

# **PALLETFLOW - DEVELOPMENT OF AN INTELLIGENT AND INNOVATIVE INTERMODAL TRANSPORT SYSTEM BASED ON PALLETIZED AND UNIT LOAD CARGO IN EUROPE**

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## **ABSTRACT**

Within the field of cargo transport multimodal transport in general and in particular the bimodal rail-road processes have so far contributed rather insignificantly to the reduction of road traffic volume. This is the result of limited capacities concerning terminals, the necessity of special reloading devices entailing high investment costs and time losses handling the cargo, as well as wide-spread scepticism regarding adherence to delivery dates, traceability of consignments and flexibility of intermodal transport. The research project PalletFlow has the goal to develop and implement an intelligent and innovative rail-road transport system based on pallets and unit-load cargo in order to eliminate these problems. PalletFlow combines the carrier-specific advantages of rail (main leg) and truck transport (collection and distribution on the pre- and post-carriage) with the quick and economical reloading process by fork-lift trucks as well as the benefits of a neutral service centre and an innovative business model for the customer.

*Keywords: modal shift, competitive rail-road transport, low-cost reloading, market-driven multimodal solution*

## **INITIAL STATUS**

The Austrian economy is highly export-oriented; exports represent 43.7% of the gross domestic product (Statistic Austria, 2008). From a macroeconomic perspective, goods traffic is the driver of commercial exchange and prosperity, it is a necessary component of an

international economy based on the division of labour (Buchholz/Clausen/Vastag, 1998). In order to guarantee the competitiveness of Austria and/or central Europe in the long-term, an efficient goods traffic sector is essential. The sustainability of the quality and the competitiveness of Austrian business locations require adequate qualitative and capacitive access to the procurement and sales markets.

Efficient transport systems are the basic condition for every successful economic area. The functioning can only be guaranteed by high effectiveness of the individual carriers and a close co-operation between the different modes (EESC, 2007). Parallel to the economic dynamics the needs concerning the traffic system are constantly changing. The accurate management of the changing requirements is difficult because of the continuous growth of the goods traffic and the various resulting problems.

Several internal and external traffic-related changes in the decision structures of the goods traffic substantially affected the modal split in the past decades. These changes can be categorized as structural, logistics, integration and interface effect and are the main factors for the disproportional development of the modes (Aberle, 2002). The ability of innovation as well as the flexibility are reasons for the domination of road transport. In this context the mode-specific system characteristics are of extreme importance (Pfohl, 1996).

The system properties of truck transports in particular matches today's requirements of the shipping and receiving economy. The interactional effect of the different influencing variables yields clear market advantages for road transport. Unsurprisingly the statistic data in Europe verifies that the majority of the goods is (and will be) transported by truck. Without any effective counteractive measures this development will dominate the future progress as well.

## **Problem**

Despite the expected considerable growth rates of goods traffic in the coming decades from the present perspective railways will not gain a corresponding share of the modal split, but will more likely stagnate at today's level (BMVBS, 2007). A substantial reason for this is because rail transport does not meet the requirements of the logistic concepts (JIT, JIS, etc.) of the producing and as a result shipping economy. Additionally transport decisions of the shipping economy are taken against the background of available quantities and qualities of the individual mode of transport and the associated traffic network (Aberle, 2002). Within these market areas rail transport, independent of the system properties like schedule-fixation, mass transport capacity, specific organisational structure, etc. (Berndt, 2001), has clear disadvantages in many aspects compared to road transport. In reference to the market, rail transport not only suffers from the effects of the changing requirements of the transportation market (Aberle, 2008) but also from not reacting timely and adequately to these changes; from the perspective of the overall traffic system the potential for improvement remains unused.

In order to obtain sustainable modal shift effects in favour of rail and multimodal transport processes, new fundamental solutions are required. In short, innovative and market-oriented

services are needed (Aberle, 2005). The classic transport from A to B can rarely satisfy the needs of the present economy. Apart from the basic services of transport, value added services (e.g. information services) are also necessary. To satisfy the needs of the customer rail transport has to create and offer new market-driven products and comprehensive logistic solutions. Therefore integrated product solutions like the inclusion of first and last mile concepts are of prime importance (Berndt, 2001). Multimodal transport contains a lot of unused potential and is the competitive service to the truck. More than that, multimodality is a substantial criterion in terms of transport decisions (Buehler, 2006). To underline the importance of multimodality: prognoses of the UIC predict (compared to 2005) indicate a 102 percent increase of intermodal transport volume up to 2015. This growth trend should continue and even accelerate beyond that date (UIC, 2008). Of course, due to the current market crisis there will be some temporal growth slowdown.

