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Assoc. Prof. **Nil Güler**, Ph. D.
Istanbul Technical University, Maritime Faculty
Tuzla 81716, Istanbul, Turkey

CONTAINERIZATION AND TERMINAL AREA REQUIREMENTS

SUMMARY

Containerisation is still spreading all over the world and the containerisation requirements in the ports had to be taken into account to meet national and international demand. Based on the present trends, it is expected that containerisation will be between 70% - 80% of all general cargo in the next decade.

A container terminal layout is usually based on various requirements for container storage and transfer between ship and land feeder modes. When planning a new container terminal quite a number of decisive factors have to be considered which again will lead to the type of handling system requesting appropriate and special types of equipment.

Further decision factors are the available area, the number of shipping lines to be served, access for operational reasons and the flow of information within the port. In addition to the above basic decisive factors, further factors are the need for handling of special containers, the market analysis and forecasting for containerisation.

In this paper, after showing the increase in containerisation in the world and in Turkish Ports, the planning of container terminals, the area requirements will be discussed with a special reference to UNCTAD planning charts.

1. Introduction

After the World War II, the economies of developed countries were marked by the progress of mass production and mass consumption centring on consumer goods, Shipping lines were faced with an expansion of world trade together with bottlenecks at ports (Bubeer, 1983) A system was required to accommodate the needs of physical distribution, from manufacturer to final destination, eliminating costly and complicated transhipment operations at ports. As a result of this, containerisation was developed, a new concept, which involved a combined transport operation to and from the port, involving highway and rail services. In this new system, there was less physical handling, breakage and pilfering of cargo. The basic difference of containerisation was the movement of goods under continuous supervision ensuring an integrated transport process between the consignor and consignee. A container could be moved on the basis of one or several unimodel transport contracts or on the basis of a multimodal transport contract (Faust, 1985).

The world growth rate for container port throughput increased by 7,3 % in 1999 following a substantial increase of 10,1 % in 1998. This reflects the trade slowdown due to the 1998 financial crisis in SouthEast Asia. In the following tables, figures related with world container port traffic and figures related with world tonnage by types of vessel are given. As can be understood from the table 2, container tonnage is steadily increasing in world fleet.

Table 1: Change in World Container Port Traffic

1999 TEUs	1998 TEUs	1997 TEUs	%Change 1999/1998	%Change 1998/1997
195 261 458	181 982 976	165 234 028	7,3	10,1

(Source: UNCTAD, Review of Maritime Transport, 2001)

Table 2: Share of World Tonnage by Types of Vessel

Year	Total Dwt	Oil Tanker	Bulk Carrier	General Cargo	Container Ships	Other Ships
	Million Dwt	%	%	%	%	%
1970	326.1	39.4	20,2	30,2	0,9	9,3
1980	682.8	49,7	27,2	17,0	1,6	4,5
1990	658.4	37,4	35,6	15,6	3,9	7,5
1998	788.7	35,6	34,9	13,1	7,8	8,6
1999	799.0	35,5	34,5	13,0	8,0	9,0
2000	808.4	35,3	34,8	12,7	8,6	8,6

(Source: UNCTAD, Review of Maritime Transport, 2001)

Table 3: Top 10 Container Ports in the World

PORT	COUNTRY	2000	1999	ACTUAL VARIATION	%CHANGE 1999/00
Hong Kong	China	18100.000	16.211.000	1.889.000	12%
Singapore	Singapore	17040.000	15.944.800	1.095.200	7%
Busan	South Korea	7.540.387	6.439.589	1.100.798	17%
Kaohsiung	Taiwan	7.425.832	6.985.361	440.471	6%
Rotterdam	Netherlands	6.300.000	6.343.020	-43.020	-1%
Shanghai	China	5.613.000	4.216.000	1.397.000	33%
Los Angeles	US	4.879.429	3.828.851	1.050.578	27%
Long Beach	US	4.600.787	4.408.480	192.307	4%
Hamburg	Germany	4.248.247	3.738.307	509.940	14%
Antwerp	Belgium	4.082.334	3.614.246	468.088	13%

(Source: Containerisation International, March 2001)

2. Containerisation in Turkish Ports

Haydarpaşa: It is the key import terminal as far as Turkey's container trades are concerned. It is located in the Asian side of Istanbul. New investment is put to improve performance levels and has a satellite container storage area away from the port. It is in central Istanbul and expansion is almost impossible.

