Synchromodal transport re-planning:
an Agent-Based Modelling approach

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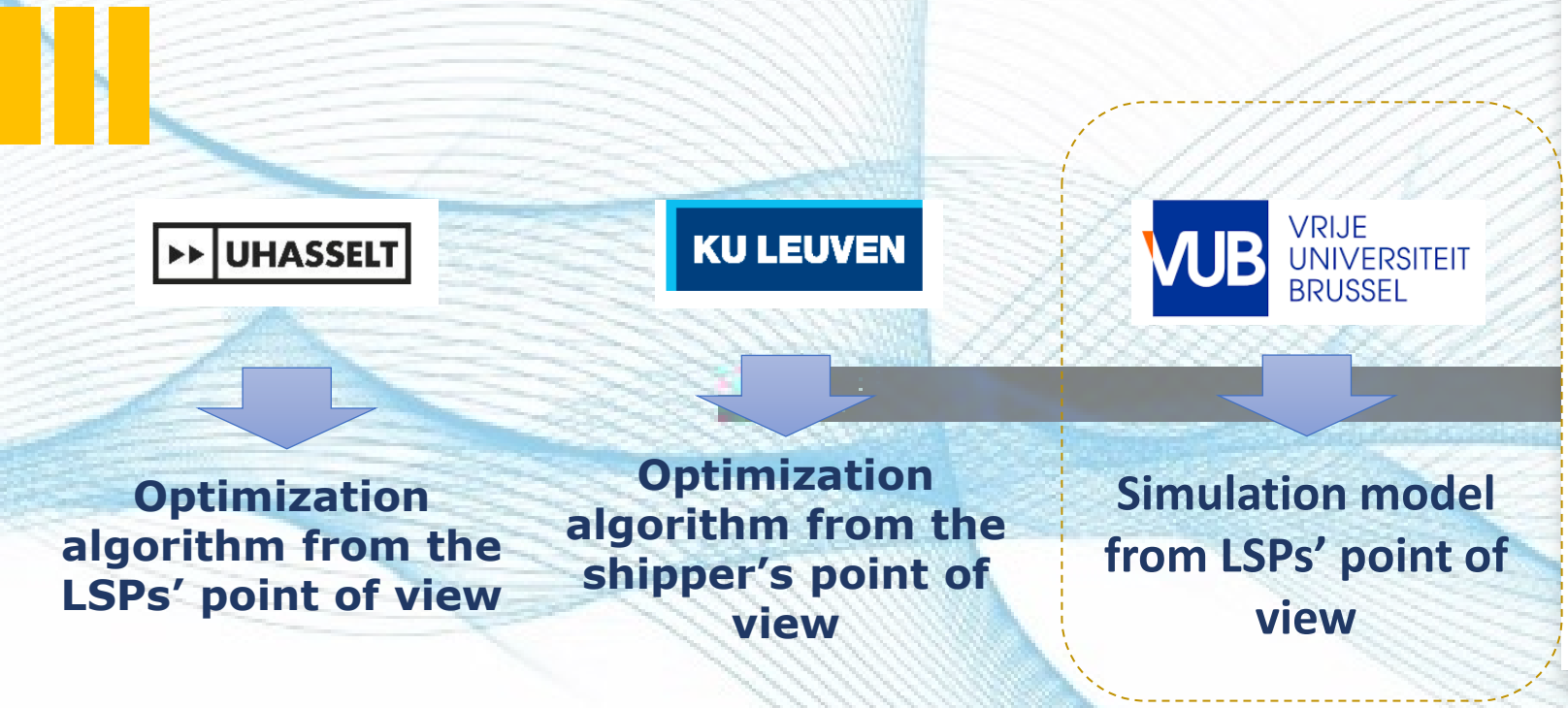
Dispatch project:

Digital Twin for Synchromodal Transport



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Simulation model

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- **What?** Agent-Based simulation of Synchromodal Transport
- **Scope:** Regional-level
- **Decision horizon:** Short-term
- **Prespective:** Logisitcs service provider
- **Logistics operations:** Centralized and decentralized
- **Goal**: to transport orders from their origins to the destinations within the time window, while minimizing the costs and emmissions.

