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Data base and comparative analysis of CT and transhipment technologies for CT

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List of Abbreviations

ACT	Accompanied Combined Transport
ACTS	*Abroll-Container-Transportsystem* (Roller container)
AT	Austria
BG	Bulgaria
C715, C745, C782	Type of swap body
CEP	Courier, express and parcel
CH	Switzerland
CT	Combined Transport
DE	Germany
DK	Denmark
DT	Deliverable Task
EVU	Railway company
FR	France
ILU	Intermodal Loading Unit
ISU	*Innovativer Sattelauflieger Umschlag* (Innovative SemiTrailer Handling Unit)
IT	Italy
ITTL	Prometni Institut Ljubljana
IU	Intermodal unit
IUT	*Innovatives Umschlag-Terminal* (Innovative Transfer Terminal)
LCA Süd	Logistik Centre Austria Süd
LU	Loading Unit
LU	Luxembourg
NETHS	*Neuweiler Tuchschmid Horizontal System*
O/D	Origin/Destination

ÖBB	*Österreichische Bundesbahnen*
P400	Railway loading gauge standard
RoLa	*Rollende Landstraße* (Rolling Highway)
RO-RO	Roll-on/roll-off
S, M, B	small, medium, big
SBB	Schweizerische Bundesbahnen
SGKV	Studiengesellschaft für Kombinierten Verkehr
SI	Slovenia
SK	Slovakia
SE	Sweden
TCS	Train Control System
TEN-T	Trans-European Transport Networks
TEU	Twenty-foot Equivalent Unit
TU	Transport Unit
UIC	*Union internationale des chemins de fer* (International Railway association)
UCT/UKV	Unaccompanied Combined Transport
V, H	vertical, horizontal
WCS	Wagon Control System
Zailog	Consortia ZAI Interporto Quadarante Europa

Summary

CT Processes and supply chain

According to a widely accepted definition Combined transport (CT) refers to “Intermodal transport where the major part of the European journey is by rail, inland waterways or sea and any initial and/or final legs carried out by road are as short as possible[1]”.

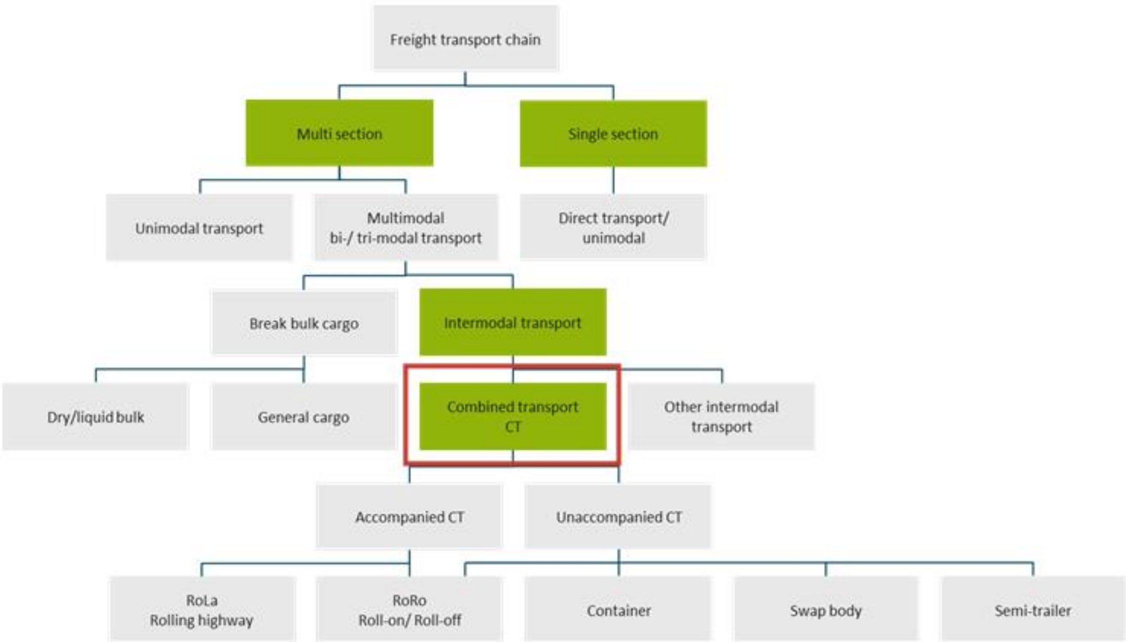


Figure 1: Combined Transport within freight transport chain
Source: SGKV, based on Posset et al. (2014): Intermodaler Verkehr Europa.

A more detailed definition is provided by the European Council Directive 92/106/EEC where “[…] ‘combined transport’ means the transport of goods between Member States where the lorry, trailer, semi-trailer, with or without tractor unit, swap body or container of 20 feet or more uses the road on the initial or final leg of the journey and, on the other leg, rail or inland waterway or maritime services where this section exceeds 100 km as the crow flies and make the initial or final road transport leg of the journey;— between the point where the goods are loaded and the nearest suitable rail loading station for the initial leg, and between the nearest suitable rail unloading station and the point where the goods are unloaded for the final leg, or

[1] Economic Commission for Europe (UN/ECE): Terminology on Combined Transport. New York and Geneva, 2001.

within a radius not exceeding 150 km as the crow flies from the inland waterway port or seaport of loading or unloading”[2].

Combined transport processes represent material and information flows from origin to destination including first mile, loading transhipment to rail, inland waterways or sea, long haul, unloading transhipment to road, and last mile.

In principle, a distinction between processes has to be made according to:

- Supply chain: Continental Combined Transport Processes and maritime Combined Transport Processes
- Technology: Accompanied Combined Transport and Unaccompanied Combined Transport with further distinction on:
  - type of loading unit (container, swap body, craneable/noncraneable semitrailer)
  - type of transhipment (vertical, horizontal)
- Geographic scope: domestic, international.

The process chain starts upon procurement of the empty loading unit (LU) at a respective shipping company or operator. The company deployed for the transport (operator) takes over the responsibility for delivery of the empty LU for loading as well as pick-up of the fully loaded LU at the terminal. Operators can also choose to hire specialized trucking companies for this process. Simultaneously the deployed company books (at the rail operator) a spot on a cargo train scheduled to depart from the initial terminal.

[2] Council of the European Union: 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. Brussels, 1991.

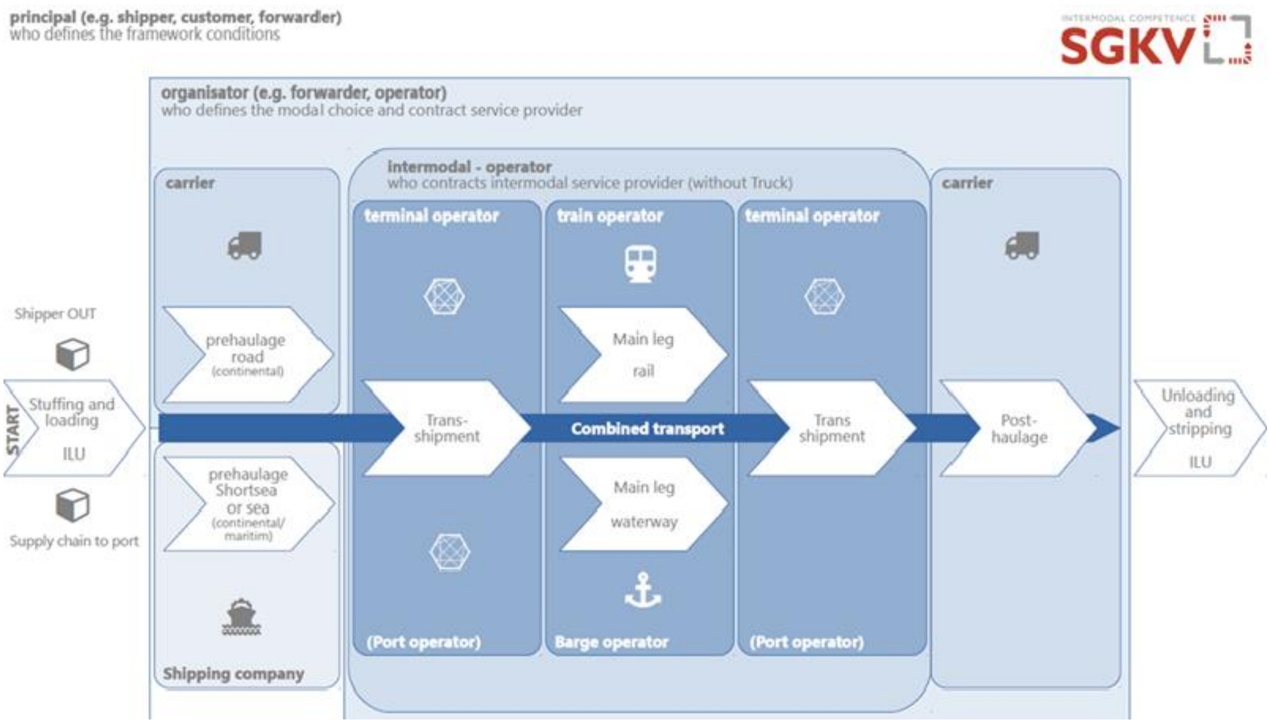


Figure 2: Stakeholders in CT
Source: SGKV, based on Eiband (2014)

First mile processes

While maritime and continental CT processes are mostly the same in terms of the first mile, processes typical for maritime CT include choosing the export port, commissioned shipping company (and timetables) as well as customs. The first-mile processes are completed upon: Departure of the train, Data pre-notification (e.g. for the purpose of tracking and tracing) and final notifications or (billing) processes concerning the forwarder or other participating service providers.

Loading Terminal

Main processes at the loading terminal include cargo check, export treatment of the container (sealing, etc.), written (paper-based) processing of the consignment by the agency of the operator, temporary storage until the train is ready (if required), loading onto the freight wagon by crane or reach stacker and composition of the train. Composition of the train consists of processes such as brake test and load control, train preparation, connection to traction wagon and transfer to a rail track from which the train is scheduled to leave. After that, the shipping documents are completed by the operator and delivered to the EVU for further handling. Train preparation is completed along with a notification to the railway infrastructure company.

Long Haul

The processes within the area of long haul transports are entirely based on rail-specific regulations. Prior to rail transport, the following information has to be gathered and shared with the operators:

- Definition of the relation
- Request for routes and timetables (schedule, number of transit days etc.)
- Definition of the time frame for the forwarding and receiving terminal
- Definition of traction weight, total length of train, type of wagon and type of adjustments
- Traction request: Type of locomotive, schedule of drivers including driver switch.

The rail transport is operated according to operational norms of the EVU regarding the different infrastructures. The long-haul section can either be operated via complete trains or through individual or bundled wagons by including those transports into existing networks.

Combined Transport technologies

Within Combined Transport services a distinction can be made between technologies and systems dealing with:

A: Accompanied Combined Transport (ACT)

B: Unaccompanied Combined Transport (UCT)

B1: non-craneable trailers

B2: systems for the transhipment of craneable trailers, containers and swap bodies

In this report we are going to analyse relevant *ACT Technologies* (Rola, Flexiwagon), *UCT B1 Technologies* (Modalohr Horizontal, CargoBeamer, ISU Innovativer Sattelauflieger Umschlag/Innovative Semi-Trailer Handling Unit, Megaswing, NiKRASA, Cargospeed, Reachstackers, RailRunner) and *UCT B2 Technologies* (Metrocargo, Piggyback technology "C": Containers, NETHS - Neuweiler Tuchschmid Horizontal System, IUT- Innovatives Umschlag-Terminal, Sidelifter, ContainerMover 3000, Mobiler).

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 transhipment requirements at loading and unloading terminal).

Comparative analysis of noncraneable trailers

As transhipment of non-craneable semitrailers is particularly challenging, this report focused on those technologies. Each of the introduced technologies presents a unique set of opportunities as well as disadvantages in terms of e.g. flexibility, handling time and costs, and investment costs. Their benefits have to be evaluated according to a predefined set of criteria that fits the situation at hand. All development efforts aim at supplementing existing terminal infrastructure or wagon/semitrailer technology but their approaches vary widely. While technologies such as Megaswing and CargoBeamer are wagon-based technologies that

require little or no modification of terminal infrastructure, for innovations such as Modalohr and Cargospeed terminals have to be built or heavily modified. Other technologies (NiKRASA, ISU) add specific handling equipment to existing terminal and wagon types. In that way, they make efficient use of existing infrastructure and keep it open to all kinds of technological solutions. This reflects on the feasibility and costs of the technology's implementation. With terminal-based technologies, initial investment costs can be significant but due to their flexibility in handling various types of existing loading units successive costs for carriers etc. might be low. In contrast, technologies based on handling equipment or wagon-based technologies are in that way more decentralized as investment costs are lower than in terminals but more frequent as a high number of wagons or handling equipment is needed for the integrated system to work efficiently. Coexistence of these technologies results in increased investment cost etc. thus research presented in chapter 5 observed a call for standardization and a European Network to ensure economic and ecological efficiency. Furthermore the question was raised if investment in infrastructure for non-craneable semitrailers was reasonable compared to investment in craneable semitrailers. Two of the presented technologies – ISU and NiKRASA - are suitable for all TEN-T corridors. Our analysis also showed the train capacities of those technologies to be the highest with 40 loading units per train. In addition NiKRASA systems can be handled with the same number of personnel compared to general CT transhipment technologies (gantry crane and reach stacker). In terms of train headway CargoSpeed, Megaswing, CargoBeamer (parallel loading) and Modalohr enable trains to leave the terminal in under an hour while NiKRASA and ISU both take about 120 minutes to unload and reload a train under the condition that all loading units arrive at the same time. However, if terminal space is an issue, CargoBeamer, Megaswing, ISU and NiKRASA seem to be the best choices.
The most important **advantages and disadvantages** are presented in the next table.

Table 1: Advantages and disadvantages of CT technologies

	Advantages	**Disadvantages**
Modalohr	• all standard semitrailers up to a height of four meters can be transported without problem • relatively fast loading and unloading of a complete train in the Modalohr terminal • robust, tried and tested wagon system • same-level loading; the tractor units can drive forwards onto the waggon for loading	• low flexibility, as only regular block train services between the Modalohr terminals are possible • high levels of investment in wagons and special Modalohr terminals are required • complex and costly technology for the positioning and swinging out of the waggons, which has to be built into the tracks of the Modalohr terminal •
CargoBeamer	• system for the automatic horizontal transhipment of swap bodies by means of bowl-shaped palettes • presence of truck drivers not required for the transhipment between rail and road • very high performance of the terminals possible	• system requires relatively high levels of investment in special terminal infrastructure • System is designed for regular block train service and thus to a large extent dependent on special terminal infrastructure (CargoBeamer terminal network). Not suitable for containers or swap bodies.

	Advantages	Disadvantages
	• due to the automatic horizontal transhipment system, a simple and fast switch between different tracks is possible • with the use of bowls that are suitable to be lifted by crane, transhipment can also be performed, when necessary, in conventional combined cargo terminals	
ISU Innovativer Sattelauflieger Umschlag/ Innovative SemiTrailer Handling Unit	• all common trailers can be carried • no additional investment for customers (heavy goods vehicle shippers)	• special loading platform, wheel grippers, ropes and lifting beam for the transhipment devices are required in the terminal • relatively complicated manual preparation of the crane process • requires a large amount of staff • heavy transhipment technology from combined cargo terminals necessary • costs for handling in terminal
Megaswing	• all common trailers can be carried • no terminal infrastructure is necessary (besides rail tracks and truck-drivable space next to them) • the loading of the wagons is carried out by the truck driver, therefore no further costs are accrued for transhipment in the terminal • flexible deployment, as the wagons can be used at almost any loading track • same-level loading by the heavy goods vehicle (tractor unit) • relatively fast and simple transhipment technology • very flexible production concepts possible	• special freight wagons require high levels of investment • energy/electricity supply necessary for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs) • Megaswing pocket can only be loaded backwards • Only suitable for trailers, not for containers etc.
NiKRASA	• no special knowhow necessary • stable transhipment because semitrailer is protected by transport-platform • standard grippers • standard process in transhipment facility • staff training by system implementation • No changes to existing standard • Minimal impact on the weight and none on the length of the train • No additional investments for CT terminals beside the system (terminal module) • No additional investment for rolling stock • No additional investment for crane technology • Standard pocket wagons allow transport of containers and swap bodies	• Additionally in origin and destination terminal a mobile terminal-platform is needed • Low price • Flexible • Storable even on top of 30" container • Option for carrying the terminal module with the train (nothing left in terminal)

	Advantages	Disadvantages
Cargospeed	• Allows easy handling of non-craneable trailers • Cost saving due to horizontal loading (no craning needed)	• investment in underground lift is needed • special freight wagons require high levels of investment • energy supply necessary at terminal for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs)

With particular reference to the relations Rostock - Verona and Bettembourg - Trieste, which are the case studies addressed in the upcoming WPs of the project, this overview of the most important new transhipment technologies serves as an important part of the knowledge pool of CT processes for stakeholders, target groups and also for the project partners.

1 Introduction

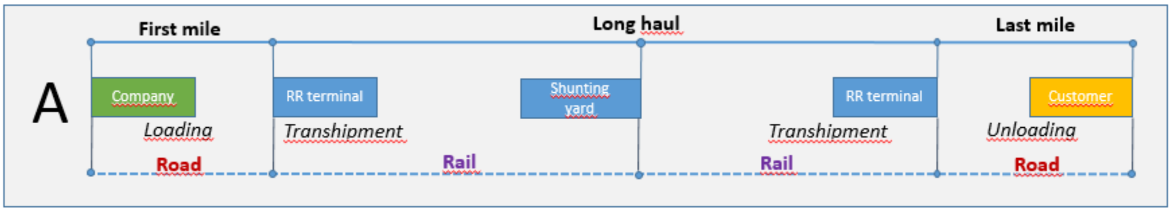
In order to identify adequate technological solutions for Combined Transport in the Alpine space, first the category of Combined Transport as well as related processes of transporting goods has to be considered. As the category of Combined Transport is related to the whole supply chain, Combined Transport is essentially divided into maritime CT and continental CT. Based on the type of Combined Transport, processes of first mile, long haul and last mile vary. This report identifies these processes and provides an analysis of possible solutions with emerging technologies to overcome some of the technical barriers. Representing an overview of transhipment technologies, the report provides benefits and drawbacks of selected CT technologies, which are then joined according to the loading unit type (trailer, semitrailer, and container or swap bodies). The data on technical and technological characteristics of individual technologies was collected from internal know-how and practical experiences within the partner's consortium and also from secondary sources. Special focus is put on transhipment technologies for non-craneable semitrailers for which a comparative analysis is made. Based on the possible technological solutions for transporting noncraneable semitrailers with Combined Transport, a suggestion of setting the criteria for technology testing in WPT4 is proposed.

2 CT Processes and supply chain in CT

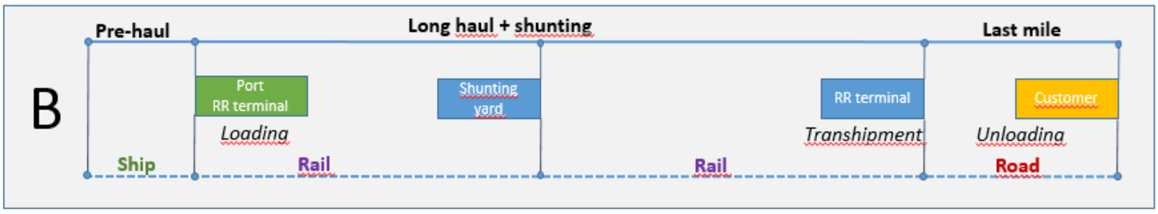
The CT supply chain is basically a series of consecutive (physical flow) and parallel (information flow) processes, characterised by the involvement of numerous stakeholders via the physical flow of ILU /ITU and related information.
The flow of begins at a consignor which is a single manufacturer or a consolidation and integrated centre or might be 3PLs/4PLs provider as the final stuffing point. First physical processes of the supply chain (e.g. receiving LU, stuffing, despatch) are initiated at this point while information flow (ordering LU) can be done by a different stakeholder in advance. The prehaulage, first leg, mainly done by road transport, transfers the LU to the handling facility where the main leg, the long distance transport, starts. Intermodal terminals as handling facilities are the main nodes and the backbone for the European intermodal transport network. The end point of the chain, the consignee, is reached by the posthaulage, last leg, executed by a short as possible road transport of the LU. Different variations of an LU supply chain exist, the ones related to the AlpInnoCT project will be described in detail in the deliverable of WPT2.

The image below essentially depicts the systematics within Combined Transport (CT), where

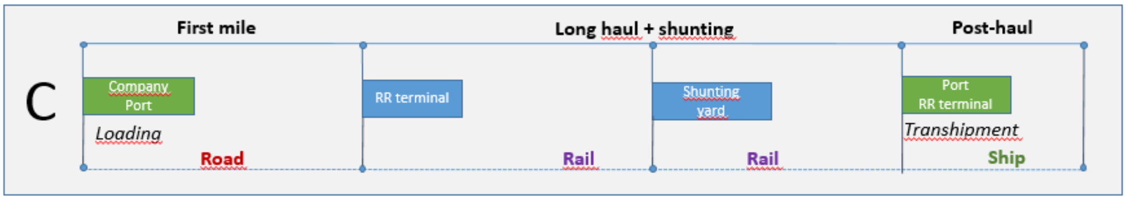
- option "A" can be considered as typical for the Continental Combined Transport,



- whereas images "B" and "C" are typical for the Maritime Combined Transport, whereby
  - the pre-haul by ship is considered as option "B“,



  - as the ship’s post-haul is considered as option "C".



In contrast to road transport, it is crucial for all CT products, being logistics-intensive and planning-intensive transports by nature, that they meet the following requirements, within the current situation regarding supply and demand on the freight transport market:

- Regularity
- Possibility of bundling
- Predictability

For that reason, most of the operations concerning combined transport are organized by operators who compile and market the following individual components within the chain of transports or the supply chain:

- Rail Services:
  - Train path
  - Traction by railway undertakings (Rus)
  - Waggon
- Terminal Services:
  - (Modal / intermodal) shift, transhipment
  - Depot
  - Other services & value-added services
- Road pre-, or post-haul

Operators in CT market their products:

- Either publicly to respectively interested clients (open CT trains)
- Or to individual clients at full capacity (so called „company trains “)

In principle, a distinction has to be made between operators in the Continental Combined Transport industry and the ones operating in Maritime Combined Transport:

- The players within Continental Combined Transport are predominantly grouped together within the UIRR organization and dispose over their own regulations due to that organization.
- In maritime Combined Transport, there exists greater diversity of operators, since in fact every partner can act as an operator who assembles the corresponding product.

