THE INFLUENCE OF SIZE, LOCATION AND FUNCTIONS OF FREIGHT RAIL TERMINALS ON URBAN FORM AND LAND USE

WJ (Wessel) Pienaar *

* Stellenbosch University, Department of Industrial Engineering, Private Bag X1, Matieland, 7602, South Africa

Abstract

This article outlines how the size, location and scope of activities of freight rail terminals influence urban form and land use. The nature of freight rail stations is outlined, and the classes of trains that make use of these facilities are described. According to size, railway freight stations can be divided into four groups: (1) railway halts; (2) small-sized goods stations; (3) medium-sized goods stations; and (4) large-sized goods stations. The factors that determine the location of stations are discussed. Rail freight stations can be divided functionally into four broad classes: (1) break-bulk rail terminals; (2) bulk rail terminals; (3) roll-on/roll-off rail terminals; and (4) intermodal terminals. The functions of the four rail terminal classes are described. The paper discusses how rail freight terminals can influence urban form and land use. Finally the conclusions of the study are presented.

Keywords: Break-Bulk Rail Terminals, Bulk Rail Terminals, Intermodal Terminals, Land Use, Location Of Stations, Roll-On/Roll-Off Rail Terminals

1. INTRODUCTION

1.1 Research need

The incompatible service and operational characteristics of passenger and freight rail systems result in the spatial separation of rail passenger and rail freight terminals. Although they may share access to the same rail network, they service completely different market segments. Nowadays, after the economic deregulation of freight transport, any proximity between the location of passenger and freight terminals tends to be coincidental. This phenomenon has a profound and costly impact on the land-use patterns in urban conurbations. The aim of this paper is to shed light on this trend.

1.2 Research method

The investigation was performed through a literature search, complemented with detailed field visits to cities in the world where such land-use changes and developments have occurred, and through interviews with representatives of major rail operators. Major rail operations and rail operators in the following cities were visited: Atlanta, Baltimore, Boston, Chicago, New York, San Francisco and Seattle in the USA; Bremen, Hamburg, London and Rotterdam in Europe; Brisbane and Sydney in Australia; Cape Town and Durban in South Africa; and Hong Kong and Singapore in Asia.

1.3 Definition of the concept of a railway station and classification of freight trains[1]

In rail transport, the functions of a terminal are fulfilled by a **railway station,** often also called a train station. 'Terminal' here means a facility where trains can stop so that passengers may board or alight, and/or freight may be loaded or unloaded, rather than referring the end of the railway line itself. RailNetEurope[2] defines a railway station as "a railway establishment which is either open or not to the public, generally staffed and which is designed for one or more of the following operations:

- formation, dispatch, reception and temporary stabling of trains
- stabling and marshalling of rolling stock
- boarding and alighting of passengers
- generally, where open to public, providing facilities for the purchase of tickets
- loading and unloading of goods".

Freight trains can be broadly divided into two classes: unit trains and wagon-load trains.[3] With a **unit train,** all wagons are connected in a fixed set, carry the same commodity and operate between the same origin and the same destination terminal without being split up. They are sorted in a marshalling yard, but may stop in a freight yard, usually in a unit train siding, for inspection, locomotive servicing and/or crew changes. Unit trains are economical only for high-volume customers. Since unit trains carry only one commodity, wagons are of all the same type and are often identical, except for possible variations in livery. When classified by freight or payload type, there are three types of unit trains: (1) bulk-commodity unit trains; (2) standard intermodal container unit trains; and (3) motorcar carrier unit trains (so-called roll-on/roll-off trains).

Non-unit trains may be referred to as **wagon-load trains**, and are formed from single wagon consignments of freight. These trains usually consist of individual wagons loaded with break-bulk freight at separate locations, transferred to marshalling yards where the wagons are formed into trains sorted by destination, then transported to a destination marshalling yard, where individual wagons are separated and assembled into trains per destination.

2. SIZE OF FREIGHT RAIL TERMINALS

According to size, railway freight/goods stations can be divided into four groups: (1) railway halts; (2) small-sized goods stations; (3) medium-sized goods stations; and (4) large-sized goods stations.[4] These are discussed in turn below.

