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Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era

COREALIS
THE PORT OF THE FUTURE

D.2.2. Just-In-Time Rail Shuttle Service Feasibility Study

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List of Acronyms

Abbreviation / acronym	Description
ACA	Additional, Complementary and Auxiliary
ADIF	Spanish Railway Infrastructure Administrator
D2.2.	Deliverable number 2 belonging to WP 2
IoT	Internet of Things
ITU	Intermodal Transport Unit
JIT	Just In Time
PCS	Port Community System
TEU	Twenty-foot Equivalent Unit
TOS	Terminal Operating System
WP2	Work Package two

Executive Summary

This report (deliverable 2.2) is the result of the activity *T2.4 COREALIS Just-In-Time Rail Shuttle Service* within WP2 (Port of the future hinterland connectivity). The report comprises a feasibility study of a Just-In-Time Rail Shuttle for a key port-hinterland corridor in the port of Valencia (Valencia-Zaragoza) to boost the rail transport mode and increase its modal share.

The solution aims to minimize the container movements in the terminal and optimize the loading/unloading operations and includes the design of the physical and operational solution (service characteristics), the information system requirements and the definition of the business models for its implementation. In this sense, the report is structured as follows:

- Section one introduces the concept of the JIT rail shuttle service for port-hinterland connections.
- Section two describes the physical and operational solution of the rail shuttle service.
- Section three provides the information system requirements compiling the current information flows for train operations as well as the data communications required among all actors involved.
- Section four proposes business models for the commercialisation and operation of the designed service.
- Finally, Section five concludes with the main outcomes of the study.

1. Introduction

The growth in container volumes at ports and the concentration of container flows on a limited number of hubs, which derives mainly from the increasing vessel size, requires higher capacity in hinterland connections. Currently, road transport represents the highest share in Europe´s port-hinterland connections, resulting in port congestion, which is associated with delays, queuing and dwell of ships and cargo at the port. These translates into extra costs and a negative environmental impact.

Although ports have developed multiple strategies and policies to improve their hinterland connections considering that rail freight transport can better connect ports to the hinterlands, rail freight transport currently holds a low share in several European countries, in which the objectives set up by the European Commission in 2011 (modal shift of 30% of the of the current freight tonnage above 300 km from road to rail by 2030 and 50% by 2050) will not be achieved.

The biggest challenge regarding attracting more shippers to use rail freight is cost reduction, which requires several actions are listed below:

i. Improve/develop rail infrastructures (rail access to ports, rail infrastructure at port terminals, rail connections with dry ports and inland terminals) in order to reduce transit time, which has a serious effect on just-in-time distribution systems.
ii. Increase the length of trains and the number of wagons to decrease operating costs.
iii. Reduce container dwell time (time taken for exports inside terminal gates to be loaded onto a ship and imports onto a truck or train): shorter dwell times enable cargo owners to save on storage charges applied by port terminals.
iv. Minimise handling movements per container at port terminals: containers are directly unloaded from the vessel and loaded onto trains.
v. Improve communications among rail actors in the logistic chain for a better planning of goods loading/unloading operations: currently, port terminals receive information about if the container will be loaded in a rail service once the vessel arrives and the container is unloaded and moved to the storage areas, which result in a waste of time, a lack of efficiency in the supply chain and an extra cost.

Focusing on points (iii) to (v), a study has been carried out within COREALIS project to analyse the feasibility of an innovative Just in Time (JIT) rail shuttle service for key port-hinterland corridors, in which containers are directly unloaded from the vessel and loaded onto trains, **minimising handling movements**.

The JIT rail shuttle service proposed, operates similar to an “air bridge” at airports: it travels back and forth at regular intervals over a particular route. Before a container vessel calls to port, port terminals will know which containers will be directly loaded into the first available JIT rail service, **eliminating the container-storage yard** (see Figure 1).

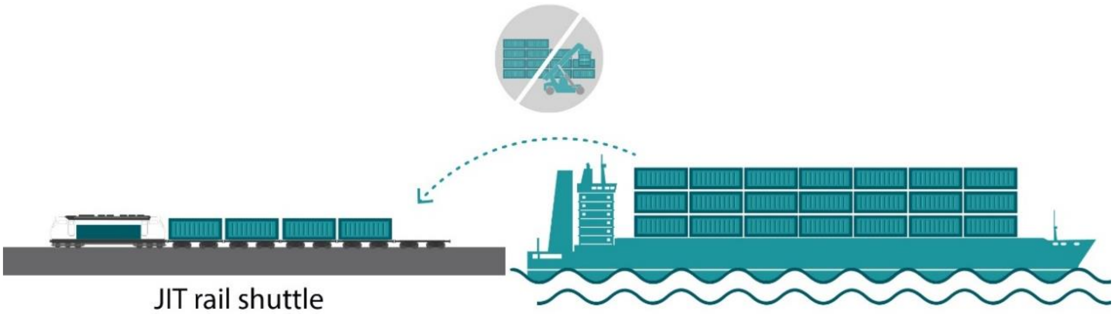


Figure 1. JIT rail shuttle concept
Source: Fundación Valenciaport

The solution proposed helps ports to lower their environmental footprint and move to cleaner transport modes supported by disruptive technologies for cargo ports in order to handle upcoming and future capacity, traffic, efficiency and environmental challenges. Indeed, this innovative JIT rail shuttle service would decrease disturbance to local population through a significant reduction in the congestion around the port.

This innovative solution fits in closely with recent way of looking at transport called Physical Internet, which will change the way that goods are handled, stored, packaged and transported across the supply chain. It mimics the Digital Internet, as freight in the Physical Internet would travel seamlessly as data is exchanged in Internet. Freight transport will become more reliable, efficient and sustainable if the customer indicates where and when the container has to be delivered, but if at the same time there is more freedom to select means of transport and route, so that transport capacity and transport options can be exploited much more effectively.

1.1 Scope of the Document

The scope of this document is to present an innovative solution to foster the rail modal share in the Port of Valencia, reducing port's environmental footprint associated with intermodal connections, improving operational efficiency and optimizing terminal yard capacity. The solution proposed comprises a feasibility study of a Just-In-Time (JIT) Rail Shuttle Service for the corridor Valencia-Zaragoza that will operate similar to an "air bridge" at airports.

1.2 Intended Readership

The work presented in this document addresses the design of the physical and operational solution, the service characteristics, the information exchange between the actors and the business model for the implementation of the innovative Just-In-Time (JIT) Rail Shuttle Service in the rail corridor between Valencia and Zaragoza.

1.3 Relationship with Other COREALIS Deliverables and Tasks

This deliverable is linked to Deliverable D2.1 "*State of the Art of Port-Hinterland Connections*", which provides and overview of the hinterland connections of the COREALIS Ports. In particular, this Deliverable D2.2 "*JIT Rail Shuttle Service feasibility study*" focuses in the rail connectivity.

2. Design of the operational solution

This section describes the methodology to design an optimal physical and operational solution of a JIT rail shuttle service for port-hinterland connections. In particular, the case study for connections between the port of Valencia and Zaragoza for container traffic is presented.

Valenciaport is the leading port in Spain and the Mediterranean in container traffic. It is also the fifth European port and 29 in the world in this type of traffic and the fourth European port in terms of growth in the last ten years.

The internal railway network of the port of Valencia (Figure 2), is directly linked to the Spanish railway network of general interest, which is managed by the Spanish Railway Infrastructure Administrator (Adif).

Figure 2. Valenciaport rail network (in red)
Source: Fundación Valenciaport

The railway connections from the port of Valencia ensure access to any manufacturing area on the Iberian Peninsula and Europe. In this regard, the port of Valencia is connected to the largest logistics platform in Europe, Zaragoza Logistics Platform (PLAZA), located in Aragon (Spain).

In this context, an efficient connection between Valencia and Aragon is required in order to increase the hinterland competitiveness of the port of Valencia.