Their interface role is essential for all operators, which means that they usually have to bear the entire capacity risk given the generally relatively modest share of added value.
There exist many mixed forms as well as special regulations for e.g. technology, transhipment, production form, and market appearance. Only the most significant factors and processes are listed and described below.

The distinction between the two main categories "maritime" and "continental" already starts with the definition of the transport vessel. Due to the changing vessel structure the result are significant differences in all product and production areas. Therefore, the differences in the vessel area will be explained first.

Vessels in Maritime Combined Transport:

- Standardized dimensions are necessary to comply with standardization norms, especially regarding ship and vessel loading points. Generally standardized according to the dimensions 20'', 30'', 40'', but special forms are increasingly arising, such as: Reefer
    - High cubes
    - Heavy duty CT
    - Container (for liquids and other goods)
- Main advantages:
    - Low sourcing and operating costs
    - Stackable, therefore potential for saving space
    - Globally deployable
    - Adapted for tracking and tracing
- Disadvantages:
    - Not tailored to EUR-pallet measures
    - Usually only front sided doors, therefore difficult to load/unload on the wagons
- Main players within the container business:
    - Shipping companies
    - Depot operators
    - Container leasing companies (increasing importance)
- Handling requirements:
    - Craneable due to standardized corner fittings
    - Easy handling with reach stackers
    - All kinds of wagons of CT are deployable (double axis, quadruple axis, tandem six axes, different construction types respectively)
    - Trucks for pre-haul and post-haul ("flatbed-trucks") economically deployable – usually owned by local specialized companies or operators.

- Excellent capacity use on rail transport possible, e.g. a 600 meters train with 20 6-axis tandem trucks can carry around sixty 40'' containers.
- Summary: Highly deployable on rails (especially on high average distances), since there is only one road pre-haul or post-haul necessary (cost advantage). Furthermore, the bundling can be carried out by operators who sell independently to multiple customers.

Vessels in Continental Combined Transport:

- Standardization according to road dimensions (maximum permissible length depending on truck size), therefore such vessels can be classified into:
    - Semitrailer
    - Swap bodies (different lengths)
    - Euro-Container (45“)
- Main advantages:
    - 100% adaptability for road transport
    - Possibility to load/unload sideways
    - Full capacity utilization with EUR-pallets
- Disadvantages:
    - Necessity for vessels to be craneable (no issues with Euro containers, but possibility of problems when it comes to semitrailers) (no issues with Euro containers, but possibility around 1 tons and eventually leads to the reduction of carriage capacity).
    - Low-floor semitrailer assembling not possible
- Main players within continental Combined Transport:
    - Major carriers or large-scale carriers, or entire carrier organizations
    - Industrial companies with regular emergence of logistic operations
- Requirements for handling and transhipping:
    - Additional equipment required on the crane
    - Not stackable (exception: 45 '' CT, larger storage area required in the terminal)
    - Special equipment required for semi-trailers
    - Depending on the type of vessel, different truck types are required for pre- and post-haul; Semi-trailers are the most convenient since only one single carrier is required.

- Excellent traction capacity rate only possible with WAB and 45''CT
    - Very limited traction capacity for semi-trailers: A 600m train with 20 6-axle tandem trucks can only carry 40 semi-trailers

Focus and boundaries of the further presentation and analysis:

- Only essential process steps in their sequence are explained roughly.
- Depending on the context, provider or location, processes may run in different order and structure.
- Special technologies, handling of CT consignments in non-terminal feeder lines etc. are not explained.
- Arguments about economic efficiency and usefulness of individual processes are not discussed, but it is pointed out that these questions are of crucial importance and further research might be reasonable.
- The following questions are essential regarding the process design:
    - Who is the transport decision-maker?
    - How is the co-operation organized between initial forwarder, freight forwarder, operator, rail cargo company, automobile company, container company (shipping company), other service companies (such as depot), customs service etc. individually within the respective interchange and traffic?
- The growing influence of IT solutions on operational as well as commercial processes has lower priority due to the large number of existing IT solutions (scheduling, billing, data exchange, and payment transactions).
- Crucial questions regarding competition, pricing, transport law, trouble shooting and their impact on processes are not further explored in the context of this presentation.
- Processes emerging in industrial marinas and ports are not elaborated as they are very different compared to processes connected to dry terminals, since they often are tailored to respective infrastructure.

2.1 General description of CT processes for the first mile, long haul and last mile

2.1.1 Maritime Combined Transport: First mile/pre-haul

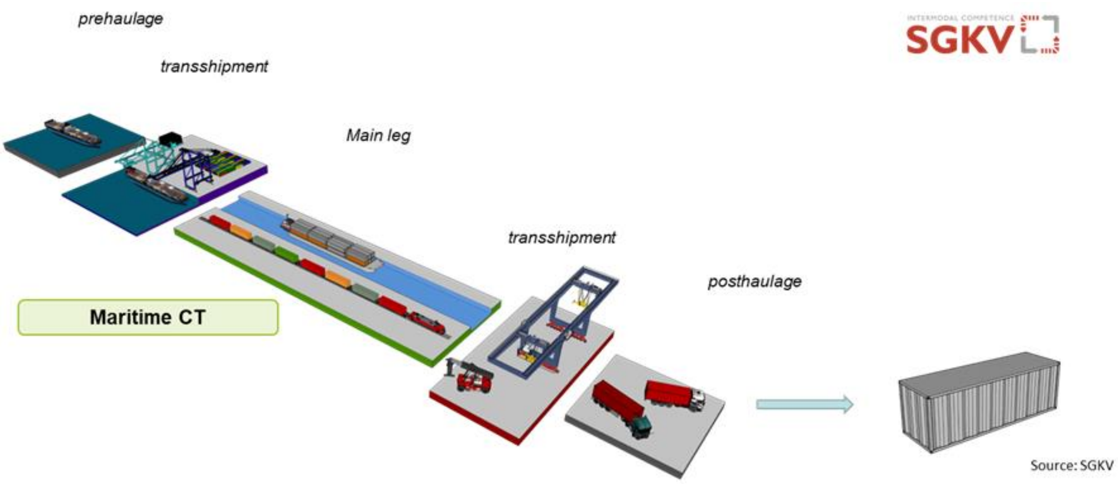


Figure 3: Transport chain in maritime CT
Source: SGKV

Shipments within maritime transport are usually shipments exported from the EU. In that context, important components are:

- The chosen port of export
- Shipping company (and related navigation plans and networks)
- Customs.

Depending on the preferences and operations of the initial forwarder, who either operates autonomously or outsources container shipments to third party service providers, the responsible party either chooses

- a shipping company
- a carrier
- or an operator.

The process chain starts upon order/procurement of the empty container at a respective shipping company or operator.

The availability of the desired type of container as well as the preferred provider is crucial, along with the proximity to a container deposit. The availability of empty ready-to-load containers is a significant competitive factor. The supply and handling of empty containers therefore gains more and more importance, especially with respect to situations of unbalanced export and import.

The company deployed for the transport (operator) takes on the responsibility for delivery of the empty container for loading as well as the pickup of the fully loaded container at the terminal. Operators can also choose to hire specialized trucking companies for this process. Simultaneously the deployed company books (with the rail operator) a spot on a cargo train scheduled to depart from the initial terminal.

Depending on the chosen transport plan, customs system etc., and the following tasks are handled by the terminal upon arrival of the truck that will be loaded:

- Cargo check
    - Container condition check
    - Evaluation of total weight – „SOLAS“
    - Etc.
    - Export treatment of the container (sealing, etc.)
- Written (paper-based) processing of the consignment by the agency of the operator
    - Contract of carriage between initial forwarder and the operator
    - Cargo contract between operator and EVU (only applicable to single wagons)
    - Etc.
- Temporary storage (if required) until the train is ready
- Loading onto the freight wagon by crane or reach stacker
- After completion of train composition:
    - Brake test and load control by the Technical Car Service
    - Train preparation by the EVU
    - Connection to traction wagon (upon exit from the terminal track) or transfer of the train set to a rail track from which the train is scheduled to leave
    - Completion of the shipping documents by the operator and delivery to the EVU
    - Handling of the train documents by the EVU and completion of the train preparation along with a notification to the railway infrastructure company
- The first-mile processes are completed upon:
    - departure of the train
    - Data pre-notification (e.g. for the purpose of tracking and tracing)

- final notifications or (billing) processes concerning the forwarder or other participating service providers.

2.1.2 Continental Combined Transport: First mile

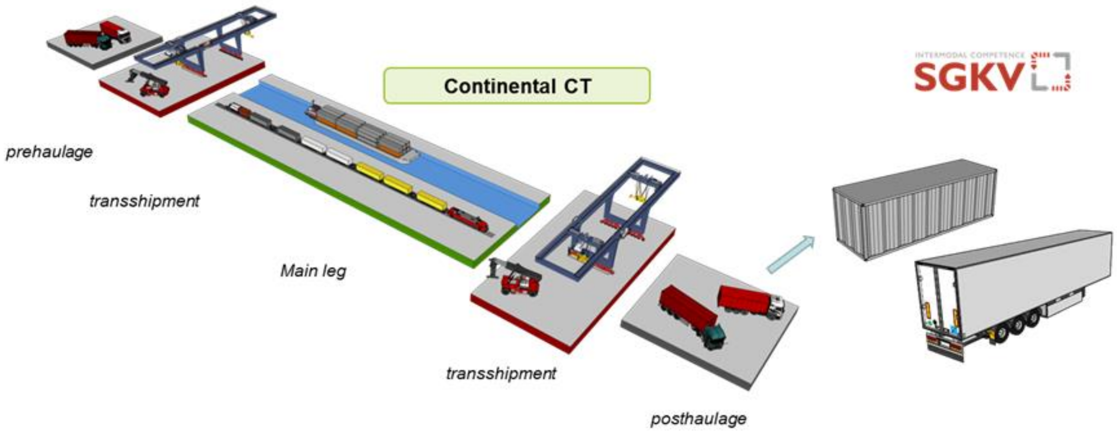


Figure 4: Transport chain in continental CT
Source: SGKV

The following section focuses on the processes that are significantly different from the processes of maritime Combined Transport. The fundamental processes are essentially the same.
Continental Combined Transport mainly takes place within the EU, so only in a few situations the following factors are of importance:

- chosen export port
- commissioned shipping company (and timetables)
- Customs

Depending on the chosen transport connections or the logistics concepts of the initial forwarder, who either act themselves or have their shipments carried out by freight forwarders or hauler organizations (large-scale carriers), an operator is assigned by the responsible party.

The decision on the transport vessel (45 "CT, semitrailer or swap body) is made by the original consignor, forwarding agent or carrier organization.

- In comparison with maritime Combined Transport shipping companies and other shipping organizations usually dispose over a bigger share of the added value.
- Logistics process planning including choice of vessels, etc. takes place before the start of the processes for the CT.
- They choose between road and rail.

- They request company trains from operators if necessary, and therefore bear a greater risk.
- They arrange the pickup of the transport vessel from the terminal.

Neither terminals nor operators are involved in the management of empty vessels. They do not organize the supply of an empty vessel, nor do they have a depot etc.. The companies book a spot on a CT train through the operating entity.

After the truck designated for pickup reaches the terminal, the following tasks have to be taken care of, depending on the transport plan chosen, customs system, etc:

- Cargo check
  - Check of the CT condition
  - Evaluation of total weight
  - Etc.
- Export treatment (if relevant)
- Written (paper-based) processing of the consignment by the agency of the operator
  - Contract of carriage between the initial forwarder and the operator
  - Cargo contract between operator and EVU (only applicable to single wagons)
  - Etc.
- temporary storage (if required) until the train is ready
- Loading onto the freight wagon by crane or reach stacker
- After completion of train composition:
  - Brake test and load control by the Technical Car Service
  - Train preparation by the EVU
  - Connection to traction wagon (upon exit from the terminal track) or transfer of the train set to a rail track from which the train is scheduled to leave
  - Completion of the shipping documents by the operator and delivery to the EVU
  - Handling of the train documents by the EVU and completion of the train preparation along with a notification to the railway infrastructure company
- The first-mile processes are completed upon:
  - departure of the train
  - Data pre-notification (e.g. for the purpose of tracking and tracing)
  - final notifications or (billing) processes concerning the forwarder or other participating service providers

2.1.3 Description of CT processes for the long haul

The processes within the area of "long haul" transports are entirely based on rail-specific regulations:

- Prior to a rail transport:
    - Definition of the relation
    - Request for routes and timetables (Schedule, number of transit days etc.)
    - Definition of the time frame for the:
        - Forwarding terminal
        - Receiving terminal
    - Definition of
        - Traction weight
        - Total length of train
        - Type of wagon and type of adjustments
    - Traction request
        - Type of locomotive
        - Schedule of drivers including driver switch
    - Other processes and requirements:
        - Transhipment
        - Storage capacities of locomotive and wagons
        - etc.
- The rail transport per se is operated according to operational norms of the EVU regarding the different infrastructures. The long-haul section can either be operated via complete trains, or through individual wagons or bundling of wagons by including those transports into existing networks.

Since most of the CT transports are operated cross-border, a certain degree of complexity emerges in the following areas:

- Infrastructure: Different national rail infrastructures, for instance single rail, multi-rail, capacity shortages, varying electricity supply systems, changing rules and regulations, language barriers, etc.
- Railway corporations: Problems through change of systems especially at confining hubs, succession of multiple EVUs to the transport
- Positioning and connection of wagons: Positioning of the wagons through several different adjustments methods.

Since the goods to be transported (vessels of Combined Transport loaded onto the rail wagons) normally undergo no change whatsoever on their way, all these processes are generally carried out according to the standards and specifications applicable in general rail freight traffic (for block trains or single wagons) –leads?. Thus, a distinction between maritime and continental traffic is not necessary.

2.1.4 Description of CT processes for the last mile

The processes occurring upon reception at destination usually take place in simplified form (in reverse order) compared to the processes of the first mile.
The responsibilities as well as the inducement of the processes usually follow the same steps which also apply to shipping:

- The liability of the railway service operator ends when the train or wagon reaches the terminal loading track.
- The unloading of the train or wagon is done by the terminal as fast as possible, usually following the instructions of the train operator.
- The responsibility of the operator ends when the shipment is handed over to the consignee (depending on the transport contract, inclusive or excluding road post-haul).

2.1.5 Review of general terminal processes

The following section reviews cases of good practice for processes in transhipment terminals. To that end, two examples of terminals within the geographic review area were selected: The terminal in Villach-Fürnitz and Terminals in Verona (Interporto Quadrante Europa of Verona).

Terminal Villach-Fürnitz

The terminal Villach-Fürnitz is located within the industrial area Fürnitz, which is about 150 hectares in total size. The area is bounded by the tracks of the major marshalling yard Villach-Süd. The transfer station is based north of the industrial area. The transhipment terminal Villach-Fürnitz operated by ÖBB (Austrian rail corporation) is located in the western part of the hub, and is designed as a terminal station. Both Accompanied Combined Transport, in particular the Rolling Highway ("Villach Süd RoLa") and Unaccompanied Combined Transport (UKV "Villach Süd CCT") can be handled at the Villach-Fürnitz terminal.

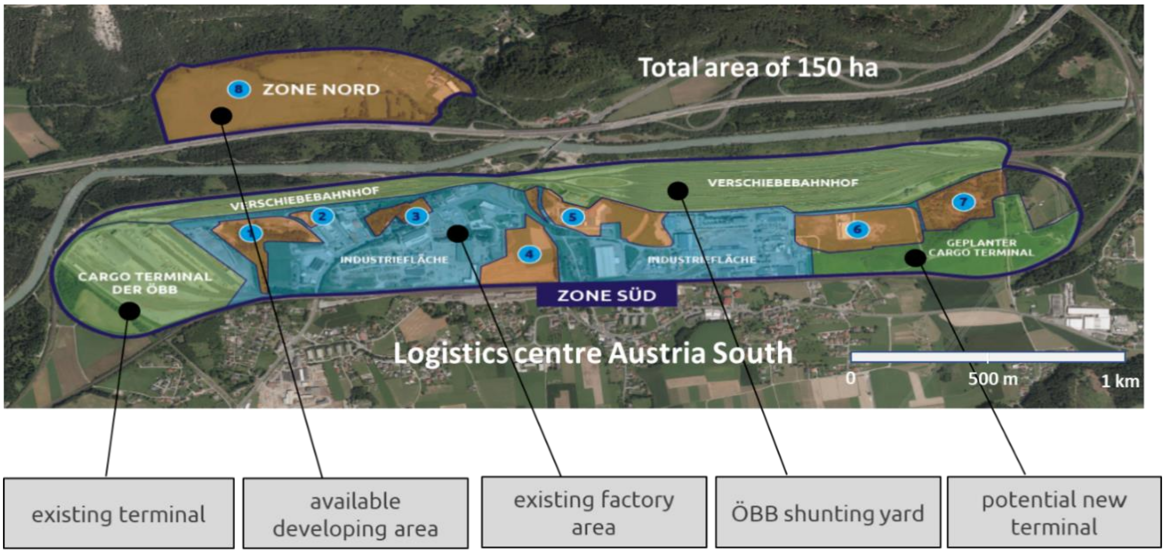


Figure 5: Villach-Furnitz terminal – aerial view of the area
Source: LCA Süd

In addition to its core function, Villach South CCT manages and uses buildings that are equipped with access to rails for logistic activities, e.g. for temporary storage. Parts of these buildings are leased to companies in the transport and logistics industry.

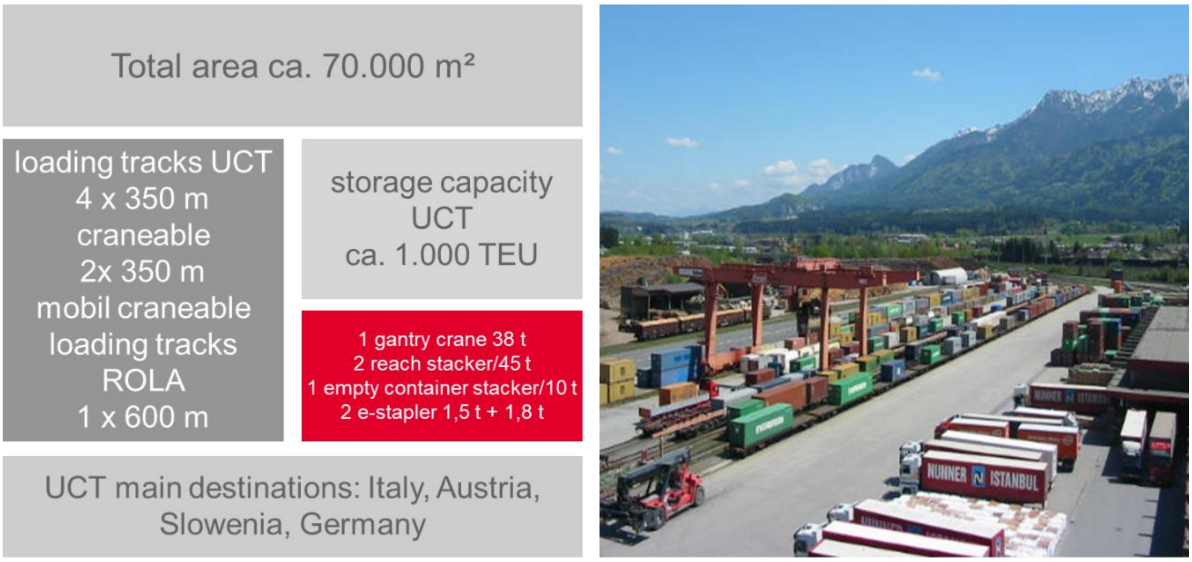


Figure 6: Villach-Furnitz terminal – schematic representation of the terminal area
Source: LCA Süd

This combination terminal's main purpose is the handling of cargo units from road to rail and vice versa. This service is currently provided for all common intermodal loading units. In addition, product-specific transhipping of goods is offered that are not delivered in containers (e.g. wood or other bulky goods) or goods that require special treatment (e.g. refrigerated goods). Also, other value-added services are offered.

On an area of around 70 000 m², the CCT Villach Süd currently operates four crane tracks, each with a track length of 350m. In order to serve the UCT, gantry cranes with a payload of 40 tons as well as a mobile crane device with a maximum load of 45 tons are available.
At the terminal containers with the sizes 20', 30', 40' and 45' are handled. Due to the available storage area of 25,000 m², the total storage capacity comprises 1,100 TEU. The daily capacity is around 280 loading units – resulting in an estimated 70 000 loading units per year during 250 operational days.

Services of the terminal:

Services relating to transhipment:

- “Hübe” Container 20' -45’
- Transhipment of grainy goods and stones
- Transhipment of agricultural products
- Transhipment of trailers
- Transhipment of shifting structures

Services:

- Last Mile Service
- Cooling and heating of containers
- CSC-Inspection, SOLAS-weighing, Agency for Operators und RU, accredited destination for controlling of packing wood
- Approved location of goods (customs)

Operation range:

- Connection to south ports
- Connection to north ports
- Building of regional and international networks

Transhipment and pre-haul infrastructure

The marshalling yard is an essential part of the terminal location Villach-Fürnitz. The nearby transhipment and supply infrastructure northeast of Villach Süd CCT or so called „RoLa“ (Rolling Highway) provides infrastructure for the separation and merging of trains, and thus forms the basis for deploying Villach Süd CCT as a gateway.
Given the situation regarding the network of intersections of major rail axes, this offers considerable potential for using the terminal as a hub as well as a linking point for international traffic.