Railway halts are the smallest stations and are usually unstaffed, or have very few staff and few or no facilities. Trains stop only on request when passengers indicate that they wish to board, or passengers on the train inform the crew that they wish to alight; trains will also stop when a single item (or a few items) that can be handled manually has to be loaded or unloaded, e.g. mailbags, parcels and portable containers (the proverbial "milk can").

Small-sized goods stations are usually located on branch lines. Whenever a section of a small passenger station is used for the loading and unloading of goods, this section is usually referred to as the "loading area" or "loading dock", and has its own access and signposting. Often there are no facilities for loading and unloading, and the consignor/consignee has to organise his own handling staff and equipment.

Medium-sized goods stations usually have a marshalling yard and shunting sidings to enable trains to be divided amongst the various local loading and sorting sidings, private sidings and the running line, at the same time performing the function of a small railway hub.

Large-sized goods stations usually include the following yard components connected to them: (1) a reception yard (arrival yard); (2) a transfer and shunting yard; (3) a repair or maintenance yard; (4) a locomotive depot; (5) a marshalling yard and in some cases also a unit train siding; and (6) a departure yard.[5]

- A **reception yard** is a yard where locomotives are detached from the wagons of an arrived train and the wagons are inspected for mechanical problems. Minor repairs, for example the replacing of brake blocks, are performed here, while wagons that may not go further are taken to the repair yard. After the inspection of the wagons has been completed and the protection removed, they must be shunted to the marshalling yard as soon as possible so as not to delay incoming trains.
- A **transfer and shunting yard** is where (a) sets of wagons are dropped off or picked up by a through train, usually situated at a junction station containing two or more loops alongside the running line; and (b) wagons are moved around for whatever reason (only one loop alongside a running line is regarded as merely a passing loop).
- A **repair** or **maintenance yard** is where wagon maintenance and repairs are undertaken.
- A **locomotive depot** is where locomotives are stabled, fuelled and serviced.
- A **marshalling yard** is equipped with multiple tracks with special layout and technical facilities, where splitting up of trains, sorting of wagons for different destinations and formation of complete trains take place. Marshalling yard layout is universally designed according to one of three methods of shunting, which will dictate whether marshalling will be performed in (1) a hump yard; (2) a gravity yard; or (3) a flat yard.
  - A **hump yard** has a constructed hill over which wagons are shoved by shunting locomotives, and then gravity is used to propel the cars to various sorting tracks.
  - A **gravity yard** is built on a natural slope and relies less on locomotives; generally, locomotives will control rolling stock being sorted from uphill of the wagons about to be sorted. They are decoupled and allowed to accelerate into the classification equipment lower down.
  - A **flat yard** is constructed on flat or almost level ground and has no hump. In this type of yard, locomotives are relied on for all wagon-shunting movements from: (a) train arrival tracks; (b) to a trainset breakdown track; (c) to a trainset assembly track; and then (d) to the departure tracks of the yard.
- A **unit train siding** is to be distinguished from a marshalling yard siding as it is available for unit trains when the existing transfer and shunting yard lines are too short or are occupied by other wagons. Unit trains carry complete and fixed trainsets all of the same wagons and payload types between the same origin and destination. Between these two trip ends unit trains are part of through traffic and are not sorted in a marshalling yard, but may stop in a freight yard on a unit train siding for other purposes: inspection, locomotive servicing and/or crew changes.
- **A departure yard** is the yard to which train loads that have already been formed in a marshalling yard are transferred. Here inspection takes place to ensure that loads are properly secured and that no noticeable wagon defects occur.

In the context of this paper, it is medium- and large-sized goods stations that have an impact on land-use patterns.

