COMMON-USER TERMINALS - THE SHIP TO QUAY INTERFACE

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ABSTRACT:

Container terminal operators face a balance between two competing interfaces. On one hand, the ship to quay interface, on the other, the quay to transport. This paper discusses some of the operational problems encountered at the 'ship interface' which inhibit container vessel productivity. It suggests that cumulative losses in the terminal process leading up to the 'lift', although well indicated, are, in practice, largely ignored.

INTRODUCTION

The Need for Speed

The increasing value of ships cargoes and the development of international trade can mean large amounts of capital are inactive while a vessel is at sea. The average speed of ocean-going ships has been progressively increased from ten to twenty knots per hour since the 1950's in an effort to reduce the burden of inactive seaborne capital (Andruszkiewicz 1983) Technological improvements in ship design construction and on board cargo handling methods have had the effect, over this period, of shrinking economic distances between ports throughout the world. In the deep-sea general cargo trades this has occurred principally through the diffusion of unitisation in the form of the container ship.

Ship surface speeds can accelerate the rotation of capital which is tied-in to ships cargoes. Speed of transportation can also mean savings to the shipper in such things as inventory costs and interest payments on cargo, which otherwise would have been incurred. The savings to the shipowner or carrier must be measured over the entire transport route. This includes the port component Rapid cargo throughput and efficient infrastructure facilities are essential in order to shorten the non-revenue earning time during which a vessel stays in port. Delays to vessels in port can often eliminate savings achieved on other sections of a ship s itinerary.

Ports are an important component within the maritime physical distribution cycle, but their individual well-being including their technological development, depends on their ability to match the cargo handling demands of shipowners. These demands may be identified as being technological responses by shipowners to the competition in the market place. The shipping industry 'forces the pace' of technological change in ports.

THE ESSENTIAL PROBLEM

Research into ports throughout the world reveals a variety of difficulties confronting container terminal operators (Johnson and Garnett, 1971; Meeuse, 1977; Imakita, 1978; Harding and Ryder 1978; National Ports Council 1978; National Ports Council, 1981; Jansson and Shneerson 1982; Travers Morgan 1983; Roberts, 1984; Ogden 1984). Within the framework of these studies operational problems between terminals appear to differ in degree rather than kind.

In Australia, there has been a growing awareness that shore-based shipping costs are comparatively high and are:

> among the factors which determine the competitiveness of Australian exports and the price of our imports.' (1)

A Shore-Based Shipping Costs Seminar in July, 1984, identified specific problem areas in which it was considered remedial action was necessary. These included:

i) problems at the interface of the transport modes which create unnecessary costs.

ii) the trend towards sub-optimisation by transport interests which results in uncoordinated links in the transport 'chain'

The seminar concluded that there was a need for research to properly examine the issues and identify practical remedies to achieve overall cost reductions.' A Task Force, formed as a result of the seminar is currently examining these 'areas of concern' identified by delegates, and is expected to report in December 1985

The essential problem' within common-user container terminals is that of operational delays. These may be induced as a result of attempting to cope with what are often uncoordinated vessel and shore transport arrival times. To users and operators of these terminals this common problem manifests itself in increased costs. To the transport industry, it represents a large scale misallocation of resources. This paper written in September, 1984, does not seek to pre-empt or duplicate any of the work of the Task Force. Much of the work of that major study could be expected to be terminal specific. Instead, it addresses some of the operational problems encountered at the common-user terminal 'ship interface' which inhibit cargo handling efficiency.

TERMINAL CHARACTERISTICS

There is a fundamental difference between a sole or limited-user and a common or multi-user container terminal. A sole-user terminal may simply be a component in a vertically integrated operation, such as a dedicated terminal, which has the financial support and backing of a parent shipping line or group of shipping companies. In contrast, a common-user terminal is frequently a port authority capital venture established to service the regular and often random requirements of a number of shipping lines - the equity risk being borne by the operator, not the user.

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1 The Hon. Peter Morris M.P. Federal Minister for Transport. 'Opening Address to Shore-Based Shipping Costs Seminar' Sydney July 1984.

Although sole-users experience similar operational problems to common-user terminals, the latter experience unique problems. Because of this, this paper considers issues more applicable to common-user terminals.

The raison d'etre of a container terminal is to service container vessels. This primary objective, which is often underestimated by landside transport operators, is what sets container terminals apart from container depots, container freight bases or similar inland 'ports'. Unfortunately, it also places container terminal operations under the transport industry's collective microscope.

The efficiency with which the terminal operator performs his mainstream activity determines the service standards he is able to offer other terminal users. The reason for this is clear-cut. A container terminal has a very high capital gearing. This means that the capital cost element of each container handled may only be reduced to commercially acceptable levels by increasing throughput. Increases in throughput per se, through the addition of more shipping lines, or larger cargoes can have a recoil effect of reducing service standards for existing users.

The terminal operator is therefore faced with a balance between two competing interfaces. On one hand, the ship to quay interface, on the other, the quay to transport. It is between these two interfaces that the terminal operator seeks to expand his activity base whilst maintaining customer service levels. In the context of this paper, the effects of efficiency inhibitors on the ship to quay interface will be examined.

BACK TO BASICS - WHAT IS A BOX?

The sea container or box is a standard multi-modal cargo transporter, measured as a twenty foot equivalent unit (TEU) (1) Various sizes of containers are available but generally either 'twenty foot' or 'forty foot' containers (the latter favoured particularly by U.S. shippers) are employed. Load factors vary between trade and commodity areas, but a twenty usually 'averages' ten tonnes and a forty foot eighteen tonnes of cargo, respectively. A cellular container vessels capacity is measured by the number of twenty foot containers, or their equivalents (TEU's) it can accommodate.

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1. 20' x 8' x 8' (or 8' 6") International Standards Organisation (ISO) dimensions 6.1m x 2.44m x 2.59m.

