Application of approximate performance indicators for master planning of large ports

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Introduction

A port master plan provides a framework for the future development of a port with its terminals, logistic zones, industrial areas, and main transportation infrastructure. The master planning process generally consists of four main steps:

1. The investigation of strategy and objectives in terms of shipping, logistics, and industrial development. The forecast of future developments, including shipping and inland traffic flows.
2. The translation of these objectives into requirements, expressed in land surfaces for various purposes, required waterfront and related back-up areas for various types of terminals, nautical access and port basin requirements, engineering requirements, and various other requirements related with inland transport connections, safety, environmental aspects and landscaping, etc.
3. The translation of these requirements into alternative concepts for major port components considering physical and environmental conditions.
4. The selection of an optimum long-term master plan, with an indication of the logical timing of the various phases of development.

In an ideal situation, the future users of a (new) port area would all be known. Step 1 and 2 of the planning process would result in an excellent set of port development requirements, based on well-thought plans of the individual future users. When a major new port is intended for one specific type of service, for example a large container terminal, this nearly ideal situation may occur indeed. Steps 3 and 4 can then be carried out on a very solid basis using various simulation techniques, in close consultation with the future user(s). An example of such a situation is the planning of the Pusan Newport in Korea (see Figure 1).

Figure 1. Pusan New Port, Korea.

Table 1: Productivity indicators for approximate planning purposes

Major steel plant (crude steel production, slab casting, rolling mills, etc.):	0.014 Mton/ha/year
Refinery complex:	0.10 Mton/ha/year
Petrochemical industries (mix of larger and smaller plants):	0.011 Mton/ha/year
Mix of various mid-range industries (such as cement industry, pulp industry, fertiliser plants, etc.):	0.015 Mton/ha/year
Major shipyard complex (new-building capacity for large ships):	8,000 DWT/ha/year
Port terminals and related facilities	
Main new container terminal:	16,000 TEU/ha/year
Quay main container terminal:	1,200 TEU/m^1/year
Quay feeder/barge terminal:	750-500 TEU/m^1/year
Quay for break-bulk cargos:	3,000 ton/m^1/year
Logistic park for value added service or light manufacturing:	2,500 TEU/ha/year
Container empty depots:	9,000 TEU/ha/year
Large port rail terminal:	18,000 TEU/ha/year
Major coal/ore terminal:	0.20-0.60 Mton/ha/year
Grain terminal:	0.5 Mton/ha/year
Tank farm for crude oil:	storage capacity 3 ton/sq m
Tank farm for oil products:	storage capacity 1.7 ton/sq m.

However, port planners will not often encounter the ideal situation indicated above. Potential future port users including port related industries, will generally only make up their mind or disclose information as to their specific developments in a certain region when the basic port infrastructure has been constructed (or will definitely become available in the near future). The promoter of a large port project must then use the best possible judgement for developing a sound master plan. Given the various uncertainties, zoning and planning must be as flexible as possible for accommodating various possible scenarios.

Approximate performance indicators

An important component of Step 2 of the planning process involves the translation of the basic objectives into requirements expressed in land surfaces and length of waterfront and related back-up areas for various types of terminals. For such assessments one may use general performance indicators, if no actual data on the planned projects in the region are available. From various sources the port planner should derive a number of average productivity indicators that relate the surface area of particular main types of industries or port activities to the total "production" per year in the area concerned. These performance indicators are expressed in million ton per hectare per year (Mton/ha/year) or mTEU/ha/year for port logistic operations. As the figures are estimated from actual situations, they take into account that even in the ultimate development of a port or industrial zone, not all sites are optimally used. Areas kept in reserve for future extension and possible chances of original plans will result in less than optimal use of certain sites.

Remarkably, the average productivity indicators for quite different type of industries (for instance in the field of cement production, wood pulp production or in the petrochemical sector) are of the same order of magnitude.

For translation of the shipping (cargo flow) forecasts into quantitative requirements expressed in length of waterfront similar performance indicators can be used expressed in number of TEU handled per m^1 quay per year (TEU/m^1/year) or Mton/ m^1/year for other types of cargo.

Some productivity indicators for approximate planning purposes are presented in Table 1.

