

Implementation of a new intermodal transport concept – From proof of concept to decision criteria for market introduction

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Abstract

Over the course of three years the EU Project TelliSys developed a market-oriented intermodal transport technology concept opening new opportunities for intermodal transport in Europe and abroad. The capabilities of the system have been proven during an extensive evaluation phase, including a profitability analysis, life-cycle assessment and test runs throughout European transport networks. This paper describes in detail the proof of concept of the new intermodal transport system and discusses the lessons learned from the evaluation phase. Derived from this evaluation, the decision criteria for choosing or avoiding intermodal transport from forwarder’s and customer’s perspectives are presented, taking into account the requirements for the implementation of different use cases. The results show that the new transport system addresses current market necessities, opening new possibilities for the intermodal transport due to the enhanced competitiveness compared to road transport.

Key words: freight transport, logistic, intermodal loading unit, decision criteria, market requirements.

1. Introduction

The increasing transport demand and the resulting growth in traffic volume, leads amongst other things to significantly overcrowded roads and is also a key reason for environmental pollution and climate change. At the same time, transport is vital for economic growth and a fundamental part of all industrialized nations. To mitigate the disadvantages and strengthen the advantages, the development of new, efficient and more environmentally friendly transport systems is a crucial challenge for modern societies. For decades, intermodal transport is considered in Europe as a potential solution to the substantial problems of today's transport system [2]. Unfortunately, the flexibility to react to changing requirements, the complexity of intermodal logistic processes, the primacy of road transportation and, last but not least, the price impede an extensive shift from road to intermodal transport. The potential shift from road to combined transport in Germany has been estimated to a share of 8% in 2014 [1]. However this value may change in the future depending on factors like the oil-price, driver availability and road conditions or new European policies attempting to react to the climate change and forcing the reduction of CO₂ emissions.

The European Commission but also manufacturers and supply carriers widely promote the use of more environmentally friendly and flexible transport systems [6]. The European Commission set the goal to shift 30% of road freight over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050 [2]. Intermodal transport will play an important role in any serious attempt to reach these goals. However, for an economically and environmentally feasible deployment of intermodal transport concepts on a larger scale, decisive questions remain unanswered. The major questions are: How to decide whether or not an intermodal route should be preferred in comparison to conventional road transport; which are the obstacles and what has to be changed in order to offer an attractive intermodal transport solution for the industry?

This paper gives answers to these questions. We present and discuss the proof of concept and the market implementation of a new intermodal transport system in Europe. The lessons learned from the recently finished project TelliSys together with the conducted interviews, workshops and surveys helped to answer the raised questions and to derive decision criteria for choosing or avoiding intermodal transport from forwarder's and customer's perspectives. This paper is structured in five chapters. After this first introduction, the project idea of TelliSys and key results of the project are discussed briefly in the second chapter. The third chapter contributes to answer which requirements are taken into account in order to decide the best transport solution. This chapter gives a detailed overview of the conducted test runs and the criteria for evaluating the concept, including an economic and environmental assessment. The fourth chapter discusses the decision criteria comparing different transport systems and presents obstacles and reasons for or against the choice of this intermodal transport concept from forwarders and manufacturers point of view. The paper concludes with an outlook on future developments.

2. A new intermodal transport concept

Within the EU project TelliSys ("Intelligent Transport System for Innovative Intermodal Freight Transport") a new intermodal transport system has been developed to contribute to a more efficient European transport and aiming to optimize the performance of intermodal logistic chains. This new transport system is composed by a family of new loading units, a super low deck truck and a

suitable chassis that enables the transport of the new loading units during pre and post carriage (cf. Figure 1). After analysing current loading units and in response to the wide variety of market requirements [8, 9], a number of different loading units have been defined for different use cases.



Figure 1: a) TelliSys system during handling operations b) Automotive loading unit.

Table 1 gives an overview on the different members of the TelliSys loading unit family. The Continental loading unit (LU), for example, includes variants with a length of 40 ft. and 45 ft., an internal height of 2940 mm and an internal width suitable for EU pallets. It has one openable long side using a purpose-built sliding-curtain and hinged roof while being stackable and offering a payload of 24 tonnes. This loading unit combines the advantages of a swap-body — like flexibility during the loading/unloading processes and the ability to be transported on rail and short sea without the unnecessary weight of a chassis — with the advantages of a container — like being stackable, robust, and theft proof.