A container ship differs from a conventional general cargo ship in several ways. Apart from their obvious physical appearances (most general cargo vessels being self-geared) the most significant difference is in their method of loading cargo Instead of a general cargo vessels myriad of differential cargo spaces, a container ships hatch or 'bay is subdivided into cells - vertical and lateral guides which stow identically sized cargo packages (containers) into predetermined slots. This means that the traditional in-port stevedoring skills of good stowage are virtually redundant. The 'skill' in loading ships is transferred ashore Cargo is pre-stowed to a precise plan whilst the carrying vessel is seaborne

Forward planning is the most important element in efficient container cargo handling operations For a variety of reasons it can become increasingly difficult to implement.

EFFICIENCY MEASURES

There are numerous factors which if left unchecked, can combine to inhibit container vessel productivity Some of the solutions to operational problems may be within others outside of the operators control.

Productivity analysis between common-user terminals poses particular difficulties not least because productivity differences between them (firm effects) do not readily avail themselves of comparative analysis. Not all of these terminals operate in a common competitive environment In other words some terminals operate under highly constrained circumstances. As an example institutional constraints (in the form of terminal working practises) significantly increase the gap between a vessels non-productive time (alongside time i e. time spent at berth) and productive (cargo handling) time

Where productivity comparisons are available, (National Ports Council. 1981; Travers Morgan, 1983; Bureau of Transport Economics 1984) - the most orthodox methods being cargo handling temporal measures of either gross or net crane rates per hour (see appendix) they should nevertheless be treated with caution.

Table 1 is useful. It provides information supplied by several shipping lines and gives handling rates for identical vessels calling at different ports. It is interesting for two reasons Firstly it inadvertently underlines the commonality of container vessels trading worldwide, compared with the disparateness of the container terminals which seek to service them. Commonality of container terminals would be a more appropriate measure and complete the equation as one would be comparing like with like. The data is largely supplied by the users not the operators of these terminals.

Secondly, and more importantly, it expresses crane rates, across continents in gross containers per hour. There are various views on the choice of this as an adequate productivity measure. Net containers per hour (a measure of the rate of carrying out the cargo work devoid of any delay time) provides the shipowner and terminal operator with a daily working tally' of productivity. Gross containers per hour includes the effect of delaying factors. The difference between the latter and the net crane rate is a measure of the significance of the delays found at a terminal. This is important, as a simple example will illustrate:

TABLE 1: HANDLING RATES FOR IDENTICAL VESSELS CALLING AT DIFFERENT PORTS

Zeta Line - 1979/1980

Port/Terminal	Berth Performance[1]		Port Performance[2]	
	Gross C.P.H.	Containers Per Day	Gross C.P.H.	Containers Per Day
Great Britain				
E	17.5	368	9.7	233
F	21.7	521	16.7	401
Europe				
EC	30.5	732	17.1	410
EE	25.1	602	25.1	456
EG	30.1	722	16.7	401
EH	33.3	741	29.3	703
EJ	22.0	506	9.3	223
EK	23.8	476	13.3	320
EL	11.5	276	6.4	154
EM	16.4	361	7.8	187
North America				
NB	47.4	1090	34.0	816
ND	34.3	755	16.9	406
NG	35.0	805	24.5	583
NH	25.1	552	11.4	274
NJ	35.2	810	11.7	281
NO	25.3	582	10.0	240
Australasia				
AA	12.2	281	8.6	206
AB	10.5	252	3.3	79
AC	20.2	485	10.4	250
AD	11.1	266	2.6	62
AE	28.6	429	8.4	202
AF	33.7	506	16.8	403
AG	24.7	371	16.7	401
AH	30.6	459	21.3	511

1. Berth Performance - Gross containers per hour: The number of containers, including restowage, handled during the gross ship working time.

2. Port Performance - Gross containers per hour: As above but based on the total port time including non-operating time and time for locking, waiting for a berth, etc.

Source: National Ports Council 1981

If 100 moves were achieved in an 8 hour shift (gross) then
100/8 = 12 5 containers per hour
but if 100 moves were achieved in a 6.75 hour shift (net) then
100/6 75 = 14.8 containers per hour.

Ostensibly 14.8 containers per hour is a higher productivity rate - and one which is usually preferred on a day to day basis as it appears to reflect the delays actually encountered at the ship/quay interface These delays, however will only be those which are identified and recorded by the ship's checker or tally clerk The rate disguises an element of unrecorded or lost vessel productivity overall, 13.6 per cent in this case. Not all of this percentage loss will have been generated on, or at the ship's side.

It was noted earlier, that, for obvious reasons, a vessel at berth is the priority or mainstream activity within a terminal. Because of this, throughput and thus productivity measures are largely attributed to the ship. There is a tendency to assume that this is the only area where vessel productivity may be gained or lost. As a result, cumulative losses in the terminal process leading up to the lift' are not monitored as closely. From the data in table 1, the substantially better performances achieved at North American terminals reflect the greater attention given by them to breakpoints in the terminal process.

Gross productivity for a vessel is calculated when it has finished cargo handling operations. Gross productivity is an index by which contractual throughput rates (if appropriate) or more general productivity rates may be measured. In practice there are various pitfalls in monitoring productivity. Some of these are summarised below:

1 It is generally accepted, (for example, in the case of a contractual arrangement) that, provided contracted box throughput rates are achieved on each vessel, or series of vessels, then the operation short of any major catastrophe, has been a success.

2 Common-users frequently service one-off vessels. Even among regular users some of their vessels may be cellular others semi or non-cellular. Productivity comparisons are difficult, if not impossible, in such cases.

3. Much of the analysis of productivity measures takes place away from the terminal. Once a dynamic container terminal system is in operation, however unsatisfactory it may be another element 'inevitable loss , tends to arise. This loss can quickly become an accepted 'terminal norm'.

