JUST-IN-TIME RAIL SHUTTLE SERVICE FEASIBILITY STUDY FOR THE PORT OF VALENCIA

Lorena Sáez, Alex Sánchez, Carles Pérez & Salvador Furió

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FUNDACIÓN VALENCIAPORT

COREALIS
THE PORT OF THE FUTURE

The COREALIS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 768994.

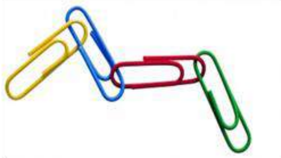
COREALIS proposes

a **strategic, innovative framework**, supported by disruptive technologies and business models *(including Internet of Things (IoT), data analytics, next generation traffic management and emerging 5G networks),*

for cargo ports to handle upcoming and **future capacity**, traffic, efficiency and **environmental challenges**

- The problem - current situation
  - Case study: Port of Valencia > Valencia – Zaragoza corridor
- Methodology, input data and hypothesis
- Optimal composition and operational model
- Cost analysis
- Information systems requirements
- Business model
- Main conclusions and future work

The problem - current situation (Case study: Port of Valencia > Valencia – Zaragoza corridor)



More complex and global supply chains

Increase of transport needs

Intermodal transport and logistics platforms become strategic for APV

Increased competition

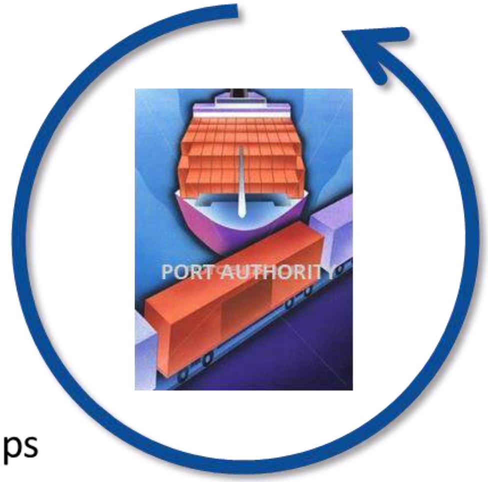
Global **Operators**

Freight Logistics

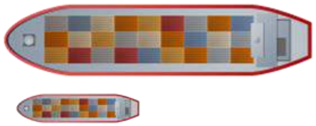
Liner Shipping

Global Terminal

mergers - adquisitions



Increased interest of the maritime industry (ports, shipping companies, terminal operators)



MEGA - Containerships

Increased environmental pressure

Policies fostering intermodal transport and modal shift to railway and inland waterways

Possible actions from a PA to develop railway port-hinterland corridors

Infrastruture

Improvement railway infrastructure

Development of inland terminals – Dry Ports
- Puerto Seco de Coslada (Madrid)
- Terminal ferroviaria PLAZA (Zaragoza)

Improvement of railway corridors
- Corredor Valencia-Madrid
- Corredor Valencia-Zaragoza

01

Operations IT (Information Systems)

Development/improvement of railway systems (traffic management, etc.)

Development of PCS services for railway operations

Improvement of integration between stakeholder's IT systems (Railway operators, Terminals, Customs, etc.)

02

Others

Bonus (taxes, etc.)

Studies (market studies, **innovative solutions**, **synchromodality**, etc.)

Cooperation agreements

Investment in railway equipment to launch new services

Research (the railway of the future)

03

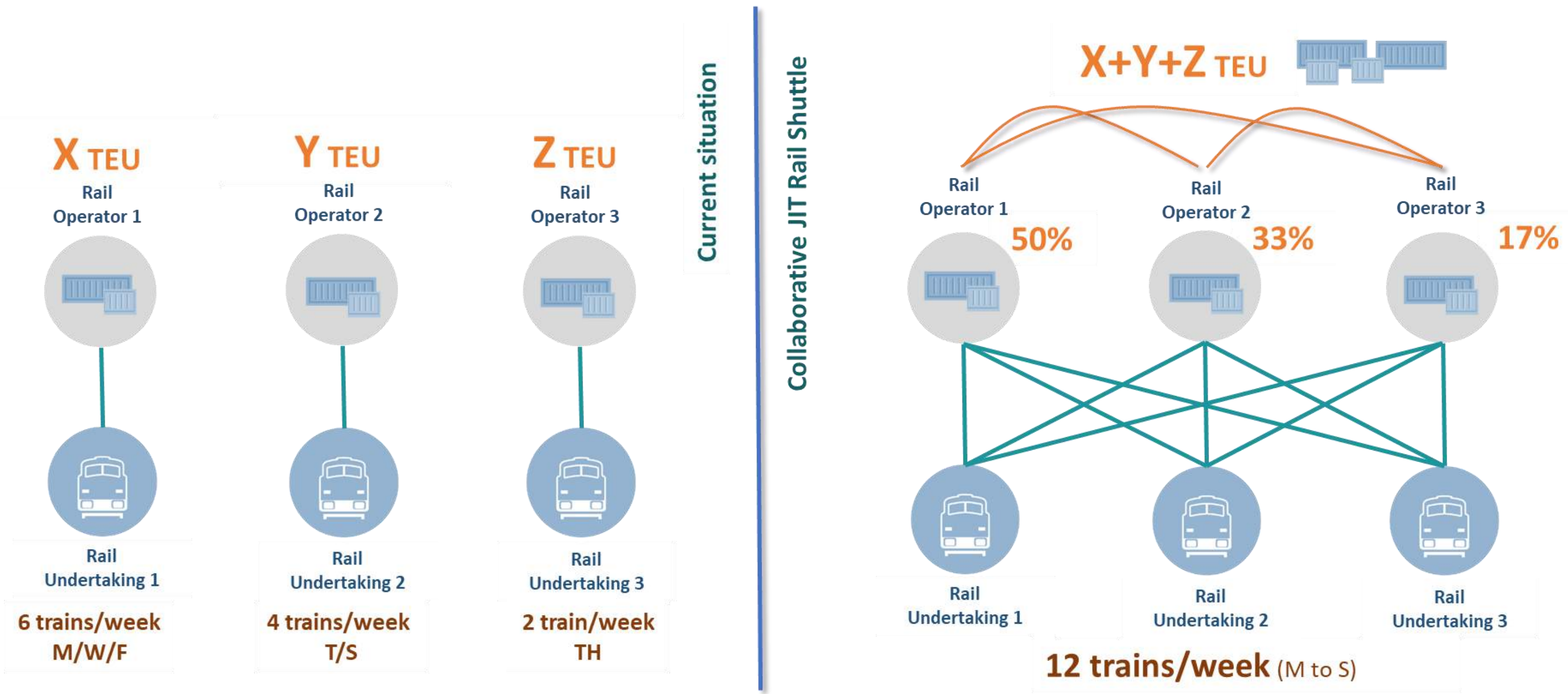
The problem - current situation (Case study: Port of Valencia > Valencia – Zaragoza corridor)

