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PLANNING OF TERMINAL CONSTRUCTION AT THE PORT OF PLOČE

ABSTRACT

The paper presents a systematic and comprehensive analysis of both the technological justification for the construction of a container/multi-purpose terminal and a dry bulk terminal, and the efficiency of loading/unloading facilities. The organisation of Croatian ports is inefficient and the technology used in outdated. Traffic links with the mainland, the continent and the world are unsatisfactory, with traffic infrastructure impacting adversely on operational efficiency. Analysis results of the present condition of port traffic and the influence of traffic on port operations and development indicate that the Port of Ploče lacks a multi-purpose terminal that would enable modern container traffic. Because of the inefficient cargo-handling procedure and manner of storing bulk cargo in the Port of Ploče, it is necessary to plan the construction of a coal and iron ore terminal taking into account spatial, technological, economic and ecological development factors. The authors also examine the importance of regional initiatives spurring the development of Croatia and, in particular, the port system as part of the EU's Pan-European transport corridor V Branch C. Research results are presented by a traffic and technological design for a container/multi-purpose terminal and dry bulk terminal capable of providing an appropriate level of service for all terminal users.

KEY WORDS

the Port of Ploče, container/multi-purpose terminal, dry bulk terminal, Corridor Vc, traffic and technological design.

1. INTRODUCTION

The development of technologies for transport, trans-shipping, storage and handling of cargo has led the ports to become increasingly specialised for specific purposes and for specific types of cargo. The first degree of specialisation involves port-to-port unitised cargo; and the final form is the automated monitoring of cargo from sender to recipient, including all operations and changes in transport. Hence, the technical and technological facilities of a port need to be adjusted to world trends and made capable of undertaking activities that are today carried out in the developed countries.

The World Bank plays an important role in the development of Croatian ports by supporting regional development through several development projects. One such project, aimed at improving the capacity, efficiency and service quality along Pan-European Transport Corridor Vc focuses on the Port of Ploče as the corridor's gateway.

The technological changes to marine cargo transport, together with the trend of global containerisation, indicate the need for investments which would help to integrate the Port of Ploče in the world flow of goods; this involves the construction of a container/multi-purpose terminal on Dock 7. The Port dry bulk terminal is no longer appropriate due to obsolete unloading technology and storage facilities. The construction of a new terminal taking into account environmental protection measures and using modern cargo-sprinkling technologies will help to improve the terminal efficiency.

2. FEATURES OF THE SPATIAL ENVIRONMENT AND ASSESSMENT OF THE CURRENT CONDITION

2.1 Assessment of the current condition, opportunities and limitations in building a container terminal

The microlocation of the container terminal has been defined based on an analysis of the port geographical position, which features easy access from the sea, protection of the basins of Quays 5 and 7 against adverse meteorological and hydrographic influences, easy access from the land by road/railway, the vicinity of required municipal infrastructure, and sufficient space for expanding the terminal.

Having minor impact on its environment, this location in comparison to the existing facilities will shield the town, as polluters will be located farther away. A berth, 280m in length, will form the future Quay 7 with a depth of 13.5m, on the bed of which a RO-RO ramp is to be constructed. In the loading/unloading zone, equipment capable of serving third generation container vessels will need to be installed. The terminal, covering an area of about 100,000 sq. m. will include a zone for unloading/loading vessels and railway cars, a storage zone, servicing zone, areas providing basic infrastructure (roads, power supply, telecommunication) and a RO-RO zone.

The construction of a container terminal will improve the offer of the Port of Ploče by providing:

- a new berth, 280m in length, capable of accommodating vessels of the highest maritime demands, up to 60,000 DWT and with no limitations to sea-gauge. The berth will be able to service either one vessel of 60,000 DWT or two smaller vessels;
- a new zone for storage and handling, with an area of about 15.4 hectares, to be used by the container terminal having a capacity of 100,000 TEU/ /year.

2.2 Assessing the current conditions and planning of traffic supply and demand

In the planning and design stage, an evaluation of the Port traffic opportunities is essential for input factors to be correctly assessed and to ensure efficient utilisation in later stages. This involves an assessment of the current situation based on the standing of the facilities relative to traffic, the traffic supply and overall traffic. This relationship is evaluated based on traffic capacity, levels of service and final asssessment. Attention is focused on critical points, that is, factors exerting negative influence on valorisation, and factors that might begin to affect adversely the traffic function of the facilities or the surrounding traffic network in the future.

The Port of Ploče encompasses several trans-shipment terminals for handling dry bulk, general cargo, container cargo and liquid cargo. Its transport network consists of a main road branching out into a number of connecting roads, which represent the handling areas of the terminal, and as such, they serve more than one function. Due to outdated traffic infrastructure, the current situation regarding trans-shipment and storage within the port cannot be assessed as satisfactory.

Constructing the terminal and linking it to the traffic network will properly connect all parts of the port connected with the border crossing, making the new roadway into the port main road. This will help to reduce the number of conflict points, improve security and enhance the rationalisation of processes within the port. The traffic design of the container terminal provides for an appropriate level of services to all terminal users.

Through planning, the Port of Ploče is preparing for the future. The planning process should coordinate the uncertainty of traffic intensity, cargo structure and the conditions that allow for planning major investments. With strategic planning, these uncertainties can be overcome, performance can be secured and a mode of economic behaviour established that would minimise the risks involved in the port development.