4. The operator on the ground is often swamped by an accumulation of operational problems. Because the common-user is dealing with multi-port multi-user customers whose vessel start and finish times do not always coincide with each other, the root cause of lost ship productivity may not always be identifiable.

5. Each vessel operation at a common-user terminal is virtually a separate venture. There is no standard terminal ship planning system for container vessels. Most existing systems are hybrids of one form or another. Some shipping lines insist on using their own individual stowage and ship

planning procedures. These multiple systems inhibit the operators ability to sustain productivity rates over time.

Productivity comparisons, in the form of container exchange rates between terminals, are limited unless their analysis reflects the optimum operating conditions of those terminals in terms of capital, equipment and throughput, per man employed.

Table 2 represents an attempt to assess this throughput. It refers to containers per annum per item of plant or man employed and includes data from five British container terminals

TABLE 2: CONTAINERS PER ANNUM PER ITEM OF PLANT OR MAN EMPLOYED

Terminal	per Quay Crane	per Straddle Carrier	per man (Total Labour force)	per man (Management Supervisors, etc.)	per man (Dock Workers)	per man (Maintenance Workers)
A	21,800	5,458	242	770	512	1 139
B(1)	23,300	3,890	374	1,944	660	1.555
C	22 600	4 250	156	739	240	1.096
D	43.600	6 600	231	1 038	307	1.600
E	20 800	3 467	127	520	217	721(2)

(1) Terminal B operates a two shift system with overtime, all other terminals work three shifts.
(2) The maintenance dept. at this terminal has significantly more items of plant to maintain than the other terminals.

Source: As Table 1.

Clearly, throughput varies widely between the five terminals and reflects a considerable degree of overmanning in terminals C and E. Container crane utilisation at four of the terminals is less than 50 per cent (see section on Throughput Assessment). Van carrier (straddle carrier) utilisation is marginally better.

Table 2, whilst providing a measure of productivity differentials between terminals, does not reflect optimum operating conditions, or, more importantly, the capital investment/expected benefit ratio. Recently, Australian data, derived from terminals under common ownership, has attempted to illustrate the investment relationship. See Tables 3 and 4.

TABLE 3: TERMINAL THROUGHPUT: CALENDAR YEAR 1983

Terminal	Capacity(a)	Utilisation (per cent)	Manning (number)	Throughput (TEU's per year)	Throughput (TEU's per man)
Port Botany	160 000	78	460	125 327(b)	272
Webb Dock	180 000	70	390	126,197(c)	324
Newstead	25,000	92	75	22 895	305

(a) With current equipment operating methods work practices etc.
(b) Coastal 25 000 per year overseas 100,000 per year.
(c) Coastal 60 000 per year overseas 60,000 per year

The original estimate for Botany Bay capacity was 250 000 TEU's per year. The best year to date achieved 145,000 TEU's throughput

Source: Bureau of Transport Economics, 1984.

TABLE 4: TEU THROUGHPUT PER MAN: CALENDAR YEAR 1983

Terminal	Assets employed 1983-84 ($ million)	Manning (number)	Investment per man ($000)	Throughput (TEU s per man)
Port Botany	42	460	91	272
Webb Dock	21	390	54	324
Newstead	1.5	75	20	305

Source: As Table 3.

Although tables 3 and 4 are self-explanatory, the following points may be raised. All the terminals are heavily utilised but throughput per man in dollar terms is varied Table 4, for example shows that for every $91 000 invested per man in Port Botany considerably lower throughput ratios are achieved than in Newstead

These data draw similar conclusions to Table 2. The terminals of Port Botany and Webb Dock are overmanned. The difficulty in productivity comparison analysis is that there are no measures of the growth of capital assets relative to the increased (assumed) contribution of the labour force. In other words as Stubbs (1983) has argued; it is difficult to measure their (capital and labour) relative contributions to increased productivity:

> 'Any such calculation would require that records of the growth of capital stock in wharfside equipment be kept as well as changes in hours worked by waterside workers; the former are not available (1)

1. op cit. p.189.

The problem is not unique to Australia. The difficulty of productivity analysis manifests itself in many overseas terminals.

WHAT DETERMINES THE SYSTEM?

Factors which act as a brake upon terminal productivity can be divided into two broad groups. These will be termed primary and secondary factors.

Primary factors include components within the hardware side of the system, such as, vessel type and size, terminal utilisation, plant and equipment choice, terminal size and layout, and ship handling performance. Secondary factors, though less discernible, comprise the 'software' package and include working practises, terminal ship planning procedures, container information control systems, the degree of loading versus discharging operations, and the type and skills of the available labour force.

There are other extraneous components within the system, which, when comparisons with other terminals are made, can make an otherwise efficient terminal appear unproductive. Principal among these is the geographical position of a terminal within a ship's itinerary. As an example, if a vessel calls at a range of ports to load or discharge containers (as in the Australia-UK/continent trade) then the final European terminal operator may often inherit restowing, lashing and loading problems generated in earlier ports. Many vessels carry a complete set of lashing gear for a 'full ship' When ships arrive part-loaded, it may be necessary to break-down and transfer coastwise lashings before deep-sea loading and lashing operations can begin.

THROUGHPUT ASSESSMENT

The discussion, so far, has described inhibitors which affect cargo handling efficiency. Before examining some of these inhibitors, it may be useful to explain the ship/quay interface in some detail. For this purpose, a common-user container terminal model has been constructed.

The Interface

Figure 1 the Model T illustrates a typical handy-sized common-user terminal. A continuous quay 1100 metres long is served by five gantry cranes. The 22 hectare container park has an additional 26 hectare back-up area. To assess its performance over any given task, a series of data need to be built in.

Craneage

A fully utilised single lift container crane should achieve a throughput of between 30/40000 units per annum (National Ports Council, 1978) and 50000 units per annum (National Ports Council, 1981). (The variation probably reflects new crane technology in the years 1978-81). For the purposes of the model a crane lift capacity of 40000 units per annum will be assumed.