The problem - current situation (Case study: Port of Valencia > Valencia – Zaragoza corridor)

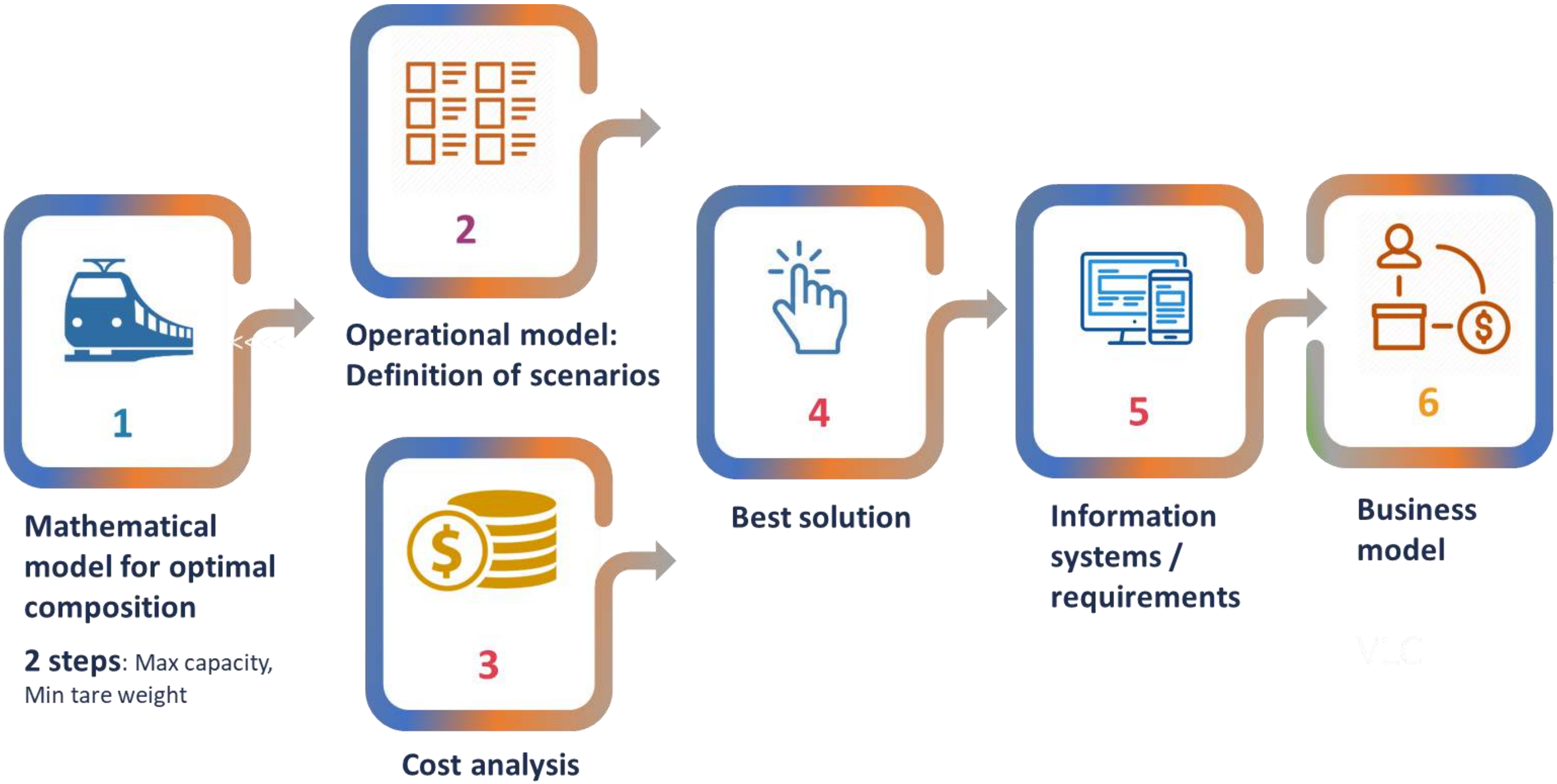
Many challenges:

- to improve rail infrastructure
- **to improve railway transport service** (frequency, transit time, reliability, etc.)
- to increase the size of trains and reduce transport costs
- to decrease operating costs
- To increase **flexibility** in the routing of shipments **(synchromodality, physical internet)**
- **to reduce container dwell time** enabling cargo owners to save on storage charges that are applied by port terminals
- **to minimize handling movements per container at port terminals**
- to improve communications among actors in the logistic chain allowing a better planning operations
- etc.