Table 1: Family of intermodal loading units [5]

Characteristics	Continental LU	Automotive LU	Intercontinental LU
Size	40 ft. /45 ft.	45 ft.	40 ft. / 45 ft.
Height (internal)	2940 mm	2970 mm	2970 mm
Width (internal)	Euro-pallet	Euro-pallet	Euro-pallet
Long sides	One open	Two open	Closed
Payload	24 t	27 t	Min. 24 t
Roof	Hinged	Hinged	Hinged
Handling	Corner castings	Corner castings, Grappler pockets	Corner castings, Grappler pockets
Stackability	2 times	Not stackable	3 times

In addition, a special automotive loading unit has been designed and built, based on the requirements of the automobile industry. The Automotive box has a length of 45 ft., with an inside height of 2970 mm, EU pallet width, and can be opened on both long sides. It also has a hinged

roof for easier loading and 24 tonnes payload [7]. The main advantage of this design is the possibility to stack up to three standardised box pallets commonly used in the automotive industry, effectively allowing for up to 50 % more cargo volume compared to standard swap-bodies or ISO containers.

The market requirement to maximize the internal loading height together with the legal requirement of keeping the total vehicle height underneath 4 m in road transport, presented a technical challenge for the vehicle combination: truck, trailer and loading unit. To be able to carry and load three layers of one meter height boxes a super low deck tractor had to be developed in order to lower the fifth wheel height as far as possible. The developed super low-deck tractor achieves a fifth wheel height of 8500 mm, which is 600 mm lower than current “low deck” tractors available on the market. This has been possible by lowering the chassis behind the engine and by the use of a very compact rear wheel suspension in combination with purpose-built 22.5" wheels on the driven axle [4]. In addition, the special low-deck tractor has a lightweight 4.0-tonne trailing axle with 17.5" wheels to allow a GVW of 44 tonnes. The decision for a 6 x 2 axle configuration allows the 44 tonnes GVW within legal requirements in Europe and has also fuel economy reasons [4]. The special new low profile tyres for the steered and driven axles are characterized by a very low height with high load capacities. To complete the transport system a special lightweight trailer with a low weight of just 3,830 kg and a coupling height of 8500 mm has been developed [3].

3. Proof of concept

During more than two years the international consortium focused on the development of the proper system to meet the requirements of the European intermodal transport. These market requirements were introduced in a previous paper [9, 11]. In order to prove the concept and create a link between scientific research and market implementation the new developed transport solution was tested and evaluated by researchers, developers, truck drivers, forwarders, terminal operators and manufacturing companies. The goal of this process was to demonstrate the system competitiveness and its ability to offer a solution for the current intermodal market.

Therefore specific use cases were defined and corresponding tests were performed by international freight forwarders within their intermodal transport operations. A total of four different prototypes were built and tested: Two loading units (Continental and Automotive), a trailer chassis and a super low deck truck (including the newly developed tyres). The successful completion of these tests is a proof of concept for the feasibility of the new intermodal system.

In order to evaluate the performance of the system the following criteria were taken into account: flexibility of loading processes, inside height, flexibility of handling operations at rail or barge terminal, cargo security, theft proof, maximum payload, stackability, transportation on sea and inland waterways, train transportation (e.g. the use of special wagons), road transportation and clearance, transport volume capacity, transport costs and environmental impact (e.g. CO₂ emissions per km). The performance evaluation of these criteria involved all project partners and consisted of various workshops, surveys and interviews for direct user feedback.

3.1 System tests

The different parts of the transport system undertook various tests between March 2015 and September 2015. Table 2 summarizes the characteristics and details of the tests performed. The first test for the Continental LU covered the route between the Netherlands, Germany, Switzerland and Italy focussing on rail and road transport and the required handling operations in multimodal terminals. Within the second test run in July 2015, the new transport system operated on the line between Germany, France and the Netherlands by combining road and barge movement, including all operational aspects belonging to these modes of transport.

In addition the second prototype, the Automotive LU was thoroughly tested as an interesting transport alternative to the currently dominant mega-trailer. For the automotive LU, road transport behaviour and load capacity tests were performed by different carriers. Afterwards this LU was tested in round trips covering the route between Italy and Turkey for more than two months.