Ýzmir: It is the Turkey's leading export port and it has a healthy increase in its container traffic. The port has five specialised cranes. Over the past years, Turkish Government has installed new computerised terminal management systems.

Mersin: It is the third biggest container port. A computerised container control system is being installed. It is the port viewed as the logical gateway for cargoes moving into the area for the massive GAP (South Anatolian Project) irrigation project is completed.

Ýskenderun: Together with Mersin port this is also expected to handle cargoes from GAP.

Samsun: It is the north country port on Black Sea Coast. Also a dedicated container terminal is planned at this port. This is expected to handle traffic to/from CIS states.

Below, the capacities and physical situations of Turkish Container Ports are given:

Table 4: Container Ports of Turkey and Their Characteristics

Ports	Haydarpaşa	Mersin	İzmir	Samsun	Bandırma	Derince	İskenderun	Total
Total Wharf Length (m)	2 765	4 605	2 959	1 756	2 788	1 092	1 426	17 390
Port Area ('1000m²/sq.m.)	320	994	902	588	246	312	750	4 110
Max. Draught (m)	- 12	- 14,5	- 13	- 12	- 12	- 15	- 12	
Number of Workers	827	1,186	554	322	282	289	567	4 027
(Total Ship Receipt (Ship/Year)	2 651	4 692	3 640	1 130	4 280	862	640	17 890
Total Wharf Capacity ('1000 Tons/Year)	8 558	10 967	11 100	4 300	7 008	2 991	6 097	51 000
Capacity of Container Wharf Equipment ('1000 Tons/Year)	354	266	443	40	40	40	20	1 203
Total Handling Capacity ('1000 Tons/Year)	5 427	5 500	5 439	2 380	2 771	2 288	3 247	27 112
General Cargo Storage Capacity ('1000 Tons/Year)	689	8 505	884	6 866	2 013	2 984	9 286	31 230
Container Storage Capacity ('1000 Tons/Year)	230	371	343	50	90	100	146	1 330

(Source: State Maritime Secretary, Dep. of Ports, 2001)

Table 5: Groups of Commodity Handled at Turkish Ports Between 1996-2000 (given as 1000 Ton)

	Dry Bulk	General Cargo	Container	Liquid Bulk	Total
1996	8.575	7.618	8.428	7.022	31.643
1997	10.204	7.478	9.659	7.429	34.770
1998	11.706	6.895	9.723	6.831	35.155
1999	10.887	6.240	9.765	7.829	34.721
2000	12.593	6.204	10.648	6.887	36.332

(Source: State Maritime Secretary, Dep. of Ports, 2001)

2.1. *Container Productivity in Turkish Ports*

In comparison to world ports and the other ports in the region, port productivity is not high especially related with container handling which is the basic function of a port.

In many ports, container productivity is about 20-25 TEU/hour. But if this is analysed per machine, this number becomes 15 TEU/hour/crane. The below tables will explain this better:

Table 6: Port Productivity in the 3 Biggest Container Ports of Turkey Based on Container Throughput

	Haydarpaşa	İzmir	Mersin
1) Container Throughput (TEU) (1998)	322.596	398.619	241.865
2) No. of Boxes	221.881	281.001	161.385
3) Total period of handling (hours)	21.812	27.628	15.949
4) Productivity (1/3) (TEU/hours)	14,78	14,42	15,16
5) Gross productivity (2/3) (box/hour/crane)	10,17	10,17	10,11
6) Revised gross productivity (box/hour/crane)	11,93	11,75	12,63
7) Net productivity (box/hour/crane)*	15,50	15,27	16,41

* *Gross productivity includes the time the machine is not working whereas net productivity does not.*

(Source: Master Plan for Turkish Ports, 2000)

Table 7: Comparison of Port Productivities of 3 Biggest Container Ports of Turkey

	Haydarpaşa	İzmir	Mersin
1) Length of Berth (m)	650*	1050	980
2) NO. of Berths	4	5	4
3) Max. Depth	-12	-13	-10 ~ -14
4) No. quay cranes	4(50t)	5(40t)	3(40t)
5) Transfer cranes	9	9	11
6) Container area	179.040	211.017	266.130
7) Container Throughput (TEU)(1998)	322.596	398.619	241.865
8) 7/1 (TEU/m)	496	379	246
9) 7/2 (TEU/berth)	80.649	79.723	60.466
10) 7/4 (TEU/crane/year)	80.649	79.723	80.621