Basic function: freight traffic turning platform and shunting centre to fragment and form freight trains

Advantages:

- Reduction of the time wagons are circulating and thereby a more economical use of freight wagons
- Speeding up of the train forming process, thus reduction of transport time
- Reduction of transport damages
- Bundling of volumes to optimize the capacity of facilities and trains
- Turning platform for freight traffic from/to Italy and south-east Europe
- Distribution centre for wagons and consignments for Carinthia and East-Styria

Infrastructure	Performance data

▪ 11 In-tracks, 40 shunting tracks
▪ 100 km tracks incl. approach tracks
▪ 320 signals
▪ 250 switches
▪ 33.000 brake elements (Dowty Retarder)
▪ Efficient systems for disposition and processing
▪ Number of ÖBB-employees ca. 260 (shift work)
	Daily capacity: ca. 3.200 wagons within 22 hours of operational time
	Workload now (on an average working day):
	▪ Trains in 95 (with 91.000 tons – 38 km length of 2050 wagons)
	▪ Disassembling on the main hill 90
	▪ Trains out 80
	  ▪ International: 20
	  ▪ National: 12
	  ▪ Near distribution: 13 with 56 train building groups

Figure 7: Villach-Furnitz terminal - Infrastructure and Performance data
Source: LCA Süd

Interporto Quadrante Europa of Verona

Interporto Quadrante Europa of Verona is one of the most important European logistic hub as witnessed by the first place awarded in the GVZ EU Ranking (the German association of Freight Villages), which aims at evaluating the best logistics hub based on more than 30 parameters. It is owned by Consorzio ZAI that is the infrastructure manager. Quadrante Europa area covers about 2 million of meter squares and with the expansion possibility of over 4 million total. It is located across the two main Italian motorways (Autostrada del Brennero – A22 and Autostrada Serenissima A4) and railways (Brennero-Modena and Milano-Venezia), respectively on the principal axis from North to South and Ovest-East. Interporto of Verona is also fully integrated to the regional and local road. The geographical position and the interconnection with the European TEN-T corridors Scan-Med and Med underlines the strategic location of Interporto. The European Rail Freight Network also includes the freight village of Verona as core Rail Road Terminal.

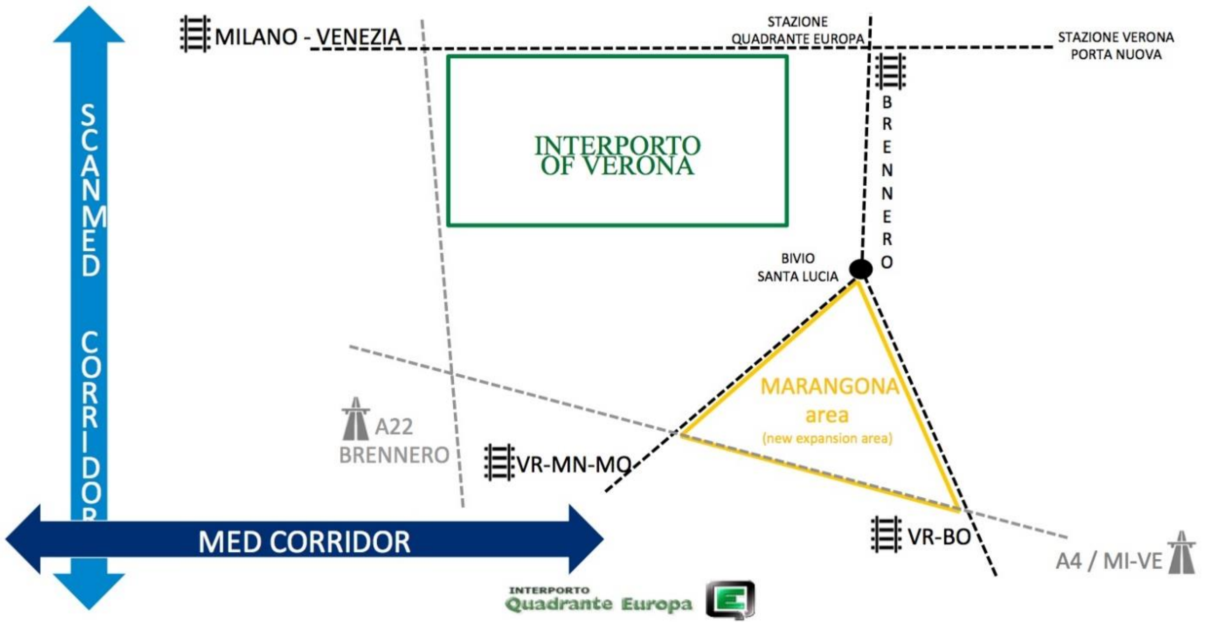


Figure 8: Interporto of Verona- geographical gateways
Source: Zailog

Interporto Quadrante Europa is an organized and integrated logistics service system that merges traffic flows, multimodal connections and gives the direct access to European transport corridors operating with a high level of efficiency. The markets of this strategic node include the international goods transport traffic to and from central and north Europe via the Brenner Pass. Over 6 million tons of goods transit in the Interporto by rail and 20 million tons by road. The main rail services are with Germany, Denmark and Netherlands. There are also weekly connections with France, Belgium, Sweden and some Eastern European countries. Other important railway destinations are related to the Italian harbours, especially to the ports of La Spezia, Genova and Livorno.

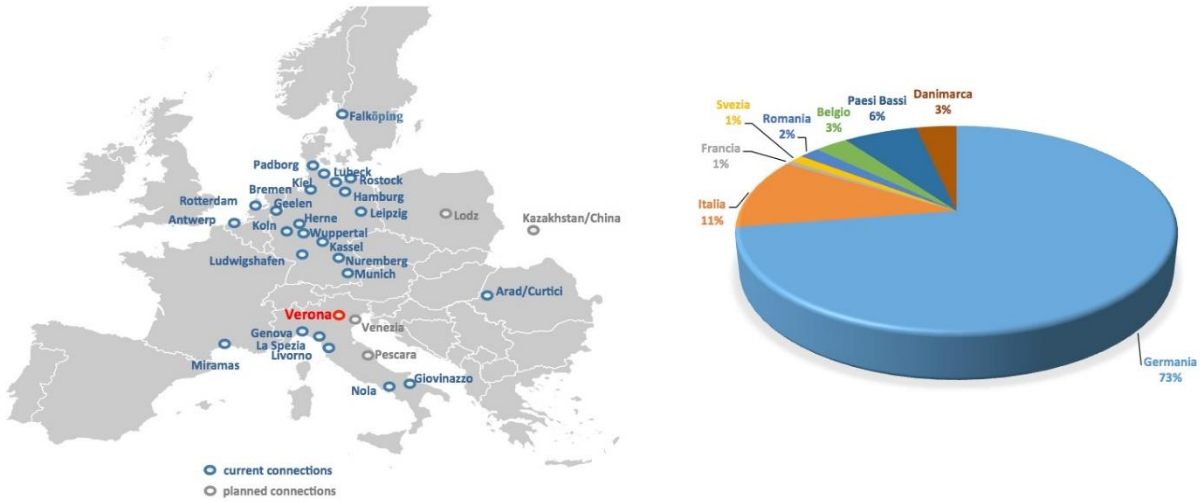


Figure 9: Interporto of Verona- connections
Source: Zailog

In the year 2016, 720,000 UTIs were handled and over 16.200 trains were moved. To guarantee these operations, the 3 intermodal terminals offer a complete logistical service, fitted for loading and unloading of different freight. At the same way, it offers other supplementary services (security, customs, dangerous goods and trucking), which are essential for the improvement of the intermodal traffic. The railway layout shows the existing situation and the three intermodal infrastructures operating in Quadrante Europa area.

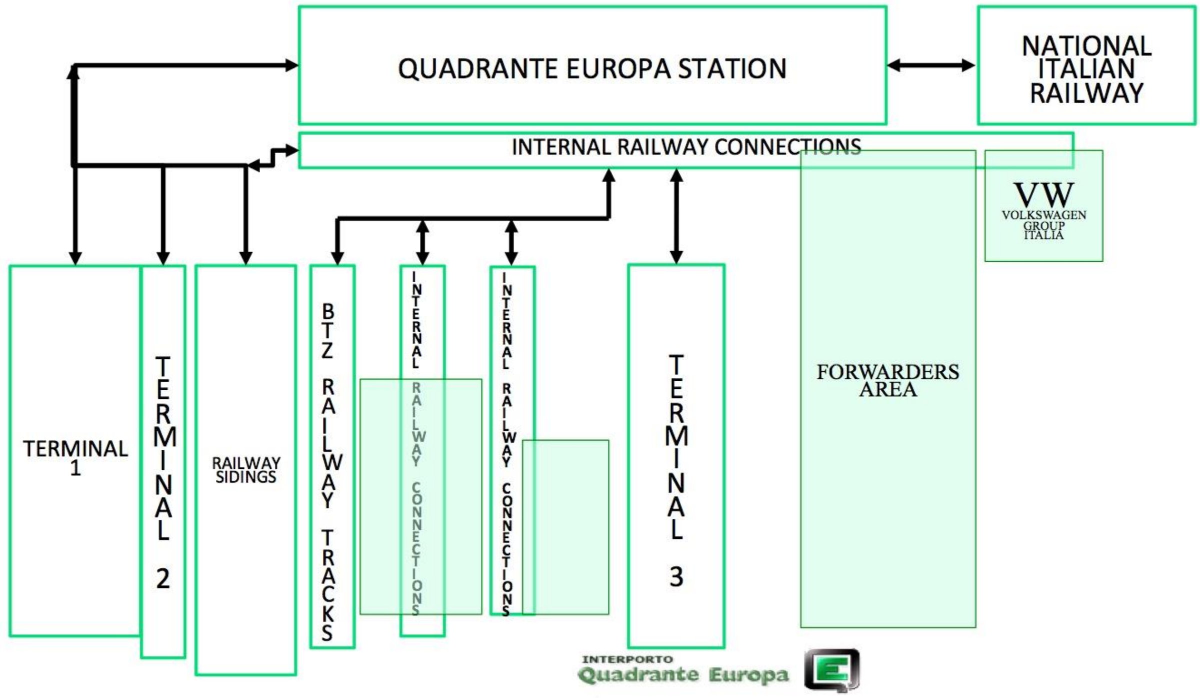


Figure 10: Interporto of Verona- railway layout
Source: Zailog

Terminal 1, 2, and 3 are different owned and managed:

	Owner	Manager
Terminal 1	RFI	Terminali Italia
Terminal 2	QETG	Terminali Italia
Terminal 3	Consorzio ZAI	Quadrante Servizi*

Quadrante Servizi is also the service provider of Interporto, especially the shunting operator of the intermodal terminals.
The figure below represents the partnership of the main actors involved in the Interporto supply chain. Consorzio ZAI is the first promoter of Quadrante Europa and it is involved in Quadrante Servizi (the main partner) and in QETG that is a new enterprise borned to build the innovative intermodal terminal closed to the railway sidings. QETG is participated by ZAI, as said before, and RFI. The national rail infrastructure manager (RFI) shares almost all the Terminali Italia capital.

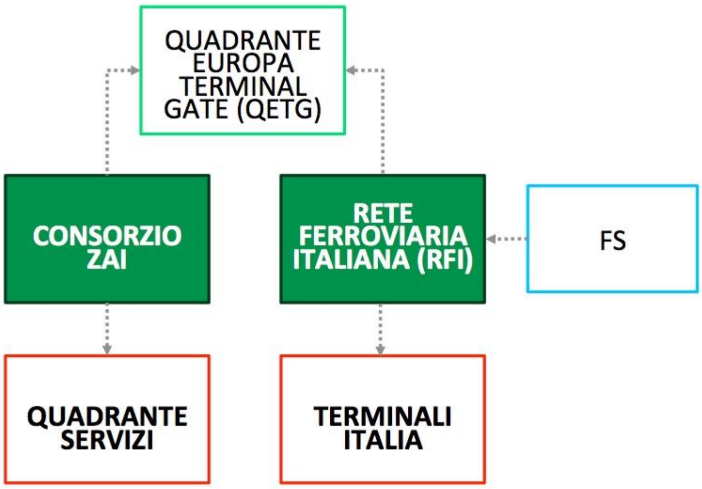


Figure 11: Interporto of Verona- ownership
Source: Zailog

In this general context, the three terminals work with a high level of efficiency and make Verona logistic hub as an EU best practise. In detail, the characteristics of intermodal terminals (services offered, operation range, transhipment and pre-haul infrastructure, performance data) that currently permit to develop the Combined transport (in Verona working only unaccompanied transport UCT) are:

TERMINAL 1 (ex-Cemat) AND 2 (QETG)

Name	Data
Total area	280.000 m ²
Operational tracks (loading and unloading)	15
Railway sidings	6
Marshalling yard	2
Maximum admissible length on tracks	700 m
Services	Shunting, handling loading unit, storage area, online check in, OCR standard, e-booking, damage surveys, SOLAS-weighing, ADR assistance (except radioactive material), Security vigilance on closing days and holidays, automated electronic exits.
Equipment	4 portal crane, 3 compact crane, 5 gru gommate, 11 reach steaker, 7 mafi
Couple trains per week	120
ITU/year	340033 (2016 by RFI)
Railway undertakings	Mercitalia Rail, TX Logistik, Serfer, RTC, ISC e Captrain
MTO	Cemat, TX Logistik, NOI, Forwardis S.A., Rail Cargo Operator
Destinations	Herne, Lubecca, Padborg, Kassel, Colonia, Lipsia, Rostock, Göteborg, Anversa, Rotterdam,

	Hannover, Kiel, Munich, Geelen, Norimberga, Ludwigshafen, Miramas, Curtici Rail Port Arad, La Spezia, Genova, Nola, Giovinazzo.
Closing hours	Sunday from 6.00 a.m. to 10.00 p.m.
Contacts	Terminali Italia s.r.l. Email info@terminaliitalia.it

TERMINAL 3 (Interterminal)

Name	**Data**
Total area	55.000 m ^{2}
Operational tracks (loading and unloading)	3
Railway sidings	2
Maximum admissible length on tracks	530 m
Services	Shunting, handling loading unit, storage area, e-booking, damage surveys, SOLAS-weighing, Security vigilance.
Equipment	4 reach steaker, 3 mafi
Couple trains per week	27
ITU/year	35490 (2016 by QS)
Railway undertakings	Mercitalia rail, DB cargo, RTC, RciT
MTO	Cemat, Kombiverker, DB Schenker
Destinations	Amburgo, Rostock, Brema, Wuppertal e Livorno.
Opening time	Monday-Friday 6.00 – 24.00 Saturday 6.00 – 14.00
Closing hours	Sunday 6.00 - 22.00
Contacts	Quadrante Servizi s.r.l. – Ufficio raccordo: Tel (+39) 045 8620124 – Fax (+39) 045 952510

3 CT transshipment technologies

Based on the analysis of CT processes and supply chains in chapter 2 (in particular the description of the terminal processes), the following chapter provides a summarized overview of relevant CT transhipment technologies.
A distinction will be made between technologies and systems dealing with:

A: Accompanied Combined Transport (ACT)

B: Unaccompanied Combined Transport (UCT)

- B1: Non-craneable trailers
- B2: Systems for the transhipment of craneable trailers, containers and swap bodies.

In the overview chapter 3 will focus on the description of the technology, requirements of terminal infrastructure and rolling stock characteristics. The section continues by summing up positive and negative aspects of the systems regarding terminal infrastructure, operational aspects and supply chain networks. Whenever reliable data based on information, know-how and practical experiences within the project consortium is available, statements regarding investments and operational costs will also be provided here[3]. A more detailed analysis and review can be found in the Annex.

3.1 CT technology A – ACT

3.1.1 RoLa- Rolling Highway

Rolling Highway (RoLa) / Piggyback technology "A": Rolling motorway[i]

Technology description	The Rolling Highway is a railway rack onto which trucks drive horizontally and in a row. It allows trucks without the necessary fittings for Unaccompanied Transport to cross the Alps by rail. Whole trucks are loaded onto special rail wagons at the terminal, while drivers travel in a separate sleeping car. On RoLa, the entire truck including the driver travel by train (or separately by other means of transport). Despite the night and Sunday driving ban, with RoLa the Alps can be crossed in both directions around the clock and year. The concept of RoLa has been developed over time by various producers and developers. Today, multiple operators are available. The System is working since 1979. The Type of transshipment technology is horizontally, there is no crane necessary. The loading unit is ACT (whole truck with driver).

[3] Additional information is also based on the overview given in:
TU Dortmund (Ed.)(2017): Vergleich der KV-Umschlagtechniken und Überprüfung auf Integrierbarkeit in das vorhandene Netz- Bachelorarbeit von Janis Schneider. Dortmund

The total time of transshipment process is 5 minutes per LU and 20 min in average per train[4].
The location of operation are the following relations:
Aiton (FR) - Orbassano (IT)
Orbassano (IT) - Aiton (FR)
Brenner (AT) - Wörgl (AT)
Wörgl (AT) - Brenner (AT)
Trento (IT) - Wörgl (AT)
Wörgl (AT) - Trento (IT) (Ökombi - high demand due to the sectoral driving ban for the Inn valley motorway.)
Wels (AT) - Maribor (SI)
Salzburg (AT) - Fernetti/Trieste (IT)
Freiburg i. Br. (DE) - Novara (IT) - including 4-meter Lötschberg-Simplon corridor(Operators: RAlpin - BLS, Hupac, SBB and Trenitalia)
Novara (IT) - Freiburg i. Br. (DE)
Basel (CH) - Lugano (CH); Singen (DE) - Milano (IT) - Gotthard route (Demand is low, because the low profile height in the Gotthard tunnel limits the market potential significantly.)
Lugano (CH) - Basel (CH)
Trient (IT) - Regensburg (DE)
Regensburg (DE) - Trient (IT)
Mainly for small* and medium terminals as big terminals usually do not have only ACT platforms, but also cranes etc.
RoLa requires a network of O/D terminals.

This technology is suitable for all TEN-T corridors in Alpine space.

The only required equipment facilities or specific terminal feature are a straight railway track with truck-drivable ends (at least 700 m), parking space, turning options for trucks, and service facilities for passenger coaches. Unlike with Unaccompanied Combined Transport (UCT), no huge logistical changes and investments are necessary. Virtually every truck approved for European roads can be transported by RoLa.
The loading ramp requires an area of approx. 80 m^2 for one transshipment unit and costs approx. 100 000 €. A RoLa-Wagon costs about 180 000 €. Maintenance costs of RoLa-Wagons are high (15 cent/km per wagon)[5].
The net load capacity of RoLa trains is lower than that of UCT. 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 tonnes for RoLa and 750 tonnes for UCT, while the average transport distance is about 300 km for RoLa and 800 for UCT. A standard freight train circulating in Central

[4] Pfohl, H. C (2010): Logistiksysteme: Betriebswirtschaftliche Grundlagen, Berlin.
[5] Bundesamt für Verkehr (2007): Betriebs- und Investitionskostenvergleich der RoLa, Stand 2007, Aktualisierung der Ecoplan-Studie "Betriebs-/Investitionskostenvergleich zweier RoLa-Systeme" aus dem Jahre 2003, Bern.

European rail networks will carry some 80 boxes of 20ft. or 7m. For customers the transport of a full truck on the route Novara - Freiburg (437 km) is about 500 € and takes about 12 hours from the closing time to the time in which trucks are ready to be unloaded.

Figure 12: RoLa - Rolling Highway. Source: http://www.ralpin.com/media/

Table 2: Rolling Highway - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Rolling Highway (RoLa) aka Piggyback technology "A": Rolling motorway	Due to minimal infrastructural requirements new RoLa services can be set up rapidly	Countries like Switzerland and Austria already have a network of terminals and many years of experience with this technology	It allows transportation despite the night and Sunday driving ban	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. A standard freight train circulating in Central European rail networks will carry some 80 boxes of 20 ft. or 7 m.
	RoLa plays an important supporting role for CT, because it accommodates CT transports which lack the special equipment that is required for UCT	It perfectly complies with the Austrian and Switzerland laws for cross-border transport	Optimisation of truck drivers' rest periods	UCT is economically and ecologically more efficient
	Needs at least 700 m of a straight railway track for loading and unloading		Optimal deployment of trucks and truck drivers	Significantly higher acquisition and maintenance costs for the required special wagons
			No delays at borders, road checks or traffic jams	
			No customs formalities at either of the two Swiss borders	

3.1.2 Flexiwagon

	Flexiwagon
Technology description	A Flexiwagon is a rail-rack which is added to a train. It is a flexible and environmentally friendly roll-on/roll-off solution. Whole trucks, buses or other vehicles can be loaded and unloaded individually via terminals that are part of the Flexiwagons. The wagon is rotatable to both sides. Loading and unloading of the Flexiwagon is done by the drivers who drive their vehicle onto the wagon via ramps on the front and rear end. Drivers are traveling separately in a wagon or sleeping car. The Flexiwagon is suitable for loading units up to 18,75 meters and up to 80 tons. The total time of transshipment process per LU is seven minutes and ten to 15 minutes per train. The type of transshipment technology is horizontal and the loading unit is ACT, as the entire truck is transported, including the driver. Mainly for small* and medium terminals as big terminals normally do not have only ACT platforms, but also cranes etc. The Flexiwagon does not require a network, as the required terminal specifications are only space for loading and unloading and a terminal platform (paved platform near the tracks, where manipulations are possible). There is the need of a platform parallel to two wagons for maneuvers of the track or vehicle, approx. 120 m^2. The Flexiwagon is under development by the Company *Flexiwaggon AB* in Östersund, Sweden and is currently in operation in Sweden. Not in operation in Slovenia, Austria, Germany, Switzerland, Italy and France. A Swedish-Swiss consortium has been formed to realize the project for the Gotthard tunnel, Switzerland. Flexiwaggon is offering a solution to annually transport 1 200 000 trucks swiftly through the Gotthard tunnel. Beside the Flexiwagon, additional equipment is required: • Additional TCS (Train Control System) is needed: Receivers are located in the locomotive with the driver. Information is received from the WCS system, which monitors the wagon's operation, wheel bearings, and deviations in the braking system, and other aspects of the wagon. With the TCS, the locomotive driver can control loading and unloading on one, multiple or all wagons in the train set at the same time. • Remote control: The wagon comes with either wireless or with wired controls for loading and unloading the cradle. The truck driver, the locomotive driver or other authorized train personnel can work the controls. The remote control also simplifies the work of maintenance and service personnel since they can control the cradle from a distance.

- Wheel stock sensors: The sensor system discovers early overheating in the wheel stock and prevents malfunction.
- Brake sensors: The sensor system registers when braking effect diminishes and brake components need replacing.

