Real-time management of urban freight loading and unloading areas

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Overview

✓ Introduction

✓ Methods for delivery area scheme planning and management

✓ An integrated methodology for supporting delivery area scheme planning and management

✓ Application to a real test case

✓ Conclusions and further developments
Introduction

Freight vehicles contribute to congestion especially in peak hours.

Local conditions could oblige freight vehicles to stop for loading and unloading outside designated spaces.

Vehicles can stop at junctions or along a lane, in both cases leading to a reduction in capacity.
Introduction

If the number of areas is not enough to match the demand in deliveries, the amount of illegal parking to deliver the goods increases.

A scheme with too many delivery areas leads to unused public space.

The scheme of delivery areas have to be planned and managed with care.

Furthermore, its performance depends on its management and operations control rules. For example, the possibility to book the loading and unloading areas, taking into account the deliveries to be performed, can help transport operators to reduce their service costs.
Methods for delivery area scheme

Planning
✓ Minimization of the total cost supported by transport operators and drivers that would like to park (Aiura and Taniguchi, 2005)
✓ Definition of size, number and location of the delivery areas according
   ➢ to empirical data (Dezi et al., 2010)
   ➢ to simulation of delivery operations (Delaitre and Routhiers, 2010)

Management
✓ Delivery operators can book delivery areas (McLeod and Cherrett, 2011; Alho et al., 2014; Patier et al., 2014)

Planning methodology has to take management rules into account
Objective

✓ Propose an integrated methodology for supporting city logistics planners and experts in planning and managing this measure.

✓ The methodology helps to optimize delivery schema planning and management with the definition of:
  • an adequate number of on-street loading/unloading areas,
  • properly located and sized to the delivery demand,
  • using a suitable methodology,
  • with a set of management rules which maximize the performance of the delivery area scheme.
Integrated methodology to support delivery area scheme planning and management

Data from surveys to stakeholders

Study area data (e.g. land use and road network)

Demand

Origin-Destination delivery flows for day time

Loading/Unloading (l/u) delivery time

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Scenario simulation

Scenario performance indicators

Scenario to be implemented

Test

Target performance indicators

NO

YES

Demand

Origin-Destination delivery flows for day time

Loading/Unloading (l/u) delivery time

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Scenario simulation

Scenario performance indicators

Test

Scenario to be implemented

Data from surveys to stakeholders

Study area data (e.g. land use and road network)
Systems for delivery area scheme management

Current Management system
✓ Imola (Ferrecchi, 2013): only pre-booking
✓ Winchester High Street (McLeod and Cherrett, 2011): pre-booking and vehicle checking for in time control only at border of study area

Limits of current literature
✓ No real time suggestions on vehicle delivery
✓ The delivery time slots are asked by users and not proposed by system
✓ No suggestions on time requested for delivering

Our proposal
✓ Real time management system which uses real time information and ITS tools to overcome the above limits
Logical architecture for real time management system

- Booking process management
- Real Time vehicle delivery plans management
- Real Time vehicle accesses management
- Real Time vehicle handling operations management

For each process a set of alternatives rules are possible.
**Logical architecture for real time management system**

**booking process management**, this stage receives as **input the data of deliveries** (e.g. freight types, location of receivers, quantity to deliver, desired departure or arrival times, delivery time constraints, type of vehicle used) from users (e.g. transport and logistic operators) and provides as **output the delivery plan** (sequence of delivery areas) with **reservations of delivery areas** according to the estimated handling time operations and time requested to reach each of them;
Logical architecture for real time management system

- Booking process management
- Real Time vehicle delivery plans management
- Real Time vehicle accesses management
- Real Time vehicle handling operations

**real time vehicle delivery plan management**, according to real time configuration of road network, the delivery plan is updated (if necessary);
Logical architecture for real time management system

- Booking process management
- Real Time vehicle delivery plans management
- Real Time vehicle accesses management
- Real Time vehicle handling operations

**real time vehicle access management**, approaching the study area, the system processes the access request and authorises the access if on time, otherwise it can suggest to stop and waiting outside the study area;

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Logical architecture for real time management system

**Real time vehicle handling operation management**, it receives as input the delivery plan and real time data from the road network, then the system has to guide the user among his delivery areas according to the forecasted times.

