Functional Design of Physical Internet Facilities: A Road-Rail Hub

Ballot, Eric, Montreuil, Benoit and Thivierge, Collin

MINES ParisTech

UNIVERSITÉ LAVAL

Objective

In their 2010 IMHRC paper, Montreuil, Meller and Ballot proposed a set of facility types that would be necessary to operate a Physical Internet, which they termed "π-nodes". This paper is part of a three-paper series for the 2012 IMHRC where the authors provide functional designs of three π-nodes.

The objective of the Road-Rail π-Hub is to overcome the current drawbacks of classic railcars marshaling yards : shocks, lead-time, delay, safety issues, huge land footprint.

The objective for the π-hub is to :
1)Operate full trains without unhooking locomotive or railcars
2)Handle and sort π-containers instead of railcars
3)Allow short stops at each hub
4)Minimize the environmental footprint (land consumption and emissions)

Background

CLAIM
The way **physical objects** are
moved, handled, stored, realized, supplied and used
throughout the world is **not sustainable**
economically, environmentally and socially

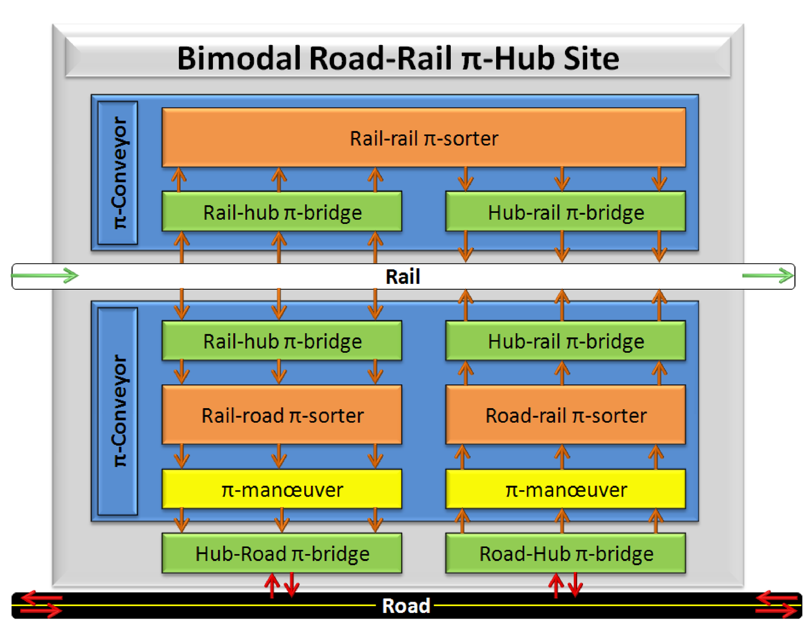
GOAL
Enabling the global **sustainability**
of bringing to users from around the world
the physical objects they need and value,
through a **triple synergistic gain**
in terms of economy environment and society

VISION
Evolving towards a worldwide **Physical Internet**

AN EFFICIENT ROAD-RAIL HUB IS A MAJOR ENABLER TO SHIFT LOADS FROM CONGESTED ROADS TO RAILROADS AND TO REDUCE INLAND LOGISTICS' EMISSIONS BY A FACTOR 2 OR MORE

Methodology

To reach these goals, the key functions of a road-rail π-hub are:
1. to receive trucks and handle π-containers so they can be sorted and loaded in the train *(π-hub's bottom right corner)*;
2. to call trucks to pick up π-containers and move them to the next π-node or the final destination *(bottom left corner)*;
3. to unload π-container from railcars and load π-containers to railcars in a given time window *(center)*;
4. to handle and sort π-containers in connection with another train *(upper part)*.

