C4R

Capacity for Rail

SP2 New Concepts for Efficient Freight systems

Interactive Workshop

A New Competitive, Reliable, Sustainable and Connected Rail Freight Transport

Brussels, 26/06/2017

Stefano Ricci

Sapienza Università di Roma

DICEA

stefano.ricci@uniroma1.it

SAPIENZA UNIVERSITÀ DI ROMA

SEVENTH FRAMEWORK PROGRAMME

Afternoon's program

Capacity for Rail

14:30 to 15:45 **Rail-Road; Rail-Sea, Marshalling Yards: Enhancement of Interfaces**

0. Introduction and scopes

1. Features and role of typical terminals and yards

2. Key Performance Indicators (KPI)

3. Real world case studies

4. Innovative technologies and operational measures: role and applicability fields

5. Future scenarios: effects of innovations

6. Economical and financial feasibility

15:45 to 16:30 **Questions and answers**

16:30 to 16:45 **Conclusions**

Introduction and scopes: focus

Capacity for Rail

"CAPACITY4RAIL aims at paving the way for the future railway system, delivering coherent, demonstrated, innovative and sustainable solutions"

SUB-PROJECT 2 works towards
"a modern, automated, intelligent and fully-integrated system for efficient, reliable freight Operations"
By means of:

WP2.1 *"Progress beyond State of the Art on Rail Freight Systems"* (Reference standards 2030 and 2050)

WP2.2 *"Novel rail freight vehicles"*

WP2.3 *"Co-modal transshipment and interchange/logistics"*

WP2.4 *"Catalogue of specifications"*

Introduction and scopes: team

C4R Capacity for Rail

SAPIENZA UNIVERSITÀ DI ROMA

DB BAHN

IK INSTYTUT KOLEJNICTWA

KTH VETENSKAP OCH KONST

New OPERA

Network Rail

Newcastle University

TRAFIKVERKET

UIC

FUNDACIÓN Valenciaport

Introduction and scopes: answers

C4R Capacity for Rail

Contributions of terminals to future rail freight systems 2030 and 2050

- **1. Features and role = *What the terminals should do***
- **2. Key Performance Indicators (KPI) = *How the terminals performances can be measured***
- **3. Real world case studies = *How the terminals are working today***
- **4. Innovative technologies and operational measures = *What the terminals can take onboard and integrate***
- **5. Future scenarios: effects of innovations = *How the terminals could work***
- **6. Economical and financial feasibility = *To what extent the terminals will be economically and financially sustainable***

Features and role: standards (1)

Equipment	**Common standard 2010**	**Incremental change 2030 ***	**System change 2050 ***
Wagons			
Running gears	Different	50% Track-friendly	All track friendly
Brakes	Casted-brakes	LL-brakes	Disc-brakes
Brake control	Pneumatic	Radio controlled EOT	Fully Electronic
Couples	Screw couples	Automatic couplers on some trains	Automatic couples on all trains
Max Speed	100 km/h	120 km/h	120-160 km/h
Max Axle load	22,5 tonnes	22,5-25 tonnes	22,5-30 tonnes
Floor height lowest	1100 mm	1000 mm	800 mm
IT-system	Way-side	Some in wagons	All radio controlled
Locomotives			
Tractive effort kN	300	350	400
Axle load	20 tonne	22,5 tonne	25 tonne
Propulsion	Electric	Some duo-locos	Most duo-locos
Fuel	Diesel	LNG/Diesel	LNG/electric
Engineers	Always drivers	Some driverless	All driverless
Trains			
Train lengths in RFC	550-850 m	750-1000 m	1000-2000 m
Train weight	2 200 tonnes	4 400 tonnes	10 000 tonnes

Features and role: standards (2)

Capacity for Rail

Equipment	**Common standard 2010**	**Incremental change 2030 ***	**System change 2050 ***
Infrastructure			
Rail Freight Corridors	18.000km	25.000km	50.000km
Signalling systems	Different	ERTMS L2 in RFC	ERTMS L3 in RFC
Standard rail weight	UIC 60 kg/m	70 kg/m	70 kg/m
Speed ordinary freight	100 km/h	100 -120 km/h	120 km/h
Speed fast freight	100 km/h	120 -160 km/h	120 -160 km/h
Traffic system			
SWL	Marshalling - feeder	Marshalling – feeder Some liner trains	Automatic marshalling Liner trains – duo -loco
Train load		Remote controlled	All remote controlled
Inter Modal	Endpoint -trains	Endpoint -trains Liner trains with stops at siding	Endpoint -trains Liner trains fully automated loading
High Speed Freight	National post trains	International post and parcel -trains	International post and parcel -train network
IT /monitoring systems			
	Some different	Standardized control system	Full control of all trains and consignments

*) Adapted to market needs in each product and line

Features and role: typical terminals

Rail-Road: interchange interchange

DB DUSS Riem – Munich (Germany)

IFB Zomerweg – Antwerpen (Belgium)

NV Combinant – Antwerpen (Belgium)

HUPAC HTA – Antwerpen (Belgium)

Typical small scale automatic linear terminal

DB DUSS Duisburg (Germany)

Rail-Rail: marshalling yard

Hallsberg (Sweden)

Rail-Sea: port rail terminal

Valencia Principe Felipe (Spain)

KPI: selection criteria

Capability to display the present performances

- Meeting requests of operators
- Effectiveness to describe terminal operation performances

Sensibility to potential changes introduced by innovations

- Capability to assess effects of new technologies
- Capability to assess effects of innovative operational measures
- Homogenization with forecasting methods and models

Large scale identification

- Rail-Road: 13; Rail-Rail: 15; Rail-Sea: 14

Fine tuning

- Most effective from operation performances viewpoint
- Most reliable method (algorithms and/or simulation) for KPI calculation
- Rail-Road: 4/13; Rail-Rail: 4/15; Rail-Sea: 4/14

KPI: selection for inland interchanges

Capacity for Rail

Total Transit Time (ITU) **Total Transit Time (vehicle)**	$TTR = \sum_{i=1}^{n} TWi + \sum_{i=i}^{n} TOi$	**Time period from the arrival of the freight unit (or vehicle) to the terminal gate from road (an external transport infrastructure) to the exit of the unit (or vehicle) from the terminal towards road or railway network.** • **TTR_v =vehicle total transit time (Truck and train);** • **TTR_{ITU} = Unit total transit time;** • **TW = waiting time;** • **TO = operational time.**	**Analytical Method**
Equipment Performance	$Ep = \frac{n_{ITU}}{h}$	Capacity of handling equipment. • n_{ITU} = number of handled intermodal transport unit; • h = hour.	Simulation model
System utilization rate	$\varrho = \frac{\lambda}{\mu}$	Queueing theory parameter useful to measure correct size of sidings. • ϱ = system utilization; • λ = average rate of arrivals; • μ = average rate of served.	

SEVENTH FRAMEWORK PROGRAMME

KPI: selection for marshalling yards

Capacity for Rail

Maximum flow through the yard	$$\Phi_{max} = \frac{N_{max}}{T - (t_{pr} + t_{av})}$$	**Useful to measure the effect of the interruptions on the maximum number of wagons daily treated.** • Φ_{max} **= maximum flow through the yard** • N_{max} **= maximum capacity of the hump** • T **= time interval** • t_{pr} **= mean interruption time for breakdowns** • t_{av} **= mean scheduled interruption**	**Analytical Method**
Mean number of wagons in the yard at the same time	$$n_{cpi} = \frac{N}{T} t_{mtw}$$	• N = mean number of trains daily handled • T = time interval • t_{mtw} = mean wagon transit time	
Average wagon transit time	$$t_{mtt} = \sum_{i=1}^{12} t_i$$	Mean time period from the arrival of a wagon to the marshalling yard from railway network to the exit of the wagon from the marshalling yard to the railway network. • t_{mtt} = mean wagon transit time • t_i = partial time (waiting or operative time)	Simulation model
Tracks utilization rate	$$A_{su} = \frac{L_{tr}}{La_{bin}}$$ $$D_{su} = \frac{L_{tr}}{Ld_{bin}}$$ $$P_{su} = \frac{L_{tr}}{Lp_{bin}}$$	Arrival sidings track utilization factor, useful to measure the tracks adequacy to receive new longer trains • L_{tr} = Average train length • La_{bin} = Average arrival sidings track length • Ld_{bin} = Average direction sidings track length • Lp_{bin} = Average departure sidings track length	

KPI: selection for port rail terminals

Capacity for Rail

Total Transit Time (ITU) **Total Transit Time (vehicle)**	$TTR = \sum_{i=1}^{n} TWi + \sum_{i=i}^{n} TOi$	**Time period from the arrival of the freight unit (or vehicle) to the terminal gate from road (an external transport infrastructure) to the exit of the unit (or vehicle) from the terminal towards road or railway network.** • **TTR_V =vehicle total transit time (Ship and train);** • **TTR_{ITU} = Unit total transit time;** • **TW = waiting time;** • **TO = operational time.**	**Analytical Method**
Equipment Performance	$Ep = \frac{n_{ITU}}{h}$	Capacity of handling equipment. • n ITU = number of handled intermodal transport unit; • h = hour.	Simulation model
System utilization rate	$\varrho = \frac{\lambda}{\mu}$	Queueing theory parameter, useful to measure correct size of sidings. • ϱ = system utilization; • λ = average rate of arrivals; • μ = average rate of served.	