Terminal Movements

The landside movement of containers can be achieved by a variety of processes. Some of the most common include:

Principal carrier	Container route (assumes discharge and delivery process)	
1. Van Carrier:	Container Crane to quay Quay to container stacking area	discharge.
	Container stacking area to road/rail interchange	delivery.

2. As Process 1 but using a Fork lift truck instead of Van Carrier.

3. Yard tractor/trailer:	Container crane to yard tractor/trailer Yard tractor/trailer to Van carrier waiting in container stacking area. Van carrier to container stacking area	discharge
	Van carrier to road/rail interchange	delivery.
4. Transtainer:	Container crane to yard tractor/trailer. Yard tractor/trailer to transtainer.	discharge
	Transtainer to container stacking area or direct to road/rail interchange.	completion of discharge or delivery

5. Any selective Permutation of 1-4 above.

Van carriers are the most flexible item of plant in a common-user terminals dedicated operational fleet. This is because they are capable of picking and delivering containers out of sequence and almost at random, and also of switching quickly between ship and road transport tasks to suit operational needs This is important. The often random arrival of vessels, because of delays in other ports, bad weather or industrial disputation, can result in unanticipated traffic peaks. The cumulative effects of operational delays caused by these peaks may require the delivery of certain imports, or acceptance of exports, to be on a priority basis. A van carrier can perform these functions with minimum disruption to shipside operations by, for example direct delivery from or to, the gantry.

Another important aspect is in their ability to cope with irregular ship work. As an example, a vessel's hatch may contain a mix of dry and refrigerated cargoes. An additional carrier transferred to a ship's gang can be used to connect import containers to a refrigeration plant. (An operation generally carried out under an engineers supervision). Allocating an additional carrier for this specific activity, which is usually performed some distance from the main stacking area, releases the ship's carriers from what could otherwise be a time consuming task. Thus through one additional carrier, selectively allocated, work flow rates ex the ship can be maintained, if not enhanced. This is achieved by simultaneously feeding refrigerated containers via yard tractor/trailers to the 'extra' carrier, while the ship's carriers continue discharging dry import containers from the same hatch into the main stacking area

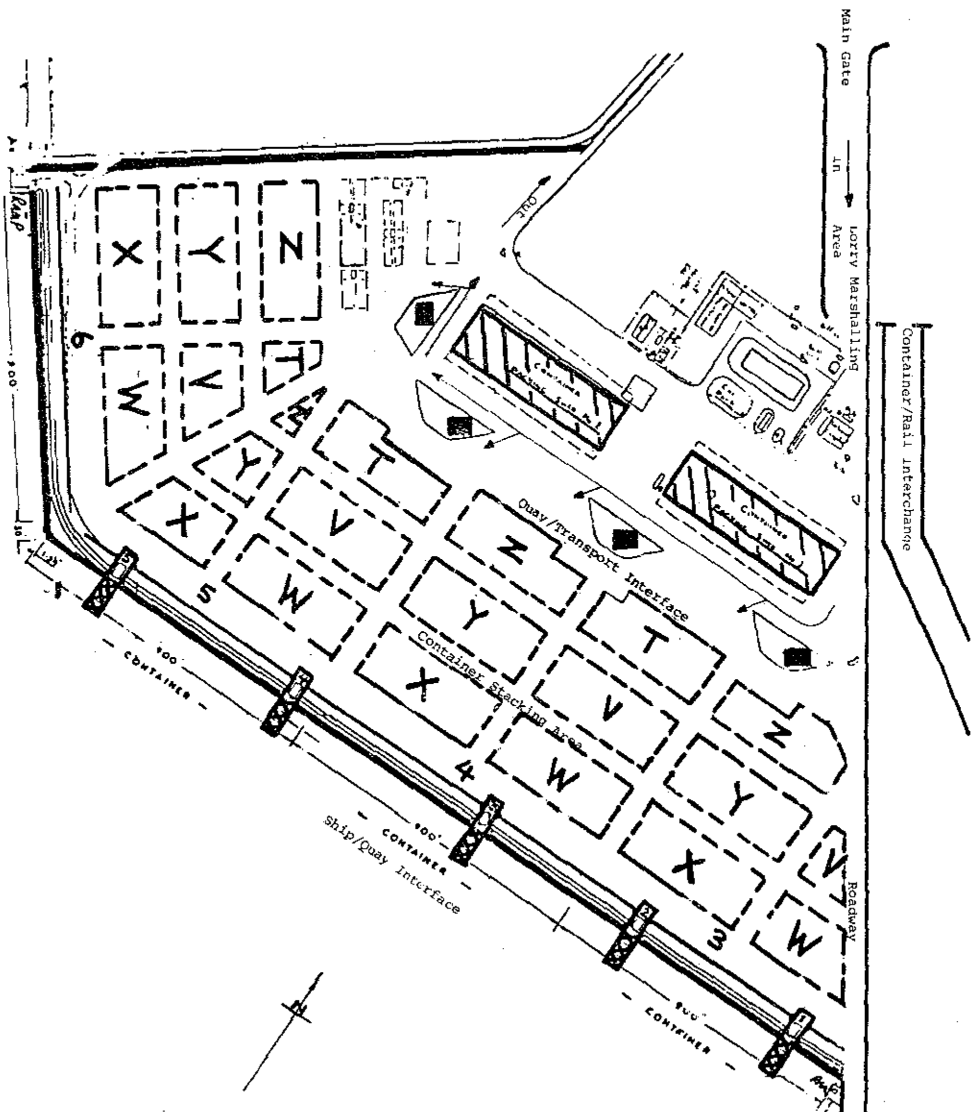


FIGURE 1. COMMON-USER CONTAINER TERMINAL: MODEL "F."

