RESILIENCE IN PI

D2.2 REPORT: DISRUPTION SCENARIOS AND CONTINGENCY PLANS

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Introduction

In this research, we focus on our foundational scenario k1700 (see Living Lab Report – Simulation Model document), which involves the transportation of goods to and from DP World's terminal at PoAB to various locations in Belgium. This scenario notably includes a traffic congestion component, particularly around the port, leading to significant shipment delays.

We modelled this congestion effect using historical data from AWV's (Agentschap Wegen en Verkeer) conductive induction loops, which capture the average speed of vehicles on Flanders' motorways. With this dataset, we created hourly average speed profiles for different points along the road network, allowing us to adjust agents' speeds when traveling through affected sections. This modelling approach enables us to simulate realistic traffic conditions and understand the impact of congestion on transportation efficiency. By incorporating these detailed speed profiles, we can identify critical bottlenecks and assess how they influence shipment delays. Additionally, this data-driven method provides a robust foundation for evaluating potential solutions to mitigate congestion and improve overall logistics performance.

Given these road disruptions, our primary objective is to assess the impact of establishing hinterland hubs near the port. These hubs, equipped with train and barge connections to the terminal, aim to bypass the most congested road infrastructure and enhance overall system efficiency.

These hubs will provide alternative routes, serving as contingency plans. To achieve this goal, we need to consider the following questions:

1. What is the ideal location for these hubs?
2. When do the rail and barge connections of these hubs become economically viable?
3. Which hub provides the greatest advantages?

Main assumptions

1. Barges and trains run: all days of week, 2 times per day
    - closing times: 06h00 and 12h00
    - ready time: 12h00 and 18h00
2. Barges and trains have infinite capacity

Internal cost model

For this experiment we use the following cost model:

- Road transport cost: 1.65 eur/km
- Handling cost: 25 eur for 40' movement, 20 eur for 20' movement
- Storage cost: 0 eur

This applies to all transportation providers and hubs. In the case of non-road transport (rail + barge), we will adjust it proportionally to the cost of road transport. This adjustment helps us determine the point at which non-road transport becomes competitive compared to road transport.

External cost model

In order to compare transport cost with external cost, we propose the following model based on the Handbook on the External Cost of Transport:

Category	Mode of Transport	Cost (€-cent/tkm)
Climate Change	Truck (Euro V, 20-28t, motorway)	0.68
	Train (long train, electric)	0
	Barge (1500t, rural area)	0.21
Air Pollution	Truck (Euro V, 20-28t, rural area, motorway)	0.26
	Train (long train, rural area, electric)	0.004
	Barge (1500t, rural area, average emission class)	1.02
Accident	Truck (HGV)	0.07
	Train and barge	0
Noise	Truck (HGV, 16-32t, average traffic and daytime)	0.01
	Train (Average traffic and daytime)	0.01
	Barge	No data
Congestion	Truck (HGV, inter-urban area, motorway, road near capacity > 80%)	4.9
	Truck (HGV, inter-urban area, motorway, road well below capacity)	0
	Train and barge	No effects
Well-to-tank Emission	Truck (Euro V, 20-28t, motorway)	0.16
	Train (long train, electric)	0.11
	Barge (1500t)	0.09

Since we have a internal and external cost model, the routing finding preferences will be both costs:

total cost = transport and handling cost + external cost

Hub locations

We propose the following locations for hubs:

- **Sint-Niklaas** (51.1680055298701, 4.175421146195386)
    - straight line distance from k1700: **13.54 km**
    - with rail connections
- **Willebroek** (51.07092172498414, 4.3674684871163905) with barge connections
    - straight line distance from k1700: **24.77 km**
    - with rail connections
- **Grobendonke** (51.17919388033208, 4.742593716056671) with barges connections
    - straight line distance from k1700: **35.68 km**
    - with rail connections

