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GETTING THE MOST OUT OF PORT INFRASTRUCTURE

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UNCTAD Monographs on Port Management

A series of monographs prepared for UNCTAD in collaboration with the International Association of Ports and Harbors (IAPH)

Monograph No. 2

PLANNING LAND USE IN PORT AREAS: GETTING THE MOST OUT OF PORT INFRASTRUCTURE

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Other monographs in this series:

No. 1 Changing from day-work plus overtime to two-shift working

No. 3 Steps to effective equipment maintenance

The views expressed in this monograph are those of the author and not necessarily those of the UNCTAD secretariat.

INTRODUCTION TO THE SERIES

In the ports of industrialized countries, operating systems and personnel development are based on skills acquired through experience, or emulation of other industries, and on the innovation which is easily undertaken in advanced industrial environments. These means are generally lacking in developing countries and port improvements occur only after much deliberation and often through a process of trial and error. Some means is required by which ports in developing countries can acquire skills that are taken for granted in countries with a long industrial history, or can learn from the experience of others of new developments and how to meet them.

Formal training is one aspect of this, and UNCTAD has devoted considerable effort to developing and conducting port training courses and seminars for senior management and to preparing training materials to enable middle-management courses to be conducted by local instructors. It was felt that an additional contribution would be the availability of clearly-written technical papers devoted to common problems in the management and operation of ports. The sort of text that will capture an audience in the ports of developing countries has to be directed at that very audience, and very few such texts exist today.

Following endorsement of this proposal by UNCTAD's Committee on Shipping in its resolution 35 (IX), the UNCTAD secretariat decided to seek the collaboration of the International Association of Ports and Harbors, a non-governmental organization having consultative status with UNCTAD, with a view to producing such technical papers. This series of UNCTAD Monographs on Port Management represents the results of their collaboration. It is hoped that the dissemination of the materials contained in these Monographs will contribute to the development of the management skills on which the efficiency of ports in developing countries largely depends.

Adib AL-JADIR
Director
SHIPPING DIVISION
UNCTAD

FOREWORD

When UNCTAD first decided to seek the co-operation of the International Association of Ports and Harbors in producing Monographs on Port Management, the idea was enthusiastically welcomed as a further step forward in the provision of information to managements of ports in developing countries. The preparation of monographs through the IAPH Committee on International Port Development has drawn on the resources of IAPH member ports of industrialized countries and on the willingness of ports in developed countries to record for the benefit of others the experience and lessons learnt in reaching current levels of port technology and management. In addition, valuable assistance has been given by senior management in ports of developing countries in assessing the value of the monographs at the drafting stage.

I am confident that the UNCTAD Monograph Series will be of value to managements of ports in developing countries in providing indicators towards decision-making for improvements, technological advance and optimum use of existing resources.

The International Association of Ports and Harbors looks forward to continued co-operation with UNCTAD in the preparation of many more papers in the Monograph Series and expresses the hope that the Series will fill a gap in the information currently available to port managements.

J.K. Stuart,
Chairman,
Committee on International
Port Development,
IAPH.

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PART I

ASSESSMENT OF REQUIREMENTS

A. Introduction

1. The need to pay close attention to planning land use in port areas begins at the moment the idea of port development arises and does not stop until a port is closed. In other words, the planning of land use in ports is a continuous process; it does not cease the moment the first master plan is completed and its neglect invariably leads to serious consequences for ports. The fact that these serious consequences are obscured by other problems does not alter the situation; land is a limited resource which can be even more limited by the way a port is planned or administered and, once fixed, it is, with the mooring areas, the most inflexible part of a port. The world is full of examples of ports which have been seriously affected or even closed by lack of attention to land use planning. The purpose of this monograph is to analyse the problem, to draw attention to the principles involved, and to suggest guidelines for the processes of initial planning, management and redevelopment in ports.

1. The port as landowner: the need for land

2. In the past, when ships often discharged direct to land transport (see fig.1), space on the quayside was limited and the port usually consisted of a narrow fringe of land along the waterfront. Increases in the size and cost of ships and the growth of international trade led to artificially constructed berths and the increased amount of cargo being handled meant that wider quays were needed for efficient working. In the case of general cargo, the relatively slow rate of handling, even with large cranes and ships' derricks, did not give rise to great increases in the need for land as was the case with bulk trades, mainly in raw materials where space for stacking was important. The situation has dramatically altered over the last two decades. The demands of world trade today and the requirements for faster turn-round of modern ships has greatly increased the pressures on ports: cargo has tended to develop towards bulk handling modes and the faster rates of discharge and loading have brought about a need for large transit areas adjoining quays (see fig.2) to provide a buffer between the capacity of land transport and quayside handling rates. Further space is needed for the extension of other activities in ports, such as port-related industry, servicing for ships and cargo (e.g. the stuffing of containers) and larger fleets of land vehicles.

2. Reasons for port ownership of land

3. It is obvious that the requirements of planning and land use control, as developed later in this paper, can be carried out by means of legislation, but experience of cases where port land requirements extend beyond the boundaries of port land have shown that planning and control by legislation alone has serious defects of inflexibility, delay and divided responsibility. Ownership of all the land required for port purposes by the port authority gives rise to maximum flexibility, capacity for immediate action and direct decision-making in ownership and management, provided that the port authority has clearly recognized the objectives in land use planning and has created adequate internal machinery for effecting control.

B. Land requirements for port operations

1. The basis of modern operational land requirements

4. Paragraph 2 above refers to the creation of cargo handling areas as a buffer, and contrasts the average size of a ship and its cargo with a land vehicle. When vessels remained in port, loading and unloading, for considerable periods, the shipper was able to take advantage of this "port time" for direct shipment without passing formally through a transit shed or storage area. Discharge could be direct to land transport and both practices led to considerable congestion and delay. As ship turn-round was speeded up, the opportunities for direct handling between ship and market were reduced. There were consequential improvements in quayside handling rates whenever direct handling practices were banished from the quayside. Figure 3 illustrates the pattern of direct and indirect cargo movements.

2. Transit storage

5. Indirect handling gives rise to a need for both short-term and long-term storage areas. Short-term storage areas take the place of the former direct handling practices and remove certain activities from the quayside so that the latter can be devoted to its proper function of loading and unloading. The functions of the short-term or transit storage areas are:-

(a) To act as a buffer between the different loading and unloading requirements of ship and land transport so that the rates of handling of these respective transport modes can be adjusted to the needs of each.

(b) To provide a holding area for cargo whilst customs procedures are carried out and port and ship documentation dealt with.

(c) To provide space for cargo consolidation and organization. Consolidation gives an opportunity for cargo sorting to take place so that ships can be loaded in the correct order for unloading at destinations. For imports, organization for dispersal and delivery is possible without delaying commencement of ship loading.

(d) To allow for:

- (i) time-table uncertainties in ship arrivals owing to weather or breakdown;
- (ii) interruptions in operations caused by shortage of labour or mechanical breakdown.

Both these circumstances can be eased by provision of further space in the storage area.

3. Long-term storage

6. Not all cargo can be passed quickly through the port and some cargo can be handled more economically by retention in storage areas to avoid double handling in the hinterland. This more slowly moving cargo is handled through long-term storage areas which are usually located further from the quay so that rapid cargo transfers near the quayside are not impeded. Long-term storage performs the same four functions as transit storage areas plus a further set of important functions:-

(a) To provide space for cargoes influenced by climate. Certain commodities are only available or can only be shipped over a short period. Harvesting of crops takes just a small part of the year but market demand may mean the spacing of deliveries over the whole year. Ice or monsoon may interfere with deliveries to the coast so that, again, there is a short sailing season.

(b) Some trade surges are created by market conditions in which shippers make speculative purchases to take advantage of low prices or quantity and, as a result, require long-term storage in ports.

(c) Political and strategic considerations may cause large and irregular movements which make similar demands on ports. The threat of withdrawal of important materials from world markets can lead to stock-piling. Ports may have to provide long-term storage until hinterland storage sites are available.

(d) The last main cause of demand for longer-term storage arises from the nature of the commodity itself. Ripening (e.g. bananas), settling (bulk wines), adaptation for land transport (freezing or packaging) or for distribution (evaporation of liquid natural gas) are examples of products requiring long-term storage in ports.

4. Ship size and cargo characteristics

7. The most important influences on the amount of space required for port operations are ship size and the storage characteristics of the cargo. It is important to qualify these factors by allowing for future demands which may increase the requirements. This requires assessment of net and gross requirements; the former will deal with what will be needed immediately and the latter will forecast future demands arising from larger ships, bulkier throughputs and larger annual tonnages.

(a) Ships

8. Two aspects of ship design give rise to problems of land use planning in ports - length and cargo capacity.

(i) Length

9. The layout of operational areas is based on the berth which must relate to the size of ship. Experience over the past 100 years shows that, although quay walls may last for that length of time the size and dimension of vessel keeps changing. Land use planning must take account of the sizes of ships to be handled but it can be severely affected by the design of the water frontages (see fig.4). As long ago as 1910, 1/ the Civil Engineer, Sir Frederick Palmer, was pointing out the great advantage of linear quays so that changes in berth length and direction caused as little waste of water frontage as possible (see fig.5). With very high costs of construction, long-term depreciation of capital costs in port accounts is essential for competitive charging and long-range planning of port layouts must secure long-term life of assets.

1/ R.E. Takel, Industrial port development (Scientechnica, Bristol, 1974), p.172.

10. The ability to plan for land use over the life of the asset is dependent upon simple layouts because development of back-up areas is greatly affected by comparatively minor changes in quay alignment (see fig.6).

(ii) Cargo capacity

11. The requirements in land use planning for operational areas are directly related to the cargo capacity of vessels (see fig.7). Whilst it may seem evident that ship size and, hence, cargo capacity, has a direct relationship to land requirements, ports provide water draughts in excess of those required for the average vessel using them. When circumstances lead to increases in the average size of vessels using the port, great problems can follow if land use planning has not followed the limit of ship size which the port can accommodate. This also leads to a waste of the investment in quays because increased space per berth can only be provided by reducing the number of berths (see fig.8).

12. Land use planning must therefore follow the principle that space for cargo operations will occupy a frontage related to the length of the vessel and a depth related to its cubic capacity. Thus, if ship's dimensions are increased by a factor 'x' the length 'ℓ' will increase to the measurement 'ℓx'. If cargo capacity increases in the same proportions, then the depth of land required (d) will increase to the measurement dx^2. This principle will not apply if cargo can be stacked to greater heights but this possibility is discussed below. As an example, if factor 'x' is two, the new length of berth will be doubled (ℓ times 2), the depth of land or berth will be quadrupled (d times 2^2) and the new area required will be the original area multiplied by 2^3. 2/

(b) Cargo characteristics

13. When a high proportion of cargo follows the direct route space requirements are limited, but ports planned on this basis will be unable to alter their methods when bulk and indirect handling techniques are introduced. Sound land use planning requires operational areas to be sufficiently large to allow vessels to be discharged quickly, to provide space for coping with weather delays and breakdown and, where necessary, to deal with seasonal flows when a year's trade arrives in a shorter period.

14. The amount of space needed will vary according to the type of cargo handled and its stacking characteristics, but it is important in planning to allow space for the most demanding cargo likely to be handled. Although this limit may not be achieved on every berth and the land behind the space actually used is sometimes regarded as surplus to requirements, it is, in fact, a false surplus of land which must be retained by the port in order to give the port flexibility in search for new trade in times of change (see fig.9).

15. The financial justification for allocation of land at this level is the low relative cost of the additional reserve compared with the modern construction cost of the berth. At 1980 prices, for example, a 200 metre berth for 30,000 dwt. vessels might cost $40 million with associated maritime works. A reasonable allocation of space to cater for cargo like packaged lumber might be 8 - 12 ha per berth and in a typical European port the area of 12 ha might have a land value of $2 million or 5 per cent of the cost of the berth. If the immediate need for the berth is represented by the first example in the diagram above, then one-third of this area would come into immediate use, leaving a false surplus of 3 1/3 per cent of the berth cost. This false surplus might be further reduced by interim uses so that the increase in port costs to secure an adequate reserve and extend the life of the port infrastructure is very low.