It is a feature of common-user terminals that peak activity in one section may be offset by off-peak conditions in another. Because of its operational flexibility, a van carriers overall performance is often affected by the level of ancillary activities it is called upon to perform. These may include such operations as shortening the quay, servicing a groupage shed, or working with overheight equipment.

As a guide, a van carrier working between interfaces should be able to handle in excess of 7000 units per annum, each container being handled, on average 2.5 times (National Ports Council, 1981).

<u>Capacity - What can the operator assume?</u>

If a dedicated van carrier operation (Process 1) is chosen for the model, then to achieve a forecast throughput of 40000 units per crane per annum at the ship/quay interface the model requires six van carriers per crane. These machines would have to be programmed to handle all landside movements including receiving and delivery at the quay/transport interface.

Based upon these figures, it is possible to compute that, in container stacking terms, 2750 TEU container park ground slots will be required. This gives a working storage slot capacity of 3667 TEU's. In other words, the operator should avoid storing more than this number of TEU's at any one time. The calculations for these figures are explained below.

Containers are normally stacked up to 1.667 - one and two-thirds on average. Ground slots are an estimate of the 'mix' in a van carrier fleets performance characteristics and the type and size of containers to be handled. Some carriers may be capable of stacking twenty foot containers three high (or one over two). These are usually first generation machines still with several more years operational life. Later model van carriers may be capable of stacking forty foot containers three high.

To determine annual capacity for the model some assumptions have to be made. Available data indicates that terminals can peak up to 33 per cent above the average throughout a vessels call. Other estimates suggest that 20 per cent of a terminals ground slots should be reserved for marshalling, planning or contingency use. (National Ports Council, 1978).

Following these conventions, the model s theoretically achievable annual park capacity is as follows:

$$\frac{A \times B \times C \times D}{E \times F}$$

where A = TEU ground slots
B = storage probability
C = Park capacity available i.e. 80% of Park
D = Working days in period (ignores seasonal or other variations)
E = Average container dwell time, in days. (e.g. for an import) This assumes; two days

to discharge and clear customs, three days 'free of quay rent' prior to collection.

F = average fluctuation above traffic flow.

Thus:

$$\frac{2750 \times 1.667 \times .80 \times 365}{5 \times 1.33} = 201293 \text{ TEU's per annum.}$$

Container parks experience congestion when 60% or more, of available container slots are occupied. The mean occupation of a container park is therefore:

$$MO = \frac{C}{F}$$

Thus:

$$MO = \frac{0.80}{1.33} = 0.60 \text{ (60\% slot utilisation)}$$

The number of static or standing slots referred to above may be calculated:

2750 x 1.667 x .80 = 3667 TEU's.

This figure of 3667 TEU's gives the operator a working storage capacity figure which is advisable at any one time.

In practice throughput capacity is dependent on the number of times each TEU working slot is used. This, in turn depends on the average dwell time for each container on the park and to some extent on ship sizes and trading patterns. As an example a daily container service of approximately 150 TEU's per ship call will probably require a shorter dwell time per container than a 2500 TEU fortnightly container service. The number of ground slots required for the larger vessel will reflect the longer dwell times for each container. Simply stated, bigger ships require bigger terminals.

<u>Summary</u>

These data represent a fairly loose set of assumptions. For the purposes of this paper they provide a framework by which some of the cargo handling problems of common-user terminals may be illustrated.

Throughput estimates enable operators to organise sufficient plant equipment and labour resources to meet anticipated demand. These estimates should be treated as 'best case' assumptions. As an example, container crane throughputs are a function of the level of the technology in the crane times the number of cranes assigned to a ship. 'State of the art' craneage has an 'engineering' physical lift capacity of 50 containers per 60 minute cycle (1.2 minutes per move). This assumes a single lift spreader (lifting/locking frame) but simultaneous loading and discharging operations. Single lift working of this order of magnitude is not achievable over a sustained period.

Efficiency inhibitors exist at breakpoints within a terminal process. These individual contributions to cargo handling losses can be difficult to quantify. The next section considers some breakpoint factors.

THE TERMINAL PROCESS

There are numerous interrelated factors which inhibit container vessel productivity. No list is exhaustive. In this section, two key elements in the terminal process will be discussed. These are:

1. Ships plans and container loading systems.

2. Labour practises.

Ships plans and container loading systems

It was noted earlier that there is no standard system of ship planning in use in common-user terminals. Jointly operated or private-user terminals can exercise a high degree of operational, and thus productivity control through the adoption of their own standardised ship loading procedures. These systems, often computerised, are designed with the parameters of the loading vessels in mind. Conversely, common-users are confronted by a range of shipping lines each with their own vessel types. Many of these lines use individual planning systems.

A computerised container information system is the optimum solution for plotting container park locations or checking ship loading lists. The majority of checking functions, however, are 'post-event'. In practice the extent to which computerised cargo control directly assists in the loading process is determined by the type and range of vessels to be serviced.

Experience has shown that container vessel loading is most suitably controlled from one point - the base of the gantry crane. A container ship's foreman unlike his conventional cargo counterpart, rarely needs to go on board ship. From his central control point (the interface of sea and land container routes) the loading supervisor can direct cargo operations

Figure 2 illustrates an information flow chart for a sequenced loading vessel berthed at Model T' terminal. The figure is based upon T4 berth the stacking areas being 4T to 4W and 4X to 4Z.

From the figure, it can be seen that information flows from T4 berth office in two directions. One set of instructions flow to the quay/transport interface. The other set to the ship In this example, which is fairly typical, van carriers 04 to 06 service the quay/ transport interchange grid. The common-user can never accurately predict road transport arrival times Where peaks can be forecast (Roberts, 1984) they do not always indicate the mix of traffic expected. This means carriers may service road vehicles carrying exports for future vessels, not just those vehicles carrying containers for the loading vessel at T4 berth. In other words, the quay/transport interface in a common-user terminal accepts containers 'as they arrive'. The common-user does not differentiate between terminal users. This is the main reason why the quay/transport interface is largely a discrete operation.

