MANAGEMENT OF CONTAINER TERMINALS WITH GEOGRAPHICAL INFORMATION SYSTEMS: THE PORT OF NAPLES

MAURO CATALANI
Istituto Universitario Navale
Istituto di Economia dei Trasporti
Acton 38, 80122 NAPLES, ITALY

Abstract

The implementation of infrastructure projects depends on the ability of local planners to attract private capital. Consequently, the utility of planning tools such as geographical information systems which can represent and describe the entire port area and movement from/to the port ,is recognised. Through specific GIS software it will be possible to develop topology intelligent maps with data base interactive connections of the processes that must be analysed .Calculating the spatial relationships between installations and routes will allow movements to be monitored so as to optimise the use machinery in terminals. An application to the Port of Naples will be described.

INTRODUCTION AND OBJECTIVES

Transport has a great impact on the social and economic life of a country, particularly traffic in ports as nodal points of the transport chain. Each year millions of tons are handled in ports all over the world. It is not surprising, therefore, that application in the field of transport have received considerable interest from the developers and users of Geographical Information System (Maguire et al.1995).Indeed ,some GIS applications in recent years have been developed to handle the individual needs of the transportation industry but do not focus on ports or the maritime sector.

The study of port infrastructure is concerned with all aspects of the physical movement of freight and services between places. Such movements are almost always constrained so that they operate over networks connecting origins and destinations of movements. This paper focusses on the linear representation of objects which can be represented in dimensional space in port systems by concepts of distance, surface and accessibility and relationships between places recorded in terms of network topology. The topology in question is described in terms of rail-road connections to the terminal and sea accessibility. In addition, more complex questions can be answered, such as which is the shortest route between two ports (this requires incorporation of distance, cost of transport, handling, frequency of service etc). New techniques, such as the neural network applied to transportation problems and the latest GIS techniques have come together to produce a user-friendly modular system (Visser J.G.S. et al.,1996).

In general, a GIS model may be defined according to the hypothesis which characterises some components of the model itself, as reported below. The paper describes a GIS application to the port of Naples. This first part describes a general application to the container terminal. The second part describes, the data-base implemented. This paper is part of research supported by PFT2/CNR under grant n.96.00.162.74.

THE GIS APPROACH IN TERMINAL PLANNING

The modern context of container movement by stacking/handling etc. involves an increasingly larger number of factors which may change effectiveness and output (Calogero et al.1994).The movement of containers in ports owing to the plurality of factors involved- the continuous flow of information in the logistic chain, the large quantity of containers transported and the fast turnover of ships- has greatly stimulated the search to standard communication planning (EDI,EDIFACT,ODETTE etc) throughout containerisation cycle. In particular, it has been determined that two areas have a strategic role: the *terminal* and the *tonnage centre.* Thus, management ,maintenance and the container site are all important to provide a large enough area .

Demand forecasting simulation model

Layout and port zoning GIS model

Origin-Destination flows logistic model

Handling –stacking optimisation model

Fig 1 Terminal planning.

For operations to be successful, a complex information system must able to interact with many different parts which are not connected directly to the terminal to offer information to all operators. Thus there is the need for careful planning of all terminal activities from the mooring to the handling and stacking to forwarding by lorry or rail. Generally a model of integrated planning of a port terminal involves a set of phases, which are shown in fig.1.

It is not the purpose of this paper to analyse these phases. We will, however, comment on the main components of containerised transport demand with a data base showing the sea and land accessibility of the port.

The use of geographical information systems applied to port planning is relatively recent. In this paper we used the MAP-INFO to define the topology of the whole area of the Naples containers terminal with some layers to analyse the data base-map interaction(Sutton. J, 1996).

PORT CONFIGURATION BY GIS

The size of the port is about 1,500,000 m^2, with a berth length of 14 km, seventy moorings with a depth of about 10-11 m., while the container terminal has 130,000 m^2 of space where the various types of container are stacked (empty, full, hazardous, refrigerating, etc).

