

# AlpInnoCT

## Guideline for integration of innovative intermodal solutions & approaches into daily CT business

Output O.T4.1 including DT4.1.1  
Measures tested in practice

January 2020



EDIT BY:  
TX Logistik  
Junkersring 33  
D-53844 Troisdorf  
Contact: Marc Braun  
[www.txlogistik.eu](http://www.txlogistik.eu)

## Content

<b>1</b>	<b>Executive summary .....</b>	<b>7</b>
<b>2</b>	<b>Foreword and introduction .....</b>	<b>9</b>
2.1	AlpInnoCT .....	9
2.1.1	Project Summary .....	9
2.1.2	Objectives .....	9
2.1.3	Outputs .....	10
2.1.4	Background Wish List .....	10
2.1.4.1	Connection between the Wish List and Pilot Cases of WP T4.....	10
2.1.4.2	Analysis of Initiatives not tackled within WP T4 .....	12
<b>3</b>	<b>Pilot Case Implementation .....</b>	<b>16</b>
3.1	Case 1: Slot management: Terminal focus.....	16
3.1.1	Description of the Pilot Case.....	16
3.1.2	How does the pilot relate to the wish list and classification? .....	18
3.1.3	Current challenges and how are these addressed in the pilot case? .....	20
3.1.4	What exactly was examined / tested and how? .....	20
3.1.5	Industry production know how – process / methods .....	23
3.1.6	Which KPIs can be used to measure the results? .....	26
3.1.7	Milestones .....	28
3.2	Case 2: Train-related electronic data interchange .....	29
3.2.1	Description of the Pilot Case.....	29

3.2.2 How does the pilot relate to the wish list and classification? .....	30
3.2.3 Current challenges and how are these addressed in the pilot case? .....	32
3.2.4 What exactly was examined / tested and how? .....	32
3.2.5 Industry production know how – process / methods .....	40
3.2.6 Which KPIs can be used to measure the results? .....	41
3.2.7 Milestones .....	41
3.3 Case 3: Feasibility tests of innovative technologies and digitalization in Combined Transport .....	42
3.3.1 Description of the Pilot Case .....	42
3.3.2 How does the pilot relate to the wish list and classification? .....	42
3.3.3 Current challenges and how are these addressed in the pilot case? .....	43
3.3.4 What exactly was examined / tested and how? .....	44
3.3.5 Which results in which form should be expected after the pilot has been completed? .....	45
3.3.6 Involved Partners foreseen (external and internal) .....	46
3.3.7 Which KPIs can be used to measure the results? .....	46
3.3.8 Timeline and Milestones: .....	46
3.4 Case 4: Appliance of production know-how on high frequent transport routes .....	66
3.4.1 Description of the Pilot Case .....	66
3.4.2 How does the pilot relate to the wish list and classification? .....	66
3.4.3 Current challenges and how are these addressed in the pilot case? .....	67

3.4.5	What exactly was examined / tested and how? .....	68
3.4.6	Industry production know how – process / methods .....	70
3.4.7	Milestones:.....	71
3.5	Case 5: Restrictions for small and medium enterprises in Combined Transport 72	
3.5.1	Description of the Pilot Case.....	72
3.5.2	How does the pilot relate to the wish list and classification?.....	72
3.5.3	Current challenges and how are these addressed in the pilot case? .....	73
3.5.4	What exactly was examined / tested and how? .....	74
3.5.5	Industry production know how – process / methods .....	77
3.5.6	Which KPIs can be used to measure the results?.....	77
3.5.7	Milestones.....	77
<b>4</b>	<b>Tested measures with reference to results of WPT2 and WPT3 (Guideline) .....</b>	<b>78</b>
<b>5</b>	<b>Conclusions.....</b>	<b>83</b>
<b>6</b>	<b>Annex .....</b>	<b>85</b>

## List of Figures

Figure 1 Review of initiatives covering top wishes.....	13
Figure 2 Railway layout of Interporto.....	17
Figure 3 Rail Traffic: The growth .....	17
Figure 4 Time Table Inter Terminal 2018 .....	21
Figure 5 Plan Do Check Act .....	23
Figure 6 First In - First Out.....	25
Figure 7 Arrival / Departure trains July 2018.....	28
Figure 8 - Visual exemplification of the impact of the pilot action on rail processes .....	30
Figure 9- example of CH30 document as generated by the Sinfomar PCS .....	33
Figure 10 – Automatic conversion from HS to NHM codes in Sinfomar.....	35
Figure 11 – Pilot Case no. 2: Detailed process flow.....	36
Figure 12 – Dashboard for Railway Last Mile Management in Sinfomar.....	39
Figure 13: Mounted GPS tracker on different train wagons .....	51
Figure 14: GPS position of train with vibration sensors .....	51
Figure 15: Architecture of GPS tracker for vibration measurements.....	52
Figure 16: Spectrogram of vibrations at a speed of 57 km/h.....	54
Figure 17: Output power of different harvesters as a function of vibration frequency (green: Perpetuum, violet: KRRI, red: Kinergizer, green: Revibe) .....	55
Figure 18: Sections of train vibrations with constant speed.....	56

Figure 19: Lab equipment with measurement devices and shaker (TIRA), where the vibration harvesters were mounted..... 57

Figure 20: Output power of different harvesters at different speeds..... 57

Figure 21 TXL Brenner-Shuttle-Concept ..... 70

Figure 22 Combined Transport Chain..... 73

Figure 23 Source – How the cooperative could look like ..... 76

**List of Tables**

Table 1 Data table and yield coefficients ..... 26

Table 2: Commercial harvesters tested with train vibrations..... 55

Table 3: Average Power consumption of GPS tracker depending on functionality 58

Table 4: Required functionality depending on infrastructure ..... 59

Table 5: Tested measures in reference to results of T2 and T3 (Guideline) ..... 82

<b>Document Title: Guideline for integration of innovative intermodal solutions &amp; approaches into daily CT business</b>				
<b>Document History</b>	<b>Version</b>	<b>Comments</b>	<b>Date</b>	<b>Done by</b>
	1		24/04/19	TX
	3		14/05/19	SSP, TX, LKZ, ZAI, TPA
	10		23/09/19	SSP, TX, LKZ, ZAI, TPA
	37		24/10/19	TX, SSP
	41		07/11/19	TX, SSP
	47		19/11/19	SSP, TX, LKZ, ZAI, TPA
	48, final		09/01/20	TX
<b>Number of pages:</b>	123			
<b>Number of annexes:</b>	1			

<b>Prepared by:</b> TX Logistik AG	<b>Principal authors:</b> Marc Braun (TX), Sebastian Ruckes (TX), Bernd Weisweiler (TX)		
	<b>Contributing authors:</b> Christoph Runge (LKZ Prien, GmbH), Achim Kuklas (IML Fraunhofer), Robert Burg (SSP Consult), Michaela Haseleu (SSP Consult), Mitja Klemencic (University of Maribor), Vlasta Rodosek (University of Maribor), Anna Carbolante (Port of Trieste), Nicolo Rebonato (Zailog), Alberto Milotti (Zailog), Nikolina Mandic (ALOT)		
<b>Review</b>	<b>Partner</b>	<b>Date</b>	
	TPA, SSP, ZAI, LKZ, TX, UM	20/12/2019	
<b>Approval for delivery</b>	<b>AlpInnoCT Coordinator</b>	<b>Date</b>	
Robert Burg	SSP Consult for StMB (LP)	10/01/2020	

# 1 Executive summary

The Alps are a sensitive ecosystem to be protected from pollutant emissions and effects of climate change. Continued growth in freight traffic volume leads to environmental problems. These trends reinforce the need to review existing transport and to develop innovative solutions to protect the Alpine Space as set out.

The Interreg AlpInnoCT project strives to apply established production know-how from various industries to Combined Transport (CT), following a pre-defined methodology and covering five consecutive work packages. The project started in 2016 with the elaboration of current production know-how, followed by an analysis of the current situation of Combined Transport in Europe and a blueprint of an optimised CT model concept. This set the framework for the fourth work package “WP T4 - Development of CT in the future – Implementation and pilot activities” with its results reported in this Deliverable – “a guideline for the integration of innovative intermodal solutions & approaches into daily CT business”.

The following pilot cases result from a wish list (Chapter 2.1.4.2), which represents the prioritisation of industry experts regarding actions needed to improve European CT in the near future. Those actions were rated by a selection of priority aspects, which are covered in the following five pilot cases:

- Case 1: Slot management: Terminal focus

This case demonstrates an innovative way to better manage and optimize processes of the intermodal terminal “InterTerminal” in Verona, IT. This model redefines the production logic of loading / unloading activities of intermodal freight trains by applying first-in/first-out (FIFO) strategies for wagon sets.

- Case 2: Train-related electronic data interchange

Successful production industries pay high attention to a consistent and harmonized data exchange. In this respect, the port of Trieste tested improve data exchange on the pilot corridor Trieste – Bettembourg. The focus of this pilot case was on creating and testing a dedicated web service to share train-related data



- Case 3: Feasibility tests of innovative technologies and digitalization in CT  
This pilot case addressed the lack of digitalization and the lack of innovative technology in Combined Transport. Therefore, selected feasibility tests were performed on innovative, self-sustaining GPS trackers by applying an energy harvesting concept, in order to ensure continuous and maintenance free operation.
- Case 4: Appliance of production know- how on high frequent transport routes  
Within this pilot case an improved transport concept has been applied to a frequently used transport route (via Brenner). By introducing a FIFO strategy for wagon sets and locomotive, availability and reliability of these crucial resources have been improved significantly.
- Case 5: Restrictions for small and medium enterprises in CT  
This concept study analysed current barriers for small and medium enterprises (SME) to use CT and outlined solutions how to overcome these, by considering the project results of AlpInnoCT.

In general, the pilot cases have demonstrated how production know-how can be successfully applied to CT and that thereby improvements can be achieved. A central point of this deliverable is provided by the table in Chapter 4, which shows the results of work package (WP) T4 based on the previously finalized WP T2 (situation analysis of CT in Europe) and WP T3 (ideal CT model concept) including necessary measures to further implement the elaborated results of the pilot actions.

In addition to that, it is crucial to accept, that each transport chain is unique, as is the composition of its stakeholders. With that in mind, it is essential to mention that options proposed in the report O.T3.1, based on the analysis done by the stakeholders in AlpInnoCT, may not have the same success potential in another transport chain.. Still, the approach is generic and therefore generally applicable.

Further to that, a number of prioritised wishes was already covered by other (EU) initiatives (see Annex) and therefore not considered in the implemented pilot cases.

The results of this study show that innovation in Alpine freight transport is possible, necessary and will continue to be significant in future. These pilot results will form the basis for the Toolbox of Action (Work package 5), which represents the last and final step of the methodology in the framework of AlpInnoCT.

## **2 Foreword and introduction**

### **2.1 AlpInnoCT**

#### **2.1.1 Project Summary**

The Alps are a sensitive ecosystem to be protected from pollutant emissions and climate change. Continued growth in freight traffic volume leads to environmental problems. These trends reinforce the need to review existing transport and develop innovative models to protect the Alpine Space (AS) as set out e.g. in the EU White Paper 2011. EUSALP set the aim to strengthen ecological transport and establish more efficient freight transport corridors. But often the efficiency of Combined Transport (CT) is low. Therefore, the project Alpine Innovation for Combined Transport (AlpInnoCT) tackles the main challenge to raise CT efficiency and productivity. The application of production industry knowhow (which is ideal to improve processes) in CT is a new approach which includes an analysis of existing strategies, policies & processes focusing on CT, thus, AlpInnoCT contributes to a sustainable system with an easier access to CT and fosters the utilization of this low-carbon transport method.

Logistics service providers will benefit from improved processes and an easier CT access. Wagon and semitrailer producers obtain insights into CT innovations. NGOs and institutions get a dialogue platform to state their interests and awareness about CT innovations. Politicians & decision makers will be better prepared to set the future CT framework with regards to environment.

As transport happens in an AS network, the project contents are developed in a unique transnational public-private partnership.

#### **2.1.2 Objectives**

- Improvement of processes and cooperation in CT networks
- Integration of innovative approaches fostering modal shift from road to rail
- Enhancement of knowledge and reinforcement of participation possibilities for each stakeholder in freight transport

### 2.1.3 Outputs

The project will provide the following outputs:

- Description of the state- of- the- art of the European transport system with a focus on CT.
- Recommendations for an ideal CT-model concept by transfer of production industry know-how.
- Guideline for the integration of innovative intermodal approaches into daily CT business.
- Alpine wide dialogue platform with dialogue events as information exchange brings together all stakeholders and target groups.
- Toolbox of Action (Handbook) with Action Sheets describing methods and processes ready for implementation to disseminate project findings.

### 2.1.4 Background Wish List

The Output "OT3.1" of Work package WPT3 describes the development of a wish list. In order to develop this wish list that represents the major stakeholders' views of the intermodal transport chain, transport chain players from four countries were asked to add their input. In summary, the verified input of more than 20 stakeholders was taken into account, including regional multipliers and disseminators representing the views of additional market players. Further information on this wish list can be found in the respective Report<sup>1</sup> of the AlpInnoCT Workpackage WP T3 *Combined Transport Model Concept*.

#### 2.1.4.1 Connection between the Wish List and Pilot Cases of WP T4

The results of WP T3 were analysed and, based on the wish list, possible pilot cases were selected for pilot implementation in WP T4.

---

<sup>1</sup> Output OT3.1. <https://www.alpine-space.eu/projects/alpinnoct/en/project-results/wp-t3-ct-model-concept>

The needs in WP T3 are divided into five categories. Already here it is evident that not all topics which are necessary to improve combined transport can be addressed in WP T4. Decisive selection criteria for implementation within the framework of the AlpInnoCT project are the required duration of implementation, the available budget, whether all necessary partners are involved and whether there are no legal obstacles in the way of implementing the pilot cases.

Therefore, within the project lifecycle, it was not possible to implement any measures that relate to regulations or large-scale technology. Smaller measures in the field of technology, e.g. technology which does not have to be approved by the railway authorities, such as IoT devices, could, however, be implemented. Likewise, infrastructure topics could not be implemented in the pilot cases due to costs and implementation time involved.

Among the top 16 wishes, the following ones could be addressed and solutions be developed within WPT4:

- Place 1: Wish 27t: Improvement of the planning and punctuality of the CT
- Place 4: Wish 53: Shorter stay of the loading units in terminals (storage time)
- Place 7: Wish 28: Continuous tracking of the loading unit (on train, ship and truck)
- Place 9: Wish 62: More slots for freight trains.
- Place 10: Wish 50: Faster wagon inspection.
- Place 11: Wish 31: Introduction of electronic freight documents
- Place 12: Wish 67: More punctually for railway undertakings (RU)
- Place 13: Wish 68: Better wagon availability
- Place 16: Wish 34: reduced waste in transport process (e.g. long storage times of loading units in the terminal)

In addition, Wish 36: More IT invests in general was addressed.

Wish 40 (5th place) could not be addressed, as no large shipper was involved in the project and a major change in the shipper was required. On the one hand, it is a change of the processes, but also a so-called mind change. It is necessary to achieve an overall optimization, currently the shippers optimize themselves at the expense of transport.

The Wishes 73 (2nd place), 72 (3rd place), 59 (6th place), 64 (8th place), 51 (15th place) – in Figure 1 below - could not be implemented, as either far-reaching technological changes had to be introduced or infrastructure issues in the network had to be addressed. The implementation time would have clearly exceeded the project duration. Nor were all the necessary partners involved, in particular the railway infrastructure operators.

Wish 35 (14th place) could not be implemented because several political bodies would have to be integrated into the project. This was not possible for various reasons.

#### **2.1.4.2 Analysis of Initiatives not tackled within WP T4**

Within AlpInnoCT project ten priority wishes were implemented through case studies identified in WP T4. As some wishes are not feasible to be tested within the AlpInnoCT time Framework (e.g. built alternative rail/CT routes on corridors), an additional review and analysis of initiatives that are relevant for priority technology and political wishes has been conducted. This analysis is based on identified initiatives (database in attachment), where main conclusion is, that currently there is no uniform platform that provides a comprehensive overview of initiatives for fostering Combined Transport. Initiatives represent relevant research and development projects identified in H2020, Shift2Rail, CEF networks, technological innovations (developed by research institutes), legal frameworks with push and pull measures, directives and standards, theoretical concepts with review of methods/algorithms to raise efficiency and modal split of CT and NGO's in Alpine space, that are acting in favour of CT.

This chapter is based on this wish list as provided in WPT 3 and initiatives.

Technical wishes	Political wishes
27. Improvement of the planning and punctuality of the CT.	1. Mainstreaming customs clearance and administrative controls (one stop shop - for all controls) for faster customs clearance.
73. Powerful alternative routes (redundancy) for main routes.	11. Introduction of a European infrastructure management.
72. Elimination of (local and general) bottlenecks on the corridors related to gauge and train length.	13. Harmonisation & Enforcement of push & pull measures in the EU at all levels (e.g. financial, regulatory and fiscal support measures, liability).
53. Shorter stay of the loading units in terminals (storage time).	14. Ensuring the preferential treatment of the CT (more incentives for CT, e.g. slot funding/ adaptation to changing needs, e.g. platooning, long trucks, lower diesel price, etc.).
40. 24/7 opening times of shippers / warehouses, depots & workshops.	10. Stimulus package rail for lower prices.
59. Faster (average) speed of trains.	12. Standard for ILU check (trains and truck check in) with standardised documents.
28. Continuous tracking of the loading unit (on train, ship and truck).	7. Automated semi-trailer handling (long term).
64. Reduce the space between two slots/trains (brakes, traffic management).	4. 24/7 operating times of the terminals.
62. More (reliable) slots for freight trains.	16. Uniform regulation of the language (lower requirements for train driver).
50. Faster wagon inspection.	LEGEND
31. Introduction of electronic freight documents.	No initiative covering this wish
67. More punctuality for railway undertakings (RU). Some RUs are more punctual than others.	Low number of initiatives covering this wish (1-5)
68. Better wagon availability.	Some initiatives covering this wish (6-10)
35. Introduction of a task force in the event of network problems (such as Rastatt).	Average number of Initiatives covering this wish (11-15)
51. More efficiency regarding shunting (e.g. autonomous shunting or automatic train coupling system).	Large number of initiatives covering this wish (15-20)
34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal).	Very large number of initiatives covering this wish (more)

Figure 1 Review of initiatives covering top wishes

The review showed an unbalanced covering of initiatives in regard to the wish list. Although initiatives cover more than just one wish, there are several wishes uncovered or only low number of initiatives are focusing on researching, testing or implementing the solutions. Top priority technical wishes that need to be more explored and solutions implemented in the future are:

- 73. Powerful alternative routes (redundancy) for main routes
- 40. 24/7 opening times of shippers / warehouses, depots & workshops
- More (reliable) slots for freight trains
- 50. Faster wagon inspection
- 67. More punctuality for railway undertakings (RU). Some RUs are more punctual than others
- 68. Better wagon availability
- 35. Introduction of a task force in the event of network problems (such as Rastatt)

Top political wishes that are not covered well through initiatives are:

- 1. Mainstreaming customs clearance and administrative controls (one stop shop - for all controls) for faster customs clearance
- 10. Stimulus package rail for lower prices
- 12. Standard for ILU check (trains and truck check in) with standardised documents
- 7. Automated semi-trailer handling (long term)
- 4. 24/7 operating times of the terminals
- 16. Uniform regulation of the language (lower requirements for train driver)

The analysis showed, that current efficient initiatives propose solutions for top wishes through:

**Digitalisation** of logistic information of all actors. This is supported by several Directives, strategies and regulations of ICT/ITS for intermodal transport (e.g. Digital Single market Strategy, eGovernmental Action Plan, European Interoperability Framework, RIS Directive, ERTMS Directive, ITS Directive, regulation on Electronic Freight Transport Information, etc.). On operational level focus is on sharing of information of estimated time of arrival and real time information for intelligent (smart) management, monitoring and maintenance of transport assets and communication technologies in order to provide better CT service to the end users.

**Automatization** of rail freight (future wagons, future locomotives, future stations, yards, Automatic Train Operations including moving block, coupling), supported processes and integrated terminal and hinterland timetable planning.

**Reorganisation** of freight logistic structures also for implementation of new technologies.

**End user view** on implementing “just in time” concepts, cash to cash cycle models and synchro-modality.

**Holistic corridor approach** with implementing recommended measures on synergic interventions of layouts of CT infrastructure, implementation of innovative technology, activities in regard to foster timetable planning, digitalisation and custom clearance.

**Education and knowledge transfer** of trainees, teachers and decision makers of different instruments in CT management (push and pull measures) for becoming more leaner and less mechanistic.

**Lean management** on terminals and railways (operation and infrastructure) through industry optimization methods (like 6SIGMA, 5S, feedback loop, Run to Failure, Time to repair), BIM (Building Information Modelling) and lean maintenance of assets (e.g. Condition based Monitoring, Predictive maintenance, selection of lightweight and noise abatement material).

Long-term measures allowing to **operate a 4m gauge corridor, 1500 m long trains and higher frequency** of CT trains

Supporting tools and strategies for CT decision makers through **central project management** (mapping and implementation plan of freight network, reasonable allocation of port resources, sharing local business and operational innovative solutions, integrated view of risks and threats for different assets in CT, evaluation tools for noise, vibration, energy consumption, CO2 footprint, costs, subsidies, road taxes and social impact)

**NGO's** which promote the principles of environmentally friendly large-scale modal shift of goods onto rail through soft measures like recommendations to the public sector or "hard" measures – protests.

A detailed description can be found in the Annex 1 attached to this document.



## **3 Pilot Case Implementation**

The Deliverable D.T4.4.1 contains a summary of measures which are tested or evaluated in pilot activities. These measures with the help of industry know-how shall help to improve the overall efficiency of CT. In addition, after the pilot phase have been finalised those measures shall be adapted in real life operations and are therefore ready for further integration in daily CT business. These measures deal as a basis for the Toolbox of Action.

### **3.1 Case 1: Slot management: Terminal focus**

#### **3.1.1 Description of the Pilot Case**

Consorzio ZAI (PP10), in close collaboration with Quadrante Servizi (a company owned by ZAI of 70% and manager of the intermodal terminal called InterTerminal), in the context of the European Interreg Alpine Space program in the AlpInnoCT project which aims to increase the efficiency and productivity of combined transport to protect the ecosystem of the Alpine Region from polluting emissions and climate change, it has identified a new operating model related to the management and optimization processes of the InterTerminal intermodal terminal. This model reinvents the logic of production of the loading/unloading activities of intermodal freight trains, utilizing innovative policies. The proposed solution is in line with the AlpInnoCT objectives. In fact, the project started in November 2016 with a budget of € 3 million, proposes to revise the current transport systems by developing innovative models to protect the Alpine crossing points in the context of a continuous increase in the volume of freight traffic. The intent is to promote the Combine Transport by creating guidelines (as for Wagons Sharing) for the integration of innovative intermodal approaches in daily management along the intermodal logistics chain. In this context the case study 1 Slot Management / Terminal Focus is located where it takes into analysis InterTerminal (one of the three intermodal terminals present at the QEVN) and now an example of excellence in operational and management terms for the intermodal infrastructures (road-rail) present at the Quadrante Europa but of European relevance being the Verona Interporto the first European structure in terms of performance, services offered and developed traffic.

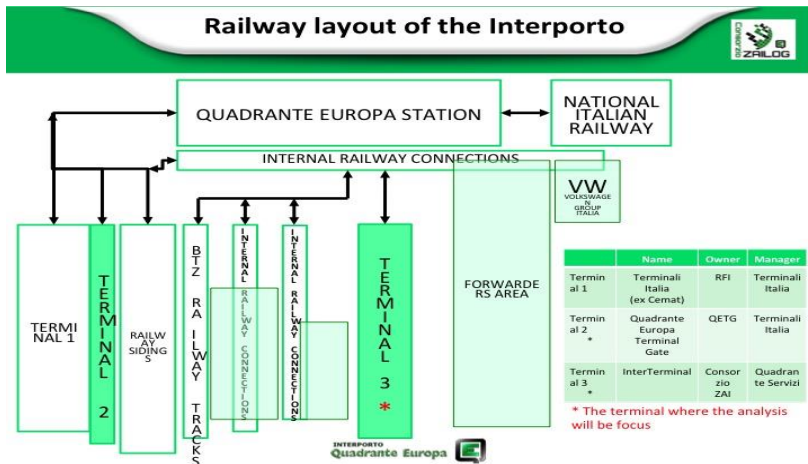


Figure 2 Railway layout of Interporto

In advantage, the numbers of Verona intermodal centre attest to an increasingly important and leading activity: 16 329 trains worked in 2017 and over 403,000 ILU moved, thus it is a reference for the combined transport logistics chain in Italy and in Europe. In this context, the performance of InterTerminal (managed by Quadrante Servizi) should be highlighted, which in the first half of 2018 saw an increase of over 13% in intermodal traffic.

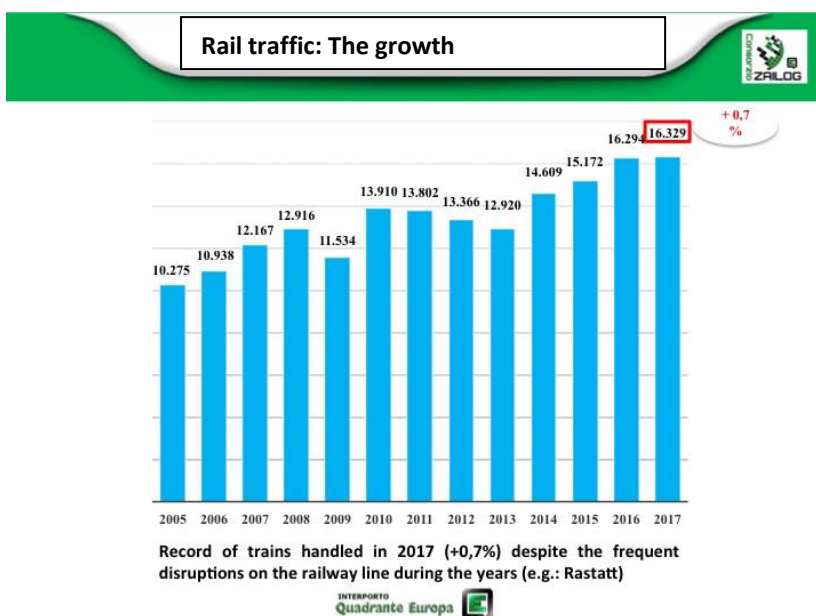


Figure 3 Rail Traffic: The growth

In Verona, today and in general in the European market, there is an excellent demand for the transnational railway transport of goods but at the same time it is difficult to make a consistent and efficient response in terms of supply. The supply currently lives two different problems. The first linked to the economic comparison related to the road transport. The second one reveals a perception of the quality and of the service offered very low by the final customer. So, the picture of intermodality observes a moment of reflection and general reorganization of resources (even beyond the Brenner Pass from the German side) necessary to respond to a growing transport demand. Furthermore, the Rastatt event (interruption of the Rhine railway line from August 2017 to October 2017) has not contributed to guaranteeing the appropriate standards of quality and confidence of the combined transport to the market. Therefore, along the axis of the Brenner and in the main European TEN-T corridors a perceived quality of service equal to the minimum terms and even lower trust is to be found.

The response of the Verona Interporto did not wait and emerged in the terminal management field. The analysis and work done by the Quadrante Servizi operator in collaboration with Consorzio ZAI (economic public body and owner of InterTerminal) is a starting point and clear answer to the intermodal customers. The organizational model created at InterTerminal in line with the activities of the last integrated railway mile and then slot management, has identified the best management structure ensuring the development, economy and competitiveness of the transnational and national traffic of goods using the railway mode as transport. As well as identifying and reformulating the supply of train services, optimizing in a synergic way the functional integration between the various railway and terminal areas that characterize the entire intermodal area. The planned organizational model includes adequate management policies, consistent with the infrastructural assets, and it is not limited only to the analysis of the shunting management, but it is contextualized within the operations of handling and reception of the road phase. The proposed model is precisely defined as Wagons Sharing.

### **3.1.2 How does the pilot relate to the wish list and classification?**

53. Shorter stay of the loading units in terminals (storage time)

- In peak times crane utilization is a bottleneck factor on which unpaid moves have an important impact. Their number has increased as some companies

use the terminals as buffers. Associated with this are longer duration times of the LUs in the terminals and thus also more unpaid LU movements.

#### 62. More (reliable) slots for freight trains

- Passenger transport by rail enjoys a higher priority than freight transport. This means that on the one hand, the freight trains have to let overtake the passenger trains and on the other hand, that in the allocation of slots, the passenger trains are preferred. However, achieving the common climate goals requires an improved offer of freight trains, including the approval of more slots.

#### 67. More punctually for railway undertakings (RU)

- Analogous to request 27, the different punctuality of RUs also poses a problem for CT. For this purpose, the causes should be identified and problem solutions found. Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

#### 68. Better wagon availability

- The availability of suitable equipment not only affects the loading units, but to a large extent also the wagons. While exchange platforms already exist successfully for loading units, the problem with wagons has not yet been solved. In addition to the innovative freight wagon, further solutions for the existing freight wagons were to be devised.

#### 34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal)

- As we are talking about optimizing processes through lean thinking all wastes in the process should be eliminated. From our perspective main waste in the process view is warehousing, so this »stage« should be minimized or even eliminated to deliver just in time.

### **3.1.3 Current challenges and how are these addressed in the pilot case?**

The prospect of increasing intermodal traffic to and from QEVV by anticipating developments in the Brenner line and overcoming the constraints of the current railway infrastructure impose certain management decisions. Therefore, the main challenge aims to improve the existing numbers working on the operational plan and optimization of the railway system. In fact, the terminal capacity intended as working railway tracks allows some infrastructural constraints beyond which it is not possible to go. On the other hand, a reorganization of human resources on the side of the railway track (operators inside the intermodal terminal) and technological tools (for example loading and unloading vehicles) increases productivity through new incoming / outgoing train reception policies.

In this perspective, two more challenges are evaluated. The current challenges and therefore the problems encountered are mainly connected in convincing two interlocutors: Multimodal Transport Operator (MTO) and wagon owner. These operators of combined transport delimit the field of action since the first (MTO) is the only customer of the terminal operator (Quadrante Servizi) and the second perceives in an inexperienced way the difficulties in the management of its assets (railway wagons). The latter notes the changes in its business model as the traceability of the wagons is not yet timely and precise as it should be. This question can therefore also stimulate the market to find solutions (already widely used in road transport) for the recognition and positioning of rolling stock in view also of damage prevention and routine maintenance. This issue will also be tackled in Pilot Case 3.