2/ See R.E. Takel, op. cit., p. 134 (fig.29).

(c) Stacking factors

16. In assessing space for cargo storage in the transit area, it is first necessary to ascertain the stacking factor of the cargo. This is not the same as the stowage factor for loading aboard ship, although the stowage characteristic affects the stacking factor. This factor, ashore, depends upon the following: 3/

(i) The stowage factor or bulk/weight ratio of the cargo;

(ii) The bearing strength of the storage site surface;

(iii) The height to which stacking can take place, including angles of repose or strengths of packing cases, or the diameter and heights of storage tanks;

(iv) The type of appliances used for transport between quay and storage area and their requirements in width of access lanes and turning circles;

(v) The amount of space needed for sorting cargo before stacking and for handling breakages;

(vi) The amount of space needed for loading and unloading land transport;

(vii) Safety factors such as spacing between piles, bunds around tank farms and anti-pollution measures.

Separate allowance should be made for parking for land vehicles.

17. Consideration of the seven points above and an analysis of practical examples will give a stacking factor in terms of units of weight (or volume) per unit of area, which can be used to calculate the space needed for any given cargo.

18. One final warning concerns the size of the sample used to assess stacking factors. This must be large enough to avoid distortion. As a general rule samples should not be less than half a hectare so that each contains an average mixture of stacking area and circulation space.

19. It will be seen that considerable variations in stacking factors can occur as a result of the range of possibilities arising from the seven points above. As an example, the normal ground strength of one iron ore stockyard could support stacks 5 metres high. By compacting the sub-soil as a result of vibroflotation processes, the possible stacking height was increased to 10 metres. Stacking to this height produces other problems because equipment for 10-metre stacking is much more expensive. The example also illustrates, as a consequence, that cost is an important factor in arriving at a stacking factor, and availability of finance must therefore be taken into account in assessing land requirements.

3/ For a great deal of helpful information, see Port development: A handbook for planners in developing countries (TD/B/C.4/175 and Corr.1), United Nations publication, Sales No. E.77.II.D.8, annex I, table I.

(d) Cargo handling rates

20. Changes in port practices, on their own, have a limited effect in speeding up ship turnround without changes in the forms in which cargo is handled. Accompanying these changes there have been increases in the volume in which cargo travels. In essence, the new principle is to modify each commodity so that bulk handling methods can be used. The most widely publicized modification is the container, which enables general cargo to be handled at high rates (perhaps 400 tonnes per container crane per hour) by packing it into standardized boxes of 20 and 40 tonnes capacity. Such adaptations materially affect stacking factors. Containers can be stacked to a much higher density per unit area than the miscellaneous consignments of general cargo which they replace. High density stacking also means that cargo occupies a smaller total area of buffer storage. As a result the average movement cycle between container stack and ship is reduced with a further increase in productivity in the loading and discharge of vessels.

C. The mathematics of cargo storage

1. Differences in storage areas

21. The advantage of having enough space for cargo handling can be illustrated by contrasting two berths. In figure 10 we assume that berth A and berth B will handle the same cargo (for example, imports of timber) and that the ships will arrive at the same intervals with the same tonnage of cargo. (The same principles apply to exports and to mixed cargoes but the comparison would become much more complex.)

22. Assume that each ship could be unloaded in two days and that in another six days (a total of 8 days), the next ship arrives. For the purpose of illustration it is also assumed that the cargo space available at berth A is twice that at berth B and is sufficient to accept the full cargo at the highest rate of discharge (two days) which will give the ship owners a fast turn-round. With perfect co-ordination, ship discharge will be at the rate of $\frac{C}{2}$ per day (C = total volume of cargo). At the rear of the site, land transport, which will have eight days to remove the cargo to the market, needs to transfer cargo at a minimum daily rate of $\frac{C}{8}$.

23. In case B, cargo handling at the quayside and removal by land transport at the same rate would fill the site after one day, less one-eighth of the total cargo removed by land transport. This would mean that only one-eighth of the total cargo (one quarter of the remaining cargo) could be discharged at the start of the second day with space for another one-eighth of the total cargo available by the end of that day. Hence, on the second day, cargo discharge equipment and labour would be idle for half the time (unloading no more than $\frac{C}{4}$ instead of $\frac{C}{2}$). The same problem would exist on the third day with only enough space for one-eighth of the total cargo becoming available by the end of the day. The unloading of this ship would not be completed until the fourth day because of lack of space, with productivity reduced by almost a half and ship time in port doubled. This situation could be improved (at a cost) by increasing the amount

of land transport used for the first part of the 8 day period and reducing it later, but the ship will still be delayed and land transport costs will still be higher. 4/ In designing a new berth, therefore, it is important to get space allocation right. For this, we need to know the most demanding cargo (in terms of space) likely to be handled and its stacking characteristics. This involves considering not only its density and the height of stacks but also the amount of space needed for circulation and for mobile or handling equipment. If varying standards of measurements are used (e.g. acres or square metres), the same standards must be maintained throughout the equation. The stacking factor derived from this, normally in terms of tonnes per hectare, can be represented by the letter "F".

2. The creation of a formula

24. If the total cargo of a ship is 'C' tonnes, then the space that cargo will require is $\frac{C}{F}$ hectares. In the example we have given, the ideal import site will be partly occupied at the end of the first day with $\frac{C}{8}$ tons having been removed by land transport. The space occupied will then be

$$\frac{\frac{C}{2} - \frac{C}{8}}{F} \text{ hectares} = \frac{\frac{3C}{8}}{F} \text{ hectares.}$$

After two days, the space used will be

$$\frac{C - \frac{2C}{8}}{F} = \frac{\frac{3C}{4}}{F} \text{ hectares}$$

25. A similar calculation can be devised for exports but the stacking characteristic of export cargo will probably differ and the time-table is reversed, with cargo having to be accumulated before ship arrival whilst only a limited quantity can be accepted into the site for loading after the ship docks. 5/ The peak demand for occupation of space by exports should be immediately before the ship starts loading.

26. For more complex calculations, such as seasonal trade with deliveries spread over a much longer period, we need to know the following: 6/

(a) The capacity of the ship for cargo (C) in tonnes;

4/ For example, higher investment in inland transport fleet, more idle time for fleet and drivers.

5/ R.E. Takel, op.cit., chap. VI.

6/ Ibid., p. 135.

(b) The stacking characteristics of cargo (F) in tonnes per hectare;

(c) The rate of loading/unloading the ship (R) in tonnes per day;

(d) The rate of arrival/departure for land transport (r) in tonnes per day;

(e) The interval between ships (x) in days;

(f) The maximum space available if this is less than the desirable limit;

(g) Number of vessels per annum (n);

(h) Number of days loading/unloading (t).

27. Naturally, in practice, there is a risk of ships "bunching" due to delays or breakdowns in equipment and more space will be needed for cargo. As technology improves, even greater quantities of cargo can be moved through a berth so that much higher throughputs per unit of space can be achieved. The ability to achieve high productivity depends upon high annual tonnages, adequate cargo handling equipment and land transport, efficient labour practices and sound operational forecasting. If any one aspect is deficient, land becomes the controlling factor in port efficiency. The danger with sites which are barely large enough is the risk of disruption and congestion if ship arrivals or equipment breakdowns alter the pattern of arrival and discharge. A formula which can give the space needed for a single ship or even a part load would be

$$\text{Area} = \frac{(R - r)\,t}{F}$$

28. In its most complex form, to give the space needed for a seasonal traffic (where a year's requirements arrive over a shorter interval), it would be

$$A = \frac{\underbrace{(R - r)\,t}_{\text{The first ship}} + \underbrace{(n - 1)\,((R - r)\,t - xr)}_{\text{The other ships}}}{F}$$

The converse formula for exports would be

$$A = \frac{C - tr + (n - 1)\,(C - (t + x)\,r)}{F}$$

If the amount of space available is less than the desirable area, the formulae can be used to calculate the adjustments necessary to other parts of the operation, such as the slowing down of ship discharge or loading (see (f) above).

3. Future trends

29. These formulae will give the areas needed for present-day traffic, and planners must bear in mind that calculations should be based on the "worst" or most demanding case. Allocation of space for present-day cargo operations will be based on these "worst" estimates, but expenditure on surface preparation is sometimes limited to the needs of the traffic handled at the time. In assessing the additional strip of land that might be needed in the future outside the initial cargo operations area, certain possibilities must be taken into account. These will suggest the size of the extra zone that should be protected from long-term development in case it is needed for cargo. They are that:

(a) Cargo will be of the lowest density carried in the largest vessels;

(b) New high-speed equipment may need more space for manoeuvre and access;

(c) Faster turn-round will enable a larger number of ships to be handled at a berth;

(d) Improved design of equipment may make it possible to serve land lying further from the quayside;

(e) Increasing world shortages of materials or political considerations may lead to greater use of port land for long-term storage;

(f) Increasing energy costs for cross-country land movements will tend to encourage the use of coastal shipping, especially in smaller land masses.

30. These considerations and the mathematical solutions will suggest the probable land requirements for cargo handling. A further guide to requirements can be given by practical examples subjected to analysis and adjusted for specific differences. Present experience suggests that for ports handling vessels up to 30,000 dwt. an average zone of 650 to 700 metres measured from the quay should suffice for modern cargo handling needs, including foreseeable reserves.

Table

Land use categories in port zones

1. Operating areas:

    Quays and jetties

2. Cargo storage:

Liquid	- tanks	)	Short-term
Dry		)	
Covered	- shed	)	Long-term
Uncovered	(hopper	)	
	(open storage	)	

3. Portside industry:

    Conveyor served
    Pipeline served
    Road or rail served
    Export-oriented (packers and assemblers)

4. Communications:

    Rail/Road/Pipeline/Conveyor

    Marshalling areas
    road vehicle
    rail vehicle

5. Port service industry:

To ships	)	Transport
To port operator	)	Maintenance
To port users	)	Services
		Dry docks

6. Commercial:

    Supplies
    Warehousing and long-term storage
    Bond
    Agency
    Insurance
    Offices, for Customs, port health etc., port operators and users

7. Land for port-related industry:

   (a) Primary manufacture, e.g.,
       Oil and petrochemicals
       Steel and non-ferrous metals
       Chemicals
       Grain
       Timber engineering or saw milling

   (b) Service industry and selected secondary industry, e.g.,
       Machinery and plant
       Transport
       Car manufacture

D. Land for other port purposes

1. Land use categories

31. The influence of land ownership on port efficiency is most directly shown by examination of cargo operations but the success of the port can also be greatly influenced by the amount of land available for other purposes. Cargo requirements, with the exception of those commodities which can be transmitted easily and cheaply by pipeline or conveyor, need space next to the quay so that movement and handling costs in port are kept to the minimum. Later, we shall consider the intensity of use in port terms, i.e. tonnes per hectare of port throughput per annum, which is a factor in considering the problem of relative location. The categories of land use involved in these other activities are as follows:

(a) Land for communications and marshalling areas;

(b) Land for supply and transfer services;

(c) Land for commercial activities and services to port users;

(d) Land for port industry.

(a) Land for communications and marshalling areas

32. It is instructive to analyse and determine the high proportion of port land required for these purposes. If the area occupied by linkages from the perimeter access to the quay is taken into account, the communications area can amount to 10 per cent of the total operations area, exclusive of the circulation space within storage areas. Communications space is used up by road, rail, pipeline or conveyor modes and should be augmented by a services strip in which water, drainage, electricity and telephone services can be laid without intruding into the cargo storage areas. The minimum width of port roads should be based on a dimension of 3.75 metres per carriageway plus an allowance for emergency parking of vehicles. Rail tracks require a strip 3.25m wide per track, including spacing between adjacent tracks.