Information flows to the ship in two forms; written information and the spoken word. The written form usually preferred is the ships plan. Computer 'print outs' can be used as working ship loading lists, but

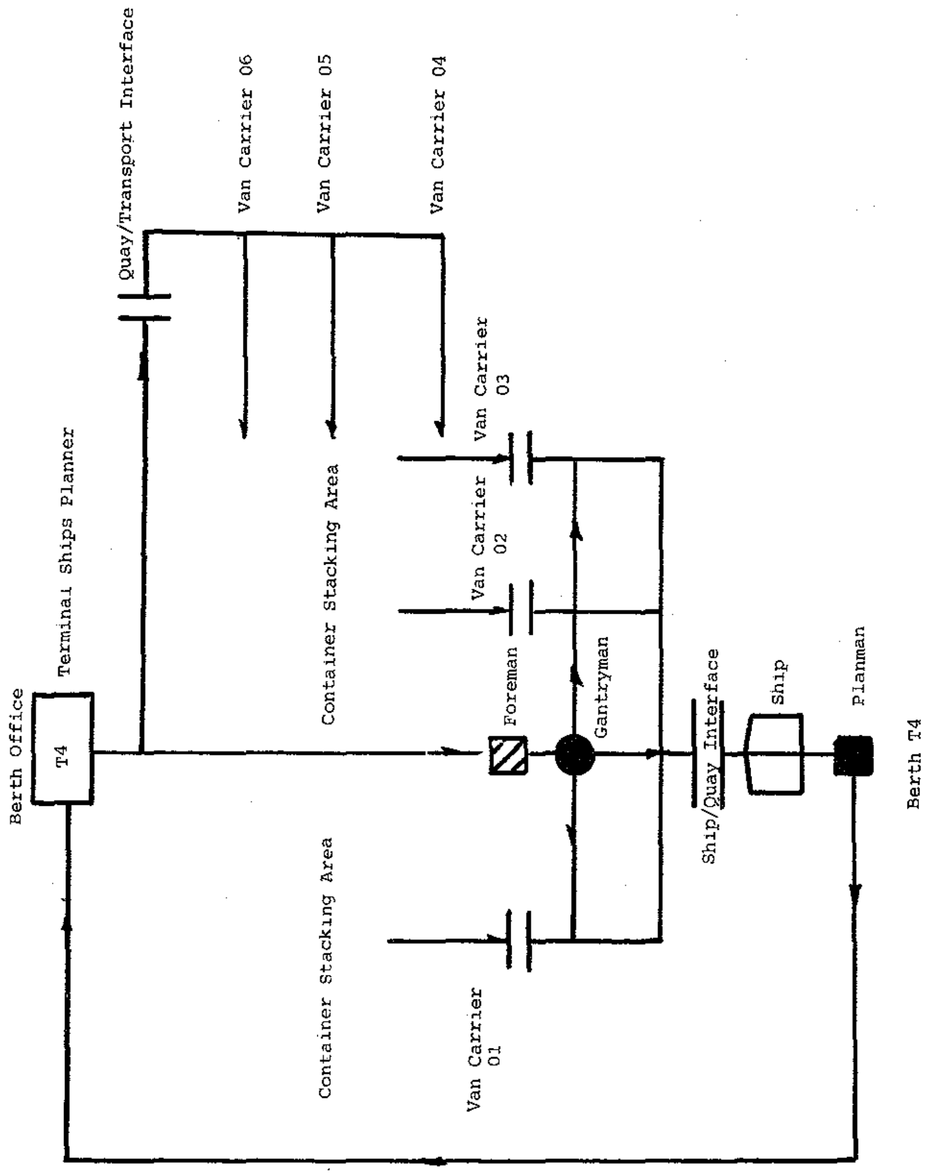
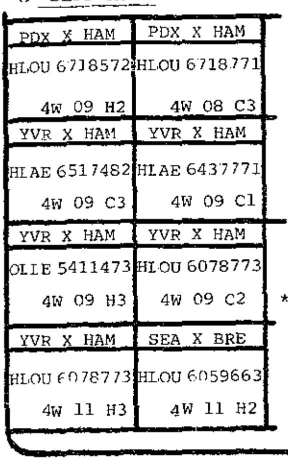


FIGURE 2: INFORMATION FLOW CHART, MODEL 'T'

they pose certain difficulties Firstly they can contain too much unnecessary information, and secondly, they are difficult to read in artificial light on the quayside. Figure 3 shows some examples of ships plans in common usage. These represent four plan 'types' which have been in use simultaneously in a terminal. The personnel involved in the loading process are representative of these types of operation These systems are closely linked to the information flow chart in figure 2

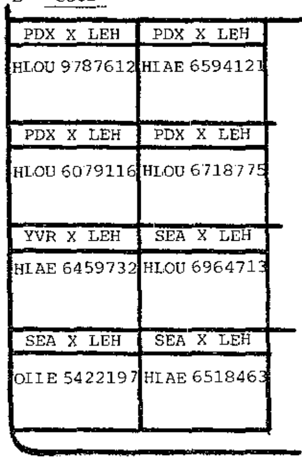
BAY 05 SEQUENCE SHEET	
OLLE 5422197	3x01 H3
HLAE 6459732	3x03 H3
HLOU 6079116	3x03 G3
HLOU 9787612	3x01 G3
HLAE 6518463	3x03 F3

A 'BEST CASE' *



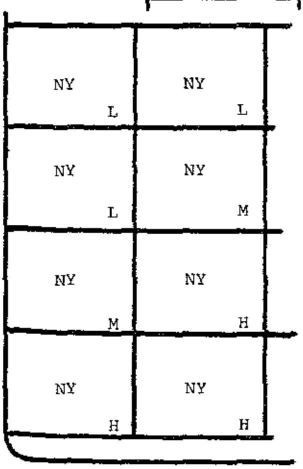
*Other additional information such as Weight/Customs/HAZ class etc. can be shown in A and B but have been omitted in the examples.