- Real Time vehicle handling operations management

For each process a set of alternatives rules are possible.
Application to a real test case
Municipality of Rome - Inner zone

Study area: Campo Marzio

LTZ is the Historic and the most famous zone in the city

Inner area (freight LTZ)

- 51,413 inhabitants
- 130,000 employees
- 24,401 retail employees

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Integrated methodology to support delivery area scheme planning and management

Data from surveys to stakeholders

Study area data (e.g. land use and road network)

Demand

Origin-Destination delivery flows for daytime

Loading/Unloading (l/u) delivery time

Scenario simulation

Scenario performance indicators

Target performance indicators

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Scenario to be implemented

YES

test

NO

Scenario to be implemented
Application to a real test case

*The dataset - survey*

- **Traffic counts** of commercial and private vehicles
  *(working day from 7am to 6pm)*

- **Driver interviews** “*Freight LTZ*” on delivery tour stops within inner area
  *(502 interviews)*
Traffic counts

The surveys

Daily incidence of freight vehicles: ✓ 9% (2008)

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<tr>
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Traffic counts

Counts of vehicles in different periods of the day:

- 7am - 8am: 2000
- 8am - 9am: 2500
- 9am - 10am: 2500
- 10am - 11am: 2500
- 11am - noon: 3000
- noon - 1pm: 3000
- 1pm - 2pm: 2500
- 2pm - 3pm: 2000
- 3pm - 4pm: 1500
- 4pm - 5pm: 1000
- 5pm - 6pm: 500

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- Scenario simulation
- Scenario performance indicators
- Target performance indicators
- Scenario to be implemented

- NO
- YES

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Application to a real test case

✓ Study area: demand

✓ About 210 goods vehicles enter in Campo Marzio from 6.00 am to 12.00 pm

✓ Peak demand between the 9.00 and 9.30 am

✓ 75% are light goods vehicle (i.e. gross laden weight less than 1.5 tons) and the remaining 25% are medium goods vehicles (i.e. less than 3.5 tons)

✓ 45% are “wholesaler on own account”, 15% “retailer on own account” and the remaining 40% “by carrier”
Integrated methodology to support delivery area scheme planning and management

- Data from surveys to stakeholders
- Study area data (e.g. land use and road network)
- Demand
- Origin-Destination delivery flows for day time
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Scenario simulation
- Scenario performance indicators
- Test
  - NO
  - YES
- Scenario to be implemented

Target performance indicators

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The estimation delivery time occupancy

\[ T[q, v, r, s, h] = t[q, v, r, s, h] + \varepsilon[q, v, r, s, h] \]

- \( T[q, v, r, s, h] \) is time requested for performing delivery operations depending, for example, on the time of day \( h \), type of the service \( r \) and type of vehicle \( v \) used for delivering quantity \( q \) of type of freight \( s \); it is assumed to be a random variable.

- \( t[q, v, r, s, h] \) is the mean of delivery time \( T[q, v, r, s, h] \), i.e. \( E[T] = t \);

- \( \varepsilon \) is the random term with \( E[\varepsilon] = 0 \).

\[
\begin{align*}
t &= \sum_i \beta_i \cdot X_i \\
\text{var}[T] &= \text{var}[\varepsilon] = \sum_j \alpha_j \cdot X_j
\end{align*}
\]

Averages and variances of delivery times can be assumed linear combination of attributes \( X_i \).
The estimation delivery time occupancy

<table>
<thead>
<tr>
<th>Freight types</th>
<th>Constant</th>
<th>Quantity</th>
<th>Light goods vehicles</th>
<th>Retailer on own account</th>
<th>By carrier</th>
<th>From wholesaler</th>
<th>To ho.re.ca.</th>
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Deliveries to ho.re.ca. usually take less time
The estimation delivery time occupancy

✓ Average estimated l/u time: about 19 minutes

✓ Max value: about 42 minutes for medium goods vehicles delivering building material

✓ min value: about 12 minutes for light goods vehicles delivering hygiene and personal products.
Integrated methodology to support delivery area scheme planning and management

Data from surveys to stakeholders

Study area data (e.g. land use and road network)

Demand

Origin-Destination delivery flows for day time

Loading/Unloading (l/u) delivery time

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Target performance indicators

Scenario simulation

Scenario performance indicators

Scenario to be implemented

NO

YES

Test

Target performance indicators

Scenario to be implemented

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Real-time management of urban freight loading and unloading areas
Application to a real test case