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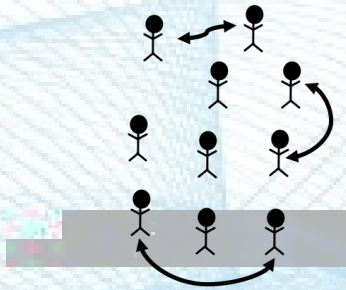
Main research questions to be answered:

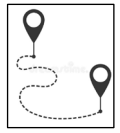
- Can ST contribute to freight modal shift by making a difference in economic and environmental costs, flexibility, reliability, and capacity utilization in compare with conventional multi-modal transport planning?
- Can horizontal collaboration between actors (in addition to vertical collaboration) improve the functioning of the ST system?

Methodology

Using **Agent-Based Modeling (ABM),** we study the behavior of multiple actors involved in a synchromodal transport system and their interactions, as well as the impact of their behavior on the entire network.



main agents in our model

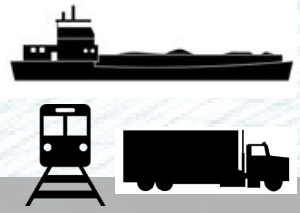


Origins,Destinations

Multimodal terminals

Depots

LSPs



Vehicles

Orders (containers)

➔ Provides the flexibility and adaptability to design heterogeneous actors that interact with each other!

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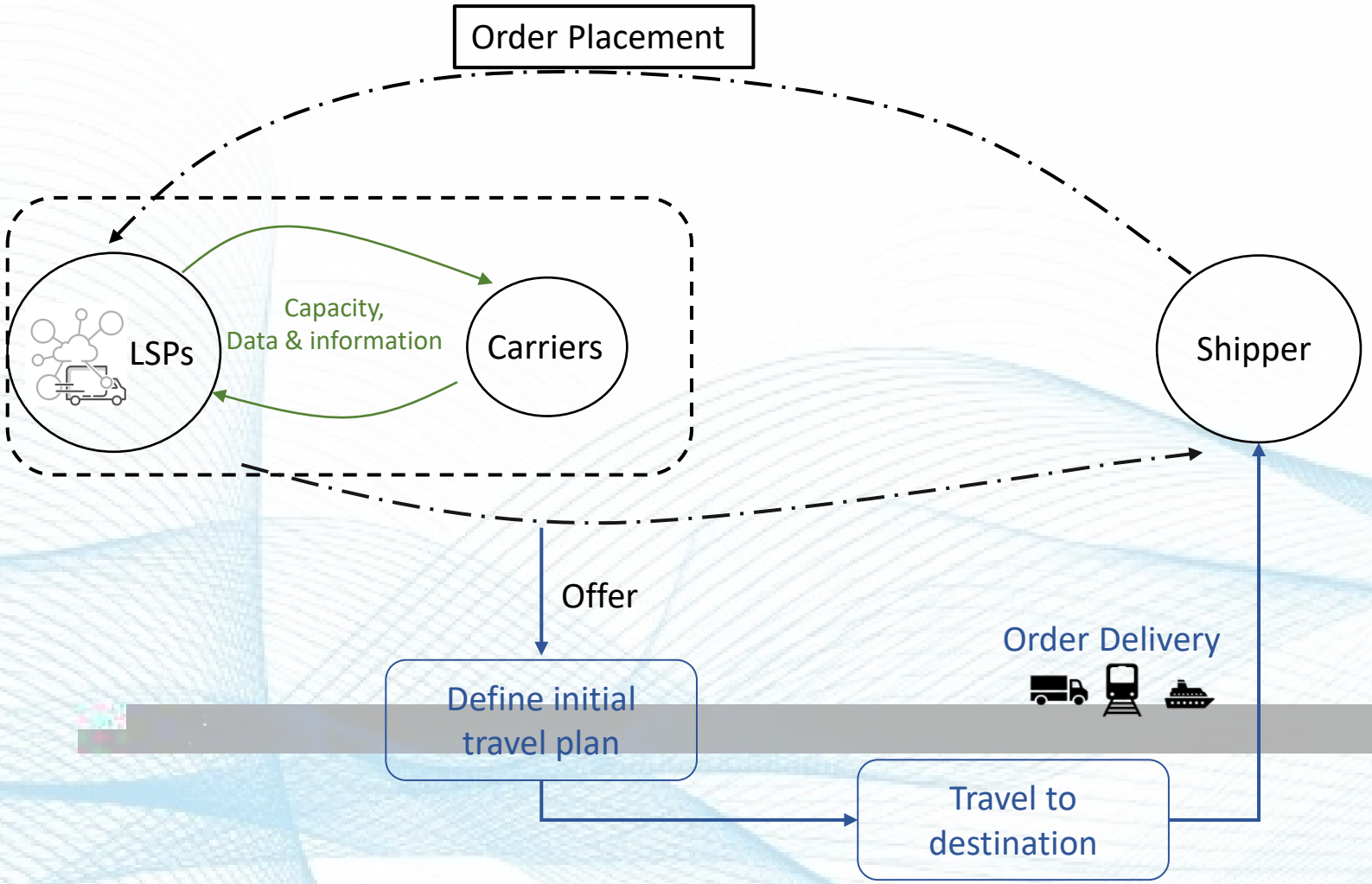
Model’s assumptions