Case studies: Riem

DB DUSS Riem Terminal – Munich (Germany)

5 arrivals tracks in the holding area
3 operative modules
14 loading/unloading tracks
6 trucks lanes
8 storage lanes
6 RMG cranes

24 trains/day

Case studies: IFB Zomerweg

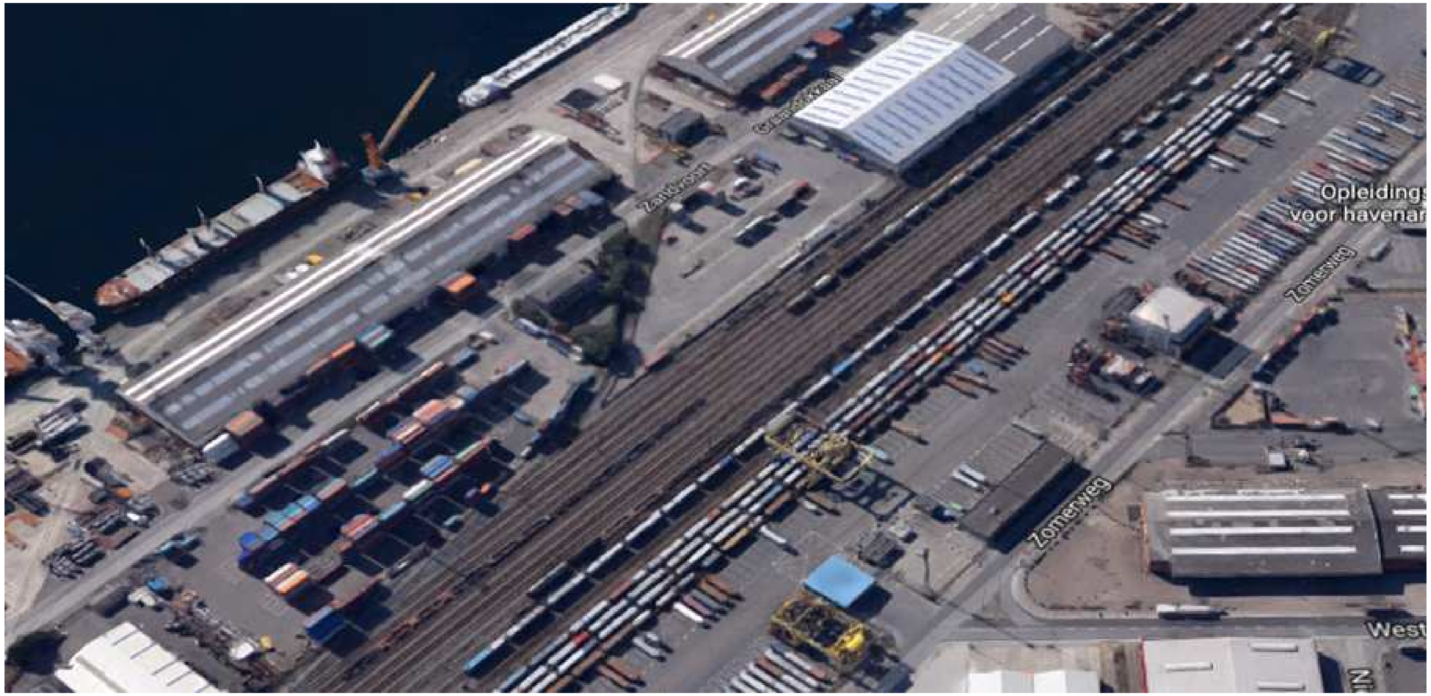
Capacity for Rail

IFB Zomerweg Terminal – Antwerpen (Belgium)

4 tracks

2 cranes + 2 straddle carriers

5 trains/day



SEVENTH FRAMEWORK PROGRAMME

Case studies: IFB Zomerweg

Capacity for Rail

NV Combinant Terminal – Antwerpen (Belgium)

5 tracks

3 RMG cranes

150,000 units/year

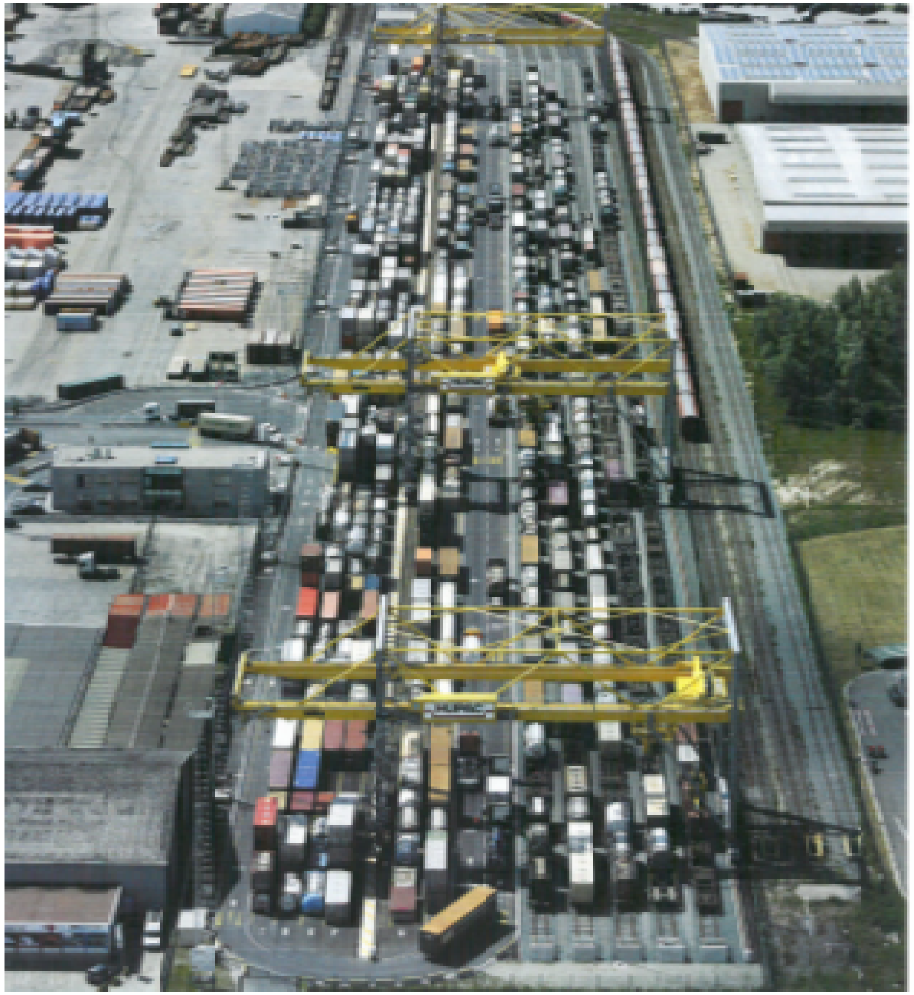
11 trains/day

Case studies: HUPAC HTA

HUPAC HTA Terminal – Antwerpen (Belgium)

4 tracks
3 RMG cranes

235 trucks/day
4 trains/day



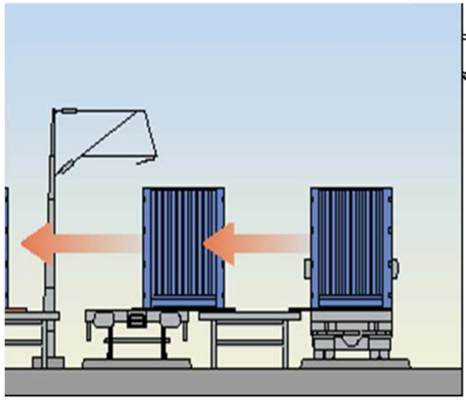
Case studies: linear terminal

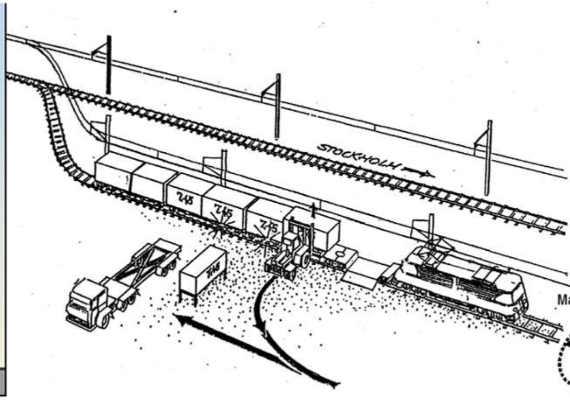
Typical small scale automatic linear terminal

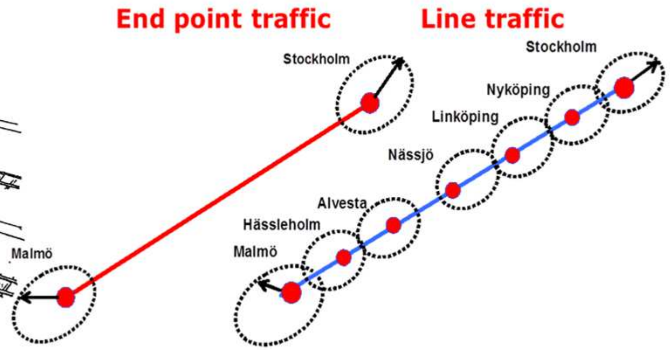
1 track (600 m)