The problem - current situation (Case study: Port of Valencia > Valencia – Zaragoza corridor)

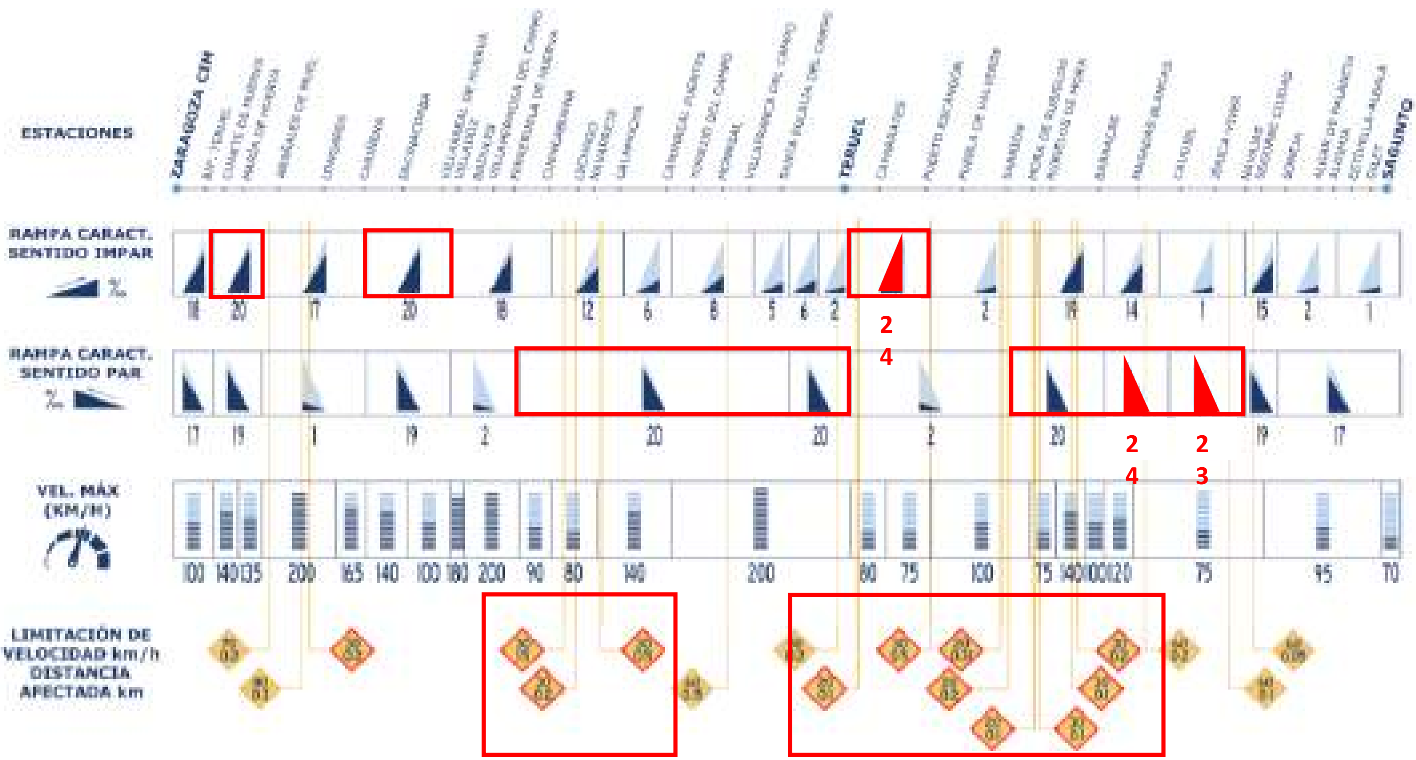


Methodology



Inputs and hypothesis

- Route – rail line characteristics



Inputs and hypothesis

- Route – rail line characteristics
- Demand analysis (Type of traffic: type of goods, containers, full/empty, etc.)

Example
Not exhaustive

	Variable	Description	Unit	Value	Hypothesis
Railway route	Door-to-port railway distance	Railway distance from the inland terminal to the origin/departure port.	Km	355	-
	Maximum train length	Maximum length of a freight train, including the locomotive.	m	-	750
Traffic – container type	Container composition	Number of 20', 40' or 45' containers carried on train.	%	-	20' = 0–20 40' = 80 45' = 0
	Full containers	Maximum number of full containers to be transported.	%	-	0.8–1
	Full ITU weight	An ITU is each (20', 40' or 45') container carried by the train. This variable indicates the average weight of a full ITU transported by the Valencia–Zaragoza rail freight service.	Tons	-	19–27
	ITU tare weight	Average weight of an empty ITU transported by the studied service.	Tons	-	3.46–3.75
	Full TEU weight	Average weight of a full TEU transported by the service.	Tons	-	11–14

Inputs and hypothesis

- Route – rail line characteristics
- Type of traffic
- Type of locomotives and wagons (operational characteristics, cost, etc.)