As mentioned before, one of the most important factors for attracting more shippers to use rail freight is cost reduction derived from minimising handling movements. Therefore, **the optimal solution will be the one that minimises the cost per unit of TEU** (Twenty-foot Equivalent Unit) **transported.**

The steps followed to design the optimal JIT rail freight solution have been:

1. Inputs and hypothesis
2. Optimal composition model
3. Cost analysis
4. Sensitivity analysis

2.1 Inputs and hypothesis

Several inputs are required to design an optimal physical and operational solution of a JIT rail shuttle service. The input variables and hypotheses used in the model are listed below.

Table 1. Explanatory variables
Source: Fundación Valenciaport

VARIABLE		DESCRIPTION	UNIT	VALUE	HYPOTHESIS
RAILWAY ROUTE	**Door-to-port railway distance**	Railway distance from the inland terminal to the origin/departure port.	Kilometres	355	-
RAILWAY ROUTE	**Maximum train length**	Maximum length of a freight train, including the locomotive.	Metres	-	750
TRAFFIC – CONTAINER TYPE	**Container composition**	Number of 20`, 40' or 45' containers carried out in the train. *See container characteristics in Annex 1	%	-	20' containers = 0-20 40' containers = 80 45' containers = 0
TRAFFIC – CONTAINER TYPE	**Full containers**	Maximum number of full containers to be transported.	%	-	0.8 - 1
TRAFFIC – CONTAINER TYPE	**Full ITU weight**	An ITU (intermodal transport unit) is each container (20', 40' or 45') carried out in the train. This variable indicates the average weight of a full ITU transported in the Valencia-Zaragoza rail freight service.	Tonnes	-	19 - 27
TRAFFIC – CONTAINER TYPE	**ITU tare weight**	Average weight of an empty ITU transported in the service under study.	Tonnes	-	3.46 - 3.75
TRAFFIC – CONTAINER TYPE	**Full TEU weight**	1 TEU= a 20' container Average weight of a full TEU transported in the service under study.	Tonnes	-	11 - 14

LOCOMOTIVE	**Locomotive type**	Locomotives running on dual mode (electric-diesel) have been selected.	-		Manufacturer: STADLER Type 1: EURO 4001 Type 2: EURODUAL
	Maximum towable load	Number of wagons that can be towed by each locomotive, which depends on the most unfavourable characteristic ramp of the section on which the train runs (24‰).	Tonnes	EURO 4001: 1,020 EURODUAL: 1,173	-
	Fuel consumption	Fuel consumption on diesel mode.	Litres/km	5.3	-
	Fuel price	Average price of diesel for locomotives.	€/litre	-	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 useful life	Estimated number of years it is likely to remain the locomotive in service.	Years	-	25
	Locomotive residual value	Estimated value of the locomotive at the end of its useful life	%		5
	Locomotive annual depreciation	Locomotive annual depreciation = (Locomotive acquisition value – (Locomotive acquisition value*Locomotive residual value))/ Locomotive useful life.	Euros	-	-
	Locomotive maintenance cost per km	Cost covering all locomotive maintenance tasks by year.	€/km	-	1.3
	Days of a replacement locomotive	Number of days using a replacement locomotive while the maintenance and repair tasks of the main locomotive are being carried out.	Days	-	10
	Replacement locomotive daily cost	Daily cost incurred in providing a replacement locomotive.	€/day	-	4,000

WAGON	**Wagon capacity**	Number of 20’ containers (TEU) per one wagon.	TEU/wagon	40’ wagon capacity = 2 60’ wagon capacity = 3 80’ wagon capacity = 4 90’ wagon capacity = 4.5	-
	Wagon tare weight	Average weight of an empty wagon.	Tonnes	40’ wagon tare = 12 60’ wagon tare = 20.3 80’ wagon tare = 27.5 90’ wagon tare = 30	-
	Wagon maximum load	Maximum load per one wagon.	Tonnes	40’ wagon load = 33 60’ wagon load = 69.7 80’ wagon load = 107.5 90’ wagon load = 105	-
	Wagon length over buffers	Length of the wagon from buffer to buffer.	Metres	40’ wagon length = 12 60’ wagon length = 20.3 80’ wagon length = 27.5 90’ wagon length = 30	-
	Wagon acquisition value	Price that the buyer will pay to the wagon manufacturer.	Euros	-	40’ wagon = 80,000 60’ wagon = 90,000 80’ wagon = 90,000 90’ wagon = 100,000
	Wagon useful life	Estimated number of years it is likely to remain the wagon in service.	Years	-	40
	Wagon residual value wagon	Estimated value of the wagon at the end of its useful life.	%	-	4
	Wagon maintenance cost	Cost covering all wagon maintenance tasks by year.	€/wagon-km	-	0.05

TRAIN OPERATION	**Roundtrips per day**	Number of maximum roundtrips per day to cover the traffic demand in the corridor selected, taking into account the distance and the transit time.	Daily roundtrips	-	Realistic scenario = 2 Optimistic scenario = 3
	Train schedule	Number of days per week in which trains are running.	Days per week	-	5
	Weeks a year	Number of weeks a year in which trains could run.	Weeks	-	52
	Total annual distance covered	Number of kilometres run by the rail services = Door-to-port railway distance * Roundtrips per day * Train schedule * Weeks a 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 inland terminals	€/ITU	-	40
	Terminal handling charge at port terminals	Costs associated to the loading/unloading of the containers to/from trains at port terminals.	€/ITU	-	35
	Handling charge at inland terminals	Costs associated to the loading/unloading of the containers to/from trains at inland terminals.	€/ITU	-	22
	Train drivers	Number of train drivers per day = Roundtrips per day * 2.	Train drivers	-	4
	Annual train driver cost	Cost of the train drivers per year.	Euros	-	80,000

TRAIN COMPOSITION	**Composition number**	Number of compositions (type and number of wagons) required to cover the roundtrips per day.	Compositions	-	Realistic scenario = 2 Optimistic scenario = 3
	Wagon composition	Number of 40`, 60’, 80’ or 90’ wagons.	Wagons	*See Section 2.2	-
	Composition length	Total length derived from the number and type of wagons Composition length = 40’ wagon length*40’ wagon number + 60’ wagon length*60’ wagon number + 80’ wagon length*80’ wagon number + 90’ wagon length*90’ wagon number.	Metres	*See Section 2.2	-
	Composition tare weight	Weight of each composition with empty wagons. Composition tare weight= 40’ wagon tare*40’ wagon number + 60’ wagon tare*60’ wagon number + 80’ wagon tare*80’ wagon number + 90’ wagon tare*90’ wagon number.	Tonnes	*See Section 2.2	-
	Composition maximum load	Total maximum load according to the number and type of wagons. Composition maximum load= 40’ wagon max. load*40’ wagon number + 60’ wagon max. load *60’ wagon number + 80’ wagon max. load *80’ wagon max. load + 90’ wagon length*90’ wagon number.	Tonnes	*See Section 2.2	-
	Composition TEU capacity	Composition TEU capacity = 40’ wagon capacity*40’ wagon number + 60’ wagon capacity*60’ wagon number + 80’ wagon capacity*80’ wagon number + 90’ wagon capacity*90’ wagon number.	TEU	*See Section 2.2	-
	Composition ITU capacity	Composition ITU capacity = Composition TEU capacity* Container composition. Composition ITU capacity = Composition TEU capacity *20’ containers + Composition TEU capacity*40’ containers/2 + Composition TEU capacity*45’ containers/2.5.	ITU	*See Section 2.2	-

