Standard Designs for Multifunctional Small and Medium-Sized Transhipment Sites

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Abstract. One of the major goals of the European transport policies is the modal shift from road to rail transportation. However, especially regarding the wagonload transport, this goal is jeopardised (hard to achieve). Due to a reduction in the number of private sidings and public loading points, the accessibility of the rail network is reasonably reduced. Thus, a new approach to counteract the reduction, especially for small and medium-sized transhipment sites is required. This paper develops a list of requirements for small and medium-sized transhipment sites based on shippers' demand. Further, based on these requirements, standard types of transhipment sites are defined. Additionally, for one of the standard type, a reference layout is also developed.

Keywords: Transhipment site · Rail freight · Single wagonload

1 Introduction

One of the major goals of the transportation policies of the European Union is a modal shift from road transportation to more environmentally friendly transport modes like railways or inland waterway shipping [1]. The freight transport volume in Europe exhibited an increase during the last decades due to the changing production strategies and the introduction of international free trade agreements. However, the transport volume of rail freight in Europe is showing stagnation during recent times. The market share for rail freight transport has been decreasing since the 1970s due to the changes in the types of goods transported (i.e. the shift from bulk goods towards manufactured goods) and new logistics strategies such as decrease in inventory, reductions in vertical integration of production and transport practices which place an emphasis on flexibility, reliability and smaller but more frequent deliveries. All these factors contributed to an increase in the modal share of road transportation. Within the rail freight sector in Europe, especially the wagonload based production schemes are largely at risk and are at the verge of vanishing completely [2].

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According to Guglielminetti et al. [3], the most critical issue for wagonload transport is the reduction of private sidings. Tracks in sidings and freight stations are removed resulting into the shippers' loose of the access to the rail freight. Thus, it becomes impossible for them to shift the transports from road to rail. Islam and Zunder [4] also argue that access points like terminals are a facilitator of a competitive rail service.

Thus, the crucial issues to keep rail freight competitive in future are new concepts for the design of transhipment sites. These new concepts need to fulfil the changing requirements of shippers as well as the operational requirements of the rail freight companies. Furthermore, the construction costs of these new transhipment sites should be cut down by modularisation and standardisation of their components because of the fact that other sectors of construction industry already recognise the benefits from those standardisations [5].

The development of standardised modules may help the shippers as well as the planners of railway loading and transhipment infrastructures to design and to build future proof facilities. From an academic point of view the research shall gain a more in-depth knowledge about the functional requirements for those transhipment sites. The functional requirements shall be standardised and transferred into standardised modules. The application of the modules in case studies shall approve the usability of standardised transhipment modules under real world conditions. From a practical perspective, guidelines for a catalogue of standardised transhipment modules shall be provided. The application of these standardised modules shall facilitate the design of new as well as the redesign of the existing transhipment sites.

According to the forementioned academic and practical objectives this study aims to answer the following research questions:

- What are the future functional requirements of the shippers and the rail freight companies for small and medium transhipment sites?
- Is it possible to transfer these functional requirements into a restricted number of standardised module designs?
- Is it possible to apply the modules to design a transhipment site under real world conditions?

2 Definitions

For further clarifications, the basic terms in this context need to be defined. These definitions are as follows:

- The term (freight) transhipment is defined as those facilities in which goods are transhipped between different transport modes - multimodal and/or intermodal (between road, rail and inland waterways).
- During transhipment, goods can either remain unpacked in the loading units of a combined transport (container, swap bodies, semi-trailer) or in other transport containers (pallets, sacks, wheeled boxes, skip/dumpster etc.), or they can be pumped in, blown in, transferred or poured out/dumped.

- Small transhipment sites have a capacity of up to 20 freight wagons per day, medium transhipment sites have a capacity of between 20 and 80 freight wagons per day.

3 Literature Review

The topic of the design of small and medium transhipment sites becomes more relevant as the structure of goods in Europe shift from mass and industrial products to consumer goods; the integration of rail freight in urban logistics processes becomes more and more relevant [6]. Furthermore, the integration of rail freight in urban logistic chains is also required. Present measures often address the terminal infrastructures, their capacities and locations. The remaining private sidings mainly focus on the supply of goods to large industrial sites.

New transhipment sites and terminals of combined transport are designed for an efficient transhipment process of long distance full-train loads, and primarily for combined transport. Based on this focus, most of the recent guidelines deal with larger transhipment sites. On an international level the guidelines of DB Netz [7] and Arendt [8] are implemented and on the Swiss level the studies about the new terminals in Switzerland by Ickert et al. [9] must be mentioned.

