A modeling approach for locating logistics platforms for fast parcel delivery in urban areas

Olivier Guyon, Nabil Absi, Dominique Feillet and Thierry Garaix

École des Mines de Saint-Étienne - CMP Georges Charpak

June, 8th 2011
Outline

1. Project PLUME
2. Marseilles field survey
3. Modeling approach
4. Screenshots of the decision-making tool
Outline

1. Project PLUME
Context

- duration: 18 months
- contributor: French Ministry of Ecology, Sustainable Development, Transport and Housing
- partners:
  - École Nationale Supérieure des Mines de Saint-Étienne
    (graduate school of science and technology)
  - Jonction
    (research team specialized in logistics and transport of goods)
  - SOGARIS
    (company involved in logistic real estate and associate services)
  - Cluster Paca Logistique
    (association which manages projects in logistics in the French region PACA)
PLUME addresses the come back of urban logistics platforms in the heart of the town

a real case study: Marseilles, with ARENC
Location of logistics platforms for an urban use

From the past . . .
limiting the presence of logistics platforms in urban areas:
  - urbanistic reasons (regulation rules)
  - political reasons (less noise and pollution for inhabitants)
  - economical (available surfaces are rare and expensive)

. . . to the future ?
← this location, far from the city, is now questioned:
  - long vehicle tours
  - more traffic pollution
  - more traffic congestion
  - impossibility to schedule several successive routes
Our study

- given a set of available surfaces in and outside of the city,
- given an average distribution activity of the city,
  - how many logistics platforms have to be built? where should they be located? and how should they be sized?
  - how should be the vehicle fleet of each logistics platform composed of?
  - what should be the (approximate) daily route of each vehicle?

so that the distribution is performed at optimal performance regarding a set of criteria including economic, environmental and social impacts
Targets

- a field study in Marseilles
- a mathematical model
- a decision-making tool (software)
2 Marseilles field survey
Framework

Fast parcel deliveries
transport of small goods, volume of $0.10-0.20 m^3$ for an average weight of 30-70kg

Logistics specialists
$\approx$ 30 companies in Bouches-du-Rhône
$\rightarrow$ 12 majors ones: 80% of the market
Surfaces

- Bouches-du-Rhône: \( \approx 95000 \ m^2 \) (docks + office)
- 2 main areas (outside the city)
- Marseilles: 40 à 50% of the market share of each company
  - surface dedicated to Marseilles: \( \approx 45000 \ m^2 \)
Transport of goods in Marseilles

Tours (1/2)

- 320 in delivery and 215 in collect (coupling ≈ 20%)
- length: from 50 to 180km
- 35 customers per tour
- average weight for a delivery: 100kg
- organization: ≈ 1 tour / borough
Transport of goods in Marseilles

Tours (2/2)

- vehicles:
  - capacities: 40% <3.5t, 40% 7 - 13t, 20% more than 13t
  - gasoline engines
- many subcontractors: 2/3 of the total number of vehicles
- volume: delivery 1120 T / day, collect 770 T / day
- customers: delivery 12 500, collect 7 000
Evaluation

More and more organisational difficulties for planning tours professionals (later and later) ≠ people (earlier and earlier)

E-business
more and more deliveries: necessity to be close to customers
← towards several tours per day
← a platform in Marseilles becomes a necessity
3 Modeling approach
3 key points in the modelling approach

- criterion to optimize?
  - economical
  - environmental
  - social

- a lot of actors (different models)
  - local authorities
  - logistics companies
  - customers / inhabitants

- how to evaluate distribution costs
9 criterion

- economical criterion
  - platforms: investment cost (fixed + variable/dock)
  - platforms: operating cost (depends on the number of docks)
  - vehicles: investment cost
  - vehicles: operating cost

- environmental criterion
  - vehicles: pollution
  - platforms: pollution

- social criterion
  - platform: acceptability by the riparian
  - vehicle: congestion
  - platform: interest in terms of employment

O. Guyon, N. Absi, D. Feillet, T. Garaix
How to estimate transportation costs?

- Necessity to deal with costs of entering and leaving the city
  - impact on the location of logistics platforms
- Necessity to deal with the fleet of vehicles
  - cost per km, autonomy (electric engines)
  - implies to manage tours of vehicles
- Hypothesis
  - Fixed costs to distribute goods into zones of demand
  - One tour = cost of entering the city + service of near zones + cost of leaving the city
Extract of a mathematical model: constraints (1/2)

\[ w_l \leq q_l \cdot u_l \quad \forall l \in L \]  
\[ \sum_{l \in L} \sum_{v \in V} x_{lvd} = 1 \quad \forall d \in D \]  
\[ \sum_{l \in L} \sum_{d \in D} z_{lvd}^\alpha \leq 1 \quad \forall v \in V \]  
\[ \sum_{l \in L} \sum_{d \in D} x_{lvd} \leq \mathcal{M} \cdot \sum_{l \in L} \sum_{d \in D} z_{lvd}^\alpha \quad \forall v \in V \]  
\[ \sum_{l \in L} \sum_{d \in D} z_{lvd}^\beta \leq 1 \quad \forall v \in V \]  
\[ \sum_{l \in L} \sum_{d \in D} x_{lvd} \leq \mathcal{M} \cdot \sum_{l \in L} \sum_{d \in D} z_{lvd}^\beta \quad \forall v \in V \]  
\[ z_{lvd}^\alpha + z_{lvd}^\beta \leq x_{lvd} \quad \forall l \in L \ \forall v \in V \ \forall d \in D \]  
\[ \sum_{l \in L} x_{lvd} + \sum_{l \in L} x_{lvd}' \leq 1 \quad \forall v \in V \ \forall d \in D \ \forall d' \in \bar{D}_d \]  
\[ \sum_{l \in L} \sum_{d \in D} \left( z_{lvd}^\alpha M_{ld} + z_{lvd}^\beta M_{ld} + x_{lvd} \text{dist}_d \right) \leq a_v^{\text{dist}} \quad \forall v \in V \]  
\[ \sum_{l \in L} \sum_{d \in D} \left( z_{lvd}^\alpha T_{vld} + z_{lvd}^\beta T_{vld} + x_{lvd} S_{vd} \right) \leq \min(a_v^{\text{tps}}, T_{\text{max}}) \quad \forall v \in V \]  

avec: \( \mathcal{M} \geq \text{card} \{D\} \)
Extract of a mathematical model: constraints (2/2)

\[
\sum_{l \in L} x_{lvd} \leq J_{vd} \quad \forall v \in V, \forall d \in D \quad (11)
\]

\[
\sum_{l \in L} \sum_{d \in D} x_{lvd} \cdot \gamma_d \leq b_v \quad \forall v \in V \quad (12)
\]

\[
\sum_{v \in V} \sum_{d \in D} x_{lvd} \cdot \gamma_d \leq \Theta \cdot w_l \quad \forall l \in L \quad (13)
\]

\[
u_l \in \{0, 1\} \quad \forall l \in L \quad (14)
\]

\[
w_l \in \mathbb{N} \quad \forall l \in L \quad (15)
\]

\[
x_{vd} \in \{0, 1\} \quad \forall v \in V, \forall d \in D \quad (16)
\]

\[
z_{lvd}^{\alpha} \in \{0, 1\} \quad \forall l \in L, \forall v \in V, \forall d \in D \quad (17)
\]

\[
z_{lvd}^{\beta} \in \{0, 1\} \quad \forall l \in L, \forall v \in V, \forall d \in D \quad (18)
\]
Outline

4 Screenshots of the decision-making tool
Screenshot: instance
Screenshot: optimization tool
Screenshot: solution