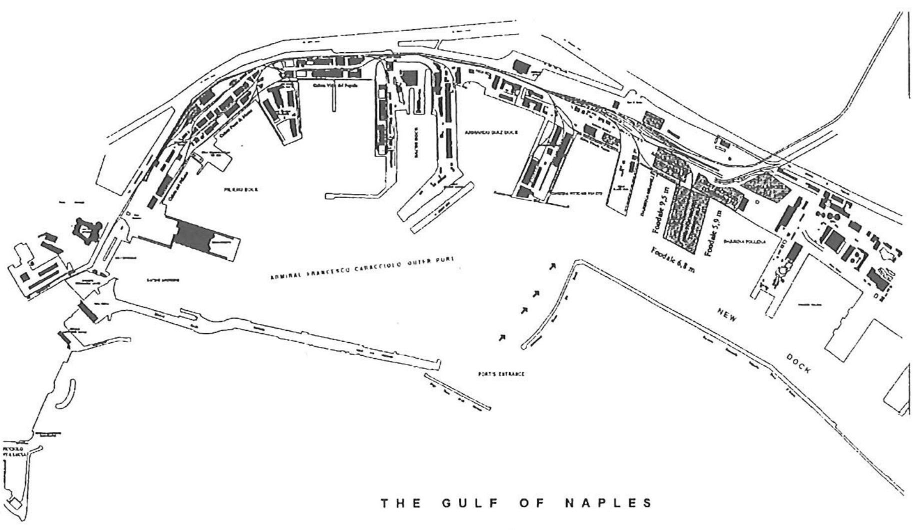


Fig. 2 Topology of the port area.

Fig 2 gives a description of the port system with buildings, roads, railways tracks, piers ,berths, warehouses, parking areas and so on. It is possible to add detailed information to the GIS map by a set of layers containing ship arrivals, the percentage of pier utilisation and movement of trains and lorries etc. The computer program will be able to visualise and position, in real time, the location of a ship, a lorry, a container etc. The port of Naples is structured according to a progressive specialisation of its berths, to offer each ship suitable moorings. The port system can be subdivided in the following way according to the movement of goods (fig.7 above):

- *General Cargo Terminal:* this is used for general cargo, passengers and break-bulk cargo. It is divided into two different areas, namely Pollena dock which is managed by a private shipping company called *Messina* and the Piliero wharf which is managed by a public shipping company *Tirrenia*;
- *Containers Terminal*: this is the largest (but there are other small areas in the port for unitised

traffic) and is equipped for Lo-Lo ships. It has a total area of 130,000 m^2 with 4 Paceco 45-ton cranes, equipped with 125 electric sockets. It also includes the Bausan dock and the Flavio Gioia dock. The Granili and Pollena wharfs are partially utilised. Accessibility is maintained by a motorway link and a national railway network connection. The storage spaces will be analysed by the GIS;

- *Forest Products and Cellulose Terminal*: this is small area and has only two warehouses situated at the end of the Pisacane dock and the Vittorio Emanuele dock; it is managed by General Stores, a private firm;
- *RO-RO Terminal for the Islands:* this is a specialised mooring for short-distance sea routes;
- *Cruise Passengers Terminal*: this is delimited by the Beverello and Angioino dock and is a maritime passenger station assigned exclusively to cruise traffic (fig 3);
- *Dry Bulk Terminal*: this is essentially used for grain. It is equipped with silos and two warehouses;
- *Oils Terminal*: this is a specialised wharf at Vigliena dock for the mooring of oil tankers (about 30,000 dwt) and is also equipped with a submarine pipeline on a floating platform .