2 temporary storages (200 m)

1 trucks lane (200 m)







Case studies: Duisburg

DB DUSS Duisburg Terminal (Germany)

5 arrivals tracks in the holding area
1 operative module
8 operative tracks (680 m) electrified up to the cranes
1 external track dedicated to specific traffic
2 trucks lanes (1 operative for 27 trucks + 1 for crossing through)
2 short term storage lanes (680 m, 2 levels, 424 TEU)
2 long term storage areas (1 with 9 lanes for dangerous goods)
3 RMG cranes with intermodal spreader (2 over 6 tracks + 1 over 8 tracks)
1 trucks check-in area with 2 gates + 18 parking places
24 h 6/7 days operational time

9 trains/day
252 units/day
280 trucks/day

Case studies: Hallsberg

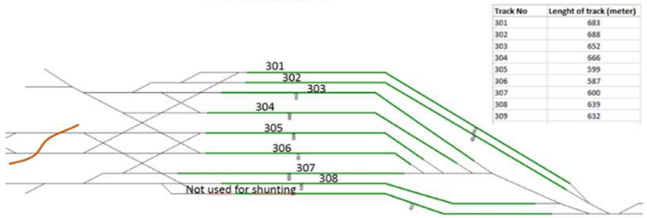
Hallsberg marshalling yard (Sweden)

Arrival sidings: 8 tracks (590÷690 m)
Double Hump
Direction sidings: 32 tracks (374÷760 m)
Departure sidings: 12 tracks (562÷886 m)
Capacity: 1370 wagons/day

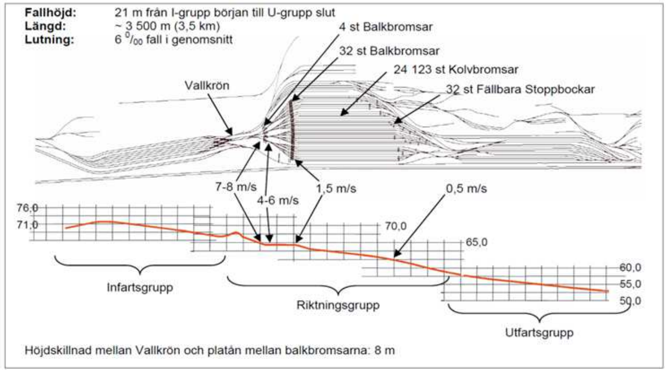
836 wagons/day

Technical Specifications	
Shunted volume (2002)	305 000 wagons/year
The capacity of the marshalling yard per year	500 000 wagons/year
Available shunting capacity over the hump (theoretical maximum value)	2 900 wagonmeters/hour
Humping Speed	Max. 1.2 meter/second
Wagongroup length	9-125 meters
Number of axles per group of wagons	Max. 20 axles
Axle Load	4.5 - 22.5 tonnes
Wheel Load	2 - 12.25 tonnes/meter
Highest allowed weight per meter (Stvm)	6.4 tonnes/meter
Max weight over hump	450 tonnes
Total Lenth of the Yard (arrival, direction and departure tracks	3.5 kilometers
Slope- Gradient ration of the yard	Average 6 meters/km. 21 meters in total, i.e. 6 ‰
Meters of track (total)	60 km
Number of point switches	170
Number of piston brakes	24 123
Number of beam rail brakes, double sides. (located at the entrance to the direction sidings)	32
Number of beam rail brakes, one side. (direction beam rail brakes).	32
Number of buffer stops	32

Hallsberg – Arrival group



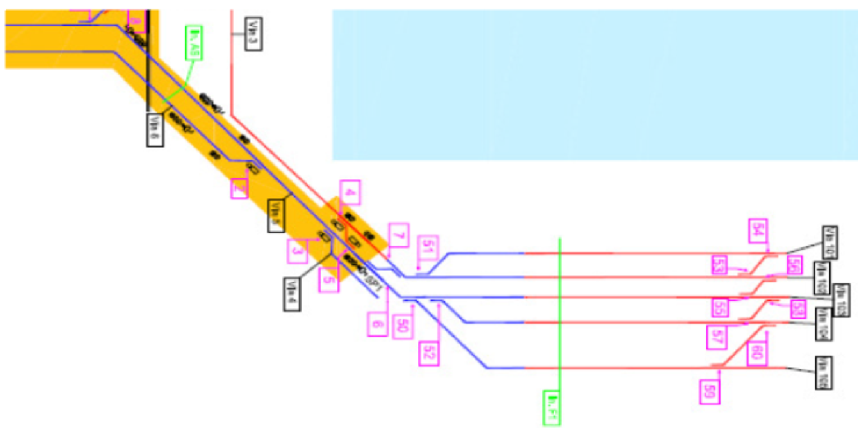
Track No	Lenght of track (meter)
301	683
302	688
303	652
304	666
305	599
306	587
307	600
308	639
309	632



Case studies: Valencia Principe Felipe

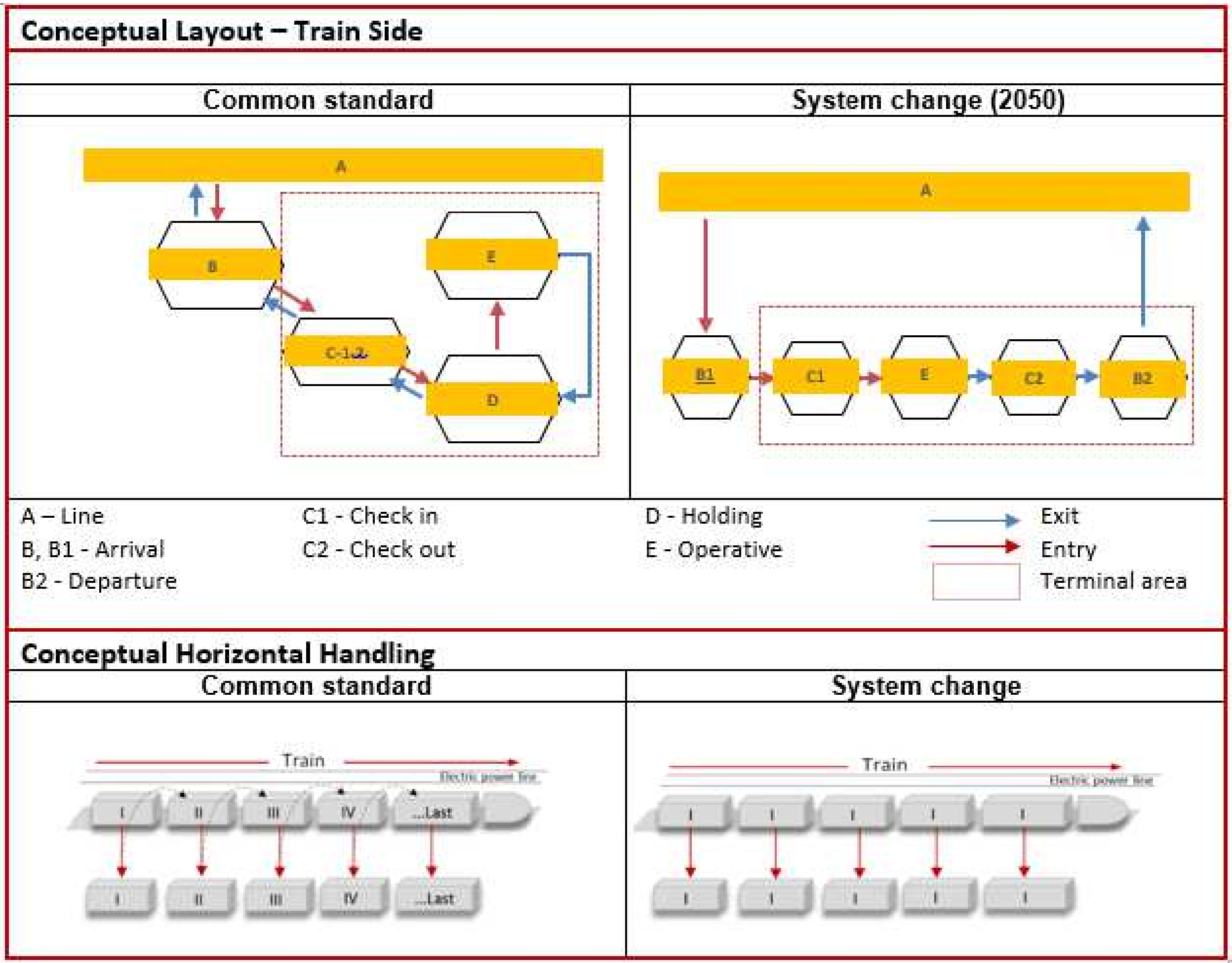
Valencia Principe Felipe port rail terminal (Spain)

Total area: 50,000 m2
4 loading/unloading tracks
Extra track to shunt locomotives
Electrified tracks until approaching loading/unloading area
Two road access
Two storage areas (9,000 + 20,000 m^2)