33. The carrying capacity of roads and railways is determined by the number of carriageways and tracks and their number is limited by the problems involved in feeding into them from cargo storage areas. Local conditions influence planning, and these include:

(i) Predictions of annual tonnage;

(ii) Average carrying capacity of road or rail tracks in vehicle units or trains per hour;

(iii) Predictions of average size of ship consignments;

(iv) Predicted rates of discharge or loading of cargo;

(v) Rate at which cargo can be accepted by the hinterland;

(vi) Acceptable capacity of networks in terms of vehicles (or trains) per hour.

34. These estimates will give the peak transport loadings needed to avoid congestion in the cargo handling areas and the capacity of road and rail networks needed to deal with the highest rate of ship discharge and loading. The ideal should be based on simultaneous occupation of all berths but, in practice, the peak number is considerably less and a 60 per cent berth utilization is considered to be high.

35. In addition to the space for movement, further space is required for holding areas for transport vehicles. These will be related to the rate at which vehicles are called on to deal with cargo transfer between port and hinterland. As a guide, lorry parks require approximately 50 m^2 per vehicle including space for manoeuvre. Sidings for short-based railway wagons accommodate approximately 380 rail wagons per hectare. Car parks for employees' vehicles require 20 m^2 per vehicle including turning space. All these figures are for individual sites of 0.5 hectares or over; for very small sites the area per vehicle increases substantially because of the amount of space needed for manoeuvre.

(b) Land for supply and transfer services

36. Allowances for pipelines and conveyors depend on the number of pipelines needed or the size of conveyors. The amount of land allocated for services, other than roads or railways, depends upon a number of factors:

(i) The total predicted requirements classified under -

(a) number of different services;

(b) number of facilities (tracks, pipes, cables, etc.) in each service;

(c) number of branches to each service.

(ii) Whether services are to be above or below ground.

(iii) The safe working width for services below ground (usually based on a strip measured by projecting an angle of 45° from the bottom of the excavation on either side) (see fig. 12).

(iv) The width of access needed for maintenance, taking into account the need to avoid passing heavy plant over services laid at a shallow depth, or the height of working for services laid above ground.

(v) The capacity of the supply services:

(a) pipelines: litres per hour;

(b) electricity cables: KVA (kilo-volt-amps);

(c) water services: bore/water pressure;

(d) drainage: sectional area of maximum flow x velocity.

(c) Land for commercial activities and services to port users

37. These two activities are linked, as one is concerned with attracting trade to the port and the other is concerned with improving the attractiveness of the port to its users. The space needed for commercial activities is small compared to other requirements and, if space is short, some activities can be concentrated in multi-storey buildings. These include:

(i) Offices for port commercial management;

(ii) Offices for shipping and forwarding;

(iii) Agents;

(iv) Specialized warehouses: cold storage or bonded stores.

38. These generally make minor demands for space in port areas, but, in some cases, the specialized nature of a hinterland can affect the issue. We have already referred to the need for long-term storage and the dividing line between long-term storage and specialized warehouses is very fine. It is crossed, in a commercial sense, when the use becomes connected with the needs of the hinterland rather than the needs of cargo handling, although the ability of the port to provide space for a borderline activity often leads to the attraction of related trade.

39. Services to port users concern the activities which supply a service, on demand, which is required by ships, cargo and other port users. They include the maintenance of the port itself. Examples include:

(v) Civil engineering yards and workshops for maintenance of quays, locks, railways and roads;

(vi) Mechanical and electrical engineering workshops for maintenance of plant and equipment including dredgers, cranes and transfer vehicles;

(vii) Ship repairing services including wet repair berths and dry docks;

(viii) Maintenance services for supply of water and power, refrigeration plant, transport vehicles;

(ix) Services to ships: land bases for tug fleets, ship supplies, compass adjusters;

(x) Services to cargo: export packers and container packing and unpacking warehouses; repair of containers.

40. The space required for activities (i) to (x) will vary considerably from port to port according to the nature and volume of trade, the port approaches, the type of vessel and the custom of shippers and shipowners; for example, shipowners have a regular programme for ship overhaul, often making use of a particular port or ship repairer. Other ports might be involved only in emergency repairs. For these and other reasons, it is not

practical to lay down universal guidelines; instead, it should be suggested that analysis of similar ports will give useful data. One group of ports, involved in bulk trades and prime industry but only a few container trades, had allocated approximately 2 per cent of its total land area for services to port users and commercial activities. This proportion would increase in ports heavily committed to container or other highly specialized trades.

(d) Land for port industry

41. Industrial location policies are determined by the economics of manufacture and the availability of markets. Where the requirements of industry, such as raw materials, labour, sites and services lie close to an adequate market, industry will be located between the two. As industry becomes more complex, both in relation to the number and place of origin of its raw materials and to the number and location of markets, so will the criteria for the choice of industrial site. This subject has been explored in depth in many studies and this monograph can devote only limited space to the subject. In port land use planning, it is important to recognize the principal characteristics of manufacture which attract certain industrial classes to port areas:

(i) Port industry uses imported raw materials or exports significant quantities of manufactured goods.

(ii) There is a reduction in bulk or weight (or both) of imported raw materials during manufacture, bringing about significant reductions in the quantities requiring inland transport after manufacture.

(iii) The imported raw materials constitute an important proportion of the total amount of raw materials used in the process.

(iv) The imported raw materials used in the process have a low value per unit of bulk or weight in relation to the costs of overland transport.

(v) The manufacturing process adds significantly to the value of the product's unit of bulk or weight.

(vi) The imported raw materials have problems of perishability (e.g. fish) or need immediate special processing (e.g., liquid natural gas).

42. These are the prime characteristics, inferring savings from the very high cost per tonne of land transport as compared with sea transport. These savings result from the low energy 7/ and bulk transport capabilities of the sea, identifying the port more closely with the foreland for the supply of raw materials. The major aim is to minimize total transport costs by a port

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7/ Road vehicles for bulk flows achieve 54 tonne/miles per gallon of oil, railways 193 tonne/miles and ships up to 1,050 miles on the St. Lawrence Seaway. See Challenges of the Future in Port planning and development, Eds. E. Schenker and H.C. Brockel, Cornell Maritime Press, Cambridge, Mass., 1974).

location, but this objective can be obscured by other influences such as subsidization of land transport. These artificial situations must be recognized, together with the possibility of change, when artificial influences are removed. It must be remembered that the greater the number of materials or the more diverse the tonnages involved in manufacture, the less will be the influence of any one factor.

43. Port or maritime industries which have these characteristics will themselves attract other industries. Sometimes these other industries will make use of the products of the maritime industries, using the same skills or types of plant: in other cases they may supply the maritime industries with replacement plant or other services. General planning of the maritime zone must recognize all these industrial elements by providing space for them and the other activities which accompany them and their workers. The port will be concerned with industries which use the port and, in ideal circumstances, will own the land on which the industries develop. Land management policies are described later but there are prime rules for allocation of industrial sites in the port industrial area.

Choice of location in relation to quaysides

(i) Industries should not intrude on cargo handling areas unless:-

- the throughput, in tonnes per hectare, matches the throughputs of cargo handling uses;
- the industry agrees to relocate if it ceases to use the port;
- the industry is compatible with port activities.

(ii) Relative locations outside the cargo handling area depend upon:-

- the ease of cargo transfer from berth to industry;
- the total annual tonnage and the size of site;
- the throughput in tonnes per hectare.

Choice of industries, for port sites, in relation to each other depends upon:-

(i) Comparative throughputs;

(ii) Interrelationships and transfer of products;

(iii) Problems of compatability and joint use of facilities;

(iv) Conflicts and "bad neighbour" characteristics;

(v) Sizes of sites.

44. Obviously, in a successful port industrial zone, there will be intense competition for sites and the port must safeguard its own interests in terms of throughput, port income and security of traffic flow. The latter increases in direct relationship to the scale of investment by industry in the industrial site.

The port needs to look carefully at the investment in port facilities and the potential productivity of a well-designed and well-equipped berth. It follows that the frontage of the available water area will be considerably less than the length necessary to give each industry a water frontage. Ports like Rotterdam and Le Havre demonstrate industrial strip development with industry coming right up to the water frontage. Developing countries may not be able to provide such lavish port facilities and will need to provide a series of zones in their industrial areas, reaching back from the port operations zone, to make the most of the water frontages available. They may be helped by the different requirements, in terms of ship size and specialization of berths, which lead to a separation of the deeper draughted berths from the general port area. Liquid-based industry, which is likely to require deeper berths, can be supplied from the quay by pipeline and can use sites remote from the quay.

45. Estimation of land requirements for the industrial area is a difficult problem because of the great variation in ports and economies, but it is better to provide too much space than too little. With the accompanying need to segregate industry from other land uses, proper spacing of new development is essential. Probably the best way of assessing requirements is to study the size of existing industrial ports and their hinterland and industrial potential. At the upper end of the scale, the Port of Rotterdam occupies more than 10,000 hectares and serves a hinterland of 150 million people but this development is a special case with a highly favoured location and funds available for port investment on a scale unlikely to exist outside highly developed industrial societies. Comparison must rest on an industrial port resembling, in size and prospects, the port for which the comparison is being made. 8/ The comparison is facilitated if similar types of industrial activity exist, since there are wide variations in space requirements for different industries.

46. The criteria for estimation by comparison are:-

(i) Choice of a suitable industrial port or group of ports in terms of

- tonnage;
- type of industry;
- prospects;

(ii) Analysis by area and throughputs of the appropriate land uses in the chosen port;

(iii) Adjustment to allow for different balances of trade and manufacture between the comparable port and the subject port;

(iv) Adjustments to allow for any elements of obsolescence or decline in the comparable port.

8/ See R.E. Takel, op.cit., chap. V.

47. The object of the comparison is to produce a total area requirement for industrial port development which must then be planned and allocated to the different uses. This task requires more detailed information.

48. The ability to calculate individual industrial site requirements has a dual value. Not only can it give guidance in subdividing a zone allocated for port-related industry but, in the absence of the comparables needed for estimation of total area requirements, it can be used to build up a calculation of total size from the component parts. The land needed for individual industrial sites can be estimated by direct comparison, choosing a satisfactory industrial example from which to obtain data and to analyse the functions performed.

49. The most straightforward basis of comparison between industries is production, just as cargo handling areas can be compared on the basis of throughput. As we are dealing with ports, the throughput of port-related industry in cargo is also important, so analysis of industries should be used to provide statistics both of port throughput and production. These are reduced to tonnes or units per hectare of land used, with the proviso that, when used to predict requirements for new industry, we are dealing with industrial units of similar size. This is important since the component uses within an industrial unit tend to change in relative areas as industrial units become larger or smaller. A range of information derived from analysis of existing sites of different size is helpful.

50. Examples of analysis are given in chapter V (pps. 115 et seq.) and annexes I and II of Industrial Port Development (copies of which are attached). 9/ These show that oil refinery sites need from 20 hectares upwards per million tonnes of throughput; and petrochemicals, from 5,000 tonnes to 7,500 tonnes of production per hectare. Fully integrated steelworks/strip mills seem to occupy about 225 hectares per million tonnes of ore, and aluminium works 26 hectares per 100,000 tonnes of raw material input and 50,000 tonnes of production. This land requirement increases if other stages in the manufacturing process, such as extrusion, are added.

51. Most port industries have fairly low employment requirements (see annexes I and II). There is a much higher average employment density in port service and secondary industry (50 persons per hectare compared with 10 persons per hectare for prime industry). Some studies have shown that employment in port service industry equals employment in port prime industry and the relative employment densities will give an easy basis of calculation for the size of associated port service industry sites. Land for secondary industry presents a more complex problem, since such industries (with a high value characteristic) do not usually need to be in the port. Sometimes a port location can be justified, especially when there is a transport saving arising from a location next to the source of primary products, which will make the secondary industry more competitive and stimulate production by the former. Calculations of site requirements in such cases can only be made on an individual basis.

9/ Later information is scarce and may be affected by the world recession.

