Session 7c Paper 1

AUSTRALIAN MODES OF TRANSPORT WITH PARTICULAR REFERENCES TO THE PORT TERMINALS

M. P. Kia, Dr E. Shayan & Dr F. Ghotb
Swinburne University of Technology

ABSTRACT

Computerised information systems and associated equipment automation are increasingly being utilised by the port terminal operators in the industrialised countries The authors review the current status of some of the Australian modes of transport with reference to ports, evaluating the means of improving the efficiency of port terminal operations by employing automation systems, computer technology and direct ship to rail unloading operations.

Contact Author

M P Kia
Swinburne University of Australia
John Street
Hawthorn
Melbourne
Australia

ATRF 96

INTRODUCTION

As an island continent, Australia relies on sea and air transport to move its exports and imports. As a result, the importance of the transport modes lies not in their direct contribution to economic activity, but their roles as a facilitator for international trade. In 1993-94 Australia transported 376 million tonnes of international cargo by sea. This included 73 per cent of the value of imports and 78 per cent of the value of exports. Therefore, ports have become complex intermodal transfer and processing facilities that must respond quickly and efficiently to changes in trade volume, form and type of commodities traded, modal technology, operating procedures, and more.

In view of the above, one might define ports as an essential link in most multimodal transport chains. They perform cargo transfer (loading and unloading) buffering and storage and physical form changes (for example, from bulk to containerised cargo) in preparation for the next form of multimodal transport. Given the importance of sea trade in the Australian economy due to the country's distance and the nature of the commodities exported and imported, any possible improvement designed to achieve greater efficiency and lower costs must be given serious consideration. They can be either transport or transfer links. Transfer links are usually provided by intermodal terminals and ports and are usually designed to perform cargo transfer (loading/unloading), buffering or storage, and physical form change operations

The following discussion covers the transportation of freight in Australia, with particular reference to computer and automation system at port terminals. The function of each mode in transporting containers from/to the port terminals is studied and the proposal of direct ship to rail system using sophisticated X-Ray equipment is also analysed.

SELECTION CRITERIA

A multimodal terminal should provide access for, and coordinate the interface of, two or more different transportation systems. This is not easily achievable because access routes, working areas, techniques, and equipment can be quite different for different modes. Unfortunately, most multimodal terminals in Australia do not provide equal and satisfactory access all modes they serve. Most terminals were built/upgraded to solve the problems of an individual mode, without a great deal of concern for requirements of future growth of multimodality has come as a second wave. Modal selection is essentially a long term decision because the choice of one mode or another often involves major loading and unloading facility investment by shippers and receivers. Basically, haul length is a primary consideration in transport and particularly important in determining the choice of transport mode.

At present there are currently around 850,000kms of roads in the country, of which 28 percent are either bitumen or concrete, 25 percent are gravel or crushed stone and the rest are formed or cleared only [1]. Australian agriculture is a major user of road transport services, directly purchasing almost A$1.5 billion worth of these services annually. Agriculture depends on the efficient supply of road transport services to maintain international competitiveness. On average, for each A$10 agricultural output, 73 cents is spent in road haulage. The corresponding figures for mining and manufacturing are 46 cents and 33 cents respectively. For some agricultural activities such as beef cattle, up to 10 percent of total cost of production is comprised of road transport costs. Due to this dependence on road transport, any increase in road transport costs have a dramatic impact on the viability of primary industry and tend to be absorbed by the farmer himself, already struggling to compete with international markets, and many are already protected and subsidised. With the constant increase of tonne/km volumes on the road, Australian authorities are currently faced with the decision to whether or not to invest more in road construction and servicing, in order to avoid an increase in congestion and decay of the system.