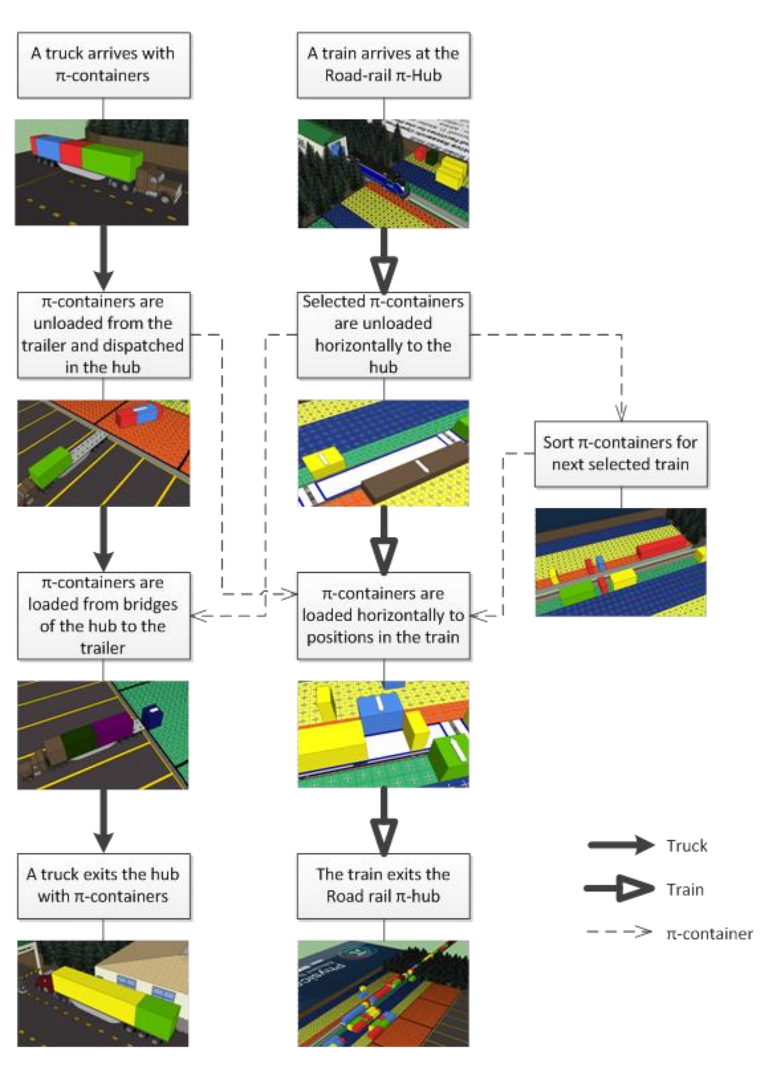


Three processes in parallel

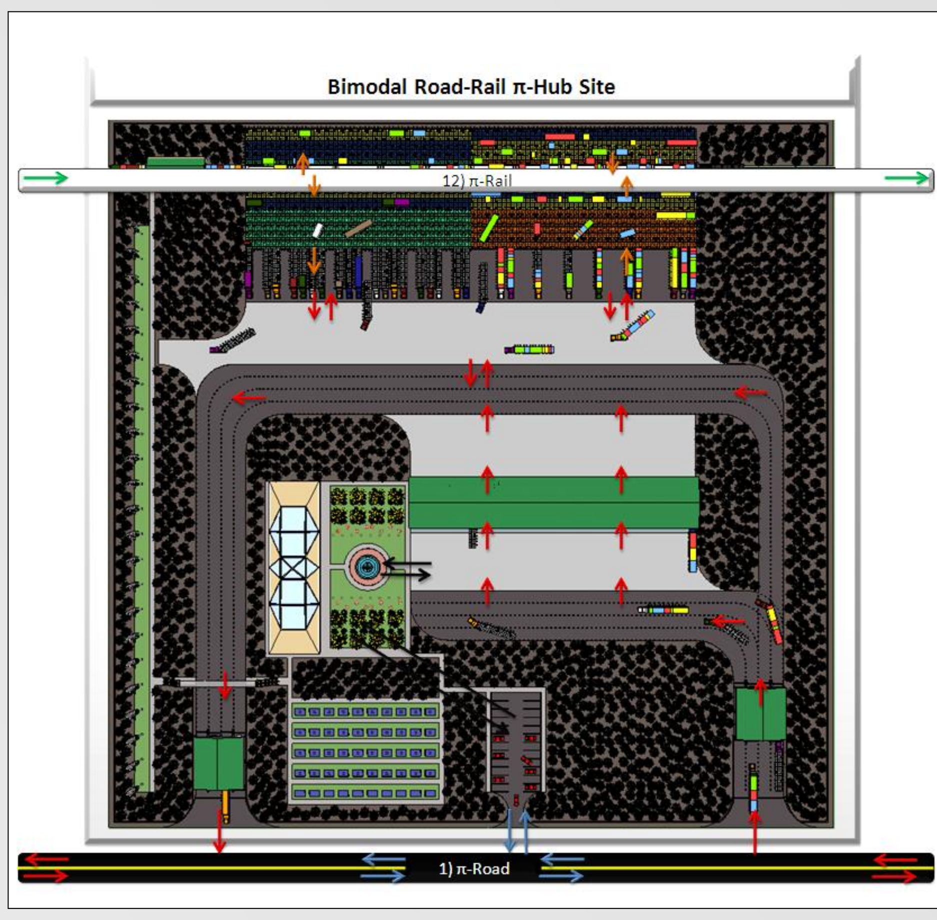
Left column: truck processing
•π-containers check in
•Inbound π-containers handling and sorting
•Outbound π-containers handling and sorting
•π-containers departure towards π-hubs or final destination

Central column: train processing
•Train arrives
•Inbound π-containers unloading from railcars
•Outbound π-containers loading to railcars
•Train leaves towards next Road-Rail π-Hub