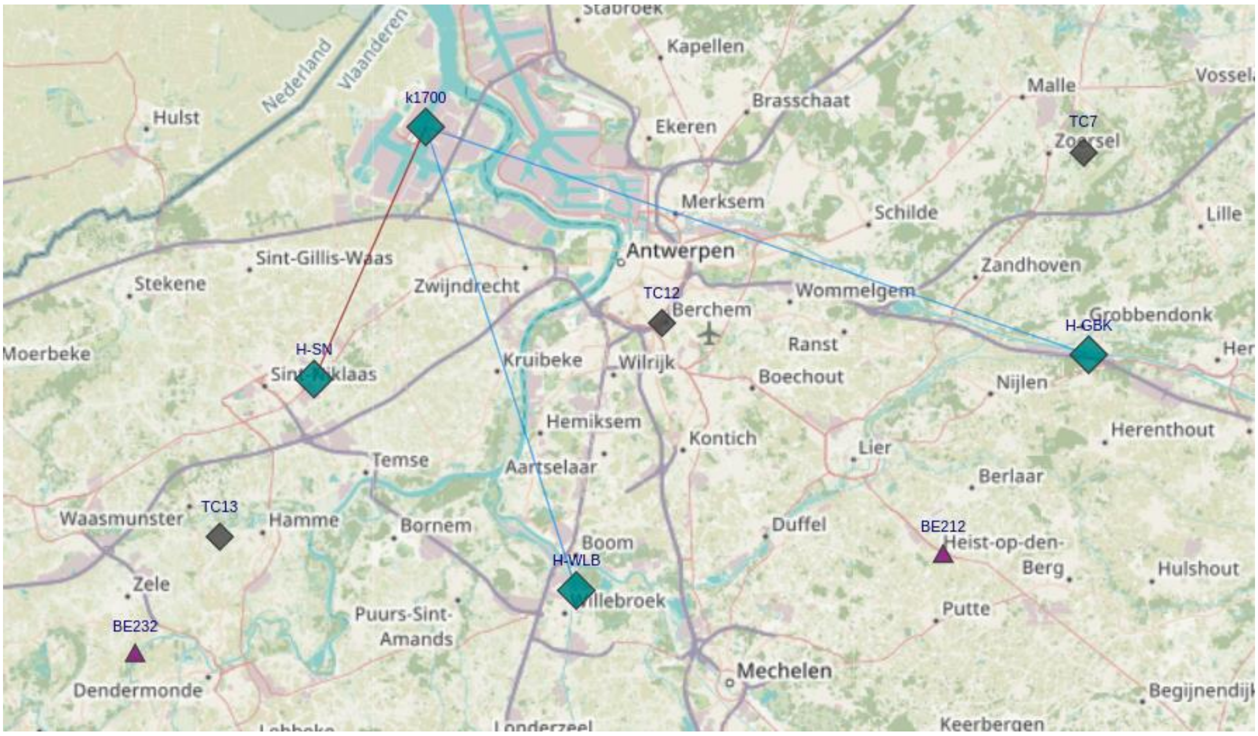
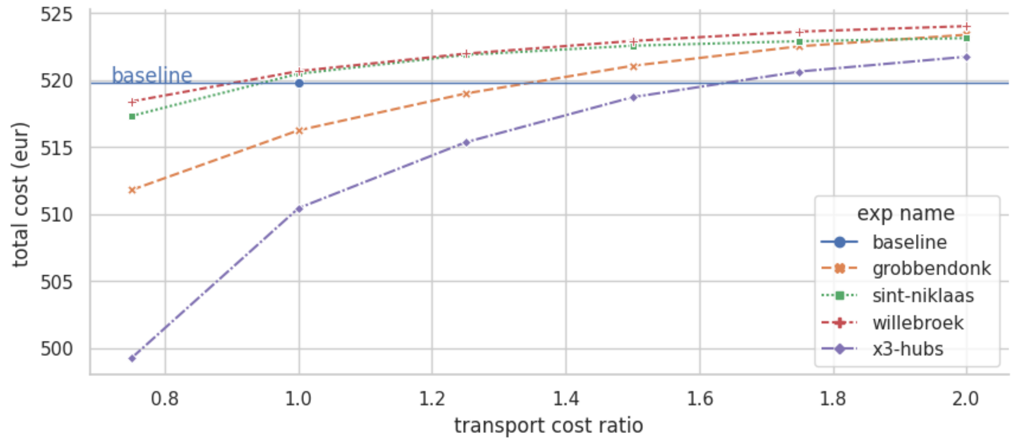