Study area – Campo Marzio district

23 delivery areas

serving

81 destination zones
Application to a real test case

The simulated scenarios

<table>
<thead>
<tr>
<th>Base scenario</th>
<th>Action scenario</th>
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<td>✓ strong enforcement system (delivery operations are only permitted in such areas)</td>
<td>✓ strong enforcement system</td>
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<tr>
<td>✓ no delivery operations outside dedicated areas are performed</td>
<td>✓ no delivery operations outside dedicated areas are performed</td>
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<td>✓ no real time ITS system</td>
<td>✓ real time management ITS system</td>
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<tr>
<td>✓ the drivers choose the delivery area closest to its final destination regardless of its status or presence of queue</td>
<td>✓ ITS system suggests delivery areas considering final destinations, real time status and queue of each area</td>
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<tr>
<td>✓ if area is occupied, driver waits in queue for using chosen area</td>
<td>✓ the aim is to minimize the total service time (time needed for all shipments in the district)</td>
</tr>
</tbody>
</table>
Integrated methodology to support delivery area scheme planning and management

Data from surveys to stakeholders

Study area data (e.g. land use and road network)

Demand

Origin-Destination delivery flows for day time

Loading/Unloading (l/u) delivery time

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Scenario simulation

Scenario performance indicators
test

Target performance indicators

NO

YES

Scenario to be implemented

Nuzzolo A, Comi A, Rosati L
Real-time management of urban freight loading and unloading areas
Application to a real test case

Microsimulation and performance indicators

Study area: Microsimulation and performance indicators

Indicators

✓ total service time

✓ vehicle request number for each area

✓ vehicle on queue for each area

✓ queue waiting time for each area

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Integrated methodology to support delivery area scheme planning and management

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Target performance indicators

Management rules and systems

Loading/Unloading (l/u) scenario definition (delivery scheme)

Scenario to be implemented

Test

NO

YES
## Application to a real test case

### Study area: Scenario simulation results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>vehicle request</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>max</td>
<td>avg</td>
<td>st. dev</td>
<td>max</td>
</tr>
<tr>
<td>action</td>
<td>16.0</td>
<td>10.5</td>
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</tr>
</tbody>
</table>

\[ \Delta \] -65% 0% -65% -86% -3% -84% -88% -9% -85% -66%
### Application to a real test case

**Study area: Scenario simulation results**

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<td>-65%</td>
<td>0%</td>
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<td>-3%</td>
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</table>

- better distribution of arriving vehicles among the available delivery bay
- the reduction of queues and delay
- The usage of the ITS system reduces total delivery time
Conclusions and further development

✓ A methodology for supporting planning of urban delivery schemes that takes into account detailed management rules has been proposed.

✓ A preliminary scenario analysis using a discrete event micro-simulation approach for management assessment has been discussed.

✓ The application test showed that the improvement margins of delivery area management and control can be very significant.
Conclusions and further development

✓ Further developments mainly regard application to a new delivery scheme that permits to have suggestions on delivery tours according to the current status of the network.

✓ Thus, transport and logistics operators can further optimize the time spent for such freight operations, and hence reduce more their service costs.

✓ At the other hand, from city administrator point of view, these new schemes can help the supply of loading and unloading areas to match the demand, and then to reduce the interferences with other city mobility components.
Real-time management of urban freight loading and unloading areas

Agostino Nuzzolo, Antonio Comi and Luca Rosati

“Tor Vergata”
University of Rome

comi@ing.uniroma2.it
Logical architecture for real time management system

✓ **booking process management**, this stage receives as input the data of deliveries (e.g. freight types, location of receivers, quantity to deliver, desired departure or arrival times, delivery time constraints, type of vehicle used) from users (e.g. transport and logistic operators) and provides as output the delivery plan (sequence of delivery areas) with reservations of delivery areas according to the estimated handling time operations and time requested to reach each of them;

✓ **real time vehicle delivery plan management**, according to real time configuration of road network, the delivery plan is updated (if necessary);

✓ **real time vehicle access management**, approaching the study area, the system processes the access request and authorises the access if on time, otherwise it can suggest to stop and waiting outside the study area;

✓ **real time vehicle handling operation management**, it receives as input the delivery plan and real time data from the road network, then the system has to guide the user among his delivery areas according to the forecasted times.