- A regional-level logistics network;
- LSP’s prespective;
- Multiple LSPs operating; all the lsps are multimodal;
- Each LSP works with multiple shippers;
- Combination of long haul and short haul;
- Orders arrive stochastically;each order= 1 container;
- One way delivery; all the orders are met;
- Three modes of transport: Roads and Rails, Inland Water Ways;
- Trucks: fleets of trucks (limited), and external (unlimited);
- External trucks without depots or returning time;
- One order per truck;
- Orders take shortest path (according to time, cost, emmissions or a combination);
- New tasks can be inserted in between a scpecific truck plan;
- The price per each mode of transport is a function of distance.

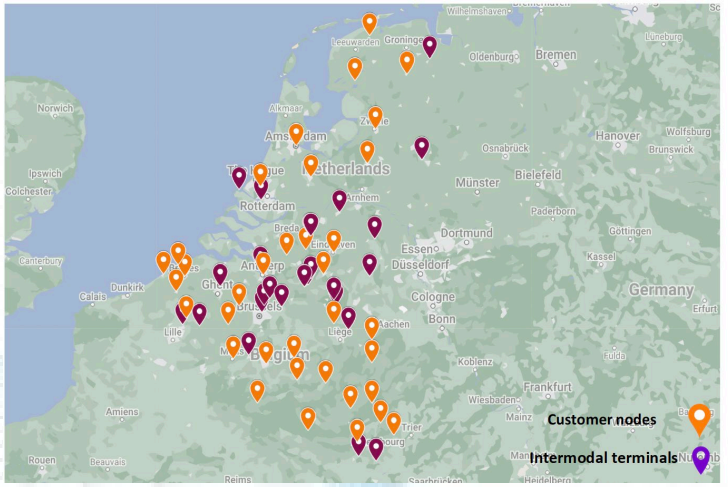
Model’s assumptions



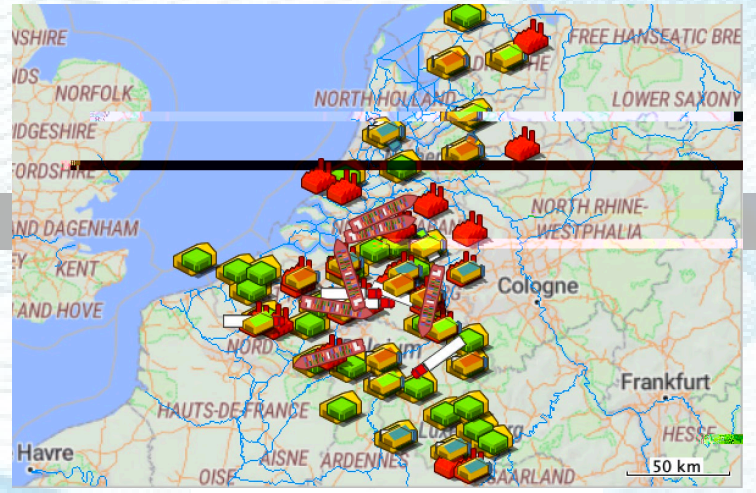
Case Study

The regional-level instance:

- 62 nodes: 27 intermodal terminal, 35 only truck access;
- 96 train services (each consisting of one or more legs);
- 80 barge services (each consisting of one or more legs);
- Capacity of 60 TEU for each train, 105 TEU for each barge;
- 3 LSPs;
- 500 orders/day- stochastic~ Poisson distribution (500);
- Service cancellation rate: 1 event/day- for barges and trains;
- Service delay rate: 4 event/day- for barges and trains;
- Delays [15- 60] mintues ;
- Each simulation run corresponds to 10 days of simulated time;



the GIS view of the studied network



the GIS view of the studied network in AnyLogic environment

Scenarios

3 levels of relations between LSPs

- Competitive;
- Collaborative;
- Centralized.