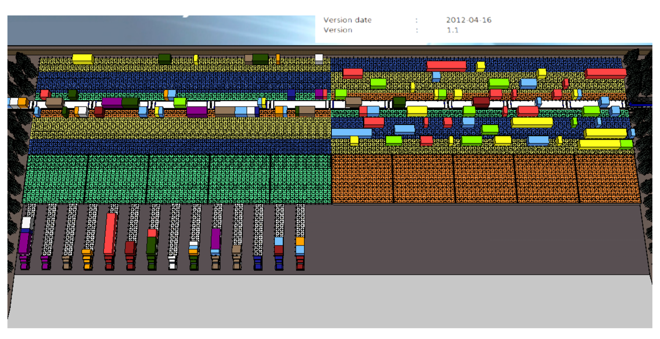
Left column: in-transit π-container processing
•Sort π-containers arrived from a previous train to be loaded on the next one, heading to their destination



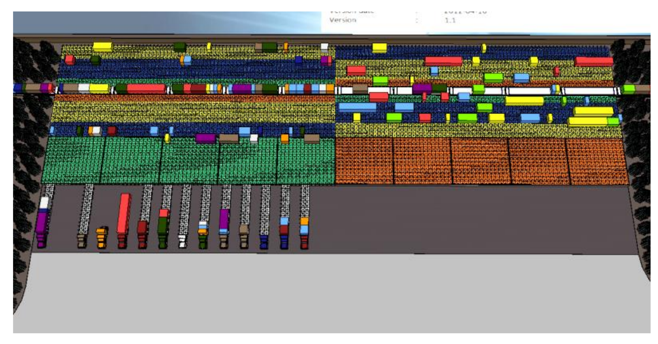
Results



Train position 2



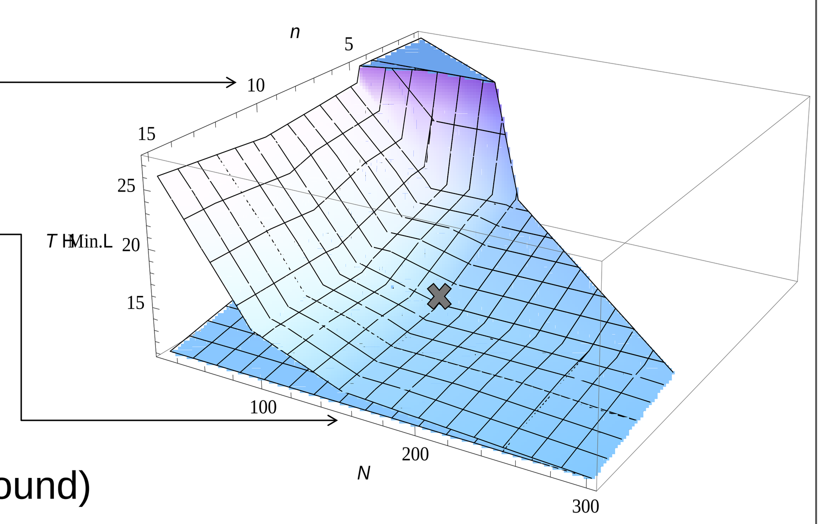
Train position 3



Example of dimensioning

KPI for 20 trains of 30 railcars per day 7 days a week p=1/3	Value
Customer	
Processing Time (Train)	25 minutes
Arrival of trucks per hour (Truck)	6.25
Average trains in connections	4
Maximum connecting time between road and rail	2h24 min.
Maximum connecting time between trains	4h48 min.
Operator	
Area of road-rail hub itself (without roads)	12,000 m^2
Number of railcars processed in parallel (load & unload)	10
Number of rows of π conveyors from road to train or vice versa	4
Number of rows of π conveyors from a train to another one	4
Number of containers processed in parallel per railcar	15
Number of road gates (In)	4
Number of road gates (Out)	4
Number of bridges Bays	24

Handling time vs. two design parameters
- Number of railcars processed simultaneously
- Maximum number of containers processed simultaneously per railcar



Up to 1800 EVP / 24 hours (inbound and outbound)

Conclusions

The goal was not to produce the design of a PI road-rail hub.

Our primary goal was to produce a functional design that performed at an acceptable level in terms of user key performance indicators (KPIs) and explore its robustness with various flows.

This design is only handling a subset of PI containers already, yet it shows a possible improvement by an order of magnitude by sorting containers instead of railcars as marshaling yards do.

The proposed design is fully scalable to manage growth.

To illustrate our subject we proposed the design of a specific configuration.

Future Work

There could be configurations capable of dealing with multiple trains concurrently.

A comprehensive discrete-event simulation model is now required to measure accurately the foreseen performance and adjust resources in the sizing of the components.

In this process, it will be particularly helpful to have discussions with companies able to supply the technologies embedded in the hub in order to further validate, and amend as necessary, the hypotheses made here, especially the handling times, conveyors speeds, sorting algorithms, just to mention the more important ones.

Acknowledgments

This research was supported in part by PREDIT Transport Research program, NSERC Discovery Grant Program, Canada Research Chair in Enterprise Engineering, and MHIA through its member organizations.

CICMHE COLLEGE-INDUSTRY COUNCIL ON MATERIAL HANDLING EDUCATION

2012 International Material Handling Research Colloquium