Table 2: List and characteristics of tests performed for evaluation of prototypes in European market

Prototypes	Test Nr	Course	Time	Mode of transport	Test performed
Truck, trailer chassis and Continental LU	0	Functional tests and certificates procurement	Dec. 2014 to Feb. 2015	–	Certification of all prototypes to be used in Europe (e.g. CSC certificate and railway label for the Continental LU)
	1	Eindhoven (NL) - Herne (DE) - Busto-Arizio (IT) - Herne (DE) - Mainz (DE) - Ascheberg (DE)	7 days (March 2015)	Road (approx. 400 km) Rail (approx. 1600 km)	Road and rail transport, loading processes (rear and lateral door) and handling at railway terminal
	2	Ascheberg (DE) - Amiens (FR) - Karlsruhe (DE) - (Rotterdam (NL))	6 days (June 2015)	Road (approx. 1500 km)	Road transport, loading processes and handling in inland waterway terminal
Truck, trailer chassis and Automotive LU	3	Germany and France	May 2015	Road (approx. 2000 km)	Road transport, loading processes, handling in multimodal terminal and barge transport
Trailer chassis and Automotive LU	4	Round trips between Italy and Turkey	June-September 2015	Road and Barge	Round trip tests for a customer-specific use case between Italy and Turkey with barge transport

3.2 Performance evaluation

The new transport system performed very well regarding the following aspects: road transport, clearance between vehicle components, clearance between vehicle and ground, flexibility during loading and unloading processes, and maximized transport volume. Also the required handling procedures for road, rail and barge transport were proven to be no issue. The handling operations of the automotive MSB did not encounter any problems during combined transport, making use of the grappler pockets to handle the loading unit. The internal height of 2970 mm is the key feature for the success of this loading unit.

For the Continental LU, the handling of the loading unit proved to be the biggest issue, as it is limited to those terminals with the necessary equipment to crane a loading unit from the 45 ft. corner castings position. Thus, the technical equipment of intermodal terminals along the supply chain of combined transport became a bottleneck for the Continental LU. A later study on the use and sale of new equipment having the ability to crane container from the 45 ft. corner castings position pointed out that currently approximately 10 % of European terminals (out of 100 enquired terminals) have the required equipment on hand¹¹. This emphasizes the need for infrastructural development on a broad European level, e.g. improving the availability of cranes able to handle containers from the 45 ft. corner castings position, in order to push the competitive level of combined transport. For the remaining test runs, the results of the study highlighted the importance to ensure that the selected route (including terminals) matched the handling requirements. Thus, the transport planning was highly influenced by the technical layout of terminals along the chain of combined transport.

The barge transport, which was also a stress test for the stackability of the Continental LU, was part of the initial plan for the second test run. Standard containers can be stacked at least 5 times which is the requirement to be fully suited for barge transport. The containers get moved around during the transport and can result that the container is going to be positioned in the bottom layer with 4 containers on top of it. Since the Continental LU is only 3 times stackable, it was assumed that terminal and barge operators could refuse to transport the Continental LU due to loss of flexibility and impossibility to crane the LU at certain terminals. This happened during the second test run in Karlsruhe. While craning the Continental LU was not an issue, the barge operator refused to take it on board because not all terminals on the route have the required equipment. However the barge transport between Italy and Turkey for the Automotive LU, which is not stackable, was performed without any issues.

The specifically for TelliSys developed super low-deck truck and trailer with a coupling height of only 850 mm performed very well during the test runs. The truck and the trailer performed during more than 11,000 km test drives always as expected. Even height differences that were challenging due to the low fifth-wheel height and low ground clearance were mastered by the truck and trailer without any complications, thanks to the newly developed suspension system. This new low-deck truck required special tyres to be able to achieve an 850 mm coupling height while having a gross

¹ Study performed by the company GEFCO Deutschland GmbH on the use and equipment acquisition of cranes which are able to handle containers from the 45 ft. corner casting position. Enquiry performed in summer 2015 to 100 multimodal terminals in Europe.

vehicle weight of 44 t. Therefore special new low profile tyres for the steered and driven axles, which are characterized by a very low height with high load capacities, were developed.

Besides this qualitative performance evaluation of the new system, the economic and environmental performance is an important factor for the decision to promote and use this intermodal system. Based on a realistic scenario, data from real transports of a transport operator for the automotive industry were used to calculate the economic and environmental performance of the new system. Since the evaluation is based on real data, we also set the currently dominant road transport via mega-trailer as a baseline scenario and compared it with an intermodal transport using the TelliSys, which we see as a target scenario for the future. So that three routes were designed for the specific transport systems: one route over road for the mega-trailer system, an intermodal route for TelliSys system and the same intermodal route for a standard transport system with 45 ft. High Cube ISO container.