Design changes are possible in the form of shorter or longer cradles, wider openings in cradles, length of loading and unloading ramps and other customer- specific needs.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 13: Flexiwagon
Source: https://www.nyteknik.se/fordon/lastbilarna-kan-ta-taget-6819593

Table 3: Flexiwagon - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Flexiwagon	Fast transshipments of cargo (7 minutes), driver operated		Transports according to schedule	UCT is economically and ecologically more efficient
	No disruption to traffic on parallel tracks		Easy to load and unload – the truck can travel on the wagon with or without the driver	Investment cost per Flexiwagon: 330.000€
	Individual loading and unloading of wagons			

	Access to electricity needed: 110/240/400 volt 50-60Hz, for cooling units or engine heaters			

3.2 CT technology B: UCT

3.2.1 B1: non-craneable semitrailers

3.2.1.1 Modalohr Horizontal

	Modalohr Horizontal
Technology description	Modalohr is a system that allows horizontal handling using a low-floor double carriage with revolving structure. By folding out the construction in specifically equipped terminals, the truck units can be driven onto the wagon. After loading, the constructions are mechanically folded back on the wagons. Because of that, Modalohr requires a lot of terminal space. The system depends on train schedules. The Modalohr technology was developed by Lohr Industrie SA and is working since 2003. The Type of transshipment technology is horizontal, the trucks drive on and off the rail-racks. Due to the flexible structure of the wagons vertical transshipment is also possible.[6] Whole trucks can be transported (ACT), but also craneable and noncraneable semitrailers, containers or swap bodies (UCT). The costs of handling per loading unit are 80 €. The total time of the transshipment process is 256 minutes for loading/unloading a whole train with 32 semitrailers, so per loading unit it is about 4 minutes. The system is operation at terminals of the following relations: Aiton (FR) - Orbassano (IT) Bettembourg (LU) - Perpignan (FR) Calais (FR) - Le Boulou (FR) Le Boulou (FR) Bettembourg (LU) E.g. transport: Semitrailer + Handling + Wagon + Rail traction Cologne - Milan costs 759 €. Mainly for small* and medium terminals as big terminals normally do not have only ACT platforms, but also cranes etc. It needs at least a pair of two terminals (O/D), but it can be more efficient within a network of terminals.

[6] http://lohr.fr/de/lohr-railway-system/die-lohr-uic-waggons/

Not in operation in Germany, Slovenia and Austria yet, but there are terminals in project in Germany and Slovenia.[7]
For this transshipment the Modalohr terminal with transshipment modules and a space of average 156 m^2 is required.
According to the manufacturer the terminal investment for one transshipment unit is 74.000 €, with 256 LU per traffic day and terminal costs of 19 Mio. €. A Modalohr wagon costs 385.000 € for 2 parking spaces.
*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 14: Modalohr Horizontal
Source: http://lohr.fr/lohruploads/2016/03/uic-2.jpg

Table 4: Modalohr Horizontal - overview

	Terminal Infrastructure	**International Terminal Network**	**Operation and supply chain**	**Costs and Investments**
Modalohr	Handling of the loading units is possible without shunting while the train is under the electricity track		Handling time is shorter than for UCT (but only if enough staff is available; 26 people for 13 wagons)	Additional costs in comparison to the traditional combined transport occur for special wagons and specific terminals

[7] Source http://lohr.fr

	The very low loading platform enables 4 meter-high trucks to be loaded within the limits of existing railway gauges (UIC GB1)		Modalohr accepts most standard trucks without modification: (Maximum height: 4.04 m, Semi-trailer maximum length 13.7 m, Semi-trailer maximum load : 38 t)	Investment costs terminal: 6,7 Mio € [8]
	Technical specification of special wagons and technically demanding terminals			
	High space requirement in terminals			

3.2.1.2 CargoBeamer

CargoBeamer

Technology description

This new wagon system handles trailers, containers and swap bodies in a linear, horizontal loading and unloading zone. Similar to a "classical" container terminal the train needs a long range of rail track. The trailers are loaded in bowls which are shifted beside the wagon for unloading and loading. The bowls are autonomous from the train. This allows loading and unloading autonomously from the presence of the train in the terminal. One train can carry up to 36 trailers and load/unload 72 of them simultaneously. This technology is developed by CargoBeamer AG. In 1998 the CargoBeamer concept was developed and in 2013 the CargoBeamer AG in Bautzen was founded with production starting that same year.
This type of transshipment technology is horizontal. The loading unit is UCT with craneable and noncraneable semitrailers, containers, swap bodies.

The cost of handling per loading unit is 75 €.

The total time of transshipment process is 15 minutes per train with 26 trailers and 13 CargoBeamer installed. The process is fully automated, with one staffer needed.
The CargoBeamer is in operation on the relation Domodossola (IT) to Cologne (DE).
Mainly for small* and medium terminals as big terminals normally do not have only ACT platforms, but also cranes etc.

[8] Realisierung einer schienengebundenen Ro-Ro-Brücke zwischen dem Hafen Triest und Bayern; FH Rosenheim, Fraunhofer IML, LKZ Prien GmbH, RMB GmbH, 2006

A network is required. This system is to be operated in origin/destination terminals, so at least it has to be installed in two terminals. The CargoBeamer system is especially useful in continental transports, but also as an extension for maritime RO-RO traffic.
The Cargo Beamer is not suitable for all TEN-T corridors in Alpine space, as the technology is required at every terminal.
It has an operational approval in Germany, Switzerland, Italy and France.
For one transshipment unit an average terminal space of 117 m^2 required.
The Cargobeamer terminal layout is flexible and its arrangement and size can be modified to suit the local conditions. The modules consist of pre-cast concrete parts so that a terminal can be installed quickly at moderate costs and expanded at any time. A transshipment module with track, parking tracks for pallets and driving lane for trucks on each side is 22m wide and 19.3m long.
Terminal investment for one transshipment unit is 67 000 € per LU with 256 LU/traffic day in an area of 425 000 m^2 and investing costs of 24.5 million €.
Cargogate : 10 - 20 million € per site
Ongoing: Maintenance of facility

A Cargobeamer wagon costs 360 000 € for 2 parking spaces, a wagon base costs 40 000 € with 2 pallets per wagon (each 20 000 €).

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 15: Cargobeamer
Source: https://www.cargobeamer.fr/CargoBeamer-Umschlagvorgang-816950.jpg

Table 4: Cargobeamer - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
CargoBeamer	Loading and unloading independently from the presence of the train in the terminal.	Approval of operation granted in Germany	Able to carry different intermodal types	
	No complex technologies onboard		Vertical handling of containers, swap bodies and craneable trailers possible, thus very flexible	
	Combination of a new linear, horizontal technique with the classic vertical handling	Still not in operational phase - no existing network available		
	Space requirements less than container terminal			
	Specialized technical infrastructure is needed			
	Needs a lot of terminal ground			

3.2.1.3 ISU Innovativer Sattelauflieger Umschlag/Innovative Semi-Trailer Handling Unit

	ISU Innovativer Sattelauflieger Umschlag/Innovative Semi-Trailer Handling Unit
Technology description	The ISU-System includes a small mobile platform. First the trailer is parked on a small mobile loading platform. After the tractor has left, the trailer is lifted into a classical pocket wagon by special lifting gear with wheel grippers. This system allows direct handling of non-craneable trailers without any new terminal infrastructure or modifications. This lifting can be operated by a reach stacker or a gantry crane. The system allows lifting of trailers with measures 4m (height) by 2,6m (width). As part of the ISU-system (wheel grippers, traverse) travels with the cargo, for parallel transshipments acquisition of multiple systems is necessary. Loading time per LU is six minutes. This system was developed by ÖKOMBI, a subsidiary company of Rail Cargo Austria and is currently in operation. The Type of transshipment technology is vertical; the containers are lifted by cranes.

The loading unit is a UCT, this system only works for craneable and noncraneable semitrailers, not for whole trucks.
The ISU is in operation on the relation Wels (AT) - Triest (IT) and Wels (AT) - Stara Zagora (BG).
The technology is applicable for all terminals – small*, medium and big. At small terminals it might be combined with a reachstacker.
This system can be integrated directly into combined train routes where pocket wagons are operated. The handling equipment must be available in the origin and destination terminals to build a network.
The ISU-System is suitable for all TEN-T corridors in Alpine space.

It is applicable in Slovenia, Austria, Germany, Switzerland, Italy and France with P400 loading gauge (UIC - GC).
The ISU-Handling equipment consists of the small loading platform (ramp 3x27 m), ISU - traverse, ISU - spreader and the lifting gear with wheel grippers.
The intermediate frame with lifting straps and two loading ramps costs 60 000 €, in addition to this the ongoing maintenance of ISU components and the crane-infrastructure is required. The double pocket wagon costs 180 000 € for 2 parking spaces.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 16: ISU (Innovativer Sattelauflieger Umschlag)
Source: https://www.verkehrsrundschau.de/nachrichten/neues-rca-umschlagssystem-wenig-erfolgreich-1229376.html

Table 5: ISU - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
ISU	Easy integration into existing services without heavy technology	First experiences with first connection from Wels to Bulgaria	Handling of non-craneable trailers	
	Easy integration into existing terminals			
	Complex loading and unloading as competitive disadvantage			
	staff training by system implementation (3 staffers needed per handling)			

3.2.1.4 Megaswing

Megaswing

Technology description

Megaswing's full brand name is "Swingable megatrailer pocket wagon". This system allows transport of non-craneable trailers without additional handling technologies such as cranes. The pocket for the trailer rotates (»swings«) to the side for loading and unloading. A normal truck tractor couples off and leaves the loading site immediately. Loading or unloading of a unit requires one staff member and takes about three minutes, the loading process of a full train can be completed within 30 minutes[9]. All technical components are included into the wagon, so beside a truck-drivable trackside along an existing rail track there is no additional terminal infrastructure needed. This results in cost-effective handling. It is able to carry almost all types of trailers up to 4m height, so called Megatrailers.

The Megaswing was constructed by the Swedish company Kockums and is in series production since 2011.

The type of transshipment technology is horizontal. The loading unit is a UCT, since the truck uncouples.

Until today there are no realized intermodal relations using the Megaswing system. It was tested under real conditions in Germany and Sweden.

Mainly for small* and medium terminals as big terminals normally do also have cranes, installed infrastructure etc.. The advantage is its flexibility at small terminals.

There is no special network needed. The system can easily be integrated into existing trains and terminals and can potentially be used for the extension of maritime RO-RO connections.

[9] http://www.kockumsindustrier.se/en-us/our-products/productdetail/?categoryid=3&productid=11

The system is not suitable for all TEN-T corridors in Alpine space as it has no operational approval in Slovenia, Austria, Germany, Switzerland, Italy and France.
There is no special terminal needed. A drivable trackside along the railway track is sufficient. It is easy to operate within existing intermodal terminals as it allows horizontal and vertical handling. Due to the platform parallel to two wagons Megaswing's space requirements add up to 120 m^2.
The Investment per rack is approximately 30 000€.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Table 6: Megaswing - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Megaswing	Allows easy handling of non-craneable trailers	No network needed	All types of specified railway loading units can be transported (containers, codified trailers and swap bodies)	Investment cost Megaswing wagon: 300 000 €
	Handling under electrified tracks possible	Successful test phase	Allows individual wagon unloading in coupled trains with multiple stop-overs	
	Allows horizontal and vertical handling	New wagon type, no experiences in daily use	Increased flexibility	
	No special infrastructure needed, a truck-drivable trackside along an existing railway track is adequate	Not realized on any relation and network		
	Possible in every existing terminal with trackside area for trucks/trailers			
	Relatively complex technical components			

	Quick loading and unloading in comparison to ACT, no special equipment/network is needed on terminals (in comparison to Modalohr), only paved platform			
	Cost saving due to horizontal loading (no craning needed)			

3.2.1.5 NiKRASA

	NiKRASA
Technology description	The system NiKRASA is a system consisting of a terminal platform and a transport platform. It consists of two components: An easy to install terminalplatform onto which trucks can drive, and the transport platform. The transport platform is used as a tool to shift a non-craneable semitrailer from road to rail. The system does not require any changes of the trailer, wagons or terminals. It is a system which enables non-craneable semitrailers to be loaded onto standard pocket wagons. NiKRASA was developed by TX Logistik AG, Bayernhafen Gruppe and LKZ Prien GmbH and was officially launched in 2014. It is a type of vertical transshipment technology, as the NiKRASA-racks are moved by cranes. NiKRASA is an UCT since it moves craneable and noncraneable semitrailers. Based on the fact that standard pocket wagons type T3000 are used, carrying containers and swap bodies is also possible. The cost of handling is 15 €/LU plus costs for craning. The Rail company TX Logistik provides transport platforms to transport companies at a rate of 50 to 70€ (real costs, subsidies not included). The total time of transshipment process per loading unit is 3 minutes. The technology is in operation on the following relations: Bettembourg (LU) - Triest (IT) Padborg (DK) - Verona (IT) Herne (DE) - Verona (IT) Herne (DE) - Malmö (SE) And is planned for the relation: Lübeck (DE) - Verona (IT) The technology is applicable for all terminals – small*, medium and big. At small terminals it might be combined with a reachstacker. For a working network the O/D terminals must be equipped with cranes or reachstackers. NiKRASA is suitable for all TEN-T corridors in Alpine space and for all corridors with a P400 railway gauge.

Beside cranes and a terminal-platform, the terminal does not need much additional equipment: NiKRASA uses standard piggy backs and standard terminal tractors for positioning the trailer and the loading platform. The terminal needs space for the mobile terminal platform (approx. 53 m²) and the traffic space for shunting the trailers on the loading platform.
The terminal platform and the transport platform will each cost a modest 5-digit amount. For simultaneous transport multiple transport platforms are needed. Ongoing costs are the maintenance of the transport platform and terminal platform. A double pocket wagon costs 180 000 € for two parking spaces. Additionally at the origin and destination terminal a mobile terminal-platform is needed.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 17: NiKRASA
Source: www.nikrasa.eu

Table 7: NiKRASA - overview

	Terminal Infrastructure	**International Terminal Network**	**Operation and supply chain**	**Costs and Investments**
NiKRASA	Stable transshipment because semitrailer is protected by transport - platform	Mobile terminal-platform is needed at origin and destination terminal. Any terminal is suitable which is operated by crane or reachstacker	Standard grippers	

	No special knowhow necessary, staff training by system implementation		standard process in transshipment facility	
	2,5 t/transportation platform		No changes to existing standard	
	No additional investment for rolling stock			
	No additional investment for Crane Technology			
	Additional investments for the NiKRASA-Systems at CT terminals			

3.2.1.6 Cargospeed

	Cargospeed
Technology description	CargoSpeed (Cargo Rail Road Interchange at Speed) is a rail-road intermodal system based on roll-on / roll-off principles. It uses the RoRo method known from ferries for loading truck semi-trailers. It has been developed by BLG Consult, Warbreck Engineering and Newrail. The type of transshipment technology is horizontal. After placing the trailer on the rack, the truck uncouples, so the system is a UCT for craneable and noncraneable semitrailers. The system is in operation in Sweden. Mainly for small* and medium terminals. As the trucks are transported on special racks, a special network of CargoSpeed-Terminals is needed to unload the trucks, so it is not suitable for all TEN-T corridors in Alpine space. There is no approval for operations in Slovenia, Austria, Germany, Switzerland, Italy and France yet. The terminal needs to invest in an underground lift. The required average terminal space for one transshipment is approx. 130 m^2. The high terminal investment for the lifting system and the additional costs for the pocket wagon have to be taken into account.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 18: CargoSpeed
Source: http://cctim.se/english/cargospeed-e.html

Table 8: CargoSpeed - overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
CargoSpeed	High investment in underground lift	Needs a network	No changes to existing standard	
	No additional investment for crane technology			

3.2.1.7 Reachstackers[10]

	Reachstackers
Technology description	A Reachstacker is a mobile crane that is the most widely used CT technology on terminals to unload, reload, pile up or move containers. With an empty weight of approx. 100t it can move loads up to 50t. Reachstackers are designed to manage loading units. They are produced by different companies and in usage since 1980.

[10] Reachstaker is not a specific CT transhipment technology, nevertheless it is analsed as an additional benchmark since reachstakers are still a common used trahipment facility.

The type of transshipment technology is vertical: Craneable, noncraneable semitrailers with mobile platform, containers and swap bodies can be moved (UCT).
The handling is approx. 25 to 30 € per LU and takes 3 minutes.

The reachstacker is used on most terminals. At small* terminals it might be the leading technology, at big terminals an addition for specific situations.
The technology is suitable for all TEN-T corridors in Alpine space and for all corridors with a P400 railway gauge. There are no special requirements.
The price of a Reachstacker varies from 100 000 to 500 000 €.

Additional there must be calculated the costs for a mobile platform / pocket wagon for semitrailers.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 19: Reachstackers
Source: SSP Consult

Table 9: Reachstackers – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Reachstackers	Reachstackers are able to transport containers, swap bodies, craneable semitrailers and noncraneable semitrailers with platforms over short distances very quickly and pile them in various rows depending on their access.	Have been in use for decades – standard technology at all terminals	Flexible	
	Reachstackers have gained ground in container 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			
	Time-consuming, as it is a manual process			

3.2.1.8 RailRunner

	RailRunner
Technology description	RailRunner bi-modal rail bogies are uniquely designed having two articulated lower frames connected to each other. There are two types of bogies: An 'intermediate' (IU) unit bogie, which connects the road vehicles (loading units) together and thus forming a railcar, and a 'transition' (TU) bogie, which connects the train to a standard freight car or locomotive. Due to the flexibility of the installment the system is suitable for a wide range of loading units. [11] Total loading time per LU is three minutes. Distance between loading units is 0,7m compared to 3,3m in classic piggyback systems. Price per transshipment is 12-15€ with an annual capacity of 12 000 units[12]. This allows for self-steering of each axle reducing the typical sway of wheels moving over the track thus reducing friction induced wear and tear of the wheel, but also the track. This also reduces the need for maintenance as

[11] Oswald, G. (2015): RailRunner Innovation im Schienenverkehr. RailRunner Europe GmbH, Hamburg. Bremen

[12] Helmke, B. (2015): Terminals ohne Kräne. In: *Schiffahrt und Technik*, 2015 (5/2015). Online verfügbar unter http://www.aprixon.de/wp-content/uploads/2015/07/RailRunner-Terminals-ohne-Kr%C3%A4ne.pdf2017

the of wheels and tracks by 30%[13]. The load carrying upper frame, also called 'drawbar', connects the road vehicles to the bogie. This primary suspension system renders a passenger-train-like smooth ride reducing vertical forces allowing transportion of sensitive cargo with less packaging requirements. A secondary suspension is supplied in case of any malfunction of the primary suspension. A combination of articulation, air suspension as well as additional shock absorbers and dampeners also reduce rock and roll of the bogie and trailers thus reducing cargo shifting and potentially permitting higher speed.

This technology was developed by Terminal Anywhere™ Solution and is in operation. RailRunner bogies have been tested in the US for up to 107 miles/hour (170 km/h). Bogies are equipped with forklift pockets allowing them to be easily taken off the rail in case of business downturns or maintenance reasons, while the road vehicle can always be used in normal road transport.

The type of transshipment technology is horizontal and it is constructed for craneable and noncraneable semitrailers, so it is a UCT. Technical requirements include a truck-drivable space next to the tracks of at least four meters width and additional storage space for loading units, vehicles and bogies to speed up the process.

It is in use in North America and mainly applicable for small* and medium terminals. The system is licensed for usage in Europe and has been tested in Verona. It is expected to run between Braunschweig (DE) and Bratislava (SK) in 2019.