2.3 Traffic analysis and development projection of the Port of Ploče

Representing a major economic force, seaports play an important role in the world and national economics and in international trade. The primary task and purpose of ports is to connect land-based and maritime traffic, supplemented by numerous activities in the port. Port activities reach deep into a country hinterland; hence, events occurring in a port may have strong repercussion on the economy of the entire

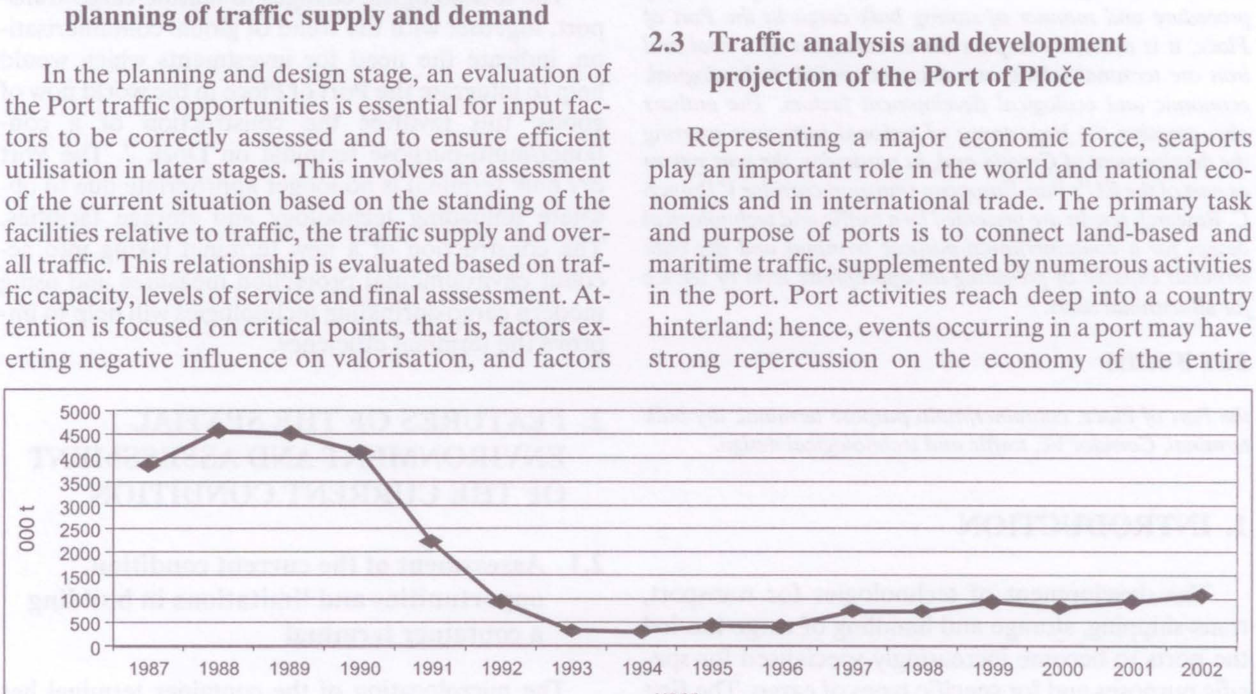

Figure 1 - Turnover in the Port of Ploče 1987 - 2002

Source: Port of Ploče Statistics

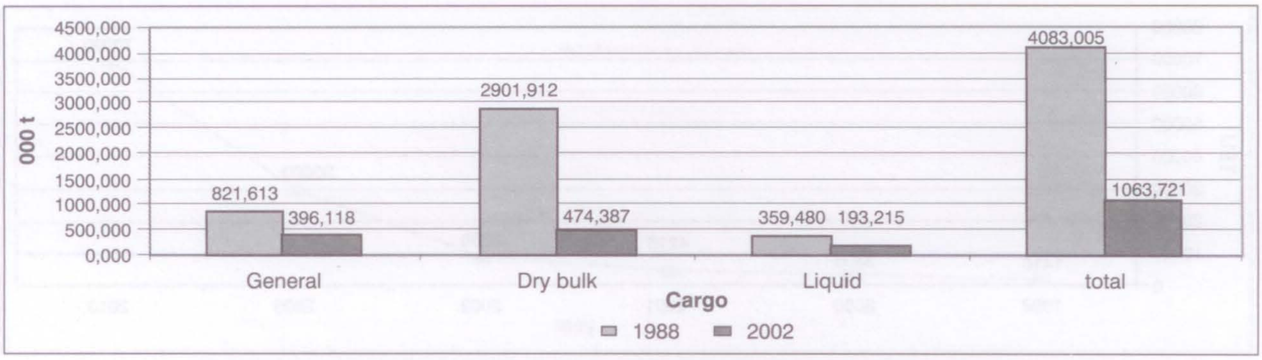

Figure 2 - Comparison of turnover in the Port of Ploče for 1988 and 2002

Source: Port of Ploče Statistics

country, and even that of other countries [8]. In the period 1987 – 2002, the Port of Ploče saw a substantial drop in traffic. Nevertheless, there has been a steady growth since 1994 (268,000 tons), reaching 1,063,000 tons in 2002. The highest turnover amounting to 4,554,000 tons was achieved in 1988, and the objective of the Port of Ploče is to reach and exceed this peak (Figure 1).

The comparison of the years 1988 and 2002 shows that the total turnover in 2002 amounted to only 26% of 1988 turnover. The reason for this is that dry bulk cargo traffic in 2002 accounted for not more than 16% of 1988 levels; general cargo traffic, for 48%; and liquid cargo traffic, for 54 % (Figure 2).

The years 2003 and 2004 marked the continuation of an upward trend in container traffic in the Port of Ploče. The volume of container traffic in 2004 reached 14,121 TEU, whereas in 2003 it amounted to 8,638 TEU. Most of the containers were handled through two feeder lines connecting, on a weekly basis, the Port of Ploče with Gioia Taura and Taranto (Italy), Malta, the Croatian Port of Rijeka, and Bar (Serbia and Montenegro). In 2003, some 525 vessels berthed at the port's wharfs and accounted for 1,284,049 tons of cargo turnover, a 21 % increase over the previous year. This growth pattern continued into 2004 with a turnover of total of 2,031,000 tons of various types of cargo (Table 1).

