VÉHICULES AUTONOMES, TRANSFORMATION NUMÉRIQUE : QUELLES PERSPECTIVES POUR LA MOBILITÉ ?

22 septembre 2016
Doper l’accessibilité aux gares par le Personal Rapid Transit: application au Grand Paris Express

Nicolas Coulombel, Fabien Leurent, Shaoqing Wang et Florent Le Néchet (LVMT)
The Grand Paris Express transportation megaproject

- An ambitious transport project at the core of the sustainable development strategy of the Paris region

- A megaproject indeed:
  - Construction of 205 km of new automated metro lines, with 68 new stations
  - Commercial speed: 55 to 60 km/h
  - Predicted ridership: 2 million users / day
  - Estimated cost: 22.6 billion €

- Key objectives:
  - Improve travel conditions and reduce car use
  - Rebalancing the development of the Paris region
  - Combat urban sprawl and agricultural encroachment
  - Promote the economic development of the Ile-de-France Region (and of France as a whole)
A NEW TRANSPORT NETWORK FOR "GRAND PARIS"
The last mile issue

- The GPE faces a critical challenge: how to efficiently access (egress) the network
  
  • ring route in order to promote suburb-to-suburb travel ⇒ most stations are to be located in medium density areas
  
  • access by car will be uneasy for most stations: congestion, lack of parking supply
  
  • same for transit: bus planned to serve as the main local feeder system
    - low to average quality of service (frequency, commercial speed)

- A key opportunity for the development of a PRT system?
  
  • providing the GPE with an efficient, short to medium range feeder system
  
  • in case of a suspended system: free vacant land for new real estate development projects
But what is Personal Rapid Transit (PRT)?
(source: Andreasson)

- Personal Rapid Transit
  - Small automated vehicles
  - Separated from other traffic
  - Off-line stations
  - Vehicle waiting for you
  - Private or chosen company
  - Departs on demand
  - Quickest route non-stop
PRT - The best of two worlds
(source: Andreasson)

- From transit
  - Accessible for all
  - Public vehicles
  - Low fare
  - Sustainable
  - Safe

- From private cars
  - On demand
  - Non-stop
  - Privacy
  - Fast
  - 24/7
Some examples of PRT systems across the world

**Morgantown**
- 40 years of service
- 80 million passengers
- No serious accident

**Masdar city**
- 1.4 km
- 5 stations
- People & freight

**Heathrow airport**
- Connects terminal T5 to the business car park
- Small network (21 vehicles, 3.8 km & 3 stations)
Assessing the potential of PRT as a feeder system for the GPE

CASE STUDY: THE FUTURE PLEYEL BUSINESS CLUSTER (SAINT-DENIS)
Study area: the Saint-Denis Pleyel station

- Located at the center of the “Culture and Creation” Cluster
- A key multimodal hub for the GPE...
  - Junction of 4 lines
  - Connection with
    - RER D (heavy rail): 100m
    - Metro line 13: 250m
  - Predicted patronage: 250 000 users/day
- …but in a medium density area (for now)
  - only 9 000 inhabitants within a 1 km radius
  - for 22 000 jobs
Objective & Methodology

- Research objective: assess the potential of Personal Rapid Transit to serve as a feeder system for the future Saint-Denis Pleyel multimodal hub
  
  • preliminary analysis at this stage ⇒ rough design, simple assumptions, …
  
  • assess 1) demand potential under favorable conditions and 2) operational feasibility

- Methodology for assessing demand (step 1)
  
  • use of a standard 4-step transport model: MODUS
    - developed and used by the State regional planning organization (DRIEA – IdF)
    - separate road & transit assignment models
  
  • refine the Traffic Analysis Zones within a 2.5 km radius around the station
    - improve the representation of service characteristics at a local scale + choices of destination, mode and route
  
  • design a PRT system that considers local land-use characteristics

  • compare the reference scenario (bus) and the project scenario (PRT)
Overview of the PRT system

- Several branches to optimize local coverage
  - Total length: 19.6 km
  - # of stations: 48
  - Average interstation: 350m

- Service characteristics
  - No stop, all turns possible
  - Initial waiting time: 1 minute
  - Travel speed: 50 km/h

- Fare
  - no fare in the 1st run
  - generalized cost analysis to appraise the optimal fare
Preliminary results step 1

Public transit demand

- Marginal increase in public transit demand

50% ex-car users
50% ex-active travelers

<table>
<thead>
<tr>
<th></th>
<th>Reference scenario (no PRT)</th>
<th>Projet scenario (PRT)</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily trips</td>
<td>Mode share</td>
<td>Daily trips</td>
</tr>
<tr>
<td>Day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private car</td>
<td>13 137 144.4</td>
<td>35.57%</td>
<td>13 117 207.5</td>
</tr>
<tr>
<td>Transit</td>
<td>8 589 867.1</td>
<td>23.25%</td>
<td>8 627 755.7</td>
</tr>
<tr>
<td>Active modes</td>
<td>15 210 790.4</td>
<td>41.18%</td>
<td>15 192 838.8</td>
</tr>
<tr>
<td>Total</td>
<td><strong>36 937 802.0</strong></td>
<td><strong>100%</strong></td>
<td><strong>36 937 802.0</strong></td>
</tr>
</tbody>
</table>

