EUROPEAN COMMISSION
DG TREN

SIXTH FRAMEWORK PROGRAMME

THEMATIC PRIORITY 1.6

SUSTAINABLE DEVELOPMENT, GLOBAL CHANGE & ECOSYSTEMS

INTEGRATED PROJECT – CONTRACT N. TREN-06-FP6TR-SO7-69821

Retrack

REorganization of Transport networks by advanced RAil freight Concepts

Deliverable no.	D2.3
Title	Terminal Technology and Systems
Dissemination level	Public
Work Package	WP 2
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Status (F: final, D: draft)	F-24012008
File Name	D2.3-Public-Terminal Technology and Systems-Final v2-Islam-24012008
Project Start Date and Duration	01 May 2007 - April 2011

TABLE OF CONTENTS

TABLES

FIGURES

Terminal Technology and Systems

1 Introduction

Terminals, either inland or port, have become increasingly important due to the rise in the demand for transhipment in regional and global trade and the dominance of containers or other inter-modal units as the primary cargo carrying modules. Terminal operators are integrating with partners along the supply chain (Notteboom, 2002). The Strategic Rail Research Agenda (SRRA 2007) states the importance of improving competitiveness through, amongst other issues, improved planning and modern efficient and effective terminal operations. This task document argues that a dedicated Trans-European Freight Network supported by modern terminals, infrastructure and planning is integral to improving rail freight performance and market share.

An efficient transport chain has to be totally integrated where terminals are in a strategic positions to make any transport chain a success. With the door-to-door service philosophy of intermodal transport some terminals have turned into wider and more versatile logistics organisations that offer warehousing, distribution and low-end value added services. Some (e.g. HHLA in Hamburg) are even involved in intermodal rail operations (Notteboom, 2002). Currently, most European intermodal terminals are operated as multi-purpose-centres. They can handle almost every intermodal loading unit. For example standard freight containers (sea and inland) are lifted by spreader, and can accommodate swap bodies and semi-trailers by grappler arms (SAIL Study, 2002). Roll on trailer services are also in evidence in inter-modal terminals (e.g. Bilk Terminal in Budapest) as a further dimension of inter-modal capability.

The objective of WP2.3 is to evaluate terminal technology and systems that can play an important role for the movement of trains, lifting equipment, personnel and other resources to minimise terminal dwell time and cost and also offer routinely high levels of reliability. Work from recent previous projects such as the SAIL study report (2002) and the INHOTRA WP2 Report (2002) are evaluated as well as primary research with terminal operators represented in the consortium, which will include Rotterdam, Ludwigshafen, Bratislava, Budapest and Constanza.

The approach taken is as follows. The terminal handling equipment typology is discussed in section 2. Then terminal analysis is discussed in section 3 and terminal design and layout (including terminal planning and operation, current working procedures in intermodal rail terminal, terminal security issues and capacity) in section 4. A detailed discussion is provided on generic conventional terminals in section 5, followed by horizontal transhipment terminal in section 6. Section 7 discusses the Compactterminal concept, one of the Horizontal terminal groups, in detail. Then the findings of field survey are discussed in section 8 and finally a summary and conclusion is drawn in section 9.

2 Terminal handling equipment

Terminal handling equipment can be of three types: cranes, horizontal transport means and assisting or support systems.

2.1 Cranes

Many different types of cranes are used at container terminals. The gantry cranes for loading and unloading containers play a major role. Two types of gantry cranes can be distinguished: single-trolley cranes and dual-trolley cranes (newly developed). The trolleys travel along the arm of a crane and are equipped with spreaders, which are specific devices to pick up containers or other cargo modules. Modern spreaders allow the movement of two 20 ft containers simultaneously (twin-lift mode). Conventional single-trolley cranes are engaged at container terminals. They move the containers from the ship or rail on to a vehicle (and vice versa for the loading cycle) or on the terminal. Single-trolley cranes are manually operated in most cases. Dual-trolley cranes are applied at very few terminals. In this case, the main trolley moves the container from the ship/rail to a platform while a second trolley picks up the container from the platform and moves it to the shore. The main trolley is manually operated while the second trolley may be automated. The crane driver, for one and two-trolley cranes, is supported by a semi-automatic steering system. The productivity performance of a gantry crane depends on the crane type and technical characteristics. Theoretically the performance of a crane is in the range of 50–60 boxes/h, but practically it is in the sustained range of 22–30 boxes/h (Steenken, et al, 2004).

A second group of cranes is deployed in the stack yard. There are three types of cranes: rail mounted gantry cranes (RMG), rubber tyred gantries (RTG), and overhead bridge cranes (OBC) (see figure 1). Rubber tyred gantries are more flexible in operation while rail mounted gantries are more stable and capable of higher lifting weights. Overhead bridge cranes are fixed and mounted on concrete or steel pillars. Usually a rail mounted gantry crane can spans up to 8–12 rows and allows for stacking containers of 4–10 high. Generally, two RMGs are employed at one stack yard to avoid operational interruption/failures and to increase productivity and reliability. Double-RMG systems embody a new development that consists of two RMGs of different height and width able to pass each other thus avoiding the risk of collision or obstruction. This results in a higher productivity and flexibility. Although most of the gantry cranes are manually driven, some terminals are using automatic driverless gantry cranes (e.g. Thamesport, Rotterdam, Hamburg) (Steenken, et al, 2004).

Figure 1: An Overhead Bridge Crane with rubber Tyre (SAIL Study final report, 2002)

The gantry cranes, used for loading and unloading trains, span several rail tracks (maximum normally six). Containers to be transferred from/to trains are usually pre-stowed in a buffer area alongside the tracks or sometimes lifted directly to or from trucks in alleys alongside the rail lines. Forklifts and reach-stackers are used to move and stack containers - in particular empty ones although modern equipment of this type is able to lift most normally loaded boxes. One of the key constraints on the use of this sort of equipment is the high point loading on the front axle of the reach stackers when lifting containers from the ground or from a rail or road vehicle.

2.2 Horizontal transport means

A selection of vehicles is employed for horizontal transport in terminal operations. The transport means can be two types. The first type is ‘passive’ vehicles that are not able to lift containers by themselves. Loading and unloading of these vehicles is done by gantry cranes. Trucks with trailers, multi-trailers and automatic guided vehicles (AGV) fit into this class. AGVs are robotics that able to drive on a road network which is built with electric wires and/or transponders in the ground to control the position of the AGVs. AGVs can either load one 40ft/45ft container or two 20ft containers – in the latter case multiple load operation is possible. The use of the AGV system demands high investment, and thus, is suitable for operation where labour costs are high and very high cargo volumes are routinely handled. Currently, they are used in ECT/Rotterdam and CTA/ Hamburg in combination with automatic gantry cranes (Steenken, et al, 2004).

Figure 2: Rich Stacker (from SAIL Study final report, 2002)

The second type of transport vehicle is able to lift containers by themselves including straddle carriers, forklifts, and reach-stackers (Fig. 2). Straddle carriers (SC) are most important in maritime terminal operations because they are used for transporting containers as well as stacking containers in the yard. They are sometimes classified as 'cranes' that are not locally bound, with free access to containers independent of their position. Its spreader allows transport of 20' or 40'containers; in twin mode it is possible to transport/stack two 20' containers simultaneously and this is becoming more common. They are very flexible and versatile. Straddle carriers exist in numerous variants and have been progressively upgraded since their first application on the 1970s. Generally straddle carriers are manually driven and able to stack 3 or 4 containers high. Recently, an automatic straddle carrier system has gone into production at Patrick Terminal, Brisbane, Australia. These straddle carriers are 4 high with an integrated differential GPS system and dead-reckoning servers for accurate positioning and routing. Also, automatic straddle carriers of lesser height are under development for transport purposes only. Their ability to lift containers permits the decoupling of the work stream of transport and crane activities by using buffers at the respective interfaces. Due to their ability to lift containers, automated straddle carriers are also designated Automated Lifting Vehicles (ALV) (Steenken, et al, 2004).

2.3 Assisting or support systems

Assisting systems play an important role for the organization and optimization of the cargo flow at terminals. This is particularly important for communication and positioning systems. Container terminal operators are supported by a very intense communication system with external parties including shipping lines, agents, forwarders, truck and rail companies, governmental authorities such as customs and waterway or port police. An electronic communication is performed on international standards such as EDIFACT (Electronic Data Interchange For Administration, Commerce and Transport). The changes of container status are communicated among the relevant parties. The most important messages are: the container loading and unloading lists which detail every container to be loaded or unloaded to/from a ship/ train/truck or stack with specific data; the 'bay-plan' or train plan which contains the list of all containers of ship/rail with their precise data and position (communicated before arrival in the terminal); the 'stowage instruction' which describes the positions where loading containers have to be situated in a ship/train or truck and which is the basis for the stowage plan of the terminal; container pre-advices for delivery by train and truck, and the timetable and loading instruction for trains. Although only some of these messages – especially the stowage instruction for ships and trains – interface directly with the operational activities of the terminal, they are very important because they serve for completeness and correctness of container data which is necessary to optimize the work flow (Steenken, et al, 2004).

Internal communication systems also play a key role in optimizing the terminal operations. The radio data communication plays an important role as it is the main medium to transmit job data from the computer to cranes and transport vehicles.

Since the middle of the 1990s Global Positioning Systems (GPS) have been installed at container terminals. At the early stage, they were used to automatically identify the position of the containers in the yard to guarantee an accurate position of container in the terminals' computer system. Later on, differential GPS (DGPS) became essential because of the size of containers and the yard layout. DGPS components are installed on top of the transport and stacking equipment. The position is measured, translated into yard co-ordinates and transmitted to the computer whenever a container is lifted or dropped. Alternatives to DGPS are optical based systems, especially Laser Radar. Also in some cases both systems are integrated to achieve a higher reliability. Container positioning systems including DGPS, dead-reckoning and Laser Radar improves the container handling productivity in the yard (Steenken, et al, 2004).

Radio-frequency identification (RFID) technology enables the automated transmission and collecting of asset information such as equipment location, meter readings(temperatures/pressures/fluid levels), maintenance status without a person needing direct line of sight or contact with that asset. Once the RFID reader gathers data, the information is passed to the organization's EAM/CMMS application. Consequently, the system may generate an alert, release a work order, revise inventory, conduct inspections, create an invoice, locate an asset, etc. Thus RFID provides a fast, accurate method of obtaining valuable asset tracking information. Also it helps asset managers to:

- Improve terminal and asset productivity;
- Reduce costs by implementing a need-based maintenance schedule rather than an arbitrary calendar-based schedule;
- Increase equipment longevity by identifying usage patterns.

3 Terminal analysis

The SAIL Study (2002) found that there are no generalised or applied standards for operations and technology in terminal operations. Basic common procedures could be found, for example, for a road-rail terminal operation. The SAIL study conducted an analysis of intermodal terminal planning in the following way:

- Analysis of the organizational and operational process at multi-purpose-terminals distinguished by throughput, terminal layout, type of handling equipment;
- Analysis of the flow of material at single-purpose container terminals;
- Comparison of the results of analyses;
- Definition of overhead functions;

- Development/design of the flow of material (process organization) at a single-purpose semi-trailer terminal model;
- Process cost analysis;
- Integration of requirements from interfaces terminal/rail and terminal/road;
- Staff requirements;
- Real time data capturing system and its use in operation and analysis

Although almost every terminal in Europe is used for transhipment and storage, and the process is based on similar principles, there are some significant differences and these are detailed below. It is difficult to compare the costs between new generation terminals and conventional terminals or shunting yards. This is because it requires specific detailed information, which in the case of conventional terminals and/or shunting yards is considered commercially confidential or is not available for others reasons or, in the case of new-generation terminals not available. The operational analysis attempted to show, by using known as well as assumed costs, an economic comparison between conventional terminals/shunting yards and new-generation terminals.