** This does not include the berth where the ship crane exists.*

(Source: Master Plan for Turkish Ports, 2000)

Table 8: Comparison of Port Productivities of 3 Biggest Container Ports of Turkey with World Ports

	Unit	3 Biggest Turkish Ports	Other Big Ports of the World
Container handling productivity	TEU/m	246-496	773-1919
Operational productivity of quay crane	TEU/crane/year	79.723-80.649	88.888-150.000
No of container in staking area	No./year	2.834-3.665	3.918-34.437

(Source: Master Plan for Turkish Ports, 2000)

As can be understood from the above analysis, the productivity in the Turkish ports is low in comparison with world ports. The reason for this can not only be explained with insufficient infrastructure or equipment since the operational productivity of quay cranes is also low. One of the main reasons of this is insufficient training of port personnel.

3. Container Logistics

Container flow through a terminal is a complex series of interconnecting activities, The output of the whole system is dependent on the capacity of the weakest link in that chain; there is a great deal of interdependence between all terminal activities which depends on container status as FCL (Full Container Load), LCL (Less Than Container Load), Empty, and Transit (Thomas and Roach, 1988). The flow of activities is as follows:

a) Ship Operation: Loading and discharging of containers between the vessel and the quayside. This is the dominant system since it ultimately determines terminal handling rates.

b) Quay Transfer Operation: Movement between the quayside and the container yard. It directly influences ship loading and discharging rates.

c) Storage Operation: The temporary storage of containers while documentary, administrative and other formalities are completed.

d) Receipt/Delivery Operation: In this activity, containers are moved between the container yard and road, rail or inland waterway interchange points, and then to the gate, where formalities are completed (Frankel, 1987).

As it is shown in figure 1, not all of the arrival or departure containers pass through CFS (Container Freight Station), but only the LCL containers are stored in CFS. The area requirements both for container storage and for CFS will be discussed in section 4.

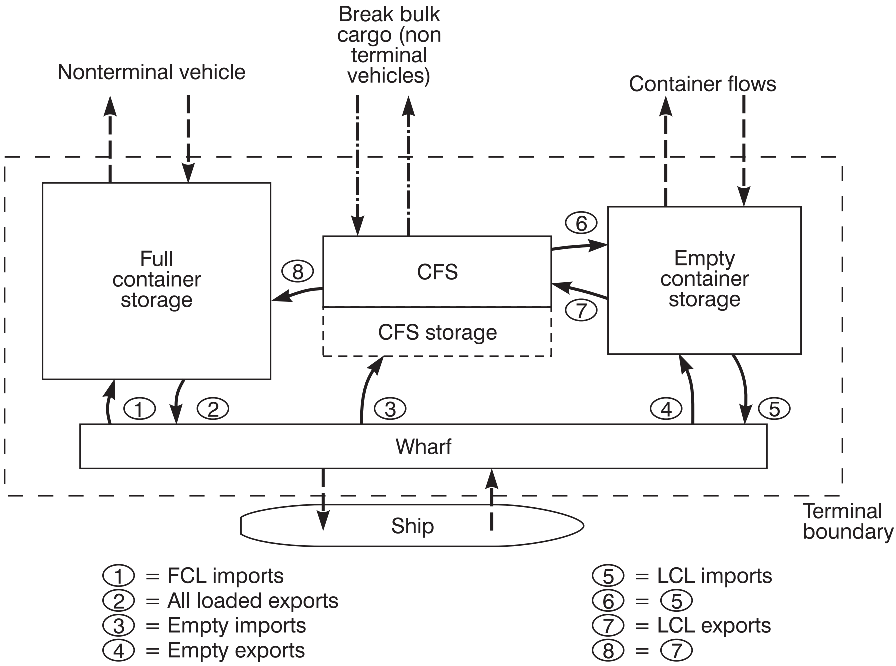
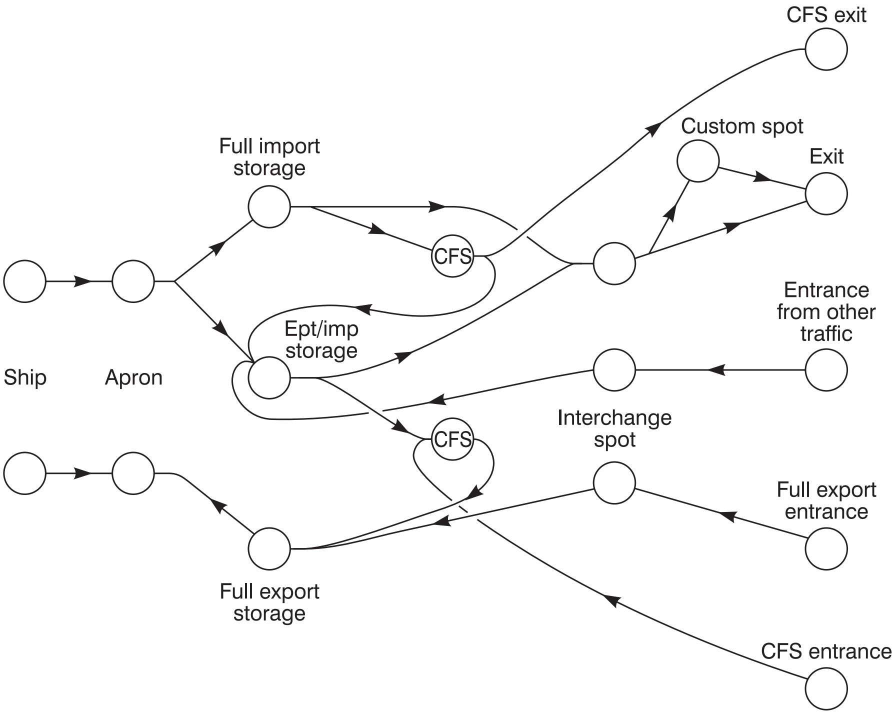