Figure 1: Inter-modal hubs around Port of Antwerp

Note that hubs situated near the port are often not economically viable for barge and train transport. This is typically applicable for hubs located > 500 km from the port. Therefore, incorporating external costs into the cost function becomes crucial.

Results

All output data can be found here. The results confirm that the overall cost (transport + external) decreases when more cost-effective non-road alternatives are accessible (fig. 2). This reduction is attributed to the consideration of external costs. Despite the increase in transportation expenses (fig. 3), there is a balancing act



with external costs (fig. 4). This equilibrium is particularly significant at lower transport cost ratios; however, the impact diminishes as the transport cost ratios rise, leading to outcomes more closely aligned with the baseline.

Figure 2: Average total cost per shipment

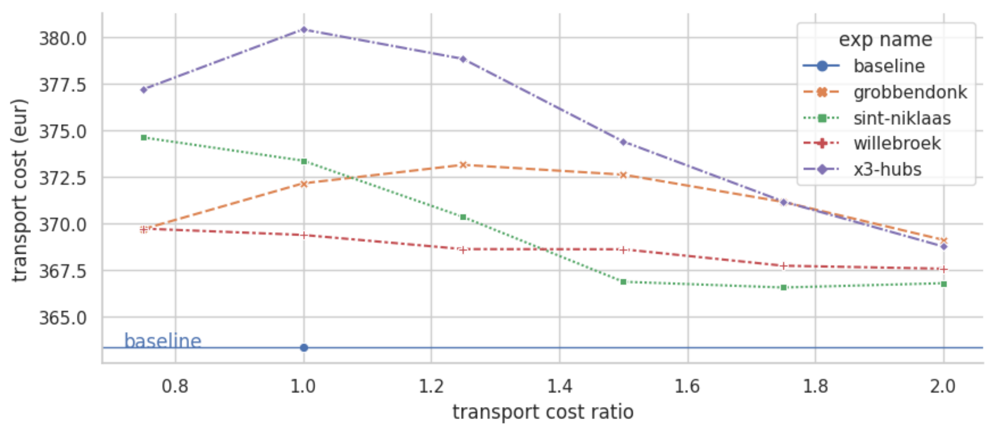


Figure 3: Average transport cost per shipment

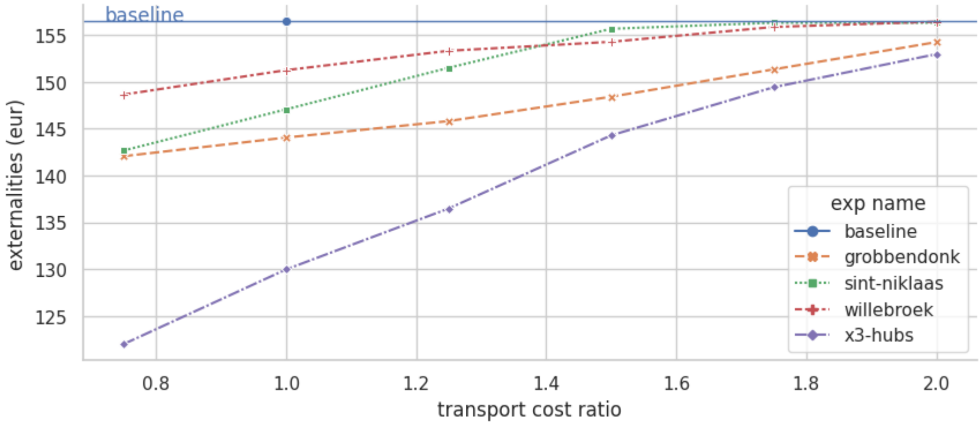


Figure 4: Average external cost per shipment

This effect is result of a lower utilization of non-road modes as they become less competitive, seen in fig. 6 as route distance by road increases. Conversely the tonne.km (fig. 7) and TEU (fig. 8) by barge and rail decreases.