Example
Not exhaustive

Locomotive	Locomotive type	Locomotives running on dual mode (electric-diesel) were selected: STADLER Type 1: EURO 4001 Type 2: EURODUAL	-		Type 1 Type 2
	Maximum towable load	Number of cars/wagons that can be towed by each locomotive, which depends on the most unfavorable characteristic ramp of the section on which the train runs (24‰).	Tons	EURO 4001: 1,020 EURODUAL: 1,173	-
	Fuel consumption	Fuel consumption, diesel mode.	lt/Km	5.3	-
	Fuel price	Average price of diesel for locomotives.	€/lt	-	0.577
	Locomotive acquisition value	Price that the buyer will pay to the locomotive manufacturer.	Euros	-	EURO 4001: 3,700,000 EURODUAL: 4,200,000
	Locomotive's useful life	Estimated number of years the locomotive is likely to remain in service.	Years	-	25

Example
Not exhaustive

Wagon	Car/wagon capacity	Number of 20' containers (TEU) per car/wagon.	TEU/wagon	40' = 2 60' = 3 80' = 4 90' = 4.5	-
	Car/wagon tare weight	Average weight of an empty car/wagon.	Tons	40' = 12 60' = 20.3 80' = 27.5 90' = 30	-
	Car/wagon max load	Maximum load per one car/wagon.	Tons	40' = 33 60' = 69.7 80' = 107.5 90' = 105	-
	Car/wagon length over buffers	Length of the car/wagon from buffer to buffer.	Meters	40' = 12 60' = 20.3 80' = 27.5 90' = 30	-
	Car/wagon acquisition value	Price that the buyer will pay to the car/wagon manufacturer.	Euros	-	40 = 80,000 60' = 90,000 80' = 90,000 90 = 100,000
		Estimated number of years...			

Inputs and hypothesis

- Route – rail line characteristics
- Type of traffic
- Type of locomotives and wagons (operational characteristics, cost, etc.)
- Train operation (speed, nº round trips, terminal handling time and costs, railway charges, etc.)

Example
Not exhaustive

Train operation	Round trips per day	Max number round trips/day to cover the traffic demand in the selected corridor, taking into account distance, transit time.	Roundtrips per day	-	Realistic = 2 Optimistic= 3
	Train schedule	Number of days per week in which trains are running.	Days/week	-	5
	Weeks a year	Number of weeks/year in which trains can run.	Weeks/year	-	52
	Total annual distance covered	Number of kms run by the rail services = door-to-port railway distance × roundtrips per day × train schedule × weeks/year.	km	-	4
	Container transfers among maritime terminals	Number of containers transferred among maritime terminals by road.	%	-	0–0.5%
	Container transfer costs	Movement of containers at port and at inland terminals	€/ITU	-	40
	Port terminal handling charge	Costs associated with loading/unloading containers to/from trains at port terminals.	€/ITU	-	35
	Handling charge at [illegible]	Costs associated with loading/unloading of containers [illegible]	€/ITU	-	[illegible]

Example
Not exhaustive

Railway charges	Access to the railway infrastructure charge	Annual charge for using Spanish railway network, managed by Adif, the Spanish administrator of railway infrastructures.	€/composition	-	0
	Railway capacity reservation charge	Charge for reserving the rail section (km) where the train will run.	€/composition km	0.0724	-
Railway charges	Rail traffic charge	Charge for the real use of the capacity reserved.	€/composition km	0.1032	-
	ACA services charge	Charge for the Additional, Complementary and Auxiliary services provided by Adif.	Euros/round trip	-	400

Inputs and hypothesis

- Route – rail line characteristics
- Type of traffic
- Type of locomotives and wagons (operational characteristics, cost, etc.)
- Train operation (speed, nº round trips, terminal handling time and costs, railway charges, etc.)
- Oher (financial data, etc.)

Optimal train composition and operational model

Objective: maximize transport capacity and minimize total transport costs

Optimal train composition

1st step

$$Max\ C = \sum_{\forall i} n_i \cdot c_i.$$ **Train capacity (TEUs)**

Subject to:

(i) $\sum_i n_i \cdot k_i + \sum_i n_i \cdot c_i (\varphi \cdot \sigma + (1-\varphi) \cdot \omega) \leq T$ — ***Max towable load limit***

(ii) $\alpha \sum_i n_i \cdot c_i \geq n_{60'}$ — ***Limit of 60ft wagons in order to avoid empty spaces***

(iii) $\sum_i n_i \cdot l_i \leq L$ — ***Max train length limit***

2nd step

$$Min\ \sum_{\forall i} n_i \cdot k_i.$$ **Train tare weight**

Subject to:

(i) $\sum_i n_i \cdot c_i \geq C$ — ***Min capacity***

Optimal train composition and operational model

Objective: maximize transport capacity and minimize total transport costs

Operational model

> Locomotive
> Speed
> Round trips per day
> Train schedule
> Number of train compositions
> Handling operations at terminals
> etc.

determined by:

> Characteristics of the infrastructure and available capacity
> Total costs
> etc.