Fig. 1. Container Terminal Circulation Scheme (Frankel, 1987)

A container terminal includes the following operations as shown in Fig. 2. Ship-apron links simulate how containers are picked up from the ship moved to the storage area or to the container freight stations.

Fig. 2. Network of Container Terminal



4. Container Terminal Area Requirements

The capacity of a container terminal is usually measured in terms of the number of containers that can be handled by the terminal per year. Since containers come in two standard sizes – 20 feet and 40 feet respectively-the capacity is usually expressed in terms of 20-ft, container equivalents called TEU (Agerschou, and Lundgren, 1983).

Container Terminals May Serve:

– Mainline transocean vessels 230 to 250 m. long (11,0 to 12,8 m, Draft), with a carrying capacity of 1.800 to 4.200 TEUs,
– Mainline secondary service with 200 to 230 m. long and 10,0 to 11,2 draft vessels with a carrying capacity of 750 to 1.800 TEUs.
– Container feeder vessels or barges, used in coastal intraport feeder service 120 m. to 150 m. long, 7-8 draft, with a carrying capacity of 150 to 500 TEUs.

4.1. *The Factors That Affect the Container Area Requirements*

Container area requirements mainly depend on the following factors:

a) Container Throughput
b) Yard Handling Equipment
c) Dwell Time of the Containers
d) Utilisation Factors

a) **Container Throughput**

The starting point for the planning and design of a container terminal is of course the projected throughput of containers expected to be handled over the life of the facility. The assessment of activity will normally be the subject of historical trends as well as geographic, demographic, economic factors. For forecasting, the most important technique is the multiple regression analysis model. The independent variables of the analysis can be:

– Commodity statistics,
– GNP of hinterland,
– GNP of the region,
– GNP of the country,
– Population growth,
– Housing construction,
– Industrial production,
– Per capita income etc.

If the cargo volume is to be linked to the country's GNP, the model can be as below:

$$C = a + (b)\,GNP + \mu \quad .$$

Where a, b = regression coefficients,
GNP = Gross National Product of the country,
μ = error term

In order to have sound model, it is necessary to collect at least 20 years of annual data or 7 years of quarterly data (Frankel, 1987).

b) **Yard Handling Equipment**: The type of yard handling equipment is another critical area of terminal design because various options have implications of different yard layouts and paving types and has different stacking heights and aisle spacing. Thus, to handle the same cargo, a variety of land areas could be necessary.

The main yard equipment is as follows (Agerschou and Lundgren, 1983):

a) Chassis system,
b) Straddle carrier,
c) Yard gantry cranes.

Chassis system: Containers are placed on or picked up from semitrailers by shipside cranes, The trailers are pulled to and from the yard by tractors. While in the yard, containers are stored on the trailers.

Straddle carriers: They pick up and deliver containers at the apron and in the yard, stack containers two or three high and remove them from the stacks.