Peak-hour

<table>
<thead>
<tr>
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<th>Projet scenario (PRT)</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit</td>
<td>1 280 256.5</td>
<td>1 291 554.5</td>
<td>+ 11 298.0</td>
</tr>
</tbody>
</table>
- Total ridership for morning peak hour ≈ 30 000 users ↔ 300 000 P+E
- Total VMT ≈ 70 000 pax.km ≈ 1 600 h of vehicle usage (commercial speed + 15% margin)

Usage and benefits of the PRT system by O-D relation

<table>
<thead>
<tr>
<th>PRT Users</th>
<th>Travel time (minutes)</th>
<th>Generalized cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Share</td>
</tr>
<tr>
<td>Internal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 631</td>
<td>10%</td>
</tr>
<tr>
<td>Study area → Outside</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 900</td>
<td>30%</td>
</tr>
<tr>
<td>Outside → Study area</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 853</td>
<td>56%</td>
</tr>
<tr>
<td>Transit</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26 680</td>
<td></td>
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</tbody>
</table>

Distances traveled by mode within the study area

<table>
<thead>
<tr>
<th>Passenger-Kilometers Traveled</th>
<th>No PRT</th>
<th>PRT</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>156 871.7</td>
<td>159 368.2</td>
<td>1.59%</td>
</tr>
<tr>
<td>RER</td>
<td>397 931.6</td>
<td>399 413.6</td>
<td>0.37%</td>
</tr>
<tr>
<td>Subway</td>
<td>447 721.2</td>
<td>435 486.1</td>
<td>-2.73%</td>
</tr>
<tr>
<td>Tramway</td>
<td>21 991.2</td>
<td>15 894.4</td>
<td>-27.72%</td>
</tr>
<tr>
<td>Bus</td>
<td>42 148.9</td>
<td>24 910.1</td>
<td>-40.90%</td>
</tr>
<tr>
<td>PRT</td>
<td>X</td>
<td>68 912.3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1 066 664.6</td>
<td>1 103 948.8</td>
<td>3.50%</td>
</tr>
</tbody>
</table>
Preliminary results step 1

PRT usage (2)

FLOWS

VOLUME OF TRIPS AND PRT SHARE
Usage of the Saint-Denis Pleyel station

Efficiency as a feeder system

Preliminary results step 1
Optimal fare

- Appraisal based on the analysis of generalized cost savings

→ Fare = 1.25€ / Revenue = 25 k€ (for morning peak hour only)
- Step 2: check system feasibility from an operational perspective
  - use of micro-simulation to model operations
- PRTsim
  - micro-simulator developed by Pr.Andreasson
  - passengers treated on an individual basis
  - supports grouping strategies at the passenger level
  - offers various control strategies at the vehicle level (centralized, decentralized…)
  - very fine network representation
  - can model ticketing
Results from micro-simulation

- Modelling assumptions
  - Vehicle fleet: 900 units (6-seat capacity)
  - Car-sharing (subject to matching criteria)
  - Control strategy:
    - Leave when 4 seats are taken or 1 minute after the boarding of the 1st passenger

- Results
  - Intensive use of the PRT network
  - Efficient operations…
    - Low waiting time
    - Very limited congestion, even on the most critical link
  - allowed by
    - High level of car-sharing
    - Low share of empty trips (16%)

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</thead>
<tbody>
<tr>
<td>Vehicle fleet</td>
<td>900</td>
</tr>
<tr>
<td>Passenger trips</td>
<td>23,906</td>
</tr>
<tr>
<td>Passengers matched</td>
<td>59%</td>
</tr>
<tr>
<td>Average load per car of 6 seats</td>
<td>3.6 of 6</td>
</tr>
<tr>
<td>Departure for 2 or 3 stops</td>
<td>18+6%</td>
</tr>
<tr>
<td>Extra stops per passenger trip</td>
<td>0.21</td>
</tr>
<tr>
<td>Average (99%, max) wait time</td>
<td>1.0 (3.2, 5.3) minutes</td>
</tr>
<tr>
<td>Average ride time including stops</td>
<td>4.8 minutes</td>
</tr>
<tr>
<td>Maximum vehicle link flow</td>
<td>1,850 vehicles/h</td>
</tr>
<tr>
<td>Maximum passenger link flow</td>
<td>6,900 passengers/h</td>
</tr>
<tr>
<td>Fleet running with passengers</td>
<td>84%</td>
</tr>
</tbody>
</table>
(Intermediate) Conclusions

- Promising results
  - Preliminary analysis shows latent demand for efficient feeder systems
  - Synergy with GPE

- Various caveats
  - Very optimistic assumptions regarding quality of service ⇒ sensitivity analysis
  - Need for cost analysis ⇒ more care in network design

- Future works
  - Study other stations and compare results
  - Investigate synergetic effects of deploying several PRT systems