3. LOCATION OF STATIONS

Before the rise of road transport, economic activities tended to cluster around rail terminals – notably business districts in cities developed around rail stations. However, as the road freight industry flourished and road infrastructure was expanded and improved, the supremacy of rail transport gradually waned and the need for many rail stations diminished, particularly in industrialised countries. Since the economic deregulation of freight transport, the socioeconomic service and common-carrier obligations of freight rail transport operators have given way to contract services, while passenger commuter transport has remained a government-controlled socioeconomic service. Consequently, functional differences affect the location of passenger and freight rail terminals. Passenger rail terminals tend to be located in urban areas where many passengers board and alight, and surrounding land-use patterns are person-friendly, while freight terminals have become increasingly separated from densely populated urban locations.[6]

Unlike passenger stations, rail freight stations do not have to be located within densely populated areas, and because they require a large land area for marshalling yards and freight storage, they are more likely to be located in non-built-up areas. For example, when dealing with bulk commodities, rail freight terminals will locate close to the production source, where they serve as the departure terminal for the bulk raw material to be hauled to markets.

The conventional break-bulk rail freight terminals with their need for multiple sidings to permit the assembling of wagons to form trainsets and the manual loading and unloading of wagons, which often took days and tied up terminal rail capacity, have become almost obsolete. Rail transport can carry large and high-density commodities and bulk consignments over long distances at low cost. Rail transport is well suited, therefore, to carrying raw materials and semi-finished goods, such as mining and agricultural products. The introduction of containers has promoted the conveyance of high-value finished products.

Consequently, a feature of freight rail systems nowadays is the reduction of stations, depots, yards and halts. By concentrating the reception and delivery of freight at fewer but larger stations, rail transport operators can attain economies of distance through longer hauls and economies of density through greater utilisation of rolling stock and intensive use of large terminals.[7]

The number of private sidings has also dropped since the economic deregulation of land freight transport. Private sidings nowadays tend to branch into large yards that often provide access to bulk rail terminals, roll-on/roll-off terminals and intermodal container terminals. In a number of countries, seaport facilities do not belong to the same proprietor as the connected rail service provider, so that rail yards at such seaports may also be regarded as quasi-private sidings. Private sidings can therefore (a) remain a single line on private property where rail wagons are used for loading, unloading and storage of goods; or (b) act as the arrival and departure line for a rail yard on private property as described above, where unit trains may be loaded and unloaded.

In addition, long-distance road haulage is becoming increasingly expensive as a result of escalating road transport operating costs and rising road traffic congestion. Long-distance shippers increasingly realise the advantages of using rail transport to a non-urban location in the vicinity of their markets. At this location, wagon loads are dispersed into smaller shipments and then distributed by road vehicles over short distances to their final, mostly urban, destinations.

Goods stations may be located:

- next to a passenger station (usually a small- or medium-sized freight terminal either on the far side of the platforms as seen from the station building or immediately alongside it);
- separately from the associated passenger station on one of the railway lines leading from it (mostly a medium-sized freight rail terminal); or
- as an independent freight terminal facility not connected with any particular passenger station (mostly a large-sized freight rail terminal).

4. FUNCTIONS OF FREIGHT RAIL TERMINALS

Rail freight terminals can be divided functionally into four broad classes: (1) break-bulk rail terminals; (2) bulk rail terminals; (3) roll-on/roll-off rail terminals; and (4) intermodal terminals.[8]

4.1. Break-bulk rail terminals

These terminals are used by trains that carry freight items packed in non-standard containers. Because of the need to also store weather-sensitive freight that is not always packed in waterproof containment, break-bulk terminals are usually also partially equipped with under-roof storage facilities. Break-bulk terminals are usually integrated with a marshalling yard, the main function of which is the assembly and break down of wagon-load trains carrying different types of non-unitised freight. This is necessary because each rail wagon could be bound for a different destination.

The rising popularity of door-to-door road freight transport and of containerisation has lessened the need for break-bulk rail terminals. Break-bulk terminals can be located at any of the three locations mentioned above: (a) next to a passenger station; (b) separately from the associated passenger station on one of the sidings leading from it; or (c) as an independent freight terminal facility not connected with any particular passenger station. Wagon-load traffic can also originate on private sidings. Two examples of these are (a) groupage traffic, which are consignments assembled by freight forwarders but presented to the railway as single wagon load; and (b) traffic related to a specific activity such as a manufacturing plant or a warehouse handling break-bulk freight.