### *Disadvantages of Multimodal Processes*

Multimodal transportation is a complex procedure, in which all the components should be seamlessly linked and efficiently coordinated. Disparities in economic development, transport policies, infrastructure across nations and modes of transport make the integration of multimodal processes a challenging task for all stakeholders. To be in line with the project goals, this paper focuses on bimodal transport solutions. The intelligent combination of the two carriers road and rail makes it possible for goods to be transferred in the most careful and efficient way. However, as mentioned above, too often multimodal services lack the ability to compete in daily transport business.

Regarding the status quo a number of concrete problems for bimodal and rail processes can be named: (1) cross-border transports causes additional costs (e.g. time lags, change of train driver, additional equipment per country) (2) lack of flexibility, planning reliability and on-time delivery, (3) capacity problems (e.g. rail tracks, terminals, rolling stock), (4) prioritization of passenger traffic, (5) policy of high pricing, (6) lack of interoperability, (7) interface problems between the carriers, (8) absence of customer orientation and individual service levels, (9) not existing or capable multimodal (cross-border) business models, as well as (10) insufficient regional structures and the absence of connections to corridors (EU-Commission, 2007 and Siegmann, 1997).

### **Idea**

The key idea is to develop an efficient end-to-end movement of goods using two modes of transport and a horizontal ground-level reloading process in an integrated transport chain. In the current economy, palletized goods or palletizable cargo represent a substantial contingent of industrial cargo volumes. Therefore the industry – based on division of labour – has a constantly growing requirement for transporting these goods. By taking advantage of the innovative multimodal PalletFlow-process the above mentioned problems can be eliminated and the requirements of the industry successfully fulfilled. Pallets and

corresponding “unit load” cargo can be reloaded quickly, safely and economically at ground level as well as at platform level by fork-lift trucks. For the pre-and post- road carriage “curtainsider” trucks are used. In this context reloading from “curtainsider” road vehicles to/from train trucks is also possible. Road- as well as rail-side reloading types of palletized goods which are both realized on the basis of the same principle (sidewise loading and unloading by fork-lift trucks) offer the possibility of implementing PalletFlow-loading junctions within the intermodal road-rail cargo transport.

## **APPROACH AND METHODOLOGY**

The fundamental idea of the PalletFlow-concept is to build the whole process on existing equipment, components and technologies as well as two important aspects of innovation. First, PalletFlow is an intelligent combination and adaption of already existing processes. The reloading process is realized by fork-lift trucks while the bimodal transport process combines the main leg by rail with the pre- and post-road carriage by trucks. In order to improve the current information and communications-systems (ICT), most of the existing hardware components have to be redesigned, and the software modules are to be adapted to the altered hardware and to the new PalletFlow processes. Second, the business model and a Neutral Service Centre (NSC) should correct and eliminate most of the well known problems of the present intermodal and bimodal transport solutions.

Problems of quality and acceptance which so far have impeded the commercial success of multimodal rail-road transports will also be avoided by the composition of the project consortium.<sup>1</sup> Through co-operation with logistics service providers as well as an additional railway undertaker (RU) it is possible to focus on both supply and demand. The research project is divided into two main phases: the preliminary study and the pilot study. Within this framework the main steps are:

1. examination of technical feasibility
2. analysis of marketplace potential and evidence of business application
3. implementation of reloading test runs and shuttle transports
4. appraisal of the results of the demonstration.

### *Goals*

The main goal of the research project PalletFlow is to develop and implement an intelligent and innovative intermodal transport system for the handling of cargo when exchanging goods between truck and train on the basis of palletized- and unit-load cargo which is supported by modern technologies of identification, communication and transport planning. The second goal is to support a significant increase in the total volume transported by multimodal processes combined rail-road transport) and as a consequence to change the modal split in favour of the carrier rail.

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<sup>1</sup> The PalletFlow project is transnational and therefore consists of two national consortiums with two research institutes and 7 companies.