The annual quay or "waterfront" capacity of various types of marine terminals (for crude oil, oil products, coal, grain, etc.) largely depends on the general ship sizes and arrangements for handling such trades in a particular port. Some order of magnitude figures are:

Crude oil tanker terminal:	0.055 Mton/m^1/year
Oil products tanker terminal:	0.017 Mton/m^1/year
Oil products barge terminal:	0.009 Mton/m^1/year
Major dry bulk terminal:	0.025 Mton/m^1/year

The area productivity indicators shown above generally allow for internal roads and services in the sites concerned.

For assessing the total (ultimate) land area requirement of a new port (or major port area extension) one should also take into account the areas needed for public infrastructure, general port services, commercial services, green zones, etc. In general about 65-75 % of the overall (gross) port area will be available for allocation to the various logistics and industrial users. Of course, the water surface areas for access channel(s), turning basins, port basins, service ports, etc. should be considered separately.

Examples of actual planning of large ports

Nansha Port, China

The first components of a new Chinese mega-port are under construction in the Nansha Port area, located in the Pearl River Delta at about 50 km southeast of the city centre of Guangzhou and 75 km northwest of Hong Kong. Nansha lies in the centre of the Gauangzhou-Hong Kong-Macao triangle, a part of China with a concentration of producers and consumers and large economic growth.

For the project, extensive areas will be reclaimed in the form of two islands, Wanqingsha and Longxue Island. Longxue Island, the most easterly island (located along the deep water channel), has an area of about 6,500 ha and is the location of the new port in addition to providing space for industrial, commercial and residential developments. Major additional industrial zones with an overall area of 3,000 ha are planned on Wanqingsha. Deepening of the navigation channel in the Pearl River Delta is

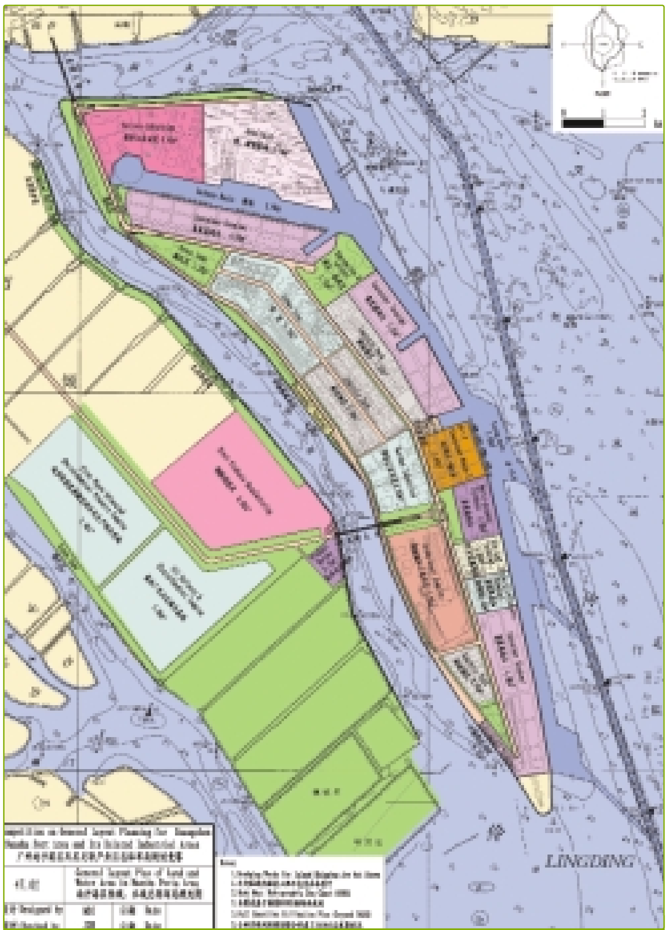

Figure 2. Masterplan of Nansha Port, China.

foreseen to make Nansha accessible for the latest generation of container vessels as well as for tankers and bulk carriers of up to about 150,000 DWT. The works currently under construction include a 1.5 million TEU container terminal, multi-purpose terminal and major reclamation works, whereas a 2x3 lanes access road and bridge connection are already completed.