The SAIL Study (2002) found substantial differences in terminals that are discussed below.

Computerisation: the use of data processing for the external activity part is generalised to each combined transport operator (e.g. exchange of data with other terminal or central office, printing of contracts etc.). Concerning the internal part, most of the Terminal Management Systems (TMS) are under improvement and increasingly deploy commonly used industry recognised systems. Managing a terminal with such a tool is important because it allows recording of real time data (e.g. position of a container) and to access those easily and avoiding costly multiple handling. It is possible to argue that the system can be incomplete as it may still need some manual operations to check the accuracy of the data.

Traffic: it is evident that the operations in rail-road terminals with a high traffic (150,000 to 200,000 ITU handled per year) differ from those carried out at small terminals (less than 25-50,000) due to the repetition of work. ITU consists of containers, swap bodies and semi-trailers equipped for combined transport. Steenken, et al (2004), noted that the daily average yard utilisation of a large container terminal in Europe is about 15,000 to 20,000 containers and 15,000 movements of containers. The average dwell time of a container is about 3 to 5 days.

Number of employees: it is interesting to point out that some smaller terminals, with fewer employees, offer a much higher ratio of ITU handled per capita.

Facilities: some terminals have different process when they offer some facilities to their clients, as for example delivery or collection haulage or long duration storage. The SAIL Study (2002) suggests that these supplementary options for clients need to be integrated in the process.

The number of combined transport operators on the terminal: the management is sometimes shared between more than one operator. They may have different activities, for example, one operator may deal with only local or international traffic.

4 Terminal Design and Layout

A container terminal is characterised by specific types of handling equipment and storage area/facilities. From a logistics point of view, terminals have two components: stocks and transport vehicles. The ‘stock’ component consists of stack yards, ships, trains and trucks. Statistically stocks are defined by their capacity to store containers but a dynamic point of view is these stocks are places where containers are stored. The routing and scheduling of ship, rail and trucks are not under the immediate or direct control of the terminal operator. On the other hand, the 'transport vehicle' component consists of cranes and vehicles for horizontal movement of containers in terminals (Steenken, et al, 2004).

A terminal can be defined as an "open system" of cargo flow with two external interfaces: landside and quayside for maritime transport (Steenken, et al, 2004) or roadside and rail-side land surface transport. Terminals involving rail freight transport can be of two types:

- inland terminal, located in rail yards, inland ports, or freight villages, providing rail access and port terminals, if they are operated separately as a Rail Service Centre (RSC), Stand alone rail terminals originally used for rail road interfaces have in many cases also attracted other activities to such sites.
- where transhipment between vessel and rail is taking place on the quay. RSCs can be located and operated in different forms. They can either focus on maritime containers if they are dedicated to a small number of marine terminals or they can offer mixed handling of maritime and continental loading units. There could be another type of terminal, privately owned and operated transhipment facilities e.g. at shippers' sites, which do not ensure a non-discriminatory access.

Whilst there is no standard layout of a terminal most share the same general operational characteristics. The train operation side of a terminal may consist of the reception and departure sidings, the arrival, departure and transport tracks (loop lines for releasing the locomotive and locomotive storage tracks) and the transfer tracks under the crane or alongside the pad area. The transhipment area comprises the rail transfer area, the materials handling equipment, the intermediate buffer area and the loading and travel lanes. The remaining area includes the HGV approach road and spare space made available for dealing with any congestion, the reception and departure gate(s), the traffic area (parking spaces and waiting areas, turning area and reversing lane), buildings and technical installations and service areas and depots where applicable.

The SAIL Study (2002) suggests that the terminal design layout for transferring semi-trailers is broadly the same as for other intermodal transport units other than for stacking. The ability to move the trailers directly to the main lifting point without any intermediary equipment is one operational advantage but this can be negated by the need for single tier parking/storage.

A model called TERMINET has been developed to determine locations and capacities of road and rail terminals where transhipment of load-units between road vehicles and trains takes place. The model consists of a traffic conversion method which translates freight flows from tonnes to numbers of load-units as well as a freight flow consolidation method using existing assignment techniques. (The issue of low weight high bulk commodities can be an issue in this calculation). The TERMINET model examines the possible binding effect of terminal infrastructure and investigates the influence of the cost structure of intermodal transport which strongly determines the possible modal-shift from road to intermodal transport. The TERMINET model makes it possible to determine interactively or automatically inland terminal locations for transhipment of load-units between road vehicles and trains. The influence of train length on terminal locations, terminal capacities and network load may be calculated. Besides these capabilities it is also possible to determine the overall system performance in tonnes, tonne-kilometres, TEUs and numbers of trains. The TERMINET model has been applied to the design of an inland road and rail terminal network in the Netherlands to be used in an intermodal road and rail freight transport system for international and Dutch domestic freight flows for the year 2015. The cost structure of intermodal transport has been examined. Cost calculations have been made to examine the effect of zero or complete passing on of external and infrastructure costs to both the road and rail mode. Furthermore, the effect of the maximum use of intermodal transport on the reduction of the growth of road transport has been examined.

Recently some terminals have been built from scratch. The reasons for this are reducing operating costs, better service, greater operational flexibility and capacity growth.

In 1995 a study was conducted on behalf of German railways on how to attract combined transport to rail, so called Mega-Hub Project. The concept was to form mega-hubs to consolidate container flows. The conclusion was that there should be three locations (north near Hanover, Wolfsburg and South-West). The shunting procedure is not quick enough in itself and therefore the proposal was to tranship containers between trains i.e. not to shunt but to tranship. The idea is that six trains would enter the terminal within a specific time window of 40 minutes, stay together for 20 min, and then leave. So after 90 minutes the position of some 360 containers could be changed. This project has not been developed on the lines originally conceived. Ironically this model has been adopted successfully by the road sector for the movement of pallets to and from hubs in an orchestrated way with very rapid exchange of cargoes.

4.1 Terminal Planning and Operation

The terminal is an essential and crucial element of a complete door-to-door intermodal chain, and thus terminal technology and systems must be evaluated within the general framework of the complete integrated transport chain. In terms of success and failure of a terminal or of a single technology used, there is no such feature as a definite success or failure. In fact success and/or failure always depend on the circumstances and a definite classification is not possible (EUTP final report).

The terminal designed for transferring intermodal loading units between different modes of transport is divided into the train operation and transhipment plant and truck movement (SAIL Study, 2002) components. Depending on the size, throughput and degree of automation these functions may be integrated and the working places in detail are spread throughout the whole terminal. The communication aspect is very important to the overall efficiency and effectiveness of terminal operation.

The RETRACK project focuses on road-rail terminal operation and technology, although it will have port terminal operation in Rotterdam and Constanza.

Terminal operating systems have many different modules that include: gate and truck monitoring, yard planning, ship stowage planning, rail planning, container packing information, customs access, EDI, equipment monitoring and performance reporting. These systems are used to continuously optimise yard space, minimise equipment utilisation, real-time monitoring of container handling etc. In so doing, these integrated systems help shippers transact business efficiently.

Terminal to terminal communication (loading list) and management of the wagon fleet (maintenance, corridor allocation, positioning) are essential for intermodal transport. But, generally intermodal transport agencies operate different bespoke information systems. A higher level of co-operation is required for the interchange of information such as booking or accounting. This is transmitted via different media (e-mail, EDI messages fax, telex and even manually etc). The latest development is on-line booking systems (e.g. CESAR) that are dealt with in task wp2.2 in this project.

Transhipment technologies have been developed that support the development of small scale inland terminals and are more fully explored in WP2.1. Suffice to say that the new horizontal transhipment technologies most likely to succeed are based on existing loading units and rolling stock. All IN.HOT.RA project demonstrators take containers from the train without the need to disassemble the train. They are designed for low scale terminals of significantly less than 10,000 loading units annually.

4.2 Current working procedure for rail intermodal transport

When developing a basic design of an intermodal terminal the management and the planning processes need to be considered.

The management process is characterised by bilateral contractual relationships at interfaces in the transport chain. Typically from origin to destination of transport haul the freight forwarder or the shipper/manufacturer is responsible for the road transport from the consignor to the originating terminal which may be separately owned or be owned by the rail operator. Various models apply. In the terminal the cargo unit is delivered into the charge of the intermodal (i.e. rail) operator, who organises the transport between the originating terminal to the destination terminal. The intermodal operator collaborates with the terminal operators and the railway undertakings, which are contracting train paths from the infrastructure managers. The terminal operator is responsible for the handling of loading units in the terminals and is also in contractual relationship to the railway undertakings which are taking over the load in the terminal for the rail shipment. In some instances the train operator is also the terminal and local haulage provider.

The characteristics of the desired service set the requirements for all other parties involved in the planning process of this transport. The preferred departure and arrival time for the rail service are the major parameters for the allocation of the train path which is assigned by the Infrastructure Manager. From the features of the respective load, basic train parameters can be developed. In addition to the timeframe {day(s) of departure, time of departure, end to end timing, routing etc} giving the basic input for the Railway Undertaking, which carries out the planning process of the operational businesses, taking into account the deployment of personnel and vehicles. The planning processes of these two main actors involved in the organisation of the rail service – the Infrastructure Manager and the Railway Undertaking – have to be coordinated very closely as train path allocation and deployment of resources (e.g. locomotives, wagon, and personnel) are directly interconnected. In addition to the train service the interface to road haulage has also to be planned and managed and linked to the handling of the consignment in the terminal. It has to be acknowledged that the terminal must be in a position to receive and dispatch cargo by both road and rail to reflect shippers and consignees requirements which may be very flexible. The ability to respond to schedule changes and service disruptions is a key consideration.

4.3 Terminal security issues

Intermodal transport is facing new challenges, since the terrorist attacks of September 11th in New York and further tragic events in Europe, more security measures are requested by different authorities. These measures burden intermodal rail transport with additional costs and time penalties. Intermodal transport is in heavy competition with road transport and therefore it is of vital interest to improve security without hampering its economic vitality. A number of projects are being implemented to improve the new security issues without compromising the economic viability of intermodal transport. For example, the ‘Intermodal Security for Combined Transport Terminals’ project started in 2005 under Marco Polo Programme. In this project, a number of major European intermodal transport operators and terminal operators such as Adria Kombi (SLO), Cemat (I), Hupac Italia (I), Kombiverkehr (D) and Novatrans (F) are working to: develop and examine effective procedures in order to increase security; set up an information campaign; set up and test a training programme for the staff of these operators and intermodal transport customers; and develop specific EDI tools for supporting the security measures which have been put in place.

Higher safety and security are competitive arguments in favour of intermodal transport, especially for the market segments of dangerous and high value goods. Its objective is to turn the challenges of security issues into a competitive advantage for intermodal transport in order to shift more traffic from road to rail through measures and adaptations of procedures. On the 4th July 2007 in Brussels the final workshop of the project was held in the premises of the European Economic and Social European Committee (ESEC). About fifty participants, representing intermodal operators and their clients, national and European authorities, infrastructure and terminal managers and other associations, attended the workshop. The final workshop allowed reporting on the results concerning risk analysis, the newly implemented measures, the EDI support tools and the training materials.

