
</tr>
<tr>
<td>NO2 (kg/day)</td>
<td>22.72</td>
<td>12.80</td>
<td>35.52</td>
</tr>
<tr>
<td>PM$_{2.5}$ (kg/day)</td>
<td>6.28</td>
<td>3.80</td>
<td>10.08</td>
</tr>
<tr>
<td>PM$_{10}$ (kg/day)</td>
<td>7.52</td>
<td>5.28</td>
<td>12.80</td>
</tr>
<tr>
<td>CO$_2$ (t/day)</td>
<td>21.8</td>
<td>12.57</td>
<td>34.41</td>
</tr>
</tbody>
</table>
CLASS: Application example

Road network performance indicators
Accidents involving freight vehicle
What there was before...

Some tools were developed in the last years and are based on different modelling approaches:

- **WIVER** (1985): vehicle trip Origin-Destination for restocking activities starting from the estimation of O-D quantity matrices and information regarding total mileage, number of trips and tours, daily traffic distribution over time, subdivided into vehicle type and economic sectors (freight types);

- **GOODTRIP** (1999): general modelling framework that simulates the freight traffic resulting from logistical choices in the supply chain like warehouse location, delivery frequencies, vehicle type and routing;

- **FRETURB** (2000): it proposes the delivery approach to build a direct link between producers/retailers and transport operators, through the use of the same reference unit.

- **VISEVA-W** (2004): simulation both the restocking and passenger flows, without considering that restocking flows are generated by the requests of end consumers that move for shopping;
What there is now...CLASS

Previous support systems are based on **empirical relationships** that well describe the current state of the system but they **fail** when **new** city logistics scenarios (before implementation) are simulated and assessed.

CLASS is a support system that implements some advanced models that allow to capture the effects of city logistics measures on actors’ behavior (Nuzzolo and Comi, 2013)

How CLASS makes it (1/4)
How CLASS makes it (2/4)

Road network model

• graph-based mode in which the main road system of the city logistics system area is modeled;

• freight vehicles move on a subset of links that for geometric characteristics (e.g. width) and traffic rules are consistent with freight vehicle dimensions;

• CLASS models the link generalized transportation cost only as function of travel time and then it is computed by BPR function.
**Demand models**
The freight vehicle O-D matrices modeling framework used in the Support System, derived from the current literature and is based on that proposed by Nuzzolo *et al.* (2013)
Assignment models
- Truck-driver path choice constrained by the vehicle size, driver preferences, vehicle and route performances (e.g. travel time, vehicle operating costs, gateway toll; Taniguchi et al., 2001; Russo et al., 2010);
- Deterministic User Equilibrium (DUE) model;
- Pre-load of passenger vehicles is performed in order to update the link costs of the network.

Traffic pollutant emission models
- COPERT model adapted for the urban and metropolitan contexts following Filippi et al. (2010)

Road accident models
- Safety Performance Functions (SPFs): the probability of accidents are evaluated in relation to vehicle flows and road characteristics, location and characteristics of infrastructures, control system, and other standardization variables (under development).
Main references