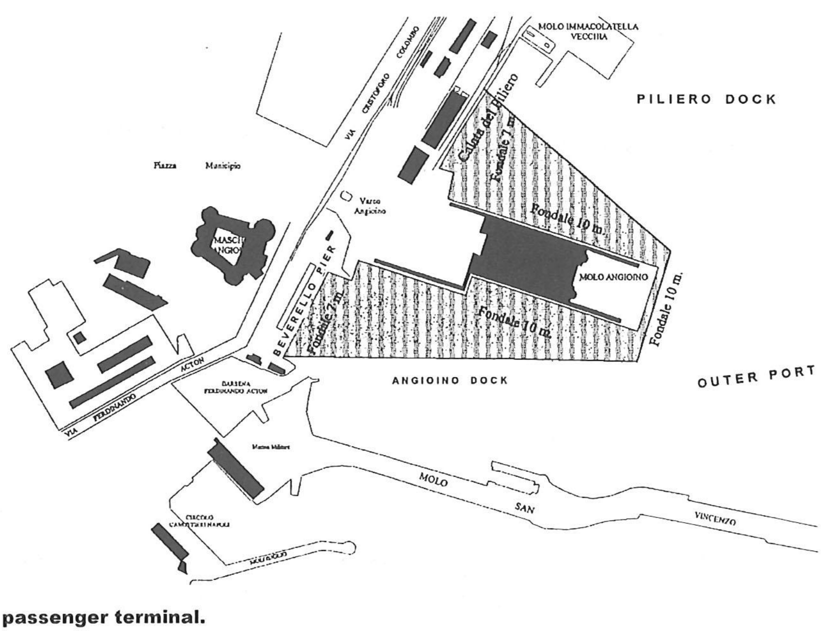


Fig.3 Cruise passenger terminal.

GIS DATA BASE OF THE CONTAINER TERMINAL

The data base used for the description of the terminal areas and activities consists of 12 files which contain the information system of the container terminal of the Port of Naples. This terminal has an average traffic in the month of about 40 ships and a throughput of 220,000 teus in the year 1997.

The port data-base with all the layers is shown in fig. 4 . Some of the data are general and cover aspects of the life-cycle of container handling, such as stacking, groupage, forwarding, etc.

Finally, for each layer we have given a brief note of its content with the Excel mask. display.

General description	Layers with description of container area, railway network, road access etc.			
Where to find the group files	Directory called : Naples container terminal			
Data source	Naples City Council			
Structure and format for group files	File Name	Format	Size	N. records
	T-BERTHS	Mapinfo		19
	T-CONTAINERS CONTROL	Mapinfo		18
	T-CONTAINERSHIPS	Mapinfo		20
	T-TERMINAL HANDLING	Mapinfo		22
	T-WAGON	Mapinfo		10
	T-TRUCK	Mapinfo		12
	T-TRANSHIPMENT	Mapinfo		11
	T-RAILWAY ACCESS	Mapinfo		11
	T-ROAD ACCESS	Mapinfo		12
	T-TOTAL COST	Mapinfo		15
	T-TOPO	Mapinfo		15
	T-BUILDING	Mapinfo		17
	T-BOUNDARY	Mapinfo		17
Geographic information	Co-ordinate System: Gauss-Boaga Fuso East			

Fig. 4 Description of all the layers.

In figures 4.1 to 4.11 the structure of the files with a brief description of their content will be described.

Fig 4.1 T-Berths.xls

	A	B	C	D	E	F
8	Pier	Width(m)	Open surface(mq)	Coveragr surface(mq)	Total srface(mq)	Berth
9	Pier Bausan (Conc. CONATECO)	160	41.000		41.000	Side W
10						
11						
12						Pierhead
13						Side E
14						
15	Quay Pollena (conc SOTECO)		1.500		32.000	
16	Wharf Flavio Gioia	160	19.000	1.000	20.000	Side E
17	(Conc GEMAC)					
28						
29						Pierhead
30						
31						Wharf
32	Wharf Vigliena	140	35.100	5.500	40.600	Side W

Foglio1 / Foglio2 / Foglio3 / Foglio4 / Foglio5 / Foglio6 / Foglio7

Fig 4.1 "T-BERTHS file description

This layer shows the situation regarding of the loading/ discharging area of the containers handling. The file contains information on the characteristics of the quay,(depth, width and length), piers and