Table 1 - Turnover in the Port of Ploče per type of cargo (1988 - 2004)

	1988	1991	1994	2000	2003	2004
General Cargo	881	521	206	266	420	346
Dry Bulk Cargo	3336	1356	39	417	675	1518
Liquid Cargo	360	336	23	121	189	167
Total	4577	2213	268	804	1284	2031

Source: Statistics of the Port of Ploče Authorities

The next section provides an estimate of the physical volume of traffic in the Port of Ploče for the short-term planning period 2004 – 2013 for all types of cargo (Figure 3).

Planning indicators show that an increase in traffic is predicted for all types of cargo. According to the plan, by 2013 the total volume of traffic should grow to almost 70% of 1988 volume. Considering the growing volume of container traffic (which increased sixfold in the period 1999 – 2002) and the impossibility of using the existing capacity of Quay 3, the construction of a new terminal should lead to the rationalisation of trans-shipment processes (Figure 4).

The container terminal's annual trans-shipment capacity is estimated at 100,000 TEU, with the possibility of expanding to 200,000 TEU/year as foreseen in the port long-term development plans.

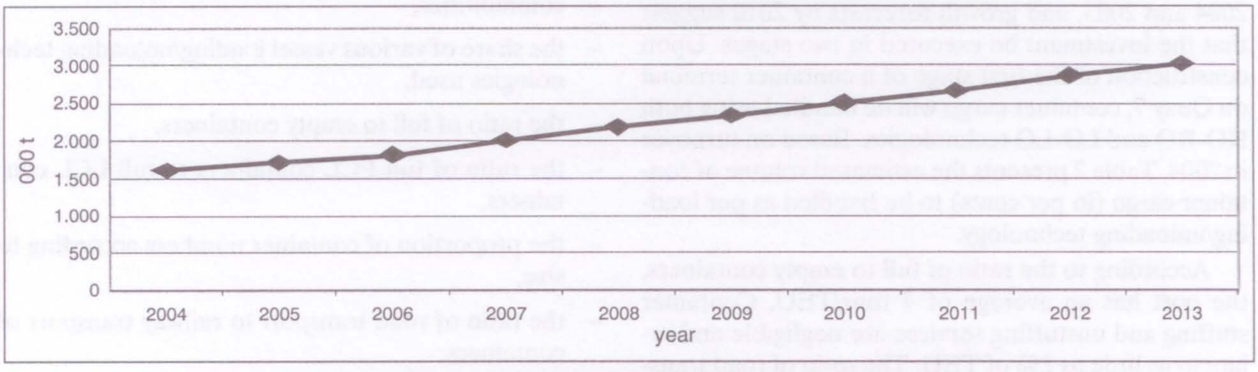

Figure 3 - Projected turnover for all types of cargo 2004 - 2013

Source: developed by the authors according to Port of Ploče documentation

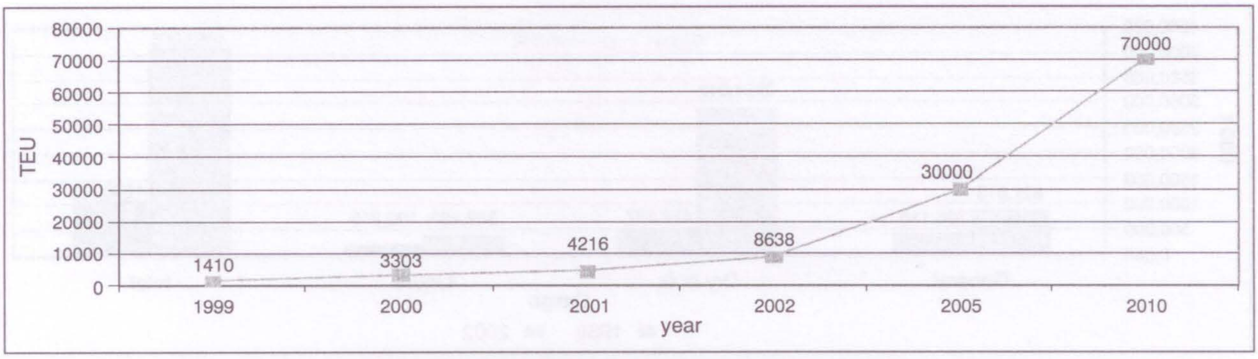

Figure 4 - Realised andplanned container traffic

Source: developed by the authors according to Port of Ploče documentation

3. SPECIFIC TECHNOLOGICAL FEATURES AND CAPACITIES OF THE CONTAINER/MULTI-PURPOSE TERMINAL

3.1 Expected performance of the container terminal

A port container terminal is a part of its system that represents a specifically constructed and equipped facility for the loading/unloading of containers through direct or indirect handling between sea vessels and transport means on land. A container terminal connects at least two transport systems, and for its successful operation specialised trans-shipping facilities are required. A multi-purpose terminal represents the best solution for a transition period in which conventional general cargo and containers will be handled [2]. This reduces the risk involved in major investments as well as the risk of making unreasonable investments. The main features of multi-purpose terminals are their flexibility as a result of their design, and efficiency as a result of the way they are organised.