Innovations: Rail-Road

Examples for inland interchanges



Innovations: Rail-Rail

Examples for marshalling yards

Rolling Stock Equipment 1			
	Common standard	**Incremental change (2030)**	**System change (2050)**
Brakes	- manual controlled track brakes and retarders - automatic controlled track brakes and retarders	- automatic retarders [1] - automatic brakes on wagons	- automatic brakes on wagons
Rolling Stock Equipment 2			
	Common standard	**Incremental change (2030)**	**System change (2050)**
Internal vehicle movement	- diesel shunting locomotives with driver	- diesel shunting locomotives with driver - driverless locomotives [2]	- driverless locomotives [2]

Input Parameters Influenced
Mean number of trains daily treated
Mean time to receive orders from the marshalling yard control office [min]
Mean time between throwing [min]
Mean time lost in the direction sidings [min]
Mean needed time for acceleration from throwing speed to mean speed in the point switches area [s]
Mean interruption time for breakdowns [min]
Mean speed for group of wagons throwing [m/s]
Mean speed along the generic direction sidings track [m/s]
Mean speed in the point switches area [m/s]
Number and type of hump retarders
Number of operators per function
Annual cost of brake maintenance
Mean shunting locomotive speed [m/s]
Number and type of shunting locomotives

Innovations: Rail-Sea

Capacity for Rail

Examples for port rail terminals

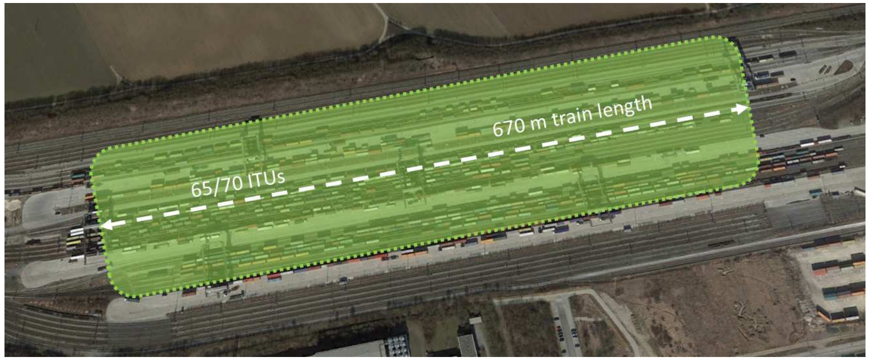
Intermodal Freight Terminal Rail - Sea			
Today´s common standard, incremental change and system change.			
Handling Typology			
	Common standard	**Incremental change (2030)**	**System change (2050)**
	- indirect and direct	- mainly direct	- faster and fully direct
Handling Equipment 1			
	Common standard	**Incremental change (2030)**	**System change (2050)**
H.E. in operative track	- transtainer and reach stacker or forklift - few systems for horizontal transfer	- fast transtainer - more systems for horizontal transfer [1], [2], [3], [4]	- automated fast transtainer with moving train [4] - automated systems for horizontal and parallel handling [1], [2], [3], [4]
Input Parameters Influenced			
Mean time of unit pick up by transfer devices [min]			
Mean time of unit drop off by transfer devices [min]			
Mean longitudinal transfer speed of transfer equipment [m/min]			
Mean transversal transfer of transfer equipment [m/min]			
Number of transfer equipment			
Number of operators on the tracks			
Number of operative rail lanes			

Innovations: combination into scenarios

Scenario Terminal Typology	Today	Consolidated Scenario CS	Scenario 1 S1	Scenario 2 S2
Rail – Road Munich Riem	X	X	X	X
Rail – Road Antwerpen Combinant	X	X		
Rail - Road Antwerpen HUPAC	X	X		
Rail – Road Antwerpen Zomerweg	X	X		
Rail – Road Typical linear		X		
Rail - Road Duisburg	X	X		
Rail - Rail Hallsberg marshalling yard	X	X	X	X
Rail - Sea Valencia Principe Felipe	X	X	X	X

Innovations: CS for Riem

- Mean number of containers: 65 (10.36 m per ITU)
- Long Train: 670 m
- H24 working time
- Direct access of train in operative area
- Automatic coupling/uncoupling loco
- Multi lift spreader handling
- ITU and vehicles automatic control and data exchange



Innovations: CS for Hallsberg

Capacity for Rail

- Tracks operative length till 1500 m
- MMM (Multi Modal Marshalling) Yard: classification tracks accessible not only via hump
- Automatic wagon identification
- Automatic coupling and uncoupling
- Automatic brakes on wagons
- Self-propelled wagons
- Duo propulsion and driverless locomotives
- Working time 24 hours

SEVENTH FRAMEWORK PROGRAMME

Innovations: CS for Valencia

Capacity for Rail

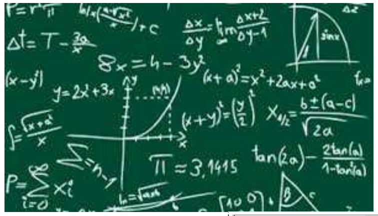
- Long Train: 850 m / 1000 m
- H24 working time
- Automatic coupling and uncoupling loco
- Number of containers: 80/100 (10.36 m per ITU)
- Multi lift spreader handling
- ITU and vehicles automatic control and data exchange

Effects of innovations: evaluation

Requirement: capability to reproduce terminals' operation

Analytical methods based on combined algorithms (e.g. queuing theory)

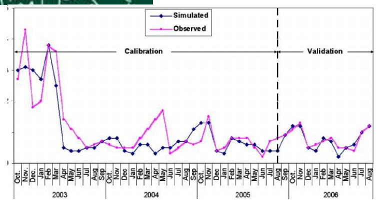
Simulation models based on event-based processes reproduction



Calibration on typical terminals

Subset of data describing the typical operation

Cross analysis of typical/calculated /simulated KPI



Tests for validation on case studies

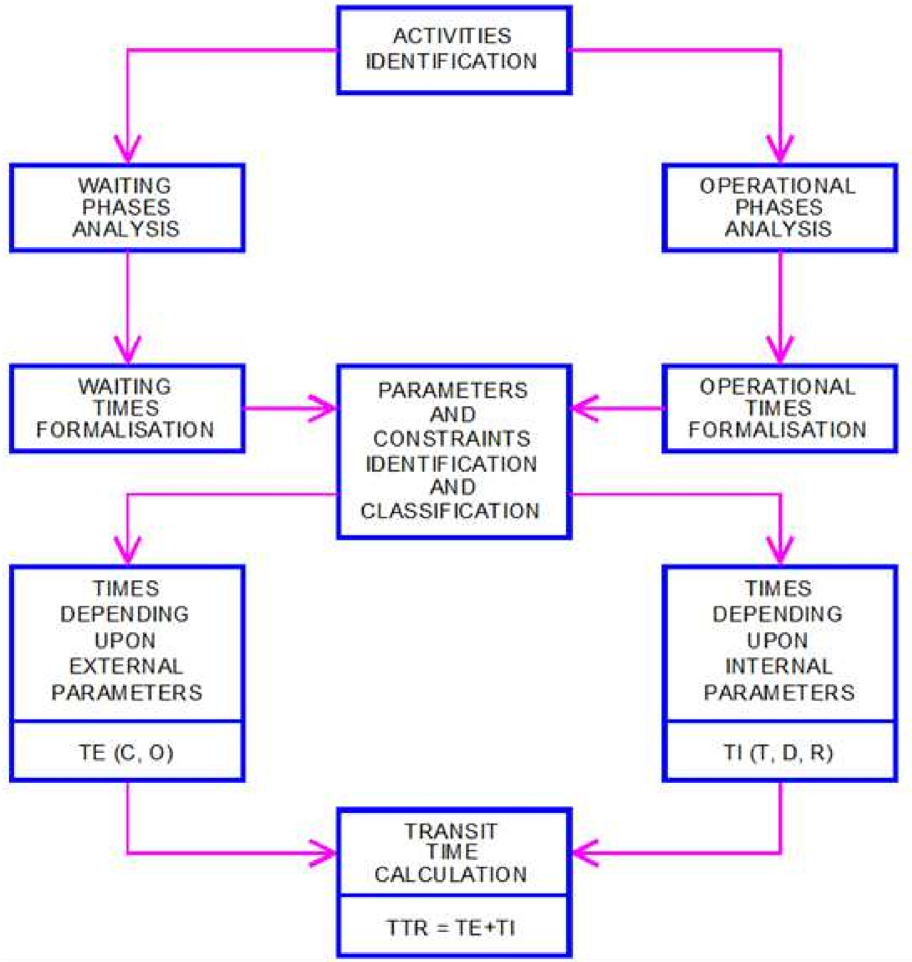
More extended set of data describing the present operation

Cross analysis of real world/calculated /simulated KPI

Extended application to selected scenarios for case studies

Effects of innovations: analytical methods

Generalised approach
Customisation to case studies
KPI calculation
Examples of calculation flows