### *Aspects of Innovation*

The most obvious aspects of innovation are the NSC and the business model itself. Both can be seen as unique selling propositions. By combining the easy and quick sidewise loading and unloading by fork-lift trucks with the benefits of road transport on short and rail transport on long distances, as well as the advantages of the NSC, a sustainable *all-encompassing holistic, implementable and competitive service* can be offered. The NSC has various duties and responsibilities. First and foremost the NSC is responsible for the successful processing and the organisation of the whole transport procedure. This entails customer support, process of buying, accounting, tracking and tracing, reloading processes, purchasing the rail and road transport capacities plus pre- and/or post- road carriage. For the services of the NSC a very small usage fee will be collected, for example 1 Cent per pallet.

### *Expected Results*

The results of the research project PalletFlow are a detailed draft of the concept, the basic information and framework for the business model as well as a catalogue of requirements for the intended implementation and a comprehensive rollout. Furthermore the verification of the operative feasibility in the form of a demonstration is contemplated and with the help of industry partners and the transnational consortium different types of domestic and cross-border tests of the system will be conducted. Additionally, necessary technologies are developed and tested within a demonstration-framework.

## **MARKETPLACE AND INFRASTRUCTURE ANALYSIS**

### **Marketplace Analysis**

The overall analysis of the market potential for Austria is based on a bottom-up as well as a top-down approach.

The bottom-up analysis consists of face-to-face interviews and a comprehensive online questionnaire. In the course of the interviews in Austria, 13 important leading companies (big players) from all fields of business were asked. Additionally, a comprehensive online questionnaire was carried out. For both kinds of analysis a questionnaire with overall 76 questions, divided in the categories inbound, outbound and general was composed. To determine the target group of the online questionnaire, based on the criteria of turnover, kind of goods and on the shipper ranking, 320 companies have been selected and contacted. The return rate averaged 7,5 percent. These 320 companies also represent the theoretical and practical maximum market potential for PalletFlow in Austria while the 13 “big players” mark the representative sample.

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The bottom-up estimation of the overall Austrian potential is based on a qualitative empirical analysis conducted on the basis of the turnover of the companies. The estimation only includes relations over 300km and a 48 hours time slot as well as palletized goods or palletizable cargo. The numbers do not include reefer cargo and hazardous products.

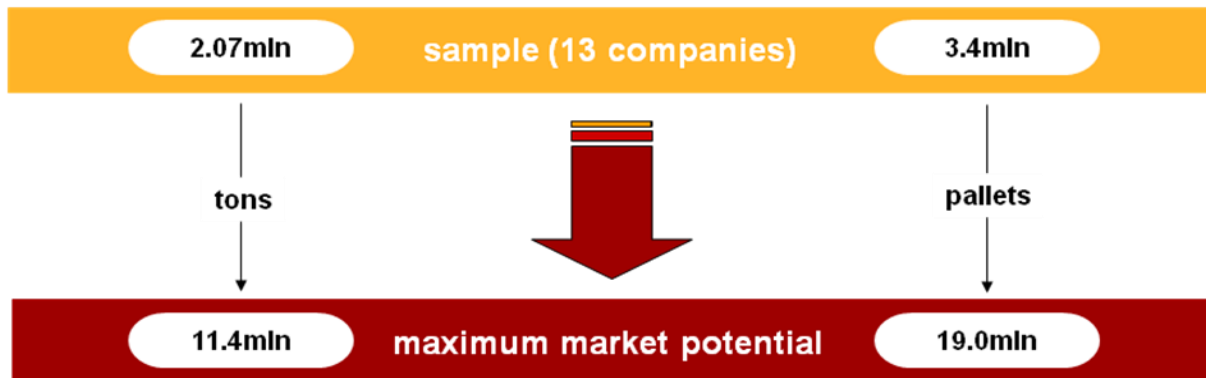


Figure 1 – The maximum market potential for Austria based on the bottom-up analysis

The top-down analysis is based on the cargo volume in tons of the source-drain transportation flows in Austria including, regional traffic, transit and international flows of the year 2005. The base data originates from the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit). For this analysis the PalletFlow-capable categories of goods were selected and the regional traffic and transit transports were excluded. Distances within Austria of less than 300km were not taken into consideration. The lack of information regarding the percentage of transports with a 48 hours time slot was compensated for by using an additional so called “empirical key of realization”. This key, calculated within the bottom-up analysis on the basis of real companies data, is about 30,1 percent and finally provides reasonable numbers.