Basic terminal security involving perimeter defences, controlled access and egress by users and any visitors to site, night time defences against intrusion including adequate lighting, alarm systems and linkages to local police forces is a high priority given the high concentration of high value items in terms of cargo and equipment within the site perimeter.

This subject is explored more fully in WP2.4.

4.4 Terminal capacity

Kessel + Partner (2004) identified 34 transport areas on selected major trans-European corridors. Of these, 25 were large inland transport areas and 9 end-of-corridor areas, The study used a methodology for analysis that assembled all terminals of a geographical zone into a “transport area”, for example, all Paris terminals are deemed as consolidated as “Paris terminal”. This may pose some problems in terms of user acceptance and possible confusion.

The report forecasted that there will exist a transhipment capacity gap for 1.7 million load units by 2015 in 18 European corridors, none of them exactly matches the corridors under review. Under the circumstances they recommend the following actions for terminal investors:

- It is crucial that terminal enlargement investments will come into operation on a timely basis to avoid temporary capacity shortages: calculate sufficient time for planning, approval procedures and financing, construction and opening of the enlarged terminals and their access infrastructure.
- As an interface between road and rail, the terminal is the most crucial part of the intermodal supply chain and thus, sufficient sustained handling capacity is a prerequisite for ensuring high performance and also to allow capacity reserves to prevent the terminal becoming a bottleneck.

The improvement in the framework conditions to promote intermodal transport can be reached by much more effective services being provided by the railways particularly relating to routinely high reliability, on time performance, product quality, strengthening the role and specific advantages of each transport mode, initial financial support, optimal use of existing infrastructures and capacities and effective use of telematic systems. On the political side the "instruments" for supporting intermodal transport are subsidies, investments, taxation, regulations and legislation and the management competence of the service providers.

5 Generic Conventional Terminal

Terminals are important nodes in the intermodal transport system. They play a vital role in integrating modal transfer. Terminals can be broadly divided into two types: conventional and modern by considering their infrastructure, operation, related facilities and status of integration into supply chain.

The integrators are increasingly playing an important role by participating in the intermodal services. But most terminals are not integrated into a system; rather they perform as individual enterprises that attempt to accomplish the task of loading and unloading depending on load type in whatever way it takes. In such cases the train schedules are operated independently of the terminal. These terminals can be termed as 'Conventional Terminal' (SAIL study, 2002).

5.1 Conventional Terminal Functions

The operation of the terminal is integrated with the train schedule, which is determined by the track allocation and sequence of operations. It must also be able to respond and react to disruptions in train plans and train path sequencing. This is laid out in such a way that the system can be optimised to take advantage of the train services available in the market. Any restriction to the terminal can cause operational disruption and this must be responded to in an efficient and effective manner. Competitive ability is a crucial important factor for intermodal freight. Ultimately price and time are the important determining factors in a terminal's success as well as in other operational aspects.

5.2 Layout of a Conventional Terminal

A conventional terminal is assumed as a standard stub end terminal (although increasingly terminals are able to be operated with trains entering and leaving at each end and connecting to the running lines) with gantry cranes supported by other mobile cranes such as fork lifts or reach stackers. Normally it is built in separate blocks, each with gantry cranes. Both blocks together can serve 6 or more rail tracks. The rail tracks have a length of 600-720

m. The trains do not normally have to be separated for loading or unloading thereby improving total in-out performance times. Table 1 describes conventional terminal facilities.

5.3 Operational Mode

The mode of operation is that the train compositions are stored outside of the crane area. These sidings are normally situated outside of the terminal area. The shunting movements lead to crossings and conflicts. The time delay is smaller than in terminals with restricted length where the train under the crane must be periodically re-shunted in order to find or release single or groups of cars. The train formations are brought under the cranes and then are unloaded or loaded. The loading units are then stored and the area under the crane is normally cleared for the next train or trains. It is important that reservations and train movement information are coordinated in order to determine and schedule the procedures. The trains could wait during the day (non-peak hours) for some time under the crane but this constrains their productivity. The full utilisation and occupancy of the tracks at the peak time means that little flexibility is available. Peak traffic times and seasonal traffic fluctuations and disruption to train arrival and departure sequences can pose operational problems between the key players. The key to success is the terminal's ability to respond to such circumstances.

5.4 Processes in Terminals

The typical processes in a conventional terminal are as follows:

The trains will arrive into the Arrival/Departure area. After checking, the whole train will be transferred into the terminal under the crane where the loading units will be unloaded off the train, and new loading units, if there are any, will be sequentially loaded onto the train. Due to the time schedule some trains may be shunted away from crane area to a railway yard, and can be shunted back when there is an open time window under crane for loading. Most shunting activities are managed with diesel shunting locomotives, which may be owned and operated by the terminal operator or a separate contractor. When a train is loaded, the departure train may be shunted once again to Arrival/Departure area to be dispatched or could depart directly to the mainlines. Some terminals allow the mainline locomotive to position the train into the main container pad area. The locomotive may remain attached to the train or be released and either reverse out of the pad area and then re-couple or move away from the terminal to other scheduled duties.

Table 1 Conventional terminal facility (Source: SAIL Study Final Report Annex, 2002)

Terminal Operator	Block A	Block B
Number of cranes:	2	2
Crane load capacity	40 tonnes	40 tonnes
Crane span	30 metres	30 metres
Total rail track length	2 x 720 metres	2 x 650 + 1x 600 metres
Tracks under crane	2 rail, 2 road, 3 storage	3 rail, 2 road, 2 storage
Stacking height under crane	2 high	2 high

Crane performance	30-35 moves/hour	30-35 moves/hour
Storage capacity	Ca 480 TEU	
Total performance	140 moves/hour (max)	
Throughput capacity	200, 000 TEU (nominal)	
Total terminal area	100,000 sq. meter	
Rail tracks terminal	5 under crane 5 arrival/departure 3 siding terminal 2 siding	
Mobile equipment	Forklift Shunting locomotive(s)	

The time schedule of the train operation is guaranteed through fixed time windows for the loading and shunting process. The minimum estimated stop in the Arrival/Departure area is around 45 minutes including processing and checking papers, file data and preparing for the unloading process. The unloading/loading process would normally take 2-3 hours depending on train length, container availability and crane productivity. The train composition could be longer but it is important to reduce to a minimum total transport cost and time. Long dwell times in container yards can make rail less attractive if the time from loading the first box onto an empty train to the time of departure and arrival at the final destination is too leisurely. This time lag may drive cargo interests to use road to meet their cargo imperatives.

5.5 Advantages and Disadvantages of Conventional Terminal

5.5.1 Advantages

- Long term storage under the cranes because of its large layout
- Mix of loaded and empty containers in the active lifting zone
- Large yearly capacities

5.5.2 Disadvantages

- High operating costs
- High personnel costs
- Conflict of operational containers with stored passive containers
- Large land take

5.6 The Future Terminal

The concept of a new intermodal terminal, or enlarging an existing installation, means making decisions based on preliminary studies, consideration of traffic flows, and other inputs. Making the right decisions means the difference between success and failure for an intermodal terminal. The important issues for a future terminal are:

- Appropriate terminal operational functions for the location, line of route terminal, hub, gateway, single or multiple modes within one terminal boundary;
- Optimal mix of capacity for the peaks, and operation in the marginal periods;
- Scope for later enlargement of the terminal;
- Degree of automation;
- Network integration, road and rail and possibly water to give a tri-modal option;
- Local position (regional site or central location); and
- ICT and telematic systems.

The SAIL Study (2002) reported that Tuchschmid has developed a software tool, which delivers decision support for new terminals and their layouts. All parameters for terminal concepts and local conditions can be introduced and evaluated. The resulting performance calculation permits a first evaluation of relevant technologies.

Terminal technology, performance level requirements, and local features can be integrated and evaluated in respect of investment and operating costs. In order to verify selected technologies, Tuchschmid uses a subjective comparative methodology, which grades various terminal technologies according to various operational functions required.

In order to gather the terminal investment the respective transport master plans (if available) and plans of the terminal operators are analysed. The first do not normally provide details such as the investment volume and improvement measures per terminal but only a long list of terminal areas and a lump annual or multi annual figure of funding, whereas the latter are very much too detailed or confidential to be used in the study. Ownership and funding of new terminal developments can be very varied in terms of equity with participation by both private and public sources.

In the following section modern terminal technology for evolving horizontal transhipment technology is presented

6 Modern Terminal technology: Interoperable Intermodal Horizontal Transhipment (INHOTRA)

6.1 Definition of Horizontal transhipment

Horizontal transhipment is defined as the transhipment between transport vehicles, buffers and storages mainly horizontal in two dimensions especial under the catenary (overhead contact line) (INHOTRA WP2 Final Report (2002)). Horizontal transhipment means that the main part of the transfer of ITU takes place horizontally. For ISO-containers and swap bodies the vertical lift is just for detaching them from the twist lock fastening on or directly from the vehicle. The movement is two-dimensional and can be simultaneous. Transhipment can be made by manipulation through transfer equipment on a rail vehicle, road vehicle or an independent device or alternatively by self-propelling. Transhipment can be done between the carrying vehicle of one mode and the vehicle of another mode (direct transfer), or to tranship the ITU to an interim buffer place from which it is transferred to the vehicle of the connecting mode (indirect transfer). The possibility to tranship under the overhead contact line (catenary) is a main feature of many horizontal transhipment technologies, which is also the limit in heights of the vertical lift.

6.2 System Elements of INHOTRA

6.2.1 Loading Lane

The loading lane is the lane or place beside the rail track where the road vehicles can be parked for the transhipment of the ITUs.

6.2.2 Loading Track

The loading track is the track where the rail wagons or trains are stopped for the transhipment of the ITUs.

6.2.3 Transfer Lane

The transfer lane is the lane where the transhipment equipment can work longtitudinally, especially those guided alongside the loading track.

6.2.4 Transfer Point

The transfer point is a place where the infrastructure is equipped just for transhipment between transport vehicles without additional services provided.

6.2.5 Storage

The storage is a place where ITUs can be stored (loaded or unloaded) for a longer time than needed for eventual transit re-loading (more than 24-72 h). The storage is a terminal service and not part of the transfer procedure, and in most cases refers to empty units.

6.2.6 Buffer

The buffer is a short time storage, where the ITUs can be pre-positioned or placed immediately after unloading from a transport mode.

6.2.7 Liner Train

Liner trains are defined through a regular service on a fixed line running according to a pre-planned timetable making regular stops, where no shunting has to be done. Loading and unloading (transhipment) of ITU are done on all terminals including intermediate stops, which can be situated either along the line or in the origin or destination region. Liner trains can also run on circular trip itineraries. Time for stops should not exceed travelling time. Liner trains can also operate on a point to point basis between a large marine terminal or port area directly to a large inland terminal for removal and onward final delivery by road.(e.g. Freightliner in the U.K.)

6.2.8 Loading unit

Loading units consists of containers and swap bodies, part of them being ITU.