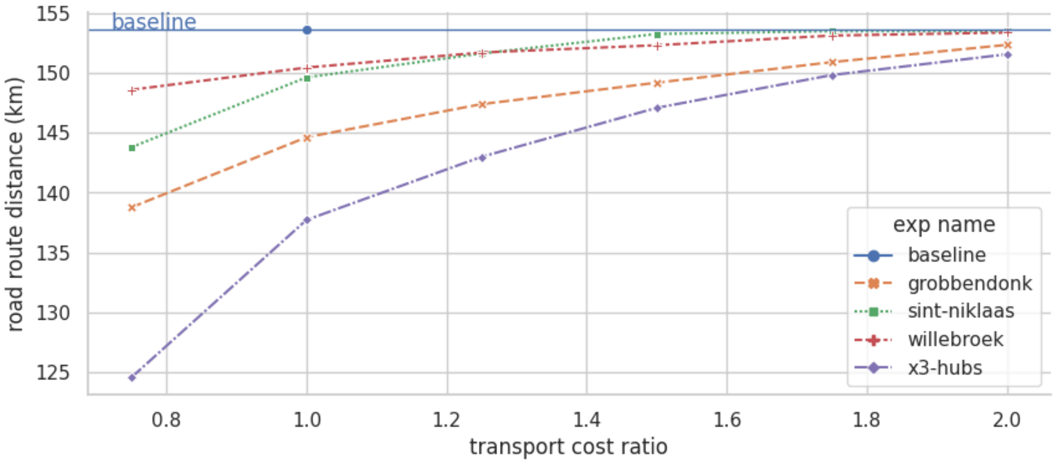


Figure 5: Average road route distance

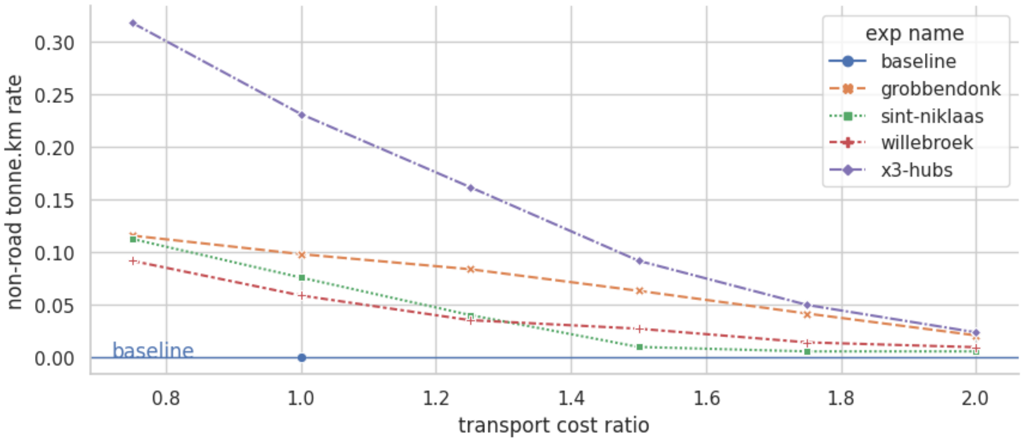


Figure 6: Mean non-road vs road tonne.km

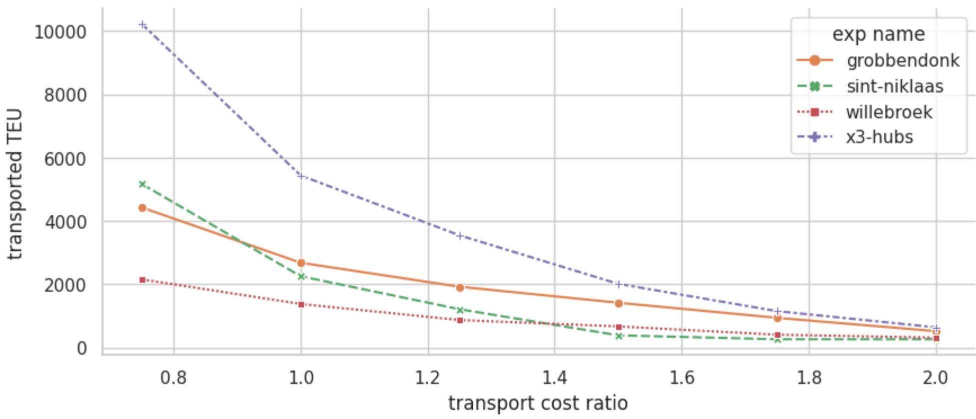


Figure 7: Mean transported TEU per corridor(s)

In terms of road disruptions (congestion), by avoiding the congested roads near Antwerp, we observe from fig. 9 that our most favourable scenario results in a 25% decrease in the average shipment road delay. Note that we did not model the terminal's truck slot system. Truck companies book time slots with the terminal operator and missing those slots requires a re-booking, which can result in further delays.

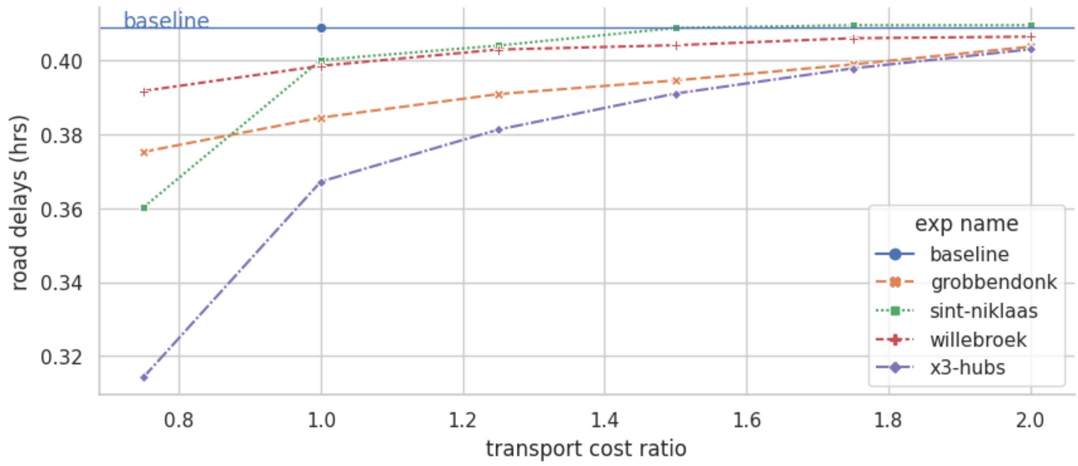


Figure 8: Average road delay per shipment

Conclusions

- Upon initial observation, the Grobbendonk hub demonstrates superior performance. At a transport cost 25% higher than road transport, it remains more cost-effective than relying solely on road transport when considering the overall expenses. It is important to highlight that Grobbendonk serves as the hub farthest from the port, which aligns with the assumption trains and barges are more competitive for longer distances.

- More significantly, the synergy among the three hubs results in a collective positive impact. Despite a 50% increase in transportation expenses, it still proves on average to be a cost-effective solution (fig. 2).

- Even within our external cost model, a penalty for congestion is imposed on all road transports as a standard practice, including extreme scenarios like the Antwerp ring. Ideally, achieving a 25% reduction in delays per shipment should yield greater benefits compared to the current measurements.

- At PoAB, road transport companies typically impose additional charges for port pick-up and drop-off services. These additional fees were not considered in this study, which could potentially enhance the outcomes.

- This study is for Belgian demand only. If considering a larger geographical area, other locations should be considered.