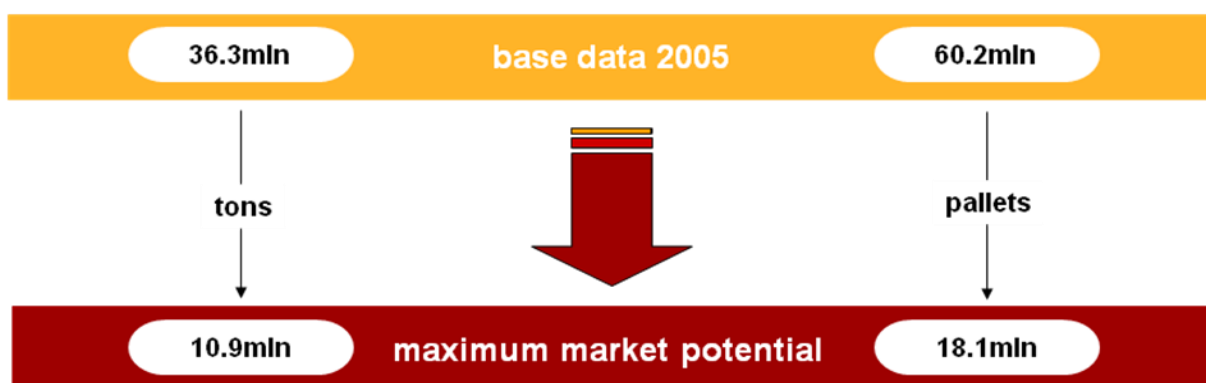


Figure 2 – The maximum market potential for Austria based on the top-down analysis

The market analysis shows notable potential and both bottom-up and top-down analysis approaches estimate similar numbers. According to these results the overall realizable freight potential p.a. would be between 18 and 19m pallets and/or 10.9 to 11.4m tons. In percent the

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potential in relation to the maximum market potential is about 25%. A calculation based on a tonnage factor of 24 tons per truck indicates that the market potential is more than 790,000 loads per annum. Therefore the annual railway freight could be raised by approximately 10 percent and the amount of unit-load suitable freight even by 50% in Austria.

## **Modal Shift**

This chapter shows the percentages of each transport mode for Germany and Austria (the measurement unit is tonne-kilometre). Considering the share of rail, the modal split in 2008 differs markedly across the countries Austria and Germany, while in Germany the share is at 15.9 percent, the share in Austria is more than twice the number (32.5%). In both countries road transport is leading and accounts for 73.1% in Germany and 63.8% in Austria. On the last place accounts the inland waterway transport with 11.0% (GER) and 3.7% (AUT). From today's perspective, future trends show a rather similar pattern (BGL, 2009 and bmvit/Logistikum, 2009).

In order to change this pattern and to be competitive the project-target is to establish PalletFlow-loading junctions at logistically relevant locations or rarely used railway sites and side tracks which provide a rapid, well organized and highly efficient loading of palletized goods. Contrary to other types of intermodal transport like containers or other systems with high investment costs the PalletFlow-system does not need any kind of backfitting of road- or rail side truck material. In fact no adaptation with regard to the loading junctions is necessary.

In summary, one of the main objectives is to develop a reloading process for combined rail and road transport that will make co-modality more competitive in comparison to road transport by taking market share from trucks. This should support the EU policy of balancing modal split between road and rail freight transport. After successfully conducting the marketplace analysis of the PalletFlow concept a realistic timeframe of 10 years was identified in which a shift up to 15 percent could be possible. In regard to the combined estimated total volume of unit-load suitable freight for Austria and Germany, which is around 120 million tons, the shift volume would be 18 million tons p.a., while the target number for Austria would be 1.75 million tons. When converted into truck-loads the potential for shifting adds up to a remarkable 750,000 loads for the Austrian/German area and a still notable 73,000 loads for Austria.