Table 2 Groups of horizontal transhipment technologies (from INHOTRA WP2 Final Report, 2002)

Technology group	Feature
Trailer train (Bimodal system)	The trailer is part of the train composition; The trailers are mounted onto bogies with no intermediate supporting structure or wagon components.; No transhipment unit needed beside a tractor or truck.
Roll-on-roll-off	The trailer is loaded and unloaded on the rail vehicle in longitudinal direction on its own wheels
Self-loading trucks	The loading unit is shifted by the transfer equipment which is mounted on and powered by the road vehicle; Road and rail vehicle have to be positioned side by side.
Turntable systems	The rail vehicle is equipped with a swivelling platform; Shifting is powered by the road vehicle; Transport units have to fit to the road and rail vehicles; Direct shifting from road to rail vehicle.
Self-loading rail vehicles	The loading unit is moved by the transfer equipment which is mounted on the rail vehicle; Movement is powered by the rail vehicle.
Horizontal transhipment units	The transhipment units are bound to the terminal site.
Network Terminals	The transfer equipment is part of terminal logistic system (sorting, storing, loading, unloading)

6.2.9 INHOTRA Methodology

The INHOTRA WP2 Final Report (2002) identified seven groups of horizontal technologies that are listed in table 2. The report discussed multiple technologies from each group. In this report one technology from each group is briefly discussed in the following sections.

The INHOTRA WP2 Final Report (2002) identified multiple technologies under each group. In the next section one technology from each group is described briefly. In the following section one technology is discussed in details.

6.3 Bi-modal systems group

The technology group of bi-modal systems included Trailertrain, Railrunner, Kombitrailer, and Tabor, of which TrailerTrain is briefly discussed below.

6.3.1 Trailertrain

1. Hostler tractor positions trailer (see figure 3)

2. Trailer air suspension lifts rear of trailer, tractor backs trailer onto rail bogie

3. Trailer air suspension is vented, steel coil springs lift tyres clear of rail.

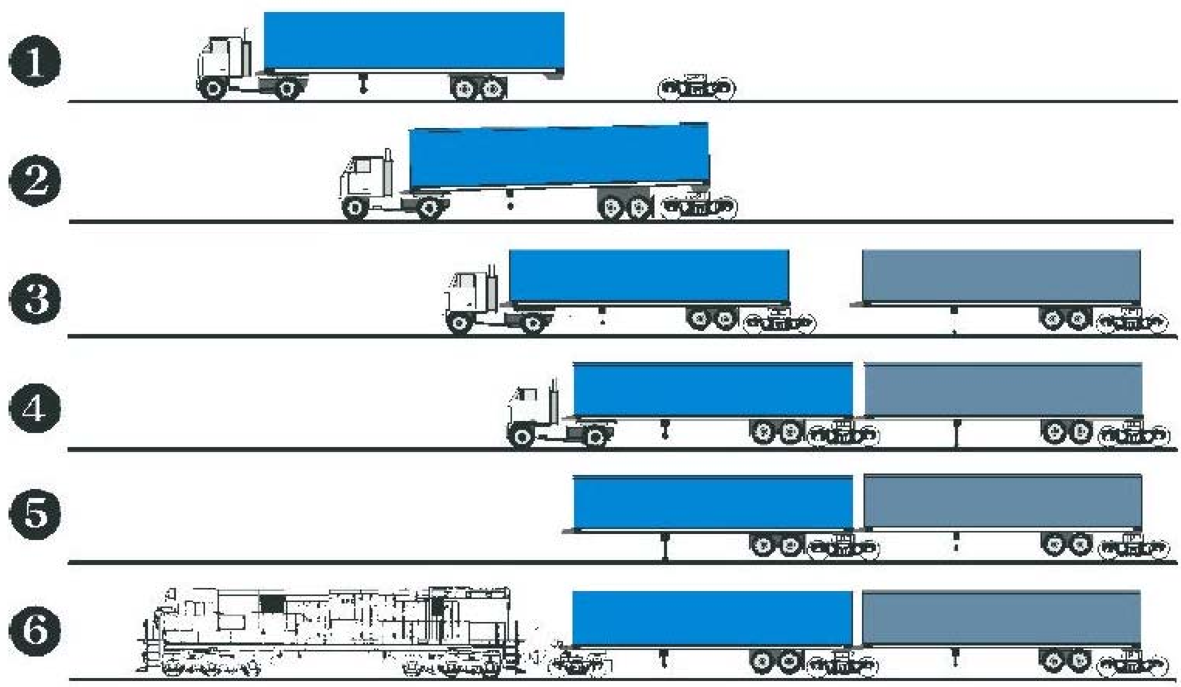
4. Tractor backs trailer to coupling with balance of train.

5. Tractor leaves leading trailer on landing gear. Air lines are connected and landing gear is raised on second trailer.

6. Locomotive backs bogie with coupling to trailer. Air lines are connected and landing gear is raised on all trailers.

This type of bi-modal technology has been deployed on trials in Europe but has not found widespread acceptance. It has mainly focused on the use of dry van type road trailers as the cargo module. Some developments in the US have incorporated a similar concept for the movement of flat bed trailers carrying international (ISO) shipping containers. The key advantage of the is technology set is that it does not rely on any external lifting device but uses the air suspension system on the trailer to make the mounting/de-mounting operation feasible. It is unlikely to be a primary focus for RETRACK in the short term given the nature of the technology.

Figure 3: Trailertrain (Source: INHOTRA Report WP2 Annex)



6.3.2 Roll-on-roll-off group

The technology group of Roll-on-roll-off includes Railtruck, Wippenwagen (swivelling-pocket wagon), CargoSpeed (developed from: Swople), Cargo Beamer, Tiphook Piggyback System (Type Sdfkmss), and Rollende Landstraße (Rolling Road), of which Railtruck is briefly discussed below.

Railtruck 2020

The basic principal of the transhipment:

When the train enters the station the frames of the wagons are moved parallel to each other without uncoupling the wagons from each other. This is made possible by:

- the special construction of the bogies and wagon frames: Two platform wagons use one common bogie. The platform, which is accessible by trucks, can be moved up to 90° relative to the bogie.
- the stretching principal: When the train enters the station, every second bogie is moved to a parallel track. The final maximum distance between the tracks is the same as the distance between the king pins of two bogies. The movement of the train on the tracks between the points moves the frames from longitudinal to lateral position or visa versa. The final position of the frames is rectangular to the direction of the two parallel tracks.
- a guiding system for the shearing forces: In the distance where the frames are turned a guiding follows the tracks. Horizontal guiding rolls, which are attached to the bogies, support the wagon on the guiding walls while the frames turn.

- the special design of the terminals: The ramps and the loading platform of the wagons have the same level.

6.3.3 Self-loading trucks

The technology group of self-loading trucks includes Sidelifter, Hammarlift, Stag, T-lift system, Linercrane, Swingthru, EKA Stevedor, and Klaus Kranmobil, Mobile, of which Sidelifter (see figure 4) is briefly discussed below.

Sidelifter:

Figure 4: Sidelifter (Source: INHOTRA Report WP2 Annex, 2002)

Steelbro Sidelifters are container handling and delivery systems. They permit loading and unloading on virtually any flat, reasonably hard surface, allow double stacking of fully loaded containers, permit stuffing and de-stuffing at ground level and make the transfer of containers to another semi-trailer a simple and safe operation. The MK6 Steelbro Sidelifter has an overall length of 13.6m (including the front arc) and easily complies with 13.72 m (45 ft) trailer length regulations. This means that 40 ft and 20ft containers can not only be loaded and unloaded with safety and ease, but can be carried in many countries without travel restrictions being imposed due to the overall length of the trailer. There are a number of other features of the MK6 Sidelifter that bring considerable benefits to the transport industry.

With a tare weight from 11 tonnes, the new design is lighter. Also, operation has been made faster through dual speed and variable speed controls. It is safer as there is greater control over the movement of the container and it is stronger as the lift capacity is rated to 30 tonnes and tested to 37.5 tonnes. Finally the MK6 is more versatile as its extended working radius enables companion vehicles to drive past during container transfers.

Major features are:

- Greater emphasis on safety;
- Rapid deployment of stabilizer legs for faster turnarounds;
- Easy to use controls;
- Variable speed remote controls for superior handling flexibility of the container;
- Greater lift capacity, particularly at full outreach;
- High speed operation, with dual speed and variable speed controls;

- Significantly reduced tare weight, now from 11 tonnes;
- Greater stability;
- New style of twist locks and lifting lugs for reduced maintenance;
- Length reduced to 13.6 m, including front arc, to suit regulations;
- Superior manoeuvrability and greater control over movement of the container;
- Rated capacity of SWL 30 tonnes (tested to 37.5 tonnes);
- Reduced shock loadings in the hydraulic system resulting in lower stresses and strains

The key advantage of this type of mobile crane is that it can be deployed quickly at locations where there is no requirement for a permanent crane or lifting device or the cargo volumes to be handled do not justify the investment in large conventional terminal equipment. Cranes can be planned to meet train arrivals, work the train cargo off and on quickly allowing the train to depart and then use the crane trailer and other trailers to perform the local delivery routines. This may be a more attractive option for terminals with lower traffic throughputs and intermittent activity or as a commercial pilot to prove the concept.

6.3.4 Turntable systems

The technology group of turntable systems included ACTS and RSS (Roland-System-Schiene-Straße), of which ACTS is briefly discussed below.

ACTS

ACTS is easy to use and operate. It links road and rail into a flexible system. Transfer of containers between rail and road needs no fixed installations. ACTS transhipment can take place in any rail yard.

Target market for the ACTS is traffic involving:

relatively small volumes;

frequently changing points of origin and destination; and

short distances (50 km and more),

which has had little benefit from standard intermodal techniques. The reality though is that ACTS is not a credible or acceptable concept for high value time sensitive commodities or traffic flows using the normal ISO dimensioned containers. Its main applications to date have been at the lower value end of the commodity spectrum

ACTS involves the following components:

- A road goods vehicle, equipped with standard rail-approved chain or hook fitting
- ACTS Container with UIC-standard base frame
- ACTS-railcar, equipped with UIC-standard ACTS turntable frames.

All components are standardised, according to UIC Document 571-4. They are not yet compatible with ISO dimensioned boxes

Transfer Road - Rail:

The ACTS wagon stands on a rail track. A lateral clearance of 10m is required for unloading.

Without need of special tools, the truck driver releases the safety locks of the ACTS railcar, and swings the ACTS frame by hand to the loading/unloading position

The truck is reversed up to this ACTS frame.

The driver uses his reversing mirror and the reflectors on the ACTS frame to verify his exact alignment

With the truck's rail-approved power-operated transfer equipment, the container is rolled on to the frame

The frame is swung back to the running position on the railcar, and the safety locks are again made secure.

The rotation of the platform with a loaded container can be done using the road vehicle, and with an unloaded container by hand.

The transfer of the container from rail to road is simple and safe, requires no fixed installations or additional personnel, and is performed in less than 3 minutes.

Components of ACTS

Road freight vehicle with rail-approved transfer equipment.

The transfer equipment is derived from a system used for many years for road transport. Containers can be loaded and be collected at an appropriate time by a road vehicle. The container is transferred to the road vehicle by chain or hook fitting. This permits road vehicle standing time to be greatly reduced and to use very simple terminals for the transfer to be effected The development of ACTS uses this principle also for transfer applications on rail.

ACTS-Containers

There is a wide, almost unlimited variety of types and dimensions of ACTS-containers. Containers are constructed according to the requirements of the goods to be carried and of the individual customer's wishes. Lengths in use for road transport vary between 4.5m and 9.5m, volumes vary between 9m³ and 60m³. For rail applications the UIC standard ACTS container length is 5.95m. The length of the frame of the container is also standardised. The maximum volume of a rail ACTS Container is 30m³. The container tare varies between 1,400 and 3,200 kg, while the payload can vary between 13,000 and 28,000 kg.