The unit financial cost of main line rail compared to the articulated truck is approximately 230 per cent lower, a factor which is not always taken into account. It is worth noting that the latest statistics [2] show the number of trucks in Australia to be 389,100 (336,600 rigid and 52,500 articulated. Road transport tends to be used for short haul movements of non-containerised non-bulk goods due to its greater flexibility and because it avoids much of the double handling associated with other modes. On the other hand, rail predominates in the short haul bulk movements of commodities, such as wheat and other grains, as well as long haul movements of containers. In comparison with rail transport, transport by truck is not characterised by a substantial element of fixed costs. A comparatively small amount of capital is necessary to start a small-scale truck business and any equipment used can be easily adjusted to the volume of traffic. Furthermore the road hauliers do not have to provide and maintain their own infrastructures (roads and depots). Their contribution to public roads is limited to registration fees and indirect excises, as for example fuel taxes. These differences based on various structures of fixed and variable costs are not the only elements influencing the shipper's choice between the rail and road services.

Sea transport in Australia tends to be used for longer distance movement of bulk goods due to its low unit-distance cost which other forms of land transport cannot match. It is interesting to note that, although approximately 67 per cent of the coastal shipping transport tasks involve interstate movements, the bulk of this interstate transport is to and from the isle of Tasmania. Most containerised and non-containerised general freight normally travels by land transport and there is relatively little movement between mainland ports.

Finally, air transport is used to move high value goods where speed of delivery is an important consideration, especially where perishable goods are concerned. However, air transport is selected in a proportionately small minority of cases. In some situations, such as remote locations, the choice of this transport mode is often limited. The most recent statistics indicate that the total air freight to/from Australia in 1992-93 was 432,810 tonnes [3]

PRESENT AND FUTURE OF THE AUSTRALIA'S RAIL SYSTEM

Inland intermodal transport is seen as a means to reduce congestion, increase safety, protect the environment and improve distribution by making more effective use of existing rail infrastructure. Our recent study [4] on truck traffics around the ports in Australia indicates that increasing road transport links to a central port entails environmental disadvantages (such as an increase in accidents and air and noise pollution)

For rail transport to be efficient, there must be rail connections between the main production and consumption areas in the hinterland of a seaport. Furthermore, hinterland terminals at focal points for multimodal operations are essential, so that containers can be transported by truck to the cargo owners premises or to wherever cargo can be collected or distributed. The lower expenditure per TEU moved for road traffic reflects the use of road as a single mode for shorter itineraries around the port. As distance increases, road transport becomes less attractive in terms of cost and the viability of rail transport increases. For journeys over 200 kms, rail becomes progressively more competitive in terms of price and service. The proportion of road use varies widely among Australian ports, as some ports use the rail as a second alternative. The following discussion focuses on the role of rail in the Australian freight industry.

RAIL AND AUSTRALIAN FREIGHT INDUSTRY

Australia's National Rail (NR), funded by the Federal Government provides closely integrated rail services with the Australian ports, farms and industrial areas. Due to road's dominance in the last decade, NR suffers from annual losses of approximately A$350m. The latest improvement in the overall freight rail operations indicates that the NR is determined to maximise its productivity and become profitable and cost effective to the extents that it will operate without government support. In order to improve the rail efficiency, between 1996-2003, NR plans to invest a total of A$1.6b in infrastructure, rolling stock, locos, terminal equipment and control systems. However, the financial year 1994-95 has been one of continued rapid development for the NR. The main focus has been on customer service, with major efforts made by all workteams to lay the foundations on which to build sustained improvements in quality service delivery. The total customer revenue of $479.7m [5] for the year was virtually identical to 1993-94 on a comparable basis and gate-to-gate turnaround time for customer's trucks improved substantially in most terminals during the year. NR claims that by the year 2000, they will have saved taxpayers $1 billion in rail freight subsidies and create a profitable industry by introduction of new services such as Trailerail and SeaTrain. It is understood that NR will revolutionise rail freight operations in Australia with the introduction of a state-of-the-art terminal system and progressive delivery of new locomotives and wagons as part of NR investment of $900 million over five years. This system will dramatically improve customer service by cutting truck turnaround times at the rail freight terminals with the use of new information technology to allow automated terminal entry and exit and computer assisted train loading. The NR is supposed to reach break even point by 1996-7. It aims to increase market share by only 10 percent, but gross revenue forecasts for 1997-8 are A$500m for intermodal and A$250m for industrial products, based on an earning of A$1.6 for every A$1 spent [6]. The NR determines to reduce the overall cost of production by 45 percent