## **Infrastructure Analysis**

A first analysis of the Austrian railway infrastructure provides a short overview regarding their PalletFlow-capability. In cooperation with the owner of the infrastructure, the Austrian Federal Railways, all temporal, capacitive and technically available loading tracks of more than 200m length were identified. Further selection criteria were a parallel cargo road and sufficient

space (the minimum depth is about 12m) for the reloading-process. In short: based on the first analysis 32 potential loading tracks have been identified.

## **BUSINESS CASE AND ECONOMIC CALCULATION**

The results of the work package “business case” should provide meaningful information about whether the PalletFlow-Process/Service will be competitive and can succeed in the transport market. For this reason the economic calculation compares different uni- and bimodal transport processes. On the basis of a new model, at the moment discrete<sup>2</sup> and, in the near future, functional comparisons will be possible. This so called “comparison model” is being developed in the course of this work package and underpinned with real market data. The results show which process is cheaper for each concrete relation A to B and/or B to A and provide further conclusions on more general questions. For example, where is the turning point from which distance PalletFlow or rail transport is the more competitive process under the present market circumstances compared to road transport?

### **The Compared Processes**

Within the “comparison model” and for this paper the following different transport processes will be compared:

1. Door-to-door trucking process (unimodal process)
  - a. **Truck I:** normal rate
  - b. **Truck II:** rate with 10 percent discount
2. PalletFlow process inclusive pre- or post-road carriage by trucks and *one* reloading process (bimodal process)
  - a. **PalletFlow Ia:** rate for main leg return by rail without freight
  - b. **PalletFlow IIa:** rate for main leg return by rail with freight
3. PalletFlow process inclusive pre- and post-road carriage by trucks and the *two-time* reloading processes (bimodal process)
  - a. **PalletFlow Ib:** rate for main leg return by rail without freight
  - b. **PalletFlow IIb:** rate for main leg return by rail with freight

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<sup>2</sup> At the moment the Logistikum is working on the function to calculate the rail price for the main leg.



*Calculation Information<sup>3</sup>*

Both processes are calculated on the basis of the following specifications: The freight consists of 1250 pallets of goods. The weight is 750kg per pallet. Three different companies provide freight for one block train and one direction. The processes are compared by using distances from 200 to 800km (200km steps). On the diagrams the reference unit for the comparison are the costs for the total transport volume (1250 pallets) per km.

Further information on the trucking calculation: The total transport volume requires 45 truckloads (27 pallets per truck). The toll per kilometre for Austria is Category 4+ with 4 and more axles. For Germany the toll represents a composite rate between the categories A, B and C. 90 percent of the different distances in every country are assumed as motorway kilometres. The 10 percent discount relates only to the price per kilometre exclusive toll. To ensure the practical relevance of the calculations we assumed that the truck transports are completely utilized in both directions whereas the return journey is not taken into consideration.

Table I – door-to-door trucking process

Price per kilometre exclusive toll:	0,95€
German toll per kilometre:	0,181€
Austrian toll per kilometre:	0,3234€

Further information on the PalletFlow calculation: As a result of the transport volume for one complete reloading process within 8 hours on one day, 12 trucks (4 runs per truck) and 2 fork-lift trucks were needed. The maximum range for the pre- and post- road carriage is 50km's. The prices for the main leg by rail include the wagon price per day, the addition price per wagon and the price for the round trip. For the calculation the price relationship between the outward journey and return journey is set at 60% (rate for main leg return by rail without freight) to 40 percent (rate for main leg return by rail with freight). The reloading process includes the costs for fork-lift trucks and fork-lift drivers just as reloading and stationary time.

Table 2– PalletFlow process

Price pre- or post-road carriage	5.040€
Price pre- or post-reloading process	457€

*Graphs*

Figure 3 shows that transport process “Truck I” is cheaper than “PalletFlow Ia” in short distance-hauling up to the turning point at 390,26km. Expressed in costs the turning point for the total transport volume is 51,54€ per km. From this point the PalletFlow process with the return journey without freight is more competitive than the door-to-door trucking process with the normal rate exclusive toll (0,95€).

<sup>3</sup> Under the terms of the project contract with the partner companies and the funding agency only selected data and information on the calculations (like all round prices) can be published.

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Processes “Truck II” (with the 10 percent discount) and “PalletFlow IIa” demonstrate a similar pattern in the short run, except the fact that because of the return journey with freight and the resulting saving of expenses the turning point is shifted down to 277,55km respectively 48,25€. In other words, process “PalletFlow IIa” is much more competitive than “PalletFlow Ia” and therefore increases the ability to compete with both truck transports considered.