There are no special requirements for a network, it only requires the terminal platform, the Intermediate Rail Unit RailRunner bogie and bimodal trailer.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 20: Railrunner
Source: https://railrunnereurope.com/de/wp-content/uploads/2015/10/RRNA_53-4erGruppe-im-Gleis.jpg

[13] https://railrunnereurope.com/de/operative-innovationen/

Table 10: Railrunner – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Railrunner	No fixed terminal installations necessary, the system needs only a special road tractor (for terminal operations).		tare/load ratio of 28-30 t of load and 15-16 t of tare (trailer and bogie), total weight on rail 42 to 43 t. Total weight of train 1500 t.	The system needs complete trains or sections of trains of bimodal type.
	No standards		Moderate reduction of transport equipment costs.	Retrofitting of vehicles: +5000 €
	Operators at terminals are obliged to assemble a wagon from a number of elements (bogies, trailers and connections) and then to form a long train; these operations take time and a number of tests are mandatory (braking and coupling tests before train departure).		Possibility to transport a high number of trailers on a single train max. 42trailers per train).	Investment cost bogie: 70 000 €
	Official approval in Europe is currently requested.		Possibility to reach customers with no direct railway access (pre- and post-haulage by road)	
			The forces affecting a semitrailer chassis while driving in a train-rack are higher than on a road, due to fixation on both ends of the semitrailer. Especially in curves the dynamic - centrifugal forces are stronger	
			The "bimodal" trailer has a chassis more powerful than usual	

			Equipment property and exploitation involve procedures that differ from the traditional and are therefore in conflict with road or rail rules	
			Any defect on one trailer involves a full stop of the train	

3.2.2 CT technology B2 - semitrailer, containers and swap bodies

3.2.2.1 Metrocargo

	Metrocargo
Technology description	Metrocargo is a technical solution to load and unload trains by using a horizontal handling technique that can be operated without shunting while the train is under the electricity track. It is a logistic concept that avoids the need of taking the train off-line for the handling activities thus shortening the actual operation of intermodal transport without modifications of the trucks and the containers. It is under development by Metrocargo. The type of transshipment technology is horizontal and it is possible to transport containers and swap bodies (UCT). It is under testing in Italy. In single use the technology is mainly applicable for small* and medium terminals and a network of terminals is required. It has no approval for operations in Slovenia, Austria, Germany, Switzerland and France yet and is therefore not suitable for all TEN-T corridors in Alpine space. Required equipment and transshipment facilities: The lifting system consists of four independent units that identify and lift a unit load placed on the wagon train. This lifting system operates on the outside of the corner block. The synchronous movement of the towers allows precise positioning through the acquisition of the locations of the four corner blocks for all types of cargo units (containers and swap bodies). Each tower is equipped with independent electric panel completed of PLC, wireless communication system, drives for engine, motors for lifting and shifting, control systems and security. The shuttle has two semi-shuttles moving parallel to the rail-road track. Each semi-shuttle has a mobile device transfer that moves perpendicular to the rail track. Each semi-shuttle is equipped with

electrical power, distribution and full PLC control of coordination and with communication system dedicated. The semi-shuttle adapt its position automatically according to size of the unit load to be moved.
The staking platforms are structures made of steel shaped to accommodate all types of unit load devices and equipped with fixed center and position sensors. The number of bays is a function of operations requested by the customer.
The average terminals space required for a Metrocargo System is approx. 100 m^2.
According to the Metrocargo engineers the construction of a single terminal requires about 10 to 15 million € depending on its size, while the implementation cost in the starting phase is about 3 to 5 million €. Terminals have a modular structure so that gradual expansion is possible.
At a first stage a 3-5 million € terminal could operate about three pairs of trains per day, while implementing the 15 million € ones would mean about 10/12 pairs of trains per day in terms of capacity.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 21: Metrocargo
Source: http://www.uominietrasporti.it/notizie_dettaglio.asp?id=1197

Table 11: Metrocargo – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Metrocargo	Handling of the loading units is possible without shunting while the train is under the electricity track.	Need for a network of specific terminals	Implementation of such a system will permit a higher speed transition of load units (reduced loading/unloading time) and cost reduction for handling and shunting operations as loading and unloading can happen simultaneously and less workers are needed	
	Compared to regular service, for shunting several additional processes are needed		All types of existing railway cars and load units can be used	
	The single terminal costs range from 3 to 15 million €, depending on its size and capacity		Currently containers have to be shipped by complete trains from origin to destination; the Metrocargo system allows to load/unload containers in transit terminals	
	The benefits related to flexibility of loading/unloading operations can not come into effect without a widespread network of terminals		Metrocargo technology creates a logistic system able to activate the large potential for synergies of the sector. The existing intermodal infrastructures (freight villages and logistics platforms) and the new ones will in fact constitute a network interconnected by shuttle trains. The collection of traditional and innovative structures will constitute a system of nodes capable of transfering freight with fast and reliable handling operations.	
			Metrocargo does not require any modification to cars and loading units: all types of existing railway cars and load units can be used	

3.2.2.2 Piggyback technology

	Piggyback technology
Technology description	Vertical movement of intermodal transport units from rail to road or vice versa is only possible by cranes. A variety of crane types by multiple producers is currently available and already in operation. The type of transshipment technology is vertical and is suitable for swap bodies, craneable and noncraneable semitrailers with mobile platforms (UCT). The total time of transshipment process is 4 minutes per loading unit. Cranes for Piggyback technology are in usage at all big* Terminals, but are also applicable for small and medium terminals at TEN-T corridors in Alpine space if economically reasonable. It requires a network. The terminal requires rail sidings, storage areas, cranes, forks, etc. The terminal investments are about 85 Mio. € on average, depending on the size and needs of the terminal the numbers can vary considerably.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 22: Piggyback technology
Source: SSP Consult

Table 12: Piggyback Technology

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Piggyback technology	High investments costs in terminal facilities: cranes, trucks, storage area etc.		Transportation possible in several types of wagon	
			Used technology facilitates full exploitation of transport capacities funds	
			LU fulfill conditions for use in other modern transport technologies	

3.2.2.3 NETHS (Neuweiler Tuchschmid Horizontal System)

	NETHS (Neuweiler Tuchschmid Horizontal System)
Technology description	The NETHS prototype can handle special ISO-freight containers with a weight up to 35 tons using two top lift beams hanging on chains. Swap bodies with a weight up to 20 tons can be handled by using concertina grapple arms. The NETHS can move, also loaded with ILU, parallel to the railway track on its own crane tracks, which are 4.25 meters wide. As the machinery consist of two almost similar and mechanically independent parts, it can adjust itself to any length of the ILU. Concerning swap bodies the prototype is limited in handling those of class C (short version). The technology is in development by the Neuweiler AG, Switzerland in collaboration with Tuchschmid, Switzerland and is optimised for company-driven container technology. The type of transshipment technology is horizontal and is suitable for special containers and swap bodies (UCT). The prototype was built in 2001 at an existing track siding of 35 meter length on the factory plant of Tuchschmid in Frauenfeld, Switzerland. Planning for a new concept of NETHS is under way. The NETHS is in principle designed for small* and medium size terminals.

This equipment could be used in freight villages and/or urban areas where site constraints, such as the lack of available open spaces, prevent the use of traditional terminal cranes.
There is no approval for operations in Slovenia, Austria, Germany, Italy and France yet, therefor it is not suitable for all TEN-T corridors in Alpine space.
The NETHS system entails relevant investment cost for the lifting facility but operational costs might be low because it does not need any operator at the terminal. As it is under development, there are no detailed costs known yet.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 23: NETHS (Neuweiler Tuchschmid Horizontal System)
Source: Bundesamt für Straßenwesen Schweiz (2005): Ausgestaltung von Terminals für den (unbegleiteten) kombinierten Ladungsverkehr.

Table 13: NETHS – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
NETHS	The main objective of this concept is to create small terminals equipped to shift freight from road to rail. It would allow a sort of decentralization of the handling activities by avoiding traditional rail terminals. These structures could be located close to factories and logistics areas. It enables the transshipment of standard semi-trailers from road to rail		It could facilitate the immediate forwarding of freight via rail without the need of reaching the traditional rail terminals	High initial investment cost
	It does not use up a lot of space in terminals		The truck driver can do the transshipment semi-automatically even if in a successive planned version also fully automated operation can be possible	
	Handling of the loading units is possible without shunting while the train is under the electricity track		It can only manage small containers or special ILU	
	Despite its high investment costs the operating costs are low because the facility does not need any additional staff in terminals		Need for specific lorry drivers training could be expensive and time consuming	
	It could be used in terminal or areas where site constraints do not allow the usage of traditional cranes			
	The transshipment is semi-automatic. The system has to be operated by the truck driver or by terminal staff			
	It is conceived for small terminal usage, thus could have problems with traffic peaks			

3.2.2.4 IUT (Innovatives Umschlag-Terminal)

	IUT (Innovatives Umschlag-Terminal)
Technology description	The IUT is a permanently installed construction next to the railway. Cranes load and unload the containers automatically and store them in a shelf system. The basic idea of the Innovative Transfer Terminal IUT of ÖBB Rail Cargo Austria is the operational splitting-up of transshipment, sorting and storage, therefore these processes can be done separately. The IUT 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'. It is in operation at the Wien Northwest terminal since January 2003. The type of transshipment technology is vertical, it can transport containers and swap bodies (UCT). Applicable for small* to big terminals, if economically reasonable. Depending on the location, the IUT can be extended from 500 meters to 700 meters in length and up to three levels. There are no special requirements for a network. There is no approval for operations in Slovenia, Germany, Italy Switzerland and France yet. In theory it might be suitable for all TEN-T corridors. The basic concept is the operational splitting up of transshipment, sorting and storage. This objective could be achieved by a mainly vertical operating stacker. This stacker with a shelf load/unload device moves the ILU between the shelves and a buffer lane (pre-sorting area) beside the loading track. A portal crane is designated for unloading and loading of the rail and road vehicles. The IUT test facility has a length of 30 meters, comprises two levels and can handle any commonly encountered container. The stacker crane and the shelf-operating device can manage containers up to a maximum weight of 45 tons. Series production IUTs are supposed to have a length of up to 700 meters and up to 3 levels. Test operation showed that all resources necessary for transshipment (facilities, personnel, energy) could be optimized and a much greater flexibility in terminal operation can be achieved.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

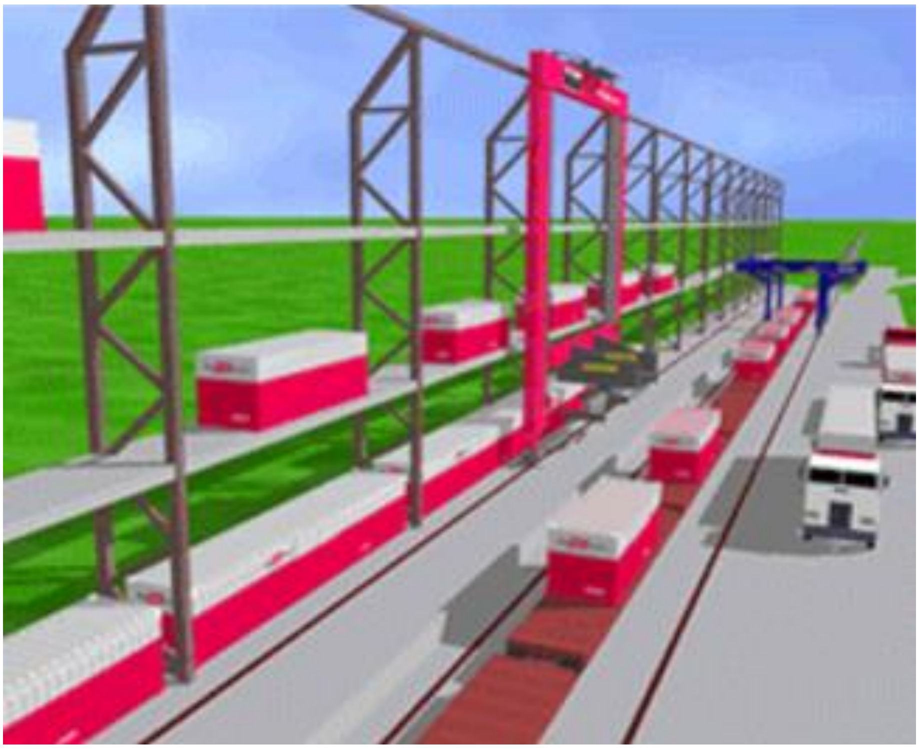


Figure 24: IUT (Innovatives Umschlag-Terminal)
Source: Bundesamt für Strassen/VSS-Forschung 1998/189 (2005): Ausgestaltung von Terminals für den (unbegleiteten) Kombinierten Ladungsverkehr, p. 45.

Table 14: IUT – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
IUT	It is possible to manage different operations with a single facility.		Not useable with craneable or non-craneable trailers	
	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 specializedmachines (container converters, rack operating units) do the same in the IUT. The efficient handling reduces the total operating costs as well as the length of stay of the KLV train and the trucks in the terminal.			

3.2.2.5 Sidelifter

	Sidelifter
Technology description	The sidelifter loads and unloads containers via a pair of hydraulic cranes mounted at each end of the vehicle chassis. The sidelifter is designed to lift containers from the ground, from other vehicles including rolling stock, from railway wagons and directly from stacks on docks or aboard container ships. A standard sidelifter is also able to stack a container at a two containers' height on the ground. If the sidelifter chassis is of 40' length or more, the cranes of the sidelifter can be shifted hydraulically along the sidelifter chassis to be able to pick up either one 20', one 40', or two 20' ISO containers at a time. The type of transshipment technology is horizontal, it is constructed for containers and swap bodies (UCT). The costs of handling are minor and approx. 35 € per loading unit. The transshipment process takes about 4 minutes per loading unit. Sidelifters are applicable for small* and medium terminals as big terminals mainly use cranes. There are no special requirements for a network and it is suitable for all TEN-T corridors in Alpine space. The average terminal space required for one transshipment unit is approx. 60 m^2, there are no other special requirements. Additional (side) lifts on trailer are needed and must be calculated as costs.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 25 Sidelifter
Source: http://www.boxmover.eu/spool/gfx/1321259759KL_Container_OEBB_Umschlag__058.jpg

Table 15: Sidelifter – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Sidelifter	Replaces stationary equipment or small sized terminals, chassis or other road vehicles		Does not require specially developed tractor units	
	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		For terminals of European scale which are part of the international network with medium and large volumes they are useful as additional devices only. A number of them serving a train at the same time will interfere with each other and conflicts are unavoidable in the loading lanes.	

	Offers double sided loading/unloading from railway wagons or storage points			
	Mobile, quick and inexpensive handling system being one-man-operated			
	Offers simple but safe operations by means of a portable, remote control panel			
	Requires no specially prepared surface area to work on			
	Can safely pick containers out of rows if these are at least 3” apart and the containers are stacked two high			

3.2.2.6 ContainerMover 3000

ContainerMover 3000

Technology description	The ContainerMover 3000 system is a device mounted onto a truck that unloads the swap bodies sideways onto a rail-rack, enabling independent road-to-rail transshipment at every freight station with a load transfer point or at private sidings. The ContainerMover 3000 is a development by InnovaTrain Ltd and is in testing since 2011. The type of transshipment technology is horizontal, the system can move containers and swap bodies (UCT). The total time of the transshipment process is 3- 5 minutes per loading unit. The System is in operation at the relation from Oensingen (CH) to Tessin (CH). An equipped O/D network is required. There is no approval for operations in Austria, Slovenia, Germany, Italy and France yet, so it is not suitable for all TEN-T corridors in Alpine space. The terminal is required to have a railway siding with asphalted road surface. The average terminal space required for one transshipment unit is approx. 60 m^2.

Other than an asphalted area beside the rails there are no further investments necessary for the terminal. Special consoles on rail wagons and trucks must be purchased.

Figure 26: ContainerMover3000
Source: http://www.innovatrain.ch/de/medien/pressebilder/

Table 16: ContainerMover3000 – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Container Mover	No costly infrastructure, just a regular railway siding and an asphalted road surface		Compatible with standard 20 foot containers and swap bodies (C715, C745, C782)	
	Compatible with standard container wagons		Can be used at all locations and easily transferred between locations	

	Easy to control by the truck driver 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	
	Railway is needed		Can be operated by the truck driver	

3.2.2.7 Mobiler

	Mobiler
Technology description	The Mobiler is a truck-mounted hydraulic system which is used to load swap bodies and containers with adapters onto railway freight cars. The truck and railway carriages are parallel next to each other. By means of a truck-specific cross-shifting device, containers are then turned over. A hydraulic lifting device on the Mobiler vehicle lifts the containers. The truck driver does the container handling directly on the loading track and is thus independent from particular infrastructure or foreign personnel. The Mobiler is produced by RailCargo Group, a member of ÖBB. The type of transshipment for containers and swap bodies (UCT) is horizontal. The total time of the transshipment process per loading unit is 4 minutes. Applicable for small* and medium terminals because of manual loading and unloading and no use of cranes. There are no special requirements to form a network, so it is suitable for all TEN-T corridors in Alpine space. For the Mobiler a basic railway siding with asphalted road surface is needed, e.g. for one transshipment an average terminal space of 60m^2 is required. Special consoles on rail wagons and trucks need to be purchased.

*(small - 20000 TEU/year, medium 20000 - 100000 TEU/year, big over 100000 TEU/year)

Figure 27: Mobiler
Source: https://de.wikipedia.org/wiki/Mobiler

Table 17: Mobiler – overview

	Terminal Infrastructure	International Terminal Network	Operation and supply chain	Costs and Investments
Mobiler	Reloading can be handled quickly and easily by a one person at almost any location		Only containers and swap bodies	
			For customers/for the development of industrial centers without rail connection	
			As a decentralized addition to the Intermodal transportation terminal	
			Safe and fast reloading of all goods in containers and swap bodies	

4 Comparative analysis with focus on non-craneable trailers

Based on the general overview provided in the previous chapters, this section presents a detailed analysis of and comparison between technologies that are mainly dealing with the transhipment of non-craneable trailers. Therefore the following transhipment technologies will be compared:

- Modalohr
- CargoBeamer
- ISU
- Megaswing
- NiKRASA
- Cargospeed

As shown in the table below, four of the seven compared technologies use a vertical type of transhipment and are suitable for all TEN-T corridors. Only NiKRASA and ISU technologies are in addition applicable for big terminals, which means over 100.000 TEU/year. Only the ISU system, NiKRASA and Reachstackers are suitable for all TEN-T corridors. Furthermore, the table describes the necessity of the size of the terminal that can be applicable for different technologies.

Table 18: Overview of the analyzed technologies

Technology	Type of transhipment	Status	Suitable for all TEN-T corridor	Applicable for S/M/B terminal
Modalohr	H	Working since 2003	No	S,M
CargoBeamer	H	In 1998 the CargoBeamer concept was developed and in 2013 the CargoBeamer AG in Bautzen was founded with production starting that same year	No	S,M
ISU Innovativer Sattelauflieger Umschlag/ Innovative SemiTrailer Handling Unit	V	Working	yes	S, M,B
Megaswing	V	Series production since 2011	No	S,M
NiKRASA	V	Launched in 2014	Yes	S,M,B

Cargospeed	H	Tested in 2006	No	S,M

V: vertical, H: Horizontal, S: small, M: Medium, B: Big

Based on the assumption of dedicated systems the following key capacity and performance indicators were elaborated in order to arrive at a comparative assessment of the technologies:

- Train capacity: The number of semitrailers, that can be carried per train,
- handling capacity of a transhipment facility,
- space requirements and
- Investment costs for a transhipment facility.

Train capacity

In order to calculate the maximum possible loading capacity of a train for each technology we began by making assumptions about the overall infrastructural conditions. It should be possible to operate CT trains with the following maximum parameters: Train weight of 2,000 t, and train length of 750 m. Assuming that one or two locomotives will be deployed, we derived the following parameters:

- Max. weight of train set: 1,800 t
- Max. length of wagon set: 700 m.

In addition, we referred to the following data (or made the following assumptions) in order to determine the system-specific train capacities:

- Load weight: a load weight of 20 tonnes was assumed as the average value across all freight groups and market segments. This is based on the following typical payloads for articulated vehicles and road trains respectively:
    - Groupage cargo and CEP (courier, express, parcel): 10 – 16 t
    - Packaged goods (automotive, chemicals, food): 18 – 22 t
    - Bulk, steel, paper, recycled materials and similar: 25 – 27 t
- Tare weight of semitrailers: manufacturers' data
- Tare weight of wagon: data from system providers and/or CT operators

The capacity calculation was done in two stages. The first step was to determine the maximum number of semitrailers that can be moved in accordance with the assumptions made above and in compliance with the maximum wagon set weight of 1,800 tons (see table 4-1). The second step was to verify whether the capacities calculated hereby complied with the maximum wagon set length of 700 meters if the system-specific wagons were employed. It emerged that this was the case for all the technologies. This calculation provided the following technical maximum train capacity for the technologies involved (see table 4-2):

Table 19: Train capacity considering train length and train weight

Technology	Loading unit (LU)			Wagon tare (t)	**Σ (LU + wagon)**	**Assumptions of max train weight[14]**	**Max LU per train**
	Payload	**Tare**	Total				
	Tones						**LU**
Modalohr	20	7,2	27,2	40,7	95,1	1.800	**38**
CargoBeamer	20	7,2	27,2	31	58,2	1.800	**30**
ISU Innovativer Sattelauflieger Umschlag/Innovative SemiTrailer Handling Unit	20	7,2	27,2	34,3	88,7	1.800	**40**
Megaswing	20	7,2	27,2	43	97,4	1.800	**39**
NiKRASA	20	7,2	27,2	34,3	88,7	1.800	**58**
Cargospeed	20	7,2	27,2	24	51,2	1.800	**35**

Source: KombiConsult

Table 20: System-specific train capacities considering train weight and train length

Technology	**Max LU at 1800 t train weight**	**Length of wagon**	**Max. Train length**	**train capacity ≤ 700 m**
	(LU)	**(m)**	**(m)**	**LU**
Modalohr	38	32,94 (intermediate wagon + 2 ends wagon)	625	**38**
CargoBeamer	31	16,20	502	**31**
ISU Innovativer Sattelauflieger Umschlag/Innovative SemiTrailer Handling Unit (double pocket T3000e)	40	34,03	680	**40**
Megaswing (duo 6-axled) Sdgnss	39	34,03	630	**37**
NiKRASA (double pocket T3000)	58	34,20	992	**40**
Cargospeed	35	18,2	637	**35**

Source: ITTL – own calculation

[14] This can be considered as theroetical max. train weights and therore differ from oprration weights.

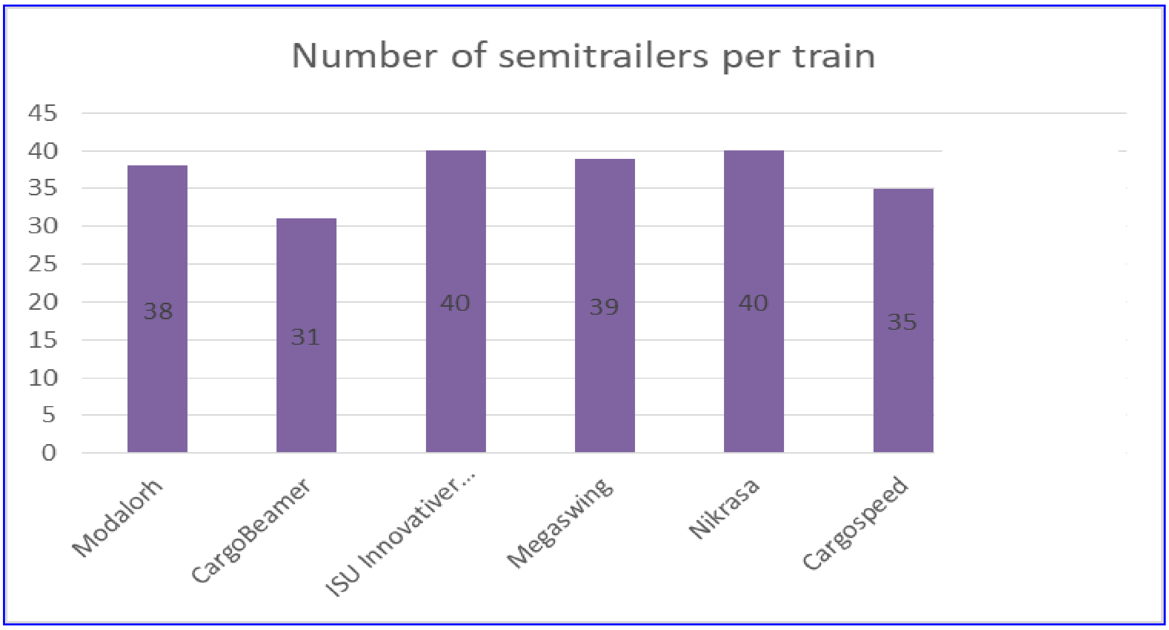


Figure 28: Number of semitrailers per train
Source: ITTL – own calculation

A. 4.1 Analysis of handling/transhipment processes of CT technologies B

The following table gives an overview depending on the way loading and unloading processes are operated and provides practical examples for each of these types.