In view of the above, undoubtedly the upgrading of the rail system Australia wide will increase efficiency. Now the same economic pressure, of low cost bulk rail container haulage, has pushed domestic intermodalism into the foreground to embrace national traffic previously carried by truck. This has become flourishing operation with rapid growth. After many years of indifferent results and reputation, with rundown on rail services, domestic intermodalism has been rediscovered. As stated above, the ability of road transport to offer flexible door-to-door delivery services to or from virtually any origin or destination is difficult for rail to match but it is understood that NR has taken different measures to attract the freight industry.

THE ROLE OF RAIL IN INCREASING PORT TERMINAL EFFICIENCY

Rapid changes in international trade over the past few years have resulted in a highly integrated transportation system, combining the water, rail and road modes of transportation. As a result of the demands of this integrated network, much attention has been brought to the facilities where the mode change occurs. As this integrated water and rail container transportation system has grown, the role played by the transfer terminal has become increasingly important. For the purpose of this paper the terminal refers to that facility or combination of facilities through which the container moves from ship to train. This terminal is the link between the rail and water modes. It is one area in the Australian transport path where significant amounts of time can be saved or wasted, during what is a highly time sensitive operation. The multimodal container rail terminal is a key link in such a rapidly developing integrated multimodal transportation system. It is a facility whose performance requirements are established by decisions and activities well outside its physical field. It is also a facility that should and will attract the imaginative and creative thinking of many in the transportation field. The recent study carried out by the American National Ports and Waterways [7] concluded that the ports which use rail as a multimodal transport element provide higher operational productivity than the ones that do not. Our research on rail facilities in the Australian ports indicates that compared to world standard ports, the rail facilities in Australia are under utilised and the loading/unloading of containers at port terminals needs to be upgraded.

The ship to rail configurations, whereby the containers are loaded/unloaded directly from/onto rail-cars by shore gantries, can increase productivity enormously, especially if a continuous looping rail system can be installed. The foregoing discussion focuses on this latest loading/unloading technology which can be adopted in the most Australian ports subject to some infrastructure modifications. However, in order to implement the system, three major factors need to be taken into considerations. These are:

- matching of the stowage plans of vessel and trains
- provision of a looping trackage for conventional or double stack trains within the narrow confines of the waterfront area
- co-handling of rail and non-rail containers in such a terminal.

The combination of most 'rail' scenarios and Vessel Cycle Configuration is of a special interest. If 3/4 of the cargo is railbound and staged directly on railcars located at the container yard, the marine container yard becomes a railyard. The containers are carried by terminal tractors which shuttle between the shore gantry and the railcars for most of the time, and between the gantry and the container yard slots for the rest of the time. Consequently, the ship-to-rail linkage in vessel cycle is almost as high as that of the under the hook, but it is much simpler and does not require any technological breakthrough. Theoretically, the difference in time between railcar loading in under the hook and vessel cycle is approximately 3 minutes, which is the cycle time of the terminal tractor. The most desirable design for rail trackage requires that the rails should be laid in perpendicular to the apron in order to allow convenience switching of large blocks or railcars, whilst they are kept intact to provide easy access to the railcars for the hostlers. The perpendicular arrangement, which is similar to the one commonly used for rubber tyred gantry or straddle carriers, will also permit handling of both railbound and truckbound containers in the same terminal, yet without interference. In principle, the ship-to-rail transfer can follow two generic intermodal configurations: it can be performed either within the marine terminal, called on-terminal, or outside it, called off-terminal.