Because the Port of Ploče lacks the specialised equipment of LO-LO technology needed for handling containers, transport has been carried out using RO-RO technology. An analysis of container traffic in 2004 and 2005, and growth forecasts by 2010 suggest that the investment be executed in two stages. Upon construction of the first stage of a container terminal on Quay 7, container cargo will be handled using both RO-RO and LO-LO technologies. Based on turnover in 2004, Table 2 presents the estimated volume of container cargo (in per cents) to be handled as per loading/unloading technology.

According to the ratio of full to empty containers, the port has an average of 7 tons/TEU. Container stuffing and unstuffing services are negligible and relate to as little as 2% of TEU. The ratio of road transportation to railway transportation in shipping containers is 20/1.

Table 2 - Ratio of container quantities according to cargo-handling technologies

	Container cargo group	Quantity[%]
1	LO – LO	2
2	RO – RO	98
	Container cargo group	Quantity [%]
1	Light (up to 5 t) empty	20
2	Heavy (up to 35 t) full	80
	Container cargo group	Quantity [%]
1	TEU 20″	45
2	TEU 40″	55
3	Other	-

Source: Port of Ploče

The planned container capacity per construction stages is:

- 40,000 TEU/upon the first stage of construction
- 100,000 TEU/ after the terminal has been complete.

To ensure the accuracy of forecasts, it is necessary to consider the frequency of incoming vessels, the volume of TEU units per arrival and departure, and user numbers from a variety of aspects relating to:

- commodities,
- the share of various vessel loading/unloading technologies used,
- the ratio of full to empty containers,
- the ratio of full FCL containers to full LCL containers,
- the proportion of container numbers according to size,
- the ratio of road transport to railway transport of containers,
- the ratio of number of day to number of containers at the terminal.

3.2 Container terminal technology and work process

In the dock area, loading and unloading cargo from land to marine transportation facilities and vice versa is a complex technological process, which, together with the production of port services involves a great number of people with specifically defined tasks. To service two quayside rails, it is necessary to build a new railway siding, which will be used as a temporary solution in the first stage of operation, until a turnover of 40,000 TEU/year is reached, upon which the terminal operations will become highly specialised. Mobile multi-purpose harbour cranes are used for loading/unloading containers onto and off vessels. When container traffic reaches 40,000 TEU/year, a transporter container-loading bridge will need to be acquired. When this volume of traffic is exceeded, a second transtainer will replace the mobile harbour crane. A terminal consisting of a 280--metre berth and two container cranes is capable of transporting one million tons of cargo or 80,000 – 100,000 TEU per year, given an acceptable berth occupancy rate of 50%. Of the four technological systems normally used in transporting and handling containers, the port terminal container will use reach stackers in combination with heavy-duty forklifts in the central warehouse. This is necessary to allow for the gradual introduction of transtainers when turnover reaches 40,000 TEU/year. When this volume peaks at 100,000 TEU/year, transtainers will become the primary storage transport equipment. In all stages, heavy-duty tractors-trailers units will be used for transporting containers to and from the quay. This approach is supported by UNCTAD as being the most economical for countries opting for transitional solutions and using the infrastructure for multiple purposes until full containerisation has been achieved.

Reach stackers in combination with heavy-duty forklifts (Front- and Loder System) are capable of stacking containers four in height, in a block two container-widths deep on each side. The utilisation rate of storage space is fairly low when using this type of equipment. With an average stacking height of 1.5 TEU for inbound containers and 3 TEU for outbound containers, utilisation rate of some 275 TEU//hectares can be achieved, given a 50:50 ratio (inbound/outbound). Although recommended for developing countries, this system finds it difficult to support a turnover volume greater than 50,000 TEU//year. In combination with a tractor-trailer, three reach stackers/forklifts are required to service one transporter container-loading bridge/mobile crane. Being general-purpose, this equipment can be used in other areas as well, although they do exert considerable pressure in areas with traffic. Upon the terminal completion, the use of transtainers (RTG) will increase the utilisation rate, making it possible to achieve up to 750 TEU/hectare given a 50:50 ratio of inbound and outbound containers, with an average stacking height of 2.5 TEU for the former and 3.5 TEU for the latter. A minimum of four transtainers is needed to service two quayside transtainers. Upon the construction of a railway siding, heavy-duty forklifts and/or reach stackers will be used for loading/unloading railway cars; if greater distances are involved tractor-trailer systems can be employed. As container traffic grows, a transtainer will need to be acquired. For transporting containers to and from the CFS warehouse, as well as for other internal transporting needs, combinations of the previously mentioned transporting equipment will be required. For handling purposes within the CFS warehouse and for other jobs, conventional machinery used in transporting general cargo should be applied. The container-handling procedure at the terminal must focus on efficiency, thus minimising the berthing time of vessels.

3.3 Terminal spatial features

The overall area of the Port container terminal, covering 128,000 square metres, consists of the following microlocations: a berth, a central container warehouse and CFS container warehouse, and a LCL warehouse to be constructed in the next stage.

The essential technical and technological features of the terminal are listed in Table 3.

Enclosed warehouses require an area of 4,000 m^2 for stacking and unstacking. This is possible providing the stack coefficient is 0.75 and the surface load 4 tons/m^2. It follows that the capacity of enclosed warehouses amounts to:

$$4{,}000\, m^2 \times 0.754 \times t\,/\,m^2 = 12{,}000\, t$$

The area of the warehouse for cooler containers is dictated by the need to accommodate 64 TEU stacked one or two high. The dimensions of all other areas are determined according to capacities (entry complex, roads, parking lots, service areas, and others, Table 8). In the final stage, it will be possible to stack 6,384 TEU in up to 4 levels at a time using transtainers (Table 4).

By stacking containers four high at the quayside railway point, it will be possible to store 608 TEU units at a time (Table 5).