### **3.1.4 What exactly was examined / tested and how?**

The solution proposed as Case Study concerns the intermodal traffic developing in the QEVV (specifically in InterTerminal) during the first half of 2018. The second half in course will make it possible to consolidate the new planned organizational model.

**TimeTable InterTerminal 2018**

Origin (Incoming Trains)	TimeTable	MON	TUE	WED	THU	FRI	SAT	MON	MTO	RAILWAY UNDERTAKINGS	SHIPPERS
HAMBURG	00:11	x							kombiverkher/ceamat	RTC	multiple
HAMBURG	02:17				x	x			kombiverkher/ceamat	RTC	multiple
HAMBURG	06:29			x			x		kombiverkher/ceamat	RTC	multiple
ROSTOCK HT	09:35	x							kombiverkher	MIR	Schenker/Transped
ROSTOCK HT	10:53		x		x		x		kombiverkher	MIR	Schenker/Transped
BREMEN	10:55	x							kombiverkher/ceamat	RTC	Paneuropa/Terratrans
ROSTOCK LKW	14:29	x	x	x	x	x	x		kombiverkher/ceamat	MIR	LKW
BREMEN	17:59		x	x	x	x	x		kombiverkher/ceamat	RTC	Paneuropa/Terratrans
WUPPERTAL	18:59			x		x	x		kombiverkher	RTC	Winner
KIEL	22:05	x	x	x	x	x			kombiverkher/ceamat	RTC	multiple
KIEL	22:23	x							kombiverkher/ceamat	RTC	multiple




Figure 4 Time Table Inter Terminal 2018

This model, examined and then actually applied in the daily management of InterTerminal, puts the resources (human and infrastructural) equal to the previous situation into play, but wants to maximize the efficiency of their use. Therefore, the operational objectives set are:

- Schedule of train loading / unloading in 12 hours
- Wagons Sharing: standard and non-discriminatory use of wagons with relative reprogramming of empty railway shuttles
- Planning of terminal activity (the following day)
- New approach to the check-in / out phase of goods by road

To each objective, corrective actions were then implemented while monitoring the entire development phase with a Plan-Do-Check-Act (PDCA) perspective (see also Chapter 3.1.5).

The introduction of Wagons Sharing in the organizational model was the real strength. In fact, the concepts of dynamism and flexibility of resources are introduced with the aim of responding to the quality criticism of the poor service. In short, the basic concept focuses on the flexible management of the railway track and the terminal slot. All this is not strictly linked to the scheduling of the arriving trains

but always respecting the departure time to guarantee the credibility of the intermodal system and in respect of the customer who has set the load reception activities in advance. Therefore, operationally speaking, the wagons are taken over by the terminal operator anonymously and not caring for the destination of arrival. Taking an example: Inbound a train with Rostock origin can be departing Bremen. This approach is based on the concept of trivializing railway shuttles. In fact, the composition of a freight train finds the reference intermodal transport unit in the semi-trailer. If this is the case then the railway wagons must also respond to relevant characteristics of flexibility. The only negative factor was to convince the MTOs and the owners of the railway wagons of this concept.

For the application of the Wagon Sharing model in the InterTerminal, it was a quite simple process of involving and convincing the actors, having to deal with Quadrante Servizi, InterTerminal manager and KombiVerkehr, MTO. Quadrante Servizi since the very beginning took active part in the elaboration and then application of the model, while several B2B meetings were organized with KombiVerkehr in order to explain first and list then few priorities and put forward two main assumptions in case of the application of the model:

- Increase in productivity of the terminal and consequent increase of number of trains processed in the terminal and traffic, increasing the turnover of MTO itself;
- Punctuality of trains guaranteed, not only this model guarantees the punctual departure of the trains from QEVN to European destinations, but it also guarantees the improvement in delay for trains arriving to QEVN.

It was also necessary to identify policies shared with railway undertakings for the management of railway queues.

In a field such as the transport of goods by rail, the delay of the train along the line is a frequent event. But if this frequent event is measured in a context such as the Verona Interporto where traffic exceeds 8100 pairs of trains per year, the management of railway queues due to incoming delays becomes a decisive element for measuring productivity and efficiency of the QEVN. During the Case Study, 56% of the trains arriving in the Interporto were delayed, 60% of which between one hour and three hours. The use of Wagons Sharing is a decisive factor for the exceeding of incoming expectations that create the aforementioned railway queues and the lack of the requested service. For the benefit, the availability

of empty shuttles becomes useful to reduce the inefficiencies of the railway system at the station. Obviously, the empty wagons are always designed for standard train compositions. The freight train is always composed by 16 intermodal wagons (e.g. T3000- a pocket wagon type). In the sense that they can be used to regulate any type of train that is delayed independently of the MTO and the type of load unit used.

### 3.1.5 Industry production know how – process / methods

Which processes could be applied and how?

In the elaboration of the operative model and consequently in the application in InterTerminal two methods were evaluated:

Plan Do Check Act

Process monitoring is followed in PDCA logic. The PDCA (Plan-Do-Check-Act) is a useful tool to manage the processes by making a continuous improvement to production, separating the phases in 4 key points in order to be able to work individually in singular processes. It is also called the Deming Cycle and pursues a concrete philosophy that aims to achieve the highest quality through the interaction between research, design, testing, and production (intended as the number of trains). A cyclicity of these elements, which as a perfect gear constantly produce excellence.

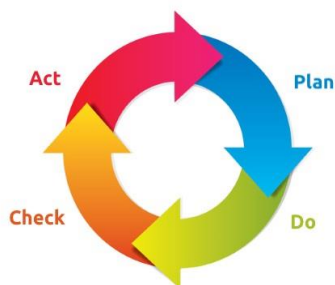


Figure 5 Plan Do Check Act



The four phases are so defined and elaborated in the Case Study:

#### PDCA: PLAN

The planning of the processes before being applied in InterTerminal has been studied in detail to understand which objectives are to be achieved. This allowed identifying:

- Costs
- Expectations (inefficiencies)
- Detailed analysis
- Evaluation of possible variants

A clear picture before starting is essential in order to avoid unnecessary waste or loss. At this stage the attached "Analysis of intermodal logistics processes in InterTerminal (state of the art)" was produced.

#### PDCA: DO

A first test phase, in a given time, allows us to apply the chosen decisions and test their validity. This phase was developed in the first half of 2018. It is the beginning of the collection of useful data, drawing graphs and reports that show that effects produce the change dictated by the Wagons Sharing model.

#### PDCA: CHECK

The control and comparison between the PLAN and the DO clearly shows if the new processes bring about an effective improvement, if they still need to be improved at some point, and then move on to the standardization of the definitive management model. Currently in progress (second half of 2018).

#### PDCA: ACTION

At this point the choice of the new process is codified and applied, having the certainty that the improvement has been demonstrated.)

The PDCA method has been taken into consideration by the fact that Consorzio ZAI and Quadrante Servizi are certified according to the ISO 9001 quality standard.

## Approach FIFO

The term FIFO is the acronym of "First In First Out" which represents the transit method in a queue (of objects of any kind). The FIFO method represents the mode of storage of physical objects in which the first object introduced is the first to exit. This logic is taken into account to explain the functioning of a warehouse and the exploitation of stocks. However, in this case it can be transferred to the Wagons Sharing case, which if the railway shuttle is intended (the set of wagons that make up the train) as a piece to store then it is possible to notice that Wagons Sharing is part of the FIFO method.



*Figure 6 First In - First Out*

Simplifying the concept, the exit order is the same as the entry order. It is possible to imagine how with a dispenser of products in a supermarket, where the items are introduced from above and the customer picks them up from the bottom, allowing the rotation of all products; or more simply, a series of people waiting in line to be served at a ticket counter.

In supply chain (and therefore in combined transport) it is rational to use the FIFO method in the logistics flow, as the first trains arrived will have to be the first to be unloaded and then reloaded to guarantee the planned departure and thus avoid delays.

Which objectives and improvements could be addressed and identified?

The main objective to highlight is the increase in traffic in InterTerminal. Already in the first half of 2018 train numbers and the relative increase attest the work done. Consequently, the benefits are:

- Improved InterTerminal production process
- Increase of the rotation of the wagons in the time of permanence of the terminal / decrease in the time spent in storage of the intermodal units

- Increased terminal capacity and therefore greater availability of empty slots for the reception of new trains
- Railway asset optimization (wagon availability)
- Reduction of waste time and delays along the entire intermodal chain
- Respect of scheduled departure times (especially useful for railway undertakings)

### 3.1.6 Which KPIs can be used to measure the results?

The scope of intervention was monitored according to appropriate indicators (KPI) and found optimal parameters. For the first half of 2018, InterTerminal disclosed:

- **$\epsilon$  = terminal efficiency** = number of dedicated binary train pairs, in one day of operation = 2.26
- **$\check{r}t$  = train rotation coefficient** = number of hours that elapse between the arrival of a freight train on a plant and its restart, after processing, from the same system = opening hours of the plant / terminal efficiency = 8, 5

It should be noted that the reference figure is for obvious reasons that of the QEVR freight station in which all intermodal traffic is reserved.

Location	$\epsilon$ = terminal efficiency	$\check{r}t$ = train rotation coefficient	Performance
QEVR station	1,684	14,25	100%
InterTerminal	2,26	8,5	+34,2%

*Table 1 Data table and yield coefficients*

The comparison in the table shows that:

- InterTerminal's performance is 34% higher than what is observed in the Interporto.
- The terminal efficiencies  $\epsilon$  is constantly measured greater than two. Take into account that  $\epsilon = 3$  is considered a factor that can only be reached theoretically.
- The train rotation coefficient exceeds (positively) the operational target set at 12 hours per cycle. In InterTerminal,  $\check{r}t$  is slightly higher than 8 and therefore + 70%.

- The numbers (and the model) reached by InterTerminal prove even more how the Verona Interporto has a margin of growth of the terminalistic capacity still of + 50% compared to today's traffic. Consideration that then reiterates the non-railway saturation of the QEVR.

Furthermore, the analysis of incoming and outgoing trains with the InterTerminal focus (July 2018 taken as a sample) shows that:

- 51% of total trains (arrivals and departures equal to 396) are late. It means one in two is not in time.
- Analysing arrivals: 38% (on total) suffer a delay between 30 and 60 minutes. 58% (most) is between hour and three hours. Finally, 4% over three hours.
- Analysing the departures: it is immediately recognized as the arrival delays are recovered at the start. In fact, half (54%) is under the hour and about the remaining part under three hours.

This result, in addition to the KPI mentioned above, demonstrates the validity of the new model.

The following graphs show the arrival and departure of trains in July 2018, during the implementation of the model.

396 trains, of which 198 inbound and 198 outbound, were processed during July in InterTerminal, with 51,52% of trains recording delay, of which 58,08% inbound and 44,95% outbound. If we analyse more in detail, it can be noted that as far as incoming trains are considered, the delays from 30' to 1 hour, amounted to 43 trains (37,39%), from 1 hour to 2 hours 67 trains (58,26%), and more than 2 hours 5 trains (4,35%), while outgoing trains registered delays from 30' to 1 hour in 48 cases (53,93%), from 1 hour to 2 hours 38 (42,70%) and more than 2 hours 3 (3,37%).

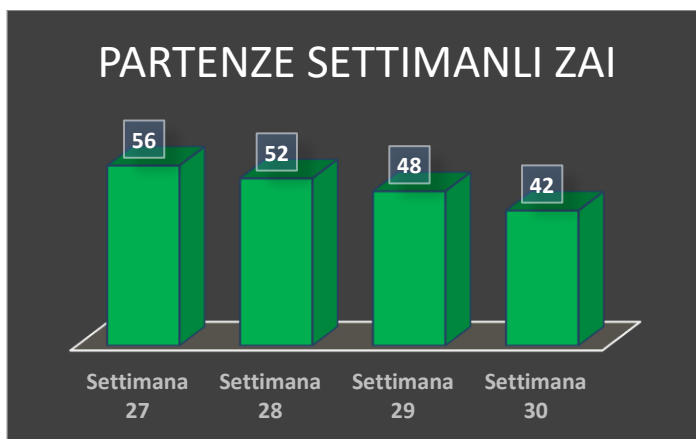
## Arrival/Departure trains July 2018



Data	Tot. Arrivi	Tot. Partenze	Tot. Treni	Arrivi			Partenze		
				<30'Rit. <60'	<60'Rit. <180'	>180'	<30'Rit. <60'	<60'Rit. <180'	>180'
lunedì 2 luglio	9	6	15	1	2	0	2	2	1
martedì 3 luglio	9	8	17	2	1	1	0	2	1
mercoledì 4 luglio	10	8	18	2	5	0	3	3	0
giovedì 5 luglio	9	12	21	0	5	0	2	5	0
venerdì 6 luglio	11	8	19	2	5	0	3	2	0
sabato 7 luglio	8	9	17	3	1	1	2	0	0
domenica 8 luglio	0	5	5	0	0	0	1	2	0
lunedì 9 luglio	11	3	14	2	3	0	1	1	0
martedì 10 luglio	8	9	17	2	2	0	5	1	0
mercoledì 11 luglio	7	6	13	1	3	1	1	0	0
giovedì 12 luglio	9	15	22	3	1	1	2	1	0
venerdì 13 luglio	9	8	17	3	3	0	2	1	0
sabato 14 luglio	8	8	16	2	0	0	2	0	0
domenica 15 luglio	0	5	5	0	0	0	0	0	0
lunedì 16 luglio	11	3	14	1	3	--	1	--	--
martedì 17 luglio	6	7	13	1	3	--	1	5	--
mercoledì 18 luglio	7	7	14	2	2	--	--	3	--
giovedì 19 luglio	8	9	17	--	8	--	2	1	--
venerdì 20 luglio	8	8	16	2	4	--	2	--	1
sabato 21 luglio	9	9	18	3	1	--	2	4	--
domenica 22 luglio	0	5	5	--	--	--	1	1	--
lunedì 23 luglio	7	3	10	1	2	1	1	1	0
martedì 24 luglio	4	8	12	1	3	--	5	1	0
mercoledì 25 luglio	7	5	12	3	2	--	1	0	0
giovedì 26 luglio	4	9	13	4	2	--	2	1	0
venerdì 27 luglio	8	5	13	--	4	--	2	1	0
sabato 28 luglio	7	9	16	2	2	--	2	0	0
domenica 29 luglio	0	2	2	--	--	--	0	0	0
Tot.	198	198	198	41	67	5	48	38	3
% Rit.	58,08%	44,95%	51,52%	37,39%	58,26%	4,35%	53,93%	42,70%	3,37%



Figure 7 Arrival / Departure trains July 2018



### 3.1.7 Milestones

- August 2017: See attachment Analysis of intermodal logistics processes in InterTerminal (state of the art)
- January 2018: Final model
- July 2018: KPI comparison
- October 2018: Premio Logistico dell'Anno 2018
- February 2019: Pilot Case Implementation Plan Final Version

## **3.2 Case 2: Train-related electronic data interchange**

### **3.2.1 Description of the Pilot Case**

In order to accommodate increasing maritime and rail cargo flows, in the last five years the Port of Trieste has been steadily investing in ICT measures able to smooth communications and data exchange along the entire supply chain to decrease congestion and enhance CT efficiency. The main goal is to develop new extensions and modules based on interoperability standards of the ICT platform currently in use, the Port Community System (PCS), now evolved in the HPCS – Hinterland Porto Community System, of the Port of Trieste, called Sinfomar.

Public and private actors that manage the processes and documentation related to rail traffic are important stakeholders involved in the current layout and future developments of Sinfomar. It is of utmost importance that electronic data are exchanged in a consistent and harmonized way and to this purpose, the Port of Trieste is willing to test such data exchange on the Trieste-Bettembourg corridor operated by TX Logistik.

Therefore, the project activities are focused on the creation and test of a dedicated Web Services to exchange train related data (such as wagon number, container plate number, type of good (HS/NHM code), semi-trailer / container, mass, tare, unladen weight, gross mass, seal number) with TX Logistik and Mercitalia Rail. In particular, the concept is based on splitting the communication flow into two separate moments:

1. Before crossing the Italian border: a dedicated Web Service (WS) is developed on the side of the PCS of the Port of Trieste, called Sinfomar. This WS will be ready to receive an xml message from TX Logistik containing the Hermes H30 data about the train and its composition. Then, the WS sends an acknowledgment (message received / error) to TX Logistik. The data sent in this communication are not verified since some changes can occur after passing the border.
2. After crossing the Italian border: a dedicated WS is developed on the side of the PCS Sinfomar. This WS is ready to receive an xml message from Mercitalia containing the Hermes H30 data about the train and its composition. Then, the Web Service sends an acknowledgment (message received / error) to Mercitalia. At this point, the data sent are

verified and possible modifications to the train composition, for instance due to dangerous goods, are already occurred. Furthermore, since these data are verified, they can be used to fill the fields of the CH30 in Sinfomar. At the same time, indications about ETA at the Port of Trieste are more precise and the operators can start to plan the ship loading more accurately.

These communication flows will have the same outline based on a dedicated WS, developed on the side of the PCS Sinfomar. This WS is ready to receive an xml message from TX Logistik/Mercitalia containing the Hermes H30 data about the train and its composition. Then, the WS sends an acknowledgment (message received / error) to TX Logistik/Mercitalia.

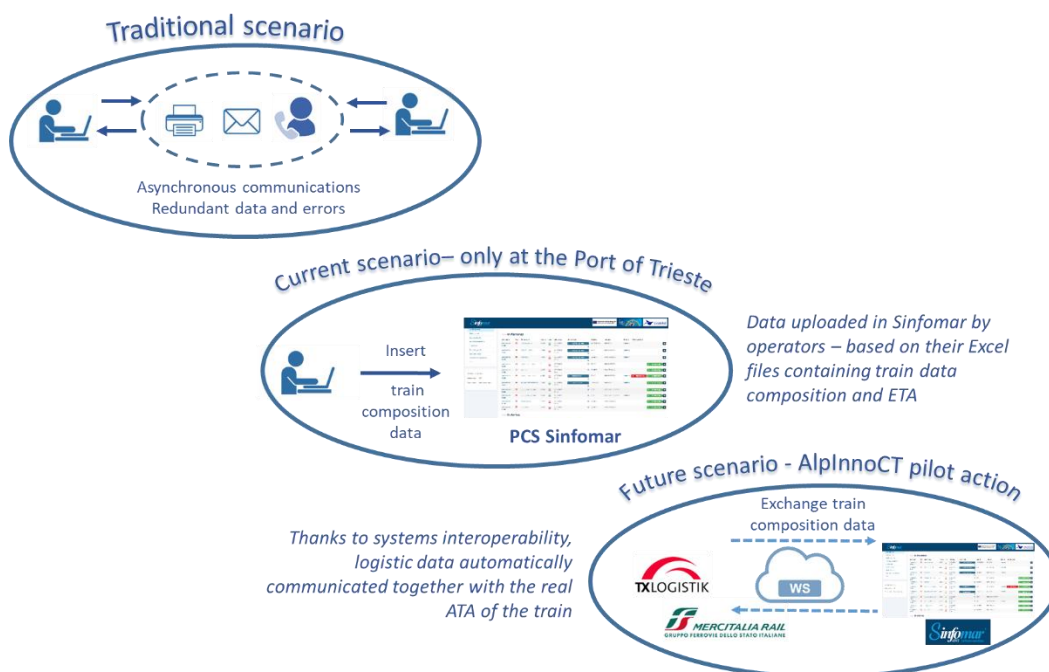


Figure 8 - Visual exemplification of the impact of the pilot action on rail processes

### 3.2.2 How does the pilot relate to the wish list and classification?

#### 27. Improvement of the planning and punctuality of the CT

- Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream

processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

#### 53. Shorter stay of the loading units in terminals (storage time)

- In peak times crane utilization is a bottleneck factor on which unpaid moves have an important impact. Their number has increased as some companies use the terminals as buffers. Associated with this are longer duration times of the loading units (LUs) in the terminals and thus also more unpaid LU movements.

#### 28. Continuous tracking of the loading unit (on train, ship and truck)

- A comprehensive and continuous tracking of loading units offers a significant added value for the actors involved in the transport chain (early adaptation of downstream processes, evaluation of data for the optimization of individual processes, etc.) as well as the customers. Also, given that this technology has long since become standard in other areas and on the road, the implementation of consignment tracking is a key element in improving combined transport.

#### 31. Introduction of electronic freight documents

- It is astonishing how long paper-based shipping documents have survived in times of digitization, although they are associated with a variety of disadvantages. It is urgent time to set the framework conditions for the electronic waybill as a standard solution to make use of the technical possibilities.

#### 36. More IT invests in general (complete digitalisation of all transport-related documents and EDI on the whole transport chain)



### 3.2.3 Current challenges and how are these addressed in the pilot case?

In order to accommodate increasing maritime and rail cargo flows (the latter: +45% between 2015-2017) upgraded railway infrastructures are needed, requiring considerable budget and time.

Meanwhile the Port of Trieste aims to ease congestion through soft measures such as ICT actions.

Final figures will be available once the impact of the IT solution is evaluated against the baseline scenario, however the action is expected to significantly contribute to shifting traffic flows to CT/rail.

The table below contains preliminary data useful to compare the rail traffic on the Trieste-Bettembourg relation as observed in the first semester of 2017 and the first semester of 2019:

	<b>January – June 2017</b>	<b>January – June 2019</b>
<b>No. of trains</b>	260	363
<b>Vehicles transported by train</b>	7,542	10,265
<b>% of full wagons</b>	95%	97%

In the periods taken as reference, this relation marked an increase of about 40% in the number of trains and of about 36% in the number of vehicles transported by train. For the reasons illustrated above, it is not possible to isolate, at this stage, the results directly linked to the implementation of the pilot action from those derived from other, further developments in the management of train-related processes.

### 3.2.4 What exactly was examined / tested and how?

The Port of Trieste will upgrade its ICT platform in order to better manage railway traffic and exchange data with TX Logistik and Mercitalia Rail.

Outbound train documents are fully digitised, and are included in the Port Community System in the so-called “CH30” document:

MMP CH30 PF - TRENO IN PARTENZA

spedizione: TRI.0155P

allibramento Sinfomar 5944 del 14/06/2017

agente: SAMER & CO SHIPPING SPA

treno nr.: 42248

diretto a: Wels

di data: 14/06/2017 ora: 21:45

in arrivo da: SAMER SEAPORTS TERMINALS









Pos.	Vagone	Targa n. container	Merce	Semirimorchio/Container			Sigilli	UNDO	Tipo documento	Numero documento doganale	Nr. Sinfomar
				Massa	Tara	M. lorda					
1	335649930997	Targa: /34 LR 2225	LEGNO, CARBONE DI LEGNA HS: 4415 20 90	24.539	7.040	31.579	04398533		TI/MEN	 TI/MEN: 17TR34130000785622 DOTAZIONE	116077
		Marca: 8	ATTREZZATURA ISU HS: 87	0	0	2.000					
2	335649932159	Targa: /38 GF 949	MOBILI HS: 9401 40 00	6.854	7.346	14.200	00652748		TI/MEN	 TI/MEN: 17TR06060000161640 DOTAZIONE	116082
		Marca: 81	ATTREZZATURA ISU HS: 87	0	0	2.000					
3	335649932324	Targa: /34 J 3908	INDUMENTI ED ACCESSORI HS: 6204 69 18	12.566	8.300	20.866	04397459		TI/MEN	 TI/MEN: 17TR34130000772324	116088
4	335649931540	CNTR : GARU1001235	MACCHINE ED APPARECCHI ELETTRICI HS: 8544 49 95	23.601	4.850	28.451	4397590		TI/MEN	 TI/MEN: 17ITQXL08003139376	116068
		Targa: /34 LH 5274	LAVORI DIVERSI HS: 9603 90 99	15.961	7.172	23.133	04470768		TI/MEN	 TI/MEN: 17TR34120000624774	116066
5	335649930781	CNTR : GARU1010392	PREPARAZIONI A BASE DI CEREALI HS: 1902 19 10	22.150	4.000	26.150	00474564		TI/MEN	 TI/MEN: 17ITQXL08003138778	116070
6	335649931649	CNTR : ECBU4645296	KULCE ALUMINYUM; TORNA APARATI HS: 76012080	21.723	4.000	25.723	04399165		TI/MEN	 TI/MEN: 17TR34130000791233	116081
		CNTR : GARU1008332	PREPARAZIONI A BASE DI CEREALI HS: 1902 19 10	22.150	4.000	26.150	00474574		TI/MEN	 TI/MEN: 17ITQXL08003138976	116067

Figure 9- example of CH30 document as generated by the Sinfomar PCS

The Port of Trieste already exchanges these data with RailCargo Austria (RCA), serving as a valuable experience for the implementation of the pilot action.

In October 2017, the Port of Trieste and TX agreed to implement an ICT-based pilot action, exchanging information on inbound/outbound trains on the relation Trieste-Bettembourg. Since Mercitalia Rail, whose TX is a subsidiary, provides the traction on the Italian territory, this operator has been also involved in the action as of October 2018, as this Railway Undertaking (RU) is better placed to exchange train-related data with the Port of Trieste. The technical exchange mainly concerns how to ensure interoperability taking into account that slightly different standards regarding train digital documents and the goods classification are in use in the two organizations. Having substantially clarified such aspects, in May 2019 TX and the Port of Trieste agreed on how to design the IT solution through which the data exchange is realized and the Port of Trieste included the relevant specifications in the tender ToR.

More specifically, the pilot action focuses on the following topics:

1. **Interoperability with TX Logistik and Mercitalia Rail**
2. **Interoperability between Sinfomar and PIC<sup>2</sup> platform of RFI<sup>3</sup>**
3. **Dashboard for Railway Last Mile Management**
4. **Interoperability with the Shunting Management system**

### **1. Interoperability with TX Logistik and Mercitalia Rail**

The application refers to procedures of data interchange concerning the CT service between Trieste and Bettembourg. This has been achieved through the development of IT services to digitalise the train-related document, such as the CH30 document, by implementing interoperability mechanisms between Sinfomar and the system in use by TX Logistik, taking into account the standards and processes already in place.

The final aims are the followings:

- to collect, manage and communicate to the involved logistic actors accurate data about the real train composition in an automatic way;
- to realise interoperability in order to directly manage also the consignment note through the use of standardised data (e.g. identification of the consignment note, date, track number, sender, receiver, destination place) also considering the needs of the different RUs, starting from TX Logistik.

Considering this last point, in order to realise such interoperability a database has been built within this pilot action. It automatically allows the conversion between the TARIC/HS (*Tariffa Integrata Comunitaria/Harmonized System*) code in use in the CH30 train documents managed by Sinfomar and the NHM (*Nomenclature Harmonisée des Marchandises*) code used in the H30 Hermes standard used by TX Logistik.

Figure 10 below shows the result already implemented and in use in Sinfomar.

---

<sup>2</sup> *Piattaforma Integrata Circolazione* – Circulation Integration Platform.

<sup>3</sup> *Rete Ferroviaria Italiana*, the Italian railway infrastructure manager.

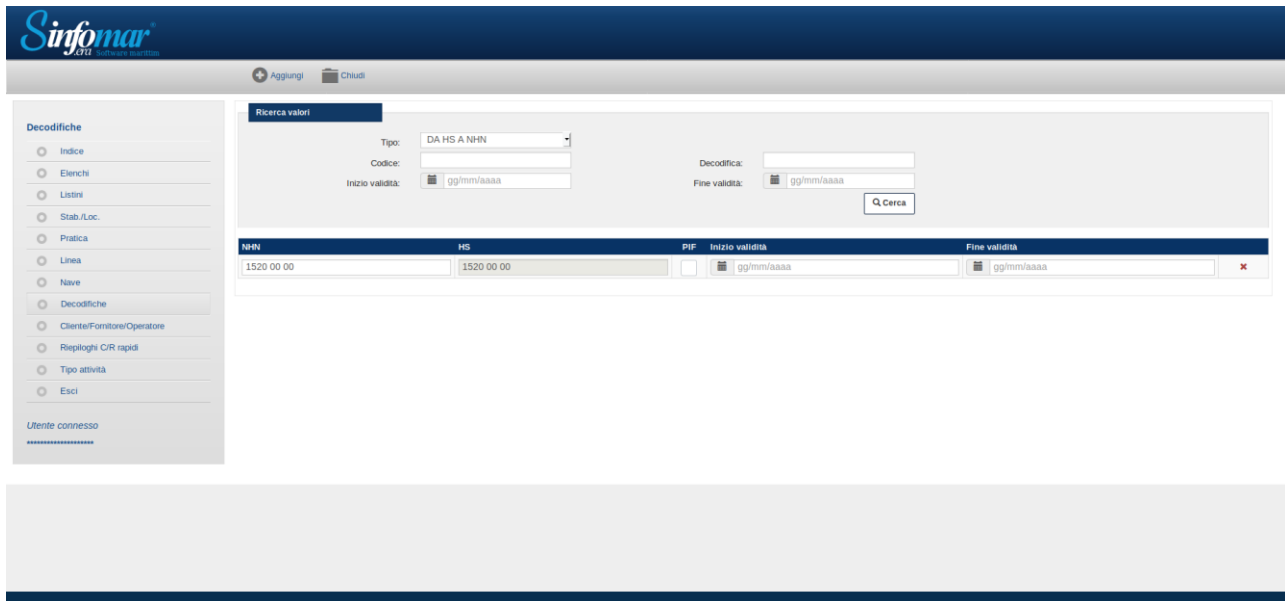


Figure 10 – Automatic conversion from HS to NHM codes in Sinfomar.

This new Sinfomar functionality is based on a database built with conversion purposes to automate the data exchange based on the same standards. As a result of this analysis, the two codes are quite similar and specifically differ for codes n. 96, 97 and 98.

Then, a dedicated Web Service (WS) based on SOAP (Simple Object Access Protocol) protocols has been realised and implemented for a test on the train Trieste – Bettembourg of the 23<sup>rd</sup> September 2019. The xml file is aligned with specification of the H30 Hermes version 2.0\_2016. The data exchanged are complete and therefore this represents a significant improvement for the involved logistic operators.

The main data are the following:

- headline (GT1 section);
- commercial data;
- complete data about wagons and the train composition;
- details on wagons (GW1 section);
- details on goods (GWL section);
- details on logistic units (GWL3 and GU sections);
- indication of dangerous goods (GWLR section) – not used in our test.