PART II

MANAGEMENT OF LAND RESOURCES

A. The protection of the port

1. Objectives

52. The main objectives in identifying, analysing and planning port land resources are:

(a) To make the most effective use of the port;

(b) To secure adequate supplies of land for current and future use;

(c) To locate uses in the best positions within the port;

(d) To avoid excessive land allocation for port purposes where land is a scarce resource.

53. Analysis will demonstrate clearly tne relationship between the operational capabilities of a port and its available land. It will also show up the differences in efficiency, productivity and costs between well-planned ports and others. Production of a port plan is a continuous process with influences on the port's evolution changing from time to time, perhaps even while the plan is being prepared. For this reason, there is a need for constant monitoring and updating of the plan and the statistics on which it is based. The constantly evolving demands on the port will imply additional objectives in land management:

(e) The replanning of existing facilities to cater for structural changes in trade.

(f) The replanning of existing facilities to cater for changes in operational practice and performance.

(g) The purchase of new land for port extension and the extension of facilities for

- increased trade
- increased vessel size
- new trades
- new maritime industry.

(h) The closure of redundant facilities and the disposal or redevelopment of land.

54. The solutions to these problems will be found by application of the processes described, updated from time to time.

2. Land use control

55. A port is beset by problems of competing land uses throughout its life. These problems can be internal arising from changes in port requirements, or external arising from pressures on land space from other causes. It is useless for port authorities to expend large amounts of time and effort to produce a long-term plan if they fail to maintain the consistent control necessary to protect that plan. Expediency is the enemy of sound long-term management and it is common sense, before yielding to temporary pressures on land resources, to examine alternatives and to have regard to the future. The problems of control fall into two parts - ownership and management.

(a) Ownership and land use control

56. It is desirable for a port to control all its land resources. The practice in ports will differ throughout the world and land use control policy will depend on local conditions. In France, ports are owned by the State, which has also created six independent ports (Ports Autonomes) to carry out specific tasks of industrial port policy. Outside France, large numbers of European ports are municipally owned, together with part or all of the adjacent maritime industrial areas. Other ports may be privately owned with separate and even unco-ordinated ownership of port and industrial area. The problems in land use control will increase in complexity in direct relationship to the complexities of ownership practices. These complexities will have human and administrative aspects.

57. It is obvious that harmonization of objectives and land use policies will be more difficult when port and industrial areas are in separate or multiple ownership. The human aspect of the difficulties stems from the fact that different interests in land will be controlled by different organizations or persons with different pressures on them, different objectives and different skills. The administrative difficulties will spring from aspects of organizational control and local law. If the possibility of unified ownership does not exist, much greater care must be taken in setting up machinery for co-ordination of policies and control. It may also be necessary to make provision for arbitration on differences in the event of disagreements between the separate ownership agencies.

58. The ideal ownership policy for effective land use control is single ownership of the port and industrial area. This has the following advantages:

(i) A single body to determine land use policy;

(ii) A single administration to enforce it;

(iii) A simple technical organization to advise owner and administration and to maintain continuity;

(iv) A common monitoring system.

(b) Management of land use control

59. Even with unified ownership, problems can arise from ineffective management practices. Examples of such problems include the grant of contracts to use port land for purposes which extend far beyond the economic life of the activity

and afterwards become an embarrassment and a frustration to the port. In one British port a 60-year contract was granted for the use of a 3 ha site to manufacture smokeless fuel for export. Twenty years after the contract was granted, exports ceased but because the contract contained no clauses to cover this eventuality, the port was denied economic port use of the area for a further 20 years before circumstances enabled changes to be made.

60. Land use management policies must aim at:

(i) retaining operational land in operational use;

(ii) retaining maritime industrial land in the appropriate classes of industrial uses;

(iii) ensuring that full economic use is made of areas in occupation;

(iv) making it possible to recover land from obsolescent and obsolete uses for redevelopment;

(v) phasing contracts as closely as possible to the life of the activity.

61. The first task is to identify the appropriate uses for port land as set out in the table above. Changes from these uses should only then be permitted after full consideration of factors which affect port trade and adjacent uses. It is to be expected, of course, that the boundaries of use zones will change over a long period as a result of new technology and changes in trade.

62. The second task is to set up the administrative organization for control. This should involve the appointment of specialist staff skilled in land use planning, land economics and contract law. These will have the function of advising the port authority, carrying out its land use policies and initiating programmes of control and enforcement. They will also need to anticipate future requirements and advise on forward requirements for redevelopment and extension. This role, known as land assembly, also involves examination of land use contracts so that action can be taken to recover land from obsolescent uses to create new areas of adequate size. Whilst such action might seem to bear harshly on occupiers, the cost of modern port facilities is so high and the profit margins in port operation so modest where new expenditure is incurred, that it is absolutely essential to bring port land back into full economic use.

63. The third task is to establish a basis of contract and assessment for land use contracts in the port. Unless the port authority acts only as a landlord, much of the port land will remain under its own use and control. If others occupy port land, the contract with them must be designed to encourage efficient operation within the uses for which the contract is created.

(c) <u>General contract provisions</u>

64. All port contracts for land should be drawn up to cover use, level of activity and length of contract.

65. The appropriate use of land is determined by the zoning on the master plan and the decision to grant a land use contract. This use must be precisely defined in the contract, with a prohibition against variation. This enables the

port to make future decisions on change of use, at the time the need arises, in the light of circumstances at the time. If the contract should be too loosely drawn up so that changes can be made without full control by the port, serious effects on the port might be the result.

66. A typical land contract for a port area needs to contain the following essential clauses:

(i) A precise description of the land involved with details of any associated rights such as rights of access, drainage and routes for services.

(ii) A description of all rights retained by the port such as a right of entry for inspection or for maintenance of underground services.

(iii) The term for which the contract is to run, together with any special provisions for termination.

(iv) An exact description of the permitted use.

(v) The payment to be made for the contract plus any provisions for review of payments at intervals. (Rent Review).

(vi) A description of the duties to be imposed on the user, such as:

- to use the port (with any trade guarantee);
- to repair the premises;
- not to cause pollution or congestion;
- to pay taxes;
- to guard against fire and explosion.

(vii) A description of any duties which the port agrees to undertake, such as:

- to provide services;
- to maintain berths and roads.

(viii) Provision for termination of the agreement in specified circumstances, such as:

- failure to observe the terms of the contract;
- obsolescence of the activity;
- reasons of national importance;
- major port alterations.

(d) Guarantees and the land use clause

67. Many old port land use contracts merely specified the use of the land in relation to the port without placing any physical limit on that use. This practice enabled users to reduce their use to negligible levels to the detriment of the port. Examples of this type even included activities like flour mills, occupying a quayside site. We have seen (para. 15) how expensive a quay can be to build today and, if this were to be sterilized by a falling off in activity, the financial loss to the port is the total annual value of the berth. This value must include a proportion of general port costs, such as maintenance of approach channels, locks and in-dock facilities.

(i) Guarantees

68. It is becoming much more common for land use contracts in ports to include a traffic guarantee clause which must take into account:

- The location of the site in relation to the berths and other port infrastructure;
- The realistic maximum capacity of the berth;
- The realistic maximum potential of the particular use and percentage berth utilization;
- The extent to which a berth can be used for traffic from other sources.

69. These factors must be assessed by port management before arriving at a decision on the level of guarantee needed, but practical considerations require that the actual guarantee should satisfy three basic criteria:

- It should stimulate the user to make use of the port;
- It should not be set at such a high level that the user will always find difficulty in meeting its requirements;
- It must contain its own remedies for non-performance. These could follow alternative forms. One could make the user pay the shortfall in port dues arising from failure to export or import. Another could be even more punitive by including all lost port revenue in the shortfall. A third remedy could be to remove any guaranteed allocation in respect of a berth to improve the berth's availability to other users.

(ii) Land use clauses

70. The drafting of clauses covering land use contains pitfalls which may vary according to the legal practice in different countries. The simplest use clause will bind a contractor to use port land for the importation or exportation of defined commodities. Loopholes in clauses of this type must be closed by specifying the port through which imports and exports should flow. Sometimes the installed facility will consist of a liquid storage area such as a tank farm linked with areas outside the port by pipeline. The direction of flow in the pipeline will have an important effect on port prospects. Suppose such a tank farm handles liquid imports for a factory some distance away. Unless the clause

specifies that the pipelines are to be used in one direction only, the factory could pump the liquid import in the opposite direction into the port's storage tanks after having obtained the commodity from a different port and use the facility for storage only.

71. Land use clauses should therefore be drafted very carefully since they are most important in circumstances which could not be foreseen with accuracy. They should be a plain, straightforward and unambiguous statement of what is intended, written in taut and all-embracing language and phrases, e.g.,

> "The (user) shall make use of the land defined by red colour on the attached plan only for the purpose of handling, stacking, sorting and forwarding to inland destinations, imported (commodity) which shall have been imported through the Port of ('X') over the quay indicated by blue colour on the said plan."

(iii) Works resumption clauses

72. In general, port users requiring land use contracts will need contract terms that enable any necessary capital investment to be written off over an adequate length of time. This length of time will also take into account the forecasted life of the trade. It is in the interests of the port to foster long-term trading relationships and this implies a stable basis of contract terms. There will be occasions, however, when land use arrangements will necessarily occupy sites where there is a risk that a need for port extensions or alterations will arise. In other cases, a port may permit some of its land to be used for purposes unconnected with the port, merely as a "catch crop", to obtain income on a short-term basis to help the port's finances.

73. In such cases, ports include a "works resumption clause" in the contract. This enables the port to terminate the contract in specified circumstances, if, for example, the land is needed for new works construction or for development connected with the trade of the port. Obviously, such clauses need technical justification at the outset and are difficult to negotiate. Users usually refuse to accept a simple right to terminate and ask for other rights to be built into the contract. These include monetary compensation for the loss of any capital investment and provision for the award of an alternative site.

3. Land purchase policies

74. The policy of land acquisition for port development will vary from country to country. In some, ample or even excess areas will be made available as a result of national policy; in others, the port authority may have to compete with other interests to secure enough space for its minimum needs. In most cases, especially with ports which have developed over a long period, the port will find itself in need of further land for expansion, or owning land which is surplus to requirements. The basic decisions on the extent of land ownership for future needs will be matters of law, finance or convenience. It is always convenient to own land for port extension well in advance of requirements, because ownership will remove one of the factors which could hold up commencement of development. It may not be possible to produce financial justification for purchase of land, if the development date cannot be forecast, because of the effect of capital expenditure incurred too far ahead of the date when income is expected. State law and practice may, on the one hand, encourage ownership

of all foreseeable requirements from the beginning. On the other hand, some State law may impose taxation or other penalties on owners of reserve land for which no projects exist. This is particularly likely to occur in those States with a high density of population or where land capable of general development is confined to the coastal strip. Sometimes the planning law of a State enables land to be "zoned" or reserved on a planning map for a particular use such as port development. In such cases the need to protect forward port planning by land acquisition is removed as a result of the law.

75. The decision of a port to purchase land for future development is affected by all these considerations. Where ownership of future port areas is not a fixed policy of the State, the port must weigh up the technical advantages of early purchase against the cost to the port. This calculation will be influenced in favour of early purchase if the port has opportunities of obtaining revenue from other uses between the date of purchase and date of development. Another influence in favour of early purchase is the risk of unpurchased and unreserved land being put to other uses, which will either increase the cost of eventual purchase or increase the difficulties of acquisition. A particular factor in some States is the effect of inflation on land values. If the rate of increase in land values, plus potential income, exceeds the rate of interest on the purchase price, early purchase is recommended, i.e.

Where

Capital value of land	= V
Rate of annual inflation in land values	= R
Annual interest on V	= i
Annual income from land before port development	= r

Then if

$R + r$ exceeds i

land purchase at cost V is justified at an early stage.

76. Where there are no financial or legal pressures on a port in relation to forward land purchase then the port policy on land purchase is dictated by convenience. The period of advance purchase will then depend upon the problems of making the land available in time for the anticipated port development. It may help to summarize the considerations which apply in such a case:

- The forecasting period: this is seldom less than five years.
- The legal and administrative procedures involved and their time scale.
- Whether or not the land is occupied for other purposes and the time necessary for re-locating occupiers and obtaining possession.
- Whether any preliminary works of preparation and consolidation are needed ahead of development, such as:

reclamation or raising levels;

providing drainage services or other infrastructure.