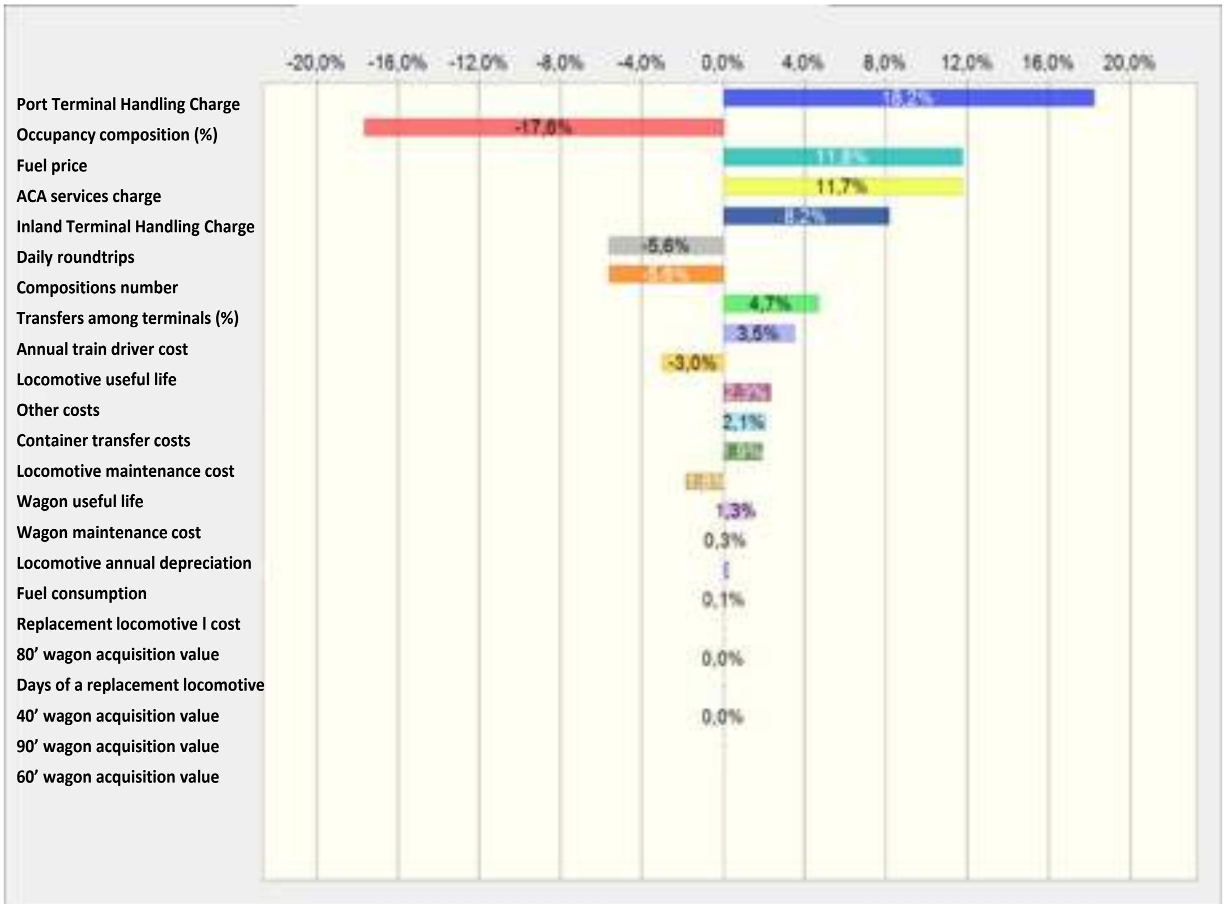
Cost Analysis

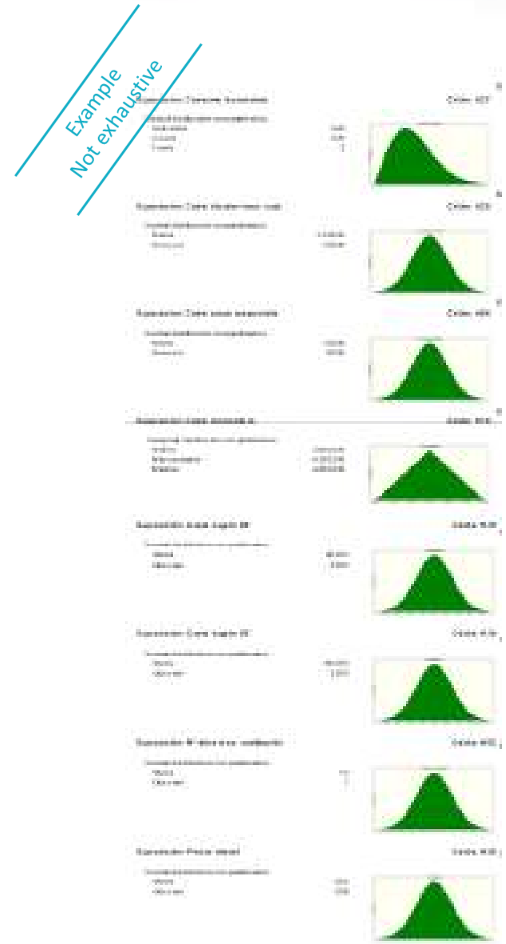
	VARIABLE	UNIT	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7
[illegible]	Locomotive type	-	EURO4001	EURO4001	EURO4001	EURO4001	EURODUAL	EURODUAL	EURODUAL
	Maximum towable load	Tonnes	1,020	1,020	1,020	1,020	1,173	1,173	1,173
[illegible]	Roundtrips per week	Daily roundtrips	10	15	15	10	15	10	10
TRAIN COMPOSITION	Composition number	Compositions	2	3	3	2	3	2	2
	Wagon composition	Wagons	40'wagon= 0 60'wagon= 0 80' wagon= 16 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 16 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 16 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 16 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 18 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 18 90' wagon= 0	40'wagon= 0 60'wagon= 0 80' wagon= 15 90' wagon= 0
	Composition length	Metres	422	422	422	422	475	475	396
	Composition tare weight	Tonnes	440	440	440	440	495	495	413
	Composition maximum load	Tonnes	1,720	1,720	1,720	1,720	1,935	1,935	1,613
	Composition TEU capacity	TEU	64	64	64	64	72	72	60
	Composition ITU capacity	ITU	38	38	38	38	43	43	30
	Composition estimated capacity (100% occupancy)	Tonnes	1,050	1,050	1,050	1,050	1,182	1,182	1,223
	Composition acquisition value	€/composition	1,440,000	1,440,000	1,440,000	1,440,000	1,620,000	1,620,000	1,350,000
	Composition depreciation	€/composition	34,560	34,560	34,560	34,560	38,880	38,880	32,400