In the first stage, the terminal container will be able to hold 2,640 TEUs, and in the final stage, a total of 6,992 TEUs stacked four high. Railway transport vehicles at the container terminal will consist of cars normally used by Croatia railways, or similar cars from other countries, such as:

Table 3 - Features of microlocations in the container terminal area

	Berth
	The length of the berth is about 280 metres, its sea-depth 13.5 metres. A vessel of 60,000 DWT or a PANAMAX container vessel can be berthed. Subject to the characteristics of quayside machinery and container transport technology, the width of the quayside zone is estimated at 40 metres.
	Central container warehouse
	In the first stage, container storage technology is suggested that requires about 15 m¸/TEU for stacking containers three-high using reach stackers/forklifts. Taking into account the lower operational stacking height, which is dependent upon the number of container moves prior to transport/destination, weight, direction(inbound-outbound), type and regularity of the ship line, a height factor of 0.7 is applied. Providing containers are held in the port for 15 days, an area of about 40,000 m2 is needed for storing 40,000 TEU, after the first stage of construction. This area is capable of holding about 70,000 TEU if transtainers are used in storage operations.
	Given the same input and with the use of transtainers, planned for the final stage (for 100,000 TEU/year) requiring about 10m¸/TEU, the storage area should be approx. 60,000 m2 .
	CFS warehouse
	The handling area per TEU unit is 29 m¸.
	In the final stage (100,000 TEU) in which the warehouse will be built, 5,000 TEU/year are planned to have LCL status.
	Transit holding time of goods – 10 days.
	The factor taking into account vehicle access and operations in the warehouse amounts to 0.4, meaning that more space is required.
	Spatial reserve 25%

Source: the authors according to Technological Study: The Port of Ploče Container Terminal, Rijeka projekt d. o. o., Rijeka 2004.

Table 4 - Calculation of quantity of TEUs stacked our high at the terminal

One high	38 x 7 x 6 =	1.596	TEU
Two high		3.192	TEU
Three high		4.788	TEU
Four high		6.384	TEU

Source: developed by the authors according to Technological Study: The Port of Ploče Container Terminal, Rijeka projekt d. o. o., Rijeka 2004.

Table 5 - Calculation of quantity of TEUs at thequayside railway station

One high	38 x 4 x 3 =	152	TEU
Two high		304	TEU
Three high		456	TEU
Four high		608	TEU

Source: developed by the authors according to Technological Study: The Port of Ploče Container Terminal, Rijeka projekt d. o. o., Rijeka 2004.

1. biaxial flatcars Kgs – z,
2. four-axial flatcars Rs – z,
3. four-axial flatcars for container transport Rgs – z, Regs,
4. special flatcars Smmps – tz, Sgss.

Truck transport vehicles commonly used at container terminals include trailer trucks and other trucks of various carrying capacities.

4. TECHNOLOGICAL FEATURES AND CAPACITY OF DRY BULK TERMINAL

The dry bulk terminal requires a location different to that of the multi-purpose terminal and an appropriate sea-depth of the port basin. This terminal specific requirements refer to area size, port infrastructure, types of loading/unloading machinery and types of storage areas.

Its operational organisation and size of the workforce required also differs from that of a general cargo terminal. Due to a higher share of mechanisation and automatisation used in loading, unloading and storing cargo, cargo transfer technologies are simpler and fewer workers are needed. When the port reaches a yearly turnover of two million tons of cargo, a special dry bulk terminal will need to be constructed and equipped with specialised high-performance port installations. Modern cargo-handling technologies should be applied in the terminal.

4.1 Assessment of the current location of the dry bulk terminal

The present location of the dry bulk terminal allows for a limited volume of turnover. It handles the unloading of dry bulk for "Mital Steel", Zenica; "GIKIL", Lukavac; "Dalmacijacement", Split; and Zvornik.

In the first six months of 2005, the turnover of the "Cargo", the Ploče branch of *Hrvatske željenice (Croatian Railways)* came to 1.1 million tons, or only 100 thousand tons less than in the previous year. June of 2005 saw the transit of more than 185 thousand tons of cargo. According to types of commodities, coal, aluminium oxide and alumina make for the majority of cargo. The reasons for this substantial increase of turnover are linked to production that has started in factories in Bosnia and Herzegovina, namely in "Aluminij", Mostar; "Birač" in Zvornik, and at the "GIKIL" cokery in Lukovac. This upward trend is also visible in container and fuel traffic, with the start-up of integral production in Zenica, which will result in the improved performance of the Port of Ploče. Under current conditions, the dry bulk terminal is functioning poorly for a number of reasons: the berth is inadequate, the areas for stacking cargo are insufficient, the waiting time for vessels in the port is too long, and too much time is required for port operations to be carried out. Hence, it is necessary to plan, project and construct a specialised dry bulk terminal that will be equipped with modern technology. A technological study presenting the dry cargo terminal project focuses on the terminal primary functions:

- loading/unloading and storage of dry bulk cargo such as coal, iron ore, coke, bauxite, with the possibility of berthing large vessels,
- loading onto railway cars for overland transport of goods to the interior,
- securing strategic and operational stocks for the above operations, and
- securing supplementary (auxiliary) service such as weighing, sample taking and cargo quality control.

At Dock 5, there is an unoccupied area stretching between the berth and warehouses, over which cargo must be transferred for more than 600 metres, increasing the costs of port operations. PANAMAX vessels are unloaded at the current location. However, the existing technology allows for the unloading of 70,000 tons of coal, whereas the warehouse capacity amounts to 160,000 tons of coal. The carrying capacity of the five installed cranes is about 10 tons. On the average, 600 tons of coal are unloaded per hour, and the daily cargo-handling rate is about 10,000 tons. Also, the fact that the dry bulk warehouse is located at some distance from the quay makes warehousing even more unprofitable, thus increasing operational costs.