Although the ship to rail configurations method is technically simple and the facilities can be used for both conventional and RoadRailer trains, but it can not be accommodated in the every current layout of marine terminals in Australia. However, it is plausible to expect that the fundamental advantages of the system will be recognised in the future. Our analysis indicates that the cost of infrastructure can be justified by a reduction in ships turnaround time and by an increase in terminal capacity and slot utilisation at container terminals. Most Australian Ports agree on the critical importance of an efficient ship-to-rail linkage [8]

ASSESSMENT OF THE PROPOSED METHOD BY SIMULATION

Computer simulation would permit an assessment to be made of any alternative designs for the above proposal. The use of computer simulation has become a standard approach for evaluating design of complex cargo handling facilities (eg ship to rail unloading) world wide. In view of the above, unloading time of 250 containers (20' & 40') including delivery time to the rail freight terminal at four Australian port terminals were observed. Subsequently, a simulation model was constructed to compare the existing unloading system and the direct ship to rail method where the customs checking is not required (eg transhipment) or at the international port terminals which are equipped with the X-Ray container checking system. It is not intended to provide the technical details of simulation in this paper, however, for the construction of the model, the following factors were taken into considerations:

- arrival of container ships and appropriate distributions
- service time distribution (ship's time at berth)
- distribution of container handling onto train
- origin-destination analysis

The outcome of the simulation experiments is illustrated in Figure 1.

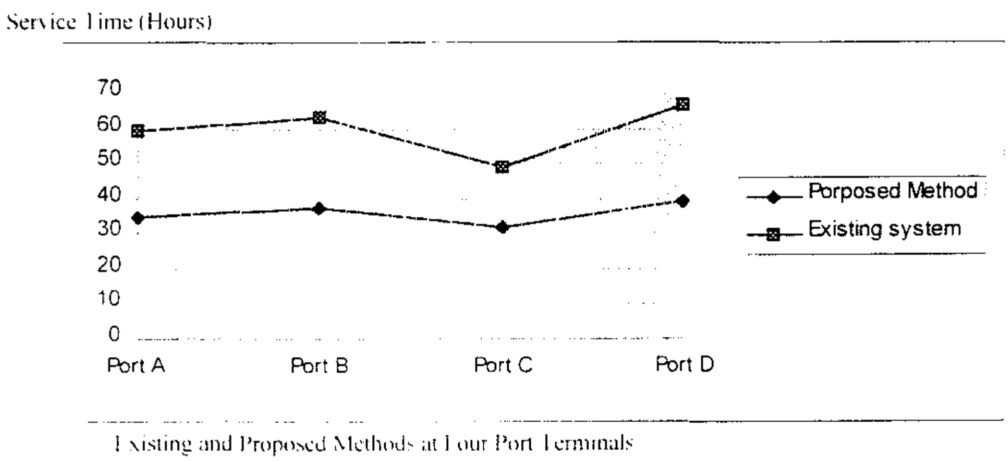

Figure 1: Simulation Results of Unloading/Delivery Time of 250 Containers

As shown above, the proposed method can save significant unloading time at port terminals. Our study on the ship to rail unloading indicates that the system increases the capacity of terminals in terms of stacking of containers, reduces traffics and eliminates capital investments on pavement construction Some of the logistic issues which must be taken into account include the actual length and width of the site, its distance and relationship to the shipping lines container yards, the location of the railroads support yard facilities, and the orientation of mainline tracks with respect to the primary service path for the railroad. Another important factor is the mode by which the containers will be transported from the container yard area to the terminal facility. One of the first considerations in facility layout is the number and length of tracks in the facility. The space available will obviously have a great influence on this item. Where possible, one track should be setup for each primary inland block, to provide the highest degree of flexibility in the variation of the number of containers to each of the destinations. The useable track length should be one half, one third or one fourth of the total train length and should also be equal to the length of tracks in the support yard. Previous planning aimed at making the terminal long enough to place a full train on one track (some port authorities/port planners in Australia have not yet adopted these new theories and still hold to the old version of a full train on one track). Most railroads have now significantly increased the maximum length of an intermodal train to the point where a terminal of equal length would have unacceptably long internal operation cycle times. It is understood that the only terminal known to practice under hook operation successfully is at Zeebrugge in Belgium.