- The time taken to investigate, research and design the proposed works.

- The time needed for construction, and the date by which the dock works have to be completed.

77. These comments will not apply to those countries where port land allocation is a matter of State policy. In either case, ports should hold sufficient land for requirements at least five years ahead.

4. Surplus land

78. From time to time most port authorities will find themselves in possession of land which is surplus to requirements. The decision on what to do with this land depends on whether it is permanently or temporarily surplus. Obviously, if such surplus land comprises a small "island" surrounded by land in operational use, its future redevelopment for other port purposes is inevitable. There are, however, circumstances in which a false surplus of operational land may arise. 10/ This occurs during changes of trade when low density cargoes may give way to high density cargoes which require much less space in transit areas. In such cases the interest of the port requires that the freed land should be considered a reserve area to be brought back into cargo use when there is a further change in the nature of trade.

79. Permanent surpluses of land arise when docks become obsolete and it is necessary to construct new berths in a different location so that the centre of operations moves. Such circumstances arise when a port develops down river or towards deeper water. It is always necessary to examine obsolete areas carefully to see if they are capable of redevelopment for port-related purposes, because of the difficulties of repurchasing such land after disposal. If land is genuinely surplus, the port has to decide how to deal with it. In general, surplus port land contains port structures and infrastructure as well as water areas and will require considerable expenditure to restore it to other economic use. Because most ports lie in or near towns, the need for redeveloping surplus land is paramount. In some cases the State may have policies for dealing with obsolete areas, in others the port authority must decide whether it has the skills, the resources and the time to devote to redeveloping surplus land for other purposes. In most cases extensive involvement in such activities can divert attention away from the main business of the authority, deprive the port of capital required for its main business and affect the efficiency and single-mindedness of the port.

10/ See figure 9.

B. Relationships between port and community

1. The nature of external relationships

80. As well as technical problems, ports have to adjust to human and political influences and their skill in dealing with external relationships can often contribute greatly to the success of their development. As a service industry, a port's existence arises from external factors and a successful interpretation of these factors will ensure that the port does not outstrip the demands of its users and will make for financial success.

81. External relationships can take many forms. They include the inter-reactions and stimuli between port and hinterland which arise from industrial growth, market demand and economic circumstances, creating pressures on the port to expand, improve or reduce services. They also include the relationships between the port authority and the formal representation of its hinterland in the form of regional or even national governments and councils. The former stimuli produce situations which require technical solutions and an understanding of the principles already discussed; the latter have their own particular effect on the land use policies of the port.

82. Obviously, the port must have regard, in land use planning, to the nature and extent of influences from its hinterland and foreland. These dictate the types and levels of trade which will require facilities. Often there may be competition from a number of ports for a share of available trade, with the possibility that the share will reach equilibrium, provided that ports remain on the same basis of comparison with each other. The development of the port involves relationships with regional and national bodies, and those with particular importance for land use include:

(a) Co-ordination of national, regional and port objectives;

(b) Development of communications;

(c) Competition for scarce resources including land.

2. Co-ordination of national, regional and port objectives

83. The nature of expertise available to different bodies will vary according to the functions of those bodies. If such a body requires advice outside its own level of expertise, it must seek out the most qualified source available. It is the duty of a port to make sure that its own type of expertise is made available to government bodies and others so that the decision-making process is well-informed. The port can be greatly affected by decisions of national and regional government so that constant vigilance of events and official liaison is necessary. The responsibility for vigilance rests on the port, which is in the best position to recognize its best interests. Typical decisions on policy at regional and national government level, which can affect the demand for a port's services and, through that, its land requirements, include:

(a) The national policy for investment in ports.

(b) Conservation. The choice of areas close to ports for conservation and the restriction of some port activities. Policies of this sort usually arise from strong political pressures but factual guidance from the port on effects or controls can often be of significance.

(c) Industry. Industrial units are becoming larger and the need for more finance for industrial development brings in government investment. Political pressures on government can often influence the areas in which such investment is made.

(d) Most modern countries undertake town and country planning to secure the best use of land resources. This task usually devolves upon regional governments which will need expert maritime advice concerning the demand and potential of ports in their area and their relationship with structure plans.

3. Development of communications

84. A port is part of the chain of communications between hinterland and foreland. It may be the only port or it may be one of a series. Because it is a part of communications, it is greatly affected by the nature and quality of the other parts of its particular chain. The maritime part is influenced by shipping and other factors but, for the purpose of this paragraph, we are concerned with the communications investments within the control of state or region. In some countries, such as the United States, France and Belgium, where the State undertakes dredging of ship channels, it has a maritime influence, but the landward network provided by the State for distribution or collection is a vital factor. Where there is only one port, an efficient land link with the market will have important effects on costs for imports and exports and, hence, upon the national and regional economy. In turn, this will affect the demand for land by encouraging investment and growth. Where there are a number of ports, their comparative attraction will depend upon their relative distances from the market and the efficiency of land transport links. A port should always be in a position to advise regional and national government of its changing needs and of the improvements in communications which may be required.

4. Competition for scarce resources

85. The demand by a port for land is highly specialized: land for its development or expansion must be sited near suitable maritime channels and structures. These structures are extremely expensive to provide so that, if they already exist, there are strong financial reasons for not changing location. If they do not exist, suitable sites for their construction are becoming increasingly scarce because of the emerging demands of shipping for deeper water and specialized facilities, including land space. In some cases, there may be competition for such sites because of the lack of any alternative space for non-maritime development or for leisure purposes. This may spring from such factors as a dense population, a small total land area in the State, or physical and climatic conditions where a mountainous or arid interior confines development to coastal areas. In other cases the economic characteristics of a prosperous seaport often attract developments of a non-maritime nature wishing to take advantage of the pool of skilled labour or to sell to the large market which exists. Common sense indicates that a highly specialized use should be allocated to the site which has the required special characteristics

and that development which does not require these rare characteristics should be located elsewhere. The same logic also dictates that, if seaport development is to go ahead, space must be provided for it to do so; if the seaport is to be allowed to expand with growth of trade, the expansion area should be provided. Where there is extreme shortage of space and compromise is necessary, the compromise should be based on a full study of the ways in which adverse affects on the seaport can be minimized. In all these circumstances, it is for the port to watch its interests and to take the initiative in providing objective information and advice on requirements. It is for the State to give proper weight to the importance of seaports and associated development for the national economy.

Annex I

ANTWERP: PORT INDUSTRIES - LAND USE ANALYSIS, January 1969

Industry	*Products*	*Annual Production Capacity (tons)*	*Employment*	*Area* (ha)	*Area (acres)*	*Tons per* ha	*Tons per Acre*	*Employees per* ha	*Starting Dates*
Oil Refining									
S.I.B. des petroles	All petroleum products	14,000,000	860	192·7	481	72,900	29,160	4·5	1951
Esso Belgium	All petroleum products	5,000,000	350	130	325	38,500	15,400	2·7	1953
Raffinerie belge	All petroleum products	2,400,000 (4,400,000 in 1970)	625	30·1	75	80,000	32,000	21	1934
International oil	All petroleum products	1,000,000	250	5·1	12·7	19,600	7,874	50	1935
Albatros	All petroleum products	2,250,000	270	120	300	18,750	7,500	2·25	1968
Anglo Belge	Intermediate products	40,000	100	2·3	5·75	17,400	6,960	44	1925
		24,690,000	2,455	480·2	1,200	53,500	21,400	5·1	
Petrochemicals									
Petrochim	Ethylene-oxide	20,000	650	30·4	76		11,900	4	
	Ethylene-glycol	12,700							
	Cumene	30,000							
	Dodecyl-benzene	8,500							
	Propylene	100,000							1951–68
	Ethylene	500,000							
	Aromatics	150,000							
	Cyclohexanes	85,000							
		906,200							
	Synthetic rubber S.B.R. and polybutadiene	55,000		14·7	36·5	3,800	1,520		1968
Union Carbide	Polyethylene (low density)	100,000	383	10·1	25·3	16,000	6,400	3.8	1962–68
	Ethylene-oxide	62,000							
	Glycols, etc.								
	Polyoxylalkylene-glycols and polyols	120,000	250	35	87·5	3,430	1,370	7.1	1968
	Acetic acid esters								
	Industrial gases O_2, N_2, Argon								
		282,000							
Amoco Fina	Lubr. additives Polyisobutylene	6,000	50	10·1	25·3	600	240	5	1961
Distrigas	Cracking plant and storage of gas	6,000	80	6·0	15	1,000	400	13	1958
Polyolefins	Polyethylene resins (high density)	30,000	75	6·0	15	5,000	2,000	12·5	1968
	Manolene resins								
	Marlex resins								
Polysar Belgium	Butylrubber	27,000	250	9·9	24·7	2,725	1,090	25	1962
U.S.I. Europe	Polyethylene (low density)	50,000	270	12·0	30	775	310	10	1968
			380	53·0	132				second phase
		1,362,200	2,388	187·2	467·3	5,670	2,918	13	
Chemicals									
Bayer	Caprolactam	70,000	600	180 (only 36 built upon)	450 (90)	2,470 (gross)	988 (gross)	3·3	1967
	Ammonium sulphate	350,000							
	Sulphuric acid	180,000				12,400 (net)	4,960 (net)		1968
	Perlon fibre	7,000							
		607,000							

[see over

Source: Published statistics of the Port of Antwerp.

ANTWERP: PORT INDUSTRIES - LAND USE ANALYSIS, January 1969 (continued)

Industry	*Products*	*Annual Production Capacity (tons)*	*Employment*	*Area* (ha)	*Area (acres)*	*Tons per* ha	*Tons per Acre*	*Employees per* ha	*Starting Dates*
B.A.S.F.	Caprolactam	60,000	1,500	455 (200 built over)	1,137 (500)	3,500 (gross) 7,900 (net)	1,400 (gross) 3,160 (net)	3·3	1967/8
	Ammonium sulphate	150,000							
	Nitrophoska	600,000							
	Vinoflex	50,000							
	Lupolen	30,000							
	Polyethylene (low density)	30,000							
	Nitric acid	325,000							
	Sulphuric acid	145,000							
	Vinyl chloride	110,000							
	Chlorine	80,000							
		1,580,000							
Monsanto Europe	Plasticizers Breach preventers Rubber chemicals		80	102	255			0·8	
Quaker furans	Furfurol	11,000	25	1·6	4	6,870	2,750	16	1968
Solvay	Chlorine	65,000	—	100	250	1,650	660		1970
	Caustic soda	100,000	—						
Degussa	Decolourizers Hydrocyanic acid White fillers		800	109	272	—	—	7·4	1970
		2,363,000	3,005	947·6 (548·6)	2,368 (1,371)	4,300	1,700	5·5	
Motorcar industry (various)	Cars	280,000			573		690 cars per acre	56	
	Tractors	30,000	13,000	231·9			1,070 tractors per acre		
	Radiators	110,000							

Annex II

LE HAVRE: INDUSTRIAL DEVELOPMENT: AREAS AND EMPLOYMENT, 10 February 1970
(Source: Published statistics of the Port of Le Havre)