Nevertheless, the distribution of wagonload shipments in a distribution network can be competitive with road transportation. Bruckmann et al. [10] proved this for container distribution in Swiss sidings. However, to increase the number of wagonload networks, accessibility to the network must be ensured. This requires new approaches in the design of small and medium sized transhipment site. Yet, their design principles are only mentioned in the context of new transhipment technologies of combined transport [11, 12]. Very little literature is available on conventional transhipment technologies in the context of rail freight.

4 Structure and Methodology

The paper starts in Sect. 5 with a brief description of the todays' demand and supply structures of rail freight in Switzerland to show the current status of rail freight in Switzerland. Thus, Sect. 5 describes the starting point of the research. Section 6 analyses the future market requirements based on the analysis of the best practices from the current transhipment sites and a macro analysis of the future demand structures and expert interviews with shippers. Section 7 derives a set of different standardised transhipment modules from the functional requirements. In Sect. 8 the requirements are combined into six standard transhipment modules. Keeping the length restriction of this paper in mind only one example with the full design is integrated in this paper. In Sect. 9 the conclusions regarding the research questions are provided.

5 Current Situation of Rail Freight in Switzerland

The first step to assess the current Swiss situation was to analyse the current structure of private sidings and public loading platforms for rail-freight (in Switzerland named as "Freiverlad"). Public loading platforms are provided as a part of the open access network, which allow any shipper to use these access points. The current leading operator for SWL transport is SBB Cargo. The analysis of the status quo is based upon their transport and network data from the year 2015. In 2015 there were 386 stations, which were served within the single wagonload network of SBB Cargo. Most of the stations (242) are served regularly as part of the basic network. 86 of them were part of the customer specific network. They were served according to the specific demands of the shippers. 58 were in the networks of (narrow gauge) private railways, and 9 were outside Switzerland. 187 out of the 386 stations provided a public loading platform, and 145 of the stations provided the opportunity to tranship intermodal transport units. This provided a basic overview of the network structure and the relevance of public loading platforms in Switzerland.

According to the number of loaded and unloaded wagons, only 3% of the stations can be considered as large stations. 12% are medium sized stations, while most of the stations (85%) are small stations with a demand of fewer than 20 wagons per day.

6 Market Requirements

To find out more about the current demand structures and the future needs for small and medium-sized transhipment sites, the authors:

- Evaluated the best practices for transhipment sites in Switzerland and other European countries,
- Made a demand prognosis for the future demand structures regarding the freight types (based on the type of consignment) and
- Conducted expert interviews with larger shippers of wagonload consignments in Switzerland

6.1 Best Practices

In order to get some information about success factors for new small and medium transhipment sites, two of them (Gossau SG and Samedan in Switzerland) were analysed. The two sites have been chosen as they have been recently redesigned (during the last five years) and they show an increase of the amount of transhipped goods. Thus, the success factors from these two sites shall be integrated in the requirements for future transhipment sites.

The prime success factors were; factors which were supported by the local authorities (canton and local community) and synergies due to the availability of railway staff for other purposes as well as a high operational reliability and stability. The best practices from other European countries were not fully transferable to Switzerland since only larger transhipment sites are in operation in other European countries.

6.2 Aggregated Demand Structures

The market analysis was conducted in two ways; firstly, as an aggregated analysis of the future demand based on existing demand prognoses [12, 13] and secondly, the authors performed their own calculations based on existing road freight data surveys of the Federal Office for Statistics [14].

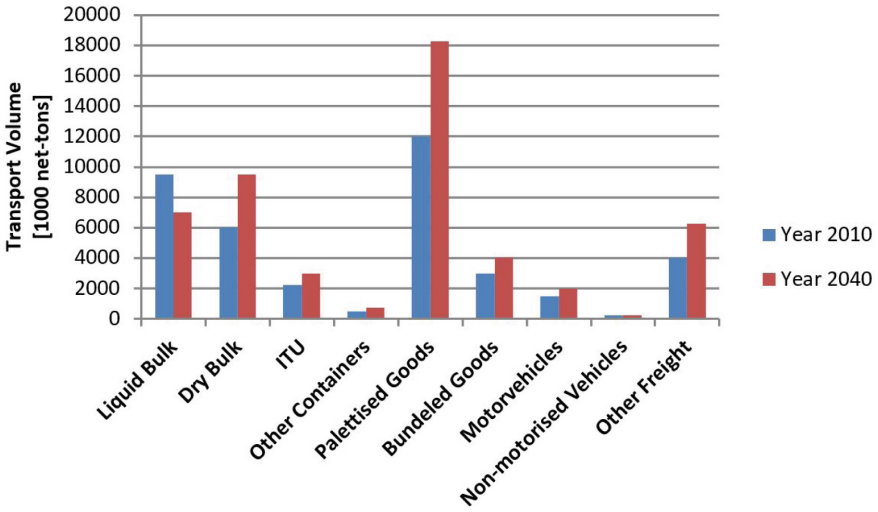

Fig. 1. Transport Volumes of rail freight differentiated by the type of goods for the years 2010 and 2040 [12, 14].