	Composition estimated capacity (100% occupancy)	Composition estimated capacity = Composition tare weight + (Composition ITU capacity * Full containers*Full ITU weight + (Composition ITU capacity*(1- Full containers) * ITU tare weight).	Tonnes	*See Section 2.2	-
	Composition acquisition value	Composition acquisition value = 40' wagon acquisition value*40' wagon number + 60' wagon acquisition value*60' wagon number + 80' wagon acquisition value*80' wagon number + 90' wagon acquisition value*90' wagon number	€/composition	*See Section 2.2	-
	Composition depreciation	Annual composition depreciation = (Composition acquisition value – (Composition acquisition value*Composition residual value))/ Composition useful life.	€/composition	*See Section 2.2	-
RAILWAY CHARGES	**Access to the railway infrastructure charge**	Annual charge for the use of the Spanish railway network managed by Adif, the Spanish administrator of the railway infrastructures.	€/composition	-	0
	Railway capacity reservation charge	Charge for the reservation of the rail section (kilometres) where the train will run.	€/composition-km	0.0724	-
	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/roundtrip	-	400
FINANCIAL DATA	**Return on investment**	It measures the gain or loss generated on the investment related to the amount of money invested in locomotive and wagons.	%	-	2.5
	Financing	Funds for business activities	%	-	0
	Financing period	Time over which the rail company borrows money	Years	-	10
	Annual interest rate	Interest rate paid on the investment	%	-	3.5

Seven scenarios have been defined based on the variables and hypothesis listed in the previous Table 1. As can be observed in Table 2, the differences among the scenarios presented are in terms of the following variables described in Table 1:

- TRAFFIC-CONTAINER TYPE: Container composition; Full containers; Full ITU weight; ITU tare weight; Full TEU weight.
- LOCOMOTIVE: Locomotive type; Maximum towable load; Locomotive acquisition value; Locomotive annual depreciation.
- TRAIN OPERATION: Roundtrips per day; Total annual distance covered; Train drivers
- TRAIN COMPOSITION: Composition number

Table 2. Scenarios
Source: Fundación Valenciaport

<table>
<tr><th colspan="2">VARIABLE</th><th>UNIT</th><th>SCENARIO 1</th><th>SCENARIO 2</th><th>SCENARIO 3</th><th>SCENARIO 4</th><th>SCENARIO 5</th><th>SCENARIO 6</th><th>SCENARIO 7</th></tr>
<tr><td rowspan="2">RAILWAY ROUTE</td><td>Door-to-port railway distance</td><td>Kilometres</td><td colspan="7">355</td></tr>
<tr><td>Maximum train length</td><td>Metres</td><td>750</td><td>750</td><td>750</td><td>750</td><td>750</td><td>750</td><td>750</td></tr>
<tr><td rowspan="5">TRAFFIC – CONTAINER TYPE</td><td>Container composition</td><td>%</td><td>20’ containers= 20
40’ containers= 80
45’ containers= 0</td><td>20’ containers=20
40’ containers=80
45’ containers= 0</td><td>20’ containers=20
40’ containers=80
45’ containers= 0</td><td>20’ containers=20
40’ containers=80
45’ containers= 0</td><td>20’ containers=20
40’ containers=80
45’ containers= 0</td><td>20’ containers=20
40’ containers=80
45’ containers= 0</td><td>20’ containers=0
40’ containers=100
45’ containers= 0</td></tr>
<tr><td>Full containers</td><td>%</td><td>80</td><td>80</td><td>80</td><td>80</td><td>80</td><td>80</td><td>100</td></tr>
<tr><td>Full ITU weight</td><td>Tonnes</td><td>19</td><td>19</td><td>19</td><td>19</td><td>19</td><td>19</td><td>27</td></tr>
<tr><td>ITU tare weight</td><td>Tonnes</td><td>3,46</td><td>3,46</td><td>3,46</td><td>3,46</td><td>3,46</td><td>3,46</td><td>3,75</td></tr>
<tr><td>Full TEU weight</td><td>Tonnes</td><td>11</td><td>11</td><td>11</td><td>11</td><td>11</td><td>11</td><td>14</td></tr>
<tr><td rowspan="3">LOCOMOTIVE</td><td>Locomotive type</td><td>-</td><td>EURO4001</td><td>EURO4001</td><td>EURO4001</td><td>EURO4001</td><td>EURODUAL</td><td>EURODUAL</td><td>EURODUAL</td></tr>
<tr><td>Maximum towable load</td><td>Tonnes</td><td>1,020</td><td>1,020</td><td>1,020</td><td>1,020</td><td>1,173</td><td>1,173</td><td>1,173</td></tr>
<tr><td>Fuel consumption</td><td>Litres/km</td><td>5.3</td><td>5.3</td><td>5.3</td><td>5.3</td><td>5.3</td><td>5.3</td><td>5.3</td></tr>
</table>

	Fuel price	€/litre	0.577	0.577	0.577	0.577	0.577	0.577	0.577
	Locomotive acquisition value	Euros	3,700,000	3,700,000	3,700,000	3,700,000	4,200,000	4,200,000	4,200,000
	Locomotive useful life	Years	25	25	25	25	25	25	25
	Locomotive residual value	%	5	5	5	5	5	5	5
	Locomotive annual depreciation	Euros	140,600	140,600	140,600	140,600	159,600	159,600	159,600
	Locomotive maintenance cost per km	€/km	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	Days of a replacement locomotive	Days	10	10	10	10	10	10	10
	Replacement locomotive daily cost	€/day	4,000	4,000	4,000	4,000	4,000	4,000	4,000
WAGON	**Wagon capacity**	TEU/wagon	40’ wagon capacity = 2 60’ wagon capacity = 3 80’ wagon capacity = 4 90’ wagon capacity = 4.5						
	Wagon tare weight	Tonnes	40’ wagon tare = 12 60’ wagon tare = 20.3 80’ wagon tare = 27.5 90’ wagon tare = 30						
	Wagon maximum load	Tonnes	40’ wagon load = 33 60’ wagon load = 69.7 80’ wagon load = 107.5 90’ wagon load = 105						
	Wagon length over buffers	Metres	40’ wagon length = 12 60’ wagon length = 20.3 80’ wagon length = 27.5 90’ wagon length = 30						

	Wagon acquisition value	Euros	40’ wagon = 80,000 60’ wagon = 90,000 80’ wagon = 90,000 90’ wagon = 100,000						
	Wagon useful life	Years	40	40	40	40	40	40	40
	Wagon residual value wagon	%	4	4	4	4	4	4	4
	Wagon maintenance cost	€/wagon-km	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRAIN OPERATION	**Roundtrips per day**	Daily roundtrips	2	3	3	2	3	2	2
	Train schedule	Days per week	5	5	5	5	5	5	5
	Weeks a year	Weeks	52						
	Total annual distance covered	km	184,600	276,900	276,900	184,600	276,900	184,600	184,600
	Container transfers among maritime terminals	%	0	0	0	0	0	0	0
	Container transfer costs	€/ITU	40	40	40	40	40	40	40
	Terminal handling charge at port terminals	€/ITU	35	35	35	35	35	35	35
	Handling charge at inland terminals	€/ITU	22	22	22	22	22	22	22
	Train drivers	Train drivers	4	6	6	4	6	4	4
	Annual train driver cost	Euros	80,000	80,000	80,000	80,000	80,000	80,000	80,000

TRAIN COMPOS.	**Composition number**	Compositions	2	3	3	2	3	2	2
RAILWAY CHARGES	**Access to the railway infrastructure charge**	€/composition	0	0	0	0	0	0	0
	Railway capacity reservation charge	€/composition-km	0.0724						
	Rail traffic charge	€/composition-km	0,1032						
	ACA services charge	Euros/roundtrip	400	400	400	400	400	400	400
FINANCIAL DATA	**Return on investment**	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Financing	%	0	0	0	0	0	0	0
	Financing period	Years	10	10	10	10	10	10	10
	Annual interest rate	%	3.5	3.5	3.5	3.5	3.5	3.5	3.5

2.2 Optimal composition model

The objective function in the model proposed is to optimise the number and type of wagons. The limitations in the proposed model are i) the maximum towable load by the locomotive on the most unfavourable characteristic of the section on which the train runs and ii) the maximum weekly roundtrips.

The optimal composition of the number and type of wagons has been obtained from the Microsoft Excel add-in programme, Solver. This programme works with a group of cells, called decision variables or simply variable cells that are used in computing the formulas in the objective and constraint cells. Solver adjusts the values in the decision variable cells to satisfy the limits on all constraint cells and produces the result for the objective function.