The used standards are the followings:

1. NHM code;
2. UN LOCODE to identify Nations.

The H30 Hermes document does not use the ISO code for container identification and therefore in the test implemented within Sinfomar, a conversion mechanism has been implemented in this case as well and it is present in the used xml file.

It is noteworthy that in the performed test, it has been possible to exchange also commercial data since all data are managed through codes and therefore no privacy-related restrictions apply.

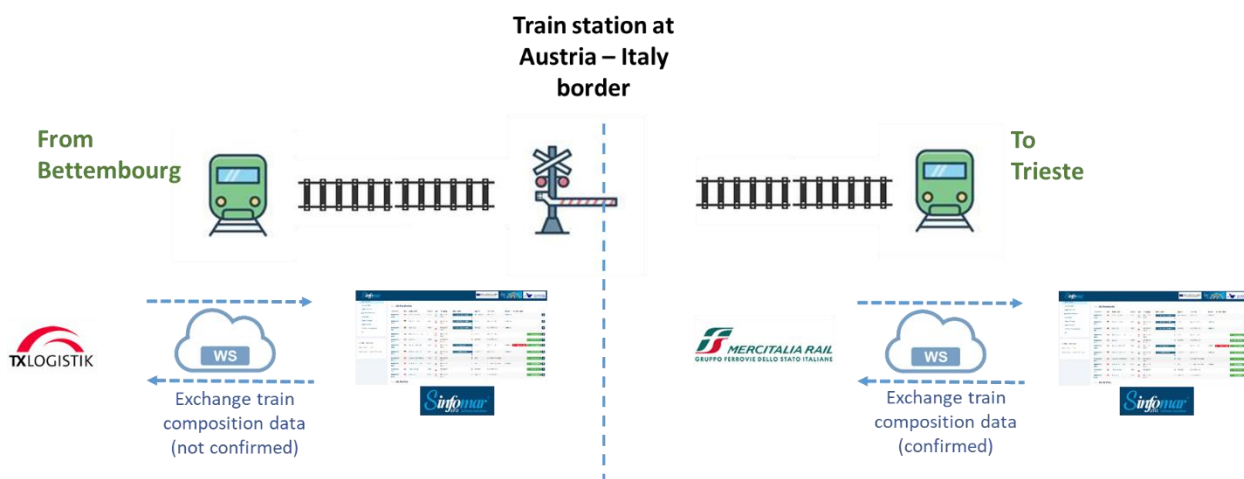


Figure 11 – Pilot Case no. 2: Detailed process flow

As described in 3.2.1, the action is split in two different moments (see also Figure 11): before crossing the Italian border and after crossing it. The test that has been implemented is based on confirmed data after the train crossed IT-AT border, however the structure of the xml file used to perform the communication flows through Web Service are already aligned with the standards in use by TX Logistik (H30 Hermes). The approach to this standard is fundamental to improve the management of the train-related data at the Port of Trieste; for this reason, the activities implemented and tested within the AlpInnoCT project can be considered as a catalyst to further enhancements and investments by the Port of Trieste. Indeed, the ultimate goal is to offer ICT solutions able to improve the daily work of its Port Community, at the same time being consistent with standards and procedures in use by other European logistic operators to foster new collaborations.

The main benefits obtained can be summarised in the smooth information exchange on trains and their composition, the availability of data directly to the RUs, without using MTOs (Multimodal Transport Operators) as intermediaries, the availability in advance of data included in Sinfomar that are already verified and approved by the Customs Agency.

This innovation facilitates the management of CT services at the Port of Trieste, promoting the shift from road to rail with resulting benefits also in terms of reduction of pollution and traffic congestion.

In addition to this interoperability test, the Pilot Case also focuses on further aspects that contribute to enhance the competitiveness of the train management system.

## **2. Interoperability between Sinfomar and PIC platform of RFI**

The realisation of the interoperability, based on SOAP protocols, between Sinfomar and the PIC – Circulation Integration Platform, used by the Italian railway infrastructure manager (RFI) allows a direct communication between the two systems on: different phases of train programming, tracks execution and planning of shunting operations. It is implemented in line with the EU Regulation no. 2014/1305 of 11/12/2014 concerning security issues, and with the national regulations of the National Agency for Railway Security – *Agenzia Nazionale per la Sicurezza delle Ferrovie (ANSF)* and the Authority for Transport Regulation – *Autorità di Regolazione dei Trasporti (ART)*.

From the system side, a site-to-site VPN is implemented in order to realise the interoperability between the platform in use by RFI, PIC and the Sinfomar PCS in compliance with RFI security policy.

As to the technical development, this is achieved through the exchange of Web Service (WS) messages, as listed in the table below:

Category	#	Item	Status	Sender
Programming	1	Timetable (e.g. on yearly, weekly basis)	Existing	PIC
	2	Changes during the course of the timetable (e.g. in the weekly/daily timeframe)	Existing	PIC
	3	Changes in the Operational Management (GO, e.g. when extra trains are added)	Existing	PIC
Real time	5	Train status	Existing	PIC
	6	Expected delay	Existing	PIC
	7	Actual track	Existing	PIC

Preliminary to the signature of the service contract binding the Port Network Authority and RFI, a specific authorization from the RUs is requested to visualize the PIC data. So far, the following RUs already gave this authorization:

- Adriafer S.r.l.
- Captrain Italia S.r.l.
- Ferrovie Udine Cividale S.r.l.
- Rail Cargo Carrier Italy S.r.l.
- Rail Traction Company S.p.A.

The data provided by PIC automatically populate the data fields included in the dashboard for the management of the Railway Last Mile.

### **3. Dashboard for Railway Last Mile Management**

The aim of this dashboard consists in optimising, through a centralised approach, the planning of shunting activities in the logistic hubs managed by the Port Network Authority of the Eastern Adriatic Sea. Thanks to this new functionality, it is possible to collect and manage data in real time concerning the execution of the different shunting activities. This data are available through Sinfomar interfaces that can be accessed via tablets to help and speed-up the communication flows among the train operators.

The dashboard called “Port System Circulation Management” (GCSP) is embedded in the Sinfomar Train Management module, and it is represented in figure 12 below.

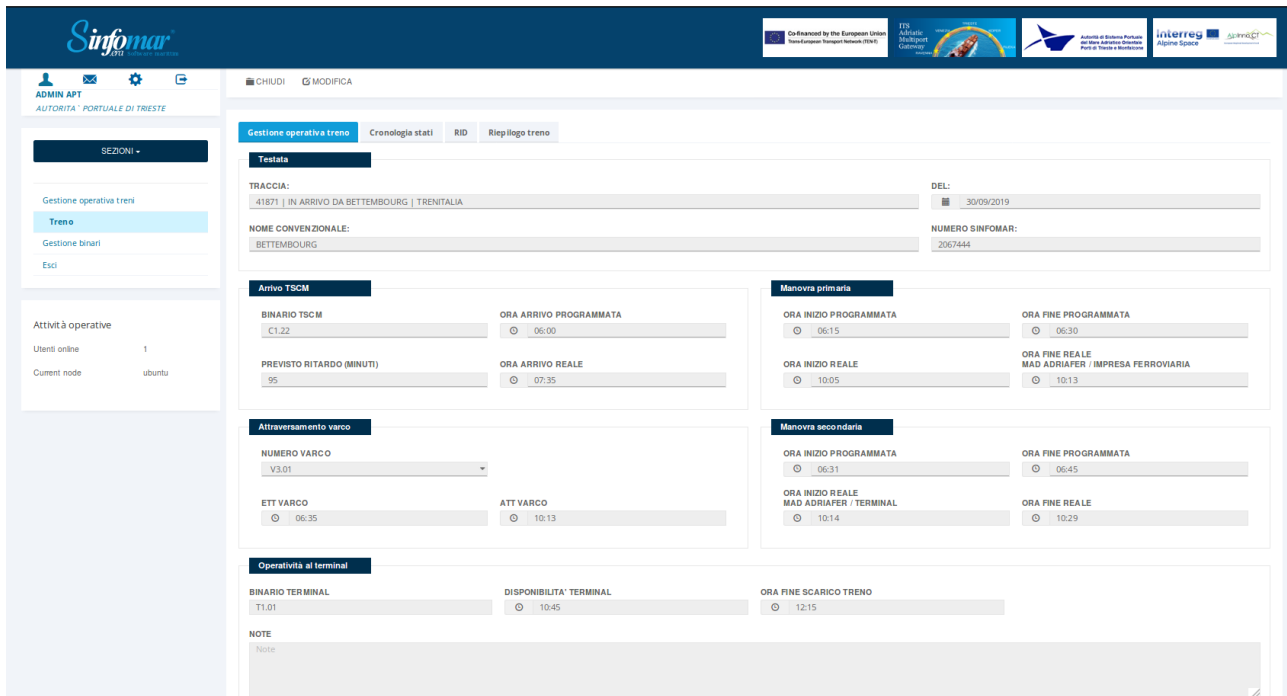


Figure 12 – Dashboard for Railway Last Mile Management in Sinfomar

The workflow is the following:

- Registered users in Sinfomar enter in the system the data related to the train paths, the railway company, the train agent and the MTO as well as other data needed to identify who has the right to declare information to the Port Network Authority, Customs Agency and Financial Police (i.e. declarant);
- The system automatically proposes train itineraries on the basis of the path data entered by the user;
- The declarant performs the procedures for generating the CH30 document – Train Freight Manifest, completely digitised within Sinfomar;
- The Port Network Authority competent department (Railway Infrastructure Dept., DIF) can access the GCSP dashboard, view the previous day's itineraries and check the operational execution of the journey (operational management feature added to the current customs management of the train). Therefore, the DIF staff should be able to enter the GCSP module and check the operational progress of a train during its journey.



#### **4. Interoperability with the Shunting Management system**

This is a new Sinfomar module aimed at defining an interoperability model dedicated to the operation and information management of the last mile from the port terminals to the inland terminals of destination. It foresees communications with:

- PIC: both in the planning and operational phases for all railway stations included in the area under the management of the Port Network Authority of the Eastern Adriatic Sea (Trieste Campo Marzio; Cervignano Smistamento; Villa Opicina; Monfalcone; Duino Aurisina);
- M53 model to automatically collect data about the planning of train services;
- Shunting monitoring: to collect accurate data concerning shunting activities and their status.

System side: same Sinfomar environment + interoperability via Web Services.

Technical development side: the Shunting Management system is being changed – from the PILSSH information system (supplier: Al maviva) to the TrainShunt information system (supplier: Binary Systems).

#### **3.2.5 Industry production know how – process / methods**

The main process to be applied is the supply chain.

Too often, the transport of goods is seen as an initial and final part of the product added value.

In fact, one of the main components of the added value is the time and cost of transport and logistics from production site to the market of destination.

Thus, the whole transport chain should be seen as a function of the overall supply chain, whereby each component of the transport chain needs to be optimised, as to reduce time and costs for the shipment of the goods.

Another success criterion is the networking of companies and the automatic transmission of the necessary data in production. This case strengthens the efforts for networking and data availability for the holistic optimization of the transport chain.

### **3.2.6 Which KPIs can be used to measure the results?**

- Time to automatically create the train-related documentation (e.g. waybill);
- Percentage of reduction of errors in train-related documentation.

Based on the results obtained through the implementation of a similar IT solution with another RU (Rail Cargo Austria), it can be estimated that the time needed for the automatic creation of the train-related documentation will dramatically decrease – by about 90%. Final figures will be available after a long-term run of the developed solution.

### **3.2.7 Milestones**

31/03/2019: start of the tendering procedure

30/06/2019: signature of the contract

16/09/2019: implementation of the pilot action on the side of the port of Trieste

30/09/2019: final results on interoperability tests and new realisations in Sinfomar

### **3.3 Case 3: Feasibility tests of innovative technologies and digitalization in Combined Transport**

#### **3.3.1 Description of the Pilot Case**

The pilot case addresses the lack of digitalization as well as a lack of usage of innovative technologies in CT. Therefore, selected feasibility tests with GPS-Trackers containing an energy harvesting device have been accomplished. All in all, three different applications were defined and elaborated. Given a number of stakeholders involved and due to the fact that processes in CT are highly regulated, this pilot was solely done from the perspective of the railway undertaking TX Logistik.

#### **3.3.2 How does the pilot relate to the wish list and classification?**

This pilot case refers very well to the following wishes:

27. Improvement of the planning and punctuality of the CT.

- Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

28. Continuous tracking of the loading unit (on train, ship and truck).

- A comprehensive and continuous tracking of loading units offers a significant added value for the actors involved in the transport chain (early adaptation of downstream processes, evaluation of data for the optimization of individual processes, etc.) as well as the customers. Also, given that this technology has long since become standard in other areas and on the road, the implementation of consignment tracking is a key element in improving combined transport.

62. More (reliable) slots for freight trains.

- Passenger transport by rail enjoys a higher priority than freight transport. This means that on the one hand, the freight trains have to let overtake the passenger trains and on the other hand, that in the allocation of slots, the passenger trains are preferred. However, achieving the common climate goals requires an improved offer of freight trains, including the approval of more slots.

50. Faster wagon inspection.

- The inspection of the trains as they take place today seems anachronistic. The wagon inspector arrives at the loading station before the train is allowed to leave, picks up the paper papers and runs the entire train. This process costs a lot of valuable time. For this, solutions must be found to adapt the tensile test to the current conditions and possibilities.

34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal).

- As we are talking about optimizing processes through lean thinking all wastes in the process should be eliminated. From our perspective main waste in the process view is warehousing, so this »stage« should be minimized or even eliminated to deliver just in time.

### **3.3.3 Current challenges and how are these addressed in the pilot case?**

Many processes in CT are currently not (fully) digitalized and still mainly paper-based with a low degree in automatic transmission (e.g. interfaces). At the same time a certain reluctance in using innovative technologies in CT can be observed. This leads to additional effort in operations, inflexibility, delays and overall competitive disadvantage.

### 3.3.4 What exactly was examined / tested and how?

This pilot case examined how innovative technologies and digitalization could enhance selected processes in CT. This encompasses:

Self-powered and maintenance-free GPS tracker for railway wagons

- GPS trackers are working battery-powered and have limited operation times. The batteries have to be recharged or replaced. Additional sensors to monitor the condition of the trains or the goods increase the power consumption, and thus reduce the operation times of the system. Since typical railway wagons are on tracks for a very long time (up to a couple of years – mainly up to 6 years), batteries are not able to power the tracker for the whole duration. Furthermore, extreme low or high temperatures limit the capacity and lifetime of batteries.

Within this pilot case a state-of-the-art GPS tracker with cellular interface and standard sensors like temperature and acceleration were used to determine the power consumption in a typical transport use-case. The system control of the tracker is adapted to fulfil the requirements of target use-case. Field tests on the trains provide information about the proper functionality and the related power consumption. Additional measurements of the accelerations during typical transport scenarios are used to characterize the vibrations available, which can be used for energy harvesting.

The goal of this pilot case is to specify and outline a fully self-powered tracking system for railway application. Such a solution will provide much higher functionality in terms of sensors and transmission rate than state-of-the-art trackers. As there have been feasible results, a self-powered tracking device is demonstrated in the field.

The innovative technology of vibration sensors allows to test additional scenarios, like wheel flat detections and wagon order assignments.

Thus, following use cases have been conducted within this pilot case:

Application 1: Maintenance-free track & trace for wagon life cycle (6 years)

- With the implementation of an energy harvesting device and wobbling motions while the train is driving, the tracker shall be able to daily operate up to 6 years (wagon life cycle)

- Parameter analysis and feasibility tests for self-powered GPS trackers (P1)
- Configuration of prototype and laboratory tests (P1)
- Field test demonstration (P2)

#### Application 2: Early stage detection of wheel flats through vibration sensors

- The idea behind this case is the assumption that wheel flats cause higher concussions on track and therefore the advanced GPS-trackers are able to predict wheel flats (predictive maintenance)
  - Data capture in field (P1)
  - Data analysis, feasibility test (P1)
  - Potential test appliance in field (P2)

#### Application 3: Automatic wagon order assignment

- With the support of near field communication and the adaption of multi hop connection, the tracker shall be able to set up the train composition as soon as the wagons are shunted together (e.g. in the terminal)
  - Feasibility Analysis (P1)
  - Potential test appliance in field (P2)

### **3.3.5 Which results in which form should be expected after the pilot has been completed?**

#### Robust and maintenance-free GPS tracker for railway wagons

- A self-powered tracking solution will enable new use-cases since no maintenance and no access to the tracker is required. A cost reduction is a further benefit of the energy harvesting power supply, due to fact that no maintenance is required. Tracking becomes more robust, flexible and reliable.

### 3.3.6 Involved Partners foreseen (external and internal)

- Fraunhofer IIS Nuremberg
- Bagszas Industrial Logistics, Berlin
- (data platform provider Kasasi)

### 3.3.7 Which KPIs can be used to measure the results?

- Maintenance Time and cost of Track & Trace devices
- Pre-notification time / alert time of wheel flat while on tracks
- Disruptions in railway operations due to damaged wheel flats
- Wagon inspection efficiency in terms of time savings (operational costs)  
Power potential wobbling tracker

### 3.3.8 Timeline and Milestones:

#### Phase 1

- Kick-off: CW 6 – done
- Development of test system / definition of the possible energy harvesting – until CW 12
- Installation test system: CW 12 / CW 14 (4<sup>th</sup> of April system was installed)
- First field tests on wagon for prototype development– until CW 14 / Delay due to defect SIM cards, new test will start in CW 19
- Evaluation of test drives and definition of requirements for an energy self-sufficient tracking system – CW 14 / Update: CW 21
- Completion of project phase 1: CW 15 / Update: CW 22

#### Phase 2

- Development of an energy profile based on the test drives results – done CW 30
- Simulation of different possible energy harvesting solutions in the Fraunhofer laboratory – done – CW 38
- Development of a new tracking solution (test modules) – under development – plan CW 39
- Test of the new tracking module in the Fraunhofer laboratory – plan CW 40
- Final report about developed energy harvesting tracking solution – plan CW 40

## Post evaluation

- Field test on rolling material
  - Similar trains than in Phase 1
  - Selected wagons for the pro-active maintenance (wheel flat)
- Analysis of the field test results in the Fraunhofer laboratory
- Potential technical adjustments based on final field tests
- Final technical proposal
  - Harvesting, communication and sensor technology
  - Communication frequencies
- Hand-over to operation (roll-out of the technology)

## **Results**

### Preparation

In Phase 1 we initially evaluated the business requirements of TX / AlpInnoCT in relation to

1. Customer and operation need in relation with the AlpInnoCT project
2. Resulting in the expected energy need
3. Investigating the possible energy harvesting effect

This evaluation was done jointly with

- Cross-functional team from TX:
  - Sebastian Ruckes, Marc Braun (Innovation Management),
  - Bernd Weisweiler, Christoph Dörre: Customer needs & transformation in operational requirements
  - Maximilian von der Schulenburg, Christoph Dörre: operational requirements and possibilities
- Fraunhofer IIS Nuremberg (IIS):
  - Dr. Peter Spies – Research project management
  - Johannes Knauer, Florian Baumgärtner – Hardware and software implementation and testing of GPS tracker
  - Vesa-Pekka Torvinen – Vibration energy harvesting and power management characterization and development,
- Bagszas Industrial Logistics (BIL)
  - Axel Bagszas project management and alignment with general logistics development in the area of CT



As a result, we concluded to limit the evaluation of energy to

- A certain part of the overall CT transport: terminal to terminal only
- Various sensors which are required to fulfil the business needs
- Tracking of the position and complete transport process on rail tracks

For the test period we agreed on certain basic assumptions like

- Average time of a wagon/train in the terminal 8 – 24 hrs
- Service interval of a wagon – 6 years
- Average speed of trains - 60 km/h

Next to this we agreed upon the following initial requirements on sensors and tracking as basic assumptions:

Process	Sensors	Tracking	Communication
Terminal	Max	Every 5 min (in motion)	Every 5 min optimal; alternative tbd. (in motion)
Track	Max.	Every 5 min; alternatively, 60 min (in motion)	Every 60 min. (in motion)
Service	Max.	Every 5 min (in motion)	Every 5 min optimal; alternative tbd. (in motion)

Some more requirements which we agreed upon:

- EX protection according to ATIX is necessary for equipment which will be used in special areas like chemical factories – for the test this is not required; for field roll-out it will be necessary.
- The housing shall be neutral, grey, without any visible markings and robust (IP6 – protection class)

## **Realisation**

A project management structure was settled which optimally supports the AlpInnoCT project team of TX.

A sensor and tracking system, designed to characterize the energy harvesting potential, was developed from Fraunhofer IIS. The system was designed to transfer the measurement data like position, velocity and vibration (x, y z) in real time on a server for a certain period of time.

In total three systems were installed on the route Herne – Verona (as part of the pilot relation Rostock-Verona via the Brenner Corridor) for a period of 6 weeks in total. Additional systems are provided to measure the vibration pattern of the wheel flats.

The results of this data have been analysed in the laboratory of Fraunhofer IIS.

This is the final time plan (2019):

- Kick-off: CW 6
- Development of test system / definition of the possible energy harvesting – until CW 12
- Installation test system: until CW 14
- First field tests on wagon for prototype – start CW 14
- Second test due to a failure in hardware - start CW 19 – end KW 21
- Evaluation of first field trails and definition of requirements for an energy self-sufficient tracking system – until CW 25
- Completion of project phase 1: CW 25
- Project phase 2 is to start directly after the end of this phase.

This was the final concrete time plan:

### Phase 1

- Kick-off: CW 6
- Development of test system / definition of the possible energy harvesting – until CW 12
- Installation test system: until CW 14
- First field tests on wagon for prototype – start CW 14
- Second test due to a failure in hardware - start CW 19 – end KW 21
- Evaluation of first field trails and definition of requirements for an energy self-sufficient tracking system – until CW 25
- Completion of project phase 1: CW 25
- Project phase 2 is to start directly after the end of this phase.

### Phase 2

- Development of the energy neutral tracking system
  - Development of the Energy profile(s): CW 31
  - Test in the laboratory Labor: CW32
  - Optimisation of the test systems: ongoing
- Test of different harvesting technologies in the Lab: CW40
- Long-term stability tests: CW41

- Check alternatives: CW 42
- Optimise Energy management and consumption scenarios for different use-cases: CW42
- Installation for three different trackers for further evaluation of regular services and flat-wheel detection scenarios: CW42
- Continuous test to further optimize the system: CW42 – ongoing
- Alignment with platform provider(s) to evaluation cross-functional data exchange scenarios – CW42

Technical evaluation of different options (mesh..) to secure the wagon order assignment – CV 43

### **Phase 3 – Post evaluation:**

#### **Results**

##### Introduction

Nowadays, GPS trackers are working battery-powered and have limited operation times. The batteries have to be recharged or replaced. Additional sensors to monitor the condition of the trains or the goods increase the power consumption, and thus reduce the operation times of the system. Since typical railway wagons are on tracks for a very long time (up to a couple of years), batteries are not able to power the tracker for the whole duration. Furthermore, extremely low or high temperatures limit the capacity and lifetime of batteries. Using ambient energy like light or vibrations to power the electronics is a promising approach called energy harvesting. There are some smaller companies on the market, which provide vibration harvesters for railway applications.

In this project a GPS tracker with cellular interface (UMTS) and standard sensors like temperature and acceleration will be used to determine the power consumption in a typical transport use-case. The system control of the tracker is adapted to fulfill the requirements of target use-case. The GPS tracker is also employed for measuring the accelerations on the trains during typical transport scenarios, which can be used for energy harvesting. Off-the-shelf vibrations harvesters are characterized in the lab with the vibrations from these field tests regarding their output and the potential to cover the trackers power budget. The power generated is compared to the requirements of different use-cases.

## Preparation - Train measurements on the track

GPS trackers with vibration sensors and UMTS connectivity were installed in Phase 1 and again in Phase 2 on different train wagons to assess the potential for energy harvesting from vibrations for powering tracking and wireless sensor systems. The measured vibrations in the x-, y- and z-axis were combined with GPS position information and were transferred over UMTS connectivity to the data server of Fraunhofer IIS. Here, the data was analyzed and used for characterization of different commercial vibration harvesters in the lab.



Figure 13: Mounted GPS tracker on different train wagons

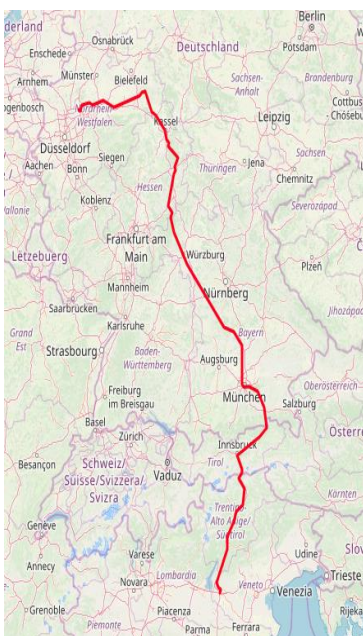


Figure 14: GPS position of train with vibration sensors

The GPS tracker architecture is shown in Figure 15. During these vibration measurements, the GPS-trackers are fully battery powered, since they have a much higher power consumption in this measurement operation mode where every 5 minutes the vibration data is transmitted to the server. In the future, the aim is to power these trackers by vibration energy harvesting, whereas typical use-cases have a much lower tracking and transmission rate and thus a much lower power consumption.

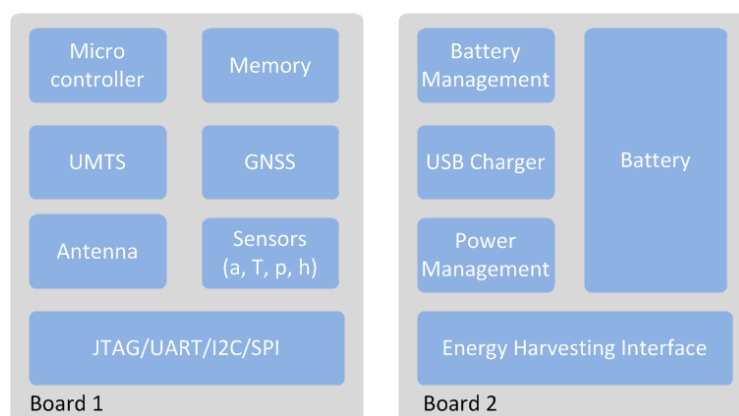


Figure 15: Architecture of GPS tracker for vibration measurements

After the measurements on the trains, several hours of vibration data were available on the server. Since in parallel to the vibrations data also the GPS position was recorded, it is possible to relate the vibration data in form of acceleration over time to the speed of the trains, which can be calculated from the GPS position.

### Business needs

The following more detailed requirements are discussed, evaluated and agreed up in order fulfill the overall needs described in 2.2:

- Full transparency for all equipment (wagons).
- Enabling pro-active information for all possible partner and customers in the CT.
- Avoiding the search for equipment in the terminal.
- Enabling the further optimisation of the terminal processes (like digital wagon order).
- Providing information which enabled pro-active maintenance e.g. for flat-wheel avoiding of failed.
- Providing the concrete track layout / course of the route.

## **Technical results**

### Technical results – Application 1 (main) - maintenance free track & trace for wagon life cycle (6 years)

#### Analysis in the lab

Commercial vibration harvesters are resonant systems working with a combination of magnet and coil (dynamo-principle) with a maximum power generation only in a certain frequency range. Thus, a first analysis of the recorded vibration data was to search for characteristic peaks in the frequency spectrum. If those peaks would be available, the harvesters could be tuned to these frequencies to get the maximum power generated.

Therefore, a so-called spectrogram calculation was done. A spectrogram is a visual representation of the spectrum of frequencies of a signal as it varies with time. In the case of the train vibration measured in acceleration in g [ $m/s^2$ ], a spectrogram shows how long a frequency is present with a certain acceleration. Since the most frequent speed of the train is around 60 km/h, this analysis was done for this speed of 57 km/h, which was found in the recorded vibration data most often.

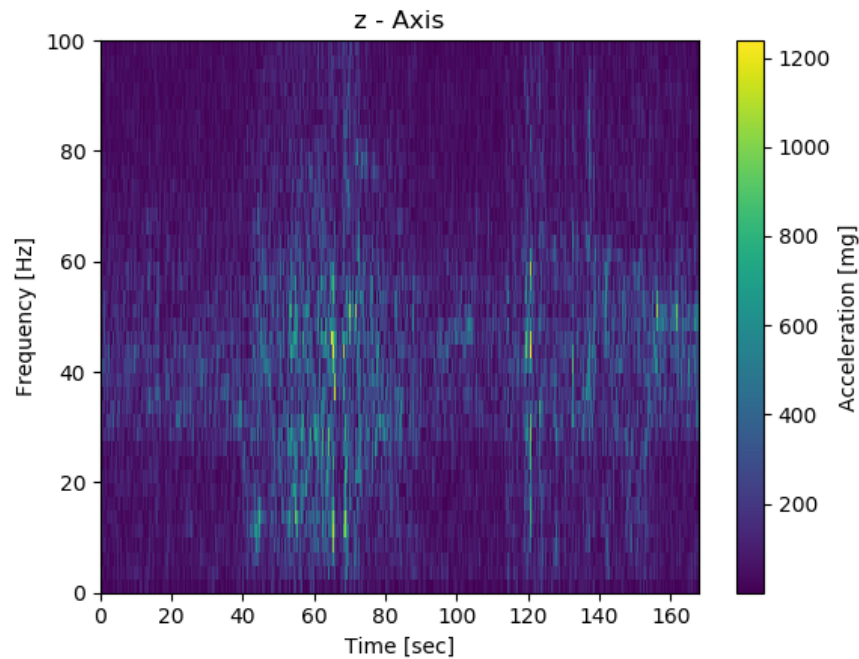


Figure 16: Spectrogram of vibrations at a speed of 57 km/h

In Figure 16 the spectrogram of the train vibrations at a speed of 57 km/h is shown. The analysis duration was 170 sec. and the duration of the sample time in which the acceleration amplitude was time-averaged was 0.4 sec. The brighter areas between 60 and 80 sec. show a more frequent occurrence of frequencies between 30 and 50 Hz, another brighter area around 10 Hz.

Different commercially available harvesters were characterized in the lab and compared regarding their employment in train applications to power GPS trackers.

Manufactured	Model	Resonance frequency [Hz]	DC resistance [ohm]	Weight [g]
Perpetuum	PMG 37 20	22	860	511
Revibe	modelD	62	290	125
Kinergizer	Hiper D	52	6000	110
KRRI	--	52	320     320	524

Table 2: Commercial harvesters tested with train vibrations

In a first characterization, the different harvesters were characterized over a certain frequency band with a constant acceleration of  $0.3 \text{ m/s}^2$ , which means the frequency was increased in given steps and the output power of the harvester was measured.