4.2. Bulk rail terminals

These rail terminals are located at primary production points (mainly mines, oil refineries and grain silos) and ports of import from where bulk commodities are carried to secondary manufacturing plants (i.e. factories and processing facilities), ports of export and tank farms at petroleum and chemical product distribution depots.

Bulk rail terminals are generally designed to be commodity-specific and to either receive loaded bulk commodity wagons (often in unit trains) or to dispatch empty bulk commodity wagons/unit trains. Three notable examples are: (1) ore departure terminals at mines designed and equipped to store and load open wagons; and bulk ore destination stations equipped to receive loaded open wagons, unload the wagons, stockpile their payloads and convey the stockpiled ore via belts to waiting ships or to beneficiation facilities; (2) oil refineries and chemical production plants designed and equipped to produce petroleum and chemical products and store the products in adjacent tank farms where rail tank wagons are loaded either pneumatically or by pouring through a top hatch; and (3) grain elevators used to store, mix and load grain into covered hopper or other suitable wagons.

Bulk rail terminals are designed and equipped to load and unload the payload of trains in a short time with very little shunting (if any), which minimises the dwell and turnaround times of trains. The storing area at bulk rail terminals required for stockpiled payload commodities is often smaller than the area that would have been needed for a marshalling yard. Bulk rail facilities at the departure side are usually located on a private siding and at the destination side, either also at a facility on a private siding or at a seaport.

4.3. Roll-on/roll-off rail terminals

These terminals are used by unit trains transporting light road vehicles, mostly motorcars, where the vehicles are rolled (driven) into and out of motorcar transporters using a ramp. Roll-on/roll-off ramps at terminals are designed and equipped to load and unload the payload of trains in a short time with very little shunting (if any), which minimises the dwell and turnaround times of trains. Although marshalling yards at roll-on/roll-off terminals are not needed, these terminals commonly require a large amount of parking space to store the payload vehicles, particularly at regional distribution centres, which usually serve as storage facilities from where regional retail outlets are supplied. Roll-on/roll-off terminals are usually located at a port of import/export and on private sidings at a vehicle manufacturing plant and regional vehicle distribution centres. Roll-on/roll-off train services usually take place from vehicle manufacturing plants and ports of import to regional distribution centres, and often also from vehicle manufacturing plants to ports of export.

4.4. Intermodal terminals

The implementation of standardised intermodal container transport has in recent decades substantially enhanced the practice of transferring loads between rail wagons and road trucks, as well as promoting the close integration of freight rail transport and sea transport at port terminals. Containerisation has significantly improved the productivity of rail terminals, since it permits quick loading, unloading and transloading of the containers, thus tying up less terminal rail capacity. This gain in productivity is achieved through good access to a port and/or the road system, supported through automated handling operations to meet the transhipment demands of modern intermodal rail operations. However, the gain in intermodal terminal productivity comes at the cost of fixed investment in terminal facilities and handling equipment. Firstly, intermodal operations require capital investments at the terminals in paved platforms and surfaces for container-handling equipment and storage space for containers. Secondly, depending on the type of operation, specific intermodal handling equipment is used. The choice of equipment is dependent on (a) equipment-specific factors, namely (i) capital investment required, (ii) equipment maintenance and upkeep, and (iii) the employment of specialised equipment operators; and (b) operational determinants, (i) mainly productivity objectives, (ii) traffic volume, (iii) the need to directly transload containers between vehicles (rail, road and water) or to store containers intermediately between reception, and (iv) container stacking density during storage.[9]

The main function of intermodal rail terminals is receiving/loading and unloading/dispatching unitised freight from rail wagons. Regardless of the growth of intermodal traffic, the number of intermodal terminals has declined. Intermodal trains serve fewer destinations – especially container unit trains that are dedicated to one origin and destination terminal. This is especially the case in industrialised countries, where many of the older break-bulk freight yards have been abolished since the late 1960s and the remaining ones converted into intermodal terminals because of the burgeoning standard intermodal container and road transport traffic.