The following steps have been followed to achieve the optimal composition (see variables description in Table 1). These two goals are considered in the objective function simultaneously.

1) Maximising the composition ITU capacity

Composition ITU capacity = Composition TEU capacity* Container composition.

Composition ITU capacity = Composition TEU capacity *20’ containers + Composition TEU capacity*40’ containers/2 + Composition TEU capacity*45’ containers/2.5.

Composition TEU capacity = 40’ wagon capacity*40’ wagon number + 60’ wagon capacity*60’ wagon number + 80’ wagon capacity*80’ wagon number + 90’ wagon capacity*90’ wagon number.

2) Minimising the composition tare weight

Weight of each composition with empty wagons.

Composition tare weight = 40’ wagon tare*40’ wagon number + 60’ wagon tare*60’ wagon number + 80’ wagon tare*80’ wagon number + 90’ wagon tare*90’ wagon number.

Wagon tare weight = Average weight of an empty wagon (in tonnes)

40’ wagon tare = 12
60’ wagon tare = 20.3
80’ wagon tare = 27.5
90’ wagon tare = 30

The results obtained from the model proposed are shown in the following table for each scenario defined in the previous section (see section 2.1). Table 3 shows that the optimal solution (wagon composition) for all the defined scenarios is to consider the 80 feet wagons, allowing to load 4x20 feet containers or combination of a 40 feet unit in the middle and 2x20 feet units at the beginning and at the end platform.

Table 3. Optimal Composition
Source: Fundación Valenciaport

	VARIABLE	UNIT	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7
LOCOMOTIVE	**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
TRAIN OPERATION	**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

2.3 Cost analysis

Once the optimal composition of the number and type of wagons has been obtained for each scenario, a cost analysis has been carried out in Table 4 from the point of view of the railway undertaking that operates the JIT rail shuttle service between the port of Valencia and Zaragoza.

This annual cost analysis for each scenario will allow select the option that minimises the cost per unit of TEU transported, which is charged to the final customer.

According to the results provided in Table 5, the Scenario 5 is the one that minimises the cost per TEU considering an optimistic number of roundtrips per day (3) to cover the traffic demand in the corridor selected. However, given that the JIT rail shuttle service will be the first operating in Spain, the more realistic option in the short term would be the Scenario 6 with only 2 roundtrips per day and the following main characteristics:

- Locomotive type: EURODUAL; Maximum towable load: 1,173 tones
- Roundtrips per week: 10 (2 daily roundtrips)
- Composition number: 2
- Wagon composition: 40’wagon= 0; 60’wagon= 0; 80’wagon= 18; 90’wagon= 0
- Composition length: 475
- Occupancy composition: 100%
- Cost per TEU transported: 95.37 Euros/TEU

Table 4. Cost description
Source: Fundación Valenciaport

COST		DESCRIPTION	UNIT
RAILWAY CHARGES	**Access to the railway infrastructure annual charge**	Annual charge for the use of the Spanish railway network managed by Adif, the Spanish administrator of the railway infrastructures.	€/composition-year
	Railway capacity reservation annual charge	Railway capacity reservation annual charge* Total annual distance covered	€/composition-year
	Rail traffic annual charge	Rail traffic charge* Total annual distance covered	€/composition-year
FIXED COSTS	**Locomotive annual depreciation**	Locomotive annual depreciation = (Locomotive acquisition value – (Locomotive acquisition value*Locomotive residual value))/ Locomotive useful life.	€/composition-year
	Replacement locomotive annual cost	Replacement locomotive annual cost = Days of a replacement locomotive * Replacement locomotive daily cost	€/composition-year
	Composition acquisition value	Wagon acquisition value* Wagon composition	€/composition-year
	Train driver annual cost	Train drivers*Annual train driver cost	€/composition-year
VARIABLE COSTS	**Fuel consumption annual cost**	Fuel consumption* Fuel price* Total annual distance covered	€/composition-year
	Locomotive maintenance annual cost	Locomotive maintenance cost per km * Total annual distance covered	€/composition-year
	Wagon maintenance annual cost	Wagon annual maintenance cost*Wagon composition* Total annual distance covered	€/composition-year
TERMINAL COSTS	**Terminal handling annual charge at port terminals**	Terminal handling charge at port terminals*Composition ITU capacity	€/composition-year
	Handling annual charge at inland terminals	Handling charge at inland terminals*Composition ITU capacity	€/composition-year
	Annual ACA services	ACA services*Roundtrips per year	€/composition-year
	Container transfer annual costs	Container transfers among maritime terminals* Composition ITU capacity*Container transfer costs	€/composition-year
OTHER COSTS	**Other annual costs**	Management, maintenance, etc. 15% of the total of the previous costs	€/composition-year

Table 5. Cost analysis
Source: Fundación Valenciaport

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 COSTS	**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

2.4 Sensitivity analysis

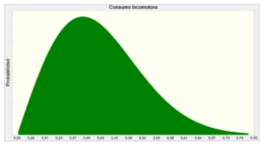
A sensitivity analysis has been carried out on the cost per TEU transported (€/TEU) applying stochastic simulation: an average has been stablished for each parameter (the value that displays the highest expected frequency) along with a confidence interval using the minimum and maximum expected values for this factor. Once the average, minimum and maximum values are attained, the probability distribution of expected changes in the parameter has been studied and stochastic variability interval or margin for error has been established with different levels of clearly defined probability.

The input variables that have been included in the simulation are shown below:

Suposición: Consumo locomotora **Celda: H27**

Weibull distribución con parámetros:

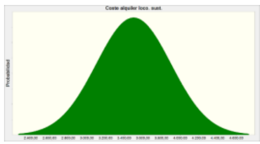
Ubicación	5,25
Escala	0,20
Forma	2



Suposición: Coste alquiler loco. sust. **Celda: H29**

Normal distribución con parámetros:

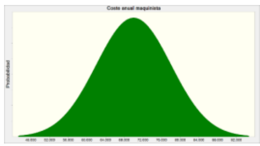
Media	3.500,00
Desv est	400,00



Suposición: Coste anual maquinista **Celda: H84**

Normal distribución con parámetros:

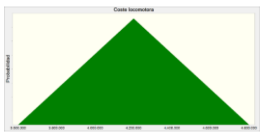
Media	70.000
Desv est	8.000



Suposición: Coste locomotora **Celda: H19**

Triangular distribución con parámetros:

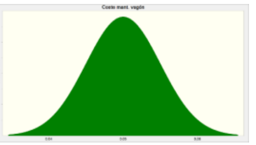
Mínimo	3.600.000
Más probable	4.200.000
Máximo	4.800.000



Suposición: Coste mant. vagón — **Celda: H40**

Normal distribución con parámetros:

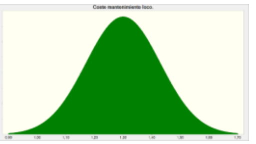
Media	0,05
Desv est	0,01



Suposición: Coste mantenimiento loco. — **Celda: H25**

Normal distribución con parámetros:

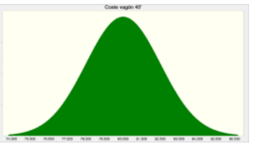
Media	1,30
Desv est	0,13



Suposición: Coste vagón 40' — **Celda: H33**

Normal distribución con parámetros:

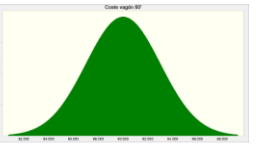
Media	80.000
Desv est	2.000



Suposición: Coste vagón 60' — **Celda: H34**

Normal distribución con parámetros:

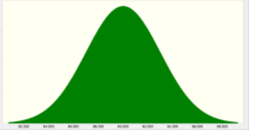
Media	90.000
Desv est	3.000



Suposición: Coste vagón 80' — **Celda: H35**

Normal distribución con parámetros:

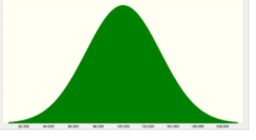
Media	90.000
Desv est	3.000



Suposición: Coste vagón 90' — **Celda: H36**

Normal distribución con parámetros:

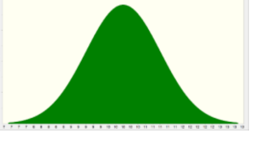
Media	100.000
Desv est	3.000



Suposición: N° días loco. sustitución — **Celda: H92**

Normal distribución con parámetros:

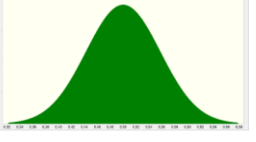
Media	10
Desv est	1



Suposición: Precio diesel — **Celda: H28**

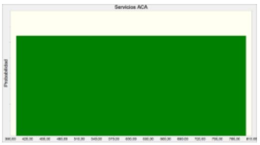
Normal distribución con parámetros:

Media	0,50
Desv est	0,06



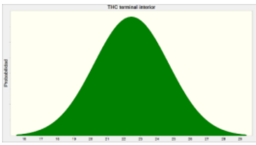
Suposición: Servicios ACA **Celda: L101**

Uniforme distribución con parámetros:
Mínimo 400,00
Máximo 800,00



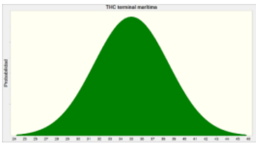
Suposición: THC terminal interior **Celda: H95**

Normal distribución con parámetros:
Media 22
Desv est 2



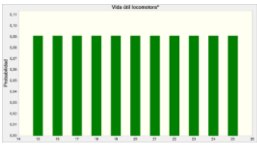
Suposición: THC terminal marítima **Celda: H94**

Normal distribución con parámetros:
Media 35
Desv est 4



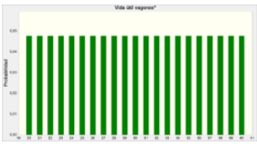
Suposición: Vida útil locomotora* **Celda: H20**

Uniforme discreta distribución con parámetros:
Mínimo 15,00
Máximo 25,00



Suposición: Vida útil vagones* **Celda: H37**

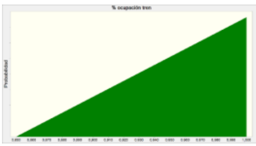
Uniforme discreta distribución con parámetros:
Mínimo 20,00
Máximo 40,00



Hoja de trabajo: [ShuttleZGZVLC_180927_revFS_Sens2.xlsx]todo_Base

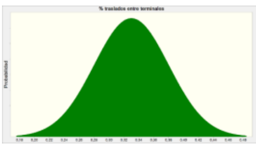
Suposición: % ocupación tren **Celda: H4**

Triangular distribución con parámetros:
Mínimo 0,850
Más probable 1,000
Máximo 1,000



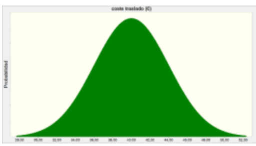
Suposición: % traslados entre terminales **Celda: H8**

Normal distribución con parámetros:
Media 0,33
Desv est 0,05



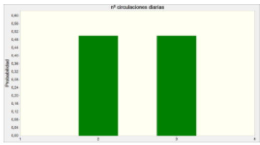
Suposición: coste traslado (€) **Celda: H9**

Normal distribución con parámetros:
Media 40,00
Desv est 4,00



Suposición: nº circulaciones diarias **Celda: H7**

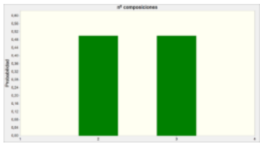
Uniforme discreta distribución con parámetros:
Mínimo 2
Máximo 3



Correlacionado con: Coeficiente
nº composiciones (H6) 1,00

Suposición: nº composiciones **Celda: H6**

Uniforme discreta distribución con parámetros:
Mínimo 2
Máximo 3



Correlacionado con: Coeficiente
nº circulaciones diarias (H7) 1,00

Suposición: Otros costes (gestión, etc.) **Celda: H10**

Normal distribución con parámetros:
Media 15%
Desv est 1%

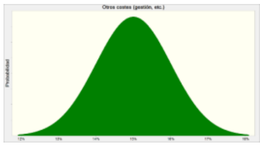


Figure 3. Stochastic input variables
Source: Fundación Valenciaport

The graph below shows the percentage of variance in €/TEU in response to changes in each specific input variable.

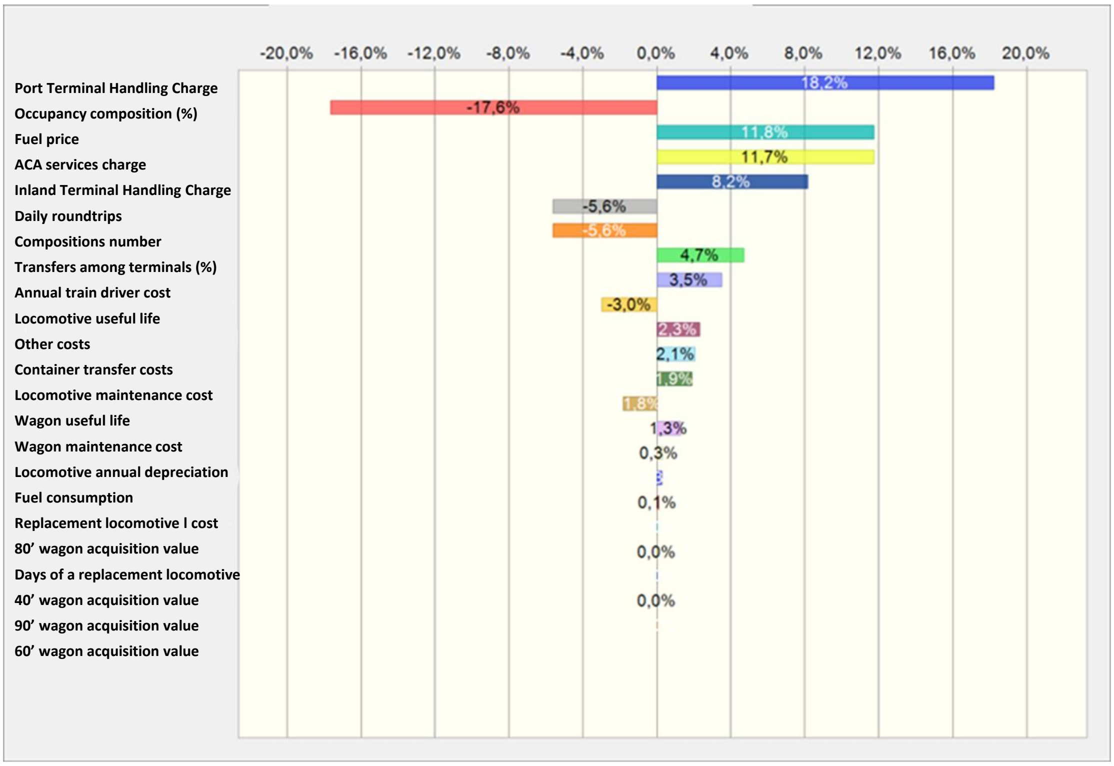


Figure 4. Sensitivity analysis, Euros/TEU
Source: Fundación Valenciaport

As demonstrated in the graph, the most determinant factors in the cost per TEU transported is the Terminal Handling Charge (THC) at port terminals, with a positive sign (18.2%). The main objective of the JIT rail shuttle service is to reduce handling movements at container terminals, resulting in cost and time-savings. The next most determinant variable is the composition occupancy, with a negative sign. The greater the number of containers transported per train, the lower the expected cost per TEU will be.

3. Information system requirements

This section aims to identify the information requirements required for the implementation of a JIT rail shuttle service.

