Synchromodal transport re-planning using Agent-Based Modelling

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Introduction

Synchromodal Transport (ST) is an evolution of multimodal transport, where involves the **flexible** planning of transport processes and the ability to switch in **real-time** between modes of transport based on the the available resources, imposing complexity to the planning process. It offers **integrated**, **optimal**, and **sustainable** logistics solution.

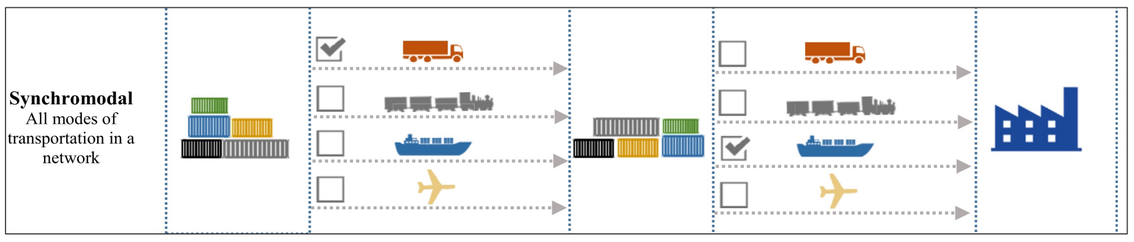
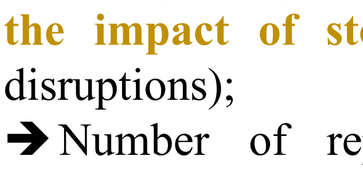


Fig1: A representation of ST [1]

Methodology

Agent-Based Simulation



- To study multiple actors' behaviour;
- Their interconnectivity and interactions.

Scope: Regional-level network;
Decision horizon: Short-term;
Prespective: Logisitcs service providers' (LSPs');
Logistics operations: Centralized and decentralized;
Goal: to transport orders to their destinations within the time window, while minimizing the costs and emmissions.

Simulation model

The model represents the operation of several LSPs, interacting to meet the transport requests. The model is a combination of short and long- haul transport. Roads, rails, and IWW are the available modes. Trucks are flexible, but trains and barges follow fixed schedules. Orders arrive **stochastically** in the system.

The **objective function** is:

➔to minimize the costs (delays, transport, transhipment);
➔to minimize the climate change impact (CO_2 emmissions cost).

An experiment is conducted in the Benelux (Belgium, Netherlands, Luxemburg) region (Fig2).

The model considers **disruptions** in the network, which results in modifications in the travel plans according to the **LSPs strategies toward the disruptions:**

(1) Conventional routing (**business as usual scenario**);
(2) Flexible re-routing (**synchromodal scenario**).

Three types of relations/collaborations between LSPs are also studied: **competitive**, **collaborative**, **centralized.**

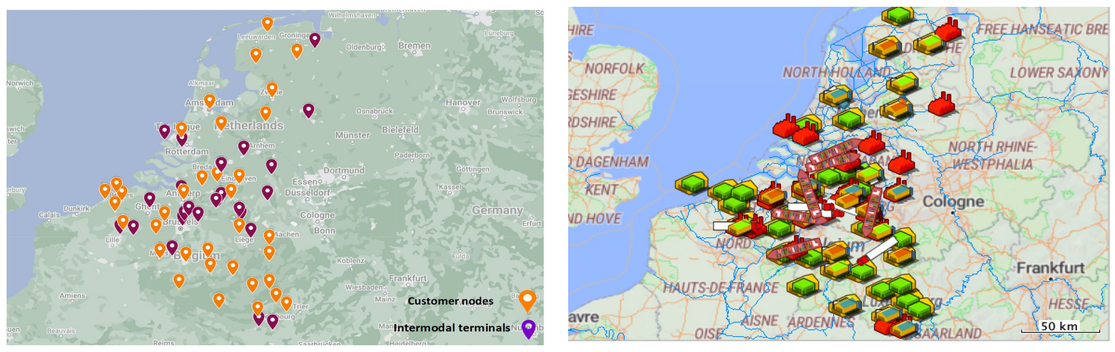


Fig2: geographic scope of the experiment

Experimental results

➔Multiple replications conducted **to reduce the impact of stochasticty** (in demand and disruptions);
➔ Number of replications decided by the software (Anylogic) based on normal disribution and at 90% confidence- level (of total cost expression);
➔ Anylogic stopped after 6 replications.

	Bussiness-as-usual	Synchromodal	
Total cost (€)	1.299.307	1.102.783	-15%
Monetary costs (€)	1.478.731	1.221.333	-17%
Emission cost (€)	880.651	826.164	- 6%
Orders transported multimodal (%)	34	44	+29%
Late deliveries	24	9	-62%
Capcaity utilization (%)	20	36	+80%

Promising outcomes

- ST planning is more **cost and environmentally efficient** than conventional planning methods;
- ST increases **flexibility** and **reliability** of the system, as the probability of **delivering orders on time** is considerably higher than business as usual scenarios;
- In synchromodal transport, the level of **capacity utilization** is greater.
- A **centralized approach**, yields in several advantages; increased efficiency, capacity utilization, as well as cost reduction.

Reference:
[1] Farahani, N. Z., Noble, J. S., Klein, C. M., & Enayati, M. (2018). A decision support tool for energy efficient synchromodal supply chains. *Journal of Cleaner Production*, *186*, 682-702.

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