The volume capacity combined with the use of railway transportation instead of road transport over more than 1,000 km show in a profitability calculation that the customer can save up to 15% in comparison to the mega-trailer system by using TelliSys (cf. Figure 2a). [11]

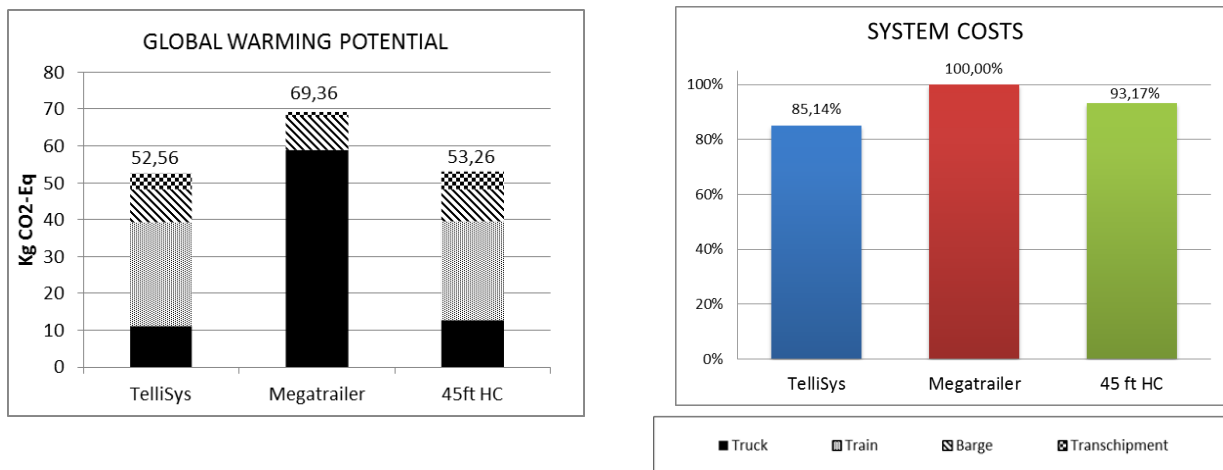


Figure 2a) System costs per year in % for the same cargo and 2b) Comparison of global-warming potential of different transport systems (functional unit of 1 m³ of cargo) [10]

Likewise, in order to evaluate the environmental burdens of the TelliSys transport system, data from the same cross European route as for the economic evaluation was gathered to perform a Life Cycle Assessment (LCA). As pointed out earlier, TelliSys was developed to increase the environmental efficiency of transport in the European transport sector while being able to compete with leading transport systems. In the LCA, TelliSys was compared with the mega-trailer and the 45 ft. High Cube ISO container system within their operation phase of the product lifecycle.

From an environmental point of view, the results of the life cycle assessment [10] show that TelliSys performs significantly better than the mega-trailer system in five impact categories: Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP), Depletion of Abiotic Resource (DAR) and Ozone Depletion Potential (ODP). In the prominent impact

category GWP the TelliSys result is about 24 % lower than the result of the mega-trailer system and slightly (1%) lower than the result of the 45 ft. HC container system (cf. Figure 2b). In the categories land use, marine aquatic ecotoxicity potential and photochemical oxidation, the results of TelliSys are higher than the ones of the mega-trailer system, which is related to the specific environmental impacts of train transport versus road transport (infrastructure, equipment etc.). This indicates that using TelliSys technology and the intermodal route, a total of 16.8 kg CO₂ – Eq. per m³ transported cargo can be saved [10].

4. Decision criteria for market introduction

Derived from the above presented evaluation the decision criteria for choosing or avoiding intermodal transport from forwarder's and customer's perspectives are presented, taking into account the requirements for the implementation of different use cases. Besides, the acceptance of the new transport system and the lessons learned from the evaluation phase are discussed.

In order to analyse the market introduction of this new transport system, several meetings with manufacturers, logistic and supply chain actors took place. While planning a new transport or a shift from road to intermodal transport, the analysis considered following steps, actors and factors (see figure 4):

1. Analyse the specific use case from manufacturer and forwarder side including the evaluation of the route, delivery frequency, return cargo in order to establish round trips, costs and possible environmental advantages.
2. Select the logistic service provider responsible for transport planning, provision of equipment (own resources or leased fleet), billing and process coordination between different carriers, terminals, etc.
3. Analyse loading unit requirements and define loading and unloading cargo processes.
4. Define a route according to available transport network and suitable terminals considering equipment and handling processes.
5. Select carrier and barge and/or train operator.