The user selects the type of container most suitable, for example:

- pallet-wide containers;
- tipping units;
- thermally insulated;
- tanks and silos;
- swap-body units;
- open/closed top units;
- containers for packets/ part-loads.

ACTS rail wagons

The ACTS rail wagon is a flat car, equipped normally with two or three sets of fittings. The rail wagon fittings for ACTS are:

- ACTS-turntable frame;
- ACTS base plate and pivot bearing;
- ACTS-Safety locks. These prevent undesired rotation of the container, and secure it vertically. They are released by the operator to initiate a transfer.

The ACTS turntable frame

This is a massive steel frame. Runners guide and support the rollers of the container, and centre the container and the frame.

The ACTS base plate and pivot

The frame rotates on a pivot, with supporting rollers. The pivot bearing is located in the base plate, which also distributes the weight of the supporting rollers on the railcar.

ACTS security fittings

The security equipment is being constantly developed by Tuchschmid. Simple central hand releases, with automatic locking, ensure that the Tuchschmid system operates at the highest safety level. Two separate security systems to prevent undesired rotation of the frame and container, and protection against vertical movement, are provided in accordance with UIC standards.

It is possible that ACTS traffic could be moved along the Retrack corridor within train services developed to serve traffic on or linked to the corridor. The equipment is bespoke and effectively confined to specific lower value traffics. It is a smaller component of total inter-modal traffic flows when compared to ISO, Eurocontainer and swap body activity.

6.3.5 Self-loading rail vehicles

The technology group of self-loading rail vehicles incude CargoRoo, Kombilifter, WAS-Wagon, Wieskötter System, of which CargoRoo is briefly discussed below.

CargoRoo

The system (in figure 5) is built on simple and low cost core elements: wagons with onboard transhipment technology, auxiliary equipment, easy to build and low-cost terminals and standard semi-trailers. The CargoRoo specific pocket wagon equipped to carry two moveable lifting devices known as ‘lafettes’ is suitable to carry one standard semi-trailer. The wagon and the lifting devices are capable to handle units up to 41 tonnes to accommodate European standards. The trains can be operated with a maximum transport speed of up to 120 km/h.

In terms of handling equipment only the lafettes are required. They are powered by an electric-hydraulic moving and lifting device and add approximately 1,500 kg each to the wagon weight. The power supply is provided by the locomotive using the standard UIC bus. The auxiliary systems, including the power converters for energy supply of the lafettes as well as for reefer trailers and the transhipment management system, are integrated in a ‘master unit’, which serves a group of up to ten wagons. To achieve a proper positioning of the wagons, a positioning system has been developed, which ensures a positioning tolerance of at least 4 cm for each wagon, which is sufficient for the semi-automatically transhipment process. The locomotive driver stops the train with a tolerance of up to ±1 m. The train is blocked at the rear and compressed by the locomotive to a defined level. After activating a barrier in the centre and at the front of the train, which is released and each wagon swings to its final position.

The terminal locations are preferably located parallel to a main line. The terminals consist of two platforms left and right of the terminal track. The platforms are built out of pre-cast concrete elements and can easily be erected, extended or removed. There is no stationary transhipment equipment. A simple and robust positioning system for the semi-trailers is integrated into the platforms. Easy trailer positioning and pick-up is enabled through alternating positioning of the trailers left and right of the train. The system is suited to semi-trailers according to ISO 1726 conditional to absence of special under-floor equipment in the area where the lafettes have to be positioned. Trailers between 13.6m and 15.1m and with a total weight of up to 37 - 41 tonnes can be handled. The Trailers have to be adapted to the system using two adapter kits. Adoption of this technology set has been limited to date.

Figure 5: CargoRoo (Source: INHOTRA Report WP2 Annex, 2002)

6.3.6 Horizontal Transhipment Unit (HTU)

The technology group of horizontal transhipment unit includes CarConTrain (CCT) Plus, TRAI 2000, Container-Lift (Kugel), , System Ringer, Container-FTS, Hochstein System, RTS (Rolling Trans System), NETHS (Neuweiler Tuchschmid Horizontal System), Roll'hydro, and Umschlaggerät Lässig-Schwanhäuser (ULS), of which RTS is discussed briefly below.

Rolling Trans System (RTS)

The RTS from Bosch Rexroth was developed to create the future possibility of moving and loading large objects (containers), improving the competitiveness of transportation considerably, with up-to-date, quick and cheaper solutions. The RTS system consists of the following two main elements:

The RTS-500 loader is loading the containers in every direction between the railway wagon, the truck and the shifting field described below;

The shifting field (RTS-600) is a buffer field for the transient storage and automatic shifting of unloaded containers in order that the containers were available in the sequence of loading up at the time of arrival of the railway wagon (or truck), i. e. during the loading bringing out the container takes not more than seconds of extra time.

The RTS 700 lifting machine, which is a fixed modified variant of the RTS 500 reloader. The design includes two lifting frames so that it is possible to superimpose 40ft containers and to lift 20ft containers simultaneously, decreasing the lifting time by half.

The general technical description of the RTS 501 horizontal container reloader, which is the developed variant of the RTS 500 prototype, is given below.

- Important technical data:
- Maximal power absorption: (2x30 kW)
- Maximal height: H = 4500 mm
- Height of loading: 760 to 1400 mm
- Empty weight: (2 x 25 tonnes)
- Maximal loadable mass: 34 tonnes
- Maximal axle load: 30 tonnes
- Maximal load on the supporting rail: 45 tonnes per 0,5 m
- Rolling rail gauge: 1435 mm
- Supporting rail gauge: 5430 mm
- Maximal container length: 40 feet
- Minimal container length: 10 feet
- Maximal velocity of the base carriage: 80 m/min
- Permitted ambient temperature in operation: -25°C to +40° C

Operating the equipment

Various reloading modes can be realised in manual, semi-automatic and also automatic modes of operation. Depending on their types containers can be moved by the equipment in three different modes of grip:

- side grip (with lower and upper lifting arms projecting from the lifting frame);
- lower grip (with the lower arm of the lifting frame and the arms of the lifting beam protruding at the ends of the container);
- fork grip (with lifting beams slid under the container).

Electrical control basically includes the automatic control of 16 synchronised rnovable axles and other auxiliary machine parts enabling the operating personnel to interfere in the course of reloading and the same time supposing the maximal feeling of responsibility, similar to conventional lifting equipment.

The education and training of the machine operators and the practical employment of this knowledge are secured.

The machine and its control meet the safety prescriptions commonly used in Europe. Possible local special requirements should be agreed when ordering.

Power supply can be realised with conducting chain, cable drum or contact rail, from 0,4 kV, 50 Hz, three phase network.

Installation

For installing the equipment a normal gauge, standard load railway track is needed that should be completed on both sides with supporting rails suitable to take a 40 tonne load occurring on the 500 mm support. The supporting rails should be prepared with a gauge of 5,600 mm. The railheads should be on the same level within ±1 cm tolerance.

The power supply can be performed with an energy supply chain, cable drum or contact rail from 0,4 kV, 50 Hz, three phase network.

IPSI Terminal

The Improved Port/Ship Interface (IPSI) study project aimed to strengthen the waterborne transport, specially short sea shipping (Ottjes and Veeke, 1999). Terminal is at the centre of an efficient intermodal logistics chain. The project conducted a simulation study to prove that IPSI terminal concept works under realistic conditions. It allows horizontal loading and unloading and offers fast throughout and short in-port time.

6.3.7 Network Terminals

Mondiso, COMPACTTERMINAL, Low flow – Fast Transhipment Terminal (LOFT), Austrian Innovative Transhipment & Terminal (A-IUT), Trans Cargo Express (TCE), of which Compactterminal is discussed in details in the next section.

7 Future Terminal: Compactterminal

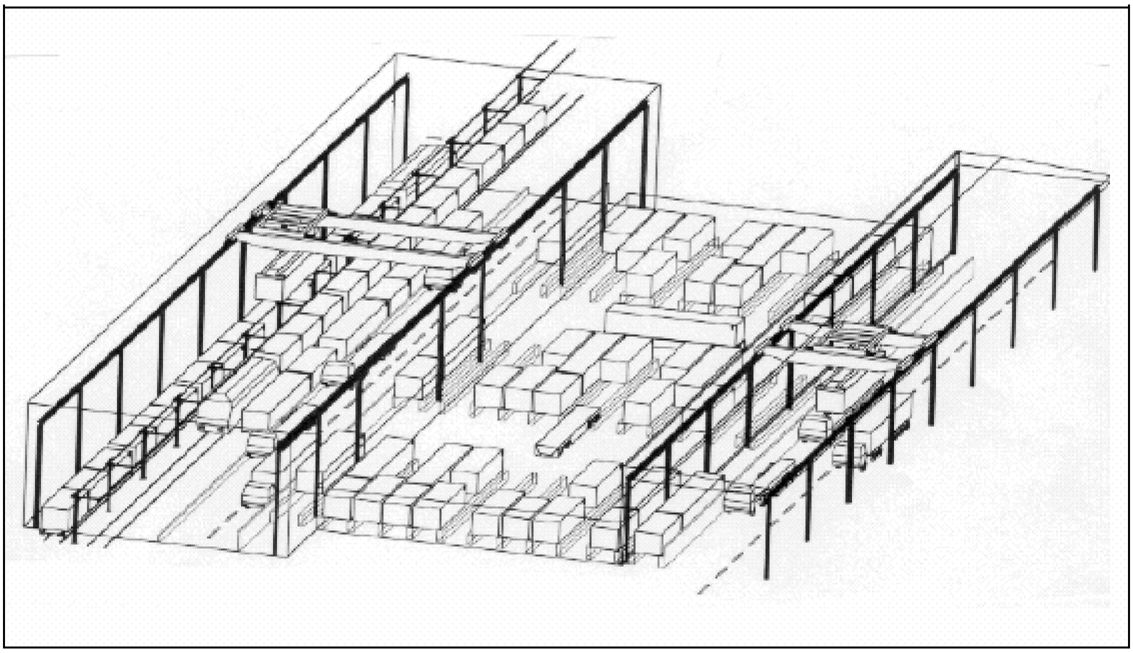
The SAIL Study reported that the Swiss company 'Tuchschmid' developed a modern terminal named Compactterminal (see figure 6) that makes intermodal integration practical, at costs which reflect the realities of new, competitive markets. Road-rail and rail-rail transfer become part of an optimised, competitive intermodal service to freight transport stakeholders. It is proposed as an ideal answer to the demands for higher terminal efficiency, identified by users and also recognised by the European Commission as an urgent priority for future competitiveness.

Compactterminal is suitable for various kinds of road and rail terminal operations. On the rail-side shuttle trains, direct block trains and intermodal loads on mixed freight trains can be served. Costs per unit lift remain low. The terminal is built up of simple modular elements that permit a wide flexibility in concepts and modifications at a later date. The Compactterminal achieves the objectives of competitive intermodal service with:

- Modular construction;
- Cost reduction in transhipment operations;
- Minimal container handling during process;
- High level of automation;
- Optimal use of space;
- Direct rail-rail/rail-road transfer;
- Integrated rail wagon/load unit identification system;
- Damage elimination with vertical transfer in place of rail shunting;
- High availability by use of proved and tested components;

- Weatherproof operation at all hours with reduced noise levels.