4.2 Dry bulk terminal technology and expected performance

Transporting and storing dry bulk cargo implies the need of establishing proper management, implementing safety at work and introducing fully automated transport processes [1]. In planning and designing a dry bulk terminal, it is important to determine stock volume and warehouse capacities. To identify the best location and the required storage area for the terminal, all interdependent variables should be studied, such as: vessel carrying capacity, vessel arrival schedules, the capacities and arrival schedules of overland transportation means, the rate of loading/unloading vessels, and others [2, 225]. In this stage, a microlocation is selected that meets the set conditions, and plans are made for the construction of a specialised dry bulk terminal.

4.2.1 Dry bulk loading/unloading, transferring and storage technologies

In addition to the basic selection factors in choosing a microlocation, it is necessary to establish that the intended use of the area is in line with spatial planning documents. An Environmental Impact Assessment (EIA) is the most important factor in determining the compliance of the dry bulk terminal with spatial use, and its possible effects on the environment. The EIA should look into the methods of protecting the population and environment of the Neretva valley from wind-borne dust during the handling and storing of coal, bauxites, iron ore and other types of bulk cargo. Selecting the appropriate technology for the terminal can ensure such protection. Hence, a water-sprinkling technology is required that involves collecting the water after sprinkling, transferring its separators for treatment, and re-using it. The use of modern technologies such as the water-sprinkling technology provides for the smooth handling of cargo. The equipment for handling dry cargo consists of a ship unloader and a reclaimer used in an enclosed receiving bunker, which is equipped with a water-sprinkling system to prevent dusting when the cargo is unloaded into the bunker. The cargo is transferred from the bunker by conveyor belts with lateral windshields; transferred to another conveyor belt, the cargo changes direction and is again sprinkled. It is finally discharged at the disposal site from a height of half a metre, where it is again sprinkled. There is also a sprinkling unit installed in the depot or warehouse into which the cargo is discharged. The water used in this process is collected, treated, transferred to basins and then re-used for the same purpose. Discharging this water into the sea is not allowed, nor is this necessary, considering the large quantities of water required by the port transport processes. In this way, the efficiency and effectiveness of cargo handling is improved.

4.2.2 Berth and storage features and capacities

According to the direction of cargo traffic, the Port of Ploče can expect inbound dry bulk cargo from Bosnia and Herzegovina, and outbound, to third coun-

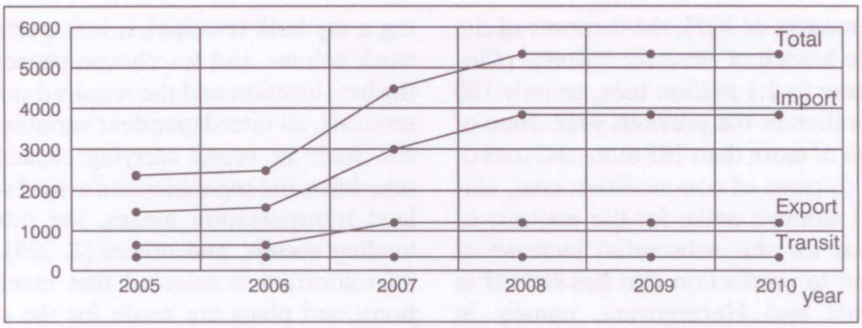

Figure 5 - Estimated growth of dry bulk traffc 2005 – 2010 in '000 tons

Source: World Bank Office, Zagreb, 2005

tries. Given the anticipated growth trend, the turnover should reach about 5.5 million tons by 2010 (Figure 5).

The terminal is expected to handle 5,300 thousand tons/year of cargo (4,100 thous. tons of inbound, and 1,200 thous. tons of outbound cargo). The maximum carrying capacity of vessels is 150,000 DWT; the minimum, 20,000 DWT. The daily quantity of unloaded cargo is estimated at 35,000 tons; the quantity of loaded cargo, 12,000 tons. The unloading rate of railway cars/day is 35,000 tons; the loading rate, 12,000 tons, meaning 17 trains for unloading and 10 for loading. Dry bulk storage has a capacity of 900,000 tons. In a later stage, the terminal will be equipped to handle vessels with a maximum carrying capacity of 150,000 GT. In the initial stage, the depth of the access channel must be increased for 80,000 GT PANAMAX vessels. Capacities for 150,000 and 80,000 vessels have been estimated.

Berth capacity estimates are based on the following input variables:

1. import (4,600,000 tons/year),
2. average quantity of cargo unloaded daily (35,000 tons),
3. one berth (350 working days/year),
4. loading/unloading vessels of 40,000, 75,000 and 150,000 GT,
5. a total of 69/78 arrivals of vessels to the port annually,
6. servicing time upon arrival for manoeuvring, opening decks, etc: 8 hours per vessel.

The berth occupancy rate is estimated at 49-50%, which is considered the highest rate for any berth. Should this rate exceed 50%, the vessel average waiting time will be longer than its unloading time. Expressed in days, this means:

- For vessels up to maximum 80,000 GT
  - unloading - 144 days,
  - servicing time - 31 days,
  - total time of berth occupancy - 175 days.
- For vessels up to maximum 150,000 GT
  - unloading - 144 days,
  - servicing time - 28 days,
  - total time of berth occupancy - 171 days.

The terminal is assumed to operate 24 hours/day, in 3 shifts, during 350 days of the year. This requires an operational utilisation rate of 96%. Equipment utilisation (availability) should be at least 90%. A regular maintenance program should be put in place to avoid unexpected repairs that could affect the required availability of terminal capacities. Equipment for preparing and loading cargo should meet the following requirements:

- stacking capacity should equal the vessel's loading/unloading capacity,
- loading/unloading capacity should equal train capacity.