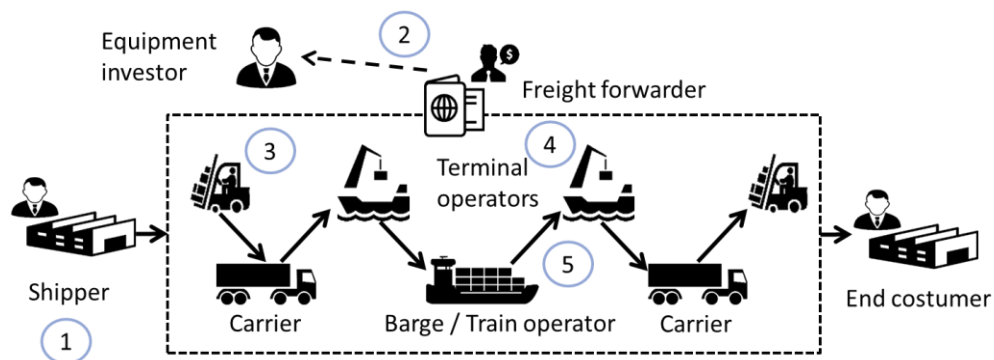


Figure 3: Schema of process and involved actors

Table 3: Decision criteria and comparison between most used high volume capacity loading units

	Continental LU	Automotive LU	Megatrailer	45 ft. HC ISO	45 ft. HC EU
Loading Processes	Rear and side loading	Rear and side loading	Rear and side loading	only rear	only rear
Loading Inside height (m)	2,94	2,97	3	2,69	2,69
Handling on terminal	corner castings	grappler pockets	grappler pockets	corner castings	corner castings
Cargo security	Yes	Yes	Yes	Yes	yes
Theft proof	yes (++)	yes (+)	yes (+)	yes (++)	yes (++)
Payload (t)	24-25	24-26	25	26	26
Stackability for storage	yes (+)	No	No	yes (++)	yes (++)
Transport sea and inland waterway	Yes	Yes	very limited	Yes	yes
Train Transport (special wagons)	low floor wagons	low floor wagons	pocket wagons	low floor wagons	low floor wagons
Road Transport and Clearance	Yes	Yes	Yes	Yes	yes
Volume capacity (m3)	100	100	100	86	89
Costs (%)	85	85	100	93	93
GWP (%)	76	76	100	93	93

Legend: (++) always applicable (+) possible in some cases

Table 3 presents the key decision criteria for choosing a transport system specified during the implementation of the new transport system. These criteria helped to compare the new system against current alternatives. The right choice of transport will always depend on the use case. The two new developments have new characteristics and are adapted to satisfy the current market requirements, which is not the case until today. On one hand the Continental LU enables maximized volume transport. On the other hand the Automotive LU satisfies the requirements for the automobile industry as mentioned in [11]. Besides, due to the modular design of the new developed loading units, changes in the components to satisfy specific user requirements can be applied easily. Thereby, the final inner height, materials used for the side wall, loading capabilities, cargo security requirements or adjustments in the handling components can be customized for a specific cargo or transport scenario.

The freight transport activity in Europe will keep on rising in the coming 35 years – with an increase of around 25 % until 2030 and 40 % until 2050 [12]. The current European transport system is not capable of meeting the challenges that arise from this development. Europe therefore is in need of a more efficient transport system, including a stronger focus on intermodal transport. During the TelliSys project it became very clear, that, to promote intermodal transport, further infrastructural development and investment in equipment is required.

5. Conclusions and outlook

The outcome shows that the new transport system addresses current market necessities opening new possibilities for the intermodal transport due to the enhanced competitiveness compared to road transport. Transport requirements as height, volume capacity, handling flexibility or stackability play an important role for the forwarder's decision for the suitable transport solution. To find the transport system for your use case with the right requirements implicates direct costs spared.

The TelliSys system opens new intermodal market possibilities, being the first loading unit able to transport efficiently up to 100 m³ by road, rail and water. Thus the system is very competitive compared with the favourite road solution: the mega-trailer. Due to its total internal height of up to 2.97 m and the flexibility of its loading process, customers transporting their goods by road with a mega-trailer may change easily to intermodal transport using the TelliSys system without changing their standardized production processes while transporting at least the same cargo amount. Besides, this flexibility stimulates horizontal and vertical cooperation between costumers and hauliers and eases the matching of cargo for return trips, thereby reducing the number of empty trips.

Based on the project experience and the conducted interviews, following obstacles for offering an attractive intermodal transport solution to the industry can be named:

- Lack of (or inadequate) communication between all actors involved in the supply chain
- Very limited data exchange and lack of cooperation between shippers and freight forwarders
- Flexibility of schedules in intermodal transport compared to road transport
- Complexity of organisation and time effort

These obstacles are to be challenged as the intermodal transport in Europe is awaiting great changes within the next years: Developments like the synchronization of production and logistic, the synergy-effects on transport goods between OEMs and carriers, a better shipment monitoring or the data analysis and optimization algorithms for better planning and reaction to unexpected changes while aiming the achievement of a global optimum, will help to overcome the described obstacles.

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