Gantry cranes: They can be either on rubber wheels or on rails and containers can be stacked 3-5 high. They can be combined with chassis system.

c) **Dwell Time**: It is the average storage time of containers in the yard area, Although the dwell time changes between 6-9 days on the average in many big ports of the world, this is around 15 days in Turkish Ports (Turkish Ministry of Transport, 2000).

d) **Utilisation Factor**: The value of area utilisation factor will be in the range of 0,25-0,5 for no stacking and up to about 1,0 when stacking containers two high (Frankel, Haumb, Moe and Bratteland, 1981).

In the planning of required container area the aim is to provide space sufficient to match the projected throughput. The required area is normally defined by the number of ground slots which is the projected area of a standard 20 ft. container. Containers can then be stacked one or more high on these ground slots (Drewry, 1998).

The required container terminal storage area can be computed in rough terms as follows:

T = yearly throughput in TEUs,
D = average dwell time per container in days
d = standard deviation of dwell time in days
a = projected area per 20 foot container = 21,60 m^2
U = total storage area utilisation – this is affected by with of lanes, span of gantries, etc. This is usually taken 0,4 to 0,6
H = average expected stack height by average number of containers in utilised stacks.

This is 0,5 to 0,7 of maximum stack height,
h = standard deviation of stack height by the number of containers,
Z = storage utilisation factor depends on stack or storage, control, management etc,
A = storage area in ha = $(T*(D + 2d)*a) / (365*Z*10^4*(H + 2h)*U)$

A numerical example in the terminal area calculations is below:

Assumptions:

1) Port equipment capacity must be enough for loading and unloading container ships of 1600 TEU/day
2) Draught is 11 m, of the above mentioned ships,
3) Working time/berth time ratio = 0,90,
4) Average output per gantry crane: 30 TEU/hour,
5) K = Loss of output for opening and closing hatches, 5% of basic output rate,
6) Port is working 24 hours,
7) Gang work 8 hours per day,
8) Dwell time is 6
9) Standard deviationof dwell time is 0.5

Average throughput/day = 24* (average output per crane)*(average number of crane allocated)* (1-K)* (working time/berth time)

1600 = 24*30*X*0,90*0,95
X = 2,59≅3 gantry cranes/ship are needed

Average throughput per year;

1600x* 365 = 584.000 containers/year

The required container storage area:

$A = (T* (D + 2d) * a) / (365*Z*10^4*(H + 2h)*U)$
$A = (584.000*6,1*21,60) / (365*0,7*10^4*1,2*0,5) = 50$ ha.

In this example Z is taken 0,7; U is taken 0,5 and (H + 2h) is taken 1,2. Here, the maximum stack height is thought te be 2 and H which is between 0,5 to 0,7 of max. stack height is taken 1,0 and the stand. deviation is assumed to be h = 0,1.

4.2. *Container Terminal Planning Charts*

These charts were originally reproduced by UNCTAD for container terminal planners (UNCTAD, 1979). Actually the methodology of the calculations for the construction of these charts will be explained here rather than the usage of the charts. Although there are 4 of these charts, 2 of them which are related with the area requirements will be handled: a) Container storage area requirement b) Container freight station area requirement.

Container storage area requirements is discussed in section 4.1. Container storage are requirements depend on many factors. In the UNCTAD method the area requirements are given dependent on throughput, handling equipment, stacking height, safety factor, and dwell time.

Container Freight Station Area Requirement (CFS): CFS is a common feature of many container terminals. It is where the stuffing and unstuffing of LCL (less than container load) traffic is performed. In this way container handling activity is streamlined and congestion is minimised (Kybart, 1985).

4.2.1. *Container Terminal Planning Chart I*

This chart (Appendix 1) is used to determine the container storage area. For the calculation of the storage area, the area requirement per TEU should be known which depends on the type of container handling equipment used and stacking height. This is shown in Table 9 (Monie, G. De,1983).

Table 9: Container Area Requirement in Relation with Handling Equipment
The needed data for this calculation is given below by a numerical example.