Required storage area is estimated as a percentage of the annual volume of cargo handled. The terminal will be built in one stage and storage requirements must be brought in line with the final stage. The dry bulk terminal will have an annual capacity of 4.6 million tons of coal, iron ore and bauxite, requiring a storage capacity of maximum 700,000 tons.

The terminal stock quantities and flexibility are based on the following requirements:

- the possibility of concurrently unloading/loading from vessel to train,
- cargo unloaded from a vessel is transported by train,
- several types of cargo have to be distinguished on the terminal and separately stocked,
- the terminal must have road access for customs and other inspections,
- all equipment must be suitable for handling ore and coal.

Two types of storage will be needed: open storage alongside the berth for contingency stock, and a stockpile storage on the berth connected by an automatic conveyor belt and stacker-reclaimer transport system. The contingency warehouse may be 240 m long and 32 m wide, with a maximum height of 15 m. Total storage capacity should amount to 700,000 tons of cargo. Bulk cargo is stacked in triangular and trapezoid forms. The construction of special water treatment facilities is not required.

4.2.3 Dry bulk terminal facilities

The terminal will be provided with modern cargo-handling facilities of required technological efficiency: a mobile harbour crane, a ship unloader, a transporter for stacking and loading, and a conveyor-belt transporter. The capacity of the mobile harbour crane is 300-400 t/hour; the capacity of the ship unloader, 35,000 t/day. To reach the cargo-handling capacity using the ship unloader, it will be necessary to use two unloaders with reclaimers, the capacity of which is 30 t per grasp. The crane has an effective capacity of about 900 t/hour. The capacity of the storage loading/unloading bridge can reach 1,500 t/hour. Alternatively, a mobile harbour crane that meets the required capacities can be used. However, this calls for a different approach due to the following reasons:

- The mobile harbour crane requires the berth to be structured in a different way, because the cargo is not as predictable as with rail-mounted cranes.
- Conveyor-belt transporters on the berth require a more sophisticated grab-bucket system for filling the transporter.
- Operations are less secure, because of the cranes construction and necessary preparation, resulting in reduced overall capacity.

The capacity required for loading trains is 15,000 t/day. To achieve this, a station with a capacity of 1,000t/hour is necessary. The effective capacity of this loading station is about 900t/hour. Railway cars can carry 58 tons of cargo. The car loading time is 3.48 minutes/car or 17.2 cars/hour. The transporter occupancy rate is 90% of its operating time. The maximum is 18,000t/day. To summarise, the planned annual capacity per station is as follows:

1. capacity of 1 station 4,725,000 t/year
2. capacity of 2 stations 9,450,000 t/year
3. capacity of 3 stations 14,175,000 t/year.

The required stacking and loading capacity is defined by a vessel maximum unloading capacity and a train loading capacity. The equipment consists of two transporters (3,000 t/hour each) and two separate dual loading transporter-stackers (1,000 t/hour each). Cargo stockpiling and loading onto the transporter is done using machinery designed to provide a stock pile and discharging height of 15 – 20 m. If separate machines are used for these operations, this will increase the amount of investment required, but it will also increase the flexibility of port operations. The cargo, namely, can be stacked to both the left and the right of the tracks, and by using two transporters, changing lines becomes unnecessary. Alternatively, two transporters-stackers can be used to stock pile the cargo to the left and right, together with two bridge reclaimers. However, bridge reclaimers are not provided with the possibility of scooping up cargo from left and right of the tracks. Hence, it is more convenient to use transporter reclaimers or mobile reclaimers together with stackers. Another alternative involves using a bucket transporter, and a stacker-cum-reclaimer. To provider improved flexibility and greater capacity, a conveyor belt transporter and a boom stacker can also be used. Two loaders should be available for collecting cargo scattered in the corners of the ship's hull where transporters cannot reach. Small-sized loaders and other equipment should be used for this purpose. It is also important to install a monitoring and alarm system in case of self-combusiton of dry bulk.

4.2.4 Equipment for the prevention of environmental pollution

Dust is a major pollutant generated by the loading/unloading of dry bulk cargo. At a terminal, dust-related pollutions can be caused by:

- an unloader discharging cargo into the transporters receiving funnel,
- an unloader with a leaking,
- a transfer station of a belt conveyor transporter,
- discharging cargo from a transporter onto the berth,
- discharging cargo from the train loading station, wind,
- the impact of wind on a belt conveyor transporter,
- dust from road traffic.

To prevent seepage, reclaimers should be installed with mufflers. Modern reclaimers offer several solutions for preventing material from scattering during operation. For such problems to be solved, a well-equipped workshop is required. The receiving funnels of ship unloaders will be installed with a water-sprinkling system. This system is made up of a large number of nozzles located along the upper flange, which are activated when cargo is discharged from the funnel onto a transporter. Transfer points on the belt conveyor are then completely closed. To prevent dust from emerging, water-sprinkling nozzles are fitted onto the entrance of the transporter, and sprinkling is activated when the transporter starts working. Cargo stock piles should also be equipped with a water-sprinkling system. To limit the quantity of water used, the system is activated only when the force of the wind exceeds the level at which dust rises from the cargo stock pile. Gutters need to be built along the berth to collect water draining off the berth as well as run-off water from the road. The water collected is transferred to sedimentation basins where it is treated prior to being discharged in the sea or re-used for sprinkling purposes. Special water-treatment facilities are not required.