Figure 6: The Compactterminal (Source: INHOTRA Report WP2 Annex, 2002)



7.1 Construction of Compactterminal

The objective of Compactterminal development can be described as 'lean logistics'. It involves simple processes, minimal container handling with short transfer moves, no modifications to rail wagons or loading units. Improved individual components and low operating costs are the most important conditions imposed on design. The production and operational systems of the user determine the productivity requirement set to the Compactterminal. A break-through in costs and efficiency for intermodal handling:

The modular concept of Tuchschmid Compactterminal means that economical and high-performance intermodal handling can be realised in all situations, in all size ranges, from minimal installations for small throughputs to high performance freight distribution centres, depending on need and situation;

The lowest transhipment costs for individual transhipment operations, with higher cycle speed and better performance;

Using proved components and a limited number of moving mechanical parts ensures high reliability and availability;

Rail track productivity in the terminal is substantially higher than with other layouts;

Permits integration of new information technology applications for EDI, terminal management systems, accountancy and management data;

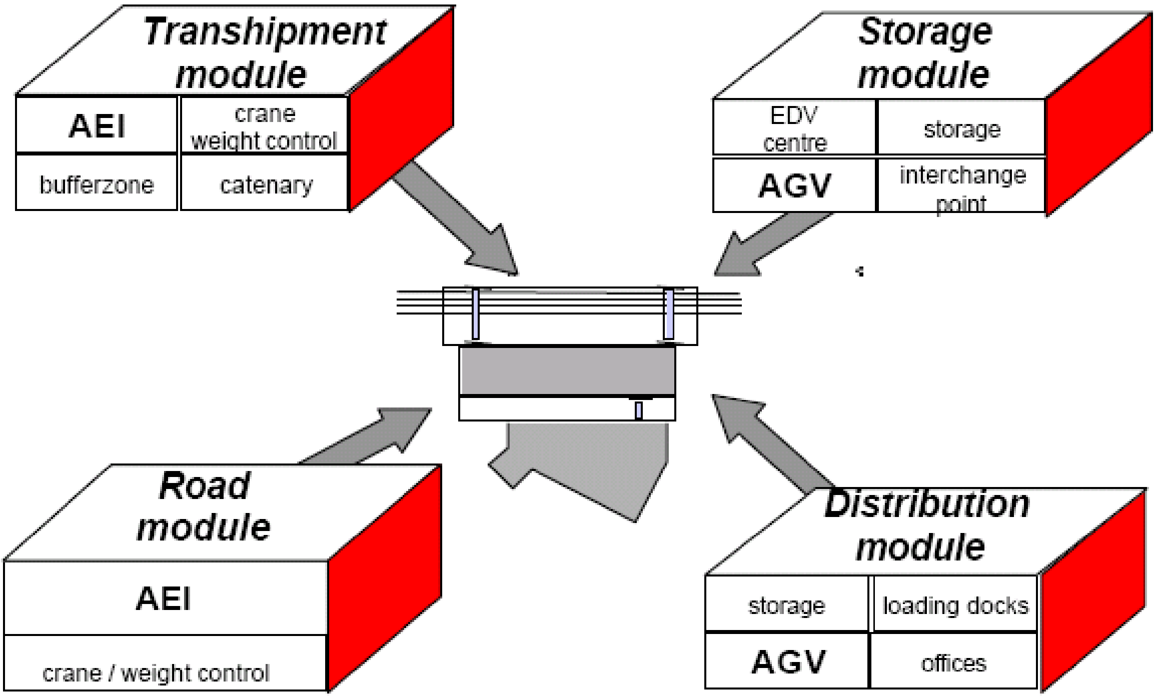
Highly flexible in handling peak demand situations by road and rail;

Cost effective container handling during low demand periods

7.2 Components of Compactterminal

The modular construction (see figure 7) of the Compactterminal makes it possible to build exactly to the user's needs. Size, logistic systems, volumes etc. can be reflected flexibly and economically. The terminal has the following modules/components: transhipment module; intermediate storage module; road module; and distribution module.

Figure 7: Modular Concept of the Compactterminal (Source: INHOTRA Report WP2 Annex, 2002)



7.2.1 Transhipment module

This is the basic module that integrates, depending on installation size, up to 3 loading and unloading tracks. Direct transfer between trains is therefore possible in such cases. The semi-automatic loading crane incorporates a spreader for containers, swap-bodies and trailers. It is fully compatible with contemporary practice and requires no adaptations to the load units. Two buffer zones extend along the rail tracks to provide short term holding of loading units. The road unloading/loading line is directly alongside the rail track that permits a just-in-time quick and easy transfer.

7.2.2 Intermediate storage module

In this module the loading units can be held between road and rail moves. In the transhipment shed loading units are taken by automatic guided vehicle (AGV) to the storage. Storage is usually on one level, but at customers' request multi-level storage can be installed.

7.2.3 Road Module

This module is installed to interface to the storage module. A crane is installed similar to that used in the transhipment module on the rail-side. Size and specification can be adapted to suit requirements. Automatic guided vehicles (AGV) move loading units automatically to the storage module or direct to the transhipment module.

7.2.4 Distribution Module

Within this module, adjoining the road module, loads can be re-sorted and loading units made up or deconsolidated for storage, distribution and logistics services. The Tuchschmid Compactterminal embraces, therefore, the concept of a classical Freight Distribution Centre or Container Freight Station (CFS).

7.3 Flexibility

The Compactterminal permits, with its modular concept, a highly flexible operation to accommodate the unco-ordinated peak demands of the different modes. Individual modules can be used to meet any local situation, or can be combined to form various types of terminal.

7.4 Operation of Compactterminal

The terminal offers flexibility as a priority. The terminal permits, with its modular concepts, a highly flexible operation to accommodate the uncoordinated peak demands of the different modes.

7.4.1 Normal operations:

Transhipment module: Mixed operation, rail-road/just-in-time road delivery and collection/ rail-storage module;

Road module: Road operation only, to or from storage area (to or from rail transport);

7.4.2 Peak load, rail:

Transhipment module: Rail-rail/ rail-storage; module closed for road

Road module: Road operation only, for all road collections and deliveries

7.4.3 Peak load, road:

Transhipment module: Mixed operation, rail-road/ storage area

Road module: Road operation only, rail transfers only via storage module

7.4.4 Low demand periods:

Transhipment module: Mixed operation, rail-rail/road-rail Road module: closed down

7.5 Advantages and Disadvantages of Compactterminal

7.5.1 Advantages:

- The short-term storage;

- Can be doubled up beside the train tracks;
- 24 hour operation;
- Terminal can be closed-in creating a proper working environment;
- Lighting, protection from the elements;
- The maximum throughput and daily capacity is extremely flexible with the transhipment road-rail;
- Spatial use;
- Flexibility of throughput at peak times because of its compactness and short term storage capabilities;
- Short loading times between different modes;
- The modular system allows for expansion when demands increase.

7.5.2 Disadvantages

The long term storage due to lack of space,

Building infrastructure, and

Very high capital cost compared with orthodox alternatives.

Unproven in full scale service or demonstration mode

8 Terminals on the RETRACK Corridor

8.1 The Netherlands

8.1.1 ECT Terminal

Currently a number of container trains moving from the port terminal on a point to point basis, not on a multi-stop service basis. This point to point operation focuses on a number of needs:

- speed to match road based competition into Germany and other neighbouring countries;
- rapid clearance from the port for imports;
- maximise the use of wagon and traction assets.
-

The key requirement is seen as schedule reliability. The use of a “turntable option” with the movement of cargo from shuttles onto a longer haul formation was discussed as a possibility with the Retrack service (possibly originating in the Ruhr area). This would avoid the complication of moving the Retrack train into an already densely occupied railway territory.

The ECT terminal is at the extreme end of the Dutch railway system served with new infrastructure and electrified lines. It is remote from the RCS terminal so traffic to/from each location would need to be considered and managed if a merged train option was to be offered. The planning of train movements, schedules, locomotive holding areas and the option to split and merge wagon formations to RSC & ECT will need to be planned.

The Retrack train could be of interest to key shippers and forwarders. Finding the potential users amongst the major deep sea lines, global forwarders or the actual shippers and cargo interests is likely to be a major task given the diversity of control over cargo movement, freight payment conventions and terms of trade used.

Within ECT rail handling is charged to the shipper or the party paying the freight charges. The importance of the pre-release document routine was further emphasised to synchronise with train movements. Accurate and updated ETA information was identified as the key competitive component. There are various options to accommodate changes in booking and container availability in response to operational circumstances. The use of open list type services is constrained by the customs cut-off time. The option of running cargo away from the port and for boxes to be cleared inland was reviewed as a potential option to accelerate the movement of boxes through the port. The whole issue of customs release, train scheduling and other constraints on the development of a routine/regular service in and out of ECT needs to be defined in more detail as the project develops.

ECT operate with a 6-weekly rolling forecast governing train schedules for main train moves, shunting, loco holding areas etc. As part of the start up process RETRACK will need to be engaged with the terminal and port authorities to ensure the preferred options can be serviced. The terminal operates 24/7 on Mondays through to Saturday 23.00 but with closure for port rail maintenance on Sundays until Monday 07.00. This pattern of working may change in response to increasing levels of traffic through the terminal and port in total.

Container flat wagons are available on a 9-month lead time so the position on wagon supply for any demonstration in 2008 will need to be managed by the end of 2007.

The terminal is highly automated and uses a mix of cranes, automated stacking cranes (90) and automated guided vehicles (185) to sustain the high level of terminal productivity. The automated stacking cranes (ASC) operate in a portal solution and as an overhead bridge crane. The ASC spans nine containers in a 1 over 5 solutions and allows economical high density stacking arranged for rapid access and retrieval. It forms a link between the quayside and landside equipment such as ship to shore cranes , terminals transport and road vehicles.

The AGV is an unmanned remote controlled transporter capable of moving 20’, 40’ and 45’ containers and are used to move containers from the quayside to the stacklyards. 2 x 20’ containers with a total gross weight are permissible with the AGV. The ECT Delta terminal has chosen to adopt an integrated terminal management and process control system to unite its gate, vessel, rail, yard and berth operations at six facilities inside the overall terminal complex. The system is designed to optimise the use of terminal handling equipment, lower costs and raise productivity.

8.1.2 Rail Service Centre (RSC) Rotterdam

The option of a train serving the Rotterdam-Constanza corridor was welcomed as a useful potential addition to the existing array of train services to/from the terminal. Any new service would be required to use the Betuwe Line (BL).

RSC was developed as a response to falling rail share in inter-modal traffic activity through Rotterdam, extensive and expensive shunting, poor reliability, slow services and low equipment utilization. These collection and delivery operations were replaced by road transport with rail being used for the long haul movement. There was formerly only one traction service provider. There are now at least eight traction providers and independent rail has a high share (80%) of the inter-modal traffic through the port. The intention behind RSC was to stem the decline of rail's participation in freight traffic by massively improving quality, capacity, capability and competitive costs. The RSC at Rotterdam lies just to the West of Kijfhoek marshalling yard. The RSC is integrated into the Eastern docks complex where containers from barges and smaller ships are landed. The container trains are owned and operated by many rail companies call at the terminal in transit to or from the Maasvlakte Delta terminal.

RSC (like ECT) use shuttle train formations operating on a point to point basis, fixed schedules and at higher transit speeds (120kph) with options to swap cargo and/or wagon blocks. On time performance and any variance is monitored and analysed for intervention and improvement. EDI & IT initiatives have been developed to facilitate operational asset management and tight control of the crane and front end loader assets in the terminal. Systems such as PortInfo link are used to monitor vehicle arrivals and to integrate terminal movements for the movement of containers in and out. There are presently 12 primary rail customers using the terminal and these are linked for the exchange of information (>90%) covering the container I/D number, cargo details including weight, any hazardous commodity details. For rail movements to the terminal from inland the operator advises the terminal of the train consist, wagon numbers, container numbers and other relevant details again to facilitate the efficient movement and handling operations within the terminal.