Handling Equipment	Stacking Height	Square metres Per TEU
Chassis	1	65
Straddle Carrier	1	30
	2	15
	3	10
Gantry Crane	2	15
	3	10
	4	7,5

Numerical example:

Data:

Expected container throughput per year	: 250.000 TEU
Dwell time	: 12 days
Area requirement per TEU for 2 stack high straddle-carrier system	: 15 m^2
Ratio of average to max stacking height	: 0,8
Safety factor	: 40%

Calculation:

Holding Capacity : 250.000 TEU* 12 days / 365 days = 8219 TEU

Net Transit Storage are : 8219 (15 m^2) = 123.285 m^2

Gross Transit Storage are : 123.285 / 0,8 = 154.106 m^2

Container stacking area : 154.106 $m^2 \times 1{,}4 = 215.748\ m^2 \cong 21$ ha.

4.2.2. *Container Terminal Chart II*

This chart (Appendix 2) has been designed to help the planner to estimate area requirements for the container freight station (CFS), the area used for packing and unpacking containers. The needed data for this calculation is as follows;

– the percentage of containers that pass through CFS,
– average transit time of consignment,
– average stacking height in CFS (in m.),
– access factor to allow for circulation and operational areas in the CFS,
– reserve capacity safety factor for periods of peak demand.

Numerical Example:

Total annual throughput	: 200.000 TEU
Containers that pass through CFS facility	: 120.000 TEU
Mean transit time	: 10 Days
Stacking height	: 2 m
Access factor	: 0,4

Safety factor : 25 %
Volume per TEU via the CFS : 35 m^3

Calculation :

Holding capacity = (120.000 TEU × 10) / 365 = 3288 TEU
CFS stacking area = (3288 TEU*35 m^3) / 2 = 57.450 m^2
CFS average storage area = 57.540 m^2 × 1,4 = 80.556 m^2
CFS design storage area = 80.556 m^2 × 1,25 = 100.695 m^2
CFS design storage area = 10,1 ha.

5. Conclusion

A very characteristic of containerisation is the space requirements for the terminals. The storage of containers in an elevated depot, or on secluded inland sites pushes up operating cost in the port, and therefore a good planning of the area requirements must be done before the development of the port.

In this paper, the terminal capacity is discussed specifically in relation to the area requirements and the logic behind the UNCTAD charts are explained. Sizing port requirements is one of the basic process to be analysed in planning a container port. For this, forecasting of throughput, equipment selection, dwell time analysis, and space utilisation data are needed.

In a container port environment, complexity and change are great. The capital costs are heavy and once decided, the investment is immobile. So some of the important considerations with area requirements are as follows:

a) The choice of operating methods and equipment and thus the area of land needed depends to a high degree on the availability of local land and soil conditions.

b) If the teminal is located far from the urban centres, and if the land is inexpensive, a system of storing containers only one high may be the most economical. For this layout, no costly equipment is needed for stacking containers.

c) If the land is scarce and expensive, the stacking of containers as high as physical conditions allow becomes a necessity.

d) A special attention should be given that the maximum stacking height cannot always be attained. In reality, the average stacking height is lower than the expected.
e) There should be a sound analysis about the dwell time of containers.

f) In addition to the container storage area, and CFS areas, the terminal requires space for marshalling areas, vehicle parking, rail and road access, customs, damaged containers, staff, administration, maintenance and dangerous goods storage facility.