B 'GOOD'



C 'FAIR'

NY20'	Wt	Location
AGHU 6017659	H	3W 01 E1
ALUK 6097652	L	3W 09 B2
ALUK 7618059	M	3W 11 H1
ALUK 6320731	H	3V 01 H1
ALUK 6420971	K	3V 01 G1



D 'WORST CASE'

20'	Wt	Location	Port
OKAU 4715767	5	5W 01 C3	OAK
HELU 7170652	10	5X 09 C3	SEA
ULLU 3130752	9	5V 11 C2	SEA
IKRU 4170532	8	5W 10 C1	YVR
URRU 7106542	5	5T 01 C3	PDX

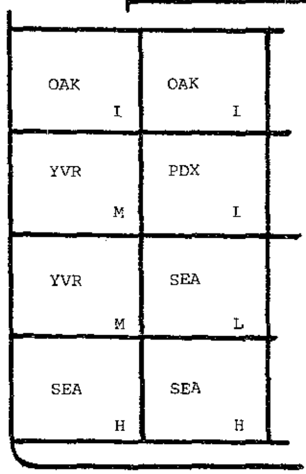


FIGURE 3. 'TYPES' OF CONTAINER LOADING SYSTEMS

Type (A) is a 'best case'. All loading information is contained on one piece of paper (the bay plan). Cargo is sequenced on the ship, which also allows the stacking area to be sequenced (see below). This has certain advantages. Because the vessel is sequenced, minimal instructions need to be given to the gantryman (the container 'spotter' who relays picking instructions via radio to the ship's van carriers). It also allows him to plan his own job without waiting for instructions. The essence of a smooth cargo handling operation is to minimise the flow of information actually required to load the ship.

The 'checkpoint' in the system is the planman. Communicating by radio only with T4 berth office, the planman records on a blank plan where each container is loaded and its slot number. These data are then relayed back to the berth office. The computerised ship loading list is then steadily deleted. Type (A) is particularly effective where overlapping shift changes are employed. 'Hand-over' problems are minimised. Fully sequenced terminals can eliminate quay side personnel. As an example, T4 berth office in radio contact with ship's carriers could effectively replace gantrymen.

Plan types (B) and (C) are variations. Type (B) is very similar to (A) except the sequence sheet is separate. Thus, personnel are only given their relevant 'bits' of the plan. Type (C) can be very effective. Where it fails, however, is when large volumes are being loaded. As an example, if 250 NY containers were being simultaneously loaded onto one vessel by three container cranes, this could result in gantrymen detailing carriers to the same container stacking rows, even for the same containers. This congestion can be overcome by gantrymen working together. However such large volumes mean bulky loading lists at the quayside which cannot be successfully 'split'.

Type (C) is the optimum where container stacks are laid down simply by weight and port. For example, six rows in 3W divided into NY 'Lights', 'mediums' and 'heavys' could be very rapidly loaded. Van carrier drivers would not have to identify specific container numbers.

Type (D) is a 'worst case'. Here, multi-port hatches are unsequenced. The loading list identifies port and weight. In practice, gantrymen prepare 'mini' sequence sheets for each hatch. 'Lost' boxes or boxes 'expected' but not yet on the terminal can create many loading problems with Type (D). Overall, this is the most unsatisfactory system.

Clearly, container park planning is closely linked to vessel planning. For a 700' vessel berthed at T4 berth, (e.g. Bow West 1600') the container park would be stacked to ensure that all export containers would be sequenced into 4W and 4X. Import containers would be placed into 4T or 4Z, the areas nearest their point of delivery - T4 berth office transport interchange.

Successful container park sequencing (i.e. the laying-down of containers in an order which directly matches the ships loading requirements) and the ultimate productivity rates of the loading vessel depend on container park segregation. This is a fundamental problem. A high degree of terminal utilisation can result in a shortage of suitable working storage slots. For example, a vessel which normally operates from T3 berth would be severely disadvantaged if, because of congestion in T3, its exports were assigned to 5W. Similarly, the terminal would suffer the productivity loss.

Inevitably, overstowing does occur. When it does, crane handling rates can be particularly sensitive to delays incurred through van carriers 'digging-out' containers in the stacking area.

Labour practises

Unlike conventional cargo operations, container terminal labour cannot be used to supplement shortfalls in cargo handling plant and equipment. The container is solely reliant on artificial lifting aids. Because of this the ratio of plant drivers to general duty workers in terminals tends to be high.

Labour disposition in terminals can vary between two extremes. Some terminals employ a permanently attached workforce who are allocated to specific machines or jobs, or who rotate between jobs within the terminal. Other terminals, particularly common-users, may be allocated workers who rotate through conventional cargo berths as well as the container terminal. Terminals which achieve consistently high productivity rates tend to be those with the minimum amount of job rotation.

Tables 5 and 6 provide rotational manning scales for a common-user terminal. From the data, it is evident that the operator at this terminal employs a large reservoir of static labour. As an example

TABLE 5: MOBILE PLANT DRIVERS - MODEL 'T.' MANNING SCALE (A)

Job Title	Personnel	Plant	
road transport interchange			
T3 berth office	5	3 van carriers	) per shift
T4 " "	5	3 " "	)
T5 " "	5	3 " "	)
rail transport interchange			
gantry	2	1 gantry	) per shift
van carriers	3	2 van carriers	)
yard tractor/trailers	6	4 units	)
shipwork			
container cranes	10	5 container cranes	) per shift
van carriers	25	15 van carriers	)
tugmaster	4	4 tugmasters	)
groupage			
van carriers	2	1 van carrier	) assumes day shift only
5t. fork lift trucks	24	24 5t. fork lift trucks	)
10t. " " "	1	1 10t. " " "	)
supervisor			
plant foremen	2	-	) per shift

(A) Does not include permanent 'reserves'

Source: Personal Communication.