Cost Analysis

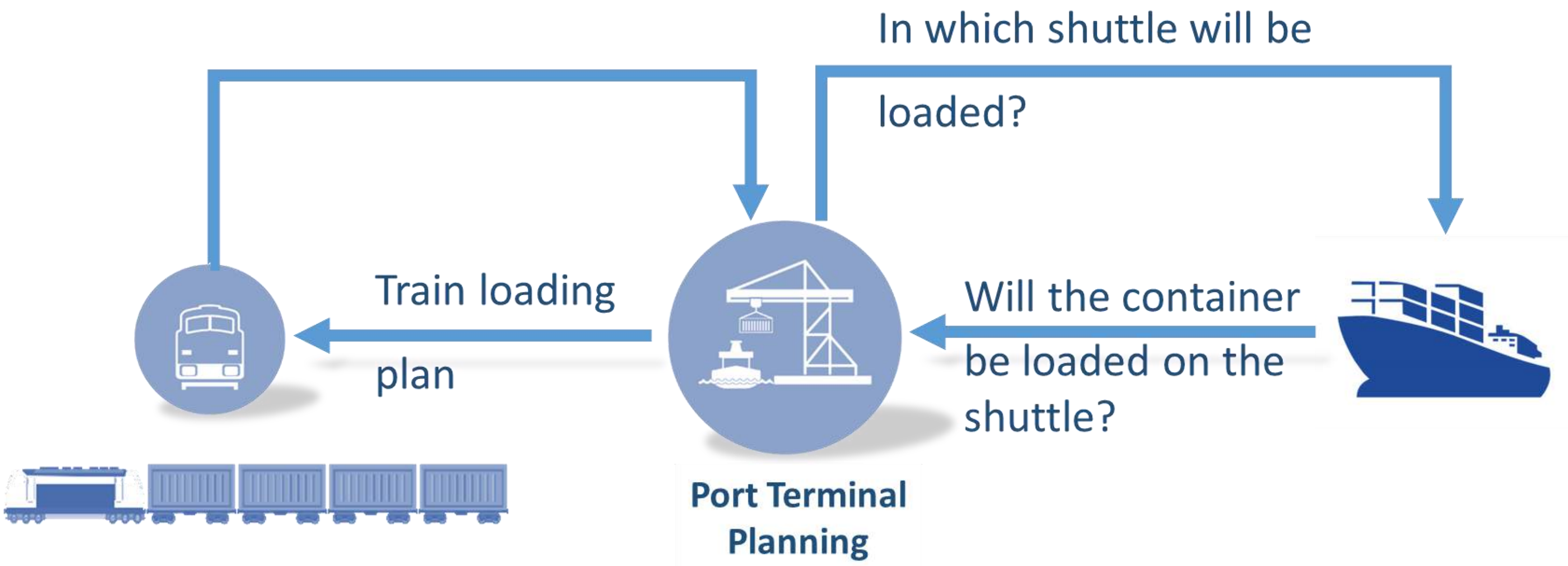
COST		SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7
RAILWAY CHARGES	Access to the railway infrastructure annual charge	0	0	0	0	0	0	0
	Railway capacity reservation annual charge	13,365.04	20,047.56	20,047.56	13,365.04	20,047.56	13,365.04	13,365.04
	Rail traffic annual charge	19,050.72	28,576.08	28,576.08	19,050.72	28,576.08	19,050.72	19,050.72
FIXED COSTS	Locomotive annual depreciation	144,115	144,115	144,115	144,115	163,590	163,590	163,590
	Replacement locomotive annual cost	40,000	40,000	40,000	40,000	40,000	40,000	40,000
	Composition acquisition value	70,848	106,272	106,272	70,848	119,556	79,704	66,420
	Train driver annual cost	320,000	480,000	480,000	320,000	480,000	320,000	320,000
VARIABLE COSTS	Fuel consumption annual cost	564,525.26	846,787.89	846,787.89	564,525.26	846,787.89	564,525.26	564,525.26
	Locomotive maintenance annual cost	239,980.00	359,970.00	359,970.00	239,980.00	359,970.00	239,980.00	239,980.00
	Wagon maintenance annual cost	147,680.00	221,520.00	221,520.00	147,680.00	249,210.00	166,140.00	138,450.00
TERMINAL COSTS	Terminal handling annual charge at port terminals	698,880	1,048,320	1,048,320	698,880	1,179,360	786,240	546,000
	Handling annual charge at inland terminals	448,282	672,422	672,422	448,282	756,475	504,317	350,220
	Annual ACA services	208,000	312,000	312,000	208,000	312,000	208,000	208,000
	Container transfer annual costs	0	0	599,040	399,360	0	0	0
	Other annual costs	437,209	642,005	642,005	437,209	683,336	465,737	400,440
TOTAL	TOTAL COSTS (Euros)	3,351,934.46	4,922,035.57	5,521,075.57	3,751,294.46	5,238,908.64	3,570,648.59	3,070,041.17
	COST PER UNIT OF TEU TRANSPORTED (Euros/TEU)	100.72	98.60	110.60	112.72	**93.29**	**95.37**	98.40