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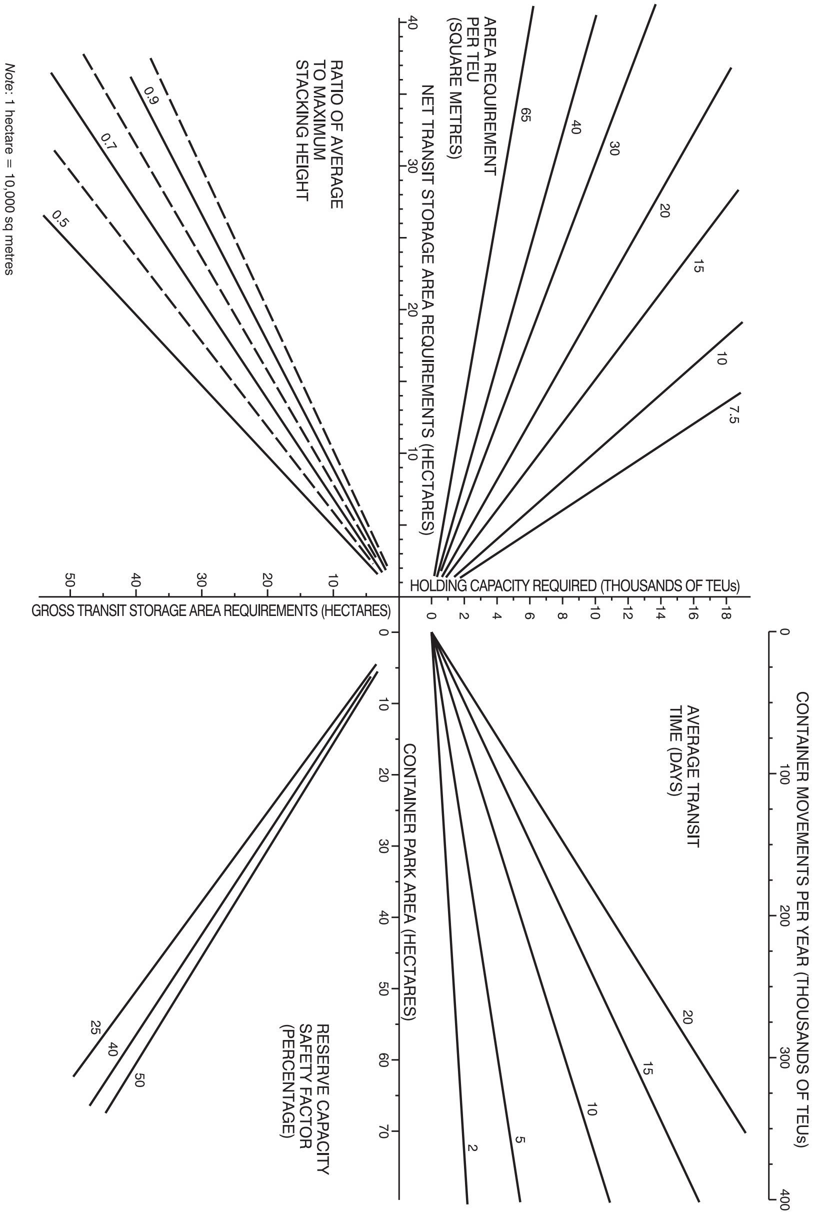
APPENDIX 1: CONTAINER TERMINAL PLANNING CHART 1: CONTAINER STORAGE AREA