5. URBAN FORM AND LAND USE

Passenger trains most often operate as unit trains and remain assembled the way they are, therefore requiring few shunting activities and marshalling yard areas, if any. In contrast, freight rail terminals, with the exception of freight unit train terminals, have to accommodate substantial shunting activities, which require separate shunting and marshalling yard facilities. Huge freight rail land requirements and activities in densely populated urban concentrations are experienced as (a) being a relatively inefficient form of urban land use; (b) an origin of external cost creation through noise, visual intrusion and often air pollution, which are perceived as being person-unfriendly; (c) a hindrance to the supply of smoothly linked street networks; and (d) a nuisance in the way of accessibility to urban amenities, the mobility of urban road users and social cohesion.

However, redeveloping conventional break-bulk rail yards into contemporary intermodal terminals is problematic. The ideal configuration for intermodal terminals is different from the conventional break-bulk terminals used by wagon-load trains prior to the large scale introduction of unit train operations, especially standard container freight transport:

Firstly, intermodal terminals require fewer but longer rail loops than break-bulk terminals. The high productivity of intermodal terminals comes at the expense of more trackside container storage space required. Intermodal rail terminal layout typically requires a site longer than three kilometres and an area equivalent to more than a square kilometre.

Secondly, for most modern intermodal rail terminals, which only serve unit trains, there will be no need for a marshalling yard. Also, intermodal terminals that do receive non-unitised container trains have less need for shunting than break-bulk terminals, because it is much easier to trace containers electronically and reposition them to another vehicle or a storage position with mechanical handling equipment than to split up a train and shunt the container wagons. Thus marshalling yards, whenever they are needed, are often operated independently from the intermodal rail yard and located elsewhere, outside urban centres.

Thirdly, good access to a port and/or road system is a requisite. Intermodal terminals are usually located at the following three places: (a) ports; (b) junction stations; or (c) locus points in major industrial and business districts, away from central business districts and densely populated urban areas.

- ***Ports***: Intermodal terminals can be part of a port facility (on-dock or near-dock facilities) where transloading between trains and ships takes place, either directly or via intermediate storage. Their infrastructure generally enables them to handle both road–sea traffic and rail–sea traffic. They have one or more quays where ships can moor, with railway tracks running parallel to the quay so that loading units can be transferred directly from ships to wagons, and vice versa, thus making substantial potentially derelict land areas available for redevelopment. The rejuvenation of such areas, because of their large size, proximity to business districts and waterfront position, has been at the forefront of the process. In addition this rejuvenation has also stimulated and changed land-use patterns in adjacent areas, for example the burgeoning of tourist amenities, convention centres and the hotel/accommodation industry. Notable examples of cities where such waterfront revitalisation and business district redevelopment has occurred on a major scale are: Baltimore, Boston, Chicago, New York, San Francisco and Seattle in the USA; Hamburg, London and Rotterdam in Europe; Adelaide and Sydney in Australia; Cape Town and Durban in South Africa; and Hong Kong.
- ***Junction stations***: At these terminals, shunting of wagons, the exchange of fixed blocks of wagon sets between crossing trains and the formation of wagon-load trains take place, access is provided to private sidings where unit trains are dispatched or received, and there may be traffic interaction with road transport. Junction stations are therefore equipped with multiple shunting sidings, unit train sidings and marshalling yards. Notable examples of cities where business and residential district redevelopment occurred on a major scale where huge rail yards at large junctions relocated to industrial areas are Atlanta and Chicago in the USA.
- ***Locus points***: Standalone inland focal rail terminals in industrial or business areas have to be accessible for road freight vehicles. These rail terminals' locations are typically separated in such a fashion that each terminal can serve a market area of about one day of road freight round or return trip. Locus point terminals may have private rail sidings (ranging from small sidings catering for light container traffic movements to major sidings catering for long container train subsets and complete container unit trains) connected to them. With the burgeoning of contemporary business logistics practice and the widespread use of intermodal containers, locus point rail terminal location has become common practice in most industrialised countries.