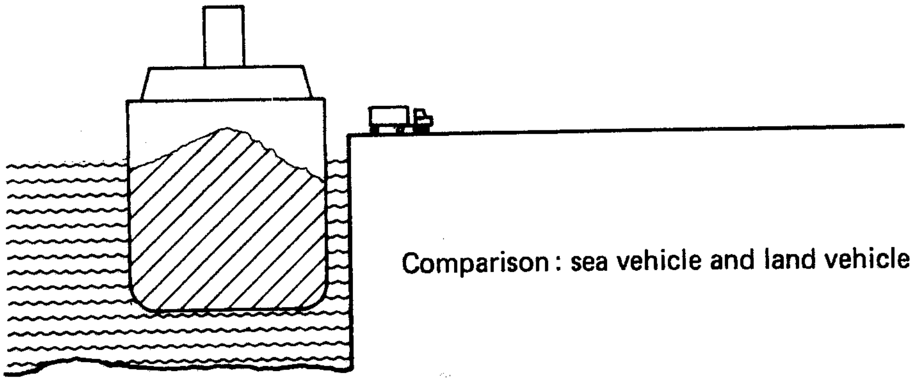
Industry	Date of Commencement	Area occupied	Employees 1.1.1970	Employees per ha	Employees per Acre
West of Junction Canal:					
Nickel treatment plant		7 ha. 40 a. 30 ca. plus option on 1 ha. 54 a. 13 ca.	—		
Metal coatings, shot-blasting and boilermaking	April, 1964	32 a. 20 ca.	12	37·5	15
Petrochemical plant	Sept., 1966	26 a. 19 ca.	21	8·0	32
Timber wharf and stockyard	Nov., 1966	1 ha. 29 a. plus Bassin Stockage 1 ha. 66 a. 02 ca.	6	4·5	1·8
Chemical plant (titanium oxide)	End, 1957	19 ha. 87 a. 44 ca.	520	26	10·5
Timber wharf. Tropical hardwoods including treatment	April, 1962	17 ha. 69 a. 76 ca. plus timber pond 2 ha. 52 a. 27 ca.	576	32·5 (excl. pond)	13
Ship and industrial woodwork	End, 1962	16 a. 54 ca.	25	150	60
Mechanical workshops (industry and shipping)	1957	70 a. 32 ca.	70	100	40
Tank cleaning plant	1959	1 ha. 39 a. 68 ca.	20	14·5	6
Chemical plant (sulphuric acid)	End, 1957	14 ha. 82 a. 54 ca.	43	2·9	1·2
Tank farm: petroleum products	1947	11 ha. 02 a. 48 ca.	87	8	3·2
Central generator	April, 1968 End, 1969	32 ha.	185	5·8	2·4
Public warehouses	1930	5 ha. 20 a.	720	138	56
Cold stores	1928	1 ha. 75 a. approx.	79	45	18
Ship repairing	(a) 1959 (b) 1962	27 a. 50 ca. 21 a. 94 ca.	} 309	790	320
Tank farm: Latex and animal and vegetable oils	1947	3 ha. 07 a. 42 ca.	41	13	5·3
Mechanical workshops	July, 1968	2 a. 40 ca.	23	950	380
Liquid natural gas storage and re-gasification	1965	9 ha. 80 a. plus 6 ha. 75 a.	32	1·9	0·8
Tank farm: petroleum products	1949	(a) land 87 ha. 67 a. 30 ca. (b) water 31 ha. 13 a. 70 ca.	264	3 (excl. water)	1·2
West of Bridge 8 and North of Tancarville Canal:					
Fitting out workshops	1952	3 ha. 66 a. 60 ca.	302	80	32

[see over

LE HAVRE: INDUSTRIAL DEVELOPMENT: AREAS AND EMPLOYMENT, 10 February 1970 (continued)

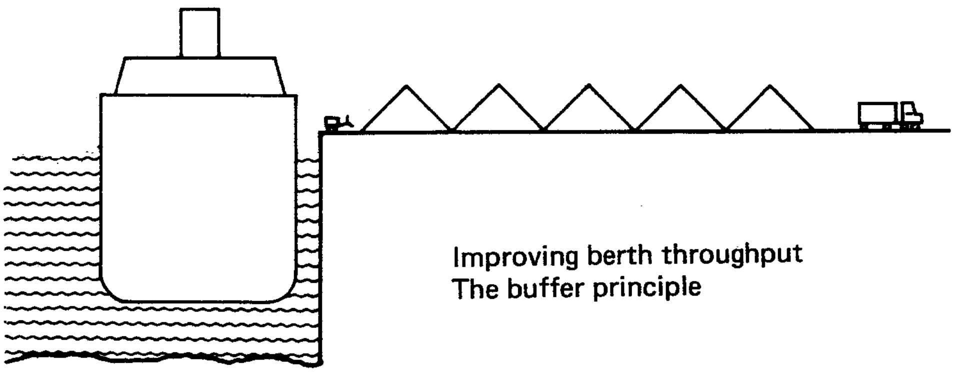
Industry	*Date of Commencement*	*Area occupied*	*Employees 1.1.1970*	*Employees per ha*	*Employees per Acre*
East of Junction Canal and North of Industrial Route:					
Butane and propane bottle filling centre	July, 1952	3 ha. 22 a. 75 ca.	79	24	10
Storage and distribution of liquid petroleum gas	1954	1 ha. 45 a. 94 ca.	1	0·66	0·27
Fuel oil storage	1966	1 ha. 11 a. 55 ca.	—		
Petrochemicals	Dec., 1958	18 ha. 98 a. 56 ca.	252	13	5·3
Petrochemicals and lubrication additives	Dec., 1958	18 ha. 58 a. 30 ca.	245	13	5·3
Refinery and petrochemicals	1933	421 ha. 70 a. 43 ca. (1968: 33 ha per million tons) (1970: 30 ha per million tons)	1,765	4	1·6
Petrochemicals	July, 1969	24 ha. 83 a.	15	0·6	0·24
Petroleum storage and blending	1970	5 ha. 97 a. plus option on 6 ha. 10 a.	—		
Storage of materials and ferroconcrete	Oct., 1969	3 ha. 06 a.	3	1	0·4
Storage of materials	Oct., 1969	99 a.	1	1	0·4
Chemicals (synthetic rubber)	April, 1963	21 ha. 97 a. 69 ca.	156	7	2·8
Car assembly	Jan., 1965	155 ha. after extension	5,452	35	14
Pipe warehouse	Sept., 1967	1 ha. 15 a.	35	30	12
Distribution centre. Brewery warehouse	May, 1969	2 ha. 04 a. 22 ca.	64	31	12·4
East of Junction Canal and South of Industrial Route:					
Metal wrapping and packing factory	Sept., 1958	2 ha. 41 a. 99 ca.	156	64	26
Petroleum products storage	1971	8 ha. 82 a. 40 ca. plus option on 10 ha. 91 a. 72 ca.	—		
Chemicals and fertilizers	1970	42 ha. 21 a. plus option on 25 ha.	257	6	2·4
Liquid gas storage	1970	5 ha. 06 a.	—		
Chemical storage	Jan., 1970	3 ha. 08 a. 50 ca. plus option on 3 ha. 95 a. 50 ca.	7	2·3	0·9
Petrochemicals	1970	65 ha. 76 a. plus option on 43 ha. 24 a.	—		
Cement works	1969	40 ha. 64 a. 63 ca. plus option on 19 ha. 35 a.	100	2·5	1
Grand total (all four areas)		1,067 ha. 42 a. 77 ca.	11,923	11·17	4·5

Figure 1



Comparison: sea vehicle and land vehicle

Figure 2



Improving berth throughput
The buffer principle

Figure 3
LINKAGES BETWEEN FORELAND AND HINTERLAND

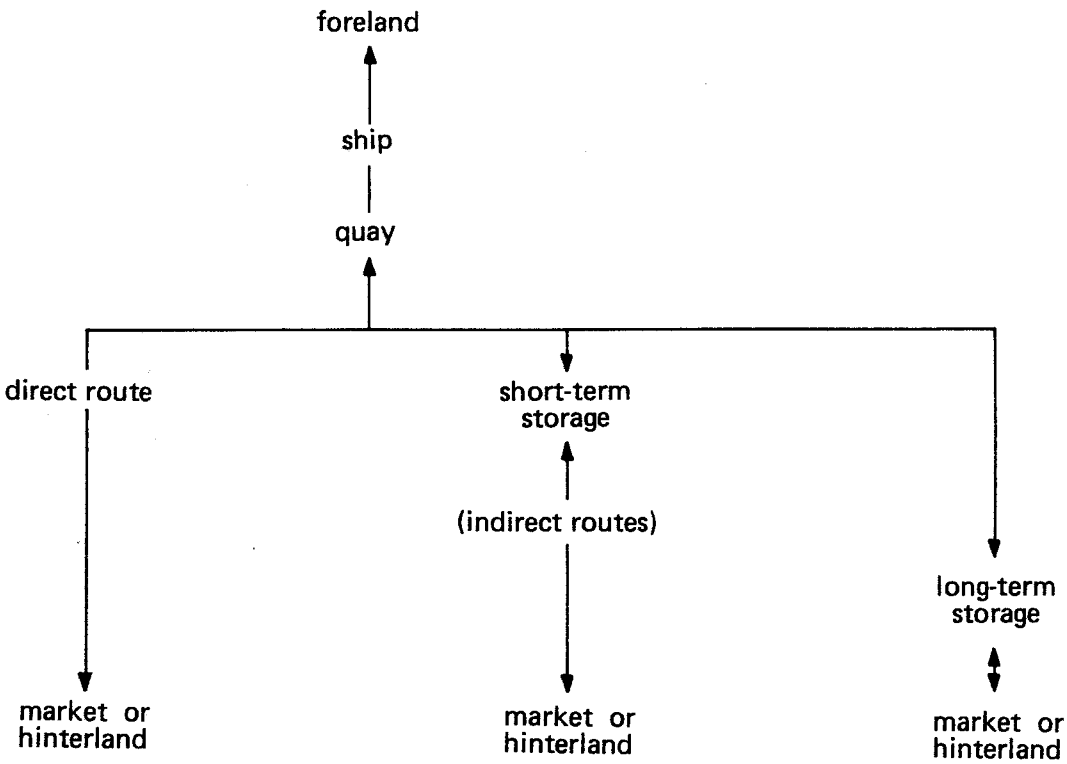


Figure 4
THE THREATENED PORT

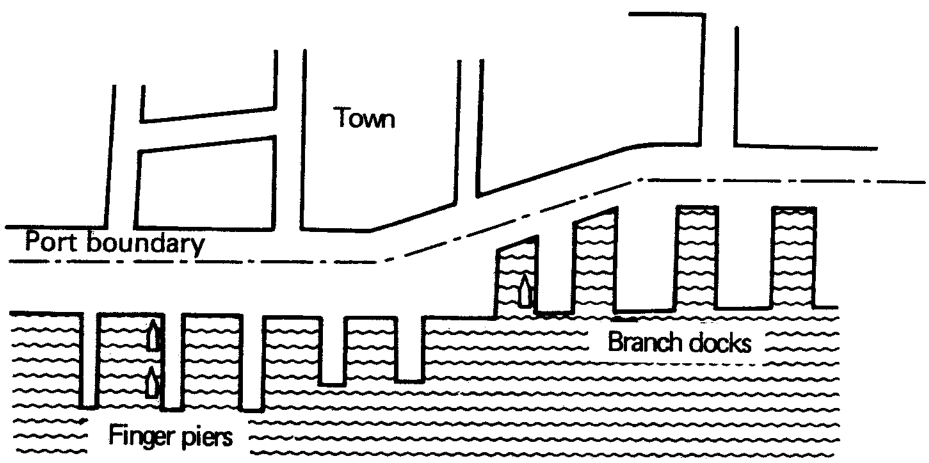
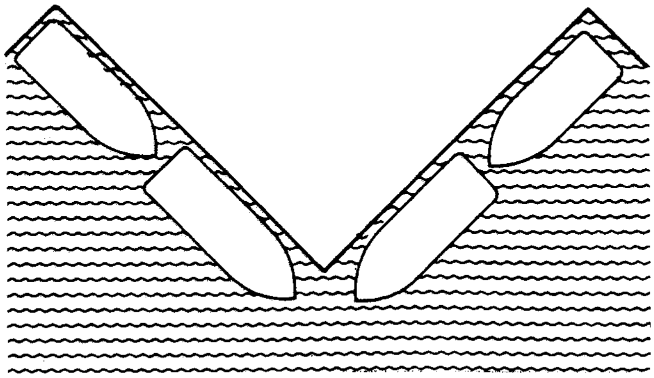


Figure 5

a)



b)