Economic studies revealed the huge potential of the region and its new port. The study of the industrial and logistic framework and the traffic and shipping forecast provided the main long-term objectives and requirements. However, few data as to actual terrain or waterfront requirements on a project-by-project basis were available. For the preparation of the master plan as shown in Figures 2 and 3, the port planners used performance indicators as discussed above in addition to other types of analyses.

In the plan, the main bulk and oil terminals are located at the southern side of Longxue (closest to the sea) and the development of the container and multi purpose terminals is foreseen towards the north, starting from the location in the middle of the island where the first container terminal is under construction already. The most northerly part of Longxue Island is reserved for a major shipyard. The western areas include a steel plant complex, various industries, logistic parks, a new residential zone and green zones.

As stated earlier, a good balance must be struck between the land areas reserved for industrial and commercial development and the related length of the waterfront needed for port facilities. In this case the best solution was to "artificially" extend the easterly (deep water) shoreline of Longxue Island by a dredged basin of 500 m wide and ultimately 6,000 m long, as will be apparent from Figures 2 and 3. The plan also envisages the construction of combined coastal and inland navigation berths, along two basins of 200 m wide and 700 m length. These basins are oriented at right angles to the main container terminal waterfront and also lengthen the waterfront for shipping purposes. The location of berths for

Figure 3. Bird's eye view of Nansha Port.

coastal-inland shipping within the zone of the main container terminals itself is favourable. It will reduce the distances of inter-terminal transport of containers and will provide the terminal operators with good control over all shipping operations.

The transport infrastructure envisaged on Longxue island itself includes a main 100 m wide central transport corridor with 2x3 lane highway, double railway track, lane reserved for dedicated container transport vehicles, a pipeline and cable corridor and green strips. A secondary corridor is envisaged to consist of a landscaped avenue running through the residential area and extending into the zones for logistic services and related business establishments (such as trade centre, offices for maritime services, port recreational facilities, etc).

The project involves huge dredging and reclamation works. For the development as shown in the figures, the reclamation volume is about 500 million m^3. In the planning of the phasing of execution of the project, particular attention was paid to balancing the volumes of dredging (from the access channel and the port areas) with the reclamation material requirements.

El Sokhha Port, Egypt

In the El Sokhna area, located along the Red Sea, approximately 45 km south of Suez and the entrance to the Suez Canal, the Egyptian government has allocated 9,000 hectares of land for economic and industrial development. This area is referred to as the Suez Special Economic Zone (SSEZ), targeting the increasing industrial demands of the region and capitalising on the strategic location near the Suez Canal. A number of companies have already selected this location for establishing a plant.

In the direct vicinity of the SSEZ, the first phase of a new deepwater port (El Sokhna Port and Logistical Centre) has been constructed, consisting of the breakwater protected port entrance and a single dredged basin, with terminals for handling containers, general cargo, dry and liquid bulk cargoes. An area of 1,000 ha has been reserved for the ultimate development of the port zone.

The main requirements for El Sokhna Port for the target year 2020 were based on the results of economic studies, considering different development scenarios. Berth and area requirements were assessed on the basis of capacity calculations in addition to using performance indicator figures.

Figure 4. Masterplan El-Sokhna Port, Egypt.

The master plan of this port, selected on the basis of a multi-criteria analysis of various alternative concepts, is depicted in figure 4. The plan consists of two long (dredged) basins in an east-west direction, connected by a north-south basin. The North Basin is expected to satisfy the requirements until the year 2020 or even later. It has two side basins of which the one closest to the port entrance is already completed. Beyond the 2020 stage, major additional port facilities will be located along the proposed South Basin, providing the plan with considerable flexibility to cater for future demands.

Conclusion

The art of a port planner is to make a satisfactory master plan on the basis of unsatisfactory (or at least insufficient or uncertain) data. The use of performance indicators may help in the planning process, but obviously that should not replace the execution of detailed studies on the aspects concerned, whenever possible. To the knowledge of the author no expert system has been developed yet which could replace the imagination of an experienced port planning and engineering team to generate the most attractive concept on the basis of a given set of requirements and local conditions.

ABOUT THE AUTHOR

Max Schreuder holds a MSc in civil engineering and has over 35 years experience as consultant in the field of ports, waterways and related subjects. He started his career in 1964 with Frederic R. Harris and joined the DHV Group in 1972 where he headed the ports and waterways section. Currently he is senior port planner with DHV.

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