Table 21: Horizontal and vertical loading procedures in CT technologies

Type of loading	Practical examples	Type of technology
Horizontal loading	Rotational wagon	Modalohr, CargoSpeed, Megaswing
	Parallel loading and unloading	CargoBeamer
Vertical loading	Piggyback systems	NiKRASA, ISU Innovativer Sattelauflieger Umschlag

Source: www.researchgate.net/publication/318672540_Facilitating_synchromodal_transport_through_interconnected_modular_and_

Modalohr is a system that allows horizontal handling using low-floor double carriages with revolving structure. By folding out the construction in especially equipped terminals, the truck units can be driven onto the wagon. After loading, the constructions are mechanically folded back on the wagons.
CargoBeamer's technology includes a universal semi-trailer loading ground plate which serves as an adapter. The ground plate is shifted from road to rail and vice versa using mechanical arms built into the terminal. All road semi-trailers fit onto these ground plates without any modifications. One main advantage is that CargoBeamer is compatible with the existing terminal infrastructure, as portal cranes and reach stackers can lift the ground plates (adapters).

With the innovative NiKRASA-system transfer of non-craneable semi-trailers from road to rail is possible within the existing standards and infrastructure. This transfer is done without any changes at the wagon, the semi-trailer or the business processes. The already existing transshipment sites for combined traffic at the terminals can be used without any additional investments and consequently utilization of these terminals can be improved.

Megaswing is innovative in that the wagon separates easily into the sections. The pocket section can be swung out and lowered to the ground. A semitrailer can then be reversed up into the pocket. Once the semitrailer is released from its truck, the pocket section can be pivoted back into position.[15]

The ISU system is desinged for direct handling of not-craneable trailers without any new terminal infrastructure or modifications. First the trailer is parked on a small mobile loading platform. After the tractor has left, the trailer is lifted with special lifting gear with wheel grippers into a classical pocket wagon. This lifting can be operated by a reach stacker or a gantry crane.

CargoSpeed is an innovative solution for the transfer of semitrailers that will enable a functioning rail freight system to operate within a truly balanced and sustainable intermodal transport system. The exchange is achieved by small pop-up mechanisms located centrally between the rail lines at mid-lengths of the railway wagons. The arriving train of about 30 monowell wagons locates the wagons over the pop-up mechanisms (tolerance of plus/minus 35 centimeters), whereupon the mechanisms rise to engage the wellfloors by twistlocks (container handling type but opposite way up) followed by elevation of the wellfloor to pop-up the semitrailer out of the wagon.[16]

Reach stackers are able to transport container, swap bodies and semi-trailers very quickly over short distances and pile them in various rows depending on its access. It is the most widely used CT technology at terminals.

B. 4.2 Analysis of time and costs of transhipment of CT technologies B

The most important parameters of the systems dealing with CT technologies B are the handling time of transshipments per one TU and transaction period between two train, terminal space, cost of handling, and investment in system and terminals. An in-depth comparison of the most important parameters is indicated in table 4-21.

The **handling time** indicates the average duration of the loading and unloading of one semi-trailer that is shown in the table below. It is therefore the average of the time required - for outbound units - to load a semitrailer safely onto the wagon after it has arrived in the transshipment area, and – for inbound units - to lift it with the crane and set it down on the road lane or, in case of horizontal systems, to remove it from the wagon.

The train headway is the train sequence period that indicates the period until the next train can be processed after completion of the loading and unloading of the proceeding train.

[15] Kockums Industrier

[16] BLG CONSULT et al: Cargospeed Final Technical Report. 2006

With a single-track system the outgoing train has to be cleared from the track first before the next incoming train can be placed in readiness. We assumed a time requirement of 60 minutes for this purpose in the case of the Modalohr horizontal transshipment technology.
CargoBeamer's unique parallel loading and unloading system works by allowing the lorry to drive onto a costum-made loading pocket which transfers the semitrailer laterally. The tractor unit can then leave the terminal even if the train has not arrived. When the train reaches the terminal, freight can be loaded and unloaded simultaneously, and according to CargoBeamer, a 36-wagon can be handled in just 15 minutes. The whole train can leave the terminal about 90 minutes after arrival.
ISU system and Reachstackers need 6 minutes to load one LU, therefore the time of loading the whole train is estimated at 120 minutes.
The Megaswing system allows transporting noncraneable trailers without additional handling technology. Megaswing`s only requirement is a flat trackside area. The loading process of a full train can be finished within 30 minutes.In a maxi terminal an entire train of 40 rail wagons can be loaded and re-loaded in only 8 minutes with the CargoSpeed system, and 20-minutes including time for the train to enter and exit the terminal.

Table 22: Comparison of handling time and terminal space between different technologies

Technology	**number of semitrailers per train (LU)**	**Handling time of transhipment process per LU**	**train headway / transaction period between two train (min)**	**terminal space for one TU (m2)**
Modalohr	38	4 min	60	156
CargoBeamer	31	15 min (per train)	90	117
ISU Innovativer Sattelauflieger Umschlag/Innovative SemiTrailer Handling Unit	40	4	120	120
Megaswing	39	3 min	30	120
NiKRASA	40	3 min	120	130
Cargospeed	35	8 min (per train)[17]	20	130
Reachstackers	40	3 min	120	130

[17] Široký: "The Trends of Road Trailers Systems for Railways", in: Perner's Contacts (4/2012). University of Pardubice, 2012.

Terminal space requirement

The terminal for NiKRASA merely needs the space for the mobile terminal platform (approx. 53 m²) and the traffic space for shunting the trailers on the loading platform, totaling about 130 m².

For the Megaswing system all technical components are included into the wagon, so no additional terminal infrastructure is needed except a truck-drivable trackside along an existing rail track. It is easy to operate within existing intermodal terminals and it allows horizontal and vertical handling.

The Cargobeamer terminal layout is flexible and its arrangement and size can be modified to suit the local conditions. The modules consist of pre-cast concrete parts, so that a terminal can be installed quickly and inexpensively and expanded at any time. A transshipment module with track, parking tracks for pallets and driving lane for trucks on each side is 22 m wide and 19.3 m long.

Modalohr wagons require specialized terminals equipped with hydraulic ground systems making it possible to open the pockets of the wagons. There is no need for gantries or lifting equipment to be installed. The total space for one LU is estimated about 156 m².A comparison of the technologies' space requirements is shown below.

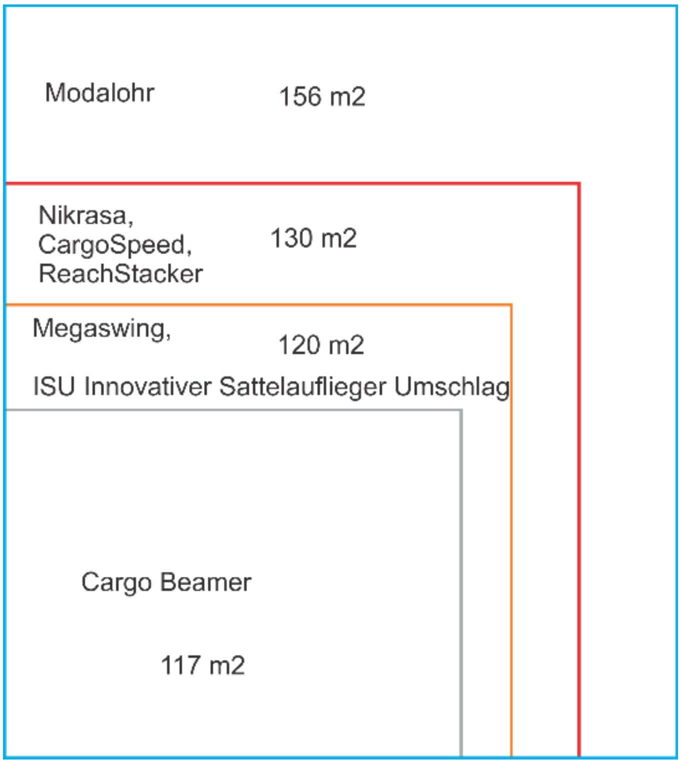


Figure 29: Space requirements of CT technologies
Source: ITL

Table 23: Comparison of costs for technologies B

Technology	Cost of handling (EUR/LU)	Investment costs per LU (EUR)	Cost of wagon and additional equipment (EUR)	Cost transshipment infrastructure and equipment (EUR)
Modalohr	80	74.000	**385 000** (Wagon for 2 parking spaces)	**7 700 000** (per site)
CargoBeamer	75	67.000	**400 000** (Wagon+2 pallets)	**10-20 millions** (per site)
ISU Innovativer Sattelauflieger Umschlag/ Innovative SemiTrailer Handling Unit	unknown	60.000	**180 000** (Double pocket for 2 parking spaces)	**60 000** (for the intermediate frame with lifting straps and two loading ramps)
Megaswing	unknown	30 000	unknown	**30 000**
NiKRASA	50	unknown	**215 000** (Double pocket for 2 parking spaces including transhipment adapter)	**Min. 60 000** (2 Terminal platform facililites – Origin and destination terminal – due to performance transhipment of blocktrains requires addition platform)
Cargospeed	unknown	unknown	**180 000** (Double pocket for 2 parking spaces)	unknown
Reachstackers	50	unknown	**180 000** (Double pocket for 2 parking spaces)	**Max 500 000** (Price of reachstacker (from 100 000 to 500 000)

Terminal costs vary widely between technologies.

Modalohr, Cargo Speed and Cargo Beamer require substantial investments and dedicated terminals. The CargoBeamer system is representative of horizontal transhipment technologies for road trailers. It offers a fairly sophisticated and easy to control horizontal transhipment system, but the need for rebuilding the terminal remains a challenge. Also its wagons' complex construction causes their purchasing price to be considerably higher than would be opportune for a system that has to compete on the open market, especially with road transport.[18]

In the next table we detail the geographic locations where the compared technologies are in operation or testing.

[18] Široký: "The Trends of Road Trailers Systems for Railways", in: Perner's Contacts (4/2012). University of Pardubice, 2012.

Table 24: Location of testing or operation of the compared technologies

Technology	Terminal or corridor
Modalohr	Aiton (FR) - Orbassano (IT) Bettembourg (LU) - Perpignan (FR) Calais (FRA) - Le Boulou (FRA) Le Boulou (FR) - Bettembourg (LU)
CargoBeamer	Domodossola (IT) - Köln (DE)
ISU system	Wels (AT) - Triest (IT) Wels (AT) - Stara Zagora (BG)
Megaswing	Until today there are no realized intermodal relations using the Megaswing system. It was tested under real conditions in Germany and Sweden
NiKRASA	Bettembourg (LU)- Triest (IT) Padborg (DK) -Verona (IT) Herne (DE) - Verona (IT) Herne (DE) – Malmö (SE)
Cargospeed	Sweden
Reachstackers	most terminals

To sum up this reports' findings, the most important **advantages and disadvantages** are presented in the next table.

Table 25: Advantages and disadvantages of CT technologies

	Advantages	Disadvantages
Modalohr	• all standard semitrailers up to a height of four meters can be transported without problem • relatively fast loading and unloading of a complete train in the Modalohr terminal • robust, tried and tested wagon system • same-level loading; the tractor units can drive forwards onto the waggon for loading	• low flexibility, as only regular block train services between the Modalohr terminals are possible • high levels of investment in wagons and special Modalohr terminals are required • complex and costly technology for the positioning and swinging out of the waggons, which has to be built into the tracks of the Modalohr terminal •
CargoBeamer	• system for the automatic horizontal transhipment of swap bodies by means of bowl-shaped palettes	• system requires relatively high levels of investment in special terminal infrastructure

	Advantages	Disadvantages
	• presence of truck drivers not required for the transhipment between rail and road • very high performance of the terminals possible • due to the automatic horizontal transhipment system, a simple and fast switch between different tracks is possible • with the use of bowls that are suitable to be lifted by crane, transhipment can also be performed, when necessary, in conventional combined cargo terminals	• System is designed for regular block train service and thus to a large extent dependent on special terminal infrastructure (CargoBeamer terminal network). Not suitable for containers or swap bodies.
ISU Innovativer Sattelauflieger Umschlag/ Innovative SemiTrailer Handling Unit	• all common trailers can be carried • no additional investment for customers (heavy goods vehicle shippers)	• special loading platform, wheel grippers, ropes and lifting beam for the transhipment devices are required in the terminal • relatively complicated manual preparation of the crane process • requires a large amount of staff • heavy transhipment technology from combined cargo terminals necessary • costs for handling in terminal
Megaswing	• all common trailers can be carried • no terminal infrastructure is necessary (besides rail tracks and truck-drivable space next to them) • the loading of the wagons is carried out by the truck driver, therefore no further costs are accrued for transhipment in the terminal • flexible deployment, as the wagons can be used at almost any loading track • same-level loading by the heavy goods vehicle (tractor unit) • relatively fast and simple transhipment technology • very flexible production concepts possible	• special freight wagons require high levels of investment • energy/electricity supply necessary for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs) • Megaswing pocket can only be loaded backwards • Only suitable for trailers, not for containers etc.
NiKRASA	• no special knowhow necessary • stable transhipment because semitrailer is protected by transport-platform • standard grippers • standard process in transhipment facility • staff training by system implementation • No changes to existing standard • Minimal impact on the weight and none on the length of the train • No additional investments for CT terminals beside the system (terminal module) • No additional investment for rolling stock	• Additionally in origin and destination terminal a mobile terminal-platform is needed • Low price • Flexible • Storable even on top of 30" container • Option for carrying the terminal module with the train (nothing left in terminal)

	Advantages	Disadvantages
	• No additional investment for crane technology • Standard pocket wagons allow transport of containers and swap bodies	
Cargospeed	• Allows easy handling of non-craneable trailers • Cost saving due to horizontal loading (no craning needed)	• investment in underground lift is needed • special freight wagons require high levels of investment • energy supply necessary at terminal for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs)

Source: ISTRA – Innovativa intermodala transportsystem for Semitrailers; Fredrik Bärthel , http://www.privatbahn-magazin.eu/index.php?cat=Magazine&page=Comparison

5 Additional studies on CT Technologies

In this chapter a review on projects and scientific studies with focus on CT technologies will be given providing a synopsis of the current state of research. This is based on the comprehensive description of projects and studies on technical solutions that aim at rationalizing the handling systems in terminals and improving the network performances (see DT 1.1.1; chapter 6.3.3 and Appendix 10) as well as the detailed description and comparison of transshipment technologies in chapters 3 and 4 of this report.
Today, different CT-technologies are installed simultaneously. Terminals do shift trailers by cranes, but as most semitrailers are not craneable, technologies like CargoBeamer or the Modalohr-technology are on the rise (BAV 2014). Wagon-based technologies such as Modalohr or Megaswing extend their reach into the market. As a result, different technologies compete (Mertel 2012). Recent research analyzed these various solutions with the objective of determining the most cost-effective and flexible system for the future goal "modern shift".

In 2014 the study „Kombinierter Güterverkehr – Aufzeigen zukünftiger Potenziale von Forschung und Innovation"[19] was based on an expert survey which was part of the program "Mobility of the Future" (Mobilität der Zukunft), funded by the Federal Ministry of Transport, Innovation and Technologies/ Austria. For this study seven international experts were asked about their opinion, experiences and expectations regarding technologies for Combined Transport. Their answers were the base for the second part of the study: An internet survey with further 77 industry experts and stakeholders.
Most experts agreed on the target to set main focus on standardized terminal innovations - as a terminal network can be the "innovation gate". A technology used at main hubs will influence other carriers and planers. Cwith further investments in rails and IT-services this might expand the terminals' capacities. Furthermore, these experts and stakeholders emphazised the necessity to improve basic conditions on judicial, international and market level, as the shifting process is still too complicated. Other important aspects for improving Combined Transport are process optimization and standardization on European level and support of further researches and developments by the affected industries.

Michael Cordes confirms the necessity of standardization. His article integrated the NiKRASA technology into the CT market trends. After outlining its development by TX Logistik the paper explained NiKRASA's benefits, costs and limits. Two excurses offered information about the Lohr-System Modalohr and the CargoBeamer technology. Moreover, the author outlined the current debate: As there are too many non-craneable semitrailers and there is no standardized system, these CT-technologies will solve problems. But he quoted voices of concern that there might be a time of confusion with different technologies – at the end the terminals´ capacities and infrastructures will limit the spread of technologies. Also, parallel systems might be counterproductive and the investment in craneable semitrailers might subside.[20]

[19] ABC Consulting/ Traffix Verkehrsplanung GmbH/ GAHO-Consult GmbH/ CombiNet – Netzwerk Kombinierter Verkehr: „Kombinierter Güterverkehr – Aufzeigen zukünftiger Potenziale von Forschung und Innovation". Wien 2014.
[20] Michael: "Mehr Trailer auf die Bahn", in: VerkehrsRUNDSCHAU (13/2015). München 2015.

As the implementation of new systems is a long-term decision that is linked to substantial investments, two studies examined the benefits for the systems Modalohr and CargoBeamer in Switzerland.
The study *„Innovationen im alpenquerenden Güterverkehr"* was based on research of the *Institute for Transport Planning and Systems* and the *Swiss Federal Institute of Technology Zurich* and was published bythe *Federal Ministry for Transport* (Switzerland). Its main object was to analyze ways to lower production costs and open up the market for new potentials (new customers, new goods) in the alpine region.
With cost-benefit analysis of different systems (e.g. shuttle-trains on corridors), different technologies (e.g. UCT) and different innovations (e.g. standardizations) the study named and compared solutions for future freight traffic. For UCT the study examined the two systems CargoBeamer and Modalohr. The study named main constraints: Both systems cause 30-40% higher costs than standard UCT and both systems require great investments in large areas at the terminal and high costs per wagon. As investments in craneable semitrailers might be more profitable, the study concluded that special technologies can only be an addition but will not be the main driver for a modal shift. [21]

Another Swiss paper, the"Study on unaccompanied combined transport of semitrailers through Switzerland" [22] (2012) focused on the possibilities of a modal shift to Unaccompanied Combined Transport in the Swiss area. A special challenge in Switzerland is the North-South axis from Basel to Tessin which currently does not allow the transport of 70% of semitrailers due to the limited loading gauge. But on behalf of the Swiss government SBB is planning to enlarge the North-South axis to a continuously 4-meter loading gauge till 2020.[23]
The study included the description, evaluation and comparison of different CT- technologies which are used or usable in the future to promote CT in Switzerland: Craneable trailers and cranes, Cargo Beamer, Modalohr horizontal and Modalohr UIC. The study compared CT-technologies by train capacity, capacity of transshipment facilities, space requirements and investment costs for transshipment facilities and system costs. It considered the capacities and scalability caused by infrastructure– not only in Switzerland but also at terminals linked to Switzerland, like Milano.
As a result, the study highlighted two options to shift trailers from street onto rail: First, to invest in infrastructure and enlarge the loading gauge on the corridor, and secondly to invest – at least temporary – in technologies for craneable trailers which can pass the Gotthard Tunnel.
According to this study the most cost-effective option would be to support craneable trailers and cranes while investing in infrastructures, since the construction and management of new technologies is cost-intensive and solves the problems at hand only temporarily.

Apparently there is a wide call for standardization as a European network might raise capacities and also flexibility.

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[21] Bruckmann, Fumasoli, Mancera: „Innovationen im alpenquerenden Güterverkehr", Zurich 2014.
[22] Mertel/ Petri/Sondermann: Study on unaccompanied combined transport of semitrailers through Switzerland. Frankfurt a. M. 2012.
[23] https://company.sbb.ch/de/ueber-die-sbb/projekte/projekte-mittelland-tessin/4-meter-korridor.html

A report by the University of Applied Sciences Brandenburg, assigned by the German party Bündnis 90 – Die Grünen, analysed future potentials for shifting freight transport from road and water to rail.
Therefor its focus was not only the complex CT system in Europe, but also its regulatory, economic and political level. The authors considered different CT-technologies (like CargoBeamer, Modalohr) and integrated them into parts of their analysis. They concluded that the necessary modal shift must be supported both financially and through regulation. They emphazized that the current system, as it isocused on deregulated costs for passages and infrastructure-charges disadvantages several involved parties and impedes fair conditions.
On the other hand Michael Cordes’ article included expert statements that voiced concern about regulations on technology already in use, as this would not be enforceable. What is more, the terminals’ infrastructure limits the capacities, so this should be the future focus.

For further information:
The “Report on Combined Transport” is published by the BSL Transportation Consultants and the UIC – International Union of Railways and is updated every two years.
It recaps the latest facts and numbers about CT in Europe and provides overviews and specific descriptions - not only about recent technologies, but also about regulatory and operational developments. The report offers detailed information about different CT technologies: ACTS, BOXmover, Boxtango, CargoBeamer, CargoRoo, CargoSpeed, Flexiwagon, Innovtrain, ISU-System, NiKRASA, ResoRail, Trimoder, Megaswing, Metrocargo, Mobiler, and Modalohr.

6 Conclusion

The objective of this deliverable as part of the WPT1 “CT and production – Analysis and basics” was to present an overview of typical operational processes in the CT supply chain (chapter 2) and transhipment technologies for CT (chapter 3). In addition a detailed analysis and comparison was conducted of technologies that are mainly dealing with the transhipment of noncraneable trailers (chapter 4). Based on these findings, chapter 5 reviewed projects and scientific studies with focus on CT technologies thus providing an outline of the current state of research (chapter 5).
This contributes to the general objectives of this WPT to establish a common knowledge base of CT processes for stakeholders, target groups and also for those project partners who are not familiar with operational CT procedures. This should serve as the theoretical foundation for the upcoming work of the other WPT.

The general description of typical CT process and supply chains shows special procedures for the different sections of the chain:
The CT supply chain is basically a series of consecutive (physical flow) and parallel (information flow) processes, characterised by the involvement of numerous stakeholders via the physical flow of ILU /ITU and related information.
The flow of begins at a consignor which is a single manufacturer or a consolidation and integrated centre or might be 3PLs/4PLs provider as the final stuffing point. First physical processes of the supply chain (e.g. receiving LU, stuffing, despatch) are initiated at this point while information flow (ordering LU) can be done by a different stakeholder in advance. The prehaulage, first leg, mainly done by road transport, transfers the LU to the handling facility where the main leg, the long distance transport, starts. Intermodal terminals as handling facilities are the main nodes and the backbone for the European intermodal transport network. The end point of the chain, the consignee, is reached by the posthaulage, last leg, executed by a short as possible road transport of the LU.