6. CONCLUSIONS

Passenger rail terminals tend to be located in urban areas where many passengers board and alight, and surrounding land-use patterns are person-friendly, while freight terminals have become increasingly separated from densely populated urban locations. Huge freight rail land requirements and activities in densely populated urban concentrations are experienced as (a) being a relatively inefficient form of urban land use, which bears a high opportunity cost; (b) an origin of external cost creation through noise, visual intrusion and often air pollution, which are perceived as being person-unfriendly; (c) a hindrance to the supply of smoothly linked street networks; and (d) a nuisance in the way of accessibility to urban amenities, the mobility of urban road users and social cohesion.

Rail transport can carry large and high-density commodities and bulk consignments over long distances at low cost. Rail transport is well suited, therefore, to carrying raw materials and semi-finished goods, such as mining and agricultural products. The introduction of standard intermodal containers has promoted the conveyance of high-value finished products. Since the economic deregulation of freight transport, the socioeconomic service and common-carrier obligations of freight rail transport operators have given way to contract services. Consequently a feature of freight rail systems nowadays is the reduction of stations, depots, yards, halts and private sidings. By concentrating reception and delivery of freight at fewer but larger stations, rail transport operators can attain economies of distance through longer hauls and economies of density through greater utilisation of rolling stock and intensive use of large terminals.

Private sidings nowadays tend to branch into large yards that often provide access to bulk rail terminals, roll-on/roll-off terminals and intermodal container terminals. **Bulk rail terminals** are designed and equipped to load and unload the payload of trains in a short time with very little shunting (if any), which minimises the dwell and turnaround times of trains. The storing area at bulk rail terminals required for stockpiled payload commodities is often smaller than the area that would have been needed for a marshalling yard. Bulk rail facilities at the departure side are usually located on a private siding and at the destination side, either also at a facility on a private siding or at a seaport. **Roll-on/roll-off rail terminals** do not need marshalling yards; however, these terminals commonly require a large amount of parking space to store the payload vehicles, particularly at regional distribution centres, which usually serve as storage facilities from where regional retail outlets are supplied. Roll-on/roll-off terminals are usually located at a port of import/export and on private sidings at a vehicle manufacturing plant and regional vehicle distribution centres. Regardless of the growth of intermodal traffic, the number of **intermodal terminals** has declined. Intermodal trains serve fewer destinations – especially container unit trains that are dedicated to one origin and destination terminal. Intermodal terminals are usually located at the following three places: (a) ports; (b) junction stations; or (c) locus points in major industrial and business districts, away from central business districts and densely populated urban areas. ***Port*** rail sidings running parallel close to the quay so that containers can be transferred directly from ships to rail wagons, and vice versa, make substantial potentially derelict land areas available for redevelopment. The rejuvenation of potentially derelict land areas at ports, because of their large size, proximity to business districts and waterfront position, has also stimulated and changed land-use patterns on the areas adjacent to them, for example the burgeoning of tourist amenities, convention centres and the restaurant/hotel/accommodation industry. ***Junction stations*** cater for the shunting of wagons, the exchange of fixed blocks of wagon sets between crossing trains and the formation of wagon-load trains. Access is provided to private sidings where unit trains are dispatched or received, and there may be traffic interaction with road transport. ***Locus point rail terminals*** are typically separated in such a fashion that each terminal can serve a market area of about one day of road freight round or return trip. With the burgeoning of contemporary business logistics practice and the widespread use of intermodal containers, locus point rail terminal location has become common practice in most industrialised countries.

From the research it is clear that the economic deregulation of freight transport in industrialised countries has, in addition to the beneficial transport economic and business logistics consequences, also had profound unintended impacts on urban land-use patterns and industries not directly related to rail freight transport. One such impact is the opportunity that is created for business revival and social enhancement in abandoned and derelict urban areas, and another is the challenge it poses to urban transportation land-use planners to timeously assist in preparing for urban renewal and redevelopment whenever it promises to be in the public interest.

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