According to Fig. 1, in the year 2040, there will be significant changes in the type of the transported goods. The transport volume of liquid bulk is expected to decrease, whereas the volume of dry bulk and palletised goods are anticipated to increase. Prime drivers for this development are presumed to be the growing demands for mostly palletised consumer goods [13]. The growth in dry bulk results from expected changes in transport regulation. In the future, shippers will be forced to use rail freight for the supply of construction materials and industrial rocks and minerals to large construction sites. These changes in the characteristics of the consignments will influence the requirements for transhipment sites as well. The increasing amount of palletised goods need to be especially considered in the future design principles.

6.3 Expert Interviews with Shippers

The authors interviewed, in total, six experts from industrial sectors relevant for rail freight transport. Some of the interviewed shippers had their own intermodal transhipment sites. The interviewed shippers conduct the transports via public loading platforms, private sidings and/or container terminals. Thus, a range of possible requirements for transhipment sites could be assessed (Table 1).

Table 1. List of the interviewed shippers.

Shipper	Sector	Type of goods	Type of freight
1	Food and beverages	Food (frozen)	ITU
2	Retail	Food, other consumer goods	ITU
3	Waste and recycling	Waste, secondary raw material	ITU, bundled goods
4	Construction and construction materials	Construction material	Dry bulk
5	Construction and construction materials	Industrial rocks and minerals	Dry bulk, ITU
6	Courier, Express, Parcel	Consolidated Cargo, other goods	Other freight, ITU

The main reasons for those shippers to use rail freight are; the availability of own transhipment facilities in their production and logistics sites, lower costs of rail freight compared to the other modes of transportation, good service offers from the railways regarding reliability and punctuality and specific need for rail freight transport due to environmental reasons.

The shippers also explained their reasons to tranship goods on public loading platforms. The reasons are presented in Table 2.

Table 2. Reasons to tranship goods on public loading platforms.

Shipper	Reason(s)
1	Own private sidings
	Avoidance of congested road sections
2	Delivery times cannot be kept with road transportation (night driving ban)
3	Own small/medium transhipment site
4	Customers require rail transport
	Own private sidings
	Environmental strategy
5	Costs
	Own private sidings
	Environmental strategy
	Overnight transport (night driving ban)
6	Costs
	Own sidings
	Environmental aspects

The interviews indicate that for shippers who own private sidings and face fewer obstacles when integrating public loading platforms with their logistics network when compared to those who do not own private sidings. Thus, private sidings seem to be a facilitator for the use of public transhipment sites at the other end of the transport chain.

The requirements for loading platforms or transhipment sites themselves are mainly defined by the transported goods and the type of the consignments. Especially for shippers who use their private sidings and special transhipment equipment (e.g. warehouses with loading ramps, gravel quarries with chutes and bunkers, cement mills with equipment for dry bulk) the required transhipment equipment is already pre-defined. They require public loading platforms and the same other equipment that exist in their private sidings.

The transhipment of ITU[1] requires additional yard areas for the temporary storage of ITUs. This allows the decoupling of road and rail transport processes and delays and other disruptions in the transport processes may be compensated. The transhipment of palletised goods requires side ramps for the loading and unloading of the freight wagons. Depending on the type of transhipped goods, different requirements need to be fulfilled for the transhipment of dry bulk. The inter-tank transfer of cement re-quires only a paved loading quay beside the track and bunkers to facilitate the transhipment of industrial rocks and minerals.

Most shippers focus only on a quick and efficient transhipment process. Thus, most of them do not need additional services on the transhipment sites. Few of them use the sites for the stabling of freight wagons or for the weighing of the trucks and the loading units.

Additional areas for the consolidation and the sorting of partial loads provide additional logistics opportunities for shippers. Nevertheless, most do not use the sites for additional services since they focus only on a quick and efficient transhipment.

In general, the shippers mentioned these functional requirements (Table 3) for transhipment sites.

Table 3. Shippers' functional requirements for transhipment sites.