Effects of innovations: simulation models

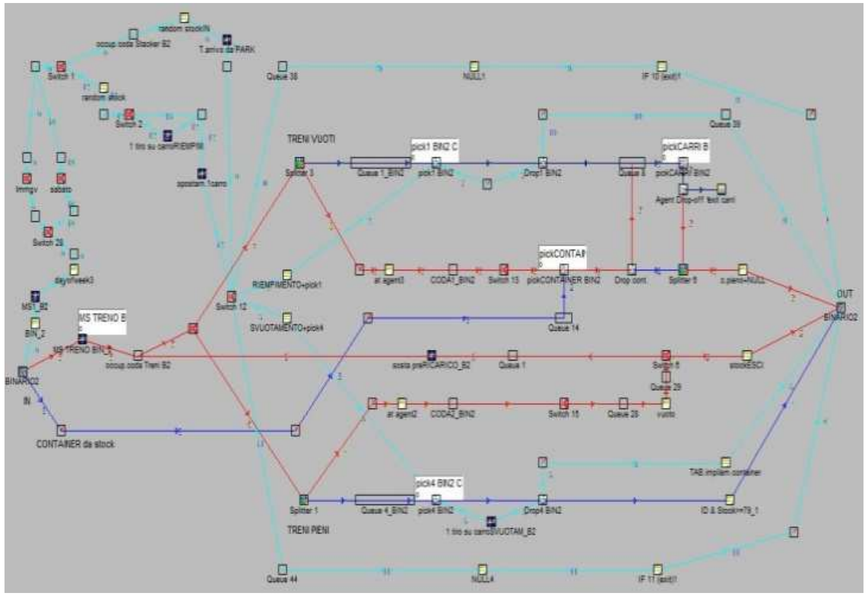
Capacity for Rail

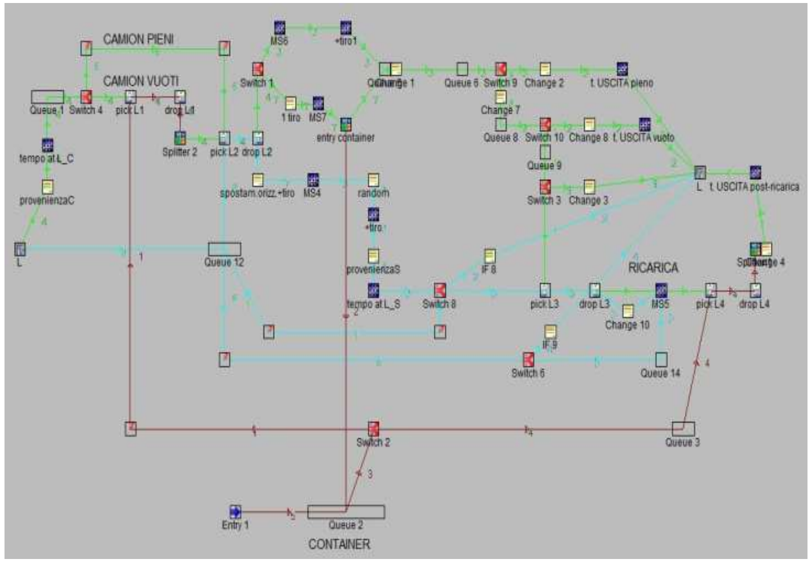
Original development by Planimate® freeware

Customisation by terminal typology

KPI calculation

<u>Examples of hierarchical layers</u>

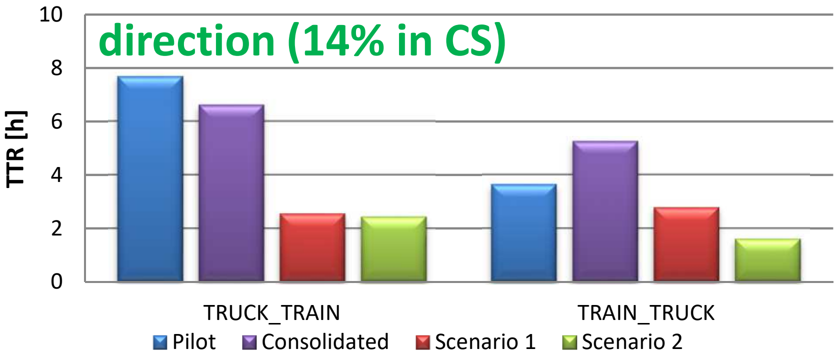




Effects of innovations: Riem

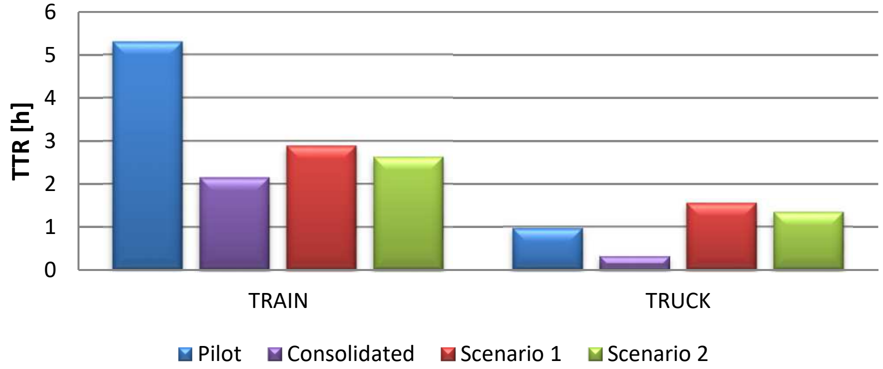
ITUs total transit time

Relevant reduction in truck-train direction (14% in CS)



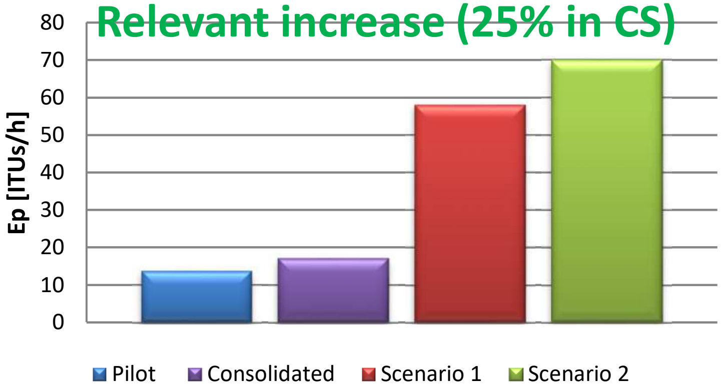
Vehicles total transit time

General reduction for train



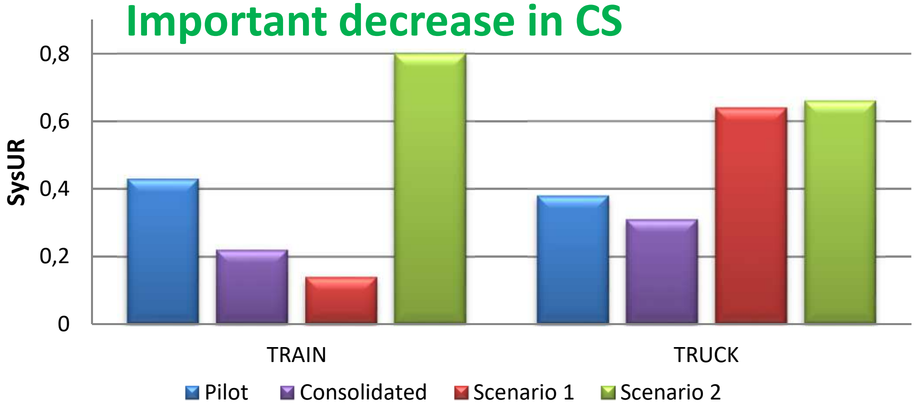
Equipment performance

Relevant increase (25% in CS)



Vehicles utilisation rate

Important decrease in CS



Effects of innovations: Riem

Capacity for Rail

Positive and negative effects

- *Green = Positive effect*
- *Red = Negative effect*

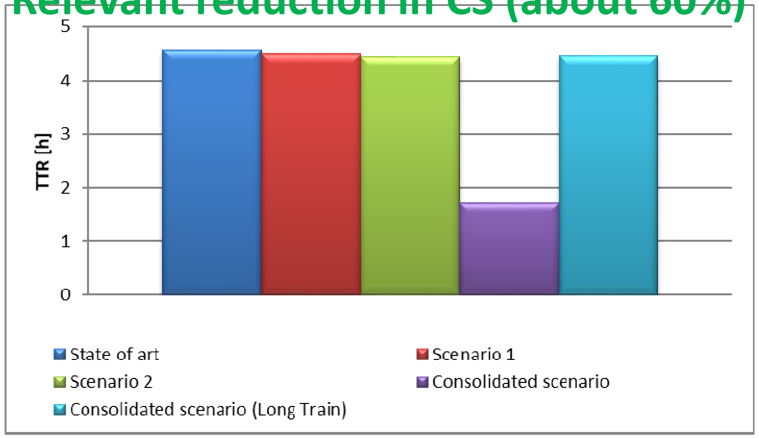
		SCENARIO					
		Consolidated				1	2
KPI		Riem	Combinant	HUPAC	Zomerweg	Riem	Riem
Total Transit Time (ITU)	TRUCK_TRAIN	Green	Green	Green	Green	Green	Green
	TRAIN_TRUCK	Red	Green	Green	Red	Green	Green
Total Transit Time (vehicle)	TRAIN	Green	Green	Green	Green	Green	Green
	TRUCK	Green	Green	Green	Green	Red	Red
Equipment Performance	CRANE	Green	Green	Green	Green	Green	Green
System utilization rate	TRAIN	Green	Green	Green	Green	Green	Red
	TRUCK	Green	Green	Green	Red	Red	Red