All train services in/out of the terminal are diesel hauled with traction currently provided by Railion. The terminal is operational for 6 days per week. The restriction of train services for line maintenance on Saturdays & Sundays needs to be recognised as a constraint for the development of the train master schedule.

The terminal is relatively small but is highly productive with the whole operation based on a minimum of planned movement. Office and site staff exchange roles and secure familiarization with each groups tasks and concerns leading to ongoing operational enhancements. Activity levels have increased from 250K movements in 1994 to a forecast level of >1.0 million in 2008/9. The terminal has two parallel cargo handling modules, hazardous cargo areas and holding bunds. Hazardous cargo makes up 20% of the current cargo volume on the terminal. The terminal can handle container traffic, swap bodies and trailers which offers flexibility for marketing the Retrack service option. The terminal uses 4 gantry cranes, 6 reach stackers, 5 terminal trekkers and a variety of multi-chassis trailers for internal container transfers.

Generic changes that are also having a compound impact in the market include the increase in the number of new traction and train service providers, the use of company owned block trains, the introduction of very large ships and increasing participation by deep sea lines in the shore side transport and logistics. Slow levels of market liberalization of rail in France and Belgium have been something of a constraint on further rail service development despite pressure to adopt market liberalization.

8.1.3 Conclusions for The Netherlands

- Both terminals could be a useful point for traffic aggregation and dispersal in Rotterdam's port area;
- They will provide access to deep sea container traffic seeking access to central and Eastern Europe. The likelihood of through container traffic being moved needs further commercial exploration but may be an option for lines which have maritime services into Rotterdam and Constanza;
- Their ability to handle ISO containers, swap bodies and trailers is potentially advantageous;
- Currently there is capacity to accommodate additional train services to/from the terminal, although there are concerns that forecast future levels of traffic activity could become a constraint. The forecast traffic will require additional rail infrastructure and shunting services.
- There are existing train shuttles operating to/from the terminal which could act as a feeder to the Retrack train if it is to be operated from the Ruhr area.

8.2 Germany

8.2.1 TriCon Container Terminal, Nuremburg

The terminal is one of several owned and operated within the area of Nuremburg. The terminal is already used as a hub for services to/from Hamburg and also to Regensburg. Current train activity is six trains per day in and out. The terminal operates 5.5 days per week Monday through to Saturday noon but could go to 24/7 operation if required.

The terminal is a modern development and will be expanded in 2008/9 to accommodate already identified growth. The existing terminal has two portal cranes of 40 tonnes capacity with an 83 m span. These are the primary cargo handling equipment on the terminal. There are three loading tracks of 700m length plus two storage tracks also of 700m. The terminal is to be expanded as traffic moves from an existing terminal in Nuremburg to the new location. Retrack would be an incremental addition to the forecast levels of traffic and train activity. Access options will be improved by the electrification of the lines into the terminal perimeter as the terminal expansion plan proceeds. This could make the Nuremburg terminal a more attractive option.

The ability to re-group cargo on the train was explored as an option in addition to the actual load and discharge of cargo originating or terminating in Nuremburg. This could be a useful reinforcement point for Retrack and make best use of rapid load on/load off options between Rotterdam and Nuremburg.

There is a cargo/LCL facility on site that could be useful for stripping and stuffing of containers originating or terminating locally. The tri-modal terminal area is not heavily used and there may be potential to exploit the available space for storage if needed. There is an adequate hazardous cargo area within the site with bunds to prevent leakage. Container repair facilities are also available on a mobile/rapid response basis within the terminal area. The whole site is secure and has no problems with noise and access issues. Customs facilities are also on site which may be an advantage for clearance issues being removed from the port areas where this may become an issue and constraint o service times.

8.2.2 Conclusions for Germany

- This is a modern facility with expansion plans already in place and scheduled to proceed in 2008/9 which could tie in usefully with the demonstration phase and subsequent moves into commercial service.
- The access position will be markedly improved with the expansion of the terminal and allow main line power close into the actual crane areas.
- The array of facilities on site is impressive and would fit all the commercial and operational requirements if this terminal is selected as a node on the corridor.

8.3 Austria

8.3.1 Terminal Wien Northwest

This terminal is a hybrid site served through a single point of entry from the main electrified running lines and requires a separate shunting operation with any lengthy wagon formation being split into the yard/pad area. Maximum train length is approximately 300 metres. There are three operating rail tracks under the two portal gantry cranes and four road alleys. Reach-stackers are used for container, swap body and trailer movements. Turning space is severely limited. Extensive container storage activities are available on site and facilities for running repairs also available. Customs clearance facilities are available on site. The terminal has the capability to load/of load swap bodies and tri-axle trailers for those traffic flows that require this type of equipment. Reefer points are available but there is limited capability for hazardous cargo and response to any leakages occurring on site. High cube traffic is handled through the terminal

The terminal also acts as a major logistics terminal for loading and stripping containers. Road access is very constrained and the whole road transport access to and from the pad area remained very congested during the whole of the inspection period with little by way of evident sequencing, control and planning of access and security. There is little room for manoeuvring and positioning on/off the pad area and this is a cause for concern about the efficient functioning of the terminal. In effect this is an older city site highly constrained by external development and other limitations. The terminal is constrained in terms of hours of operation (Mon-Friday 06.00-19.20, Saturday 06.00-11.00) and any ability to expand realistically to absorb additional traffic on a reliable basis. There are existing long distance trains operations through the terminal into Germany, North Sea ports and to Budapest.

Loading additional two trains per week is probably feasible, two additional trains per day may be more problematic in terms of sustained reliability and productivity. It may be possible to begin Retrack operations using the existing terminal as a trial but as a long term option the obvious physical and organizational limitations are a real constraint to competitiveness. There are recognised problems of interface links between train operations and terminal operations. Trains routinely lose paths and schedules in and out. The impact of disruption and the ability to accommodate off-schedule trains could be a significant mark against the use of this terminal to serve the Austrian market

The long-term future of this site is uncertain as closure has been predicted for some years. There is limited scope for upgrading and enhancement given the confined site and the likely impact of the new tri-modal terminal (Wiener Hafen) which will remove significant heavy traffic volumes from an inner city zone.

8.3.2 New Tri-modal terminal – Wien-Freudenau.

This is a modern terminal, owned by the Port of Vienna with two other minority shareholders, which is being expanded to accommodate future growth in international container traffic. The existing terminal is heavily used and evidently busy and is focused entirely on deep-sea traffic (ISO containers) activity. But it is unlikely that continental non-ISO traffic (e.g. swap body) can be accommodated. A significant upgrading of terminal space and access arrangements is underway targeting operation in 2008/9. This will include direct electrically hauled trains to and from the rail terminal area with no intermediate shunting.

The terminal already handles block train operations to German, Dutch and Italian ports with intermediate loading/discharge of traffic linked to the Vienna conurbation including traffic to/from Budapest. The option to load to/from river traffic exists but appears less heavily used than predicted. Most of the existing terminal traffic is road/rail and serviced using a fleet of reach stackers. Annual traffic activity is 300,000 teus. Approximately 15% of this is transhipment activity between the existing network of rail services. Other activity on the site includes local haulage, customs services, container stuffing and stripping, container repair, storage, cleaning and plug in facilities for reefer traffic. The present expansion programme will lift terminal throughput to 400,000 teu per year with up to seven trains being serviced simultaneously in the combined new and existing terminal areas. A gantry crane will be installed on the existing terminal to reinforce and substitute for reach stacker operations. Reachstackers are the primary transfer technology used on the existing terminal. The new pad area will incorporate four new cranes, improvements in terms of road access and circulation area and improved links to the national motorway net. The enhanced rail access will incorporate increases in rail axle loads to 22.5 tonnes and increased speeds to/from the site using electric traction.

A key improvement is the introduction of a terminal planning and communications system for the manipulation of equipment inside the terminal and the expediting of documentation interchange between all parties using the site. This could be a significant and useful benefit to Retrack if such a measure allows the trains to be serviced more rapidly. Customs clearance is available on site in addition to container stuffing and stripping services. The absence of hazardous cargo handling capabilities is a serious limitation.

The existing terminal is served by a mix of OBB/RCA and private rail operators for shunting and main line operations. Current operating hours are Monday to Thursday 06.00-19.00, Friday 06.00-16.00 with the option for requested service at the weekend. The site is less constrained than the Wien Nord-West terminal in terms of noise and traffic activity and is firmly located inside the port area. The three existing train lines are all over 650 m long and thus could be accommodated without a train being split.

8.3.3 Conclusion for Austrian Terminal

For inter-modal traffic to/from Vienna the Freudenau terminal appears to be a preferred option when compared to the alternative Northwest option. Its capacity is already at a premium in the terminal and the new capacity being developed is also likely to be used up by other rail services. The development of capacity beyond the current programme is already being considered.

The use of this terminal will require rapid action by RETRACK consortium operator to fix schedules and terminal times and to declare this requirement within the next 8-10 months. The benefit of direct rail access to and from the site plus the road links will be an advantage.

8.4 Hungary

8.4.1 Bilk Container Terminal.

This is the most modern inter-modal and logistics facility in Budapest. It acts as a central point within Hungary for international services for inter-modal block train services and has extensive logistics facilities (Hungaro-Camion) adjacent to the terminal area. Water links are a further option not far removed from the site. Bilk is linked to other terminals functionally in terms of transport links and commercial/managerial activities.

The site currently has only one rail lead but is electrified up to the terminal boundary. Trains are normally shunted in/out by the terminal switch engine. A second lead into the terminal is planned as part of the next phase of expansion which will make access and manoeuvring across and to running lines less complex. There are holding positions for the main line locomotives.

The terminal was developed as public private partnership (PPP) with a mix of private and state investment, where 60% of the investment has come from MAV Cargo, 4% from the Hungarian State Railway Authority, 12% from MAV Combi and the balance from private investors. The high proportion owned by MAV may be an issue on privatisation. The public investment included the rail links in/out and the electrification and signalling links.

The combined site has customs facilities, warehousing, truck parking and a major logistics centre. Reefer points and hazardous cargo sumps for any leaking boxes or tanks are also available. Container repair and storage facilities are also available. Access to the national road network is good as is access to the city road network.

The terminal is currently handling 130,000 (85,000 in 2005) teu per annum of which 95% are deep sea services in and out from a range of ports. The terminal also handles RoLa services at a current activity rate of 20, 000 trucks per annum. Two specialised tracks with ramps are available for this type of special cargo. The terminal is also able to handle swap-bodies.

Rail services currently operate to Rotterdam, Bremerhaven, Hamburg, Munich, Wells, Emms, Prague, Vienna, Trieste and Bologna. Train services are planned (excluding Retrack) to Constanza and to Kiev. There is an existing service from Rotterdam to Budapest which may be seen as a potential competitor if this was to be linked to any other new service connection to Constanza ahead of Retrack. The possibility of piggybacking on this might be investigated as a means of spreading investment and operational risk until market potential can justify a separate Retrack product or service.