CONTAINER TERMINAL AUTOMATION

Today, the most advanced container terminals around the world are equipped with highly sophisticated automation systems Our study on the most recent automation systems at the international port terminals indicates that most applications are either expensive or due to the infrastructure modifications can not be implemented in Australia. However, it is not intended to describe a great deal of detail (such as electronics, computer and technical drawings) in this section but due to the importance nature of the system and specially combining with the existing rail system at ports, we reveal only one type of automation as described below

As stated above, although the container terminals in Australia technically are not ready to accept this sophisticated system of driverless container handling, but future trends most probably will go towards more autonomous navigation techniques, enabling the flexible use of Automated Guided Vehicle (AGV) also on existing facilities without installing complex infrastructural provisions. In recent years, there has been intensified investigation into novel and highly automated carrier-systems for container yard-operation. Most of the schemes currently being proposed are automated systems employing Automated Guided Vehicles (AGV) in combination with overhead yard gantry crane equipment. Moreover, in the next years we will see sustained growth in container traffic in Australia which will result in significant structural changes of the handling techniques used in container yards. This, for example, could affect a terminal whose yard operation is exclusively based on straddle carriers and for reasons of limited yard space and competitiveness is forced to look for alternatives. Finally, new automation and sensor systems as well as advanced navigation technology are available. The AGV provides automation, accessibility, versatility, divisibility and mixability. These factors are combined to determine the operational flexibility. Some of the major factors of AGV system which should be taken into account are reliability and economic constraints which are described below.

Experience in Europe, North America and Asia indicate that with 50 AGV's operational and an MTTF (Mean Time To Fail) of 50 hours gives one AGV breakdown per operational hour [9]. The minimum MTTF level to achieve therefore is set to 150 hours, which is already ten times better than straddle carriers nowadays. In 1992, port of Rotterdam tested 8 vehicles for nine months. All vehicles had made about 3000 running hours (some 200.000km's compared to road trucks) which resulted in 500 problem reports, 60 adoptions in vehicle components and hardware configurations and numerous software adoptions.

Whilst technically feasible, reliable and an appealing concept, the AGV concept has also proved economically viable in the German ports. It is worth noting that the purchasing price of the machine itself varies between US $1.71 and US $4.3 million excluding site preparation [10]. New technologies are measured in terms of productivity gains, reduction of operation costs and the like. It is generally argued that the up-front investment of an automated AGV-terminal is higher compared with conventional alternatives, requiring a higher degree of planning. Potential users attempting a gross approximation of economic viability have therefore expressed a simple profitability criterion. The various design options should be examined in terms of AGV-type, container loading and propulsion. Largely, three different applications can be defined. There are driverless, with driver and hybrid. These can be briefly described as follows:

The driverless operation is suitable for point-to-point or grid-like, free-ranging operation possibly requiring restrictions of the terminal layout for safety reasons. It is argued that areas operated with AGVs are to be free off human operating personnel. For the same matter, combined carrier traffic with other yard equipment such as sideloader and straddle carrier has to be restricted. Although AGV-concepts are normally associated with manless operation, there are certain applications derived from public transport where automatic guidance in combination with a driver can offer real advantages. That is, for example, given when long distances (largely extended terminals) need to be covered at higher speeds, or when several external parameters (public road-crossings etc) have to be considered. And finally, the hybrid AGV combines the advantages of an automated machine for computerised guided control, with the intuitive appeal of a human operator. Inside the restricted yard area for automatic AGV traffic the AGV operates like a robot. Outside such area the AGV is driven possibly at higher speeds by a driver giving a high degree of flexibility. The hybrid type also lends itself readily to a combination with other yard equipment or, when for operative reasons there is container flow from an existing terminal with manned operation to an automated AGV yard area.