Effects of innovation: Hallsberg

Capacity for Rail

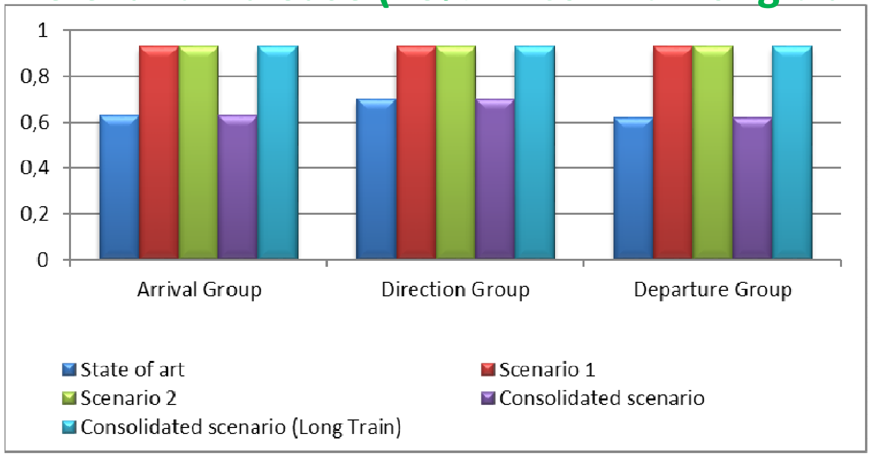
Average wagon transit time

Relevant reduction in CS (about 60%)



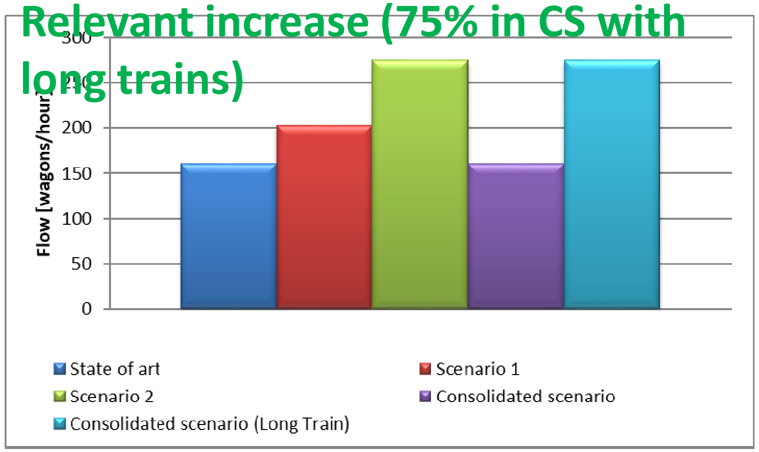
Tracks utilization rate

Relevant increase (48% in CS with long trains)



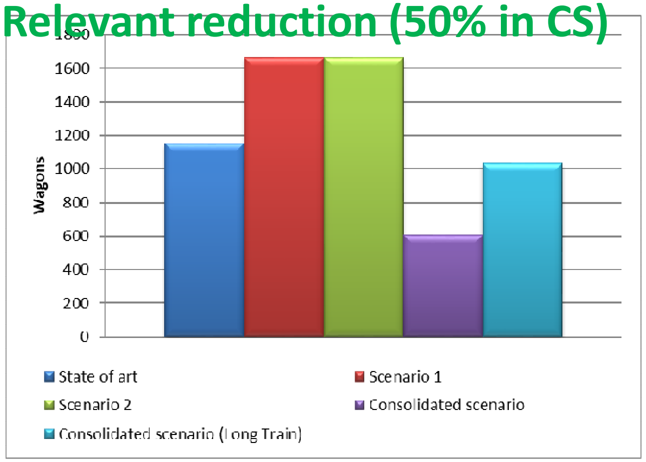
Maximum flow through the yard

Relevant increase (75% in CS with long trains)



Average number of wagons in the yard

Relevant reduction (50% in CS)



Effects of innovation: Hallsberg

Capacity for Rail

Positive and negative effects

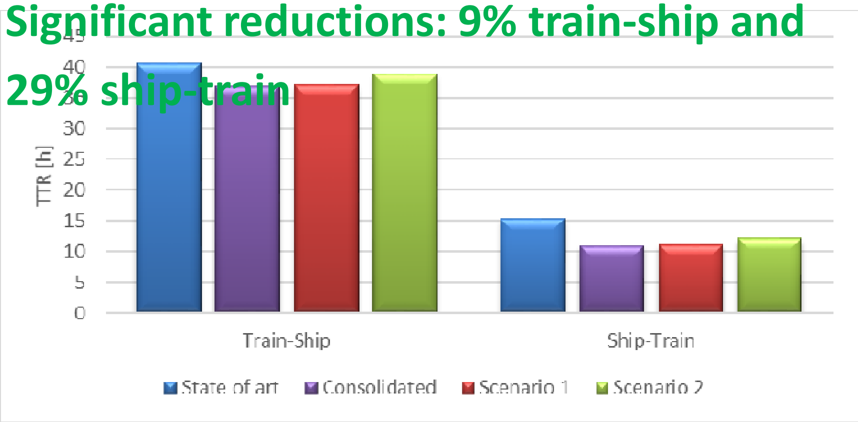
- *Green = Positive effect*
- *Red = Negative effect*

KPI		SCENARIO			
		Consolidated	Consolidated (Long Train)	1	2
Average wagon transit time					
Tracks utilization rate	Arrival Group				
	Direction Group				
	Departure Group				
Maximum flow through the yard					
Average number of wagons in the yard					

Effects of innovation: Valencia

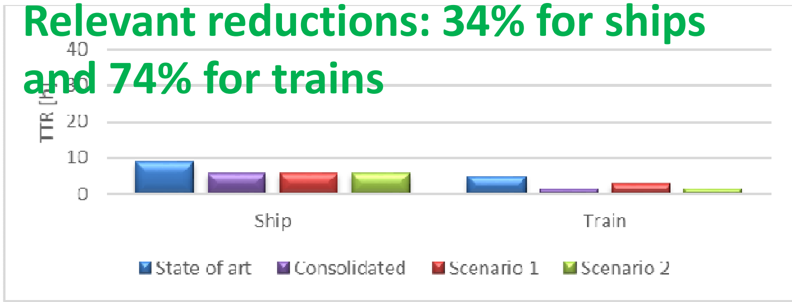
ITUs total transit time

Significant reductions: 9% train-ship and 29% ship-train



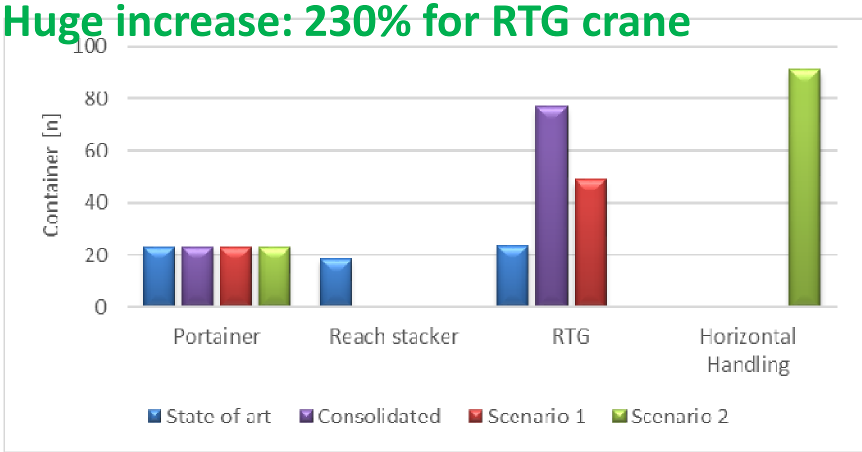
Vehicles total transit time

Relevant reductions: 34% for ships and 74% for trains



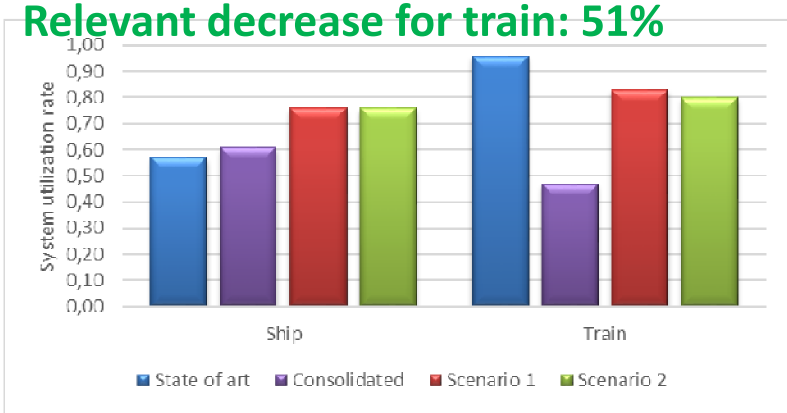
Equipment performance

Huge increase: 230% for RTG crane



Vehicles utilization rate

Relevant decrease for train: 51%



Effects of innovation: Valencia

C4R
Capacity for Rail

Positive and negative effects

- *Green = Positive effect*
- *Red = Negative effect*

KPI		SCENARIO		
		Consolidated	1	2
Total Transit Time (ITU)	TRAIN-SHIP			
	SHIP-TRAIN			
Total Transit Time (vehicle)	SHIP			
	TRAIN			
Equipment Performance	PORTAINER			
	REACH STACKER	-	-	-
	RTG			-
	HORIZONTAL HANDLING	-	-	
System utilization rate	SHIP			
	TRAIN			

