Functional Design of Physical Internet Facilities: A Road-Rail Hub  
Ballot, Eric, Montreuil, Benoit and Thivierge, Collin

**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 "x-nodes". This paper is part of a three-paper series for the 2012 IMHRC where the authors provide functional designs of three x-nodes. 

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

The objective for the x-hub is to: 
1)Operate full trains without unhooking locomotive or railcars 
2)Handle and sort x-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 x-hub are: 
1. to receive trucks and handle x-containers so they can be sorted and loaded in the train (x-hub’s bottom right corner) 
2. to call trucks to pick up x-containers and move them to the next x-node or the final destination (bottom left corner) 
3. to unload an x-container from railcars and load x-containers to railcars in a given time window (center) 
4. to handle and sort x-containers in connection with another train (upper part). 

Three processes in parallel 

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

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

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

Results

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

*Example of dimensioning* 

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containers</td>
<td>200, 300, 400</td>
</tr>
<tr>
<td>Time window</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Number of railcars processed simultaneously</td>
<td>100, 200, 300</td>
</tr>
<tr>
<td>Maximum number of containers processed simultaneously per railcar</td>
<td>10, 20, 30</td>
</tr>
</tbody>
</table>

Conclusion

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.

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