Shipper	Transhipment and storage area	Logistics and operational equipment	Service equipment
1	Highly stable pavement	Only transhipment	Electricity supply
2	Gantry crane, loading quay	Only transhipment	–
3	Housing (due to unpleasant odour)	Special equipment for the consolidation of waste and secondary raw materials	–
4	Simple loading quay	Only transhipment	Truck scale, stationary air compressor
5	Paved areal, bunker	Only transhipment	Truck scale
6	Side loading ramp	Preliminary sortation facilities	–

[1] ITU – Intermodal Transport Unit: Maritime container, semitrailer and swap bodies.

7 Requirements for Multifunctional Transhipment Sites

The results from the best-practices' analysis, the market analysis and the interviews with shippers were transferred into a catalogue of functional requirements for transhipment sites. The requirements were categorised as follows:

- Transhipment and storage area
- Infrastructures for rail and road vehicles
- Additional logistics services and operational equipment
- Equipment for measuring, weighing and safety.

The requirements are differentiated between small and medium sized transhipment sites. Furthermore, the stakeholder groups (users of the site, operators of the site and the administration) which require these characteristics are indicated.

7.1 Transhipment and Storage Area

As already mentioned, the transhipment sites are mostly used for palletised goods, (dry) bulk, general cargo, bundled goods and ITUs. Thus, Table 4 shows the functional requirements of the transhipment sites.

Table 4. Requirements for the transhipment and storage area. (X compulsory/(X) optional)

Requirement	Size		Stakeholder group		
	Small	Medium	User	Operator	Government
Transhipment of ACTS[a] containers	X	X			
Transhipment of ISO containers, swap bodies and semitrailers	(X)	X			
Transhipment of bulk goods	X	X			
Transhipment of overlong goods	X	X			
Transhipment of hazardous goods	X	X			
Transhipment of general cargo	X	X			
Transhipment of hazardous goods	(X)	X			
Yard for short term storage of ITUs	(X)	X			
Yard for long term storage of ITUs	(X)	(X)			
Storage of bulk goods	(X)	(X)			
Storage of palletised, bundled or other goods	X	(X)			
Storage of refer container	(X)	(X)			
Storage of hazardous goods	(X)	(X)			
Roof	(X)	(X)			
Housing	(X)	(X)			

[a]ACTS is a specific type of ITUs for rail and road transport.

7.2 Infrastructures for Rail and Road Vehicles

The infrastructures for road and rail are mainly defined by the amount of transhipped goods. Further requirements can be derived from the goods types and the consignments. Usually, the equipment for transhipments (e.g. Reach Stacker) defines the pavement's minimum stress resistance in the transhipment area.

The connection between transhipment site and public railway network shall be provided within a railway station and not as an additional siding on the open line (Table 5).

Table 5. Requirements for rail and road operations. (X compulsory/(X) optional)

Requirement	Size		Stakeholder group		
	Small	Medium	User	Operator	Government
Road – only one way roads	(X)	X			
Road – single lane roads used in both directions	X	(X)			
Road – unpaved surface	(X)	(X)			
Road – paved surface	X	X			
Road – extra strong paved surface	(X)	(X)			
Road – suitable for hazardous goods	X	X			
Railway – single sided connection to mainline	X	X			
Railway – double sided connection to mainline	(X)	X			
Railway – non electrified tracks	X	X			
Railway – electrified tracks sections towards the main line	(X)	(X)			
Railway – connected to station tracks	X				

7.3 Additional Logistics Services and Operational Equipment

The requirement of additional logistics services and operational equipment strongly depends on the specific demand structure of the transhipment site. In general, the demand of the single shipper's for equipment is quite low. Thus, these facilities should be shared between several shippers (Table 6).

Table 6. Additional logistics services and operational equipment. (X compulsory/(X) optional)

Requirement	Size		Stakeholder group		
	Small	Medium	User	Operator	Government
Service – stuffing/stripping of containers	(X)	(X)			
Service – maintenance of containers and other equipment	(X)	(X)			
Service – cross docking	(X)	(X)			
Service – customs clearance	(X)	(X)			
Waiting areas for trucks	(X)	(X)			
Truck parking facilities	(X)	X			
Gate/Offices	–	(X)			
Parking lots for employees	(X)	X			
Parking of equipment	–	(X)			

7.4 Equipment for Measuring, Weighing and Safety

The required equipment for measuring, weighing, control and safety are devised from the goods' types and consignments transhipped at the specific site. Generally, the only required equipment is the equipment which is used for weighing trucks, rail cars and/or consignments. This might be either demanded from the shippers themselves or as safety requirement from the rail freight or truck operators. Furthermore, the identification of vehicles or load units may be relevant. Due to security reasons the sites also may have fencing, gates and video surveillance. The security equipment will become more relevant in future (Table 7).

