Smart transfers through unravelling urban form and travel flow dynamics

M. Bierlaire  N. Molyneaux  R. Scarinci  Y. Oyama

November 19, 2018
Outline

1. The TRANS-FORM project
2. Pedestrian management
3. Management strategies: an example
4. Results
5. Conclusions
The TRANS-FORM project
Consortium

Academic partners

- Delft University of Technology, The Netherlands (Project Coordinator)
- École Polytechnique Fédérale de Lausanne, Switzerland
- Linköping University, Sweden
- Blekinge Institute of Technology, Sweden

Expertise

- Urban public transport
- Human mobility
- Train operations optimization

Industrial partners

- IBM Research, Switzerland
- ETRA (Mobility and Integrated Services), Spain

Expertise

- Big data
- Traffic data visualization
Stakeholders

Public authorities & (private) operators

- HTM, public transport operator in The Hague
- City of Den Haag
- Railforum, network of Dutch urban public transport companies
- Regional public transport authority of Blekinge
- Trafikverket, Swedish Transport Administration
- EMT, public transport operator in Madrid
- DGT and TPG, public transport agency and operator in Geneva
- SBB Swiss Federal Railways

Roles

Data Providers | Current practice | Future needs
Stakeholders

Roles

Data Providers: TPG, SBB, DGT

Current practice: BTH, LiU, EPFL, IBM, TUD

Future needs: Netport Karlshamn, Trafikverket, Blekinge trafiken, ETRA, EMT, HTM, Den Haag, Rail Forum

Data Providers: TPG, SBB, DGT

Current practice: BTH, LiU, EPFL, IBM, TUD

Future needs: Netport Karlshamn, Trafikverket, Blekinge trafiken, ETRA, EMT, HTM, Den Haag, Rail Forum
Goals

Understand transferring dynamics in public transport systems

- Multi-modal, multi-level
- Traveler-focused metrics
- Smart/Big-data exploitation

Develop methods for operating robust services

- Real-time, disruption, integrated
- More accurate models
- Improved management strategies

Apply (simulation) and evaluate transfer strategies

- Strategies for operators
- Practical recommendations
Key aspects

Move from tactical to real-time coordination
- Real-time operations and control
- Short-term forecasts

Consider the different operators involved
- Stakeholder involvement
- Identify integrated traffic management plans

Focus on the travellers rather than the infrastructure
- Passenger behavior and experience
- Normal operations and under disruptions
Modelling

Key aspects

- Passenger oriented
- Smart/Big data approach and visualization
- Multi-level

Case studies

- Blekinge Region, Sweden
- Den Haag, Netherlands
- Lausanne, Switzerland
Case study: Regional (Blekinge, Sweden)

Location

Data

Goals

• Assessing passenger flows between regional and national train services.

• Design and optimization of robust services of trains and connections.
Case study: Urban (Den Haag, Netherlands)

Location

Goals

- Inferring passenger transfers between train, metro and buses.
- Real time information and strategies for transfers.

Data
Case study: Hub (Lausanne, Switzerland)

Location

Goals

- Modelling pedestrian movement inside transportations hubs.
- Development and testing of pedestrian management strategies.

Data
Pedestrian management
Context

Pedestrians suffer from congestion just as vehicles do:

- increased travel time,
- excessive density.

Which in turn can make you:

- be late for your job interview,
- despise traveling with public transportation,
- miss your connecting train or plane,
- ...


11 / 26
Context

Higher capacity & faster PT services, to serve higher demand.
Context

Some of the services available at the Lausanne (CH) train station...
Motivation

- Lack of comfort, hazardous situations, miss connections.

- How to prevent this? Some possibilities:
  - Decrease pedestrian demand (counter productive!)
  - Spread the load over time & space
  - Influence pedestrian’s routes
  - ...  

- Simulation is needed to address the complexity of the problem

Goal: **Integrate management strategies specific to pedestrian traffic within a Dynamic Traffic Management System (DTMS).**
Framework

Traffic controller

State evaluation → Decision taking

Flow separators

Control devices

Data

Pedestrian traffic

Pedestrian motion

Activity scheduling
- activity location
- route choice

Reality/Simulation

Policy Application

Implementation
Possible strategies

(a) time table

(b) moving walkways

(c) gating

(d) separating flows
Existing strategies

Road traffic management

- Ramp metering
- Perimeter control
- Variable message signs
- Traffic lights
- ...

Pedestrian management

- Little research on dynamic strategies.
- Some static measures (design) have be studied.
Management strategies: an example
Objective

Head-on-head “collisions” induce significant extra travel time.

⇓

Reduce this counter-flow to a minimum.

⇓

Dynamically allocate part of the available corridor width to each direction.
Setup

Figure: Schematic presentation of the devices used to separate the opposing flows. The inflow at each end determines the width available to each directed flow.
Width available for each direction is proportional to flows:

\[ w_{AB}(t) = \begin{cases} 
  w_{AB}^{min}, & \text{if } w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}} \leq w_{AB}^{min} \\
  w_{AB}^{max}, & \text{if } w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}} \geq w_{AB}^{max} \\
  w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}}, & \text{otherwise}
\]
Results
Simulation environment

Traffic controller

Descrete event simulator

Control devices

Reality/Simulation

Pedestrian traffic

Microscopic pedestrian simulator: NOMAD (TU Delft)

DATA

APPLICATION
Case study setup

(a) Demand pattern

(b) Corridor setup

\[ \begin{align*}
q_{BA} & \downarrow \\
q_{AB} & \uparrow \\
w_{AB} & \leftrightarrow \\
w_{BA} & \leftrightarrow
\end{align*} \]

Possible range of node walls

Flow separator

\[ q_{\text{pedestrian flow}} \]
Travel times

(a) Without flow separators

(b) With flow separators

Significant improvement in

- mean travel time: 37.86s $\rightarrow$ 30.31s ($-19\%$)
- travel time variance: 9.94s $\rightarrow$ 3.39s ($-66\%$)
Conclusions
Conclusions

- Big picture: integrated multi-level, multi-modal approach.
- Focussed research objective: pedestrian DTMS.
- Real-time monitoring, control and information.
- Simulation-based.
- Years of research and development for vehicular traffic.
- Almost nothing for pedestrians.
- Illustration: flow separators.
Next steps

1. Prediction based.
2. Dynamic control: moving walkways.
3. Information: compliance.
4. Simulation based optimization.
Acknowledgments

This research was performed as part of the TRANS-FORM (Smart transfers through unravelling urban form and travel flow dynamics) project funded by the Swiss Federal Office of Energy SFOE and Federal Office of Transport FOT grant agreement SI/501438-01 as part of JPI Urban Europe ERA-NET Cofound Smart Cities and Communities initiative. We thankfully acknowledge both agencies for their financial support.