Cost Analysis – sensitivity analysis

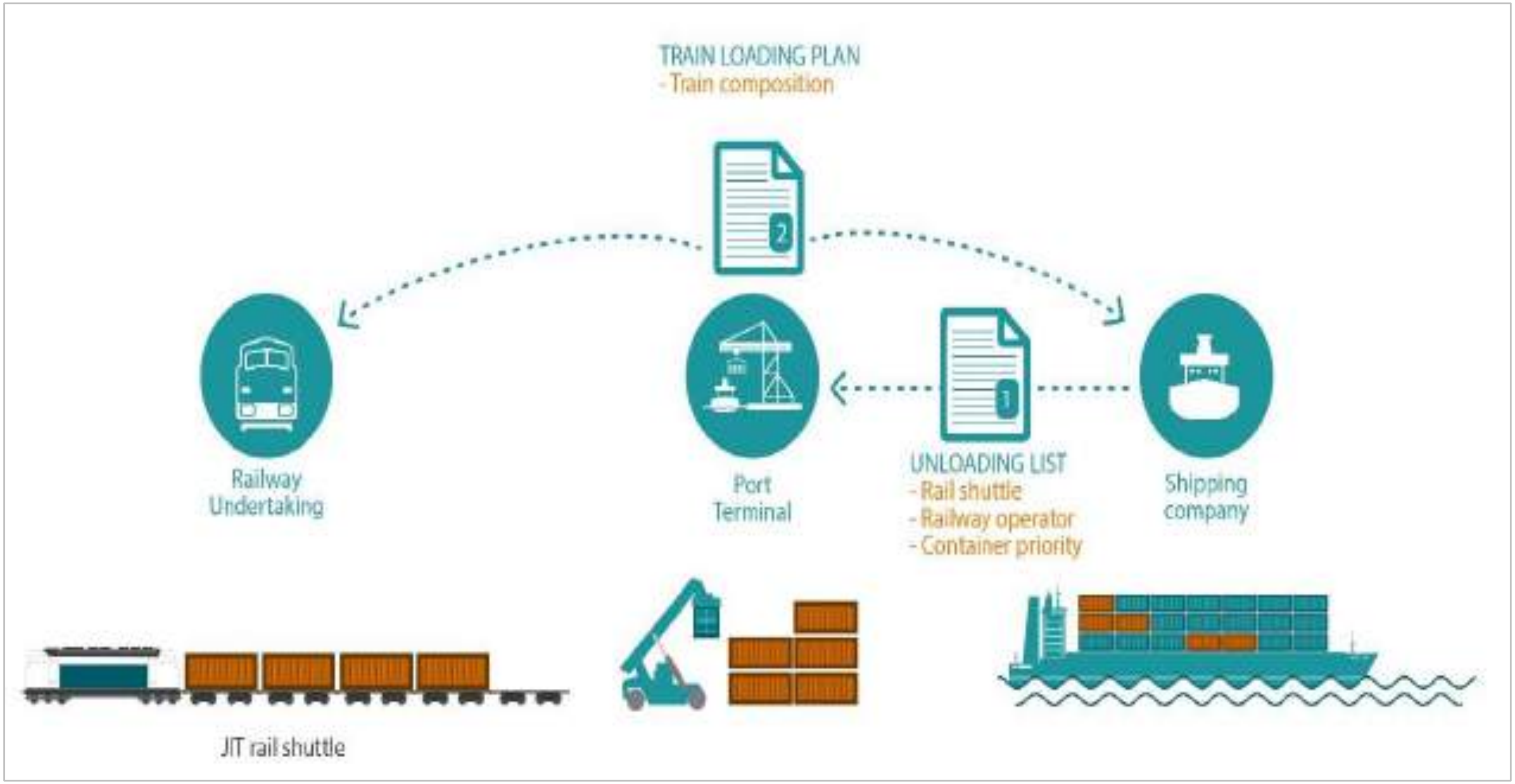




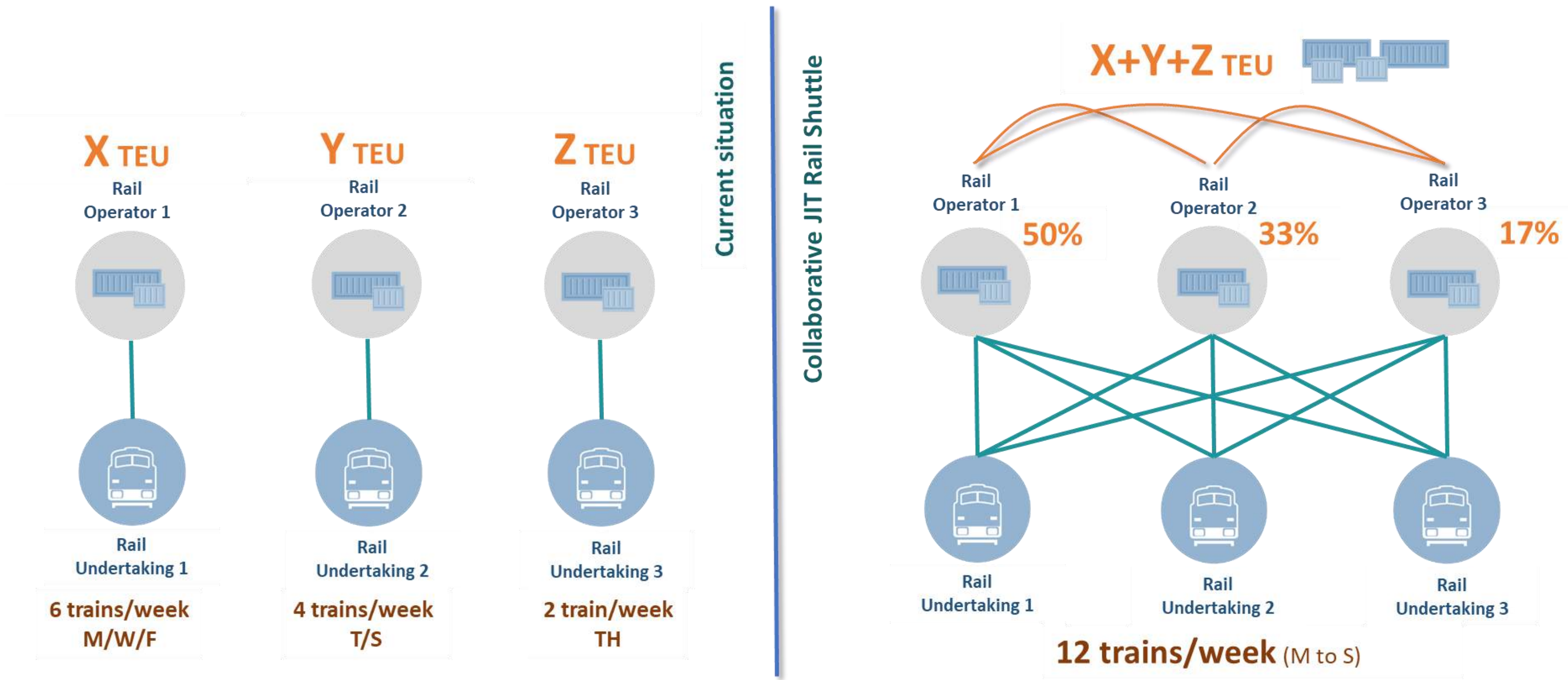
Information systems requirements



Information systems requirements



Business model



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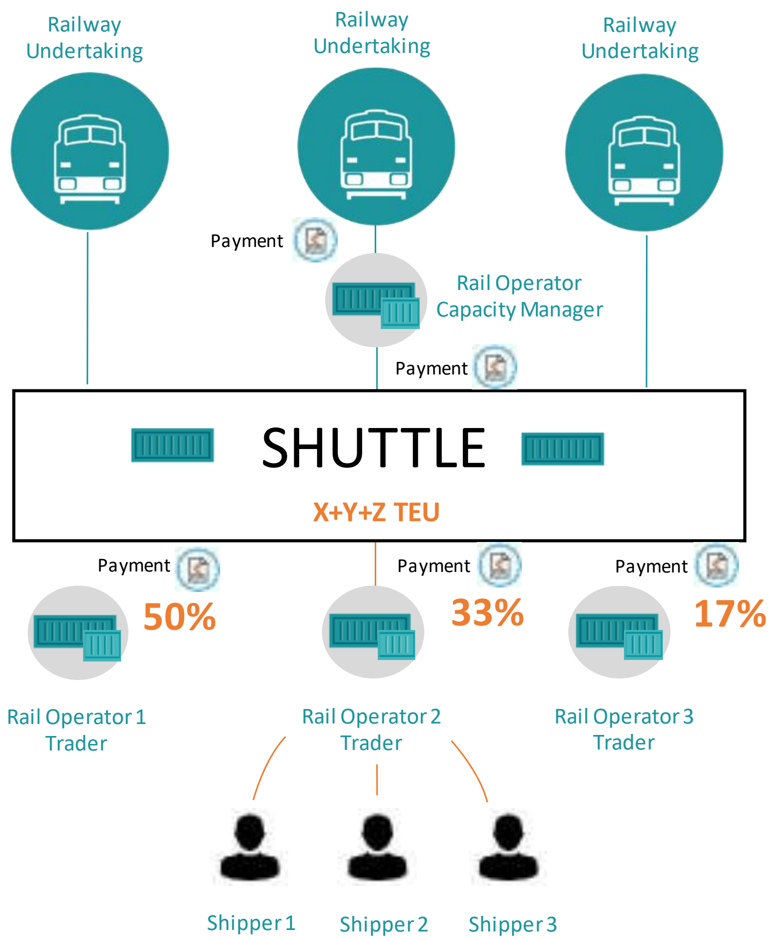

2. Railway companies add capacity under a "call for capacity" issued by the SHUTTLE entity. Once selected, railway companies are paid for the services that will carry out during a established period of time.

1. **SHUTTLE** entity is a private/public or PPP company that issues tender contracts called "calls for capacity" to select railway companies that wants to add capacity at lowest prices while maintaining an established quality of service.

3. After a railway company is selected, SHUTTLE entity issues a bidding process to sell the available slots among the interested rail operators/freight forwarders.

4. Rail operators/freight forwarders make their bids to be able to trade a certain percentage (%) of the available slots in the shuttle.

5. SHUTTLE entity studies the offers and choose the best bids (those that guarantee a lowest €/TEU for the shippers)

A financial compensation system is managed by the SHUTTLE entity so that rail operators can use more/less capacity than the one assigned in the bidding process.

Conclusions and future work

- → **Many ports are working to increase the rail modal share** as one of the solutions to deal with port-hinterland transport and sustainability challenges.
- → The port of Valencia is doing so and is **looking for innovative solutions to foster rail transport** at port-hinterland connections.
- → A **collaborative shared JIT rail shuttle service for specific corridors** where containers are unloaded from the vessel and loaded directly in the first available train, minimising container handling movements, seems to be a **good option to reduce costs and improve the service**.
- → **Future work is required in order to develop further the business model** and identify and **assess** the different **barriers** that can exist from different stakeholders in order to change to a model like this.

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