Current situation:

- Lack of information in the unloading list related to the containers to be loaded in train services.
- Delays in the container information to be loaded in trains: port terminals receive information about if the container will be loaded in a rail service (in the unloading list) once the vessel arrives and the container is unloaded and moved to the storage areas.
- Railway operators do not share slots in the different trains. Therefore, the available resources (*assets*) are not fully used.

New situation for a JIT rail shuttle service

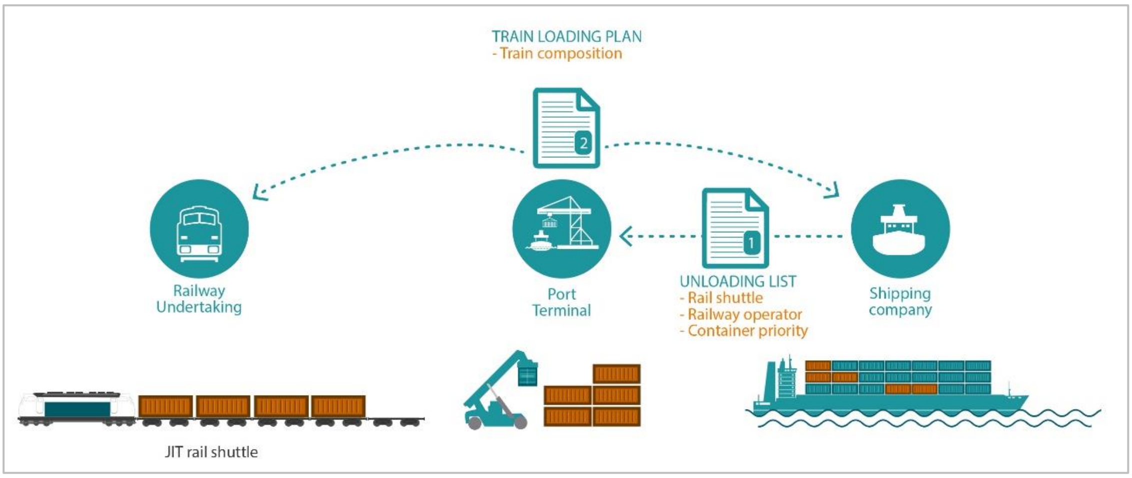


Figure 5. New information requirements
Source: Fundación Valenciaport

3.1 Current situation

At present, the information flow around Valenciaport is very complex and involves a huge amount of agents. Each container movement requires multiple communications between several Port Community members, creating a complex information network. Therefore, in order to deal with complex information flows, the different agents participating in the rail transport procedure use ValenciaportPCS as their main system. ValenciaportPCS is an open and neutral electronic platform that allows a safe and smart information exchange between public and private agents in order to improve our competitive position as a Port Community.

In this regard, the main documents required in a maritime-rail transport and exchanged via ValenciaportPCS are the following:

- Transport orders (Transport Instructions)
- Acceptance/release orders

- Train Loading or Discharge List
- Train Composition

Thus, Port Community actors directly involved in sending/receiving this information are:

- Shipping Agents
- Port-rail-inland terminals/Container Terminals
- Freight Forwarders
- Railway Operators
- Railway Undertakings

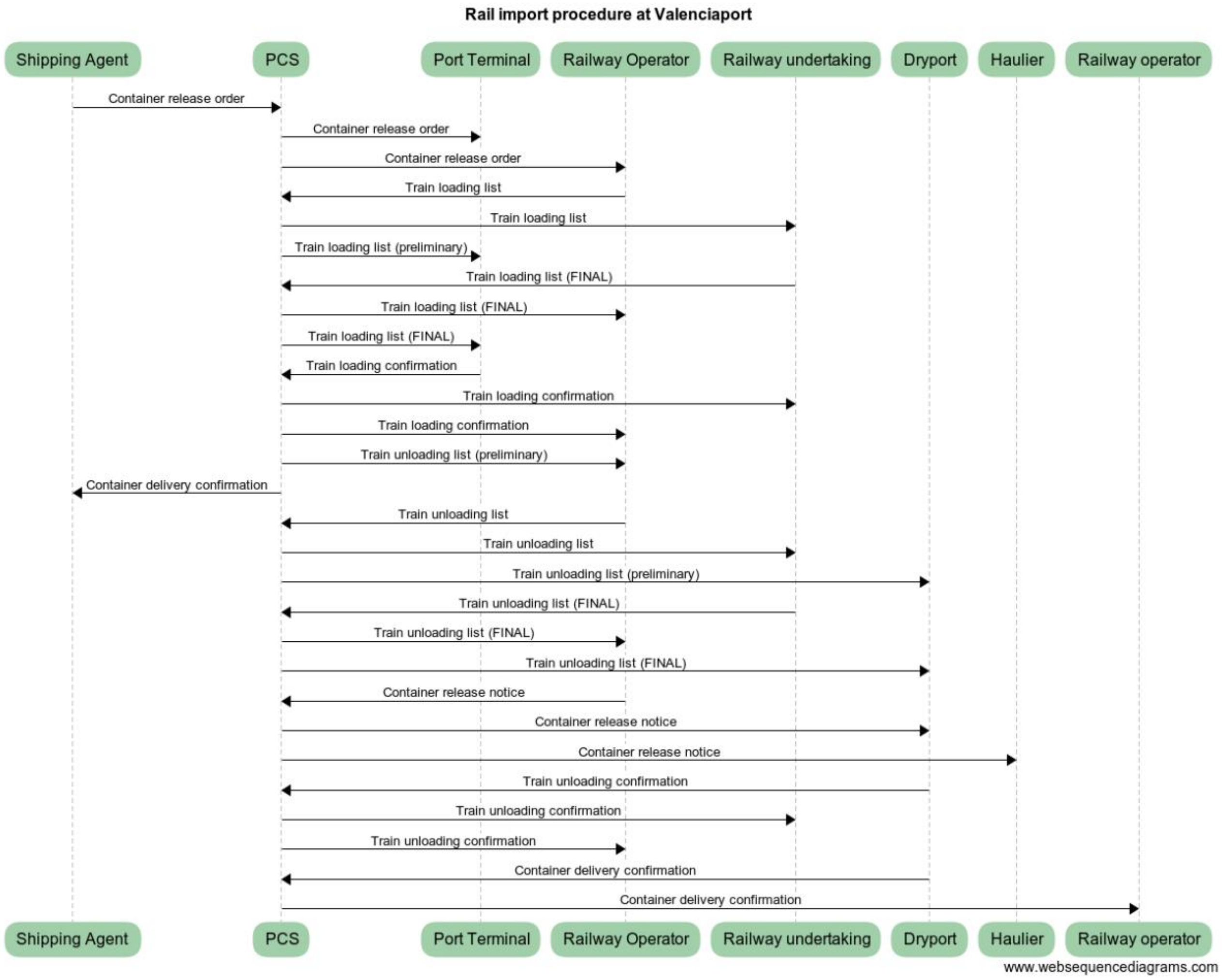


Figure 6. Current rail import procedure at Valenciaport
Source: Fundación Valenciaport

The transport instruction or transport order is sent by the shipping agent or freight forwarder to the railway undertaking. The main fields are:

- Shipper and Transport operators' information: name, address and phone
- Admission/Delivery place: indicating the dry port or intermodal railway terminal destination, maritime terminal or depot where the empty and full container have to be place or deliver.

- Final destination of goods and the customs for clearance or transit procedures. For merchant-haulage (land leg controlled by the freight forwarder) such a request is not necessary, but the shipping agent should also be informed about the rail transport to give the proper instructions to the maritime terminal.
- Maritime transport information: port of origin and destination, shipping line, shipping company, ship's name, call, number of voyages.
- Merchant information: description, Bill of Lading, and container information
- Other additional information or observations.

In import operation, the shipping agent sends a release order to the railway operator and to maritime terminal together an acceptance order for empty container to the empty container depot where the empty container should be placed once emptied. The release order indicates to the terminal operator who is the railway operator or railway undertaking and the destination of the container. In export operations, an acceptance order for full container together a release order for empty container to the empty container depot where the empty container should be placed once emptied. These documents are sent by the shipping agent to the maritime terminal and to railway operator. The acceptance order (received by the container terminal) indicates the name of ship in which the container should be loaded, the number of call of this ship and the destination of the container as well as the information regarding the transport operator that is going to deliver the container to the terminal, this transport operator can be the railway operator or the railway undertaken.