The possible loading requirements for AGV are terminal specific and depend on the particular operational structure loading one container "single loading" ideally with a symmetrical weight balance, is only a hypothetical option. A symmetrical loading, could be for a single container or a twin loading (2 x 20 ft) requires more precise design particularly with regard to proper steering, eg during such time intervals with only one 20ft container placing the weight largely on one axis. Another loading operation is multiple loading. That is for applications requiring 2-high stacking on the AGV. Finally, in a trailer operation an AGV is combined with trailers for multiple transport. Electronic tracking systems employing inductive loops are well introduced and proven. At AEG and Daimler Benz such systems have been supplied for public transport and high speed applications, such as the Euro tunnel. Laser systems can be used for the AGV docking as well as for positioning. Lasers can be arranged in triangular geometric configuration, provided there is undisturbed view of the AGV with three or more fixed positions the relative AGV position can be detected. Transponders are a most suitable choice for indoor and outdoor applications giving excellent position accuracy.

INFORMATION SYSTEMS IN CONTAINER TERMINALS

Growth in container traffic over the past few years has resulted in varied development in ports around the world. Despite Australia, container ports in the developed regions of the world (such as Europe and America) are being subjected to intense competition. Thus, terminal owners and managers are being forced to focus on avenues for increasing productivity of existing infrastructure by computerising their handling systems, while cutting costs. The foregoing discussion focuses on the computer technology are/will be used in the advanced container terminals worldwide.

In the last 3 years, only a handful of container terminals in Europe had installed sophisticated high resolution graphic based easy to use systems for pre-planning and planning to replace the otherwise intuitive process of pouring over dozens of manual vessel and yard plans. This situation was partly the result of the cost of computer hardware, insufficient application systems knowledge in system house worldwide and the result of inadequate understanding (within both ports and systems houses) of what computers can do to assist in terminal competitiveness. It is understood that almost all the container terminals in Europe (unknown in Australia) have such systems installed and integrated them with their daily operational systems. These range from the simpler systems that handle mainly container inventories and invoicing, to the more sophisticated systems employing state of the art computing technology, such as real time container tracking and yard/stacking equipment control. Terminals such as Felixstow in the UK, Bremerhaven and Hamburg in Germany and Rotterdam in the Netherlands have actively participated in the development of such productivity enhancing specialised planning system, which have resulted in customised solutions taking into account their terminal specific operational procedures and features of yard and quay equipment.

COMPUTER AND CARGO/CONTAINER HANDLING

Study of the operation of container terminals identify several areas where research is worthwhile, in particular the problem of containers remaining on the terminals for long period of time. The length of time containers remain on the terminal (dwell time), directly affects throughput capacity for a given size of stacking area, in that the longer the dwell time the lower capacity. To increase capacity there must be more ground slots, higher stacking, reduced dwell time or some combination of these. From the port's point of view, reducing dwell time appears to be the most rewarding approach as increased capacity can be provided without the need for additional physical resources. In an attempt to identify the main factors affecting dwell time, the container traffic before and after the ships' departures at three Australian ports were investigated. It is understood that during heavy traffic at port each terminal operator reacts differently to create extra capacity for stacking of containers, but the principal of terminal congestion before ship's arrival and after departure is the same. This is illustrated in Figure 2.