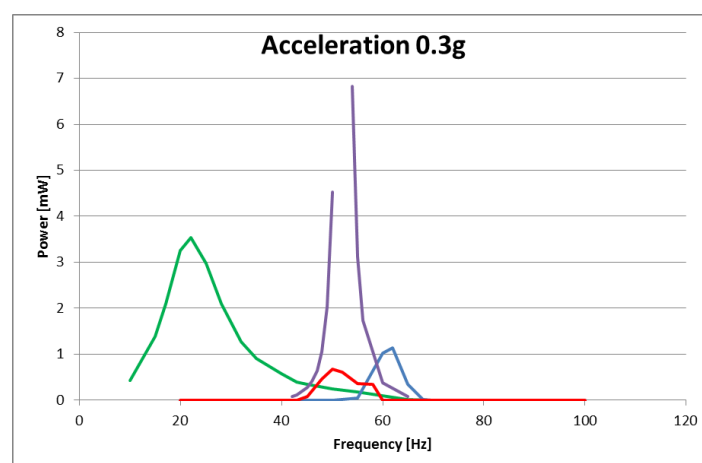


Figure 17: Output power of different harvesters as a function of vibration frequency (green: Perpetuum, violet: KRRI, red: Kinergizer, blue: Revibe)



In the next step, the recorded vibrations were used to characterize different commercially available vibration harvesters. For these tests sections of constant speed during the measured vibration data were selected. These sections of vibration data were then replayed on a shaker in the lab. The different harvesters were mounted on this shaker and the output power of the harvesters was measured. The power generated from the harvester was stored in a rechargeable battery. Between the harvester and the battery a rectifier and impedance matching circuit was use to adapt the current profile of the harvester to the energy storage device. These measurements were done with three different speeds.

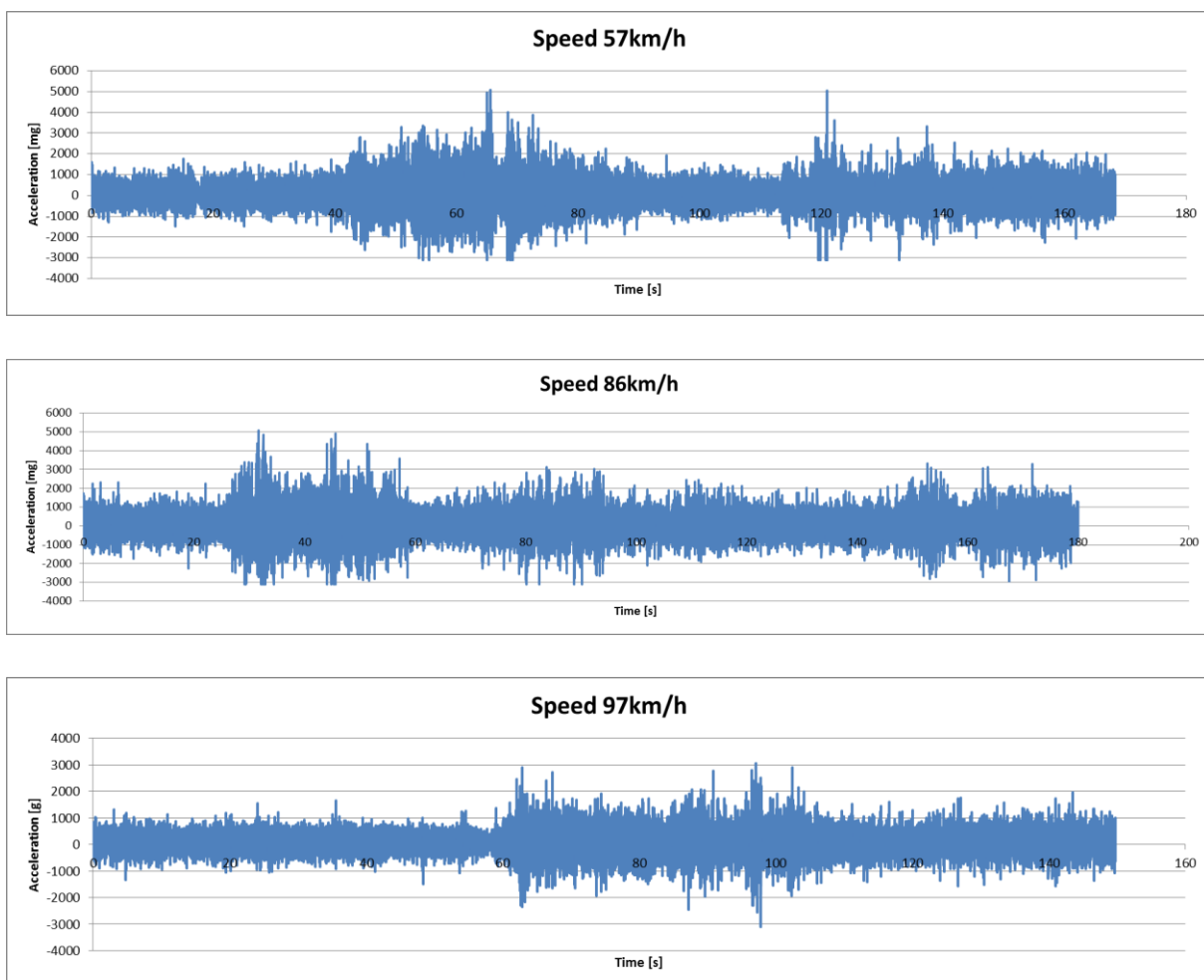


Figure 18: Sections of train vibrations with constant speed

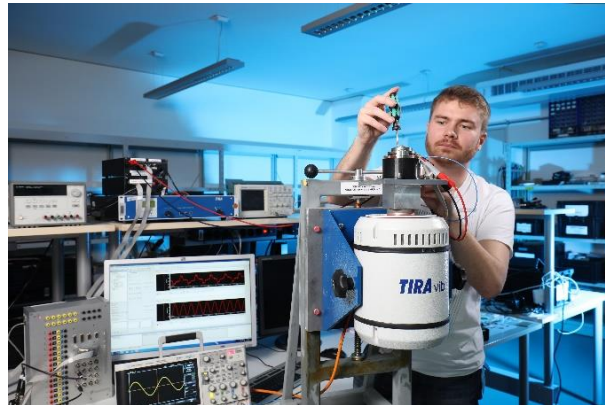


Figure 19: Lab equipment with measurement devices and shaker (TIRA), where the vibration harvesters were mounted

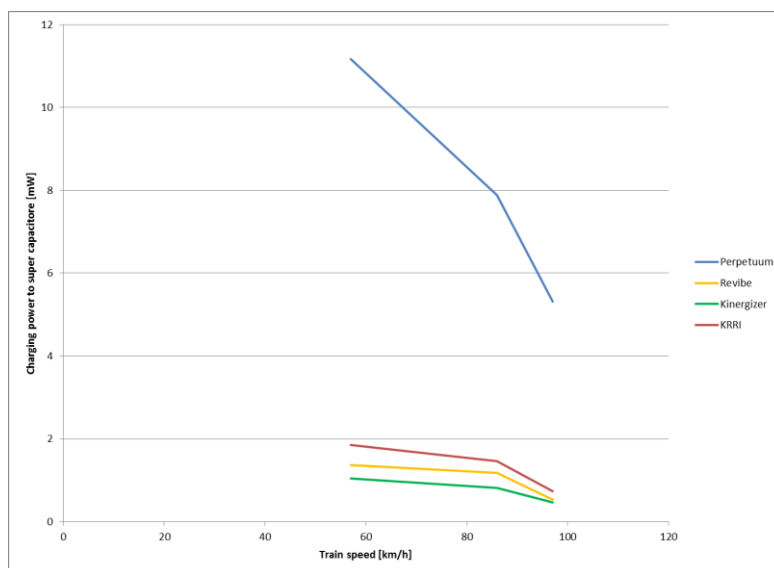


Figure 20: Output power of different harvesters at different speeds

In Figure 20 the measured output power of the harvesters at three different train speeds is shown. The harvester from Perpetuum delivers between 11 and 5 mW. The other harvesters provide much lower output power in the range of 1 to 2 mW. Interestingly, the power is decreasing with higher speed. The high output power of the Perpetuum can be explained by the lower resonant frequency of 22 Hz and the higher weight of 511 g.

## Verification of use cases

The power consumption of GSP trackers is strongly depending on the functionality and performance like position acquisition, data transmission or sensor read-out. Depending on how often the position is measured or calculated or how often related information is transmitted over cellular connectivity, the average power consumption is changing. In Table 3 the average power consumption of the GPS tracker is shown as a function of number of position measurements and data transmissions over UMTS per day. If for example every 120 min a position is measured and transmitted, the power consumption will be on average 9 mW. This can covered by the best suited harvester characterized in this study.

<b>c</b>	<b>Positions / Day</b>	<b>UMTS / Day</b>	<b>Power [mW]</b>
1	2	1	2,5
2	6	2	3,5
3	12	12	9
4	24	24	17

Table 3: Average Power consumption of GPS tracker depending on functionality

Since the data transmission over cellular connectivity is consuming the most power, it is beneficial to investigate the use-case and decide carefully, when a transmission is mandatory and when it is just sufficient to check position or sensor data on the GPS tracker without sending notice to the server. Therefore, in Table 43 the required functionality depending on position is elaborated. Here, a minimum of one message per day is required and additional transmission are only produced when a certain geo-fence is reached. or crossed.

PROCESS	SENSORS	GEOLOCATION	COMMUNICATION
Terminal	1x daily	After stop in Geofence terminal  Addition: 1 x daily	After stop / start in Geofence terminal → timeframe e.g. for defining the shunting
Stretch	1x daily or with Geofence (E.g. in front of the Terminal)	Without motion – after stop  In general and in motion: every 60 minutes  Frequency differentiation between domestic and abroad	Without motion – after 30 minutes sending a stop message – afterwards going ahead with the drive  Supplementary deviation from timetable (Define frequency)  In motion: every 3 hours  Frequency differentiation between domestic and abroad
Maintenance / Workshop	1x daily  (if it's not sleeping)	After stop (Stagnation 30 Min)  Addition: to clarify – Solution with sleeping mode	After stop (Stagnation 30 Min)  Addition: to clarify – Solution with sleeping mode

Table 4: Required functionality depending on infrastructure

As it was already explained above, with such long duration of complete inactivity, it is more efficient to shut the system completely off and active all components only when an action is required. The power consumption of a timer clock to count this inactive time and control the wake-up process is in the range of a few microwatts and can be neglected.

The present hardware and software implementation of the GPS tacker was characterized and an energy consumption of 0.71 mWh for one GPS position and 0.63 mWh for one UMTS telegram was measured. Here, it is considered, that the module was completely off before, which is most power-efficient when only very frequent (e.g. once hour) activities are carried out. The high-power consumption for GPS localization is explained by a higher time required after cold-start (completely off before and afterwards) to find sufficient satellites and process data. These values

also depend strongly on base station coverage and satellite constellation. However, if we consider 3 GPS positions (3\*0.7 mWh) and 1 UMTS message (0.63 mWh) every 3 hours, around 2.7 mWh are required in 3 hours. If this energy requirement is compared with the energy output from the best harvester in this study, which is 5 mWh per hour, 15 mWh in 3 hours, there is still enough headroom available for further sensors and messages, e.g. when leaving the geo-fence or after stop of the train.

## **Application 2: Early stage detection of wheel flats through vibration sensors**

In the second phase of the operational test we've added tracking test in a special flat-wheel field test.

- Terminal: Herne
- Flat wheel status: very early (manually almost not detectable)
- Test: 5km

Results

Analysis of the vibration amplitude

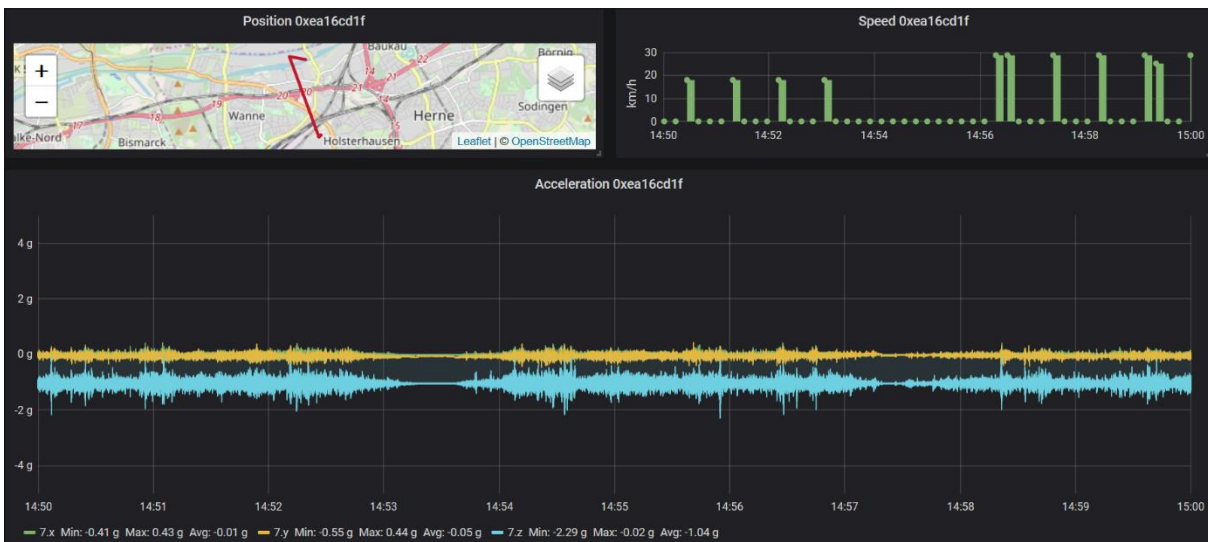
### **Tracker Oxea**



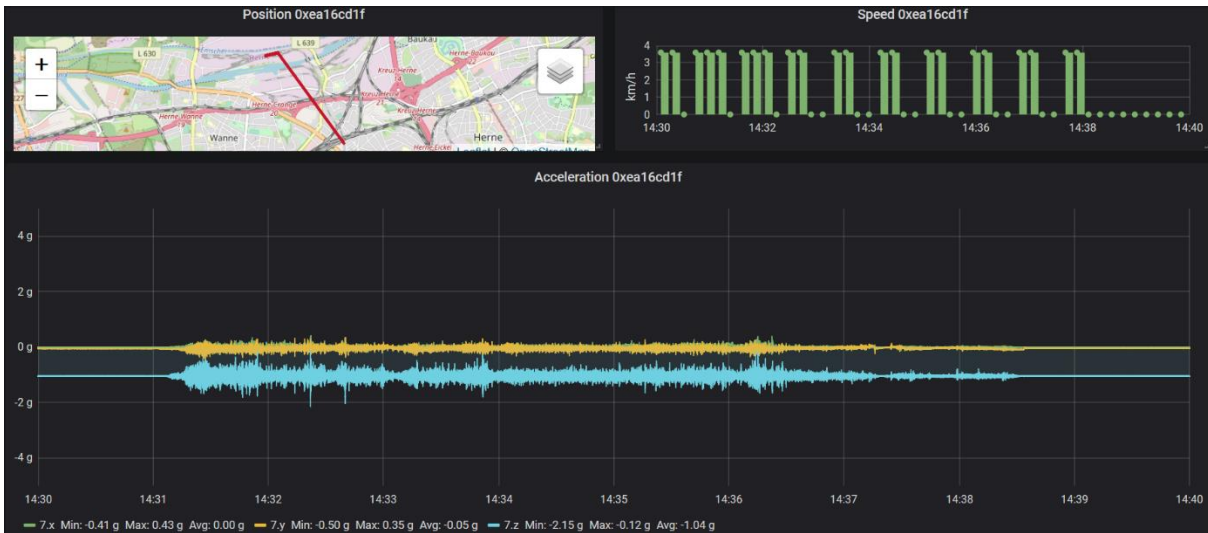
**Without wheel flat, 58 kmh**



**Without wheel flat, 10 kmh**



**Without wheel flat, 19-29 kmh**



Without wheel flat, 4 kmh

### Tracker 0x3b



Without wheel flat, 55 kmh



Without wheel flat, 10 kmh



Without wheel flat, 10 29 kmh





**Without wheel flat, 7 kmh**

Conclusion:

The analysis of the vibration amplitude did not show good enough results in order to clearly identify flat-wheels pro-actively. Further investigations, like a frequency distribution (spectrogram) is planned in the remaining project period. If this doesn't show any positive results, additional sensors at the main shaft shall be considered.

### **Application 3: Automatic wagon order assignment & additional functionalities**

Additional functionalities like wireless connected sensors can be considered as well with this tracking system and energy harvesting power supply.

Wireless sensors like door sensors or temperature sensors at interesting spots on the wagon will be connected over a wireless short-range communication interface. These technologies like Bluetooth Low-Energy (LE) or Zigbee consume orders of magnitude lower power than UMTS or GPS. A typical Bluetooth LE connection for simple data transmission can be expected in the range of 200  $\mu$ W for a transmission every second. This can easily be covered by the harvesters characterized in this study, even if these sensors are powered permanently.

Multi-hop networks are more critical since the sensors nodes in such a mesh network have to be powered on permanently to ensure to receive any request from a neighboring device or sensor. More power-efficient in such a scenario are star-networks, where only one master node is on permanently. Such star networks could also be used for digital acquisition of the wagon order.

### **Conclusion and outlook**

This application investigated the potential for using energy harvesting to implement self-powered tracking systems in railway applications. It was shown that commercial, off-the-shelf vibration harvesters generate power in the range of 1 to 11 mW, depending on type and speed of the train. Typical use-cases in railway applications require typical position updates of once per hour and several information transmissions per day. The necessary energy for this action can be provided by state-of-the-art harvesters. Still on-going research is targeting the power optimization of the tracking system for the specific use-case requirements. Furthermore, new implementation of vibration harvester has been ordered and will be characterized in the coming months.

## **3.4 Case 4: Appliance of production know-how on high frequent transport routes**

### **3.4.1 Description of the Pilot Case**

Within this pilot case an improved transport concept has been applied to a frequently used transport route (via Brenner). In addition to that, it was demonstrated how the appliance of know-how from production industry affects efficiency, reliability and use of resources within intermodal transportation.

### **3.4.2 How does the pilot relate to the wish list and classification?**

This case fits very well to the following wishes:

27. Improvement of the planning and punctuality of the CT

- Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

53. Shorter stay of the loading units in terminals (storage time).

- In peak times crane utilization is a bottleneck factor on which unpaid moves have an important impact. Their number has increased as some companies use the terminals as buffers. Associated with this are longer duration times of the LUs in the terminals and thus also more unpaid LU movements.

62. More (reliable) slots for freight trains.

- Passenger transport by rail enjoys a higher priority than freight transport. This means that on the one hand, the freight trains have to let overtake the passenger trains and on the other hand, that in the allocation of slots, the passenger trains are preferred. However, achieving the common climate goals requires an improved offer of freight trains, including the approval of more slots.

67. More punctuality for railway undertakings (RU). Some RUs are more punctual than others.

- Analogous to request 27, the different punctuality of RUs also poses a problem for CT. For this purpose, the causes should be identified and problem solutions found. Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

68. Better wagon availability.

- The availability of suitable equipment not only affects the loading units, but to a large extent also the wagons. While exchange platforms already exist successfully for loading units, the problem with wagons has not yet been solved. In addition to the innovative freight wagon, further solutions for the existing freight wagons were to be devised. In this pilot a harmonized wagon park builds the foundation for optimisation.

34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal).

- As we are talking about optimizing processes through lean thinking all wastes in the process should be eliminated. From our perspective main waste in the process view is warehousing, so this »stage« should be minimized or even eliminated to deliver just in time.

### **3.4.3 Current challenges and how are these addressed in the pilot case?**

Given that 20-25 trains per day are being operated on this route, the Brenner corridor plays a major role in the overall transport network at TX Logistik and can be regarded as a bottleneck. Any disruptions, blockage or delays affect the overall performance of the trains operated. Within the past setup only minor dependencies between these different trains were taken into account.

### 3.4.5 What exactly was examined / tested and how?

Within this pilot case an overall analysis of the entire transport network, which is operated on the Brenner route, has been made and optimization with the help of production know-how can be demonstrated. This was done by a prior analysis and simulation as well as a demonstration /daily operation in field.

Focus lays on the following aspects such standardization of used equipment/resources, especially wagons, locomotive & track. Moreover, a FiFo principle has been introduced in the terminal of Verona.

- **Resource “wagon”:**

#### As-IS Situation (2018):

Due to different wagon sets and individual wagon types it was hardly feasible to interlink different traffic models. Moreover, different relations have different requirements regarding customer needs. Therefore, some wagon sets have a mix of container wagons and double-pocket wagons, and others only consist of double-pocket wagons and T3000 (wagons for loading mega trailers). Wagons with multiple transport functions exist, but they are more expensive.

#### To-BE Situation (Start 01/19):

Due to the flexibility of certain relations and their customer needs, not all relations can be considered in such a Hub and Spoke concept. However, after a first analysis it became clear that all relations from and to Verona could be aligned regarding their wagon set as customer needs for wagon set composition are similar. Moreover, a Fifo-System could help the Verona traffic to be more robust in terms of punctuality and reliability. The aim is to harmonize all wagon sets in order to offer a flexible system to all customers on this route.

- **Resource “locomotive”:**

#### As-IS Situation (2018):

Same as with wagons, there is a variety of locomotive (loco) types and models in the market available. Moreover, specific country requirements including software packages do make locomotives expensive and unique. Due to different

destinations in different countries, it is not easy to harmonize all locos in a hub and spoke system. Again, all relations from and to Verona via the Brenner are of interest, as they all face Germany, Austria and Italy.

#### To-BE Situation (Start 01/19):

After a first analysis it became clear, that not all locos on this traffic need all three expensive country software packages (Germany, Austria, Italy). Especially the second loco required for the ascent of the mountains (banking) does not need the entire software package. Therefore, the locos will be changed in Kufstein (German/Austrian border). This should increase efficiency due to lower costs etc.

- **Resource “track”:**

#### As-IS Situation (2018):

Every single train has its determined train path (schedule) from its start in e.g. Germany to its destination in e.g. Italy. A train path is valid for 24 hours. If the train is late, a new train path needs to be ordered. This leads to increased costs as well as manual operation effort on TX side.

#### To-BE Situation (Start 01/2019):

As with all relations to and from Verona, TX basically have a train northbound and southbound on the Brenner axis (Kufstein – Brenner – Verona) roughly every two hours. The idea behind this shuttle concept regarding the tracks is the following: If one train is e.g. four hours late, another train which arrives earlier than expected e.g. at Kufstein can use the train path of the delayed train. This available train path can be used by the delayed train. In this way, the system can be optimized and allows to minimize waste in terms of waiting times (muda, Lean concept). Again, this leads to a more robust and flexible setup.

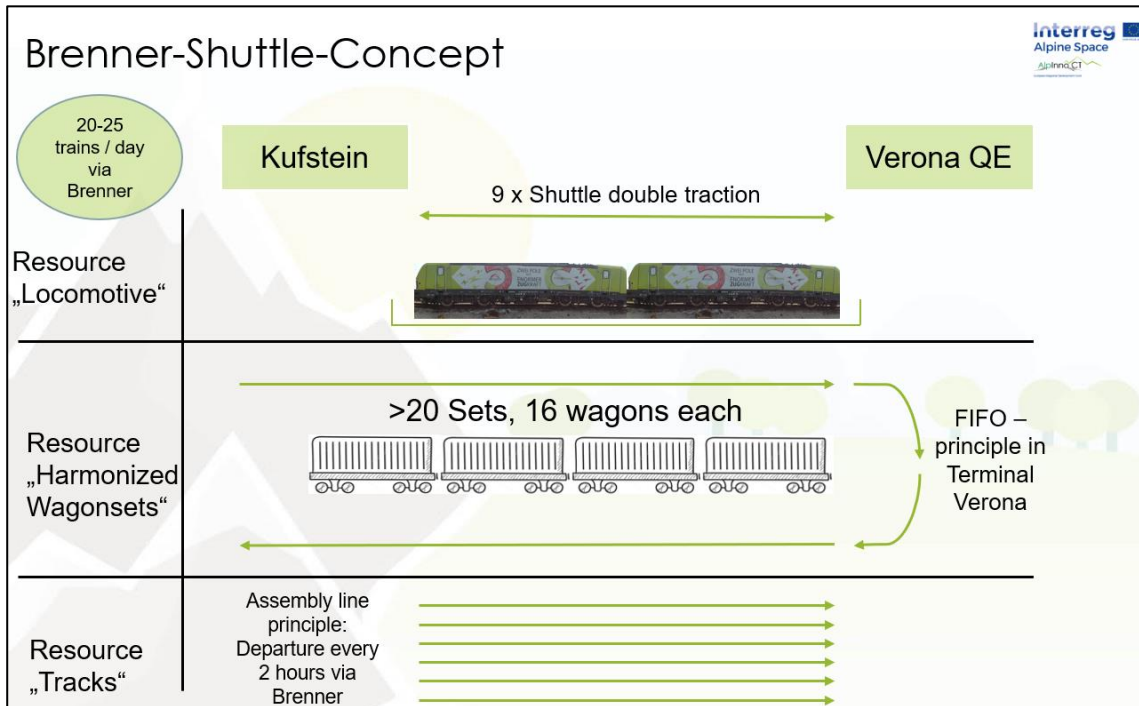


Figure 21 TXL Brenner-Shuttle-Concept

### 3.4.6 Industry production know how – process / methods

Which KPIs can be used to measure the results?

Production know-how includes the entire knowledge of the production process. It consists of many sub-processes, which can achieve the overriding goal of an efficient and optimized production only if they work together in a coordinated manner.

From this it becomes clear that one success factor is the detailed knowledge of the processes. With that, the pilot achieved success through the implementation of production know-how such as Fifo, use of standardization, etc.

The following KPIs can be deducted (comparison between Q1 / Q2 of 2018 and Q1/ Q2 of 2019):

- Wagon availability
  - The wagon availability remains 99% (compared to 2018). However, now there is with the same amount of wagons an entire wagon park for quality buffer available. This leads to an increased flexibility and resilience of the whole system
- Increased loco kilometres
  - Since the implementation of the Brenner-Shuttle-Concept the average loco kilometres have been increased by 4,2% which relates to a higher utilisation rate by using this concept
- Increased tons of loading
  - Due to the harmonized wagon park TX is able to transport one additional Loading Unit per train. The weight has been increased by 2% in average
- Decreased cancelation of trains
  - The cancelation has been decreased by 3 percentage points
- Increased punctuality of trains in Verona
  - The overall punctuality (<60 minutes) of trains has been increased by 4 percentage points

### **3.4.7 Milestones:**

- Q4 – Pre- Analysis and operational concept
- CW 1 – Operational start of the system
- Q1 2019: Field tests in daily operation
- Q2 / Q3 2019: Evaluation and final analysis, results and KPI's



## **3.5 Case 5: Restrictions for small and medium enterprises in Combined Transport**

### **3.5.1 Description of the Pilot Case**

Due to the current system differences between single road traffic and combined transport, it is very difficult for small and medium-sized (SME) transport companies to participate in CT. The following study describes existing restrictions and develops out solutions by using the project results of AlpInnoCT. The basis for this is the working processes of the transport company Eberl. The results contribute to an easier access to CT and thus provide important input for the project results.

### **3.5.2 How does the pilot relate to the wish list and classification?**

This case fits very well to the following wishes:

#### 27. Improvement of the planning and punctuality of the CT

- Increasing punctuality and predictability in combined transport remains a major challenge. Improved punctuality makes it easier to plan downstream processes and thus increase the level of responsiveness of the stakeholders and customers involved. Unfortunately, it is currently the case that punctuality as well as predictability due to a lack of information on delays leave much to be desired.

#### 53. Short stay of the loading units in terminals (storage timer)

- In peak times crane utilization is a bottleneck factor on which unpaid moves have an important impact. Their number has increased as some companies use the terminals as buffers. Associated with this are longer duration times of the LUs in the terminals and thus also more unpaid LU movements.

#### 34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal)

- As we are talking about optimizing processes through lean thinking all wastes in the process should be eliminated. From our perspective main waste in the process view is warehousing, so this »stage« should be minimized or even eliminated to deliver just in time.

### 3.5.3 Current challenges and how are these addressed in the pilot case?

Work processes in SME transport companies are usually designed for their own optimal operation and thus represent isolated solutions. These processes are optimized for internal efficiency. The CT in contrast to the road transport has increased organizational and personal efforts. Because of this, the focus of SME transport haulage companies is often on the road freight transport.

The increasing complexity of CT is often based on the increasing number of participants in CT (one carrier in road transport vs. three carriers in CT). This number of participants is necessary to guarantee a successful process flow. In particular, the interfaces between the individual transport chain links in CT have to be optimally coordinated with each other (for example, punctual arrival times of trucks at a transshipment centre usually lead to long waiting times). In general, the SME transport company does not have its own organization or special vehicles at the destination of the CT.

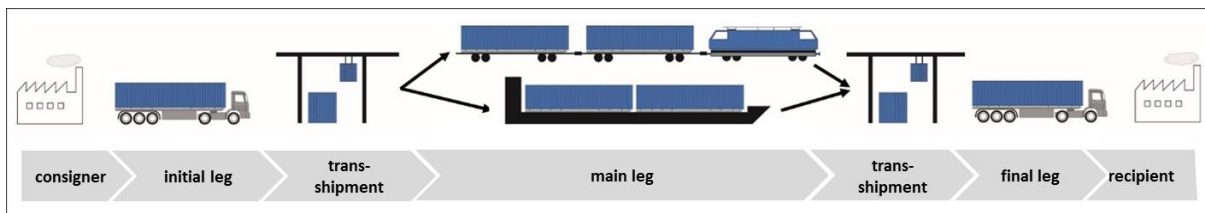


Figure 22 Combined Transport Chain

This additional coordination effort in CT leads to an increased internal and external communication effort. Language and cultural barriers can also lead to obstacles in the whole process chain. Furthermore, SME transport companies are no longer able to coordinate the whole transport chain. The transport companies outsource their main business to external service providers in CT and are thus depended on their price, performance and punctuality. The customer of the transport company expects the same performance as continuous road transport and this has to be guaranteed by the transport company, even though it has no longer direct access.

