A Decision Support System for Synchromodal Transport and the Physical Internet

PhD Candidate: Tomas Ambra
Supervisors: Prof. dr. Cathy Macharis, Prof. dr. An Caris

Freight transportation forms an imperative pillar of our society and economy. However, with projected growth of international trade and cargo demand, the current infrastructural capacities are put under pressure, resulting in congestion problems, safety issues, environmental concerns and decreasing reliability of services. The PhD addresses the Physical Internet and Synchromodal transport concepts which present opportunities to improve the current unsustainable freight transportation, by increasing fill rates and inducing a positive modal shift from roads to rails and inland waterways.

On one hand, Synchromodal transport concerns operational aspects such as real-time re-routing of loading units over the network to cope with disturbances and/or customer requirements. On the other hand, the Physical Internet is to replicate the digital internet by mimicking digital flows in the physical world; the same way messages are delivered via the internet, the goods could be delivered via the Physical Internet. The first contribution of the PhD thesis is conceptual, where the main objective is to assess and explore the correlations between these two concepts in order to understand how they can reinforce each other.

The logic of the two concepts is assessed by a dynamic computational model (SYMBIT) which computes movements of agents in geographically referenced space. The SYMBIT model captures stochastic parallel processes for each mode, and simulates decentralized delivery performances of orders and assets. The methodological contribution rests on the combination of agent-based modelling, discrete-event modeling and Geographic Information Services (GIS). SYMBIT’s architecture and its abilities are applied to two case studies.

The case studies form the empirical/experimental contributions. The first case is a synchromodal application with an interregional European focus. The routing of individual orders and their responsiveness to disruptions are studied on a sample which concerns imports of retail goods by unimodal truck (road-only) transport from France to Belgium. The case tests synchromodal resilience to perturbations where the dynamic re-routing and modal switching is compared to static intermodal solutions. The objective is to provide a deeper understanding of modal shift potential in recovery settings. The objective of the second case is to investigate the impact of inserting extra service points into existing dedicated freight flows of a service driven company in Brussels. The model simulates different transparency levels, routings to new pick-up locations, and evaluates the impact in terms of altered lead-times, covered distances and fill rates.

The SYMBIT model and its simulations rely on network openness and benevolence of other carriers to flexibly change and/or bundle goods in a virtual risk-free environment. The final practical contribution refers to the exploration of how to connect the risk-free virtual environment and its functionalities to the physical system, so that users can assess different what-if scenarios when needed. In this regard, the concept of digital twinning (or Digital Twin) is discussed in relation to modelling, new applications, sensor technologies as well as stakeholder involvement and their role(s) in digital freight networks.