Transhipment of non-craneable semitrailers is particularly challenging therefore this report focused on those technologies. Each of the introduced technologies presents a unique set of opportunities as well as disadvantages in terms of e.g. flexibility, handling time and costs, and investment costs. Their benefits have to be evaluated according to a predefined set of criteria that fits the situation at hand. All development efforts aim at supplementing existing terminal infrastructure or wagon/semitrailer technology but their approaches vary widely. While technologies such as Megaswing and CargoBeamer are wagon-based technologies that require little or no modification of terminal infrastructure, for innovations such as Modalohr and Cargospeed terminals have to be built or heavily modified. Other technologies add specific handling equipment to existing terminal and wagon types. This reflects on the feasibility and costs of the technology’s implementation. With terminal-based technologies, initial investment costs can be significant but due to their flexibility in handling various types of existing loading units successive costs for carriers etc. might be low. In contrast, technologies based on handling equipment or wagon-based technologies are in that way more decentralized as investment costs are lower than in terminals but more frequent as a high number of wagons or handling equipment is needed for the integrated system to work efficiently.

Coexistence of these technologies results in increased investment cost etc. thus research presented in chapter 5 observed a call for standardization and a European Network to ensure economic and ecological efficiency. Furthermore the question was raised if investment in infrastructure for non-craneable semitrailers was reasonable compared to investment in craneable semitrailers.
Two of the presented technologies – ISU and NiKRASA – are suitable for all TEN-T corridors. Our analysis also showed the train capacities of those technologies to be the highest with 40 loading units per train. In addition NiKRASA systems can be handled with the same number of personnel compared to general CT transhipment technologies (gantry crane and reach stacker). In terms of train headway CargoSpeed, Megaswing, CargoBeamer (parallel loading) and Modalohr enable trains to leave the terminal in under an hour while NiKRASA and ISU both take about 120 minutes to unload and reload a train under the condition that all loading units arrive at the same time.
The most important **advantages and disadvantages** are presented in the next table.

	Advantages	**Disadvantages**
Modalohr	• all standard semitrailers up to a height of four meters can be transported without problem • relatively fast loading and unloading of a complete train in the Modalohr terminal • robust, tried and tested wagon system • same-level loading; the tractor units can drive forwards onto the waggon for loading	• low flexibility, as only regular block train services between the Modalohr terminals are possible • high levels of investment in wagons and special Modalohr terminals are required • complex and costly technology for the positioning and swinging out of the waggons, which has to be built into the tracks of the Modalohr terminal •
CargoBeamer	• system for the automatic horizontal transhipment of swap bodies by means of bowl-shaped palettes • presence of truck drivers not required for the transhipment between rail and road • very high performance of the terminals possible • due to the automatic horizontal transhipment system, a simple and fast switch between different tracks is possible • with the use of bowls that are suitable to be lifted by crane, transhipment can also be performed, when necessary, in conventional combined cargo terminals	• system requires relatively high levels of investment in special terminal infrastructure • System is designed for regular block train service and thus to a large extent dependent on special terminal infrastructure (CargoBeamer terminal network). Not suitable for containers or swap bodies.
ISU Innovativer Sattelauflieger Umschlag/	• all common trailers can be carried • no additional investment for customers (heavy goods vehicle shippers)	• special loading platform, wheel grippers, ropes and lifting beam for the transhipment devices are required in the terminal

	Advantages	Disadvantages
Innovative SemiTrailer Handling Unit		• relatively complicated manual preparation of the crane process • requires a large amount of staff • heavy transhipment technology from combined cargo terminals necessary • costs for handling in terminal
Megaswing	• all common trailers can be carried • no terminal infrastructure is necessary (besides rail tracks and truck-drivable space next to them) • the loading of the wagons is carried out by the truck driver, therefore no further costs are accrued for transhipment in the terminal • flexible deployment, as the wagons can be used at almost any loading track • same-level loading by the heavy goods vehicle (tractor unit) • relatively fast and simple transhipment technology • very flexible production concepts possible	• special freight wagons require high levels of investment • energy/electricity supply necessary for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs) • Megaswing pocket can only be loaded backwards • Only suitable for trailers, not for containers etc.
NiKRASA	• no special knowhow necessary • stable transhipment because semitrailer is protected by transport-platform • standard grippers • standard process in transhipment facility • staff training by system implementation • No changes to existing standard • Minimal impact on the weight and none on the length of the train • No additional investments for CT terminals beside the system (terminal module) • No additional investment for rolling stock • No additional investment for crane technology • Standard pocket wagons allow transport of containers and swap bodies	• Additionally in origin and destination terminal a mobile terminal-platform is needed • Low price • Flexible • Storable even on top of 30” container • Option for carrying the terminal module with the train (nothing left in terminal)
Cargospeed	• Allows easy handling of non-craneable trailers • Cost saving due to horizontal loading (no craning needed)	• investment in underground lift is needed • special freight wagons require high levels of investment • energy supply necessary at terminal for swinging the pocket • relatively large amount of technology in the wagon (therefore potentially higher maintenance costs)

With particular reference to the relations Rostock - Verona and Bettembourg -Trieste, which are the case studies addressed in the next WPs of the project, this review of the most important new transhipment technologies can serve as an important part of the knowledge pool of CT processes for stakeholders, target groups and for the project partners.

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8 Appendix:
Detailed description of CT Transshipment technologies

Category	A	A
ID	1	2
Name of technology	Rolling Highway (RoLa) aka Piggyback technology: Rolling motorway	Flexiwagon
Picture of technology		
Technology description	The Rolling Highway allows trucks without the necessary fittings for unaccompanied transport to cross the Alps by rail. Whole trucks are loaded onto special rail wagons at the terminal, while drivers travel in a separate sleeping car. On RoLa, the entire truck including the driver travel by train (or separately by other means of transport). Despite the night and Sunday driving ban, with RoLa the Alps can be crossed in both directions around the clock, 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 who can continue their drive immediately after arrival at the destination terminal.	Flexiwagon is a flexible and environmentally friendly roll-on/roll-off solution. Whole trucks, buses or other vehicles can be loaded and unloaded individually on terminals that are part of the Flexiwagons. Drivers are traveling separately in a wagon or sleeping car. The wagon is rotatable to both sides. Loading and unloading of the Flexiwagon is done by the drivers who drive their vehicle onto the wagon via ramps on the front and rear end. The Flexiwagon is suitable for loading units up to 18.75 meters and up to 80 tons.

Category	A	A
ID	1	2
Advantages	• No delays at the border, at road checks or traffic jams • No customs formalities at either of the two Swiss borders • Drivers can comply with and make optimal use of legal rest times • Optimal deployment of trucks and truck drivers • Truck journeys can be scheduled 24 hours a day •Possible optimisation of truck drivers' rest times (they can rest on the train journey and start driving again as soon as they get to the arrival terminal) • Allows transportation despite the night and Sunday driving ban • In countries like Switzerland and Austria already existing network of terminals and long-time experience with this technology • Accommodates CT transports which lack the special equipment that is required for UCT 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 tonnes for RoLa and 750 for UCT, while the average transport distance is about 300 km for RoLa and 800 for UCT. A standard freight train circulating in Central European rail networks will carry some 80 boxes of 20 ft. or 7 m. 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(in some important cost components) costs per unit that are almost double as high as the systems that use vertical transport	• Quick, easy and efficient transhipments of cargo; takes just 7 minutes and is driver operated • Easy to load and unload – the truck can travel on the waggon with or without the driver • No disruption of traffic on parallel tracks • Individual loading and unloading of wagons
Disadvantages	• The net load capacity of RoLa trains is lower than that of UCT • UCT is economically and ecologically more efficient • CO2 savings of UCT shipments are higher than on RoLa • Significantly higher acquisition and maintenance costs for the required special wagons. The investment cost of wagons required for RoLa is double than in UCT. Wagon maintenance costs are four times higher. This requires a level of subsidies per consignment • Needs at least 700 m of a straight railway track for loading and unloading	• Access to electricity needed: 110/240/400 volt 50-60Hz, for cooling units or engine heaters • UCT is economically and ecologically more efficient
Producer/Developer	Concept has been developed over time by various producers and developers; multiple operators available today	Flexiwagon
Type of transhipment technology	Horizontal (no crane necessary)	horizontal
Loading Unit	ACT (whole truck with driver)	ACT (whole truck with driver)
Cost of handling (EUR/loading unit)		

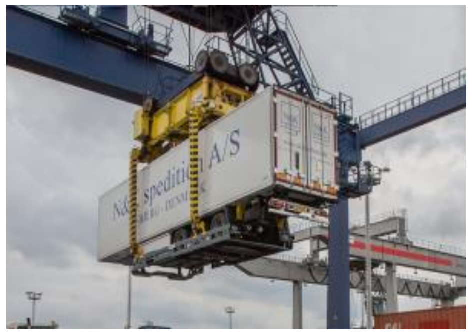
Category	A	A
ID	1	2
Total time of transhipment process per loading unit (min)	5 minutes per LU	7 min
Link	•http://www.adriakombi.si/products/rolling-motorway • https://www.RoLa.at/	www.flexiwagon.se
Status	In operation since 1979	In development
Location of testing or operation (terminal or corridor)	Aiton (FR) - Orbassano (IT) Orbassano (IT) - Aiton (FR) Brenner (AT) - Wörgl (AT) Wörgl (AT) - Brenner (AT) Trento (IT) - Wörgl (AT) Wörgl (AT) - Trento (IT) (Ökombi - high demand due to the sectoral driving ban for the Inn valley motorway) Wels (AT) - Maribor (SI) Salzburg (AT) - Fernetti/Trieste (IT) Freiburg i. Br. (DE) - Novara (IT) - including 4-meter Lötschberg-Simplon corridor (Operators: RAlpin - BLS, Hupac, SBB and Trenitalia) Novara (IT) - Freiburg i. Br. (DE) Basel (CH) - Lugano (CH); Singen (DE) - MIlano (IT) - Gotthard route (Demand is low, because the low profile height in the Gotthard tunnel significantly limits the market potential) Lugano (CH) - Basel (CH) Trient (IT) - Regensburg (DE) Regensburg (DE) - Trient (IT)	Sweden: A Swedish-Swiss consortium has been formed to realize the project for the Gotthard tunnel, Switzerland
Applicable for small/medium or big terminal (small - 20000 TEU/year, medium 20000 - 100000 TEU/Year, big over 100000 TEU/Year)	Applicable for small and medium terminals	Applicable for small and medium terminals
Network	O/D terminals	No special requirements
Suitable for all TEN-T corridors in Alpine space	Yes	No

Category	A	A
ID	1	2
Suitable for all TEN-T corridors in Alpine space - detailed	Yes, Applicable in Slovenia, Austria, Germany, Switzerland, Italy and France with P400 loading gauge (UIC - GC)	No approval for operations in Slovenia, Austria, Germany, Switzerland, Italy and France
Required equipment and transhipment facilities	The only specific terminal feature are a length of at least 700m of a straight railway track with truck-drivable ends, parking space, turnaround possibilities for trucks and service facilities for passenger coach. Unlike Unaccompanied Combined Transport (UCT) no huge logistical changes and investments are necessary. Virtually every truck approved on European roads can be transported by RoLa.	Terminal platform
Average terminal space required for one transhipment unit (m2)	Loading ramp - approx. 80 m²	Approx. 120 m²
Terminal investment for one transhipment unit (EUR)	Loading ramp - approx. 100 000 €	Appropx. 30 000 € (whole terminal infrastructure)
Additional information (if any)	The net load capacity of RoLa trains is lower than that of UCT. 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 tonnes for RoLa and 750 for UCT, while the average transport distance is about 300 km for RoLa and 800 for UCT. A standard freight train circulating in Central European rail networks will carry some 80 boxes of 20 ft. or 7 m. For customers the transport of a full truck on the route Novara- Freiburg (437 km) is about 500 € and takes about 12 hours from the closing time to the time in which trucks are ready to be unloaded.	
Additional cost of equipment	RoLa wagon : 180 000 €	• Flexiwagon is the main cost (330 000 €) • Additional TCS (Train Control System) is needed: Receivers are located in the locomotive with the driver. Information is received from the WCS system, which monitors the waggon's operation, wheel bearings, deviations in the braking system, and other aspects of the wagon. With the TCS, the locomotive driver can control loading and unloading on one, multiple or all waggons in the train set at the same time • Remote control: The wagon comes with either wireless or with wired controls for loading and unloading the cradle. The lorry driver, the locomotive driver or other authorized train personnel can work the controls. The remote control also simplifies work by maintenance and service personnel since they can control the cradle from a distance. • Wheel stock sensors: The sensor system discovers early overheating in the wheel stock and prevents malfunction. • Brake sensors: The sensor system registers when braking effect diminishes and brake components need replacing. • Design changes are possible in the form of shorter or longer cradles, wider openings in cradles, length of loading and unloading ramps and other customer- specific needs.

Category	B1	B1	B1
ID	3	4	5
Name of Technology	Modalohr Horizontal	CargoBeamer	ISU Innovativer Sattelauflieger Umschlag/Innovative Semi-Trailer Handling Unit
Picture of technology			
Technology description	Modalohr is a system that allows horizontal handling using a low-floor double carriage with revolving structure. By folding out the construction in specially equipped terminals, the truck units can be driven onto the wagon. After loading, the constructions are mechanically folded back on the wagons. Due to this, Modalohr requires a lot of terminal space. The system depends on train schedules.	This new wagon system handles trailers, containers and swap bodies in a linear, horizontal loading and unloading zone. Similar to a "classical" container terminal the train needs a long range of rail track. The trailers are loaded in bowls which are shifted beside the wagon for unloading and loading. The bowls are autonomous from the train. This 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.	This system allows direct handling of non-craneable trailers without any new terminal infrastructure or modifications. First the trailer is parked on a small mobile loading platform. After the tractor has left, the trailer is lifted with special lifting gear with wheel grippers into a classical pocket wagon. This lifting can be operated by a reach stacker or a gantry crane. The system allows lifting of trailers with measures of height 4m and width 2,6m. However, due to a low degree of automation the handling requires a lot of personnel capacities (3 employees). Otherwise the required technical infrastructure is relatively cheap in purchase and easy to integrate into existing terminal structures.
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 (UIC GB1) • Accepts most standard trucks without modification: (Maximum height: 4.04 m, Semi-trailer maximum length 13.7 m, Semi-trailer maximum load : 38 t)	• 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 • Approval of operation granted in Germany • Test operation will start soon	• Handling of non-craneable trailers • Easy integration into existing services without costly equipment • 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

Category	B1	B1	B1
ID	3	4	5
Disadvantages	• Additional costs in comparison to the traditional Combined Transport for special wagons and specific terminals • Technical specification of special wagons and technically demanding terminals • High space requirements at terminals	• Special technical infrastructure is needed • Needs a lot of linear space at terminals • Not suitable for containers and swap bodies	• Little experience • A lot of personnel needed (manual preparation of crane process) • Movement and swinging of trailer (e.g. with wind) • Complex loading and unloading procedure as competitive disadvantage • Staff training by system implementation • Purchase of multiple ISU systems necessary for parallel transshipment • Heavy transhipment technology from combined cargo terminals necessary
Producer/Developer	Lohr Industrie SA	CargoBeamer AG	ÖKOMBI (a subsidiary company of Rail Cargo Austria)
Type of transhipment technology	Horizontal; vertical also possible	Horizontal; vertical	Vertical
Loading unit	UCT (craneable and noncraneable semitrailers, containers, swap bodies); ACT	UCT (craneable and noncraneable semitrailers, containers, swap bodies)	UCT (craneable and noncraneable semitrailers)
Cost of handling (EUR/loading unit)	Approx. 80 €	Approx. 75 €	Unknown
Total time of transhipment process per loading unit (min)	256 minutes for loading/unloading of whole train with 32 semitrailers; 4 minutes per LU	Unknown	6 minutes
Link	http://www.lohr.fr	https://www.cargobeamer.com/	http://www.railcargo.com/de/Produkte_und_Innovationen/ISU/ISU_ppt.pdf
Status	In operation since 2003	In 1998 the CargoBeamer concept was developed and in 2013 the CargoBeamer AG in Bautzen was founded with production starting that same year.	In operation
Location of testing or operation (terminal or corridor)	Aiton (FR) - Orbassano (IT) Bettembourg (LU) - Perpignan (FR) Calais (FR) - Le Boulou (FR) Le Boulou (FR) - Bettembourg (LU)	Domodossola (IT) - Köln (DE)	Wels (AT) - Triest (IT) Wels (AT) – Stara Zagora (BG)

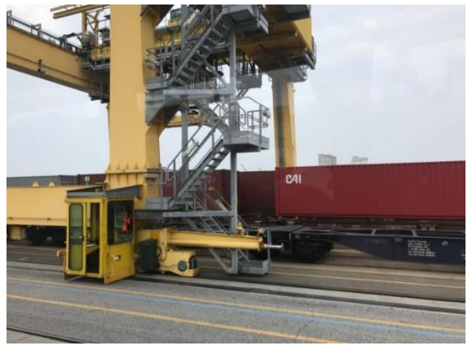
Category	B1	B1	B1
ID	3	4	5
Applicable for small/medium or big terminal (small - 20000 TEU/year, medium 20000 - 100000 TEU/Year, big over 100000 TEU/Year)	Applicable for small and medium terminals	Applicable for small and medium terminals	Applicable for all types of terminals
Suitable for all TEN-T corridors in Alpine space	No	No	Yes
Suitable for all TEN-T corridors in Alpine space - detailed	No approval of operation for Germany, Slovenia and Austria yet	No approval for operations in Slovenia, Austria and France	Yes, Applicable in Slovenia, Austria, Germany, Switzerland, Italy and France with P400 loading gauge (UIC - GC)
Required equipment and transhipment facilities	Modalohr terminal with transhipment modules	A special terminal infrastructure (Cargo gate with transhipment module) is required, but could be combined with regular container terminal infrastructure. Another option is a wagon composition with crane biting edges. The wagon type is also used to carry containers and craneable trailers in vertical handling.	ISU-Handling equipment is needed: small loading platform (ramp), ISU - traverse, ISU - spreader and the lifting gear with wheel grippers
Average terminal space required for one transhipment unit (m2)	156 m^2	117 m^2	
Terminal investment for one transhipment unit (EUR)	• 74 000 € per LU • 256 LU/traffic day, 40 000 m^2, 19m € Investment: ca. 6 700 000 – 7 700 000m € per terminal site ; • Ongoing: Maintenance of facility	• 67 000 € per LU • With 256LU/traffic day: 425 000 m2, 24,5m € • Cargogate : 10 - 20m € per site • Ongoing: Maintenance of facility	• 60 000 € for the intermediate frame with lifting straps and two loading ramps • Ongoing: Maintenance of ISU components
Additional information (if any)	• Transhipment at Modalohr-terminal: know-how necessary for technical handling, because new system does not comply with the standard transhipment • Semitrailer + Handling + Wagon + Rail traction Köln - Milano 759 €		
Additional cost of equipment	Modalohr wagon: 385 000 € for 2 parking spaces	Cargobeamer wagon: 360 000 € for 2 parking spaces Wagon base: 20 000 €*2 pallets per wagon = 40 000 €	Double pocket wagon: 180 000€ for 2 parking spaces

Category	B1	B1	B1	B1
ID	6	7	8	9
Name of Technology	Megaswing	NiKRASA	Cargospeed	Reachstackers
Picture of technology				
Technology description	It is officially called “Swingable megatrailer pocket wagon”. This system allows transport of non-craneable trailers without additional handling technology. The pocket that transports the trailer rotates to the side for loading and unloading. A regular truck tractor couples and is able to leave the loading site immediately. The loading process of a full train is completed within 30 minutes. All technical components are included into the wagon, so no additional terminal infrastructure is needed except a truck-drivable trackside along an existing rail track. This results in cost-effective handling. The system has similar technical specifications and loading gauges as the pocket wagon type Sdgnss. It is able to carry almost all types of trailers up to 4m height, so called Megatrailers.	The system NiKRASA consists of a terminal platform onto which trucks can drive and a transport platform which is used as a tool to shift non-craneable semitrailers from road to rail. With NiKRASA all standards remain the same and no changes of the trailer, wagons, terminals or processes are required. NiKRASA is a system which enables non-craneable semitrailers as well as containers and swap bodies to be loaded onto standard pocket wagons.	A solution that is built around managing trailers. 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.	• Most widely used CT technology at terminals • Reachstackers are used to manage loading units

Category	B1	B1	B1	B1
ID	6	7	8	9
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-driveable trackside along an existing railway track is sufficient • Increases flexibilities • No network needed • Possible in every existing terminal with trackside area for trucks/trailers • Successful test phase • Unloading of individual wagon in coupled trains with multiple stop-overs • Loading/unloading is carried out by the truck drivers	• No special know-how necessary • stable transhipment because semitrailer is protected by transport-platform • Standard grippers • Standard process in transhipment 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	• Easy handling of non-craneable trailers • Cost saving due to horizontal loading (no craning needed)	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
Disadvantages	• New wagon type, thus high levels of investment • No experiences in daily use • Relatively complex technical components (costly maintenance) • Only suitable for trailers, not for containers etc. • Energy supply necessary at the terminals for swinging the pockets • Megaswing pocket can only be loaded backwards	A mobile terminal platform is needed in origin and destination terminal	• Investment in underground lift • Investment in special freight wagons • Energy supply needed at the terminal for swinging the pockets • Relatively large amount of technology in the wagons (pontential for high maintenance costs)	• Required space for shunting and driving and • Low lifting capacity
Producer/Developer	Swedish wagon constructor Kockums	TX Logistik AG, Bayernhafen Gruppe and LKZ Prien GmbH	Cargospeed	Different producers
Type of transhipment technology	Vertical	Vertical	Horizontal	Vertical
Loading Unit	UCT (craneable and non-craneable semitrailers)	UCT (craneable and non-craneable semitrailers)	UCT (craneable and noncraneable semitrailers)	UCT (craneable and noncraneable semitrailers with mobile platform, containers, swap bodies)
Cost of handling (EUR/loading unit)	Unknown	50 €/LU (15€/LU plus craning costs)	Unknown	Approx. 25-30 €/LU
Total time of transhipment process per loading unit (min)	Unknown	3 minutes	Unknown	3 minutes