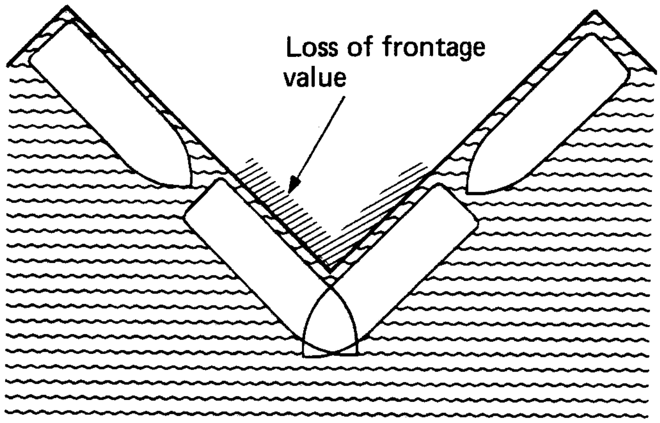


Figure 6

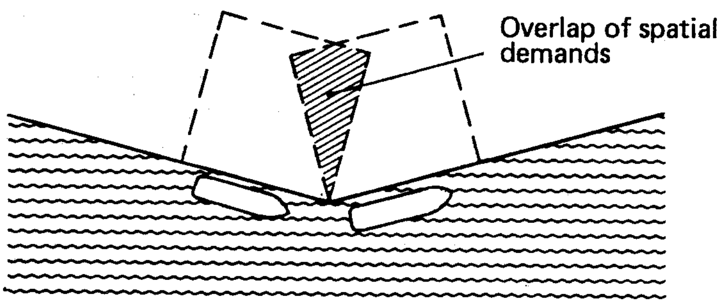
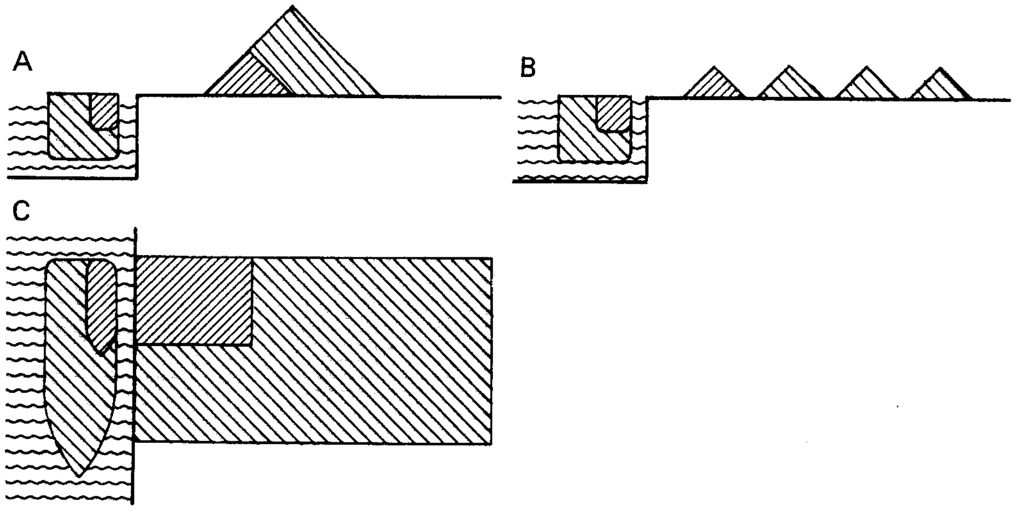


Figure 7



A Increased stacking height and increased ground strength

B No increased stacking height and no increased ground strength

C Area increases in proportion to volumetric increases in ship size where there is no increase in stacking height

Figure 8

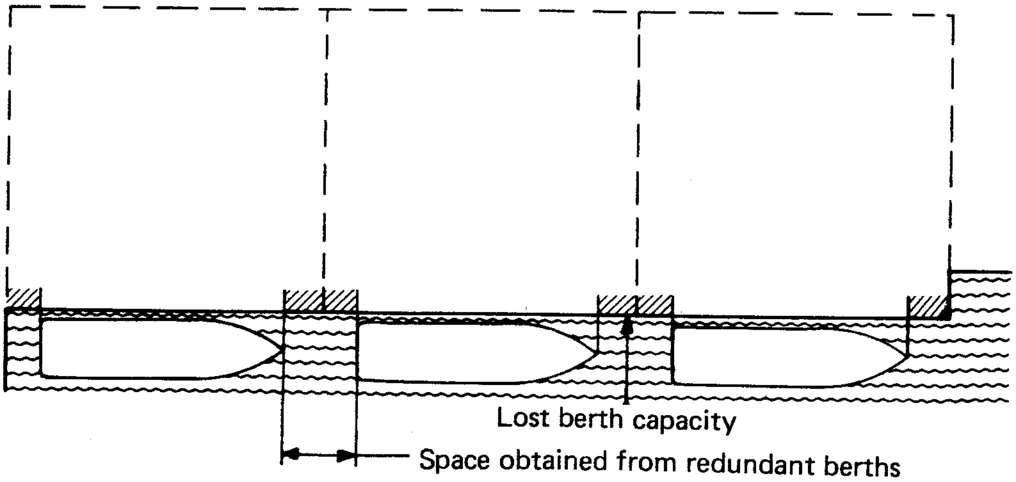


Figure 9

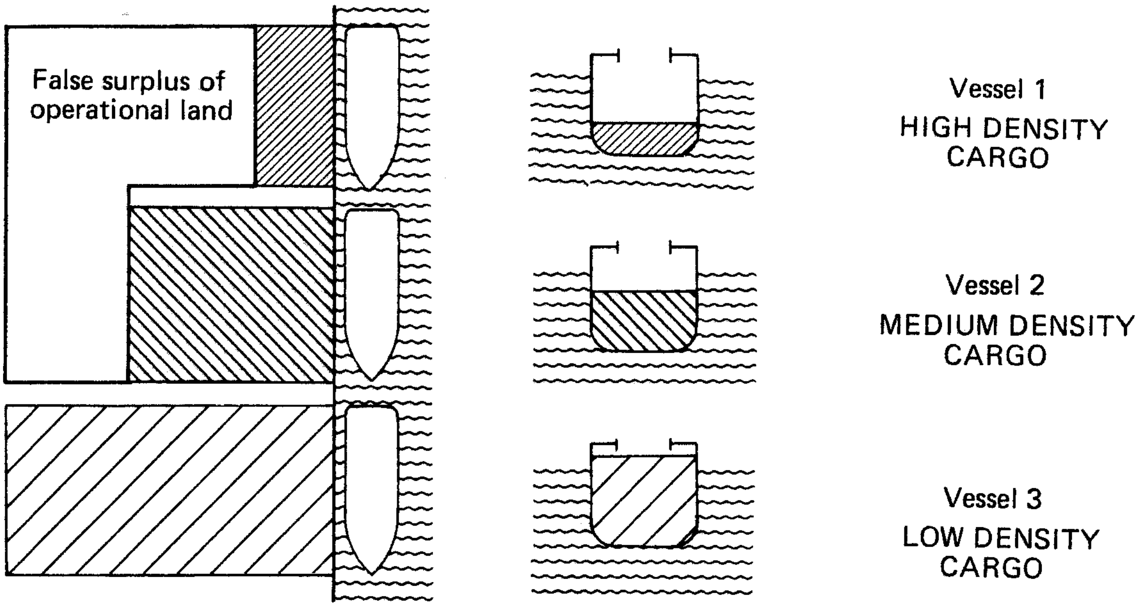


Figure 10

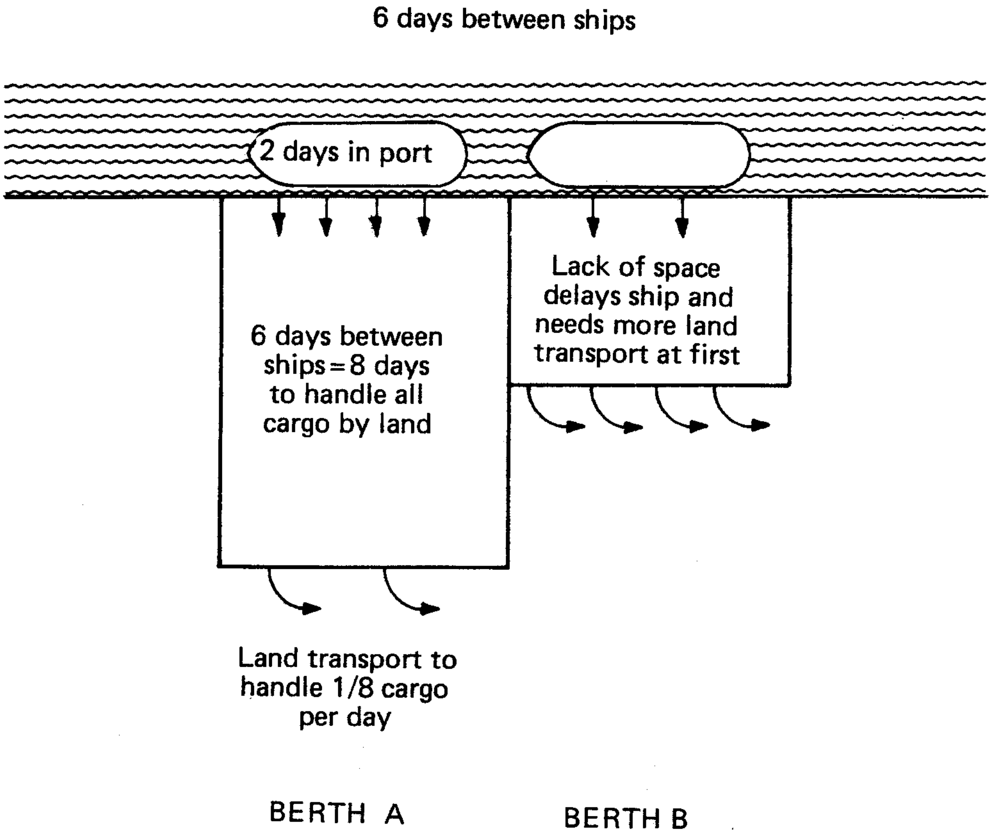
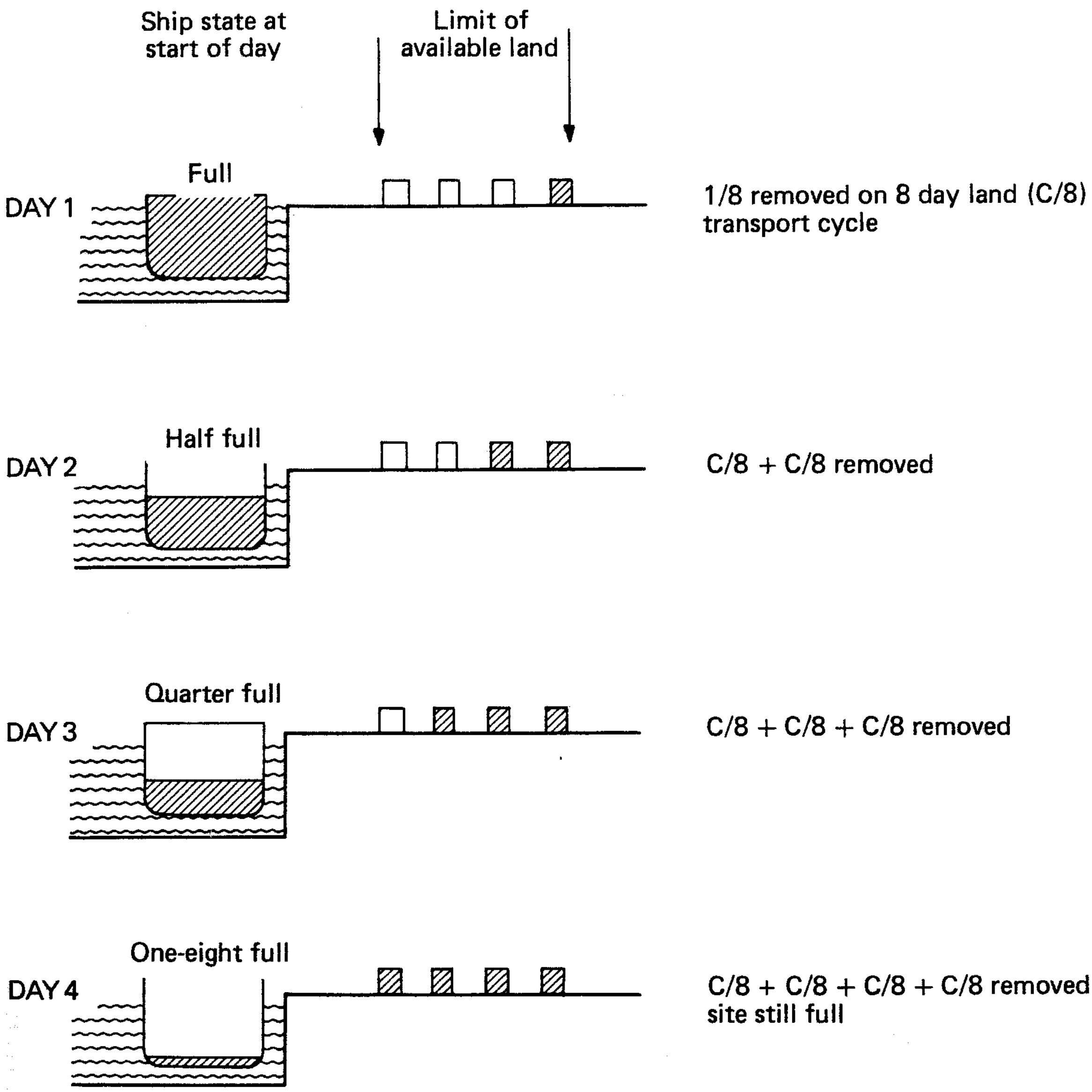