The terminal is well placed strategically to serve traffic to many parts of Europe and act as an interchange between services and corridors. The Black sea ports are known to be interested in the development of regional feeder services and the ability to switch cargo amongst corridor operations. It may be possible for Retrack to exploit these links, traffic demands and developing corridor connections as part of the wider marketing strategy. Much will depend on the train formation to be operated, call patterns and type of services (inter-modal/conventional) offered.

The main terminal has 4X 750m rail lines under two gantry cranes supported by two reach stackers. The whole terminal is paved, well lit and in excellent condition. The terminal can be made available for 24/7 working as required and responses to disruption and delay as required. Additional investment is being made and will include three additional 750m tracks, additional container storage (950 teu) and the procurement of a shunting locomotive. Current train activity is 7-10 trains per day but is likely to increase to 20 when the new investment phase is commissioned.

8.4.2 Conclusion for Hungarian Terminal

This looks like the only realistic prospect to service the Hungarian market and others using the existing array of corridor services. The terminal is modern, well equipped and competent. Capacity is being expanded to accommodate identified growth and Retrack could usefully sit inside this. As service levels grow there may be additional pressure on the site and further expansion may be constrained.

In terms of rail access the existing single lead in/out will be reinforced by an additional link providing bi-directional access. The main line locomotive will be able to coast into the site or the train could be shunted by the terminals own switch engines.

The terminal is fully capable of handling ISO containers, swap bodies, trailers and RoLa traffic.

Terminal ownership might become an issue if the current owner is bought out by a strong regional competitor.

8.5 Romania

The Constanza port currently has 3x 600m rail tracks under the main terminal cranes. Four additional tracks are planned to be in operation within two years (2009). The largest ships calling at the port are 7000 TEU.

The port terminal is equipped with reefer plugs and has a hazardous cargo leakage pit zone. Retrack will need to secure quality train paths to/from the port plus the associated shunting capability by early 2008. Reefer and tanker traffic could be significant components of both import and export traffic.

The port terminals operate on 24/7 basis.

8.5.1 UMEX

UMEX is the smaller terminal area in the Constanza port complex and has access to container traffic, general cargo and the shipment of trucks and cars and the movement of locally produced goods. The terminal is subdivided by activity type. Most container traffic is regional within the Black Sea and Mediterranean area. The traffic activity is around 80,000 teu per year. Some deep sea operators use the terminal in preference to the larger newer terminal so this terminal could still act as a source of traffic activity for Retrack. The key liner operators include K-Line, CMA-CGM, Yang Ming & Hapag Lloyd.

The terminal does not have direct contact with the train operators but is aware of the current constraints caused by the infrastructure enhancements in the port and approach lines. The condition of the rail infrastructure on this terminal was adequate but would need attention if routine high levels of traffic were to be operated. Siding length is 200m. The main lifting equipment is a small fleet of front end loaders and reach stackers. Reefer points are available and a hazardous cargo zone has been designated.

The terminal configuration is congested and there was evidence of truck congestion at the gates of this terminal.

Train length maximum is 600m with a maximum single locomotive load of 1500 gross trailing tonnes. This can be boosted to 2600 tonnes with the use of a second locomotive but may be compromised if train sequencing is disrupted or passing loops are not available. Splitting and then re-forming the train may be an option but would compromise transit time. The line section North of Ploiesti is heavily graded and transit times will need to reflect this. An overall transit time between Constanza and the Hungarian border of 36 to 40 hours was proposed as being feasible. The option to service Bucharest as a shuttle is a possible service option.

Concerns over border crossing routines were expressed and there was interest in simplifying procedures (technical/operational) but these are governed by treaties and protocols that need to be unpicked to reflect new strategic circumstances. The department for the Interior is responsible for this.

Transit inspections (take 20-30 minutes) are made at 300km intervals, although rationale for this is not clear.

8.5.2 Conclusion for Romanian Terminal

The DPA terminal in Constanza is a world class facility and is a major potential target market for ISO import container traffic from the Far East and South Asia moving into South Central Europe. It is an obvious source of valuable inter-modal traffic on the Retrack corridor. Equally export traffic from South Central Europe could be directed through the terminal to balance traffic and equipment flows. Most of the traffic through the DPA terminal is deep sea traffic moved by individual lines and consortia who also have services into North west Europe through Rotterdam and other North Sea ports. Lines may elect to use the Retrack corridor as a conduit to direct cargo (imports and exports/ loads and empty equipment) in response to fluctuating cargo load factors and directional balance.

The older part of the port (UMEX) is used by a mix of deep sea and services operating into the Black Sea and Mediterranean. The latter are wholly different markets but Retrack could potentially service them. The terminal equipment in the UMEX port terminal area is less sophisticated than the DPA terminal and will require some upgrading in terms of configuration, mobile plant and IT systems.

The key to serving both of these terminals adequately is to secure much improved access for import and export traffic. The market share held by rail has declined as road transport has developed (new roads being built) and the inadequacies of the present lines into the port areas exposed. There is at present inadequate capacity to handle the traffic by the terminal, shipping lines and forwarders are pressing for.

9 Summary and Conclusion

Terminals play a vitally important role for the operation of an efficient, cost effective and integrated transport chain. The competitive door-to-door intermodal transport service cannot be achieved without efficient and effective terminals. The Terminal efficiency largely depends on the technology and management information system used in the terminal.

Assisting systems, including communication and positioning systems, play a vital role in the organization and optimization of cargo flow at terminals.

Container terminal operators require a very intense communication system, for example for the change of a container location, with external parties including shipping lines, agents, forwarders, truck and rail companies, governmental authorities such as customs, waterway police. Electronic communication may be performed on international standards such as EDIFACT. Internal communication systems, for example through radio, also play important role to communicate job data from computer to cranes and transport vehicles.

There is no standard in terminal operation and technology. There are substantial differences among the terminals reflecting activity rates, the range of roles and services offered, terminal topography and successive expansion phases. For example a terminal with traffic of 150,000 ITUs differs significantly from a small terminal with traffic of 50,000 ITUs or less. The SAIL study (2002) found that some small terminals are more efficient in terms of employee versus ITU ratio. Some terminals have different processes for example, for regional haulage or long duration storage. Some container terminals may share their management between more than one operator.

There is no standard layout of a terminal although most share the same generic characteristics.. Depending on the size, throughput and degree of automation these functions (operation, transhipment and truck) are integrated and spread all over the terminals.

Terminal operating systems have many different modules including gate and truck monitoring, yard planning, ship or barge stowage planning, rail planning, container packing information, customs access, EDI, equipment monitoring and performance reporting. These systems continuously optimise and update yard space, minimise equipment utilisation, real-time monitoring of container handling etc.

Freight forwarders are usually responsible for the road transport from the consignor to the originating terminal but in some instances the manufacturer or shipper will assume responsibility for this activity. In the terminal the cargo unit is delivered into the charge of the intermodal (i.e. rail) operator, who organises the transport between the originating terminal to the destination terminal. The intermodal operator collaborates with the terminal operator and the railway undertakings, which are contracting train paths from the infrastructure managers. There may be scenarios where the train operator will also provide the pre or end haulage. The terminal operator is responsible for the handling of loading units in the terminal and is also in a contractual relationship with the railway undertakings which are taking over the load in the terminal for the rail shipment. The contractual, managerial and liability relationships amongst the various players can be complex, dynamic and at times contradictory. The desired departure and arrival time for the rail service are the major parameters for the allocation of the train path which is assigned to the Infrastructure Manager.

More security measures are now demanded by different authorities and this is an increasing burden to an intermodal transport system. However, the issue of higher safety and security can be turned to a competitive advantage, for example, for transport of dangerous goods (details discussed in WP2.2).

The literature review found terminals of two types: conventional and more modern depending on their infrastructure, operation, facilities and status in terms of integration into the supply chain. Terminals may perform as an individual enterprise or part of a network under various ownership models and the train schedule is prepared independently. The operation is integrated with the train schedule. This is laid out in such a way that the system can be optimised to take advantage of the shuttle and other services available in the market. Ultimately the price and service time are important determining factors in terminal as well as operational competence. A conventional terminal is good for long term storage and large capacity but commonly it has high operating and personnel costs.

The important issues for a future terminal are:

- appropriate terminal operational functions;
- route; hub; gateway;
- optimal mix of capacity for the peaks;
- operation in the marginal periods;
- scope for later enlargement;
- degree of automation;
- network integration; road and rail and water;
- location (regional site or central location).

For ISO-containers and swap bodies the vertical lift is for detaching them from the vehicle and positioning to ground or to stack storage.. Transhipment can be made by manipulation through transfer equipment on a rail vehicle, road vehicle or an independent device or alternatively by self-propelling. Transhipment can be made between the carrying vehicle of one mode and the vehicle of another mode (direct transfer), or to tranship the ITU to an interim buffer place from which it is transferred to the vehicle of the connecting mode (indirect transfer).

Horizontal transhipment is the movement between transport vehicles, buffers and storages with minimal vertical lift (normally to disengage from twistlocks) The possibility to tranship under the overhead contact line (catenary) is a main feature of many horizontal transhipment technologies, which is also limits the heights of the vertical lift. Horizontal transhipment uses a different approach to that used in a conventional terminal.

The Compactterminal, innovated by Tuchschmid, falls into the group of Network terminals. It aims to make intermodal transport practical, at a cost which reflects the realities of new and competitive markets. Through this system rail-road and rail-rail transfer of containers become optimised. It is claimed as an ideal answer to the demands for higher terminal efficiency, identified by users and also recognised by the European Commission as an urgent priority for future competitiveness..

The Compactterminal is not suitable for those containers/cargoes that need long term storage facility.

For RETRACK the overwhelming majority of terminals use very orthodox terminal technologies for the movement of containers between modes. Gantry cranes operating in multiple are evident in terminals in The Netherlands and in larger German terminals. Expansion activity in the main terminal in Vienna will imply more cranes are deployed to replace the use of reachstackers and also to allow easier movement of trains directly on and off the terminal area. A similar position applies to the main new terminal in Budapest. The use of cranes for lifting containers between modes is the dominant technique although others equally use reachstackers to support loading and off loading. There was no evidence of the use of horizontal transfer technology which at present is not sufficiently well developed, robust or cost effective when compared to the conventional alternatives.

The development of terminals with easier direct rail access by the main line haul traction is notable as this mitigates the need for excessive shunting. The need to avoid catenary under the cranes is resolved by the use of terminal shunting or switching locomotives. Holding the mainline locomotives close to the terminal is a key issue to ensure rapid movement to/from the inter-modal transfer point without incurring unnecessary delays.

Terminals have developed their own individual approaches to container handling, transfer of containers between modes and stack or storage areas. Increasingly a lot of formerly manually based planning and intervention is now being completed by computerised systems for monitoring container position, status, load condition and security as well as time in situ or from last move. Terminal planning and operational planning recognise the three dimensional issues of containers in stacks and allow for fast retrieval and positioning. The functional separation of active containers from those which are in a terminal for storage or between loaded moves is increasingly practised as a means of keeping the activities apart.

Some terminals operate on a tri-modal basis with the option of a mix of road, rail and water movements. In reality the terminals with this capability on the RETRACK line of route do not fully exploit the water-borne capability. For RETRACK the ability to handle ISO, European sized units, swap bodies and road trailers would be of great interest and most of the terminals inspected to date have that capability.

The ability to use different terminal documentation systems under some form of open architecture may need to be considered to avoid the plethora of individualised formats, contents, protocols etc. This will be of particular importance in terms of advising terminals ahead of train arrival of planned activity. Common language formats will need to be considered for the whole route. The use of output from previous projects (IRIS) might be a useful launch point.

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