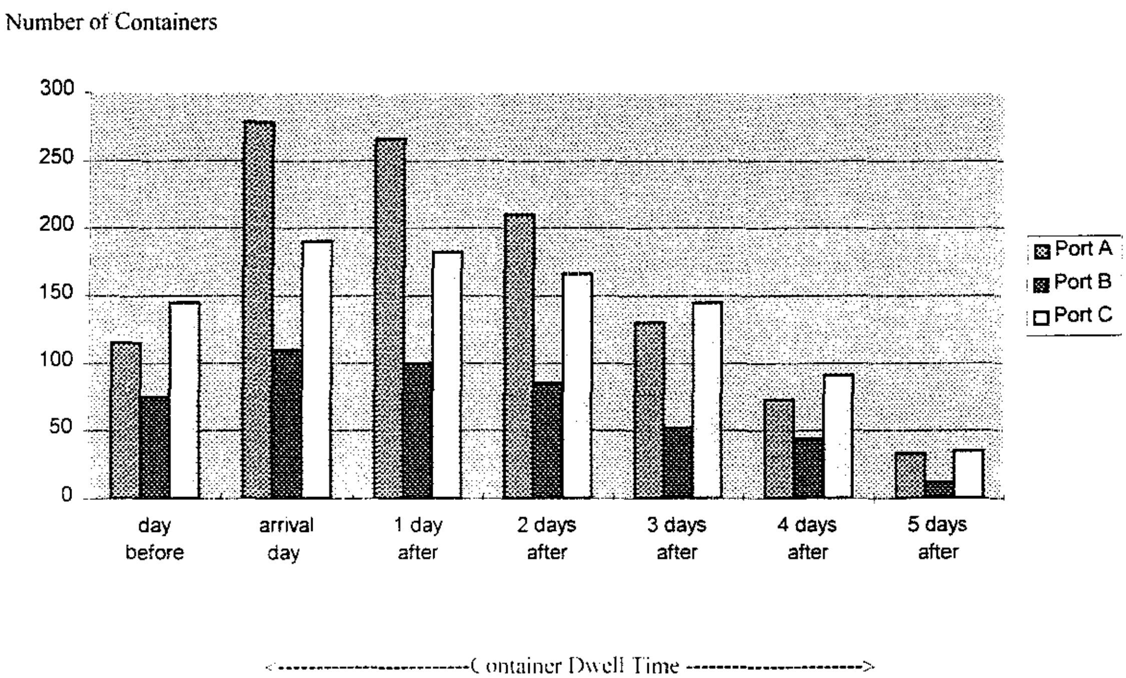

Figure 2: Changing the Overall Dwell Time

The following discussion reveals some of the efficiency improvements in relation to customs inspection at the international port terminals.

Since the 1960's the western world has become increasingly sophisticated in its use of computers to track cargoes and the customs duties that may be payable on them. The customs officer and clearance applicant can input cargo details to a computer terminal anywhere. Customs can decide whether they wish to examine the goods or they can be cleared without examination and the customs can transmit that information back to the applicant and to the organisation holding the cargo itself. Customs intervention in the collection of duties is far more sophisticated than in the 1960's with particular types of cargo, particular importers or particular transport routes being targeted, rather than the previous reliance on random checks and investigations. The power of the computer has allowed customs to see a broader picture of possible duty evasion. The system has been adopted by some international port terminals where the containers should not touch the ground before reaching destinations by rail. Due to the depth of the subject, it is not intended to describe a great deal of detail. However, we believe that the method could produce a significant time/money saving to the users of the Australian ports. The foregoing discussion focuses on the use of X-Rays at the international port terminals.

One major element in terminal slot occupancy in Australia is the inspection by Customs of imported/exported cargo. The detail of inspection and the methods adopted is beyond our discussion. However, the longer containers stay at terminals and occupy the slots, the more time will be spent by the handling equipment tracking the containers. As a consequence, travel time of the machines within terminals will increase drastically. In other words, a lower level of occupation in a yard will result in more efficiency for its handling equipment. In many countries revenue from tariffs represents a significant contribution to commercial sector income as well as a substantial portion of government income. Detecting goods currently escaping tariffs can be done with X-ray based cargo inspection leading to significant economic benefit through enhanced collection. Carriers using X-ray based cargo inspection can verify cargo identity and quantity against shipping documents to increase revenue and limit liability