Figure 11

EFFECT OF INSUFFICIENT LAND ON CARGO HANDLING PRODUCTIVITY



Source: Takel, R.E., *The Structure of Ports* (to be published).

Figure 12
RESERVATION FOR PIPE OR CABLE SERVICES

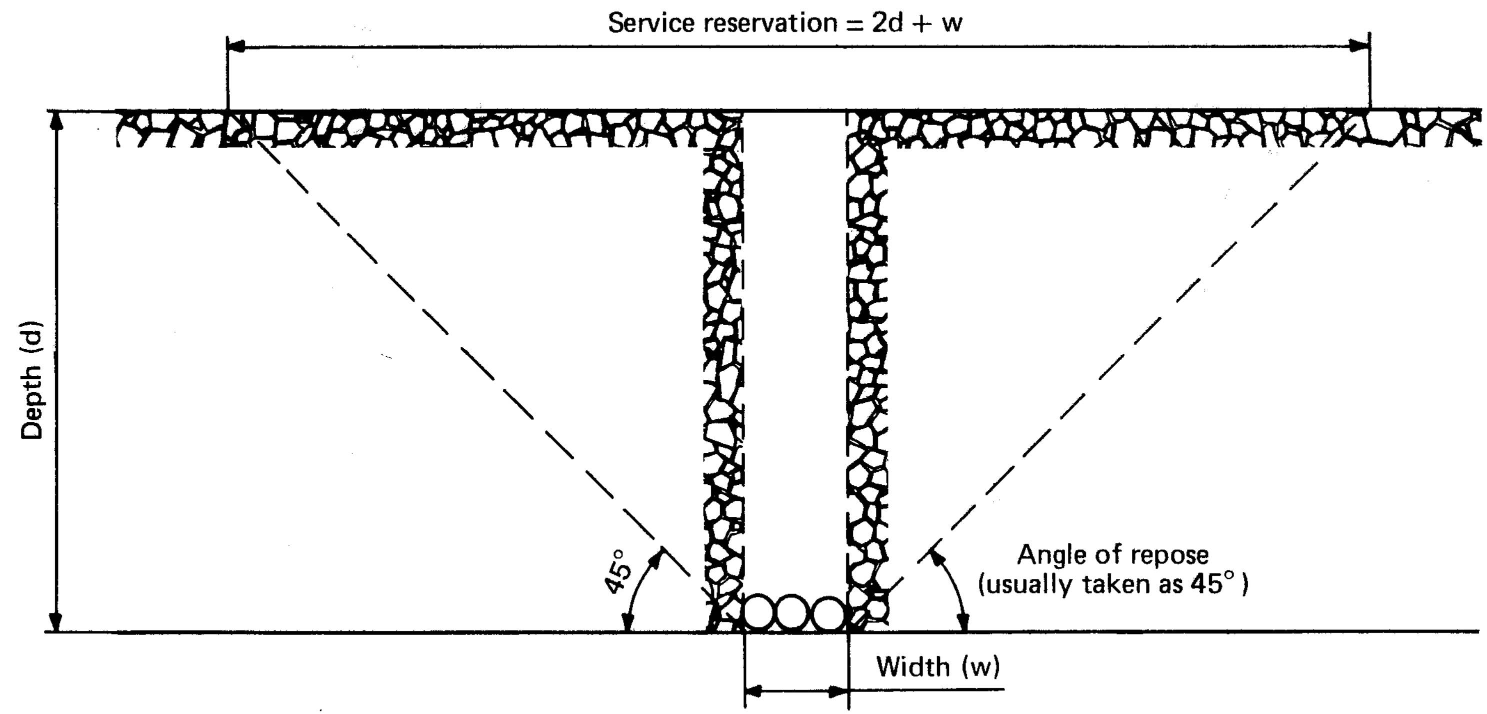
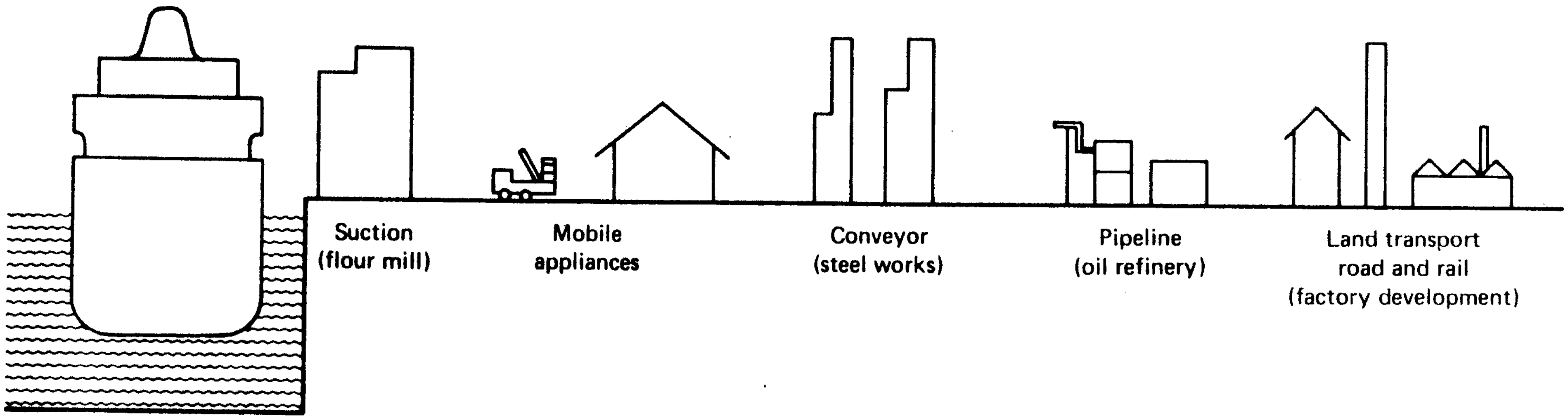


Figure 13

RELATIVE LOCATION DEPENDS ON CARGO HANDLING PROBLEMS



Aspects of port land requirements. Based on Takel, R.E., and Thomas, B.J., Port Training Module <u>Cargo operations and port storage</u> (Geneva, UNCTAD, 1979).

Figure 14

MARITIME INDUSTRIAL LINKAGES
STEEL AND OIL

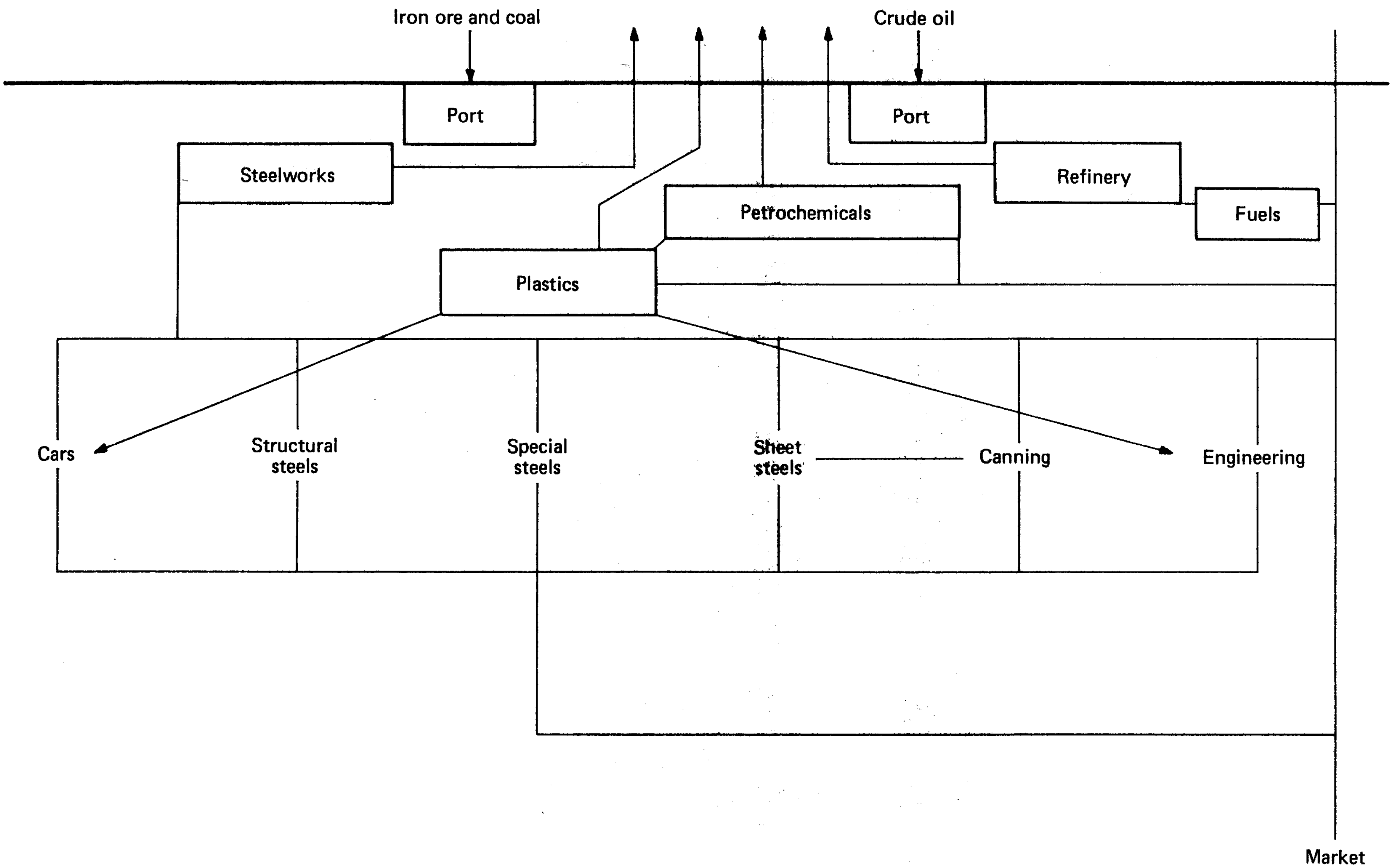


Figure 15
PORT DEVELOPMENT
EVOLUTION OF A LAND USE PLAN