An additional interference is also the necessary amount of cargo required for the realization of a block train in order to facilitate an economic transport. Since it is seldom possible for most SME transport companies to fill a complete train with its own loading units, these are highly depended on third party operators.

### **3.5.4 What exactly was examined / tested and how?**

The previous mentioned workshop, technical interviews and a survey at the “Transport Logistic Fair 2019” in Munich showed, that there are many restrictions for transporters to take part in the CT:

#### **1. Punctuality and reliability**

- Goods cannot be loaded, time sequence of the forward carriage and subsequent transshipment not compatible with loading times of freight stations.
- The freight forwarder can only concentrate on maximum safety and reliability, but cannot influence the transport speed of the railway company.
- Railway company can't guarantee the transport of time-critical goods

#### **2. Promise of performance cannot be guaranteed**

- Weak points in the transport system result in additional technical, personnel and organisational costs.
- Decreasing driving performance increases the fix costs of a truck.
- Costs and services are not balanced for transport companies (benchmark is the single road transport).
- In addition to own fix and variable costs the SME transport has to pay to for the costs for railway transport in advance.
- Customers required time windows must be adhered to.

#### **3. Quality requirements**

- Shipper can hardly influence the process of the whole transport chain.
- Just-in-time deliveries are almost impossible.
- Deliveries of high-quality, transport-sensitive and time-critical products in combination with railway company are only possible to a limited extent.
- Delivery quantity and delivery times can no longer be planned individually for each customer.

- Accompanied shipment of goods almost impossible (accompanied CT has declined by 29% since 2004 → Reason: saving in personnel costs)
- Special cargo securing material is needed.
- Third-party workflows cannot be influenced and managed.

#### **4. Infrastructure and politics**

- Distance between transshipment stations is too long → only few transshipment centres are available.
- Usually CT is only profitable from approximately 700 km on.
- Special cargo securing material is needed.
- Restrictions because of cabotage.
- Radius of 150 km for pre- and post-haul which allows loading additional 4 tons is often too small.

#### **5. The core competence in consulting**

- Failing advice (no consulting is available).
- No direct contact to the mentioned consulting's.
- Questions regarding the handling, workflows, and so on, cannot be answered.

On the other hand, there are barriers for railway companies:

##### **1. Critical mass**

- Trips per week, each with 36 trailers necessary to cover all costs.

##### **2. Complex transport system**

- Handling options only possible to a limited extent.

##### **3. Special equipment & know-how**

- Transshipment of loading units, suitable transshipment centres and special equipment is necessary.
- Practical know-how

##### **4. Balanced transport streams**

- Buffering and scheduled transports.

**5. International administration**

- Access to all CT companies has to be made possible.

**6. Minimum flow of 72 h**

- Because of required capacity, trips have to be planned in advance.

**How can these restrictions be solved?**

One high potential solution is the creation of a cooperative which centrally organises CT. This cooperative unites members from transport companies, politicians, railway companies and all other participants which will take part in CT. This cooperative can facilitate participation in CT by a central organisation of all involved actors and work flows. It also can provide help, support and advice.

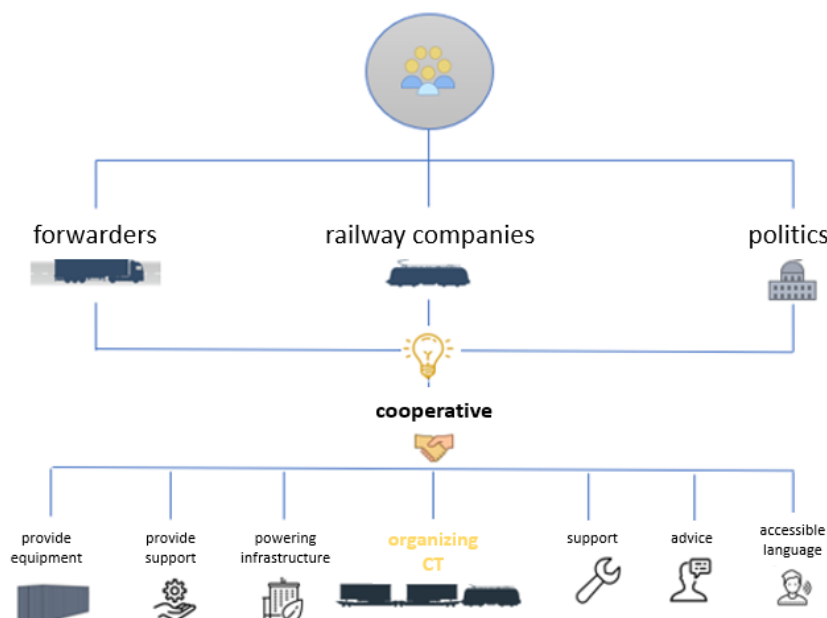


Figure 23 Source – How the cooperative could look like

### 3.5.5 Industry production know how – process / methods

- Standards (in transport units and processes).
- Definition of quality & service requirements (along the whole transport chain).
- Definition of a customer.
- Transparency and information.

### 3.5.6 Which KPIs can be used to measure the results?

- Operation performance:
  - Lead time = time from start of the CT until the end (→ benchmark = road transport time)
- Service quality performance:
  - Timeliness = reliability of transport times for customers
- Financial performance:
  - Costs and pricing = no (significant) additional costs for CT compared to road transport
- Environmental performance:

Emissions → saving of e.g. CO<sub>2</sub>-emissions of CT compared to road transport

### 3.5.7 Milestones

- Analysis of the current situation → April 2019.
- Practical Feedback & Workshop → May 2019.
- Finalization of the case-study with results and recommendations → June 2019.

## 4 Tested measures with reference to results of WPT2 and WPT3 (Guideline)

The aim of this guideline is to describe the necessary measures, already tested in daily CT business, based on the findings of work package 3 (optimal CT model concept) and out of the findings of work package 2 (situation analysis of CT in Europe).

Prior to this report, the Deliverable/Output O.T2.1 "Description of the state-of-the-art of the European transport system with a focus on CT" was produced. This deliverable included a profound analysis which described the current state of Combined Transport in Europe. The processes in daily business of transport companies were recorded and analysed.

The last chapter of O.T2.1 is about "the derivation of optimization potentials". Based on this, certain potentials were further elaborated during the lifetime of the five pilot cases.

On the basis of the optimization potentials, a wish list of all players in Combined Transport was created and presented in O.T3.1 "Recommendations for an ideal CT model concept" including the presentation on the needs of the players along the transport chain.

The aforementioned wish list in combination with the acquired production know-how was further developed in real life, namely in five use cases. Those cases formed the concrete basis for this Deliverable O.T4.1 "Guideline for integration of innovative intermodal solutions & approaches into daily CT business". The following table shows the references and the connection between the different work packages which result in a guideline for the operational use:

<b>Case description</b>	<b>Reference to T2</b>	<b>Reference to T3</b>	<b>Measure tested in T4</b>	<b>Results / Guideline for operational use</b>
Case 1 “Slot management: Terminal focus”	“Media transition or low digitalization” and “Double check-in” including the following consequences for processes in CT: bottlenecks in the terminal related to wagon capacity and truck delivery (first/last mile) by road.	<ul style="list-style-type: none"> <li>• Focus on simple production principles (FiFo)</li> <li>• Use continuous improvements for a further optimization of the company</li> </ul>	This model redefines the production logic of loading / unloading activities of intermodal freight trains by applying first-in/first-out (FIFO) strategies for wagon sets.	FiFo concept proven to be beneficial, shows clear improvements. Shall be extended to other Parts of Terminal Quadrante Europa to intensify improvement effect.
Case 2: “Train-related electronic data interchange”	“Interface problems between the individual RUs and Terminals” including the following consequences for processes in CT: many individual systems, elaborate interface creation and some necessary legal basics increase the	<ul style="list-style-type: none"> <li>• Achieve a high level of transparency</li> <li>• Establish stable, holistically planned and standardized processes</li> </ul>	Successful production industries pay high attention to a consistent and harmonized data exchange. In this respect, the Port of Trieste tested improved data exchange on the pilot corridor	This innovation facilitates the management of CT services at the Port of Trieste, promoting the shift from road to rail with resulting benefits also in terms of reduction of pollution and traffic congestion. Shall be further extended to further harmonize data exchange and



<b>Case description</b>	<b>Reference to T2</b>	<b>Reference to T3</b>	<b>Measure tested in T4</b>	<b>Results / Guideline for operational use</b>
	documentation effort.		Trieste – Bettembourg. The focus of this pilot case was on creating and testing a dedicated web service to share train-related data.	the competitiveness of the train management system.
Case 3: “Feasibility tests of innovative technologies and digitalization in CT”	“No detailed localization of the train is possible”, including the following consequences for processes in CT: the transparency towards the customer as well as towards partners in the logistics chain is not given.	<ul style="list-style-type: none"> <li>• Establish stable, holistically planned and standardized processes</li> <li>• Create a customer-oriented system to create added value</li> </ul>	Selected feasibility tests were performed on innovative, self-sustaining GPS trackers by applying an energy harvesting concept, in order to ensure continuous and maintenance free operation.	Technical feasibility is given (sufficient energy supply).  As this is innovative technology (energy harvesting) further long-term tests are recommended.
Case 4: “Appliance of	“Locomotive or system change	<ul style="list-style-type: none"> <li>• Focus on simple production</li> </ul>	Within this pilot case an	FiFo concept proven to be

Case description	Reference to T2	Reference to T3	Measure tested in T4	Results / Guideline for operational use
production know-how on high frequent transport routes"	at the Brenner" and "No Backup planning in transport" including the following consequences for processes in CT: interruption of the logistic chain, increased scheduling processes, inefficient utilization of resources.	principles (FIFO) <ul style="list-style-type: none"> <li>• Establish stable, holistically planned and standardized processes</li> <li>• Use continuous improvements for a further optimization of the company</li> </ul>	improved transport concept has been applied to a frequently used transport route (via Brenner), introducing a FIFO strategy related to wagon, locomotive and track.	beneficial, shows clear improvements. Shall be applied to additional comparable setups. Benefits in terms of punctuality, flexibility and robustness. Certain standardisation aspects are to be taken into account (e.g. harmonization of wagon park, loco compatibility)
Case 5: "Restrictions for small and medium enterprises in CT"	"Lack of or difficulty in accessing CT for SMEs" including the following consequences for processes in CT: due to difficult access, this environmentally friendly method of transport is difficult to realize	<ul style="list-style-type: none"> <li>• Establish stable, holistically planned and standardized processes</li> <li>• Create a customer-oriented system to create added value</li> </ul>	This concept study analysed current barriers for small and medium enterprises (SME) to use CT and outlined solutions how to overcome these	Overall positive feedback from different stakeholders. Cooperation has been regarded as beneficial. Further guidance to promote SME's participation in CT is still needed.

<b>Case description</b>	<b>Reference to T2</b>	<b>Reference to T3</b>	<b>Measure tested in T4</b>	<b>Results / Guideline for operational use</b>
	for freight forwarders and the potential for transferring road freight traffic to railway is limited.			

*Table 5: Tested measures in reference to results of T2 and T3 (Guideline)*

## 5 Conclusions

This report shows that innovation in Alpine freight transport is possible, necessary and will continue to be of significant importance in the future. This guideline referred to the pilot actions in WP T4 to the previously finalised WP T2 and WP T3 and derived necessary measures to further improve daily operation in CT.

In the course of this development, it was shown that production know-how and processes can be applied to Combined Transport and thus potentials for increasing efficiency can be discovered and implemented in the Combined Transport chain.

In general, to optimize any production process, there are some basic rules to be considered first (derived from O.T3.1 including DT 3.1.1):

- Focus on simple production principles
- Create a customer-oriented system to create added value
- Achieve a high level of transparency
- Establish stable, holistically planned and standardized processes
- Use continuous improvements for a further optimization of the company

In addition to that, it is crucial to accept, that each transport chain is unique, as is the composition of its stakeholders. With that in mind, it is essential to mention that options proposed in the report O.T3.1, based on the analysis done by the stakeholders in AlpInnoCT, may not have the same success potential in another transport chain. Still, the approach is generic and therefore generally applicable.

The aforementioned wish list in combination with the acquired production know-how was further developed in real life, namely in five use cases. Those cases formed the concrete basis for this Deliverable O.T4.1 "Guideline for integration of innovative intermodal solutions & approaches into daily CT business". In detail:

- Case 1: Slot management: Terminal focus  
This case demonstrates an innovative way to better manage and optimize processes of the intermodal terminal "InterTerminal" in Verona, IT. This model redefines the production logic of loading / unloading activities of intermodal freight trains by applying first-in/first-out (FIFO) strategies for wagon sets.
- Case 2: Train-related electronic data interchange  
Successful production industries pay high attention to a consistent and harmonized data exchange. In this respect, the Port of Trieste tested improved data exchange on the pilot corridor Trieste – Bettembourg. The focus of this pilot case was on creating and testing a dedicated web service to share train-related data.

- Case 3: Feasibility tests of innovative technologies and digitalization in CT  
This pilot case addressed the lack of digitalization and the lack of innovative technology in Combined Transport. Therefore, selected feasibility tests were performed on innovative, self-sustaining GPS trackers by applying an energy harvesting concept, in order to ensure continuous and maintenance free operation.
- Case 4: Appliance of production know-how on high frequent transport routes  
Within this pilot case an improved transport concept has been applied to a frequently used transport route (via Brenner). By introducing a FIFO strategy for wagon sets and locomotives, availability and reliability of these crucial resources have been improved significantly.
- Case 5: Restrictions for small and medium enterprises in CT  
This concept study analysed current barriers for small and medium enterprises (SME) to use CT and outlined solutions how to overcome these, by considering the project results of AlpInnoCT.

These cases describe technological knowledge enhancement and strengthen the ability to participate in Combined Transport. As described above, each transport chain is unique and thereof implementing those necessary measures presented in the cases to other transport chains is not easy. However, the results of this deliverable show best practice solutions and a potential for a certain integration in different transport chains with a different stakeholder setup.

Furthermore, these possibilities were presented, discussed and improved with the help of a trade fair appearance, dialogue events and various workshops. With the help of these events, the cases could be presented to a broad professional audience.

The development of these cases further demonstrated that innovation and further investment in all parts of the process chain will be needed to maintain the competitiveness of Combined Transport across Europe. In addition, only through further pronounced and intensive cooperation of all stakeholders, a continuous improvement of the whole process can be guaranteed.

These results will form the basis for the AlpInnoCT Toolbox of Action (WP T5). In order to create transparency and receive feedback on further best practice solutions currently implemented in CT, these results will be vividly presented to the general public.

## 6 Annex



---

**Report within**  
**Alpine Innovation for combined transport (AlpInnoCT) T4**  
**Analysis of initiatives not covered in AlpInnoCT**

**July 2019**

**Prepared by:**

University of Maribor

**Principal Authors:**

Mitja Klemenčič

Vlasta Rodošek

Tomislav Letnik

Stanislav Božičnik

**Contribution:**

Katja Hanžič

## **Content**

<b>Introduction</b>	<b>87</b>
<b>AlpInnoCT Wish List and list of initiatives/projects</b>	<b>88</b>
<b>Wishes covered by projects (case studies)</b>	<b>89</b>
<b>a. H2020</b>	
<b>b. Shift2rail</b>	
<b>c. Interreg, CEF and other</b>	
<b>Wishes covered by technological innovations</b>	<b>96</b>
<b>Wishes covered by directives and standards</b>	<b>99</b>
<b>Wishes covered by theoretical concepts</b>	<b>101</b>
<b>NGOs and networks in macro-region Alps and their role in promotion of rail transport</b>	<b>107</b>
<b>Comprehensive overview of initiatives according to priority wishes</b>	<b>113</b>
<b>Political wishes</b>	<b>117</b>
<b>References</b>	<b>119</b>

## 1. Introduction

Within AlpInnoCT project 10 priority wishes were tested through case studies identified in WP T4. As some wishes are not feasible to be tested within AlpInnoCT time Framework (e.g. built alternative rail/CT routes on corridors), this report serves for review and analysis of relevant initiatives that are relevant for priority technology and political wishes. The analyses is based on identified initiatives (Database in annex), where main initiatives represents relevant research and development projects identified in H2020, Shift2Rail, CEF networks, technological innovations (developed by research institutes), legal framework with push and pull measures, directives and standards, theoretical concepts with review of methods/algorithms to raise efficiency and modal split of CT and NGO's in Alpine space, that are acting in favour of CT.

This report is based on this Wish List as provided in WPT 3 and initiatives identified by University of Maribor.

### Methodology

Methodology for identification of initiatives was elaborated through an iterative process in three steps 1. Identification of Initiatives and elaborating a database; 2. Assignment of initiatives to wishes and 3. Analysis of initiatives covering priority wishes.

Initiatives where collected through different databases, processes and previous Deliverables within AlpInnoCT project.

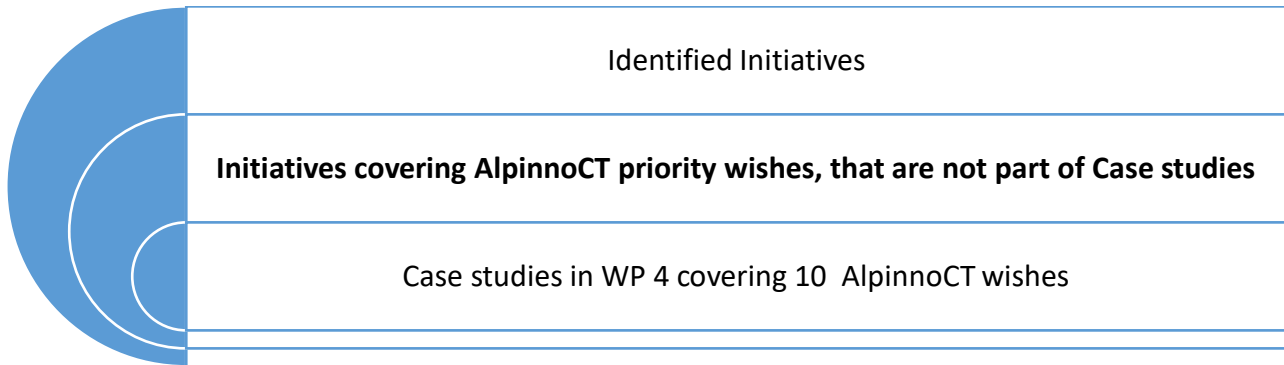
Initiatives covering research and development projects were selected, based on keywords "combined transport" in H2020 framework ([https://cordis.europa.eu/search/en?q=contenttype%3D%27project%27%20AND%20\(%27combined%20transport%27\)%20AND%20\(programme%2Fcode%3D%27H2020%27\)&p=1&num=10&srt=Relevance:decreasing](https://cordis.europa.eu/search/en?q=contenttype%3D%27project%27%20AND%20(%27combined%20transport%27)%20AND%20(programme%2Fcode%3D%27H2020%27)&p=1&num=10&srt=Relevance:decreasing)), all relevant SHIFT2RAIL projects ([https://projects.shift2rail.org/s2r\\_projects.aspx](https://projects.shift2rail.org/s2r_projects.aspx)), MULTIMODAL CEF projects (<https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-transport-mode/multimodal>) and projects identified in WP1.

Initiatives covering Technological innovations and legal frameworks were selected from the database developed in WP1 and the Ursa Mayor Workshop in Verona.

Initiatives covering theoretical concepts where identified from science databases Sciencedirect, Scopus, Wiley online library, Sage journals and Taylor and Francis. The filtered results were based on searching the databases for articles with combination of words "combined transport" OR "intermodal transport" OR "railway" AND "lean" OR "efficient" OR "production" OR "modal split" in Abstract, title or key words.

Initiatives covering NGO's and combined transport were selected from google database with combination of words "combined transport" OR "intermodal transport" AND "NGO"





## 2. AlpInnoCT Wish List and list of initiatives/projects

The wishes identified in AlpInnoCT were structured using following categories:

Following the categories used for structuring wishes of AlpInnoCT, the initiatives/project were categorized using following categories:

- **Initiative/project:** name if the initiative/project
- **Funding programme:** if initiative/project has received EU funding, the programme is stated
- **Level:** the level of entire transport chain corresponds to *macro level*, the level of single process step within entire transport chain corresponds to *micro level*
- **Category:** for each initiative/project a main category was assigned according aspect of each wish. We have used following categories
  - o **Technical categories** – *Organization, Infrastructure, Technology, Communication*
  - o **Political category** – *Political*
- **AlpInnoCT wish relevance:** relevance for specific AlpInnoCT wish (sequence number of relevant wish is stated)
- **Benefits/objectives:** expected benefits (objectives to be reached)
- **Link:** web-link to initiative/project if existing

The initiatives/projects were structured to according to above categories as shown in the table below.

Table1: Structure of the existing initiatives/project in relation to AlpInnoCT wishes

Initiative/project	Funding programme	Level	Category	AlpInnoCT wish relevance	Benefits/objectives	Link 1

The structure of Table 2 was used for gathering and matching of existing initiatives/projects with AlpInnoCT wishes. The full data base is available separately.

## Wishes covered by projects (case studies)

### a. H2020

Top priority wish on **Improvement of planning and punctuality of the CT planning (Wish 27)** focuses on the increase of predictability and easier downstream process, with increased level of responsiveness of all involved stakeholders. The H2020 projects suggest following solutions:

- CLUSTERS 2.0.: an Open network of **hyper connected logistic clusters** towards Physical Internet – through prototypes of new modular Load Units, terminal management systems and develop Business Models and Robust Business plans for Clusters 2.0
- SAFE-CTS - Efficient and cost-effective intermodal road-rail container freight system is based on **container transfer system** (CTS) and a disruptive re-organization of freight logistic networks in regional HUB/BASE structure.

In order to realize **Wish 53 on Shorter stay of the loading units in terminal** following project was developed:

- INTERMODEL EU - Simulation using **Building Information Modeling-BIM** Methodology of Multimodal, Multipurpose and Multiproduct Freight Railway Terminals Infrastructures, where an advanced ICT environment based on BIM methodology adapted to intermodal freight rail terminals in order to support decision-making regarding both design and planning as well as operating phases through the whole life-cycle **of the terminal** was developed. The ICT environment includes a BIM design able to interact with several simulation tools of the terminal performance and its outside impacts. This integral approach will consider static and dynamic indicators such as CAPEX (Capital expenditures), OPEX (Operational expenditures), maintenance scheduling, costs, energy efficiency, productivity, capacity, reliability and environmental impacts.

**Wish 31 – Introduction of electronic freight documents** is tackled within H2020 projects through project:

- SELIS - Towards a Shared European Logistics Intelligent Information Space, where connected nodes provide a distributed common **communication and navigation platform with unifying operational and strategic business innovation agenda** for pan European green logistic. The concept is based on **sharing local innovative solutions through a platform.**

In order to find solutions for **Wish 68 – Better wagon availability** following project was created:

- HERMES - Development of **smart and flexible freight wagons and facilities** for improved transport of granular multimaterials is based on combined industrial expertise on **wagon design** and construction, where **advanced materials** for lightweight construction and logistics are used.

**Wish 35. Introduction of a task force in the event of network problems (such as Rastatt).**

RAGTIME – Risk based approaches for Asset integrity multimodal Transport Infrastructure Management where innovative management approach with planning software was developed. The software enables holistic management throughout the entire lifecycle of the infrastructure, providing an integrated view on risk based approach, implementing risk based models, resilient concepts and mitigation actions. SW includes lean approaches through monitoring with smart systems and in line with ROI, management, guarantee LOS and improve resilience through maintaining the service.

## b. Shift2rail

Top priority wish **on Improvement of planning and punctuality of the CT planning (Wish 27)** focuses on the increase of predictability and easier downstream process, with raised the level of responsiveness of all involved stakeholders. The Shift2Rail projects suggest following solutions:

- ARCC - Automated Rail Cargo Consortium: Rail freight automation research activities to boost levels of quality, efficiency and cost effectiveness in all areas of rail freight operations through:  
**Automated trains, automated support processes at system's nodes** (terminals, yards and transshipment points), improved network management through **advanced timetable planning**. The improvements are tested **within better information flow between terminals – in real time** and eco-efficient and energy efficient driving.
- AEOLIX - Architecture for EurOpean Logistics Information eXchange developed a **cloud based collaborative logistic ecosystem for configuring and managing logistic related information pipelines**. Low complexity and low cost connectivity of local ICT platforms the Aeolix system is scalable, trusted and secure exchange of information for all actors in the supply chain.

### **Wish 72: Elimination of local and general bottlenecks on the corridors related to gauge and train length**

- GATE4RAIL - GNSS Automated Virtualized Test Environment for RAIL developed test architecture of simulating GNSS based ERTMS applications and defined their interfaces.

### **Wish 59: Faster (Average speed of trains)**

- FINE 1 - Future Improvement for Energy and Noise demonstrate tools for evaluation different of **technological solutions for rail track, vehicles and interior in order to reduce noise, vibration and energy**.
- FFL4E - Future Freight Loco for Europe with **digitalization, automation in train operation**, energy supplied freight wagons with hybrid technology and energy storage also of **1500 m trains**
- IN2STEMPO - Innovative Solutions in Future Stations, Energy Metering and Power Supply developed smart **system energy management** solutions.
- IN2TRACK - Research into enhanced tracks, switches and structures developed a **holistic whole system approach based on dynamic wheel-rail interaction** to degradation of S&C, subsystems, components, track foundation.
- NEAR2050 - Future challenges for the rail sector
- PLASA - Smart Planning and Safety for a safer and more robust European railway sector and PLASA-2 - Smart Planning and **Virtual Certification** developed smart planning approach for railway operators including complex cross border simulations for European corridors and larger networks. Through **enhances authorization process** a reduction of needed vehicles contributes to lower LCC.
- S-CODE - **Switch and Crossing** Optimal Design and Evaluation
- VITE - Virtualization of the testing environment for reduction of on-site tests for signalling systems.

### **Wish 28. Continuous tracking of the loading unit (on train, ship and truck).**

- FR8HUB - Real time information applications and energy efficient solutions for rail freight develops **real time network management system** for improved operational planning in rail freight transport, simulate the increase of average speed of train through better train dynamics, and improved network and yard planning. Additionally

**intelligent video gate** is tested for reducing dwell time in terminals and locomotive of the future have powerful last mile propulsion system to reduce the need for shunting locomotives and **intelligent auxiliary management**. Hybridization of legacy shunters is standardized and modular (working also without catenary). Wagon bogies are managed with **condition based maintenance** thus reducing the number of failures and breakdowns.

#### Wish 64: Reduce the space between two slots/trains

- ASTRAIL - Satellite-based signalling and automation systems on Railways along with formal method and **moving block validation** included ERTMS with moving block, ATO and GNSS positioning.
- CONNECTA (Phase 1. and 2.)- CONTRIBUTING to Shift2Rail's NEXt generation of high Capable and safe TCMS and brAkes develops **wireless information transmission** for ECN (Emergency communication networks),ECB, train to ground communication, and train to train communication
- DYNAREIGHT - Innovative technical solutions for **improved train DYNAMics** and operation of longer FREIGHT Trains through freight running gear with reduced wheel and track wear **and path for regular operation of long trains**
- DESTINATE - Decision supporting tools for implementation of cost-efficient **railway noise abatement measures in the vehicle design** process.
- EMULRADIO4RAIL - Emulation of radio access technologies for railway communications provides an **innovative platform for tests and validation of various radio access technologies** (Wi-Fi, GSM-R, LTE, LTE-A, 5G and Satellites)
- ETALON - Energy harvesting methodologies for trackside and on-board signalling and communication elaborated **train integrity functionalities including with Smart radio connected wayside objects**.
- GOSAFE\_RAIL - Global Safety Management Framework for RAIL Operations includes demonstration projects for **Intelligent Asset management**, integration of Open linked Data, Real time methods for object detection, analytical models incorporating Artificial Intelligence relevant for EU Infrastructure managers.
- Marathon2Operation - M2O - MAke RAIL The HOpe for protecting Nature 2 future OPERATION provides **orders over GSM-R from the driver of the master locomotive to the unmanned traction units for maximum 1500 m trains**
- MISTRAL - Communication Systems for Next-generation Railways provides **technical specifications for Technical, Business and Validation process of GSM-R into national railways**
- MOVINGRAIL - MOving block and VIRTUAL coupling New Generations of RAIL signalling –**procedures and testing methods for moving block signalling and virtual coupling**
- PIVOT - Performance improvement for vehicles on track explored **materials, joining techniques and manufacturing of car bodies, running gear, brakes entry systems and interior including cab**,
- X2RAIL-1 - Start-up activities for Advanced Signalling and Automation Systems, X2RAIL-2 - Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing **Traffic Management System** functions and X2RAIL-3 - Advanced Signalling, Automation and Communication System (IP2 and IP5) – Prototyping the future by means of capacity increase, autonomy and flexible communication developed flexible real time intelligent traffic control management and decision support systems **for Virtual coupling**, enable trains to operate closer to one another

#### Wish 31: Introduction of electronic freight documents

- B4CM - **Block chains** as a Distributed Ledger for Attribution of RCM Data in Rail (industry)
- CYRAIL - **Cybersecurity** in the RAILway sector

**Wish 67: More punctuality for railway undertakings (RU). Some RUs are more punctual than others.**

- FR8RAIL - Development of Functional Requirements for Sustainable and Attractive European Rail Freight
- FR8RAIL II - Digitalization and Automation of Freight Rail developed new automatic couplers, telematics and electrification for CBM – **Condition based monitoring and cargo monitoring systems with wagon on-board Unit**, Real time network management to reduce or even **eliminate manual communicating by integrating medium to short term operational planning at terminal and in rail network**. Future freight wagon design with telematics, electrification, optimized aerodynamics and acoustic. Functionalities for **automated locomotives** (and ATO – Automated train operation) and **1500 m trains (braking forces)** were developed through Connected Driver Advisory systems (C-DAS) to the Traffic Management system in train control centres of IM

**Wish 68: Better wagon availability**

- RUN2RAIL - Innovative RUNning gear soluTiOns for new dependable, sustainable, intelligent and comfortable RAIL vehicles demonstrates **innovative sensors**, enabling condition monitoring, optimized materials and manufacturing technologies, active suspension and mechatronics, methodology for predicting noise and vibration

**Wish 35. Introduction of a task force in the event of network problems (such as Rastatt).**

- ASSETS4RAIL - Measuring, monitoring and data handling for railway assets; bridges, tunnels, tracks and safety systems, where **holistic view of railway system condition** is proposed through a data representation layer with data coming from all source segments (onboard, wayside and remote)
- MOMIT - Multi-scale observation and monitoring of railway infrastructure threats **developed remote sensing technologies and monitoring tools**

**Wish 51: More efficiency regarding shunting**

- OptiYard - Optimized Real-time Yard and Network Management provides an optimal decision support system for Yard managers including **automated yard management** and organization, **real time interaction and automated ad-hoc timetabling**.
- SMART - Smart Automation of Rail Transport developed **autonomous obstacle detection system** with vision technologies (thermal camera and image intensifier) and real time marshalling yard management system will base on TAF TSI.