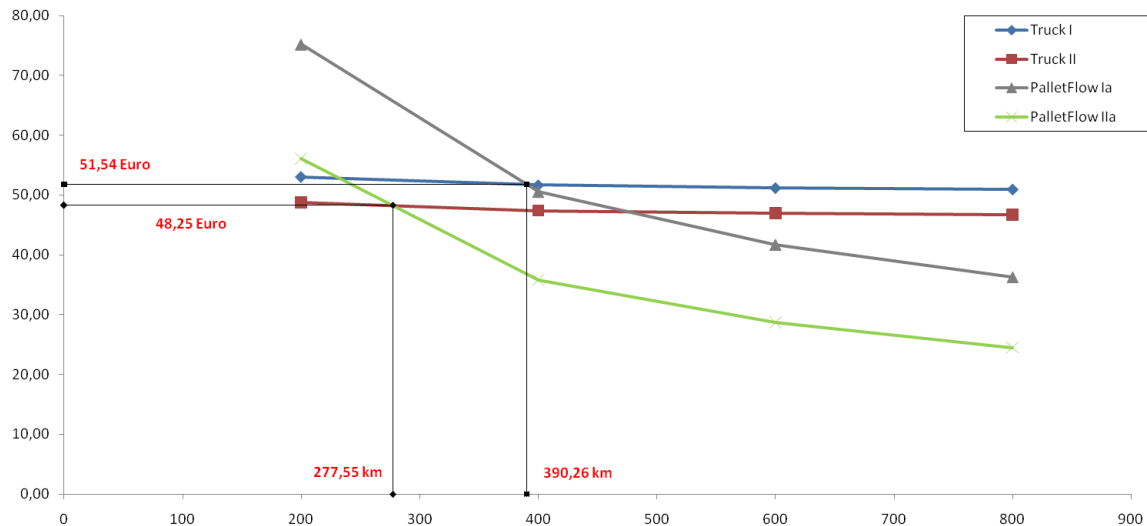


Figure 3 – Door-to-door trucking process (1.) compared to the PalletFlow process inclusive pre- or post-road carriage by trucks and *one* reloading process (2.).

Figure 4 indicates, contrary to Figure 3, pre- *and* post-road carriage by trucks *and* the two-time reloading processes. Therefore the additional occurring expenses reduce the competitiveness of both PalletFlow processes related to the distance by a reasonable amount of 141,23km in the case of “PalletFlow Ib” and 192,03km considering “PalletFlow IIb”. Measured monetarily, the turning points are 51,25€ and 47,36€ respectively.