TABLE 6. GENERAL DUTY AND ANCILLARY LABOUR - MODEL 'T.' MANNING SCALE

Job Title	Direct Labour	Duties	Ancillary Staff	Duties	
road transport interchange					
T3 berth office	2	basic documentation and inspection	8	all documentation) associated with) shipwork and) landside transport) operations)	per shift
T4 " "	2	" "	8		
T5 " "	2	" "	8		
gate house	3	documentation	-	-)	per shift
lorry queue	1	marshalling	-	-)	
rail transport interchange					
general duty man	4	) 1 foreman) 3 general duties	-	-)	per shift
checker	1	basic documentation	5	documentation)	
shipwork			(see above)	(see above)	
holdsman	40	shipboard duties/lashing		)	
checker	10	cargo handling delays and basic documentation	" "	" ")	
deckhand	10	gantry driver liaison		)	
gantry man	10	van carrier contact	" "	" ")	per shift
foreman and assistant	10	supervision	" "	" ")	
fore 'n' after	5	lashing		)	
planman	-	-	5	container loading) records)	
park foreman	-	-	4	container stack) planning)	
groupage					
porter	36	packing and unpacking of containers	-	-)	assumes day shift only
foreman	1	supervision	-	-)	
wharfinger/counter-off	-	-	20	cargo control and) documentation)	

Source: As Table 5

as table 5 shows, to balance plant labour supply against variable operational demand, the terminal operator over-employs plant drivers on a daily basis. When the terminal is slack, labour surplusses occur.

Within this terminal over-manning, there are a further set of factors. In nearly all continuous operation terminals, cargo handling jobs are 'over-manned', sometimes to the extent of double the actual number of workers necessary to complete the task. (see Table 6) The reasons for this are to allow covers for 'rolling' tea-breaks and also to relieve fatigue in certain key operators such as container crane drivers. Multiple manning, however, does not overcome lost productivity as a result of labour inflexibility.

Examples of lost productivity due to inflexible working practises arise where:

1. Drivers refuse to be allocated to more than one machine/job in a working period.

2. Van carrier drivers change over' with their relief at the terminal canteen and not at the ship, despite the provision of a terminal bus.

3. Mobile plant is parked at random' around the terminal or at the nearest point to the car park at the close of each shift.

4. Rotational plant drivers have to be drafted in from other berths. This results in delays before machines actually start moving.

5. Drivers are unwilling to transfer to another ship on completion of their work.

6 Gangs employed on shipwork insist on their full unit of manning. This means crane, van carrier and tugmaster drivers must be hired even if there is a requirement for only lashing

7. Rotational labour means that plant drivers are only at the terminal for relatively short periods. Because of this, lack of interest may be shown.

8. Because a lot of shipwork for example, discharging and backloading the same hatch, does not require holdsmen in attendance there is a tendency for them to 'drift' from the job, in some cases from the terminal. A flexible manning system would allow these workers to be usefully employed elsewhere.

Clearly the operator of the terminal shown in Tables 5 and 6 is severely restricted in his ability to balance labour supply against demand. This is particularly true for his permanently assigned ancillary staff who constitute 25 per cent of his total labour force.

Formal manning agreements can be used to identify working arrangements which restrict productivity. However these productivity losses are usually recorded losses which can be 'negotiated out'. Where unrecorded productivity shortfalls occur within existing labour agreements it is quite often a case of lapsed or inefficient terminal rule keeping.

CONCLUSION

Internationally comparable productivity measures reflect a considerable degree of overmanning within container terminals A major difficulty in productivity comparison analysis appears to be that there are no reliable measures of the growth of capital assets in container terminals, relative to any assumed increase in manpower productivity.

Within the general parameters of a common-user terminal, this paper has discussed some of the factors which inhibit container vessel cargo handling productivity. By concentrating on the ship to quay interface it has been suggested that some breakpoints in the terminal process leading up to the 'lift', although well indicated, are in practice, largely ignored. Using two key elements has illustrated why there can be marked productivity differences between what is theoretically feasible and what is actually achievable, at the ship interface.

These examples even allowing for static labour inflexibility, indicate that some improvement is possible at the terminal level irrespective of external constraints.

APPENDIX

Terminology

1. Crane Rate - Gross Containers Per Hour

Ship's throughput divided by the total Gross Crane Working Hours (see definition 2) accumulated during a ship call gives the number of containers handled per crane per hour. This is the rate of work which includes the effects of delaying factors. By its nature it will vary as a result of delays and therefore the difference between this rate and Net Crane Rate is a measure of the significance of the delays found at a terminal

2. Gross Crane Working Hours

Number of hours spent on cargo working recorded at each crane from start to completion of its work, but excluding time when the terminal does not normally work i.e. meal breaks and time between shifts. Also excluded would be holidays which are not worked or time when the terminal decides not to work the ship. Gross time includes delays due to mechanical failure, strikes, etc., when it is intended that work should be in progress. The hours of each crane used on a particular ship are accumulated to give the Gross Crane Working Hours for the ship.

3. Crane Rate - Net Containers Per Hour

Ship's throughput divided by the total Net Crane Working Hours (see definition 4) accumulated during a ship call gives the number of containers handled per crane per net hour. It is a measure of the rate of carrying out the cargo work devoid of delay time.

4. Net Crane Working Hours

Net Crane Working Hours accumulate in the same way as Gross Crane Working Hours. The difference between the two is that all delays, measured in crane hours, due to mechanical failure, strikes, etc., are substracted from the gross hours to give net hours. Net Working Hours is therefore the time spent on cargo work and the ancillary tasks connected with it such as moving hatch lids, lashing and changing spreaders.

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