### c. Interreg, CEF and other

Top priority wish **on Improvement of planning and punctuality of the CT planning (Wish 27)** focuses on the increase of predictability and easier downstream process, with increased level of responsiveness of all involved stakeholders. The Interreg, CEF and other projects suggest following solutions:

- 2014-UK-TA-0298-W EURO-HUB - Investing in a handling facility and rail equipment for just-in-time deliveries with London/UK: aimed to develop sustainable freight services along the North Sea-Mediterranean corridor by investing in an open access finished vehicle handling facility, and interoperable rail equipment able to accommodate high frequent corridor train services.
- 2015-IT-TM-0247-M Enhancing Interporto di Padova - Step 2: ancillary measures and ICT solutions for optimizing terminal operations, accessibility and interconnections: aims to support the ICT development and ancillary works in the terminal and it is part of the Global Project for the improvement of the multimodal performance of Interporto (concern the ICT infrastructure, gate automation, rail tracks improvements and safe and security upgrading as well as a study on the optimization of freight flows).
- 2016-FR-TA-0312-S MiRO – Multimodal ROute connecting Barcelone to Paris: eliminating the bottleneck in the cross-border section between France and Spain by offering a sustainable multimodal solution that allows shifting semi-trailers from road to rail on the long-distance, while maintaining the flexibility of road transport for the last mile. Encompasses studies for the final designs of the two new multimodal terminals, the development of dedicated software for the optimization of rail motorway, the definition of a business plan, project management and communication was made. In the long run it will contribute to enhanced multimodality and allow a better environmental performance to the logistic plan.
- 2016-HR-TMC-0082-S Upgrade of the Rijeka Port infrastructure - Port Community System (POR2CORE-PCS): develop an ICT solution for a Port Community System (PCS) at the port based on the Port Community System (PCS) ICT solution already developed in the Port of Ploče, which will, once developed, also be used by other Croatian cargo ports. This action is a necessary first step in order to proceed with the works afterwards. In the long term contribution to an improvement of regional transport flows and better multimodal integration and interoperability is expected.
- ChemMultimodal: based on a detailed analysis of the needs for improving multimodal transport of chemical goods, the project will develop a toolbox to support chemical companies and logistics service providers in their strategic and operational planning for increasing the share of multimodal transport. (tested in 6 pilots with 30 chemical companies).
- NexTrust: develop business model to support horizontal collaboration including a trustee. One additional approach is a C-ITS cloud based smart visibility software to support the re-engineering of the networks, improving real-time utilization of transport assets. A specific focus is on CT. (coordinating more than different pilots which address problems across the length and breadth of the logistics industry).
- SWIFTLY Green; Sweden-Italy Freight Transport and Logistics Green Corridor: develop a toolbox with measures and recommendations to “green” the TEN-T Corridors, especially the Scan-Med Corridor. This was done by analyzing the Corridor, meaning that the traffic flows were evaluated, and the same was done for the infrastructure, the various tolls and the varying regulations in the various regions.
- SysLog+: contribute to the reduction of greenhouse gas emissions through the professional qualification of the logistics and freight forwarding industry. The use of sustainable, complex transport systems is to be promoted by trainees, teachers and decision-makers.

**Wish 73: Powerful alternative routes (redundancy) for main routes**

- 2015-AT-TM-0289-S Rhine-Danube CNC: connection to the existing freight terminal Wels and provision for the interconnection between the RRT & other modes: connect the existing Wels freight terminal to the East, allowing an effective rail interconnection towards Linz and the integration of the terminal into the Rhine-Danube Core Network corridor.
- 2016-FR-TA-0144-W Improvement of freight services between Bordeaux and Dax – first phase between Morcenx and Dax: several sections of this line are being upgraded in order to cope with an increase of freight and passenger traffic volumes.

**Wish 72: Elimination of local and general bottlenecks on the corridors related to gauge and train length**

- 2014-ES-TM-0481-W New Southern Rail and Road Access to the Port of Barcelona: the new rail access to Port of Barcelona will be 10.8 km long in both UIC and Iberian gauge and absorb around 70% of the railway traffic in the Port. The new road access will measure 10.4 km and absorb 60% of the road traffic in the Port, avoiding numerous existing level crossings.
- 2014-ES-TM-0500-S Algeciras-Madrid-Zaragoza-Barcelona railway section: Madrid-Vicalvaro freight railway terminal upgrade: contribute to adapt the terminal to accept 750 metre long trains, enhance rail interoperability, remove a bottleneck and facilitate modal split. The Action concerns the preparation of technical specifications and procurement.
- 2014-ES-TM-0547-M Intermodal logistics platform in southwestern Europe: design and works to build a 132 hectare multimodal logistics platform, including the road and rail accesses to the Atlantic Corridor-intermodal terminal will be ready to handle 750 metre long trains and will have an operating capacity of 470,000 TEUs/year.
- 2014-FR-TM-0260-W New multimodal terminal of the Port of Strasbourg/Lauterbourg: develop nine ports in the Upper Rhine for improving the accessibility and the capacity of a multimodal platform at Strasbourg/Lauterbourg port to absorb the expected traffic growth.
- 2014-FR-TM-0504-S Studies on the optimization of the 2nd phase of the Rhine-Rhone high speed line (eastern branch) and the handling of the Mulhouse node.
- 2015-BE-TM-0248-W Improving of the multimodal logistic platform of the port of Zeebrugge in order to accommodate long freight trains.
- 2015-CZ-TM-0406-W Intermodal Terminal Melnik, Phases 2 and 3: optimizing and developing the terminal by extending/constructing 3 railway tracks to adapt to 740 m long trains which will increase the modal shift from road to rail.
- 2015-ES-TM-0329-S: actions to receive the ability to handle 750 metre long standard gauge trains.

**Wish 53: Shorter stay of the loading units in terminals (storage time)**

- Control Tower Container trucks Transparency of waiting and service times: waiting times trucks on average per day per terminal. Service times trucks at terminal per day and time

- URSA MAYOR - ITS tools at the port of La Spezia for buffer area management: IPS – Intelligent Parking System Innovation Trucking companies / drivers should have the possibility to know the congestion state of the area and the forecast for the next hours to plan as better they can the port operations.
- URSA MAYOR NEO- Port of Ravenna - Automated gates; THE NEW ACCESS CONTROL SYSTEM AT THE MAIN GATES OF PORTO MARGHERA: deployment of dynamic information system for truck drivers.

**Wish 28: Continuous tracking of the loading unit (on train, ship and truck)**

- 2016-EU-TA-0185-S Sharing of train tracking & estimated time of arrival information
- WOLF – Web Oriented Logistic Platform: real-time information for customers via interface.
- ELETA - Electronic exchange of Estimated Time of Arrival information: encourage and facilitate the efforts to overcome legal, operational and technical obstacles in the electronic exchange of ETA information.

**Wish 31: Introduction of electronic freight documents**

- 2014-EU-TM-0686-S e-Freight implementation Action (e-Impact): implementation of an e-Freight system in Italy, Poland and Portugal, with the aim to simplify and reduce the cost of exchanging information between different actors and transport modes along the chain.

**Wish 51: More efficiency regarding shunting**

- ARCC - Automated Rail Cargo Consortium: rail freight automation research activities to boost levels of quality, efficiency and cost effectiveness in all areas of rail freight operations: Transporting and delivering freight transport via automated trains; Developing automated support processes that are carried out at the system's nodes (e.g. terminals, yards and transshipment points); Improving yard and railway network management through advanced timetable planning.

Also some projects are dealing with measures and actions, regarding AlpInnoCT's political wishes. The priority political wish on **Mainstreaming customs clearance and administrative controls (one stop shop – for all controls) for faster customs clearance (Wish 1)** under multiple processing of load units by the inch along the transport chain leads to unnecessary delays of transport. Within the Interreg, CEF and other projects, ILKÖ; Integriertes Logistiknetzwerk KV in Österreich project study is dealing with it.

**Wish 11: Introduction of a European infrastructure management**

- AGORA; Intermodal Terminals in Europe: improving management capabilities of intermodal terminal operators throughout Europe and increasing capacity by a set of innovative, smart operational measures and the involvement of users. It is also set to creating awareness of terminal capacity enlargement needs and contributing to a more effective intermodal transport in Europe by improving know-how and experience and sharing it with all intermodal stakeholders.
- AlpFRail; Alpine Freight Railway: demonstrated that solutions can be found in short term by developing a transnational network which is coordinated by a central project management. Main results: Operation solutions for the transalpine railway freight traffic for sustainable management of connections of the economic areas within the alpine space (ex.: it is necessary to have train concepts ready for the container growth at the Mediterranean ports before the containers are travelling on the road via the Alps).
- IN2DREAMS: related to the technology development and demonstrator implementation in order to realize: A non-intrusive Smart Metering sensor network at Railway System level. An open system and interface for data collection, aggregation and analysis in an open source Operational Data Management (ODM) Platform.



### **Wish 13: Harmonization & Enforcement of push & pull measures in the EU at all levels**

- IMonitraf!: analyzed Best Practice measures as well as impacts of common steering instruments. Partners have provided information on Best Practices and environmental and traffic indicators in their region. Results are visualized through the WEBgis system.
- TER4RAIL: reinforce the cooperation between rail-related stakeholders to improve the efficiency of the consensual exploratory research in the rail sector, in order to facilitate emerging innovative ideas and the cross-fertilization of knowledge from other disciplines or of disruptive technology and innovation.

### **Wish 14: Ensuring the preferential treatment of the CT**

- AlpCheck; Alpine Mobility Check
- AlpCheck2; Alpine Mobility Check - Step 2
- Future Trailer (simply fits on and off the road)

### **Wish 10: Stimulus package rail for lower prices**

- Innovationen im alpenquerenden Güterverkehr: Schlussbericht, Bundesamt fuer Verkehr (BAV): answers for measures of Innovations of the transport system which present completely new systemic solutions for the transport chain and covering several sectors such as rolling stock, infrastructure and operational services offered; Innovations related to the rolling stock which include improvements of the rolling stock and its components; Innovations related to the infrastructure leading to improvements of the fix infrastructure or its components; Innovations related to processes which optimize the proceedings at the existing railway system at existing technology. For each category, examples of detailed measures with a high degree of market and industry readiness are defined.
- Suivi de Zurich - Working Group, Heavy goods traffic management systems in the alpine area, Review on Combined Transport in Alpine countries: review of the different offers of Combined/multimodal/rail transport services aiming at enhancing the transparency for consigners and transporters about existing and planned services by rail, in particular using Combined Transport.

## **Wishes covered by technological innovations**

Within Combined Transport services a distinction can be made between technologies and systems dealing with Accompanied Combined Transport and Unaccompanied Combined Transport (non-craneable trailers and systems for the transshipment of craneable trailers, containers and swap bodies). The relevant *ACT Technologies* (Rola, Flexiwagon), UCT non-craneable trailers *Technologies* (Modalohr Horizontal, CargoBeamer, ISU Innovativer Sattelaufliieger Umschlag/Innovative Semi-Trailer Handling Unit, Megaswing, NiKRASA, Cargospeed, Reachstackers, RailRunner) and UCT systems for the transshipment of craneable trailers, containers and swap bodies *Technologies* (Metrocargo, Piggyback technology "C": Containers, NETHS - Neuweiler Tuchs Schmid Horizontal System, IUT- Innovatives Umschlag-Terminal, Sidelifter, ContainerMover 3000, Mobiler) were analyzed according to AlpInnoCT wishes, dealing with technology (transshipment, entire transportation, first/last leg, main haul). Technologies differ in terms of terminal infrastructure requirements (vertical/horizontal, space) and rolling stock characteristics (special wagons needed), operational aspects (e.g. additional workers needed) and supply chain networks (availability of transshipment requirements at loading and unloading terminal) which is related to AlpInnoCT **Wishes 36, 55, 71, 70, 37, 50, 51, 44, 15, 3, 18, 14, 13.**

Top priority wish **on Improvement of planning and punctuality of the CT planning (Wish 27)** focuses on the increase of punctuality and predictability in combined transport and easier downstream process, with increased level of responsiveness of all involved stakeholders. The technologies with possible solutions are also in correlation to AlpInnoCT wishes: 53-Shorter stay of the loading units in terminals, 64-Reduce the space between two slots/trains, 51-More efficiency regarding shunting).

**Modalohr Horizontal** - requires a lot of terminal space. The system depends on train schedules. Technology advantages: handling time is shorter than for UCT (but only if enough staff is available; 26 people for 13 wagons); handling of the loading units is possible without shunting while the train is under the electricity track; very low loading platform enables 4 metre-high trucks to be loaded within the limits of existing railway gauges; accepts most standard trucks without modification: (Maximum height: 4.04 m, Semi-trailer maximum length 13.7 m, Semi-trailer maximum load : 38 t).

**CargoBeamer** – new wagon system. Similar to a “classical” container terminal the train needs a long range of rail track. Allows loading and unloading independent from the presence of the train in the terminal. One train can carry up to 36 trailers and load/unload 72 of them simultaneously. Technology advantages: loading and unloading is independent from the presence of the train in the terminal; very quick loading and unloading; vertical handling of containers, swap bodies and craneable trailers possible; no complex technologies on-board; able to carry different intermodal types; combination of a new linear, horizontal technique with the classic vertical handling; demand of space less than container terminal.

**Megaswing** - allows transport of non-craneable trailers without additional handling technology. The loading process of a full train is completed within 30 minutes. No additional terminal infrastructure is needed. It is able to carry almost all types of trailers up to 4m height. Technology advantages: easy and quick handling of non-craneable trailers; suitable for all types of specified railway loading units (containers, codified trailers and swap bodies); handling under electrified tracks possible; horizontal and vertical handling; cost saving due to horizontal loading (no craning needed); very quick loading and unloading; does not need special infrastructure, a truck-drivable trackside along an existing railway track is sufficient; increases flexibilities; no network needed; possible in every existing terminal with trackside area for trucks/trailers; allows individual wagon unloading in coupled trains with multiple stop-overs; loading/unloading is carried out by the truck drivers.

**NiKRASA** - all standards remain the same and no changes of the trailer, wagons, terminals or processes are required. System enables non-craneable semitrailers as well as containers and swap bodies to be loaded onto standard pocket wagons. Technology advantages: no special know-how necessary; stable transshipment because semitrailer is protected by transport-platform; standard grippers; standard process in transshipment facility; staff training by system implementation; no changes to existing standard; no additional investments for CT terminals beside the NiKRASA-system itself; no additional investment for rolling stock; no additional investment for crane technology; low price; storable even on top of 30“ container; option for carrying the terminal module with the train (nothing left in terminal); minimal impact on weight of the train and none on its length.

**Cargospeed** - most trailers cannot lift so an alternative is needed. It runs the whole rig up a special top of a carriage, which has turned to be easily able to lift both the upper part of the truck with the trailer and then lower it into the purpose-built railway carriage. Technology advantages: easy handling of non-craneable trailers; cost saving due to horizontal loading.

**Reachstackers** - most widely used CT technology at terminals. Technology advantages: reach stackers are able to transport containers, swap bodies and semi-trailers very quickly over short distances and pile them in various rows depending on their access.; reach stackers have gained ground in loading unit handling in most markets because of their

flexibility and higher stacking and storage capacity when compared to forklift trucks; using reach stackers, container blocks can be kept 4-deep due to second row access; there are also empty stackers or empty container handlers that are used only for handling empty containers quickly and efficiently.

**Railrunner** - reduces the need for maintenance of wheels and tracks by 30%. Reducing cargo shifting and potentially allowing for higher speed (170 km/h). Technology advantages: no fixed terminal installations necessary, the system needs only a special road tractor (for terminal operations); good tare/load ratio of 28-30 t of load and 15-16 t of tare, total weight on rail 42 to 43t; moderate reduction of transport equipment costs; transports a high number of trailers on a single train (42 max.); able to reach customers with no direct railway access (pre- and post-haulage by road); it is impossible to open trailer doors while the trailers are mounted on the bogies.

**Piggyback technology "C": Containers** - technology advantages: transportation possible in several types of wagon; used technology allows full exploitation of transport capacities funds; container construction enables their use in container transport; containers Loading units fulfil conditions for use in other modern transport technologies.

**NETHS (Neuweiler Tuchschnid Horizontal System)** - designed for small and medium sized terminals; can handle special ISO-freight container with a weight up to 35 tons. The NETHS can move, also loaded with ILU, parallel to the railway track on its own crane tracks, which are 4.25 meter wide. It is limited in handling swap bodies class C (short version). Technology advantages: little space in terminals; the handling of the loading units is possible without shunting while the train is under the electricity track; despite its high investment costs the operating cost are low because the facility does not need any additional staff in terminals; it could allow the immediate forwarding via rail of freight without the need of reaching the traditional rail terminals; it could be used in terminal or areas where site constraints do not allow the usage of traditional cranes.

**IUT (Innovatives Umschlag-Terminal)** - consists of a land saving multi-level high-rise shelf for ISO-freight containers and swap bodies up to a usable length on each storage place of 45'. Technology advantages: it is possible to manage different operations with a single facility; the buffering option provides the system with flexibility and avoids space consumption in terminals; instead of a huge crane, which carries out all necessary steps in succession, two highly specialized machines (container translators, rack operating units) are used - efficient handling reduces the total operating costs as well as the length of stay of the train and the trucks in the terminal.

**Sidelifter** - able to stack a container at a two containers' height on the ground. If the sidelifter chassis is of 40' length or more, or two 20' ISO containers at a time. Technology advantages: replaces stationary equipment or small sized terminals; mobile, quick and inexpensive handling system being one-man-operated; double sided on/off loading from railway wagons or storage points to its own chassis or other road vehicles; safely pick containers out of rows if these are at least 3" apart and the containers are stacked two high; simple but safe operations by means of a portable, remote control panel; no specially prepared surface area to work on required; good performance on small yards with a restricted catchment area for pre- and post-haulage and with clients asking for additional handling (transshipment) by the shipper because they lack their own equipment.

**Container Mover 3000** - no dedicated fixed infrastructure is necessary, nor is there a need for extra personnel. Standard containers can be handled. The system can transfer weights up to 22 tons and is operated remote-controlled. Swap bodies and containers can be lift by up to 40 cm. Technology advantages: compatible with standard 20 foot containers and swap bodies (C715, C745, C782); can be used at all locations and can easily be transferred between locations; no costly infrastructure, just a simple railway siding and an asphalted road surface; compatible with normal standard container wagons; easy to control by truck drivers, using a remote control; can be used for a wide range of containers

and therefore products, e.g. fresh consumer products, frozen and deep-frozen products, bulk & liquid products, industrial products, timber.

**Mobiler** - quick and easy operation; smooth handling of containers and interchanges between trucks and rail wagon without crane or own connecting line. Technology advantages: for customers without rail connection; pre - and post-running at the factory site using MOBILE-vehicle; for the development of industrial centres without rail connection; decentralized supplement to the Intermodal transportation terminal; safe and fast reloading of containers and swap bodies; reloading can be handled almost everywhere quickly and easily by a single person.

#### **Wish 53 – Shorter stay of the loading units in terminal (storage time)**

**Rolling Highway (RoLa) aka Piggyback technology: Rolling motorway** - despite the night and Sunday driving ban, with RoLa the Alps can be crossed almost 365 days a year. It allows transit through Switzerland from EU country to EU country without time-consuming customs clearance at the border. In addition, the ride is a rest for truck drivers. An average RoLa train transports approx. 20 trucks, while a UCT train moves up to 36 road consignments. The net weight per train is about 400 tons for RoLa and 750 for UCT, while the average transport distance is about 300 km for RoLa and 800 for UCT. Since the costs for traction and for the slot use in rail network are costs per train (irrespective how many loading units it carries) this technology shows costs per unit that are almost double as high as the systems that use vertical transport.

#### **Wish 59 – Faster (average) speed of trains**

**ISU Innovativer Sattelaufleger Umschlag/Innovative Semi-Trailer Handling Unit** - allows direct handling of non-craneable trailers without any new terminal infrastructure or modifications and lifting of trailers with measures of height 4m and width 2,6m. Due to a low degree of automation the handling requires a lot of personnel capacities. The required technical infrastructure is cheap and easy integrated into existing terminal structures. Technology advantages: handling of non-craneable trailers; easy integration into existing services; complex loading and unloading. All common trailers can be carried; especially for long-distance routes; very low degree of automation; easy integration into existing terminals; first experiences with first connection from Wels to Bulgaria.

**Technologies Metrocargo, Flexiwagon and Truck Platooning I** are correlated to technical **Wish 71 on Improving the times and conditions of implementing new railway technologies** and also the political **Wish 14 – Ensuring the preferential treatment of the CT** and **Wish 15 – EU wide portal for construction work on the three modes of transport.**

## **Wishes covered by directives and standards**

The research of international, national and local policies, directives and standards are a fundamental support for the improvement of CT services in correlation to wishes, recognized through the AlpInnoCT project. The strategy that politicians could adopt is complex and it can include **multiple proposals** (also not directly referred to CT), which can lead to the same goal, i.e. the reduction of freight externalities. They could be a form of regulation against road transport or they could directly encourage CT services (for example by introducing specific subsidies). By taking into account content-related and territorial characteristics, a specific **database** about CT policies, directives and standards has been created. Within the framework of the creation of a single market and enlargement of the EU in 2004 and in 2007, more open to competition, has noticeably improved the exchange of goods. Ten policies are able to influence the European CT market actively: the Council Directive 92/106/EEC and its amendment, the Council Directive 91/440/EEC, the Communication

from the Commission about the Community guidelines on State aid for railway undertakings (2008/C 184/07), the Directive 2011/76/EU and its proposed revision, the Directive 2012/34/EU, the Regulation (EU) No 913/2010, the EUSALP and the White Paper on Transport (EC, 2011). There is also some specific standards, recommendations at EU and national level.

Top priority wish on **Introduction of a European infrastructure management (political Wish 11)** focuses on problem that currently each country has its own infrastructure management, since the CT often acts transnationally. The **White Paper on Transport** (EC, 2011) sets a long-term strategy for the development of an integrated European transport system. The goal of the version released in 2011 is the shift of 30% of road freight over 300 km to rail and waterborne transport by 2030 and 50% by 2050. The importance of the TEN-T corridors as the main infrastructural elements that can guarantee a more balanced distribution of the traffic according to the different modes is underline. It is important to improve truck efficiency, through the development and the uptake of new engines and cleaner fuels, the use of intelligent transport systems and further measures to enhance market mechanisms. An efficient co-modality is needed. The EU needs developed freight corridors, optimized in terms of energy use and emissions, minimizing environmental impacts. (correlation to AlpInnoCT wishes: Introduction of a European infrastructure management and Standard for ILU check with standardized documents).

**Wish 13: Harmonization & Enforcement of push & pull measures in the EU at all levels**

- Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area: set out the requirements and procedures for the allocation of railway infrastructure capacity and methods for the calculation and collection of infrastructure charges; The Directive contains some basic principles to the functioning of terminals. The European Commission Implementing Act on Access to Service Facilities – under Directive 2012/34 – has been emerging over the course of 2016. This act will help MSs to interpret the basic provisions contained in the Directive, and could ultimately foster the regulatory harmonization.
- EUSALP (EU strategy for the alpine region): built upon three general action-oriented thematic policy area and one cross-cutting policy area - mobility and connectivity; promote inter-modality and interoperability in passenger and freight transport).

**Wish 14: Ensuring the preferential treatment of the CT**

- Order of 25 September 1991 on the execution of the combined transport of goods between the Member States of the European Economic Community: defines: the meaning of "Combined Transport"; the transport document to be produced by the road haulier in the case of transport for hire or reward; the purpose of "all hauliers established in a Member State of the agreement on a European Economic Area who meet the conditions of access to the occupation and access to the market for transport of goods between Member States of this agreement have the right to carry out initial and/or final road haulage legs, which form an integral part of a combined transport operation between Member States of this agreement and which may or may not include the crossing of a frontier"; the purpose of the provisions; other dispositions about initial road haulage leg in a combined transport operation between Member States of the agreement on a European Economic.
- Directive on international (border-crossing) transport of goods and cabotage traffic: the measures about initial and final road haulage legs by hauliers established in Member States of the European Economic Area; the measures about initial and final road haulage legs by hauliers not established in Member States of the European Economic Area.

**Wish 10: Stimulus package rail for lower prices (national and regional law and regulations)**

- Austrian government program (Regierungsprogramm) (2013-2018)
- “Brenner Memorandum 2015” and the Decision No. 17/2014 of the parliament of South Tyrol
- Ministry of Infrastructure and Transport - Ministerial Decree 14 October 2010, n.750 "Incentives in favour of combined and trans-ship rail transport"
- Decree on combined transport. Official Gazette of RS, Nos. 4/01 and 49/13

#### **Wish 12: Standards for ILU check (trains and truck check in) with standardized documents**

- Council Directive 92/106/EEC of 7 December 1992 on the establishment of common rules for certain types of combined transport of goods between Member States: The transport document to be provided in the case of combined or intermodal transport must specify the rail loading and unloading stations relating to the rail leg, the inland waterway loading and unloading ports relating to the inland waterway leg or the maritime loading and unloading ports relating to the maritime section of the journey.

Through the research some directives and strategies **on ICT/ITS** were found and analyzed: Digital Single Market Strategy, 2015; ICT Standardization Priorities for the Digital Single Market, 2016; eGovernment Action plan, 2016-2020; European Interoperability Framework Strategy, 2017; Conclusions on the digitalization of transport, EU Council of Ministers, Dec 2017 : ““Transport needs to go digital to be competitive, connected, safer, cleaner and more inclusive”; 3rd Mobility Package, May 2018.

In framework of **Data protection regulation (GDPR)**, Directive on cybersecurity (NIS), 2016; Revision of the Public Sector Information (PSI) Directive, 2018. Also **RIS Directive; EETS Directive; ITS Directive; ERTMS framework; SES framework; VTMS framework** were added to database with respect to AlpInnoCT wishes content.

**Regulation on Electronic Freight Transport Information (EFTI)** is dealing with harmonized EU general framework for business-to-authority electronic exchange of “regulated” freight transport information. **Regulation on a European Maritime Single Window (EMSWe)** is the legal and technical framework for electronic transmission of information in relation to reporting obligations and procedures for the port calls in the Union.

**Digital Transport & Logistics Forum (DTLF) - support EFTI:** etransport documents, recommendations and preparatory work for the Proposal on electronic Freight Transport Information (EFTI) gives an overview of the “documents” used in the context of transport and logistics, also recommendations on EU support for enabling wider electronic exchange of information on the means of transport and their personnel.

## **Wishes covered by theoretical concepts**

The research of Theoretical concepts and theories was split into research initiatives that foster efficiency of combined transport and research initiatives that foster modal split of Combined transport. The methodology for searching was based on key words and searching limited to Title/Keywords and abstract in main scientific databases: Scencedirect, Scopus, Sage journals, Taylor and Francis and Wiley online library. After filtering process 31 research articles were found, which cover more efficient, productive or lean Combined transport, while 49 research articles were identified to cover theoretical approaches of combined transport and modal split.

### **Wishes covering Combined Transport and Lean / efficient production**

#### Technical wishes

Top priority wish on Improvement of planning and punctuality of the CT planning (27) focuses on the increase of predictability and easier downstream process, with increased level of responsiveness of all involved stakeholders. The theoretical research articles suggest following developments:

- Network approach:
  - o Combined transport (with focus on main haul - rail freight transport) is embedded in social logistic system, which is identified as scale- free network. The operation of the whole logistic system is optimized with algorithms considering the network freight flow volume and connection between groups and connection within groups (graph theoretic approach based on combination between centrality - Barabasi – Albert algorithm). The optimization algorithm alleviate and balance the load of hub node and make operation of logistic system more efficient and at lower cost. (Lu & Ju, 2012)
- Sequence approach:
  - o Integration of interterminal and hinterland rail transport optimizes the movement of containers considering interterminal transport connections, train formation and railway timetable. Rolling horizon optimization framework is used for identifying solutions in more connections between terminals and a flexible outbound railway timetable to improve the container performance (Hu, Wiegmans, Corman, & Lodewijks, 2019)
- Using lean principles
  - o A conceptual framework for using lean principles to drive operational improvements in intermodal container facilities demonstrates how lean approaches like waste elimination, standardization, levelling and continuous improvement can be used to identify improvement areas.(Olesen, Powell, Hvolby, & Fraser, 2015)
  - o Model of lean construction based on CAS (complex adaptive system) theory is developed for railway infrastructure projects, where support for production efficiency and construction quality is provided in all stages of the construction management.(Wang, 2017)
  - o Integration of modern management models based on principles of lean production suggest the sequence of stages of implementation of three models: lean production, the theory of constraints and six sigma. The model is proposed for Russian industry sector including Russian Railways. (Balashova & Gromova, 2017)
  - o Automated monitoring system was developed as an instrument of lean production of a railway traction power supply system on Russian railways, where advantages of unused capabilities were detected through reduction of time for repair work, an increase in overhaul periods, an increase of reliability of the traction power supply system, and making the work time more effective of the maintenance personnel. (Makasheva, 2016)
  - o A model of Lean production for improving railway transport efficiency proposes changing operation management methods, improving internal contractual relationships and optimizing transport organization structures for reasonable allocation of various resources of railway enterprises and strengthens controllability of the resources. All staff in railway enterprises would transform from their traditional production pattern based on routine and experience to a new production and management pattern, which is scientific and intensive, based on lean process and information technology (Rong, 2008)

Next top priority wish is Powerful alternative routes (redundancy) for main routes (73), where alternative routes should be developed and defined, which can be quickly used in an emergency. No research articles were found in dealing with lean solutions on this topic, but a paper was prepared for development of a tool for shippers, where a new **cash to cash**

**cycle model** improves route selection by incorporating both transport cost and cash flow consideration, thus generating considerable savings (Holter, Grant, Ritchie, Shaw, & Towers, 2010).

For the wish on Continuous tracking of the loading units (28) a research article suggest **RFID** technology for **coal supply chain traceability and transport tracking** for the purposes of quality control. (Qiao, Chang, Hao, & Kong, 2012).