Fig 4.2 Container Controll.xls

	A	B	C	D	E	F	G	H	I	J	K
5	Code	N° Cont.	Ship	At Naples on	Seal	Size	Weight kg	Commodity	B/L	Loading Port	Discharging p
6	Pieni 1	ACLU-271236.4	Viviana	02-gen	408275	20'	18000	Potatoes	1	Alexandria	Anversa
7	1	MSCU-227181.5	Viviana	02-gen		20'	11000	Prod. Chimici		Fos	
8	1	ICSU-125754.7	Sextum	09-gen		40'	8 500	Frigoriferi			
9	1	IEAU-454356.6	Sextum	23-gen		40'	16 500	Lavatrici			
12	1	ACLU-272693.8	Viviana	02-gen		20	12000	Garlic	2	Alexxandria	Anversa
13	1	ACUU-201851.0	Viviana	02-gen		20	20400	Dried fruit	1901	Alexsandria	Helsinky
14	1	CLOU-236160.0	Viviviana	02-gen		20	10 000	Tyres	1902	Alexsandria	Gotheborg
15	1	CLOU-236913.3	Viviana	02-gen		20	5360	Effects	1907		jedda
16	1	MSCU-200807.5	Viviana	02-gen		20	14126	Cotton	1908		Oslo
17	1	MSCU-201350.7	Viviana	02-gen		20	15 800	Skins	3		Rotterdam
18	Vuoti 2	MSCU-225973.8	Gina	02-gen		20	5922	Garhents	1001		Djbuty
19	1-2	MSCU-227181.5	Viviana			20	5000	Furniture	1002		Frema
20	1	MSCU-233021.9	Viviana	02-gen		20	18000	Potatoes	1004	Alexandria	Jedda

foglio 1 / Foglio2 / Foglio3 / Foglio4 / Foglio5 / Foglio6 / Foglio7

moorings, railway platforms, crane productivity , general equipment, etc .

Fig 4.2 "T- CONTAINER CONTROL" file description

This layer contains data about the movement of containers: code number, arrival date by ship, departure from the terminal empty / full ,data about the consignee, B/L number, goods transported, total units transhipped and reshipped (inbound-outbound), direct total units (discharging-loading), loading port, discharging port .

Microsoft Excel - FIG.4.3 T-CONTAINERSHIPS.xls

	A	B	C	D	E	F	G	H
1	Ship Name	Arrival	Departure	Flag	DWT (tonn.)	NRT (tonn.)	Draft In	Length (mt)
2	Meklenburg	17-gen	17-gen	German	18.353	5.786	27'	174,2
3	Kislovodsk	16-gen	17-gen	Russian	16.075	8.022	27'	173,5
4	Sextum	08-gen	08-gen	Panama	26.750	14.290	33'	209
5	Sachsen	08-gen	08-gen	German	18.342	5.786	26'	174,2
6	'Altinia	26-gen	26-gen	Italian	8.707	2.619	21'	150
7	Romea	30-gen	30-gen	Italian	7.567	2.270	21'	138
8	Rosemary	22-gen	22-gen	Panama	24.602	9.328	33'	235
9	Luisa	14-gen	15-gen	Panama	26.954	9.166	33'	208
10	Floriana	25-gen	25-gen	Malta	21.648	11.148	34'	187
11	Robur	15-gen	15-gen	Italian	7.095	2.128	21'	126
12	Resolute	18-gen	18-gen	United States	17.042	6.388	28'	186

Foglio1 / Foglio2 / Foglio3 / Foglio4 / Foglio5 / Foglio6 / Foglio7

Fig 4.3 "T-CONTAINERSHIPS" file description

This layer describes ,for each ship: flag, dwt, grt, load and light draft vessel data (name, voy in, voy out, service),vessel time (planned arrival, pilot on board, gangway ashore ,custom cleared)working time (labour on board, first lift, last lift, labour ashore) operational delays (crane breakdown, unlashing), parking code assigned inside the terminal etc.