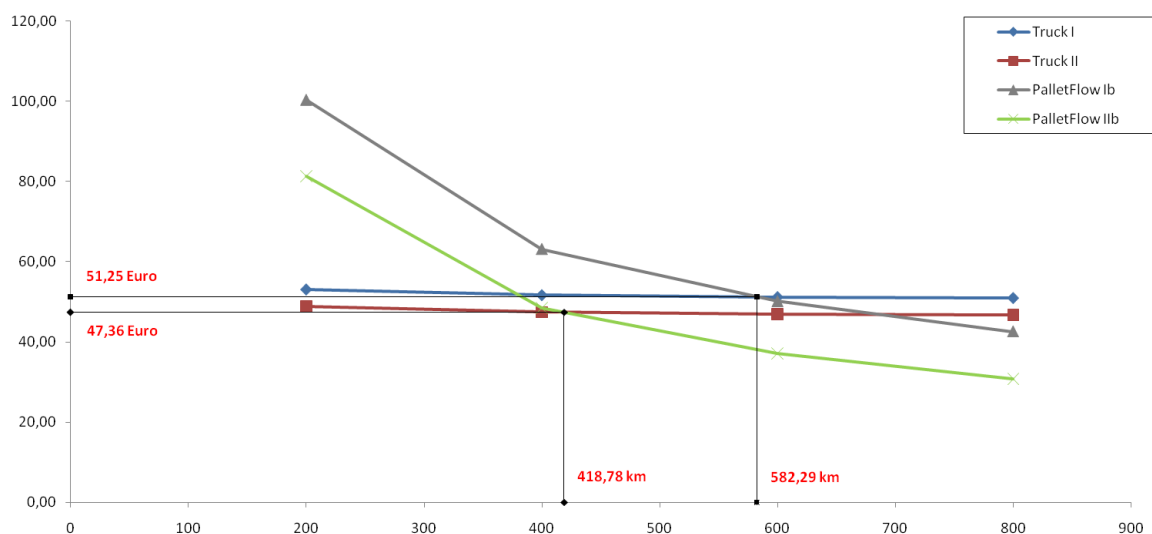


Figure 4 – Door-to-door trucking process (1.) compared to the PalletFlow process inclusive pre- *and* post-road carriage by trucks and the *two-time* reloading processes (3.).

The two line diagrams above provide evidence that PalletFlow can compete within the transport market, especially in the long run and on cross border relations.

## **TECHNOLOGICAL ASPECTS**

### **Neutral Service Centre (NSC)**

From an NSC-point of view the basic ICT-characteristics of the PalletFlow-system are:

1. Identification of the pallet/unit-load volumes carried out by automatic systems (i.e. barcode- and/or RFID-based). Thus, the data acquired is directly stored in the system without further manual operating expense.
2. The NSC is set up on the tracking- and tracing system and provides information along the transport route about the current position of the pallets, the calculated time of arrival and the information about potential delays etc. Therefore a pro-active information service is provided (Franke, 2006).
3. A tracking- and tracing system allows all institutions concerned with the consignments to trace the pallets. This includes information retrieval of current pallet positions at any time (tracking) and the ex post backtracing of the exact course of the consignment as well as all important incidents (tracing).

### **Determination of the Pallets-Position**

The determination of position of the pallets and fork-lift vehicles in the reloading area will be enabled by using a set of different technologies like radio location and inertial sensors. Thus, it is possible to track the pallets carried by the fork-lift vehicles and the goods on the pallet. In this way, it can be ensured that the envisaged pallets are picked up at the right place and are taken to the position that has been targeted. When identifying the pallets the location system recalls their destination from the database, and the position is presented on a display in the fork-lift vehicle. In the default case of releasing the pallets at the wrong location or in case of picking up the wrong pallet, a warning message is displayed to the driver (Schmidt, 2006 and Lehner, 2003).

### **Location System**

For the successful realization of the ICT-characteristics several technologies for radio location have to be taken into account. The state of the art-system employs a combination of a wideband frequency modulated continuous wave (FMCW) radio signal for round trip time (RTT) estimation and an attached narrowband signal for estimating the direction of arrival (DoA).

For determining the RTT, the signal propagation time between the infrastructure node and a tag is measured in order to calculate the distance. Investigating both travelling times, the one from the node to the tag and the returning answer from the tag, secures an elaborate temporal synchronization (Gasselseder, 2007). The DoA algorithm estimates the direction of the incoming signal, i.e. the direction where the tag is located relative to the hardware node. Based on the known position of multiple infrastructure nodes, the obtained information on the distances and the directions are combined to identify the tag position. In order to track moving tags, this data fusion is extended in the temporal dimension using a sequence of successive measurements.

The system will be referred to as “Goniometer system”. To adopt the existing “Goniometer system” for outdoor applications it has to be adapted to be less sensitive to the weather conditions and less prone to interfering signals. Consequently, in the course of developing new hardware components for the Goniometer unit, a weatherproof body will be constructed (Schmidt/Herrler, 2009).

## **OUTLOOK**

The results of the marketplace analysis and business calculation clearly illustrate that the PalletFlow process does have remarkable potential and, especially on long-distances, is competitive. On the basis of these facts the consortium will try to implement and enter the market in the medium-term time-frame.

Therefore the next work packages cover all aspects related to the envisaged implementation. Through several test runs the functionality of reloading from “curtainsider” road vehicles to/from train trucks, the ICT-aspects of the turnover process as well as all operational aspects will be reviewed. National and international demonstrators additionally have to verify the frictionless functioning of the PalletFlow operation in practice and have to verify that tracking and tracing this process is feasible and beneficial. As a result a catalog of specifications and requirements plus a survey of the collected data will be developed. This catalog represents the basis for the implementation and combination of hard- and software components as well as the innovative business model.

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