The railway undertaking receives from railway operator/s (depending on single client or multiclient) the train loading list/discharge list; the railway undertaking consolidates this information and sends train loading list/discharge list to the terminal. Once the terminal loads, the train sends the loading or discharge confirmation to the railway undertaking, the railway operator and the dry port or destination terminal. The main fields of these lists are:

- General information: Date, Route, Origin and Destinations, Kind of merchant, train number, number of origin and destination stations, Estimated Time of exit and Estimated time of arrival. Number, Type, locomotive series' and number (UIC), length, locomotive mass and mass braked of the locomotive.
- Train composition: This section includes information regarding to the wagons and the locomotives: UIC Number, origin and destination, goods, wagon position, container position, Consignment C number 47, container number, foots, type, ISO Code, Full/Empty, Loading Weight, deadweight, Shipping Line, Ship, Destination, Loading Terminal, Discharge Terminal, Addition comments.

3.2 New information requirements

The new JIT Rail Shuttle Service will require additional changes that affect the current information flows to manage the departure of import cargo from the port. The changes will **reduce the number of handling movements** carried out in the terminal, seeking the maximum optimization through a Just in Time service. This involves providing certain information to the terminals so that, just as the containers are being unloaded from the ship, they can be positioned in the rail terminal loading areas without the need to be stored in the container yard prior to loading. In this sense, the number of total movements is reduced and a greater immediacy is achieved in the loading of the container in the railway shuttle.

The proposed procedure is the following: port terminals assume a **new role** in the loading/unloading procedure since they are the ones receiving information from the shipping companies about which containers will be transported by train. Besides, they will also have to assign to which shuttle train a certain import container should be loaded on. In this sense, Shipping Agencies will have to indicate in the Discharge Lists (transmitted through the PCS) which containers should be loaded into the shuttle service and their priority. Then, the PCS will transmit the discharge list to the port terminal operating systems (TOS) so that they can generate Shuttle Loading Lists.

Once the TOS systems of the terminals have defined which containers should leave on a given train, a provisional Train Loading Plan will be generated and communicated to the Railway Company through the PCS. At this time, the Railway Company will be in charge of checking and validating the containers to be loaded on a given train. Once the final Freight List is received with the appropriate modifications, the port terminal may begin its freight operations. The definitive Freight List will be communicated to all the other actors involved in the chain (maritime agents, Railway Operators, freight forwarders, etc.)

4. Business model

Business models determine the value proposition of a given product or service, how it will be exploited, who will be the main customers and partners, and which will be the main sources of financing and marketing channels.

In the case of the JIT Rail Shuttle Service, the business and operating model have been defined together with companies from the port community within the framework of the Living Labs carried out in Valencia. In this regard, the proposed business model is a jointly stablished agreement that aims to promote efficiency and market acceptance. With this goal, debate sessions were set up to identify shortcomings in the current business and operating models, seeking at all times the maximum participation of companies in the definition of a model that would facilitate the use of the rail-shuttle instead of other means of transport. After all these meetings and taking into consideration the different opinions and sensitivities, it was decided that the JIT Rail Shuttle Service should have a collaborative business model whose main value proposal consists of minimizing waiting times at container terminal, achieving a ship-to-train interconnection without additional movements in the terminal.

Therefore, as it is mentioned above, one of the main characteristics of the model is that it reinforces the need for collaboration between the different agents, aiming at increasing the railway transport use and its efficiency. In this regard, a "SHUTTLE" entity is created to manage the capacity (trains) that is added to the service and the "*slots"* (spaces in the train) that are sold to the different Railway Operators.

SHUTTLE entity is a private/public or PPP company that owns locomotives and wagons. This company issues **tender contracts** called "calls for capacity" to select railway companies that wants to operate the shuttle service at a certain price while maintaining an established quality of service. Once selected, railway companies are paid in advance by the SHUTTLE entity for those services that will carry out during an established period of time. In addition, after a railway company is selected, the SHUTTLE entity issues a bidding process to sell the available *slots* among the interested railway operators/freight forwarders.

Rail operators/freight forwarders make their bids to be able to trade a certain percentage (%) of the available slots in the shuttle. SHUTTLE entity studies the offers and choose the best bids (those that guarantee a lowest €/TEU for shippers).

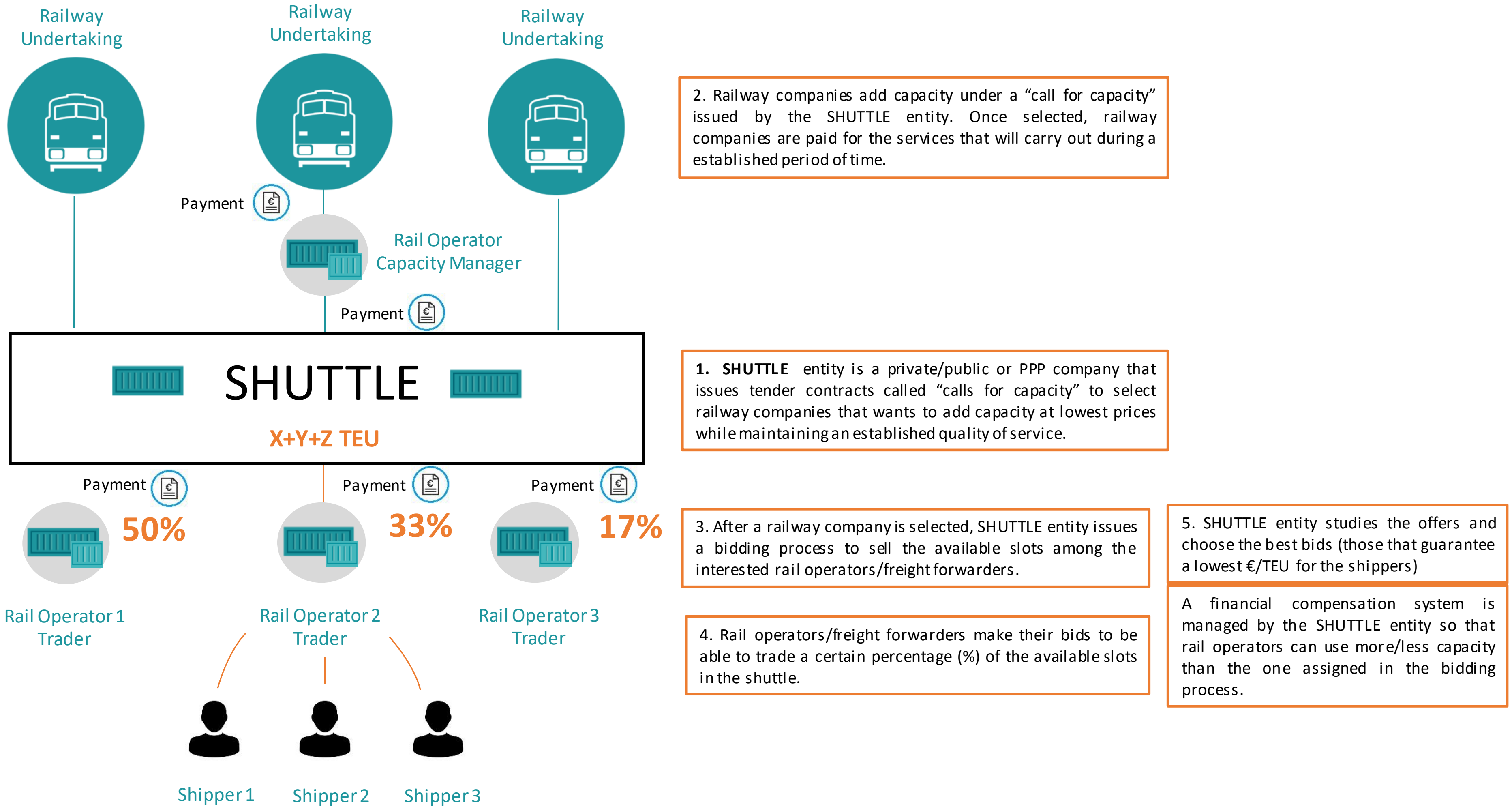


Figure 7. Business model to operate the new Rail Shuttle Service at Valenciaport
Source: Fundación Valenciaport

On the other hand, a financial compensation system is managed by the SHUTTLE entity so that railway operators can use more/less capacity than the one assigned in the bidding process. In this regard, the new business model includes a mechanism for slot exchange between the different railway operators, so that, if a one of them does not fulfill all its available capacity on a given train, it can be used by another operator and vice versa. In this way, the trains are more likely to be completed and greater flexibility and lower financial risk is given to railway operators.