Microsoft Excel - FIG 4.4 T-TERMINAL HANDLING.xls

	A	B	C	D	E	F	G	H	I	J
2	Code	Parc.Terminal	Surface	Container N	Dimension	Empty/Full	Hazardous	Staddle carrier	Conteveyor	Direct
3	P1	Park container exp.	34.100 m	ACLU 23456	20	F	y	n	n	y
4	P2	Park.container imp.	10.000 m	ACLU-271236.4	20	E	y	n	n	y
5	P3	Park.full container	15.000 m	MSCU-227181.5	40	E	n	n	n	y
6	P4	Park.full container	27.100 m	ICSU-125754.7	40	F	n	n	n	y
7	P5	Park empty container	12.450 m2	IEAU-454356.6	20	E	n	n	n	y

Foglio1 / Foglio2 / Foglio3 / Foglio4 / Foglio5 / Foglio6 / Foglio7

Fig 4. 4" T- TERMINAL HANDLING " file description

This layer describes the situation of the terminal regarding slot distribution ,stacking code area for export and import, hazardous goods, import and export customs, empty / full containers, total terminal costs, mechanical equipment etc.

FIG 4.5 WAGON.xls

	A	B	C	D	E	F	G	H	I	J	K
4	Staytment	CTRN N.	Empty/Full	Wagon	track n.	Go out	Cost	Final Destination	Terminal station in	Empty/Full	Date
5	P1	AUCU 257043.3	Empty	FS 23	1	nov21	250$	Bari	Neaples Terminal	E	24-nov
6											
7											

Foglio1 / Foglio2 / Foglio3 / Foglio4 / Foglio5 / Foglio6 / Fogli

Fig 4..5 "T- WAGON" files description

This file describes the movement of the container by the wagon from / to the terminal with railway operator , the costs of loading on and off, accessibility, annual traffic, etc.

Code	Staytment	Containers	Empty/Full	Date	Consignee	Go in	Staytment	Truck Cost
1	P1	CLU275262.9	Empty	27.nov	Fiat	28.nov	P3	200.000

Fig 4.6 "T- TRUCK" file description

This layer describes the movement of the truck inside / outside the terminal: forwarder ,consignee and came back data, movements inside the terminal, road accessibility, cost of the consignee, etc.

Cont.N.	Ship	At Naples o	Seal	Size	Weight kg	Commodity	B/L	Loading P
ACLU-271236.4	Viviana	02-gen	408275	20'	18.000	Potatoes	1	Alexandr
MSCU-227181.5	Viviana	02-gen	408351	20'	12.000	Chem.products	8	Fos
ICSU-125754.7	Sextum	09-gen	395643	40'	19.000	Furnitures	10	Usa
IEAU-454356.6	Sextum	23-gen	419865	40'	20.000	Refrigerators	15	Gioia Tau
IEAU-454356.6	Viviana	24-gen	432543	40'	19.000	Washing machines	200	Napoli
IEAU-454356.6	Rosemary	26-gen	423145	40'	18.500	Skins	131	Livorno
ACLU-272693.8	Viviana	02-gen	409435	20	12.000	Garlic	2	Alexsandı
ACUU-201851.0	Viviana	02-gen	554433	20	20.400	Dried fruit	1901	Alexsandı

Fig 4.7 "T-TRANSHIPMENT" file description

This layer shows the number of total units transhipped, inbound / outbound (full-empty), 20' or 40', arrival date, container number, weight, commodity, etc.