In order to realize the wish on Reduce the space between two slots/trains (brakes, traffic management) (64) in order to increase the frequency of trains on the rail network and to more efficient use of existing infrastructure research article proposes a lean implementation concept based on **intelligent maintenance methods (e.g. Run to failure – RTF)**, where maintenance supply chain is the priority. Lean principles on identifying non value added activities were used for maintenance of traction substation on railways, while additional or alternative activities were implemented to shorten the maintenance process. This increased availability of the railway system and indirectly affected the capacity (Croucamp & Telukdarie, 2018). The lean concept was developed for Railway Transportation organization - Urumqui Railway Bureau in China, where implementation methods such as **transportation resource integration, station zone organization, dispatch command optimization and railway performance index** were implemented (Li, Hong-Chang; Rong, Chao-He; Song, 2008).

Wish for Better wagon availability (68) covers the topics of availability of suitable equipment for wagons. The theory proposes a **concept of feedback loop** and identifies mechanisms that are working well and not working well within the industrialization process of railway wagon components. (Chirumalla, Jackson, Bruch, Andersson, & Löf, 2018).

For Wish 34: Reducing waste in transport process (e.g. long storage times of loading units in the terminal) theoretical lean thinking approaches were developed:

- Industry production optimization methods
  - o **5S Framework** for container demand uncertainty includes special stacking pattern and appointment system (pre gate arrangement). Sorting framework in container yard is based on the 5 S method and improves the turnaround time (TAT) of the trucks entering the terminal. (Poojith, Vishnu, & Sahay, 2018)
- Economic management models
  - o **Kohonen neural network model** is constructed to divide the economic hinterland of a port into classes. According to different types of economic hinterland, targeted management measures are put forward to make reasonable allocation of port resources, increase container throughput of a port, and enhance the competitiveness of a port sea rail combined transport (Ye & Chen, 2018).
- Evaluations and simulations
  - o Quality and energy evaluation of rail road terminals by microsimulation proposes a tool for simulating of the **impact of arrival rates for trucks and reducing the duration of check-out and cranes operations**. (Carboni & Deflorio, 2017)
  - o A tool for simulations introducing changes on the **terminal characteristics (specifications of the elements, layout, etc.), the operating rules (used to unload/load trains, store containers, etc.) and the demand for services (train timetable, truck arrival pattern, etc)** provide information on productivity, service level as well as resource and infrastructure use. (García, 2016)
  - o Simulations for storage processes show, that **guided specific rules** may result in a significant reduction in energy demand in the course of handling containers. (Zajac & Restel, 2014)
- A heuristics procedure for the optimization of the stacking activities in an inland intermodal terminal with the aim of increasing total efficiency in the whole transshipment node (Carrese & Tatarelli, 2011).



## Political wishes

For top political Wish 1 on Mainstreaming customs clearance and administrative control (one stop shop – for all controls) for faster customs clearance a concept of **Agile port and inland operations model** is proposed to improve intermodal service and secure lean supply chains for containerized cargo. Identify not needed subjects in the process and involvement of customs authorities and inspection companies to organization of agile services in the ports on the borders between different countries and at final destinations. (Beškovnik & Tvrđy, 2011)

For second priority political wish on Introducing a European infrastructure management lean thinking approaches may support the procedures in faster acting of national decision makers. Several concepts are developed for:

- Lean construction:
  - o Key techniques for lean management of High Speed Railway Tunnels are BIM technology (Building information modelling) tunnel surrounding rock measurements, 3D laser scanning and cloud based information management system (Zhi, Shi, Wang, & Xie, 2018).
  - o Lean implementation for rail substation processes proposes lean maintenance strategies (Croucamp & Telukdarie, 2018).
  - o CAS theory (Wang, 2017).
- Location of dry port
  - o A multi-criteria decision making model for best dry port location was developed, where with a Factor analysis relationship between logistic policy and geographical determination is investigated. Categorical based evaluation technique MACBETH is used to measure attractiveness of location, while preference ranking organization method PROMETHEE is used for enrichment of evaluations. (Komchornrit, 2017).
- Selection of Intermodal terminal
  - o Planning and development of efficient intermodal terminals depends on different structural elements and a benchmark for other terminals. The selection model combines the fuzzy EDAS (Evaluation Based on Distance from Average Solution) method of multi-criteria decision-making, used for defining the input weight limits based on the requirements of the stakeholders, and the AR DEA (Assurance Region Data Envelopment Analysis) non-parametric method, used for evaluating the efficiency of the types of inland terminals. (Tadić, Krstić, & Brnjac, 2019).

For the third political wish on Harmonization and enforcement of push and pull measures in the EU (13) at all levels providing solutions on matching different instruments (financial, regulatory, taxes) proposes a regulatory reform on railroad/CT management, where younger and educated personnel enables the management structures for becoming more leaner and less mechanistic. (Grimm, Kling, & Smith, 1987)

For ensuring the preferential treatment of the CT (Wish 14) the end user view should be more exposed. The implementation of on lean and green supply chain management is suggested to shift demand from road to rail through a number of pathways for action related to planning and management, assets, train services, collaboration, legal issues and incentive schemes. The results were investigated from a fast moving consumer goods industry. (Colicchia, Creazza, & Dallari, 2017).

Wish 7 - Automated semi-trailer handling can be solved with a development of autonomous driving and handling. A integrated software concept was developed, which proposes a software guidance of unmanned combined transport,

which includes animation and evaluation of simulated traffic on railway terminal and disposition of a large number of autonomously operating real commercial vehicles. (Zöbel & Weyand, 2010).

## Wishes covering Combined transport and modal split

### Technical wishes

For Wish 73 Powerful alternative routes for main routes relevant measures present big infrastructure investments in redundancy of existing corridors (e.g. Koralmbahn on Baltic – Adriatic Axis - (Adelsberger & Eicher, 2008).

Measures relevant for Wish 72 – Elimination of (local and general) bottlenecks on the corridors related to gauge and train length interoperability are telematics applications like ETCS and following the Network 21 Strategy on segregating slow and fast services and taking targeted actions to remove bottlenecks. It is also important for noise mitigation. Additionally a long distance based charges for heavy goods was identified as key enabler of rail exploitation to the needs of customers. (Kohl, 2009).

Reduce the space between two slots (Wish 64) can be solved with introduction of higher frequency of Ro-Ro trains. Increase of four journey per day would increase 4 % of total shipment, while 10 journey per day would according to estimation increase it to 9 % (Dalla Chiara, Deflorio, & Spione, 2008).

### Political wishes

For top political Wish 1 on Mainstreaming customs clearance and administrative control (one stop shop – for all controls) for faster customs clearance streamlining of border post operations (both border and those that could be moved from the border) was identified as most relevant measure from total supply chain view (Havenga, Van Eeden, & Pienaar, 2013). The model determines the logistic cross border costs and prioritized opportunities for improvement, which are identification of most important border posts (based on traffic flows), a product profile for imports and exports on these border stops, modal split, the annual logistic costs incurred on the corridors feeding the border posts and additional cost incurred due to border delays.

For second priority political wish on Introducing a European infrastructure management modal split is to be changed through **Intermodal network design and pricing** strategy model was developed to determine port operators the dry port locations and pricing strategy to maximize profit considering the shipper's route choice behaviour. A Nash equilibrium solution algorithm as game-theoretical model is adapted. The modal split is related to the number and location of dry ports. (Zhang, Wang, Peng, Zhang, & Guo, 2018)

For the third political wish on Harmonization and enforcement of push and pull measures in the EU (13), fourth wish – Ensuring preferential treatment of the CT (14) and fifth wish on stimulating rail (10) modal split can be changed through:

- Horizontal transshipment technologies, where 42 % market penetration ratio for Combined transport is suggested to be subsidies mostly for rail line hauling. Additional measure is the introduction of longer trains (35 %). The model also reveals, that policies that directly promote combined transport have a stronger effect on modal shift, that policies that discriminate against road traffic. Additionally the leverage of the transport policies for the medium range distance is significant higher than for the long distances (Truschkin & Elbert, 2013).

- Synchromodality. A synchromodal framework was developed where shippers can manage their supply chains more flexibly to increase the potential for modal shift, without increasing total logistic costs and reducing service level. Environmental impact has an important role. (Dong, Boute, McKinnon, & Verelst, 2018).
- Hinterland Connectivity.
  - o Based on the quality of the hinterland transport (physical characteristics – rail capacity, train services), the modal split can be increased(Chen, Jeevan, & Cahoon, 2016).
  - o Innovative mixed integer intermodal freight location-allocation model based on hub-location theory was developed to model different policies. Results suggests that subsidizing has a significant impact on the volumes transported by intermodal transport, and, to a lesser extent, that optimizing terminal location increases the competitiveness of intermodal transport. On the other hand, internalizing external costs can negatively impact the promotion of intermodality. Innovative last-mile transports are needed in order to reduce the external impacts of drayage operations. (Santos, Limbourg, & Carreira, 2015).
- Institutional rail reform
  - o liberalization of freight market vs institutional change (Grushevska, Notteboom, & Shklar, 2016).
  - o research conditions of the liberalization of the railway freight market in the context of a sustainable transport system(Dolinayova, Loch, & Camaj, 2016).
- Evaluation and harmonization of measures
  - o Integrated and transnational strategy based on economic valuation of Well to Wheel CO2 emissions from freight transport along main transalpine corridors (Nocera, Cavallaro, & Galati, n.d.)(Nocera & Cavallaro, 2016).
  - o Private and social cost efficiency of port hinterland container distribution (Iannone, 2012).
  - o Impact of energy costs and transportation mode mix on forest fuel (Rauch & Gronalt, 2011).
  - o European freight model (based on logit analysis and neural networks) assess the consequences of various types of eco-taxes on road transport in Europe.(Nijkamp, Reggiani, & Bolis, 1997).
  - o Multi-level strategies that encourage modal shift based on environmental and social impacts (Nocera et al., n.d.).
  - o Toll on haulage charging, night time ban for trucks, a better management of rail network in Europe, substantial increase in costs for road transport, while new rail bypasses and eco point system have no effect on modal split when they are implemented only locally (Knoflacher, 2001).
  - o Estimating trade-off among logistics cost, CO2 and time – A model was developed for solving linear programming based transportation problem, where relationships of attributes serve for setting policy directions on freight transportation system development and determine the level of subsidies for shippers or carries who shift from road to rail (intermodal)(Park, Kim, Park, & Kim, 2012). Costs of competitive modes. A evolution model was developed based on history data of costs for individual mode and sequences of time (Ferrari, 2013).
  - o The right ratio of minimization of operational costs and additional road taxes. A model was developed for estimating the modal split based on different economic and environmental policies(air pollution external costs).(Mostert, Caris, & Limbourg, 2017).

Other identified concept are covering not prioritized wishes and mainly address different methodological approaches for modal share calculations and determination.

## NGOs and networks in macro-region Alps and their role in promotion of rail transport

Various political actors in the Alpine region are lobbying for the adoption of a European Macro regional Strategy for this area. The NGOs, Alpine-wide networks and organizations gather as observers to the Alpine Convention to contribute to alpine-wide solidarity and cooperation between regions beyond the perimeter of the Alpine Convention. They form a diverse network bringing together different cultural and linguistic backgrounds but one common aim: ensuring sustainable development in the Alpine Region as defined in the Alpine Convention. They advocate for an active involvement of civil society as well as of organizations and networks at the interface between the Alps and the metropolitan areas in a macro-regional process. They want to contribute to a better co-operation between the EU, the Alps and their surroundings and to embedding the EU's aspirations for a macro-regional approach more firmly across the Alpine region. The Alps and their surrounding areas have to co-operate as equal partners and build upon the existing co-operation mechanisms and experience, particularly of the Alpine Convention. The Alpine Convention is an existing, legally binding instrument and offers clear objectives for sustainable development, an important knowledge base and proven experience of effective alpine-wide cooperation.

NGOs covering the Alps have a long upheld culture of co-operation and exchanges through the Alpine Convention. The Alpine Convention formulates goals for the protection and the sustainable development of the Alps, offers instruments and a basis for co-operation.

They ask for the Convention to be acknowledged as an integral part of the emerging Macro-regional Strategy that underpins all its aspects of concern. The sustainability aims of the Alpine Convention are equally relevant to and can also be applied in its adjacent regions.

CIPRA and the networks of municipalities, Alpine Associations and scientists are therefore demanding that the spirit of the Alpine Convention should also live on into an European Strategy for the Alpine space.

Eight of these organizations:

- CIPRA International– International Commission for the Protection of the Alps  
CIPRA, is a non-governmental umbrella organization with national representatives and one regional representative in the seven Alpine countries. It represents more than 100 associations and organizations. CIPRA works towards achieving sustainable development in the Alps; it also strives to preserve the natural and cultural heritage, maintain regional diversity, and bring about solutions to cross-border problems in the Alpine region.
- ISCAR, Comité scientifique international recherche alpine  
ISCAR: promotes interdisciplinary collaboration in the entire Alps in relation to Alpine research and supports also the transfer of research results into practice; ensures continuity and scientific quality of the Forum Alpinum, raises Alpine-relevant issues and implements them in research programs associated with mountain issues; examines research interests of the Alpine Convention and gives advice to committees of the Alpine Convention.
- Alliance in the Alps,  
The network of municipalities "Alliance in the Alps" is an association of local authorities and regions from seven Alpine states and was founded in 1997. Its members, together with their citizens, strive to develop their alpine living environment in a sustainable way. "Exchange - Address – Implement" is the main idea

behind the Alliance’s activities. The basic and guiding principle for sustainable development is the Alpine Convention. Its implementation is to come to life wherever individuals are able to shape their future – in the community.

- CAA- Club Arc Alpin
 

The CAA is the umbrella organization of the eight leading mountaineering associations of the alpine arch with more than 2 million members. As observer of the Alpine Convention it is committed to its implementation, issues statements and represents the interests of its associations. The three commission (mountaineering, training and safety; huts and trails; nature protection and alpine spatial planning) are platforms for the exchange of information and for the development of common positions.
- Alpine Town of the Year,
 

Alpine towns which act sustainably and balanced in economic, social and environmental belongings, in line with the principles of the Alpine Convention, have been getting awarded “Alpine Town of the Year” since 1997. The awarded towns work together in the homonymous association, being composed by over a dozen of cities of all the Alpine countries.
- WWF – Word Wide Fund For Nature
 

WWF's mission is to stop the degradation of our planet's natural environment, and build a future in which humans live in harmony with nature. In order to achieve this mission, WWF focuses its efforts on two broad areas: The first, is to ensure that the earth's web of life - biodiversity - stays healthy and vibrant for generations to come. We are strategically focusing on conserving critical places and critical species that are particularly important for the conservation of our earth's rich biodiversity. The second, is to reduce the negative impacts of human activity - our ecological footprint. We are working to ensure that the natural resources required for life -land, water, air - are managed sustainably and equitably. From our experience as the world's leading independent conservation body, we know that the well-being of people, wildlife and the environment are closely linked. That's why we take an integrated approach to our work. We spend a lot of time working with communities, with politicians and with businesses to find solutions so people and nature can thrive.
- ProMONT-BLANC
 

The tri-national umbrella non-governmental organization ProMONT-BLANC (that consists of Alpine clubs as well as local, regional, national and international environmental organizations) has been engaged in better trans frontier protection via a management plan of the Franco-Italian-Swiss massif since 1991 and promotes the most sustainable development possible within the prosperous tourism region of “Espace Mont-Blanc”, the alliance of the 35 municipalities of the three countries around Mont Blanc.
- IUCN – International Union for Conservation of Nature
 

IUCN is the world's oldest and largest global environmental network. It is a democratic union with more than 1,000 government and NGO member organizations and some 10,000 volunteer scientists in more than 150 countries. IUCN helps the world to find pragmatic solutions to our most pressing environmental and development challenges by supporting scientific research, managing field projects all over the world and bringing governments, NGOs, the UN, international conventions and companies together to develop a policy, laws and best practices.

The above listed eight organizations, have in their joint document “New co-operation between the Alps and their surrounding areas for sustainable development”, besides natural resources and energy, devoted special attention also to mobility planning.

The main common aims listed in the field of “Mobility planning” are: reducing the negative impacts of the mobility of goods and passengers. Increasing mobility threatens the natural and human environment in the Alpine region. The Alps and the metropolitan areas must jointly promote the principles of environmentally friendly mobility as well as a large-scale modal shift of persons and goods traffic onto rail. In order to reduce traffic and to make mobility more sustainable, strong regional economies and a regional supply of goods (including, for example, agricultural products), as well as effective public transport and service infrastructures have to be in place. Producing creative solutions for a future life in the municipalities and cities of the Alps requires an increased awareness that the Alps and their surrounding areas are closely related in regard to the above-mentioned essential topics. New forms of co-operation between the actors involved are needed. With the support of large European network stretching across and beyond the Alps, the joint eight organizations are ready to play an active part in this co-operation.

### **Transport working group**

The main objective of the Transport Protocol of the Alpine Convention is "to pursue a sustainable transport policy which will reduce the negative effects of and risks posed by intra-Alpine and transalpine transport to a level which is not harmful to people, flora and fauna and their environments and Habitats, inter alia, by transferring an increasing amount of transport, especially freight transport, to the railways, in particular by creating appropriate infrastructures and incentives in line with market principles." *Promoting sustainable transport* is also one of the six priorities set in the Multiannual Work Programme 2017-2022 of the Alpine Convention. At medium-term, the Contracting Parties to the Alpine Convention aim at decoupling economic growth from an ever-increasing transport demand. This objective and the implementation of the Transport Protocol are supported by the activities of the Transport Working Group.

A "Transport Protocol" Working group was initially mandated to elaborate and negotiate the Transport Protocol of the Alpine Convention, which was adopted in the year 2000. In 2002 the Working Group was mandated to support the exchange of information and experience among the Parties of the Alpine Convention, related to chapter IV of the Transport Protocol (“Monitoring and Evaluation”).

Since 2002 the Transport Working Group has been operating on the basis of two-year mandates on specific issues. A major focus of the work in recent years, continued in the current period 2017-2018, is the assessment and internalization of the real cost of transport (art. 14 of the protocol) especially with reference to the implementation of the Eurovignette directive, as well as monitoring and control of the environmental impacts of transports (art. 15 and 16). The working group is also investigating innovative logistics solutions, including innovations in the rail system and the deployment of alternative fuels infrastructure. It is exchanging information with different bodies working on transport in the Alps, such as the Zurich Process and EUSALP AG4.

The Contracting Parties to the Alpine Convention delegate experts to be members of the Working groups/ Platforms. Observers to the Convention may also nominate representatives.

The main objectives of the Transport Working Group are to:

- develop coordinated information in the field of freight and passenger transport in the Alps;
- monitor the implementation of the Alpine Convention and mainly the Transport Protocol;
- work on reducing the negative impact of transport on health and environment, in particular by contributing to creating favourable conditions for the use of more sustainable means of transport;
- gather, analyze and develop good practices.

## **Multiannual Work Programme of the NGOs within the Alpine Conference 2017-2022**

**Priority 5 transport:** Promoting sustainable transport. The transport sector has a substantial impact on the distribution of people, economic activities and job opportunities in the Alps, while also having a predominant role in defining spatial planning patterns. Often, these impacts are not equally distributed within the Alpine 5 perimeter. Both rail and road transport should contribute to guaranteeing continuity of traffic and connections between central and remote valleys on the one hand and between the Alps and their surrounding regions on the other hand. Efforts need to be made in order to make transport more efficient, real cost covering, well balanced, integrated and interconnected. For this purpose, the priorities will remain those laid down in the articles 14-16 of the Transport Protocol. This aims at fostering the integration and harmonization of external costs generated by heavy goods transport in general and at a cross-border level. Innovative solutions inspired by fast-growing mobility concepts (e.g. sharing mobility) and by effective demand-responsive transport systems (DRTS) should be developed and promoted at local and regional level, so as to ensure high levels of accessibility to the whole Alpine territory. In the same spirit, more efforts are necessary to evaluate the most appropriate measures in terms of tolling and transport management instruments for heavy goods transport related to the environmental impacts and emissions (air pollutants, CO<sub>2</sub>-emissions, noise) and to promote the use of alternative fuels with greater energy efficiency and lower CO<sub>2</sub> and pollutant emissions. Moreover, it will be crucial to support a more widespread use of accessible and user-friendly Intelligent Transport Systems (ITS) for road and rail, unleashing their potential as promoters of environmentally friendly solutions. Striving to strike the balance between economic development and sustainability in its full sense will be the key to effectively contributing to this and other MAP priorities (such as climate change, or greening the economy). At medium-term, this means to decouple the increasing transport demand from economic growth. In this sense, the Alpine Conference will as well pursue relevant links within the EUSALP process and make available its decades long expertise and approach in this field.

### **AlpInnoCT project findings and suggestions for the Alpine space freight transport**

Taking into consideration the EU strategy for the Alpine space and listed common aims of the NGOs and organizations of the Alpine region under the “Mobility planning” issues, where environmentally friendly mobility of goods and people and large scale modal shift of goods and people onto rail is strongly emphasized, the following suggestions (“wishes”) of the AlpInnoCT project are particularly in line with the common strategic agenda:

Stimulus package for lower (more competitive) prices of the rail transport. The rail transport is much more environmentally friendly than the road transport. In order to achieve substantial shift from road to rail transport of passengers and goods measures for making rail transport more competitive are needed. So far, unfortunately, the statements of the politicians are not in line with the deeds, namely a noticeable strengthening of the rail system in the form of a strong economic stimulus package is needed if shift to rail aims are to be achieved.

1. Introduction of a single European rail infrastructure management structure, which can enable quicker and more efficient decision making process in particular in the case of transnational rail (combined transport) issues. It would have been a significant added value for improving rail (combined) transport in Alpine space in particular and the entire European Union in general. Currently has each country its own rail infrastructure manager which is responsible for rail (freight) operations on the national rail infrastructure, which causes problems in the segment of the cross border transport, because of more emphasized national rail transport priorities by the allocation of railway infrastructure capacity. On the other side common principles of charging for the use of railway infrastructure are needed too on the Alpine space regional as well as on the EU level.,

2. Ensuring preferential treatment of the combined transport. Due to shorter product life cycles, the road has significant advantages in terms of introducing innovations. In order to enable the combined transport to be competitive with the road freight transport preferential treatment in favour of technological development and introduction of innovations is needed. On this way the shift to rail of freight transport can be more successful and combined transport more competitive on the long run.
3. Measures for support and enforcement of combined transport differ from member state to member state sometimes even from region to region. There is a strong need for harmonization for both combined transport pull as well as of push measures on the EU level, if the efficient single combined transport market is to be achieved.
4. Manufacturing industry is using, already for decades, the principles of lean manufacturing, just in time, just in sequence, Kanban etc. in the manufacturing processes. Transport and logistics, as such, is lagging behind the manufacturing industry in this respect. Transfer of good practices of manufacturing processes principles into transport/logistics environment is a challenge for rail transport in particular, if it wants to be stronger competitive partner to the road transport.

Taking into consideration that the above stated findings of the AlpInnoCT project are in line with basic aims of the Alpine Convention and the stated aims of the NGOs of the Alpine region, it is advisable that all listed NGOs and organizations are informed about the findings, suggestions and conclusions of the AlpInnoCT project in order to be taken into consideration by their future lobbying activities aiming at making the shift to rail process faster and more efficient. Of crucial importance is the role of NGOs also in the awareness raising process of all citizens (voters) and politicians in favour of environment friendly, socially responsible and sustainable rail transport of goods and passengers, within the framework of the Transport working group.

#### Appendix 1

### **Mandate proposal of the working group “Transport” for the period 2017-2018**

1. Establishment of the Working Group/Platform Alpine Conference decision for the establishment of the Working Group/Platform 19th Permanent Committee – 6th and 7th September 2001 – Aoste .
2. Tasks within the context of the Alpine Convention Correlation with the corresponding protocol(s) of the Alpine Convention or the Framework Convention Transport Protocol – 31st October 2000 Coherence with the topics of the Multiannual Work Programme of the Alpine Convention (if existing) Transport and mobility is one of the six areas of priority action of the multiannual work programme.
3. Activities within the mandate period Description of core activities 1. Continuation of undertaken work relating to the implementation of Article 14 of the Transport Protocol of the Alpine Convention. - Updating of the document on measures already taken or planned by the Alpine countries about infrastructure charging for heavy goods vehicles; 2/3 - Continuation of work on the calculation of external costs of HGV in the Alps. Supplement of the study of 2015-2016 and delineation of sections of main transport routes which meet specific characteristics of mountain areas in the Alps; - Identification of the possible necessity of further academic work on the question of external costs in mountainous areas; - Proposals for a further revision of the Eurovignette Directive and any future steps. 2. Continuation of work on the analysis of innovative logistics solutions. Development of recommendations for a coherent approach for a better interoperability of the systems. Updating of document on measures already taken or planned by the Alpine countries with the main focus on the shift from road to rail and inter- and multimodality for heavy goods vehicles. New focus on



innovations in the rail system to make it more competitive, e.g. automatic shunting and coupling of wagons, automatically driven freight trains and long Alpine tunnels as well as soft policies to make rail more attractive, including for the passengers and also for small and medium enterprises based on service centres. Based on good practice analysis, recommendations should be elaborated. 3. Continuation of work relating to the deployment of alternative fuels infrastructure and analysis of the coherence of the national strategies. Drawing of conclusions and recommendations to assure adequate continuity and connectivity of cross-border territories.

4. Strengthening knowledge exchange and communication activities between the different bodies working on transport in the Alps, such as the Zürich Process and the European Union Strategy for the Alpine Macro Region (EUSALP). 5. In application of art 15, addition of 2015 data on existing maps. Addition of new topics such as environmental impact and work for nuisance reduction. 6. In application of art. 16, evaluation of the most appropriate measures in terms of tolling / transport management instruments for heavy goods transport related to the environmental impact and emissions (air pollutants, CO<sub>2</sub>-emissions, noise) in cooperation with other existing bodies active in this 3/3 field. Description of main outputs – Updated synthesis on the present application of Eurovignette Directive (HGV pricing) in the various alpine countries; – Progress report on the calculation of external costs of transport (HGV) in the Alps; – Detailed document on various innovative logistic solutions for freight transport; – Gathering of national plans of alpine countries for the deployment of alternative fuels infrastructure. Communication activities of the Working Group/Platform Intensified exchange with other bodies working with transport in the Alpine Convention area. Cooperation with other WG-PF No present cooperation with other WG-PF Activities in the scope of the EUSALP strategy and of the Action Group 6 Active participation of the WGT presidency and other members in EUSALP AG4 on mobility. 4. Presidency and Work Plan Presidency and Participation Presidency: France The WG will be composed of nominated experts from the Contracting parties and Observers. On a case by case basis, additional experts can be invited to specific meetings of the WG. Work plan The WGT usually meets twice a year.

## Appendix 2

### Past activities, documents, results of the Working Group Transport

- Transport Working Group Activity Report 2015-2016
- Synthesis of questionnaire on application of Directive Eurovignette (2016)
- Bibliographical review on traffic-related external environmental costs (2016)
- Analysis of innovative logistics solutions such as rolling highways or solutions for other sustainable modes of long-distance Alpine crossing transport (2016)
- Public workshop: "Road transport security in the Alps and risk management related to natural hazards: challenges, best practices and possible long-term solutions", Saint Vincent 15th October 2013
- Ecological quality of passenger and goods transport in the Alpine area (find in DE, FR, IT, SL) (2011)
- First Report on the state of the Alps: Transport and Mobility in the Alps (2007)
- The real costs of transport in transalpine corridors (find in DE, FR, IT, SL) (2007)
- Cooperation on Alpine Railway Corridors (2006)

Sub-group "Sustainable Mobility" (2008-2014):

- "Mobility solutions in the Alps" Database (2015)
- Alp Info Net Handbook "Better informed, better travel" (2015)

- Sustainable mobility solutions in remote Alpine territories (2014)
  - o Full report
  - o Executive summary
  - o Brief Synthesis (in DE, IT, FR, SL)
- Sustainable Solutions for logistics and urban freight delivery in the Alpine Region (2014)
  - o Full report
  - o Executive summary
  - o Brief Synthesis (in DE, IT, FR, SL)
- Report Alpine Urban Mobility (2011)
- Tourist Sustainable Mobility in the Alps (find in DE, FR, IT, SL)
- Public transport accessibility of Alpine tourist resorts from major European origin regions and cities. Synthesis Report (2008)
- Sustainable Mobility in the Alps. Examples of Good Practices and Analysis of the Mobility System. (Find in DE, FR, IT, SL) (Annex EN) (2008).

## Comprehensive overview of initiatives according to priority wishes

An overview of the initiatives, actions, methods and impacts to processes identified in AlpInnoCT WPT3 and correlation with the Wish List as the result of WPT3 (WPT3 Report - An Ideal Process Model for Combined Transport (available at <https://www.alpine-space.eu/projects/alpinnoct/outputs/deliverable-ot3.1-presentation-of-the-wishes-of-the-actors-along-the-transport-chain.pdf>), were made. Particular emphasis was placed on the wishes, which were through AlpInnoCT project and KPI recognized as most important for whole combined transport process improvement (first leg, last leg, entire transportation chain).

Using the available databases on projects, technologies of CT, theoretical concepts, directives and standards as well as NGO's in the form of a table own database was created for reviewing initiatives against a wish list, also related to the introduction of industrial processes in combined transport. Based on specific pilot projects within the AlpInnoCT project (Route Management, Calculation of Estimated Time of Arrival of a Consignment to a Consignee, Digitized Wagon Check, E-waybills and Monitoring of Combined Transportation Driving Performance), an overview of existing initiatives covering priority wishes is presented. To provide a better overview, initiatives are presented only once for the most relevant wish, although they cover more wishes.