Category	**B1**	**B1**	**B1**	**B1**
ID	**6**	**7**	**8**	**9**
Link	http://www.kockumsindustrier.se/en-us/our-products/productdetail/?categoryid=3&productid=11	• http://www.nikrasa.eu/en/home.html • http://www.txlogistik-nikrasa.eu/en/	http://cctim.se/english/cargospeed-e.html	
Status	Series production since 2011	Officially launched in 2014	Tested in 2006	In operation since 1980
Location of testing or operation (terminal or corridor)	Until today there are no realized intermodal relations using the Megaswing system. It was tested under real conditions in Germany and Sweden	Bettembourg (LU) - Triest (IT) Padborg (DK) - Verona (IT) Herne (DE) - Verona (IT) Herne (DE) - Malmö (SE)	Sweden	Most terminals
Planned terminal or corridor		Lübeck (DE) - Verona (IT)		
Applicable for small/medium or big terminal (small - 20000 TEU/year, medium 20000 - 100000 TEU/Year, big over 100000 TEU/Year)	Applicable for small and medium terminals	Applicable for all terminals	Applicable for small and medium terminals	Applicable for all terminals
Network	There is no special network needed. The system could easily be integrated into existing trains and terminals. Also interesting for extension of maritime RO-RO connections.	O/D link	A special network of terminals needed	Network of terminals
Suitable for all TEN-T corridors in Alpine space	No	Yes	No	Yes
Suitable for all TEN-T corridors in Alpine space - detailed	No approval for operations in Slovenia, Austria, Germany, Switzerland, Italy and France	Suitable for all corridors with a P400 railway gauge	No approval for operations in Slovenia, Austria, Germany, Switzerland, Italy and France	Suitable for all corridors with a P400 railway gauge

Category	B1	B1	B1	B1
ID	6	7	8	9
Required equipment and transhipment facilities	No special terminal needed. Minimal requirement is a drivable trackside along the railway track. It is easy to operate within existing intermodal terminals; it allows horizontal and vertical handling.	• Terminal does not need much additional equipment, just the terminal platform. Any terminal that is operated by crane and reachstacker is suitable. • Standard piggy backs and standard terminal tractors for positioning the trailer and the loading platform	The terminal needs to invest in underground lift	No special requirements
Average terminal space required for one transhipment unit (m2)	Platform parallel to 2 wagons - approx. 120 m²	The terminal only needs space for the mobile terminal platform (approx. 53 m²) and traffic space for shunting the trailers on the loading platform	Approx. 130 m²	Approx. 130 m²
Terminal investment for one transhipment unit (EUR)	approximately 30 000 €	• Terminal platform: modest 5-digit amount • Transport platform: modest 5-digit amount • Ongoing: Maintenance of transport platform and terminal platform	Unknown	Reachstacker 100 000 to 500 000 €
Additional information (if any)		NiKRASA has been developed with the following requirements: the system must shift non-craneable standard semitrailers from road to rail into standard pocket wagons without any change at the trailer, the wagon, terminal processes and handling technologies (e.g. cranes). During the development it was often difficult to fulfil these requirements. As the NiKRASA system affects a broad range of stakeholders (e.g. terminal operator, railway companies, trailer technology and after all the customers), a lot of know-how from completely different fields had to be collected and brought together. Despite these difficulties, all requirements were fulfilled.		
Additional cost of equipment	Unknown	• Double pocket wagon: 215 000 € for 2 parking spaces • Mobile terminal-platform is needed at origin and destination terminal - about 60.000 €	Pocket wagon	• Mobile platform • Pocket wagon for semitrailers

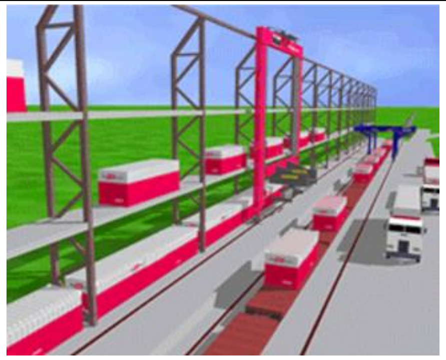
Category	B2	B2	B2	B2
ID	10	11	12	13
Name of Technology	Railrunner	Metrocargo	Piggyback technology	NETHS (Neuweiler Tuchschmid Horizontal System)
Picture of technology				
Technology description	RailRunner bi-modal rail bogies are uniquely designed having two articulated lower frames connected to each other. This allows for self-steering of each axle reducing the typical sway of wheels moving over the track thus reducing friction induced wear and tear of the wheel, but also the track. This also reduces the need for maintenance of wheels and tracks by 30%. The load carrying upper frame, also called 'drawbar', which connects the road vehicles to the bogie, rests in air suspension. This primary suspension system renders a passenger-train-like smooth ride reducing vertical forces allowing transportation of sensitive cargo with less packaging requirements. A secondary suspension is supplied in case of any malfunction of the primary suspension. A combination of articulation, air suspension as well as additional shock absorbers and dampeners also reduce rock and roll of the bogie and trailers thus reducing cargo shifting and potentially allowing for higher speed. RailRunner bogies have been tested in the US for up to 107 miles/hour (170 km/h). Last, bogies are equipped with forklift pockets allowing them to be easily taken off the rail in case of business downturns or maintenance reasons, while the road vehicle can always be used in normal road transport. This flexibility also enables operators to easily balance equipment shortcomings. There are two types of bogies: An 'intermediate' (IU) unit bogie, which connects the road vehicles together and thus forming a railcar and a 'transition' (TU) bogie, which connects the train to a standard freight car or locomotive.	Metrocargo is a technical solution to load/unload trains efficiently by using an innovative horizontal handling technology that can be operated without shunting while the train is under the electricity track. It is a logistics concept focusing on speed and safety of the activities for the goods as well as the operators. It avoids the need of taking the train off-line for the handling activities thus reducing the actual operation of intermodal transport without modification of the trucks and the containers. Used in: • Terminal service network • Port-Dry Port connection • Port requirements • City logistics • Short Sea Shipping	Vertical movement of loading units from rail to road or opposite only by cranes.	It is meant to be a new handling concept for Combined Transport based on the use of a special facility enabling the lifting of intermodal loading units (ILU) from trucks. The NETHS is essentially designed for small and medium sized terminals. The NETHS prototype can handle special ISO-freight container with a weight up to 35 tonnes using two top lift beams hanging on chains. Swap bodies with a weight up to 20 tonnes can be handled by using concertina grapple arms. The truck driver can manage the transhipment semi-automatically even if in a successive planned version also fully automatic operation can be possible. The NETHS can move, also loaded with ILU, parallel to the railway track on its own crane tracks, which are 4.25 meter wide. As the machinery consists of two almost similar and mechanically independent parts, it can adjust itself to any length of the ILU. Concerning swap bodies the prototype is limited in handling those of class C (short version).

Category	B2	B2	B2	B2
ID	10	11	12	13
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 (trailer and bogie), total weight on rail 42 to 43 t • 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	• The implementation of such a system will permit higher speed transition of load units (reduced loading/unloading time) and cost reduction for handling and shunting operations. • Apart from the time savings in loading/unloading operations one of the most important aspects is the flexibility the system provides. Metrocargo in fact allows bypassing the concept of a complete train from an origin to a destination by providing the option of loading/unloading of each flatcar without the need of putting the train off-line. This way, loading units can be handled at any station of a route without relevant waste of time • Shorter handling time (about 30 minutes for the loading/unloading activities) • Handling of loading units is possible without shunting while the train is under the electricity track • All types of standardized railway cars and load units can be used • Low handling costs and -times in comparison to the traditional solution • Currently containers are only shipped by complete trains from point A to point B; the Metrocargo system allows to load/unload containers in transit terminals. • Metrocargo could optimise some operational Metrocargo technology creates a logistic system that activates the large potential synergies of the sector. The existing intermodal infrastructures (freight villages and logistics platforms) and the new structures will in fact constitute a network interconnected by shuttle trains. The combination of traditional and innovative structures will constitute a system of nodes capable of transferring freight with fast and reliable handling operations.	• Transportation possible in several types of wagon • Used technology allows full exploitation of transport capacities funds • Loading units fulfil conditions for use in other modern transport technologies	The main objective of this concept is to create small terminals capable to shift freight from road to rail. It would allow a sort of decentralisation of the handling activities, by passing the traditional rail terminals. These structures could be located close to factories and logistics areas. It enables the transhipment of standard semi-trailers from the road to the rail. • It does not use a lot of 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
Disadvantages	• No standards • No sufficient semitrailer chassis as the system needs complete trains or sections of trains of bimodal type • The "bimodal" trailer's chassis is more powerful than standard trailers, therefore payload of the trailer is reduced (by about 2 to in relation to standard road trailers) • Operators at terminals are obliged to assemble a wagon from a number of elements (bogies, trailers and connections) and to then form a long train; these operations take time and a number of tests are mandatory (braking and coupling tests before train departure) • Equipment property and exploitation involve procedures that differ from the traditional and are therefore in conflict with road or rail rules • Any defect on one trailer involves a full stop of the train	• Need for a network of specialized terminals • Terminal costs range from 3 to 15 million €, depending on its size and capacity • Only with a widespread network of terminals the benefits related to flexibility of loading/unloading operations become effective	Huge investments costs for terminal facilities: cranes, trucks, storage area etc.	• Initial investment cost is substantial • It can only manage small containers or ILU • The transhipment is semi-automatic. The system has to be operated by the truck driver or by terminal staff. • Need for specific lorry drivers training could be expensive and time consuming • As it is conceived for small terminal usage, it could have problems with traffic peaks • Optimized for the company's own loading units
Producer/Developer	Terminal Anywhere™ Solution	Metrocargo	Crane manufacturers	Neuweiler AG, Switzerland in collaboration with Tuchschmid, Switzerland

Category	B2	B2	B2	B2
ID	10	11	12	13
Type of transhipment technology	Horizontal	Horizontal	Vertical	Horizontal
Loading Unit	UCT (craneable and non-craneable semitrailers)	UCT (containers, swap bodies)	UCT (craneable and noncraneable semitrailers , containers, swap bodies)	UCT (containers, swap bodies)
Cost of handling (EUR/loading unit)	Unknown	Unknown	Unknown	Unknown
Total time of transhipment process per loading unit (min)	Unknown	Unknown	Unknown	Unknown
Link	http://railrunner.com/	http://metrocargoautomazioni.it/index.php/it/		
Status	In operation	In development	In operation	In development
Location of testing or operation (terminal or corridor)	• In operation in North America and Verona • Braunschweig (DE) - Bratislava (SK) in 2019	Italy	Big Terminals	The prototype was built in 2001 at an existing track siding of 35 meter length on the factory plant of Tuchschmid in Frauenfeld, Switzerland. Planning for a new concept of NETHS is under way.
Applicable for small/medium or big terminal (small - 20000 TEU/year, medium 20000 - 100000	Applicable for small and medium terminals	Applicable for small and medium terminals	Applicable for all terminals	Applicable for small and medium terminals

Category	B2	B2	B2	B2
ID	10	11	12	13
TEU/Year, big over 100000 TEU/Year)				
Network	No special requirements	Network of terminals	Network of terminals	This equipment could be used in freight villages and/or urban areas where site constraints, such as the lack of available open spaces, prevent the use of traditional terminal cranes.
Suitable for all TEN-T corridors in Alpine space		No	Yes	No
Suitable for all TEN-T corridors in Alpine space - detailed		No approval for operations in Slovenia, Austria, Germany, Switzerland and France	Yes	No approval for operations in Slovenia, Austria, Germany, Italy and France
Required equipment and transhipment facilities	Terminal platform	Lifting tower The lifting system consists of four independent units that identify and lift a unit load placed on the wagon train. It operates on the outside of the corner block. The synchronous movement of the towers allows precise positioning through the acquisition of the locations of the 4 corner blocks for all types of cargo units (containers and swap bodies). Each tower is equipped with independent electric panel including PLC, wireless communication system, drives for engine, motors for lifting and shifting, control systems and security. Shuttle The shuttle has two semi-shuttles moving parallel to the rail-road track. Each semi-shuttle has a mobile device transfer that moves perpendicular to the rail track. Each semi-shuttle is equipped with electrical power, distribution and full PLC control of coordination and with communication system dedicated. The semi-shuttle adapts its position automatically according to size of the unit load to be moved. Platforms The staking platforms are structures made of steel shaped to accommodate all types of unit load devices and equipped with fixed centre and position sensors. The number of bays is a function of operations requested by the customer.	Rail sidings, storage areas, cranes, forks, etc.	This lifting facility, using concertina grapple arms, successively lays down the ILU on the rail wagon.
Average terminal space required for one		Approx. 100 m^2		Unknown

Category	B2	B2	B2	B2
ID	10	11	12	13
transhipment unit (m2)				
Terminal investment for one transhipment unit (EUR)		According to the Metrocargo engineers the construction of a single terminal requires about 10 to 15 million € depending on its size, while the implementation cost in the starting phase is about 3 to 5 million €. Due to their modular structure gradual expansion of terminals is possible. At a first stage a 3-5 million € terminal could operate about 3 pairs of trains per day, while the 15 million € ones handle about 10 to12 pairs of trains per day. Metrocargo does not require any modification to cars and loading units: All types of existing railway cars and loading units can be used.		The NETHS system entails relevant investment cost for the lifting facility but it has low operational costs because it does not need any operator at the terminal
Rolling stock				
Additional cost of equipment	• Intermediate Rail Unit RailRunner bogie • Bimodal trailer needed	No	Wagons, trucks, cranes	No

Category	B2	B2	B2	B2
ID	14	15	16	17
Name of Technology	IUT (Innovatives Umschlag-Terminal)	Sidelifter	ContainerMover 3000	Mobiler
Picture of technology				
Technology description	The basic idea of Innovative Transfer Terminal IUT of ÖBB Rail Cargo Austria is the operational splitting up of transhipment, sorting and storage; therefore the processes can be done separately. The IUT 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'.	A sidelifter is a specialised vehicle or semi-trailer used to transport ISO standard intermodal containers over longer distances or for transhipment to rail. The sidelifter loads and unloads containers via a pair of hydraulic cranes mounted at each end of the vehicle chassis. The cranes are designed to lift containers from the ground, from other vehicles including rolling stock, from railway wagons and directly from stacks on docks or aboard container ships. A standard sidelifter is also able to stack a container at a two containers' height on the ground. If the sidelifter chassis is of 40' length or more, the cranes of the sidelifter can be shifted hydraulically along the sidelifter chassis to be able to pick up either one 20', one 40', or two 20' ISO containers at a time.	The system ContainerMover 3000 is a device mounted onto a truck enabling independent road-rail transhipment at every freight station with a load transfer point or at private sidings. The system can be used for the direct transhipment between road and rail vehicles of standard class C745 and C782 swap bodies or 20' and 40' containers. Thanks to the ContainerMover 3000 system, no dedicated fixed infrastructure is necessary for intermodal load transfer, nor is there a need for extra personnel since truck drivers can handle the transhipment on their own. Removable adapter frames on the rail vehicle ensure that the ContainerMover3000 can be operated with any intermodal flat wagon. The ContainerMover 3000 can handle standard containers and is therefore a significant improvement in comparison to existing horizontal transhipment techniques. The ContainerMover can transfer weights up to 22 tons. The system is operated remote-controlled, and a video camera and two distance lasers support the truck driver in positioning the road vehicle alongside the wagon. The ContainerMover-3000 can lift swap bodies and containers by up to 40 cm. The Mover truck is therefore also an efficient means of delivering swap bodies to their standing area with their retractable legs extended.	• Quick and easy operation thanks to hydraulic lifting device on the MOBILER vehicle • Smooth handling of containers and interchanges between trucks and rail wagon without crane or own connecting line

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.	• 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 • Can 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 • No specially developed tractor unit required • Good performance on small yards with a restricted catchment area for pre- and post-haulage and with clients asking for additional handling (transhipment) by the shipper because they lack their own equipment	• 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	• 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 all goods in containers and swap bodies • Reloading can be handled almost everywhere quickly and easily by a single person
Disadvantages	• Not useable with craneable or non-craneable trailers	• For terminals of European scale that are part of the international network with medium and large volumes they are useful as additional devices only • A number of them serving a train at the same time will interfere with each other and conflicts are unavoidable in the loading lanes		The system seems to be restricted to containers and swap bodies
Producer/Developer	ÖBB	Boxmover	InnovaTrain Ltd	ÖBB
Type of transhipment technology	Vertical	Horizontal	Horizontal	Horizontal
Loading Unit	UCT (containers, swap bodies)	UCT (containers, swap bodies)	UCT (containers, swap bodies)	UCT (containers, swap bodies)
Cost of handling (EUR/loading unit)	Unknown	35€/LU	Unknown	Unknown
Total time of transhipment process per loading unit (min)	Unknown	4 minutes	3 -5 minutes	4 minutes
Link	www.oebb.at	http://www.boxmover.eu/products_video.php	http://www.innovatrain.ch/en/containermover/	https://www.railcargo.com/de/Produkte_und_Innovationen/MOBILER/index.jsp
Status	In operation since 2003	In operation	Testing since 2011	Unknown
Location of testing or operation (terminal or corridor)	At the Wien Northwest terminal since January 2003		Oensingen (CH) - Tessin (CH)	Unknown

Applicable for small/medium or big terminal (small - 20000 TEU/year, medium 20000 - 100000 TEU/Year, big over 100000 TEU/Year)	Applicable for small and medium terminals	Applicable for small and medium terminals	Applicable for small and medium terminals	Applicable for small and medium terminals
Network	No special requirements	No special requirements	O/D network must be equipped	No special requirements
Suitable for all TEN-T corridors in Alpine space	No	Yes	No	Yes
Suitable for all TEN-T corridors in Alpine space - detailed	No approval for operations in Slovenia, Germany, Italy Switzerland and France		No approval for operations in Austria, Slovenia, Germany, Italy and France	
Required equipment and transhipment facilities	Operational splitting up of transhipment, sorting and storage. This objective is achieved by mainly vertically operating stackers. These stackers, equipped with a shelf load/unload device, move the ILU between the shelves and a buffer lane (pre-sorting area) beside the loading track. A portal crane is designated for unloading and loading of the rail and road vehicles.	No special requirements	Basic railway siding with asphalted road surface	Simple railway siding with asphalted road surface
Average terminal space required for one transhipment unit (m2)	The IUT test facility has a length of 30 meters, comprises two levels and can handle any standard container. The stacker crane and the shelf-operating device can cope with containers up to a maximum weight of 45 tons. Series production IUTs are supposed to have a length of up to 700 meters and up to 3 levels. Test operation showed that all resources necessary for transhipment (facilities, personnel, energy) can be optimised and much greater flexibility in terminal operation can be achieved.	Approx. 60 m^2	Approx. 60 m^2	Approx. 60 m^2
Terminal investment for one transhipment unit (EUR)		None	Minor	Minor
Additional cost of equipment	No	Additional (Side) lifts on trailer are needed	Special consoles on rail wagons and trucks	Special consoles on rail wagons and trucks

[i] One of the most important Accompanied Combined Transport (ACT) connections at the transalpine level is the Austrian-Italian relationship between the intermodal terminals of Wörgl and Trento via Brenner/Brennero. The total length is equal to about 230 km. In 2015, it counted for 3,591 kt out of 4,173 kt, thus constituting about 86% of ACT between Austria and Italy. An overall amount of 137,566 HGVs was transported (+8% compared to 2014, when they were 127,391). This amount represents about 8% of the total freight transport along the Brenner corridor, and it is lower than the potential supply offered (currently, up to forty ACT trains per day can circulate along the Brenner line).
From an infrastructural point of view, the intermodal terminal of Trento is equipped with three railroad tracks, each of them 500 m long, whereas the Wörgl terminal has two railroad tracks. The service is provided by the Austrian company "Rail Cargo Operator - Austria GmbH/ROLA", one of the most important ACT provider at the international level.
The booking system can be performed maximum 4 days in advance and at latest two hours before the reservation deadline. Different methods can be adopted: by fax, by e-mail, by an on-line booking center and, as last option, directly at the terminal, as long as there are free spaces left.
As far as the dimensions of the HGVs are concerned, the maximum height is 4 m, width 2.6 m and length 18.8 m, while the ground clearance has to be at least 17 cm. The total weight of the truck may not exceed 40 t. Higher weights (up to 44 t) are possible under certain conditions. Furthermore, it is possible to exceed the dimensions of 4 m height and 19 m in length only between Wörgl and Brenner, where an intermediate intermodal terminal is available.
The cost of the service depends on the weight transported. For an HGV not overcoming 44t, and including up to two drivers who are transported in a dedicated passenger wagon, it is fixed at €419 (VAT excluded). The cost decreases proportionally, according to the weight: for an HGV <40.2t, it is €326; for an HGV <30t, it is €266, whereas for an HGV <20t, it is €217. This price includes the incentives provided by the Autonomous Province of Trento (see below). For the transport of dangerous goods, an additional charge of €15 has to be counted.

Figure 27: RoLa service at the intermodal terminal of Trento. Source:
Source: http://www.interbrennero.it/site/ibsite/

Figure 28: Aerial view of the Trento intermodal terminal
Source: Google maps

Regional politicians support RoLa service along Brenner, in order to reduce the road component of freight transport and its related externalities. The incentives granted to ACT by the Autonomous Province of Trento and, from 2018 onwards, from the Autonomous Province of South Tyrol (€3M/year each, €33 per unit loaded) for the stretches included in their Provincial borders, aim at further increasing the number of HGVs transported by rail. This policy is consistent with the Tirolean push-measures, which include the sectorial driving ban along A12 from Langkampfen to Ampass, as well as the block admission system. The former includes all vehicles that transport all types of wastes; stones, soil, excavation; round timber and cork; motor vehicles; non-ferrous and iron ores; steel (except for reinforcing and construction steel for delivery to constructions sites); marble and travertine; ceramic tiles. With the introduction of this ban (November 2016), it has been calculated that almost 50% of goods belonging to the categories mentioned above were transported by rail and not by road.
Further technical aspects could improve the efficiency of the RoLa and make it more competitive (e.g., the length of rail tracks equal to 750 m, more rational operating spaces and spaces for manoeuvring, the possibility to interrupt the electric traction of the tracks, once that the loading/unloading operations are ready to be performed). The opening of the Brenner Base Tunnel (expected for the year 2027) will reduce the travel times, the slopes, the number of locomotives and the energy required to cover the stretch between Innsbruck and Fortezza/Franzensfeste. This would allow the use of longer and heavier trains (up to 750 m and 1600 t), which have to be handled at intermodal terminals that are ready to grant this type of service.