Feasibility: traffic estimation

Capacity for Rail

Increase factors and increase rate per year

	Increase factor			Increase % per year		
	2015 2030	**2030 2050**	***2015 2050***	**2015 2030**	**2030 2050**	***2015 2050***
Business as Usual	1.16	1.17	***1.37***	1.0%	0.8%	***0.95***
Modal shift Low scenario	1.34	1.38	***1.87***	2.0%	1.6%	***1.8%***
Modal shift High scenario	1.65	1.84	***3.06***	3.4%	3.1%	***3.2%***

Feasibility: capital costs

Capacity for Rail

Capital costs analytical calculation (e.g. Riem - inland interchange)

Investment costs					
	Unit	Number	Cost € / unit	Cost Thousands €	Share %
Terminal Investment					
Land acquisition (m2)	m2	280 338	25	7 108	6,9%
Connection Track 200 m (5 tracks) - Track foundation	m	1 000	317	317	0,3%
Connection Track 200 m (5 tracks) - Track structure	m	1 000	634	634	0,6%
Points (switches) (excluding heaters)	m	45	169 035	7 607	7,3%
Handling tracks - Track foundation	m	9 800	317	3 106	3,0%
Handling track - Track structure	m	9 800	634	6 212	6,0%
Shunting tracks - Track foundation	m	8 000	317	2 536	2,4%
Shunting tracks - Track structure	m	8 000	634	5 071	4,9%
Buffer stop	No.	5	4 226	21	0,0%
Catenary to the handling tracks (200m)	m	600	1 056	634	0,6%
Catenary to other tracks	m	8 000	1 056	8 452	8,2%
Road link to the main network	m	2 800	53	148	0,1%
Fences, gates, barriers	m	2 880	37	106	0,1%
Security equipment (cameras / alarms)	m	2 880	53	152	0,1%
Handling and space requirements - dim. 110-tonne axle load	m2	138 171	116	16 057	15,5%
Administrative building & maintenance depot (m2)	m2	800	528	423	0,4%
Fuel tanks	No.	2	4 226	8	0,0%
Lighting	m / track-m	301	1 056	318	0,3%
Drainage	m	9 800	106	1 035	1,0%
Noise barrier	No.	3	2 112 939	6 339	6,1%
Crane runway	No.	3	4 014 584	12 044	11,6%
Rainwater retention	No.	1	1 584 704	1 585	1,5%
Forch water	No.	1	316 941	317	0,3%
Spill through	No.	1	105 647	106	0,1%
Land examination	m2	0	-	-	0,0%
IT system	No.	3	306 376	919	0,9%
Sum		700	-	81 254	78,5%
Technical eqiupment					
New reachstacker	No.	1	475 411	475	0,5%
Used reach stackers	No.	1	158 470	158	0,2%
RMG cranes	No.	6	3 486 350	20 918	20,2%
Locomotive	No.	1	739 529	740	0,7%
Sum				22 292	21,5%
Total Investment Costs				103 545	100,0%

SEVENTH FRAMEWORK PROGRAMME

Feasibility: operational costs

C4R Capacity for Rail

Operational costs analytical calculation (e.g. Riem - inland interchange)

DUSS Munich-Reim terminal Annual terminal operational cost components/items	Share %	Cost € Thousands	Source
Annual transhipment equipment running/hire (excluding procurement) cost	5,8%	487	DB
Annual transhipment equipment maintenance cost including procurement of spare parts but excluding major procurement /investment	12,6%	1 053	DB
Annual Personnel cost (split into salaries + social/health/pension insurance)	43,1%	3 585	DB
Annual insurance cost (equipment + operation)	1,7%	142	DB
Annual energy cost	4,1%	338	DB
Annual Terminal hire/rent/mortgage/bank interest cost	3,9%	323	DB
Annual infrastructure maintenance cost	9,8%	813	DB
Other terminal costs (fuel tanks, truck depots security and others)	9,6%	802	DB
Rent	4,2%	350	DB
Annual cost for shunting engine	5,2%	433	KTH model
Cost in thousand Euros - Total (Average for the period 2011-2014, Excluding VAT)	100%	**8 326**	

SEVENTH FRAMEWORK PROGRAMME

Feasibility: total costs

Capacity for Rail

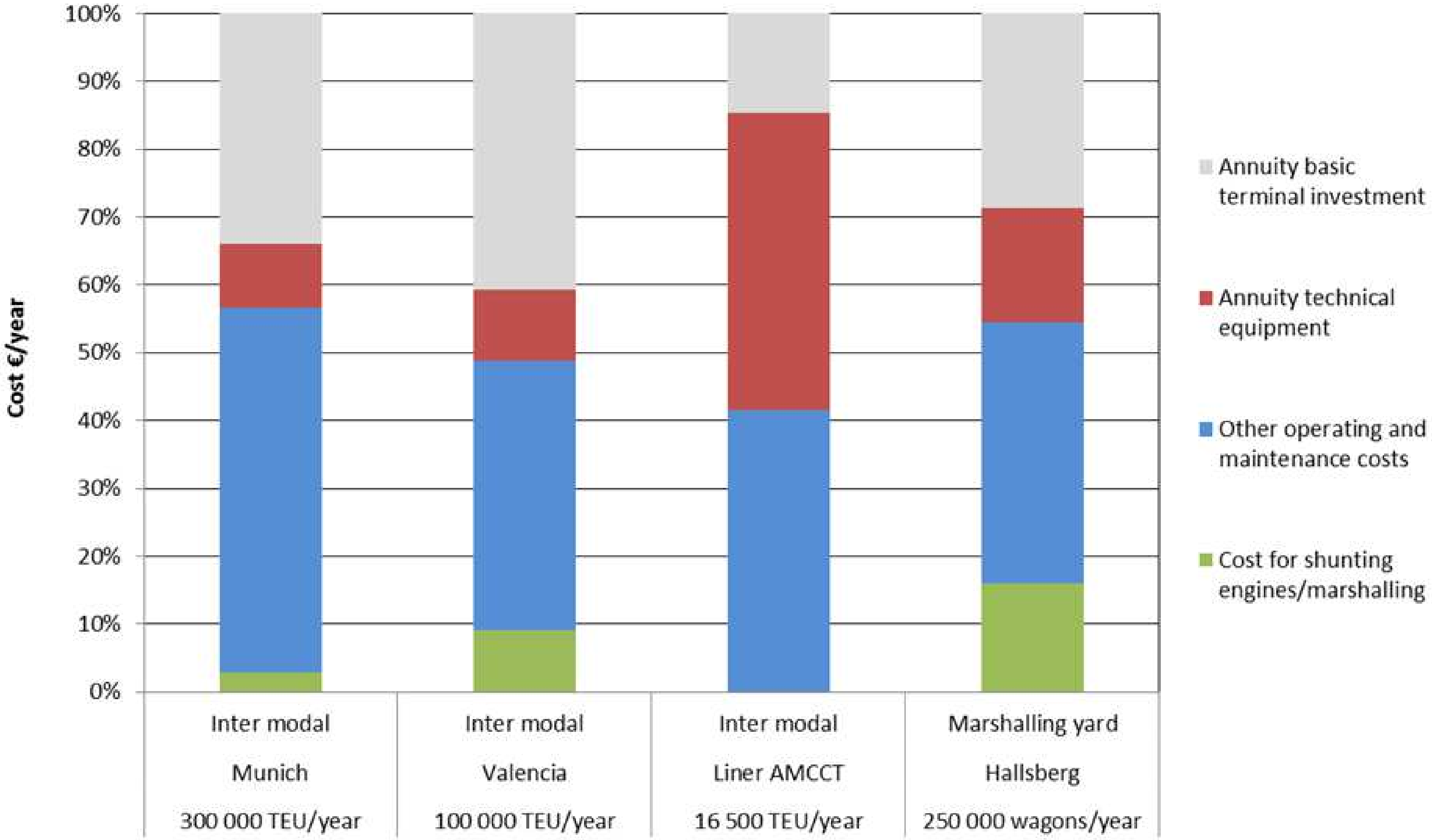
Total costs calculation (e.g. Riem - inland interchange)

Total costs			
		Cost €/year	Cost €/TEU
Capacity for calculation TEU/year	300 000		
Operational cost			
Cost for shunting engine		433 153	1,4
Other operating costs		7 949 000	26,5
Sum		8 382 153	27,9
Capital cost			
Annuity technical equipment		1 395 268	4,7
Annuity basic terminal investment		5 033 966	16,8
Sum		6 429 234	21,4
Total cost		14 811 386	49,4
Total cost excluding basic terminal investment		9 777 420	32,6