5. CONCLUSION

Port services, like other transport services, are created and developed within the framework of general economic development in an area that can be called the port-gravitating area with regard to the existing and (or) future transport infrastructure. These services are the result of the need of at least two, national and international, economic entities to exchange goods using the sea as a transport route. A port system cannot operate successfully if it lacks a consistent port policy, as a competent part of a country's transport policy, aimed at achieving the optimum development of port infrastructures.

By constructing a container terminal and linking it to the traffic network, all parts of the Port of Ploče will be adequately connected with the border crossing, and the new roadway will become the port main road. This will help to reduce the number of conflict points, improve safety in handling cargo, and enhance the rationalisation of processes within the port. The traffic design of the container terminal provides for an appropriate level of services to all terminal users. The container/multi-purpose terminal will provide the Port of Ploče with an annual traffic turnover of about 100,000 TEU/year. Some 30% of this volume will be transported by rail; 70%, by truck.

The dry bulk terminal requires a location different to that of the multi-purpose terminal and an appropriate sea-depth of the port basin. This terminal specific requirements refer to area size, port infrastructure, types of loading/unloading machinery and types of storage areas. Its operational organisation and size of the workforce required also differs from that of a general cargo terminal. Due to a higher share of mechanisation and automatisation used in loading, unloading and storing cargo, cargo transfer technologies are simpler and fewer workers are needed. In the first stage of construction, the specialised dry bulk terminal should be equipped with appropriate high-performance port installations, and modern cargo-handling technologies should be applied. In accordance with the Environmental Impact Assessment, and the requirements of modern technologies and performance efficiency, a water-sprinkling system should be installed in the new terminal. New investments in development should be economically sound and environmentally acceptable.

A container/multi-purpose terminal and a dry bulk terminal are important for further development of the Port of Ploče, not only with regard to size of the investment required, but also with regard to the volume of traffic that is expected. Greater turnover through the application of modern loading/unloading technologies for container and dry bulk cargo will provide for enhanced performance efficiency and long-term development of the Neretva region.

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SAŽETAK

PLANIRANJE IZGRADNJE TERMINALA U LUCI PLOČE

Autori u radu sustavno i pregledno analiziraju tehničko-tehnološku opravdanost izgradnje kontejnerskog/višenamjenskog terminala i terminala za rasute terete u luci Ploče te učinkovitost prekrcajnih sredstava. Hrvatske luke imaju neučinkovitu organizaciju te se koriste zastarjelom tehnologijom. Prometna povezanost sa zaobaljem, svijetom i kontinentom nije zadovoljavajuća, pri čemu prometna infrastruktura negativno djeluje na poslovnu učinkovitost. Luci Ploče nedostaje višenamjenski terminal na kojem bi se odvijao suvremeni kontejnerski promet što je rezultat analize postojećeg stanja prometa u luci i utjecaja prometa na funkcioniranje luke i njen razvoj. Zbog neučinkovitosti tijeka prekrcaja i načina skladištenja rasutog tereta u luci Ploče potrebno je planirati izgradnju terminala za ugljen i željeznu rudu na način da se uvaže prostorni, tehničko–tehnološki, ekonomski i ekološki činitelji razvoja. Autori istražuju i značaj regionalne inicijative koja potiče razvoj Hrvatske, a posebice lučkog sustava u funkciji razvoja koridora Vc Europske unije. Rezultati istraživanja prezentirani su kroz prometno i tehnološko rješenje kontejnerskog/višenamjenskog terminala te terminala za rasute terete, koje pruža adekvatnu razinu usluge za sve korisnike terminala.

KLJUČNE RIJEČI

luka Ploče, kontejnerski/višenamjenski terminal, terminal za rasute terete, koridor Vc, prometno i tehnološko rješenje

LITERATURE

[1] **Dundović, Č.**: *Analogni transportni model prijevoza i prijenosa rasutih tereta*, Pomorski fakultet u Rijeci, Zbornik radova, Rijeka, 1996.

[2] **Dundović, Č.**: *Lučki terminali*, Pomorski fakultet u Rijeci, Rijeka, 2002., p. 27

[3] **Dundović, Č, Grubišić N.**: *Tehničko-tehnološki parametri vrednovanja prekrcajnih sredstava na kontejnerskom terminalu*, Pomorski fakultet u Rijeci, Proceedings, Rijeka, 1998

[4] **Dundović, Č.** and **Kesić, B.**: *Tehnologija i organizacija luka*, Pomorski fakultet u Rijeci, Rijeka, 2001

[5] *Hrvatska u 21 st., Strategija razvoja, pomorstvo*, Ured za strategiju razvitka RH-e, Zagreb, 2001.

[6] Izmjene i dopune prostornog plana Općine Kardeljevo do 2000.

[7] Izmjene i dopune generalnog urbanističkog plana Kardeljeva

[8] **Kesić, B.**: *Organizacija i ekonomika lučkih sistema*, Fakultet za pomorstvo i saobraćaj, Rijeka, 1992., p. 1

[9] *Prostorni plan Dubrovačko – neretvanske županije* Županijski zavod za prostorno uređenje, Dubrovnik

[10] *Strategija i program prostornog uređenja RH* (Ministarstvo prostornog uređenja, graditeljstva i stanovanja, Zavod za prostorno planiranje, 1999., NN 50/99)

[11] *Studija kolosiječnih kapaciteta u luci Ploče te željezničkoj stanici Ploče*, Institut za saobraćaj - Sarajevo, studeni 1988.

[12] Tehnološki elaborat: *Kontejnerski terminal luke Ploče*, Rijeka projekt d. o. o., Rijeka 2004.

[13] UNCTAD: *Port development*, UN New York, 1978.

[14] www.port-authority-ploce.hr

[15] www.worldbank.hr