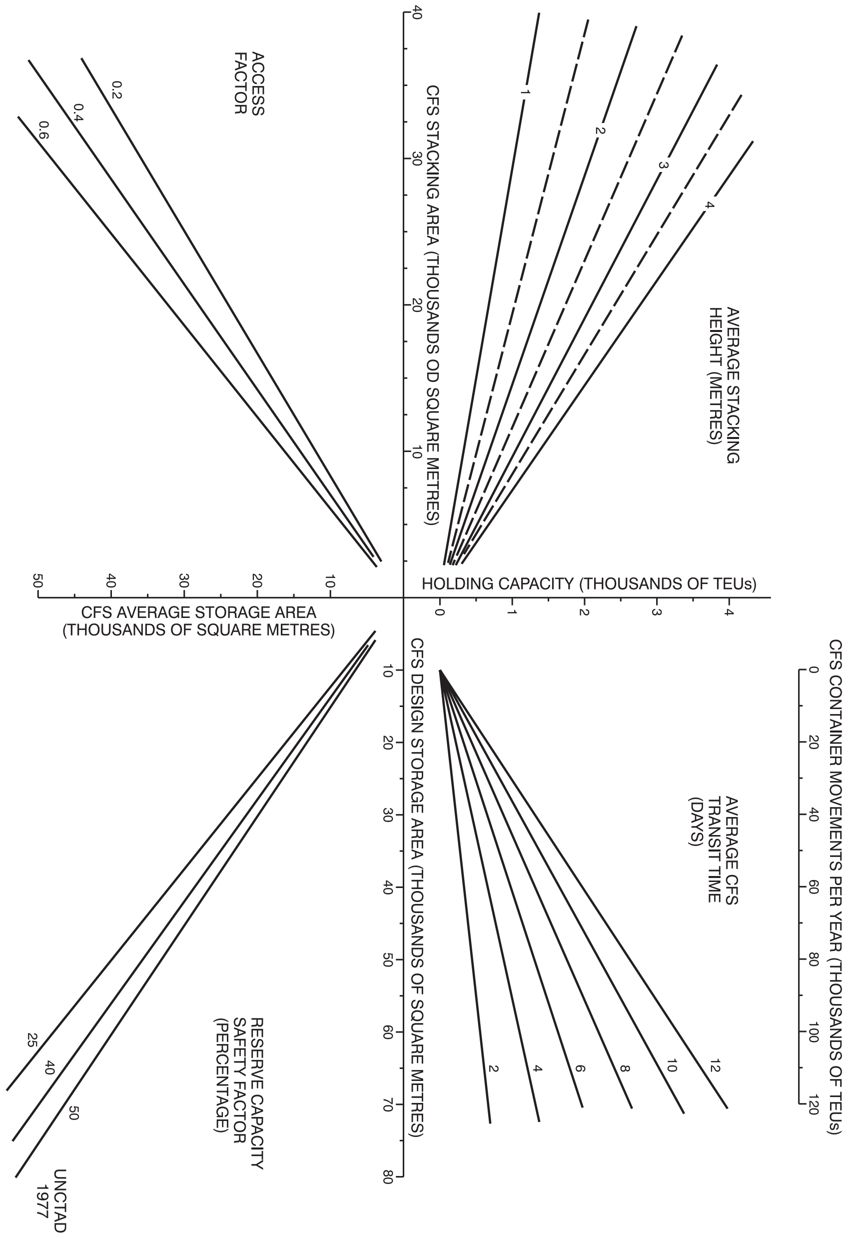
APPENDIX 2: CONTAINER TERMINAL PLANNING CHART II: CONTAINER

FREIGHT STATION AREA



Container terminal, planning chart I: container park area

Container terminal, planning chart II: container freight station area



Nil Güler

KONTEJNERIZACIJA I PROSTORNE POTREBE TERMINALA

SAŽETAK

Kontejnerizacija se nastavlja širiti svijetom i o zahtjevima kontejnerizacije valja voditi računa radi zadovoljavanja domaće i međunarodne potražnje. Temeljem prisutnih kretanja očekuje se da će u narednome desetljeću kontejnerizacija obuhvatiti 70-80% od ukupnoga generalnog tereta.
Raspored kontejnerskoga terminala obično se temelji na raznim zahtjevima za skladištenjem i premještanjem kontejnera između broda i kopnenih načina dostavljanja (feeder). Pri planiranju novih kontejnerskih terminala nužno je razmotriti poveći broj odlučujućih činitelja koji opet vode do sustava rukovanja teretom koji zahtijeva odgovarajuće i posebne vrste opreme.
Daljnji odlučujući činitelji uključuju raspoloživu površinu, broj brodskih linija koje treba opsluživati, operativni pristup te tijek informacija unutar luke. Pored spomenutih temeljnih odlučujućih činitelja, dodatnu ulogu ima potreba za rukovanjem specijalnim kontejnerima, analiza tržišta te predviđanje kretanja kontejnerizacije.
U ovome će radu, nakon prikaza rasta kontejnerizacije u svijetu i u turskim lukama, biti riječi o planiranju kontejnerskih terminala i prostornim potrebama uz poseban osvrt na UNCTAD-ove planske karte.

CONTAINERIZZAZIONE ED ESIGENZE DI AEREE OPERATIVE DEI TERMINALI

SOMMARIO

La containerizzazione si sta ancora diffondendo in tutto il mondo e i porti ristrutturati per accogliere i contenitori hanno dovuto conformarsi alle condizioni imposte dagli organi nazionali ed internazionali. In base agli odierni orientamenti per la prossima decade si prevede una containerizzazione del carico generale tra il 70 e l'80 per cento.
La sistemazione di un terminale contenitori di solito deve tener conto di varie esigenze per lo stoccaggio dei contenitori ed il trasbordo tra la nave ed i "feeder" a terra. Nella progettazione di un terminale per contenitori nuovo bisogna prendere in considerazione una molteplicità di fattori come ad esempio il sistema di movimentazione dei contenitori e il tipo adequato e specializzato delle attrezzature.
Altri fattori decisivi riguardano l'area disponibile, il numero delle linee marittime facenti capo allo scalo, l'accesso al porto, il sistema di flusso di informazioni entro lo stesso porto. Oltre a ciò altri elementi determinanti possono riguardare il maneggio di contenitori specializzati, l'analisi di mercato e previsione di trasporto containerizzato.
Lo studio, oltre a porre l'accento sull'incremento della containerizzazione nel mondo e nei porti della Turchia, tratta la progettazione dei terminali per contenitori, le esigenze di superficie con speciale riferimento al quadro di progettazioni UNCTAD.