At the end of each month, depending on the real occupation used, the Port Community System extracts a series of reports with which the SHUTTLE entity can make the corresponding adjustments. Under this model, railway operators achieve greater flexibility, frequency and regularity of service, and Railway Companies achieve greater train utilization by better amortizing of the available resources/assets.

Additionally, the possibility of having a financial compensation system with the same cost/slot for all railway operators provides greater flexibility and a lower financial risk for traders. As shown in the following figure, if a certain railway operator does not reach the contracted capacity in a given month (for example, 50 slots/train), it is possible that another operator use this space, compensating it at the end of the month and, therefore, reducing its losses at the end of the month.

	Current situation			New Busines Model		
	RO 1	RO 2	RO 3	RO 1	RO 2	RO 3
Acquired capacity (nº slots)	50	33	17	50	33	17
Real ocuppancy Shuttle 1 (nº slots)	40	33	17	40	43	17
Real ocuppancy Shuttle 2 (nº slots)	50	23	17	50	23	17
Real ocuppancy Shuttle 3 (nº slots)	45	33	17	45	33	22
Gap between acquired capacity and real occupancy (nº slots)	**-15**	**-10**	**0**	**-15**	**0**	**5**
Shuttle system gap		-25,00			-10,00	
Cost/slot (Euros)				100		
Monthly cost	5.000 €	3.300 €	1.700 €	4.500 €	3.300 €	2.200 €
Loss	- 1.500 €	- 1.000 €	- €	- 500 €	- €	500 €

Figure 8. Business model to operate the new Rail Shuttle Service at Valenciaport
Source: Fundación Valenciaport

Therefore, as it is shown in the table, the proposed business model benefits all the agents involved as railway operator 1 would be benefited because RO 3 would compensate part of the slots that has not been able to sell in the first shuttle. On the other hand, RO 3 would be also benefited as it would be able to sell more slots that, with the current situation, would not have been able to dispose, as its capacity is limited to 17 slots/train.

Additionally, RO 2 will also have benefits, as the fact of not having been able to make use of all its occupation in the second train would not have caused losses to it having had the possibility of consuming this capacity in the first shuttle.

Once this has been assessed, it is important to point out that the proposed business model requires an important technological leap through the intelligent compensation module and through the new processes and information flows that have already been described in point 3.2. These innovations make it easier for operations to be planned even before the arrival of the ship at port, speeding up the transfer of containers from the ship to the train and minimizing the dwell time in port.

Finally, the proposed model is based on the basic principles of the *physical internet*[1] through which all participants in the supply chain act as an interconnected network through which information is transferred and shared, maximizing the efficiency of operations and achieving just-in-time services as well as the elimination of those superfluous costs generated by inefficient processes.

[1] https://www.picenter.gatech.edu/node/516

5. Conclusions

The Port Authority of Valencia aims at increasing the rail modal share for import/export cargo and because of this, it is interested in innovative solutions that can help to foster the rail transport mode. In this sense, the deliverable *2.2 COREALIS Just-In-Time Rail Shuttle Service feasibility study* of the WP2 (Port of the future hinterland connectivity) pursues this objective and presents a study for the implementation of Rail Shuttle Service for a key port-hinterland corridor in the port of Valencia, the corridor Valencia-Zaragoza.

The solution proposed aims at directly unload the containers from the vessel and load them onto trains, minimising handling movements and operating as an “air bridge” at airports, so that the shuttle does roundtrips within a day and in which the containers are loaded into the first available JIT rail service. The key successful factor for the JIT Rail Shuttle implementation will be the cost, which will attract shippers to use rail instead of the road transport mode. Thus, the optimal solution will be the one that minimises the cost per unit transported (minimum cost per TEU).

To get the optimum physical and operational solution a set of hypothesis were analysed. These hypotheses resulted in seven scenarios for which, firstly, it was needed to obtain the optimal composition of the shuttle train based on the number and type of wagons. As can be seen in the section 2, the optimal solution for all the defined scenarios (scenarios 1-7) was 80 feet wagons, which allow to load 4x20 feet containers, or a combination of a 40 feet unit in the middle and 2x20 feet units at the beginning and at the end platform.

Secondly, a cost analysis was carried out from the point of view of the railway undertaking that operates the JIT rail shuttle service in the selected corridor. In this sense, the Scenario 5 was the one that minimised the cost per TEU (93.29 Euros/TEU). However, given the fact that this JIT rail shuttle service will be the first rail shuttle operating in Spain, the Scenario 6 (95.37 Euros/TEU) that only does 2 roundtrips per day instead of 3 like the Scenario 5 was selected as a more realistic option in the short term. Besides this, a sensitivity analysis was performed on the cost per TEU transported (€/TEU) applying stochastic simulation to see which are the most relevant parameters that affect it. In this sense, the port and inland terminal handling charges, the fuel price and the ACA services explain almost 50% of the cost per unit transported.

Another important issue for the shuttle implementation is the information exchange between the actors involved (Shipping Agents, Port-rail-inland terminals/Container Terminals, Freight Forwarders, Railway Operators and Railway Undertakings). The study reveals that the implementation of the new JIT Rail Shuttle Service requires important changes that affect the current information flows. In this sense, port terminals will assume a new role in the loading/unloading procedure since they are the ones that will manage which containers are transported by the shuttle. For this purpose, the PCS and the TOS will also play a fundamental role.

Finally, the business model proposed for the operation of the shuttle will be a collaborative business model whose main value proposition consists of minimizing waiting times at container terminal by achieving a ship-to-train interconnection. In this regard, a “SHUTTLE” entity will be created to manage the capacity of the shuttle (trains) and the “slots” (spaces in the train) will be sold to external Railway Operators. Besides, railway operators will have the possibility to exchange slots so that they will achieve greater flexibility, frequency and regularity of the service and Railway Companies will achieve greater train utilization. Thus, minimum cost per unit transported.

References

[1] M., Acciaro & A., McKinnon (2013). *Efficient Hinterland Transport Infrastructure and Services for Large Container Ports*. ITF/OECD Discussion Paper 19, 2013.

[2] Peter W. de Langen (2008). *Ensuring Hinterland Access. The Role of Port Authorities* ITF/OECD Discussion Paper 11, 2008.

Annex 1: ‘Characteristics of shipping containers

Characteristics of shipping containers

20’ containers	Internal Dimensions: Length: 5.9 m; Width: 2.4 m; Height: 2.4 m Cubic Capacity: 33 m^3 Max Gross Weight: 30,480 kg Tare Weight: 2,280 kg
40’ containers	Total number of 40’ containers, which have the following characteristics: Internal Dimensions: Length: 12.0 m; Width: 2.4 m; Height: 2.4 m Cubic Capacity: 67 m^3 Max Gross Weight: 32,500 kg Tare Weight: 3,700 kg
45’ containers	Total number of 45’ containers, which have the following characteristics: Internal Dimensions: Length: 13.6 m; Width: 2.4 m; Height: 2.7 m Cubic Capacity: 85 m^3 Max Gross Weight: 32,500 kg Tare Weight: 4,900 kg