2 responsive scenarios toward disruptions

- Conventional re-routing;
- Flexible re-routing.

Scenario	Scenarios' name	(Re)routing strategy	LSP relation
S1	Conv-Comp	Conventional	Competitive
S2	Conv-Coll	Conventional	Collaborative
S3	Conv-Cent	Conventional	Centralized
S4	Flex-Comp	Flexible	Competitive
S5	Flex-Coll	Flexible	Collaborative
S6	Flex-Cent	Flexible	Centralized

Case Study- cnt'd

To Evaluate:

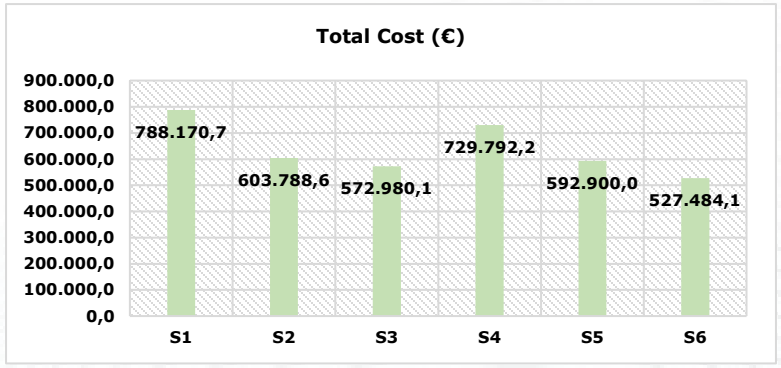
- Total costs;
- Emmission costs ;
- Orders late delivery
- Modal split;
- Resource utilization.

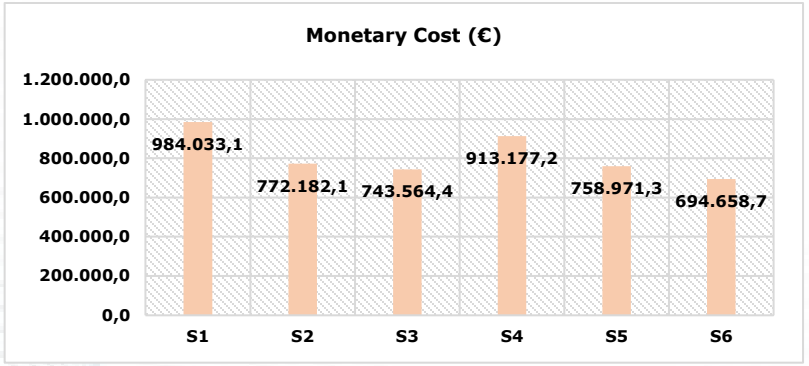
To reduce the the impact of stochasticty

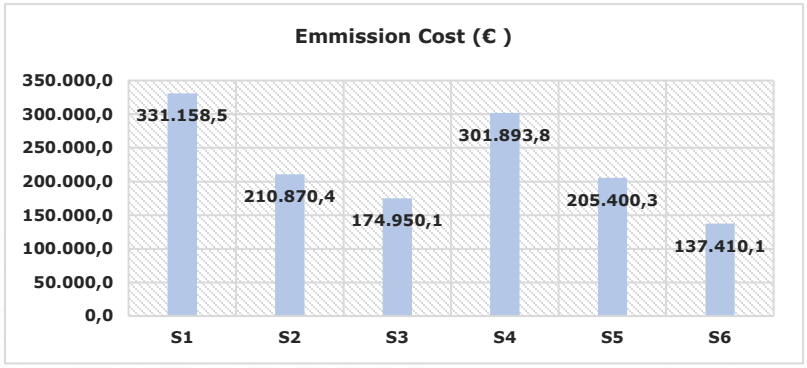
- Multiple replications;
- Number of replications decided by Anylogic
- Min=2, Max= 20;
- Minimum confidence level= 90% (for the total cost)
- Error = 0.005