Top priority technical **Wish 27** – Improvement of planning and punctuality of the CT planning, is covered with Initiatives related to digitalisation of logistic information of all actors (e.g. AEOLIX), logistic clusters, terminal management and developed Business models and plans for all actors in supply chain (CLUSTERS 2.0). Dedicated software is to be implemented on multimodal routes connecting 2 or more cross-border multimodal terminals (MiRo), while planning and punctuality is to be supported with “track and Trace” IT tools, with different solutions for interoperability (e.g. dual gauge change functionality of wagons-MEDAS). Additional automatisations of trains, supported processes and advanced timetable planning integrating long haul and terminal activities are currently researched (e.g. ARCC, Sequence approach to integrate interterminal and hinterland rail transport (Hu, Wiegman, Corman, & Lodewijks, 2019)). For reorganisation of freight logistic structures a Container transfer systems (SAFE-CTS) is proposed, while “just in time” concepts for individual end user industry (e.g. Chemical- Chemmultimodal, Automotive -MEDAS, EUROHUB, fresh fruits, forest fuels

- (Rauch & Gronalt, 2011) represent the user friendly orientation of planning. Holistic approach with identified measures and recommendations for “greening” the main corridors (e.g. Switly project developed a Toolbox with 120 measures for Scan – Med corridor) are also important, together with education and knowledge transfer of trainees, teachers and decision makers (SYSLOG+). On theoretical level a network approach to balance the load of hub nodes (Lu & Ju, 2012) and lean management concepts for operations on terminals and railways are developed and needed to be further tested on operational level (e.g. concepts of waste elimination, standardization, levelling and continuous improvement (terminals) - (Olesen, Powell, Hvolby, & Fraser, 2015) and sequence of stages through lean production, theory of constraints and six sigma ((Balashova & Gromova, 2017) for Russian railways). Lean construction management based on CAS (Complex adaptive systems) - (Wang, 2017)).

For infrastructure **Wish 73** Powerful alternative routes (redundancy) for main routes and **Wish 72** – Elimination of (local and general) bottlenecks on the corridors related to gauge and train length interoperability following the long-term strategy from **White Paper on Transport** (EC, 2011), where the goal is to shift of 30% of road freight over 300 km to rail and waterborne transport by 2030 and 50% by 2050 through TEN-T corridors represents the main legal framework. Additionally some sections of TEN-T Core network corridors or Freight Corridors due to political willingness already include two main routes on same relations, which could be developed as alternative routes or as redundancy of existing corridors (e.g. Koralmbahn on Baltic Adriatic axis). On theoretical level tool for shippers is developed, where a new cash to cash cycle model improves route selection by incorporating both transport cost and cash flow consideration, thus generating considerable savings (Holter, Grant, Ritchie, Shaw, & Towers, 2010). From technical point of view - technical solutions for interoperability are being developed for 30 years, where main initiatives are:

- ERTMS as united European rail system is structured from ETCS (signaling), GSM-R (communication) and ETML (Management). Currently GNSS Automated Virtualized Test Environment for RAIL is developed to test architecture of simulating GNSS based ERTMS applications and defined their interfaces (GATE4RAIL).
- Network 21 Strategy - segregating slow and fast services and taking targeted actions to remove bottlenecks.
- Modification of a number of tunnels, platform roofs and catenaries in order to operate a 4 m corridor
- CEF is co-financing projects on connectivity of roads to terminals, multimodal terminals enlargements allowing faster transshipment with new cranes, 750m long trains and railway connections to Core Network corridors.
- Technological innovations on dual gauge functionality of wagons (MEDAS).
- New cross-border constructions with standard UIC gauge .

Organizational and regulative (safety) interoperability represents additional challenge.

For **Wish 53**: Shorter stay of the loading units in terminals (storage time) initiatives suggest solutions through: Synergic interventions of gantry cranes, extending the train length to 750 m and redefining terminal layout (e.g. For bulk goods), Intelligent parking systems and automatic gates (CEF financing projects in Padua, Ploče, La Spezia), Control tower container management (port of Rotterdam), Use of special reach stackers for empty containers, Simulations using Building Information Modelling (BIM)- INTERMODEL EU, Economic management models in order to make reasonable allocation of port resources, increase container throughput of a port, and enhance the competitiveness of a port sea rail combined transport(Ye & Chen, 2018) and simulations for storage processes with **guided specific rules** (Zajac & Restel, 2014)

No initiatives were identified for **Wish 40: 24/7 opening times of shippers/warehouses, depots & workshops**

**For Wish 59: Faster (average) speed of trains several initiatives were identified with solutions through** Evaluation tools for noise, vibration and energy improvements of different technological solutions (FINE-1), Digitalisation and

automatisation of train operations with future Loco for Europe (1500 m trains, hybrid technology- FFL4E), future stations (with smart system energy management- IN2STEMPO), smart track with **dynamic wheel-rail interaction of railway assets** (Switches and crossings- S-CODE, subsystems (e.g. substations), components, track foundation)- IN2TRACK, Smart planning (cross border simulations and enhanced authorization process with virtual certification - PLASA and virtual testing of signaling systems-VITE), **Smart Metering sensor network** at Railway System level (IN2DREAMS), where a non-intrusive, open system and interface for data collection, aggregation and analysis in an open source Operational Data Management (ODM) Platform is developed. Additionally important is long term planning with future challenges for the rail sector (NEAR 2050).

**For Wish 28. Continuous tracking of the loading unit (on train, ship and truck) solutions suggest** Real time information applications for energy efficient network management systems (with simulation of speed through better train dynamics and yard planning) – Intelligent video gate, intelligent auxiliary management- FR8HUB, Sharing of train tracking and estimated time of arrival information (ELETA; CONTECH), Real time information for costumers via web oriented platform- WOLF, Real time utilization of transport assets with C-ITS cloud based smart visibility software (Next Trust) and RFID technology for end user industry (e.g. coal supply chain)- (Qiao, Chang, Hao, & Kong, 2012).

**Wish 64: Reduce the space between two slots/trains is covered with lean concepts** for more efficient use of existing infrastructure assets (with automated monitoring systems (e.g. traction substation) and methods like Run to failure or Time to repair for more effective organization of maintenance personnel). Intelligent Asset management system can apply Artificial intelligence for analysis of safety critical systems (GOSAFE\_RAIL). Lean concepts are also proposed for organization of transport resources (e.g. rolling stocks), station zone organization and dispatch command optimization (Li, Hong-Chang;Rong, Chao-He;Song, 2008) and for material selection to improve overall performance (e.g. PIVOT). Additionally with better hinterland Connectivity (rail capacity, train services), the modal split can be increased (Chen, Jeevan, & Cahoon, 2016), while port hinterland container distribution with rail may lead to private and social cost efficiency (Iannone, 2012). The space between two slots/trains can be reduced with initiatives testing moving block (validation of ERTMS, ATO and GNSS – ASTRAIL; testing for moving block signaling and virtual coupling – MOVINGRAIL) and high capable Traffic Control Management systems and brakes with wireless information transmission between trains, tracks and control tower (CONNECTA – emergency communication networks, ETALON- energy harvesting, Marathon2Operation – M2O9 – orders from the driver to unmanned traction units – 1500 m trains, X2RAIL 1,2,3 – Advanced signaling and Automation systems supporting decision on virtual coupling Regular operation of long (1500 m) trains (DYNAPREIGHT). In parallel also initiatives for better noise abatement vehicle design (DESTINATE) can contribute to faster operations, while smart planning of communication technologies (platform for tests and validation of various radio technologies- EMULRADIO4RAIL, Technical specifications, Business and Validation process of GSM-R- MISTRAL) reduce communication lead time and can therefore indirectly affect the space between trains. In regard to new technologies, innovative Transshipment technologies like CargoSpeed, Megaswing, Cargobeamer and Modalohr enable trains to leave the terminal in less than an hour.

**For Wish 62: More (reliable) slots for freight trains** a mapping of the rail freight network and implementation plan of freight dedicated network (EUR2EX, NEW OPERA) is developed.

**For Wish 50: Faster wagon inspection** no relevant initiatives were found

Initiatives covering **Wish 31: Introduction of electronic freight documents** are related to e-Freight implementation Action on international level allowing exchanging information between different actors and transport modes along the

chain (CEF). This is supported by Digital Transport & Logistics Forum (DTLF) and with sharing local innovative business and operational solutions through a platform (SELIS). Advanced e-technologies for freight documents should also be in line with block chains as a Distributed Ledger for Attribution of RCM Data in Rail (industry) (B4CM) and Cybersecurity in the RAILway sector (CYRAIL).

**Wish 67: More punctuality for railway undertakings (RU). Some RUs are more punctual than others** is to be solved with digitalisation and automatisisation of future rail freight (wagons, automated locomotives, ATO, braking of 1500 m trains, TMS, Driver Advisory systems) through functional requirements for new automatic couplers, telematics and electrification for CBM – **Condition based monitoring and cargo monitoring systems with wagon on-board Unit** (FR8RAIL I and II).

**For Wish 68: Better wagon availability** initiatives propose Lightweight design and construction of freight wagons and facilities for improved transport (of selected cargo - granular multimaterials – HERMES; with innovative sensors, active suspensions and condition based monitoring for optimized materials, noise and vibrations - RUN2RAIL, predictive maintenance and cargo monitoring and tracing - INNOWAG) . Additionally initiative proposes suitable equipment for wagons with a concept of feedback loop for identifying mechanisms that are working well and not working well within the industrialization process of railway wagon components.(Chirumalla, Jackson, Bruch, Andersson, & Löv, 2018).

**For Wish 35. Introduction of a task force in the event of network problems (such as Rastatt)** a planning software tool provides an integrated view of risks and threats for different assets of multimodal transport infrastructure (including bridges, tunnels, tracks, switches and signal systems). The SW includes lean approaches thru holistic smart monitoring of system conditions and integrating results with management and LOS (RAGTIME, MOMIT).

**For Wish 51. More efficiency regarding shunting (e.g. autonomous shunting or automatic train coupling system)** an automated yard and network management and organization with real time interaction and automated ad-hoc and advanced timetabling is being developed (e.g. OptiYard, ARCC – including automated trains and support processes, SMART – with autonomous obstacle detection system based on TAF TSI) . Additionally Innovative Transshipment technologies like NETHS or Metrocargo serve to eliminate shunting, if implemented on the network of terminals. To reduce the need of using shunting locomotives powerful last mile propulsion locomotive can be applied (e.g. FR8HUB).

**For Wish 34. Reduced waste in transport process (e.g. long storage times of loading units in the terminal)** optimizing stacking activities with: Industry production optimization methods (**5S Framework** for container demand uncertainty includes special stacking pattern and appointment system (pre gate arrangement) is recommended. Organized sorting framework improves the turnaround time (TAT) of the trucks entering the terminal (Poojith, Vishnu, & Sahay, 2018) , while using heuristics procedures aims of increasing total efficiency in the whole transshipment node (Carrese & Tatarelli, 2011). Simulations for quality and energy evaluation of rail road terminals proposes a tool for simulating of the **impact of arrival rates for trucks and reducing the duration of check-out and cranes operations**(Carboni & Deflorio, 2017), while a tool for simulations introducing changes on the **terminal characteristics (specifications of the elements, layout, etc.), the operating rules (used to unload/load trains, store containers, etc.) and the demand for services (train timetable, truck arrival pattern, etc)** provide information on productivity, service level as well as resource and infrastructure use. (García, 2016).

## Political wishes

**Wish 1: Mainstreaming customs clearance and administrative controls (one stop shop – for all controls) for faster customs clearance is tackled through:** Rail Freight Corridors (RFCs) – eg **Scanned corridor** – where internationally coordinated corridor activities cover timetable planning, ad hoc traffic and Reserve Capacity Corridor through One-Stop-Shop. Additionally a concept of **Agile port and inland operations model** proposes involvement of customs authorities and inspection companies to organization of agile services in the ports on the borders between different countries and at final destinations. (Beškovnik & Tvrđy, 2011). Additionally identification of most important border posts (based on traffic flows) and a product profile for imports and exports on these border stops may improve the custom clearance process and lower logistic costs. (Havenga, Van Eeden, & Pienaar, 2013).

**For Wish 11: Introduction of a European infrastructure management** a Central project management (like AlpFRail - Alpine Freight Railway is responsible for implementing short term solutions in the Alps) and Transport Decision Support System (TDSS) (like Alpcheck for Alpine Road network) are proposed. Additionally the center should consider lean construction (BIM technology (Building information modelling) tunnel surrounding rock measurements, 3D laser scanning and cloud based information management system (Zhi, Shi, Wang, & Xie, 2018), based on CAS (Complex adaptive systems) theory (Wang, 2017) and lean maintenance strategies for rail substation (Croucamp & Telukdarie, 2018). Management is to be responsible for intermodal network design, pricing strategy and location of dry port ((Komchornrit, 2017); (Zhang, Wang, Peng, Zhang, & Guo, 2018)).

**Wish 13: Harmonization & Enforcement of push & pull measures in the EU at all levels** is to be realized with learning from best practice on Push and pull measures (e.g. IMonitraf) and education and knowledge transfer of different instruments in CT management (financial, regulatory, taxes) for younger decision makers for becoming more leaner and less mechanistic (Grimm, Kling, & Smith, 1987). On EU level selected measures e.g. toll on haulage charging, night time ban for trucks, a better management of rail network in all Europe, substantial increase in costs for road transport are to be implemented, while new rail bypasses and eco point system have no effect on modal split when they are implemented only locally (Knoflacher, 2001). The measures are to be evaluated with European freight model (based on logit analysis and neural networks) which assess the consequences of various types of eco-taxes on road transport in Europe. (Nijkamp, Reggiani, & Bolis, 1997). Additionally the implementation of on lean and green supply chain management is suggested to shift demand from road to rail through a number of pathways for action related to planning and management, assets, train services, collaboration, legal issues and incentive schemes. The results were investigated from a fast moving consumer goods industry. (Colicchia, Creazza, & Dallari, 2017).

For **Wish 14: Ensuring the preferential treatment of the CT** the development of decision support systems and strategies based on CO<sub>2</sub> footprint of transport systems are suggested (e.g. GIFT - Green Intermodal Freight Transport - map, analyse, and evaluate with an intermodal corridor with innovative web tool (green observatory); Integrated and transnational strategy based on economic valuation of Well to Wheel CO<sub>2</sub> emissions from freight transport along main transalpine corridors (Nocera, Cavallaro, & Galati, n.d.)(Nocera & Cavallaro, 2016); Multi-level strategies that encourage modal shift based on environmental and social impacts (Nocera et al., n.d.); freight location-allocation model based on hub-location theory (Santos, Limbourg, & Carreira, 2015); model to compare the level of subsidies for shippers or carriers who shift from road to rail (intermodal)(Park, Kim, Park, & Kim, 2012). Model of Costs of competitive modes, which is

based on history data of costs for individual mode and sequences of time (Ferrari, 2013); Model for selection of the right ratio of minimization of operational costs and additional road taxes (Mostert, Caris, & Limbourg, 2017). Additionally a synchromodal framework was developed where shippers can manage their supply chains more flexibly to increase the potential for modal shift, without increasing total logistic costs and reducing service level. Environmental impact has an important role. (Dong, Boute, McKinnon, & Verelst, 2018). On strategic level EUSALP (EU strategy for the alpine region builds upon three general action-oriented thematic policy area and one cross-cutting policy area - mobility and connectivity; promote inter-modality and interoperability in passenger and freight transport) also through the Alpine Convention which is an existing, legally binding instrument and offers clear objectives for sustainable development, an important knowledge base and proven experience of effective alpine-wide cooperation, where NGO's (e.g. CIPRA International, ISCAR, Comité scientifique international recherché alpine, Alliance in the Alps, CAA- Club Arc Alpin, Alpine Town of the Year, WWF – World Wide Fund For Nature, ProMONT-BLANC, IUCN – International Union for Conservation of Nature) jointly promote the principles of environmentally friendly mobility as well as a large-scale modal shift of persons and goods traffic onto rail. Additionally reducing the costs of the last mile by introducing new solutions such as platooning, longer/heavier trucks, e-trucks, and LNG-trucks (e.g. COMBINE) are relevant. Preferential treatment of CT is to be possible also with recommendations to the public sector to support future policies and projects and reshape EU Programmes (**Susfreight; Sustainable Freight Transport guidelines**) and organizational conditions for intermodal terminals, transport networks and innovative transshipment technologies.

**For Wish 10. Stimulus package rail for lower prices** several regional or national subsidies already exists: (e.g. Austrian government program (Regierungsprogramm) (2013-2018); “Brenner Memorandum 2015” and the decision No 17/2014 of the parliament of South Tyrol ; Ministry of Infrastructure and Transport - Ministerial Decree 14 October 2010, n.750 "Incentives in favor of combined and trans-ship rail transport"; Decree on combined transport. Official Gazette of RS, Nos. 4/01 and 49/13). Introduction of Horizontal transshipment technologies is planned to be successful through subsidies mostly for rail line hauling, following with introduction of longer trains. Additionally policies that directly promote combined transport have a stronger effect on modal shift, that policies that discriminate against road traffic. Additionally the leverage of the transport policies for the medium range distance is significant higher than for the long distances (Truschkin & Elbert, 2013). Additional obstacle presents the institutional rail reform for open freight market, where the process of liberalization in some countries is still ongoing or questionable (e.g. Ukraine- (Grushevskaya, Notteboom, & Shkliar, 2016); (Dolinayova, Loch, & Camaj, 2016)).

**For Wish 12. Standard for ILU check (trains and truck check in) with standardised documents** directives and strategies on ICT/ITS in intermodal transport support the development through: Digital Single Market Strategy, 2015; ICT Standardization Priorities for the Digital Single Market, 2016; eGovernment Action plan, 2016-2020; European Interoperability Framework Strategy, 2017; Conclusions on the digitalization of transport, EU Council of Ministers, Dec 2017 : ““Transport needs to go digital to be competitive, connected, safer, cleaner and more inclusive”; 3rd Mobility Package, May 2018. Additionally support is needed through technical frameworks and directives: In framework of Data protection regulation (GDPR), Directive on cybersecurity (NIS), 2016; Revision of the Public Sector Information (PSI) Directive, 2018. Also RIS Directive; EETS Directive; ITS Directive; ERTMS framework; SES framework; VTMS framework. Regulation on Electronic Freight Transport Information (EFTI) is dealing with harmonized EU general framework for business-to-authority electronic exchange of “regulated” freight transport information. Regulation on a European

Maritime Single Window (EMSW) is the legal and technical framework for electronic transmission of information in relation to reporting obligations and procedures for the port calls in the Union.

**For Wish 7. Automated semi-trailer handling (long-term)** an integrated software concept was developed, which proposes a software guidance of unmanned combined transport, which includes animation and evaluation of simulated traffic on railway terminal and disposition of a large number of autonomously operating real commercial vehicles. (Zöbel & Weyand, 2010).

**For Wishes 4. 24/7 operating times of the terminals and 16. Uniform regulation of the language (lower requirements for train driver)** no relevant initiative were found.

## References

### Scientific journals

- Balashova, E. S., & Gromova, E. A. (2017). Russian experience of integrating modern management models. *Espacios*, 38(53).
- Bešković, B., & Twrdy, E. (2011). Agile port and intermodal transport operations model to secure lean supply chains concept. *Promet - Traffic - Traffico*, 23(2), 105–112. <https://doi.org/10.7307/ptt.v23i2.137>
- Carboni, A., & Deflorio, F. (2017). Quality and energy evaluation of rail-road terminals by microsimulation. In W. F. & D. G. (Eds.), *International Congress on Transport Infrastructure and Systems, TIS 2017* (pp. 617–624). Department of DIATI, Politecnico di Torino, Torino, Italy: CRC Press/Balkema. <https://doi.org/10.1201/9781315281896-81>
- Carrese, S., & Tatarelli, L. (2011). Optimizing the stacking of the Intermodal Transport Units in an inland terminal: An heuristic procedure. In *14th Meeting of the Euro Working Group on Transp. - In Quest for Adv. Models, Tools, and Methods for Transp. and Logist., EWGT, 26th Mini-EURO Conf. - Intelligent Decis. Making in Transp. and Logist., MEC, 1st Eur. Sci. Conf. on Air Transp. - RH* (Vol. 20, pp. 994–1003). University Roma Tre, Via Vito Volterra 62, 00146 Roma, Italy. <https://doi.org/10.1016/j.sbspro.2011.08.108>
- Chen, S.-L., Jeevan, J., & Cahoon, S. (2016). Malaysian Container Seaport-Hinterland Connectivity: Status, Challenges and Strategies. *The Asian Journal of Shipping and Logistics*, 32(3), 127–138. <https://doi.org/10.1016/J.AJSL.2016.09.001>
- Chirumalla, K., Jackson, M., Bruch, J., Andersson, N., & Löf, R. (2018). Exploring feedback loops in the industrialization process: A case study. In J. W., W. L., W. X.V., & O. M. (Eds.), *8th Swedish Production Symposium, SPS 2018* (Vol. 25, pp. 169–176). Mälardalen University, Drottninggatan 12, Eskilstuna, SE-632 20, Sweden: Elsevier B.V. <https://doi.org/10.1016/j.promfg.2018.06.071>
- Colicchia, C., Creazza, A., & Dallari, F. (2017). Lean and green supply chain management through intermodal transport: insights from the fast moving consumer goods industry. *Production Planning & Control*, 28(4), 321–334. <https://doi.org/10.1080/09537287.2017.1282642>
- Croucamp, P. L., & Telukdarie, A. (2018). Lean implementation for rail substation processes. *Journal of Quality in Maintenance Engineering*, 24(4), 468–487. <https://doi.org/10.1108/JQME-08-2017-0056>



- Dolinayova, A., Loch, M., & Camaj, J. (2016). Liberalization of the Railway Freight Market in the Context of a Sustainable Transport System. *Transportation Research Procedia*, 14, 916–925. <https://doi.org/10.1016/J.TRPRO.2016.05.071>
- Dong, C., Boute, R., McKinnon, A., & Verelst, M. (2018). Investigating synchromodality from a supply chain perspective. *Transportation Research Part D: Transport and Environment*, 61, 42–57. <https://doi.org/10.1016/J.TRD.2017.05.011>
- Ferrari, P. (2013). Freight transport through the Swiss Alps: Evolution as determined by application of a new model of modal split. *Ingegneria Ferroviaria*, 68(6), 547–565.
- García, A. (2016). Study of alternative operation strategies in railroad terminals using simulation. In F. J.M., P. G. P., & A. A. (Eds.), *International Conference on Industrial Engineering and Systems Management, IEEE IESM 2015* (pp. 725–732). Departamento de Ingeniería Mecánica, Universidad Carlos III de Madrid, Avda. De la Universidad, 30, Leganés (Madrid), 28911, Spain: Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/IESM.2015.7380239>
- Grimm, C. M., Kling, J. A., & Smith, K. G. (1987). The impact of U.S. rail regulatory reform on railroad management and organizational structure. *Transportation Research Part A: General*, 21(2), 87–94. [https://doi.org/10.1016/0191-2607\(87\)90002-1](https://doi.org/10.1016/0191-2607(87)90002-1)
- Grushevskaya, K., Notteboom, T., & Shkliar, A. (2016). Institutional rail reform: The case of Ukrainian Railways. *Transport Policy*, 46, 7–19. <https://doi.org/10.1016/J.TRANPOL.2015.11.001>
- Havenga, J. H., Van Eeden, J., & Pienaar, W. J. (2013). Supply chain cost improvement opportunities through streamlining cross-border operations. *Risk Governance and Control: Financial Markets and Institutions*, 3(3), 28–34. <https://doi.org/10.22495/rgcv3i3art3>
- Holter, A. R., Grant, D. B., Ritchie, J. M., Shaw, W. N., & Towers, N. S. (2010). Long-range transport: Speeding up the cash-to-cash cycle. *International Journal of Logistics Research and Applications*, 13(5), 339–347. <https://doi.org/10.1080/13675567.2010.518563>
- Hu, Q., Wiegmans, B., Corman, F., & Lodewijks, G. (2019). Integration of inter-terminal transport and hinterland rail transport. *Flexible Services and Manufacturing Journal*. <https://doi.org/10.1007/s10696-019-09345-8>
- Iannone, F. (2012). The private and social cost efficiency of port hinterland container distribution through a regional logistics system. *Transportation Research Part A: Policy and Practice*, 46(9), 1424–1448. <https://doi.org/10.1016/J.TRA.2012.05.019>
- Knoflachner, H. (2001). Problems caused by the motorway/railway freight traffic share in the Tyrol. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 215(1), 45–51. <https://doi.org/10.1243/0954409011530612>
- Komchornrit, K. (2017). The Selection of Dry Port Location by a Hybrid CFA-MACBETH-PROMETHEE Method: A Case Study of Southern Thailand. *Asian Journal of Shipping and Logistics*, 33(3), 141–153. <https://doi.org/10.1016/j.ajsl.2017.09.004>
- Li, Hong-Chang; Rong, Chao-He; Song, D.-X. (2008). Applicability and Methods of Lean Production in Railway Transportation Organization: A Case Study of Urumqi Railway Bureau in China. *International Journal of Railway*, 1(2), 45–58.

- Lu, H., & Ju, S. (2012). Network structure optimization of railway freight embedded in social logistics system based on combination betweenness centrality. *Zhongguo Tiedao Kexue/China Railway Science*, 33(6), 120–125. <https://doi.org/10.3969/j.issn.1001-4632.2012.06.19>
- Mostert, M., Caris, A., & Limbourg, S. (2017). Road and intermodal transport performance: the impact of operational costs and air pollution external costs. *Research in Transportation Business and Management*, 23, 75–85. <https://doi.org/10.1016/j.rtbm.2017.02.004>
- Nijkamp, P., Reggiani, A., & Bolis, S. (1997). European freight transport and the environment: empirical applications and scenarios. *Transportation Research Part D: Transport and Environment*, 2(4), 233–244. [https://doi.org/10.1016/S1361-9209\(97\)00014-X](https://doi.org/10.1016/S1361-9209(97)00014-X)
- Nocera, S., & Cavallaro, F. (2016). Economic valuation of Well-To-Wheel CO<sub>2</sub> emissions from freight transport along the main transalpine corridors. *Transportation Research Part D: Transport and Environment*, 47, 222–236. <https://doi.org/10.1016/J.TRD.2016.06.004>
- Nocera, S., Cavallaro, F., & Galati, O. I. (n.d.). Options for reducing external costs from freight transport along the Brenner corridor. <https://doi.org/10.1186/s12544-018-0323-7>
- Olesen, P., Powell, D., Hvolby, H. H., & Fraser, K. (2015). Using lean principles to drive operational improvements in intermodal container facilities: A conceptual framework. *Journal of Facilities Management*, 13(3), 266–281. <https://doi.org/10.1108/JFM-09-2014-0030>
- Park, D., Kim, N. S., Park, H., & Kim, K. (2012). Estimating trade-off among logistics cost, CO<sub>2</sub> and time: A case study of container transportation systems in Korea. *International Journal of Urban Sciences*, 16(1), 85–98. <https://doi.org/10.1080/12265934.2012.668322>
- Poojith, V. S., Vishnu, K., & Sahay, M. (2018). 5S in container terminals - A framework to reduce container demand uncertainty. In *2nd European International Conference on Industrial Engineering and Operations Management. IEOM 2018* (Vol. 2018, pp. 652–663). Amrita School of Business, Amrita Vishwa Vidyapeetham University, Coimbatore, Tamil Nadu, India: IEOM Society.
- Qiao, B., Chang, X., Hao, M., & Kong, D. (2012). Application studies of RFID technology in the process of coal logistics transport. In *4th International Conference on Digital Image Processing, ICDIP 2012* (Vol. 8334). Computers and Software College, Taiyuan University of Technology, No. 79, Yingze Street, Taiyuan City, Shanxi Province, Taiyuan, 030024, China. <https://doi.org/10.1117/12.966824>
- Rauch, P., & Gronalt, M. (2011). The effects of rising energy costs and transportation mode mix on forest fuel procurement costs. *Biomass and Bioenergy*, 35(1), 690–699. <https://doi.org/10.1016/J.BIOMBIOE.2010.10.015>
- Santos, B. F., Limbourg, S., & Carreira, J. S. (2015). The impact of transport policies on railroad intermodal freight competitiveness - The case of Belgium. *Transportation Research Part D: Transport and Environment*, 34, 230–244. <https://doi.org/10.1016/j.trd.2014.10.015>
- Truschkin, E., & Elbert, R. (2013). Horizontal transshipment technologies as enablers of combined transport: Impact of transport policies on the modal split. *Transportation Research Part A: Policy and Practice*, 49, 91–109. <https://doi.org/10.1016/J.TRA.2013.01.024>
- Wang, J.-S. (2017). Research on the Model of Lean Construction Based on the CAS Theory. *Journal of Railway Engineering Society*, 34(7), 96–100.

- Ye, C., & Chen, S. (2018). Research on the economic hinterland division of port sea-rail combined transportation. In *13th International Conference on Computer Science and Education, ICCSE 2018* (pp. 308–313). School of Economics and Management, Tongji University, Post-doctoral Degree in Business Administration, Shanghai, China: Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/ICCSE.2018.8468700>
- Zajac, M., & Restel, F. J. (2014). Bottlenecks of inland container terminals. In *12th International Probabilistic Safety Assessment and Management Conference, PSAM 2014*. Wroclaw University of Technology, Poland: Techno-Info Comprehensive Solutions (TICS).
- Zhang, Q., Wang, W., Peng, Y., Zhang, J., & Guo, Z. (2018). A game-theoretical model of port competition on intermodal network and pricing strategy. *Transportation Research Part E: Logistics and Transportation Review*, *114*, 19–39. <https://doi.org/10.1016/j.tre.2018.01.008>
- Zhi, P., Shi, T., Wang, W., & Xie, Y. (2018). Key Techniques for Lean Construction Management of the High Speed Railway Tunnels. *Modern Tunnelling Technology*, *55*(6), 26–32. <https://doi.org/10.13807/j.cnki.mtt.2018.06.004>
- Zöbel, D., & Weyand, C. (2010). An integrated software concept for autonomous driving in the context of intermodal freight traffic. In *6th International Conference on Autonomic and Autonomous Systems, ICAS 2010* (pp. 125–130). Institute for Software Technique, University Koblenz-Landau, Koblenz, Germany. <https://doi.org/10.1109/ICAS.2010.25>

#### Web

- <https://www.alpconv.org/en/home/topics/transport/>
- [https://www.alpconv.org/fileadmin/user\\_upload/downloads/downloads\\_en/1\\_convention\\_en/convention\\_protocols\\_en/transportprotocolEN.pdf](https://www.alpconv.org/fileadmin/user_upload/downloads/downloads_en/1_convention_en/convention_protocols_en/transportprotocolEN.pdf)
- <https://www.alpconv.org/en/home/organization/observers/>
- <https://alpenallianz.org/en/alpine-convention>
- <https://www.cipra.org/en/media-releases/ngos-and-networks-for-a-macro-region-alps>
- <https://www.cipra.org/en/media-releases/ngos-and-networks-for-a-macro-region-alps/131212commoninputeustrategie.pdf/inline-download>
- <https://www.eda.admin.ch/aboutswitzerland/en/home/dossiers/die-schweiz-und-ihre-bergrekorde/nicht-regierungsorganisation-cipra.html>
- <https://www.cipra.org/sl>

#### + AlpInnoCT Deliverables and working documents