In order to reduce the containers dwell time, in 1993 a German scientist group was awarded to research on the technical adoption of cargo inspection system for Hamburg harbour [11]. The aim was to facilitate the customs searching for contraband, such as, weapons, drugs and explosive, hidden in cargo, containers and vehicles. Recently, the group came up with an X-ray imagine system which can be tailored to the individual requirements of each customer. The system's flexibility has enabled the position of the inspection tunnel, operator building as well as packing hall - where recheck and devanning of suspicious trucks takes place - to be planned with regard to the constraints of space. The cargo inspection system uses high energy X-ray sources which allow one to actually see through the walls of sealed containers so enabling examination of its contents without the need to open it up. By this process, it is possible to detect the presence of suspicious substances and thereby make a determination as to whether or not physical inspection is required. The container to be inspected is guided through a specially constructed building which houses the X-ray equipment. Via a conveyor system, the container is guided through the inspection tunnel past the X-ray sources. In the meantime, the manifest has been scanned electronically and is shown on the monitor of the inspection analyst. By means of image and data processing, the manifest can be compared with X-ray images to determine if there is anything suspicious about the container's contents. Therefore, only containers determined to have questionable cargo need to be manually inspected or unloaded. This process takes less than two and half minutes to accomplish, ensuring a minimum throughput of 25 containers per hour. The inspections are nonintrusive and are accomplished without opening the container and without damage to its contents. This serves to lower insurance and overall shipping costs.

More technical detail of system's function is beyond this study. However, this exercise will reduce the scenario of double handling of containers within terminals substantially. In other word, most containers can be delivered directly from ship to rail's wagon to the quay area without touching the ground. It is understood that the combination of this system with rail could also save significant time and money for customs and increasing the effectiveness of the inspection process. A certain radiation dosage is employed for the screening of large steel plate containers and double wall ISO (International Standard Organisation) containers. However, the system will be equipped with highly sensitive detectors and digital image processing. A high resolution X-ray image is obtained can be easily recognised and interpreted without the risk of contamination of the cargo particularly foodstuff. It is understood that this system was introduced to the world market in the late 1995.

CONCLUSION

The interface between the ports in Australia and the road and rail network is a crucial element in overall transport chain efficient and can have a significant effect on the ultimate productivity of the ports. The ship-to-rail facilities reduces the ship turnaround time in the port and increases terminal productivity significantly. The results will bring a significant saving in handling containers at port terminals. The importance of computer technology at port terminals reduces container dwell time, increase terminal capacity and seems to be an ultimate solution to the terminals with heavy traffic. Although the port terminals in Australia are not ready to accept the revolution of the terminal automation, but the dynamic progress of most European/American ports should not be ignored.

REFERENCES

1. Federal Bureau of Statistics. (1987). Competition and Regulation in Grain Transport.
2. Australian Bureau of Statistics Year Book (1995).
3. Coastal Shipping. (1994). Bureau of Industry Economics. International Performance Indicators.
4. Kia, M.P and Shayan, E. (1994). "Intermodalism in Australian transport industry" International Dedicated Conference on Multimodal Approach to Freight transport, Auchen, Germany. November 1994.
5. National Rail Corporation. (1995). Project Update.
6. Melbourne-Adelaide Rail Standardisation Moves Closer. (16 December 1994) Australian Financial Review
7. Kia, M.P and Ghotb, F. (1995). " Multimodalism and Australian freight industry" 7th world Conference on Transport Research, Sydney, Australia. July 1995
8. Asaf, A. (1990). Intermodal Transfer and the Case of Long Beach Port, Maritime Policy, Vol. 17.
9. Intermodalism. (1994). Automated Guided Vehicle Go East. International Cargo System.
10. International Cargo Handling Co-ordination Association. (1995) International Cargo System.
11. ICHCA Annual Report. (1995) The World of Cargo Handling.