- Anylogic stopped after 6 replications

Numerical experiment- results

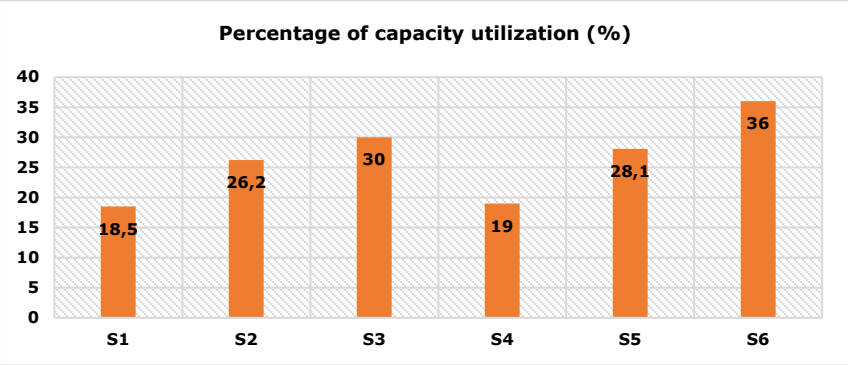


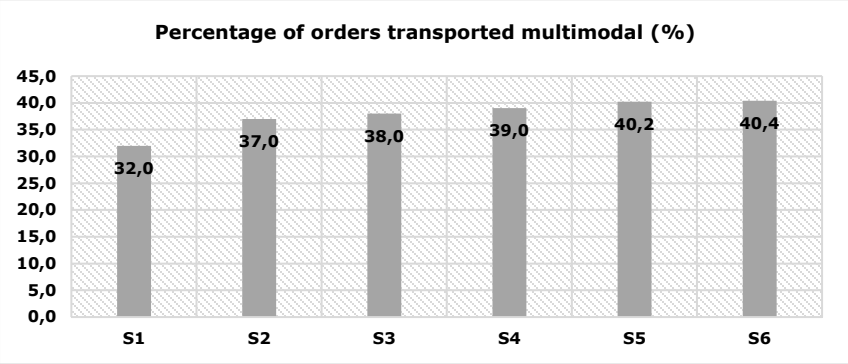


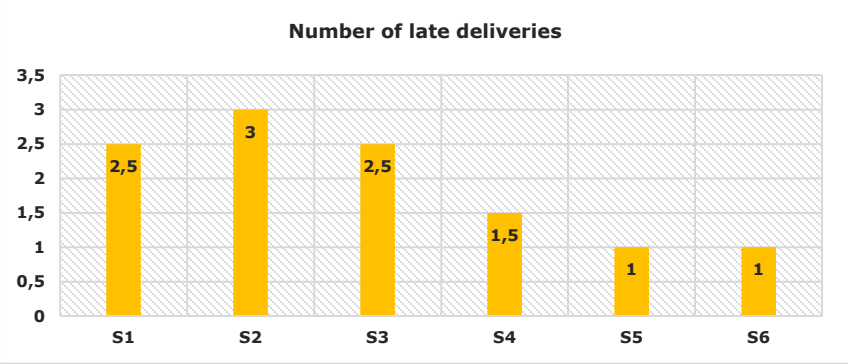


- The total cost in S1(BAU) ~ 48% higher S6 (ST); the cost efficiency of ST in compare with BAU;
- Flexible scenarios (S4,S5,S6) result in lower costs than the same scenarios in conventional approach (S1,S2,S3)- for emissions, monetary, and total costs;
- In the competitive scenarios (S1 and S4) the monetary are considerably (between 16% to 24%) higher than in the other scenarios- LSPs bear significant amount of costs if they opt for a competitive approach and do not collaborate with other LSPs.

Numerical experiment- results







- The highest share of capacity utilization is associated with the cases that a central operator manages all the capacities (S3, S6) and subsequently to the collaborative scenarios (S2, S4), where LSPs opt for collaboration with each other;
- Around 32%- 40% of the orders are transported at least in one leg by railways or inland waterways;
- In the scenarios without flexibility(S3, S1, S2), after disruptions, the number of late deliveries is larger- in the cases more related to ST (S4, S5, S6), the reliability is higher.

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Any Questions?

Let’s connect!

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