Table 7. Equipment for measuring, weighing and safety. (X as a rule/(X) optional)

Requirement	Size		Stakeholder group		
	Small	Medium	User	Operator	Government
Identification/Counting	(X)	(X)			
Load scanner (X-ray)	–	(X)			
Truck and/or freight wagon scale	(X)	(X)			
Container scale	(X)	(X)			
Fencing	(X)	(X)			
Gate	(X)	X			
Video survey	–	(X)			
Equipment for losses/Fire extinguishers	(X)	(X)			

8 Example Module

8.1 Definition of the Modules

Based on these defined requirements which are further based on the application of morphological boxes, three standardised transhipment modules for the supply of urban regions (Table 8) and three modules for rural regions (Table 9) have been developed.

Table 8. Standard modules for urban regions. (X compulsory/(X) optional)

Type of transhipment site	Logistics function	Type of freight				Overlong goods	Hazardous goods	Size
		Bulk	ITUs	Palletised	Bundled			
Urban consumer goods	Transhipment		X	X	(X)		(X)	Small or medium
	Storage		X	X	(X)		(X)	
	Additional services		X	X	(X)			
Urban construction materials	Transhipment	X	X			X		Small or medium
	Storage	X				X		
	Additional services							
Urban waste	Transhipment	(X)	X					Small or medium
	Storage		X					
	Additional services							

Table 9. Standard modules for rural regions. (X compulsory/(X) optional)

Type of transhipment site	Logistics function	Type of freight				Overlong goods	Hazardous goods	Size
		Bulk	ITUs	Palletised	Bundled			
Rural Construction materials	Transhipment	X	X			(X)		Small or medium
	Storage	X	(X)			(X)		
	Additional services							
Rural waste	Transhipment	X	X			(X)	(X)	Small or medium
	Storage		X			(X)	(X)	
	Additional services	(X)	(X)					
Rural agricultural products	Transhipment	X	X			X		Small or medium
	Storage	X	(X)			X		
	Additional services	(X)	(X)					

8.2 Example Design

For each of the above mentioned types of sites, a standard design has been developed. Here as an example, only the type rural construction materials are depicted (in Fig. 2). The standardised design includes the following characteristics:

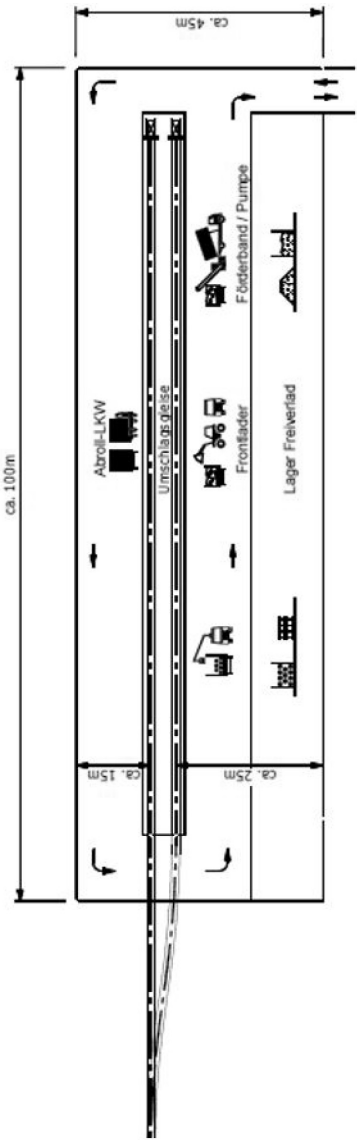

Fig. 2. Standard design of a transhipment site for construction material in rural areas

- Transhipment of ACTS container is possible.
- The available transhipment equipment is a truck-mounted crane, front loaders and conveyor belts for bulk materials.
- The roads are paved and used in one-way traffic.
- The siding is connected to the railway line is connected at only one side, the tracks are not electrified.
- There are additional storage facilities for bulk goods and overlong goods.
- The transhipment site is illuminated.

9 Results and Conclusion

According to the market analysis, there will be a future demand for small and medium sized transhipment sites for wagonload consignments. The required transhipment equipment will change according to the increasing demand for palletised goods and dry bulk goods. But there will be also a remaining demand for conventional liquid bulk goods.

For each type of the goods a different set of requirements towards transhipment site could be identified. Nevertheless, it was possible to derive a standardised transhipment module for each demanded type of goods. All of these modules were integrated in a catalogue of transhipment modules.

In a case study a detailed design for a transhipment site for construction materials in a rural region under usage of the standardised modules was developed. Thus, the real world applicability of the standard modules could be approved.

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