SEVENTH FRAMEWORK PROGRAMME

Feasibility: total costs distribution

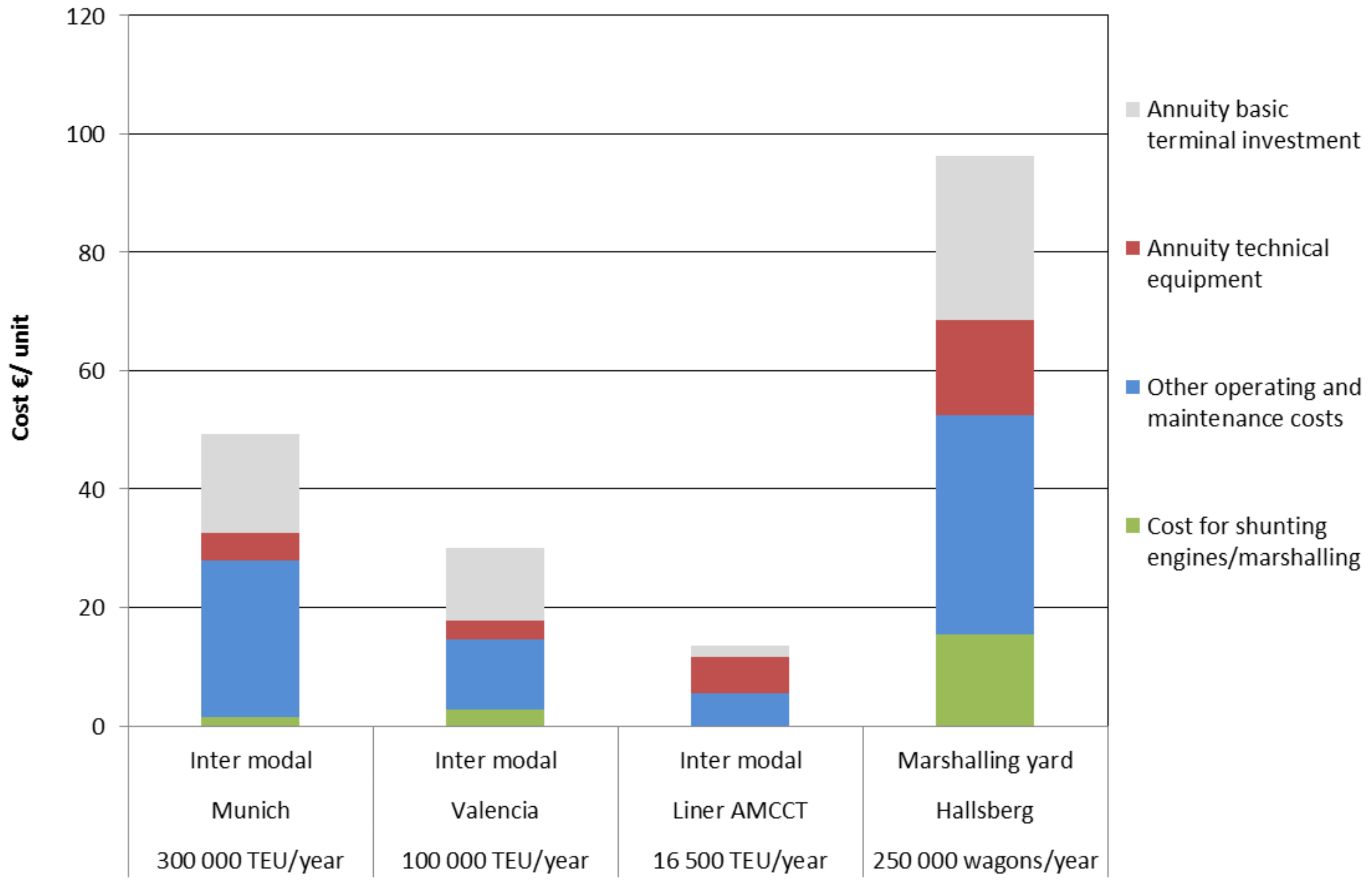
Capacity for Rail



Feasibility: unit costs

Capacity for Rail

Calculation and distribution by terminal typology



Feasibility: cost benefit analysis

Capacity for Rail

Assumptions

BENEFITS	
Time saving [3] [4] [5] [6]	1.0÷1.7 Euro / t h
External costs reduction due to road to rail modal split [2]	30.8÷40.2 Euro / kt km

[2] CE, INFRAS, Fraunhofer ISI - External Costs of Transport in Europe - Delft, September 2011

[3] Significance, VU University Amsterdam, John Bates services - Values of time and reliability in passenger and freight transport in The Netherlands - 2012

[4] De Jong, G.C. - Value of freight travel-time savings, revised and extended chapter for Handbooks in Transport, Volume 1: Handbook of Transport Modelling (Eds. D.A. Hensher and K.J. Button) - Elsevier, 2008

[5] Halse, A.H. and M. Killi (2012) Verdsetting av tid og pålitelighet for godstransport på jernbane (Values of transport time and reliability for railway freight), TØI report 1189/2012, TØI, Oslo.

FURTHER ASSUMPTIONS	
Technical life of new infrastructure	30 years
% of other costs on average EU28 labour costs [Eurostat, 2014]	24.43
% taxes and VAT on average EU28 cost of electricity [Eurostat, 2014]	25.00
Average EU yearly inflation % rate 1999-2015 [Eurostat, 2015]	1.73

Feasibility: Rail-Road NPV

C4R Capacity for Rail

Riem inland terminal

Net Present Value [Billion €]									
	Consolidated Scenario			**Scenario 1**			**Scenario 2**		
Rate of Return	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**
2%	139	189	267	348	429	578	418	501	652
3%	117	158	222	288	354	475	354	422	545
5%	85	113	156	198	242	324	259	305	387

Small-scale linear terminal

Net Present Value *[Billion €]*			
Rate of Return	**BAU**	**Low**	**High**
2%	86	93	102
3%	74	80	86
5%	56	59	62

Feasibility: Rail-Rail and Rail-Sea NPV

Capacity for Rail

Hallsberg marshalling yard

Net Present Value *[Billion €]*									
	Consolidated Scenario			**Scenario 1**			**Scenario 2**		
Rate of Return	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**
2%	-133	-117	-104	-204	-203	-202	-176	-174	-173
3%	-115	-102	-91	-179	-178	-177	-155	-154	-152
5 %	-88	-79	-71	-141	-140	-140	-123	-122	-121

Valencia Principe Felipe port rail terminal

Net Present Value *[Billion €]*									
	Consolidated Scenario			**Scenario 1**			**Scenario 2**		
Rate of Return	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**	**BAU**	**Low**	**High**
2%	360	410	501	464	527	642	467	529	644
3%	305	346	420	394	445	538	396	447	540
5 %	224	251	301	288	322	384	290	326	387

Feasibility: confirmed subjects

CONFIRMED

C4R
Capacity for Rail

Objectives

a) Definition of terminals typologies capable to cover large majority of rail freight traffic
b) Identification of a set of KPI by terminal typology capable to represent operational modes of terminals and to be sensitive to effects of innovations
c) Focused and enlarged case studies to comply with all typologies
d) Identification of innovations suitable to be included in consolidated scenarios for each terminal typology and case study
e) Identification of innovations suitable to increase global efficiency of logistic chains
f) Assessment of future terminal performances including effects of innovative technologies and operational measures
g) Calculation of operational and capital costs of newly designed terminals
h) Consolidation of a suitable methodology for future traffic estimation

Quantitative results

1) Achievable operational standards of intermodal and wagonload terminals;
2) Financial business case of future terminals
3) Economic results from societal viewpoint useful to select future European actions in freight transport and rail systems fields

Discussion: feedback from 10/09/15

C4R Capacity for Rail

Suggestions from the audience

- Self-propelled wagons to be included in all scenarios for marshalling yards
- Duo-locomotive already used today not to be considered in 2030-2050 scenarios
- Smaller shunting stations to be proposed and simulated
- Digitalization of information to be included in all scenarios to overcome barriers against transparency in information exchanges
- Vision papers on future framework of logistics (EC projects, logistic operators associations, etc.) to be considered for scenarios

- Added value of logistic services to be taken into account in business cases
- Future terminals able to manage effectively traffic of parcels and carriers services

Discussion: suggested items for today

Capacity for Rail

Terminals for 2030-2050

- **ambitious and visionary, anyway feasible?**

Declared scope *"modern, automated, intelligent and fully-integrated system for efficient, reliable freight Operations"*

- **addressed?**

Different approaches

- **KPI? Scenarios? Methods and models? Case studies? Integration with logistic chains? Economic and financial analysis? Others?**

Suggestions for next steps

- **Compilation of a catalogue of solutions in SP2 (WP2.4) by 09/2017**
- **Shift2Rail projects: CFM and OC 2016 (ongoing), CFM and OC 2017 (start: 09-10/2017)**

SEVENTH FRAMEWORK PROGRAMME

Thank you!

Capacity for Rail