Terminal Code	Raiway track N	Connection Railways Station	distance	Annual traffic wagon	Total Containers movements
P6	3	y	4km	10.000	140.000

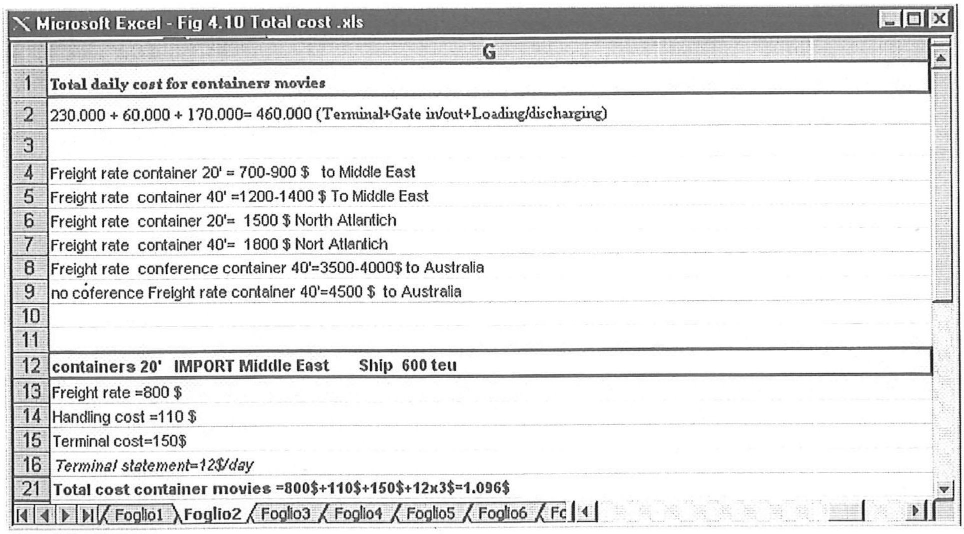
Fig 4.8 "T-RAILWAY ACCESS" file description

This layer shows the port railway station, number of tracks, accessibility in terms of distance to the national railway network. As it is a simple graphic representation the file contains little information.

Terminal code	Road Tipology	Parking area	Number Trailer	Fork lift	Custom	Internal street	External depot	Cost
P5	motorway	y	15	6	y	5	2	60.000

Fig4.9 "T-ROAD ACCESS" file description

This layer contains data about road accessibility to the terminal. As above, the file contains only few data.



Microsoft Excel - Fig 4.10 Total cost .xls

	G
1	**Total daily cost for containers movies**
2	230.000 + 60.000 + 170.000= 460.000 (Terminal+Gate in/out+Loading/discharging)
3	
4	Freight rate container 20' = 700-900 $ to Middle East
5	Freight rate container 40' =1200-1400 $ To Middle East
6	Freight rate container 20'= 1500 $ North Atlantich
7	Freight rate container 40'= 1800 $ Nort Atlantich
8	Freight rate conference container 40'=3500-4000$ to Australia
9	no coference Freight rate container 40'=4500 $ to Australia
10	
11	
12	**containers 20' IMPORT Middle East Ship 600 teu**
13	Freight rate =800 $
14	Handling cost =110 $
15	Terminal cost=150$
16	*Terminal statement=12$/day*
21	**Total cost container movies =800$+110$+150$+12x3$=1.096$**

Foglio1 Foglio2 Foglio3 Foglio4 Foglio5 Foglio6

Fig 4.10 " T -TOTAL COST" file description

The layer contains a series of information on the terminal pricing, port charges, freight rates by routes, total costs for container typology with destination Far East, etc.

FIELD NAME	DESCRIPTION - Unit of measurement	TYPE	SIZE(bit)
IDENTIFICATION.	Building code	char.	6
DESCRIPTION	Building name	char.	50

Fig 4.11 "T-BUILDING" file description

This layer contains information about the main buildings of the port. Only few buildings have been coded.

"T BOUNDARY" file description

This layer shows the external boundary of the port area. As it is only a simple graphic representation the file contains little information.

"T-TOPO" DESCRIPTION FILES

This layer contains the topology of the port system with all the indications of the facilities, infrastructures and the perimeter of the port area.

CONTAINER TERMINAL CONFIGURATION BY GIS

The drawing of the whole terminal area by co-ordinate system allows the description of all the spaces which it comprises .The piers, equipment, storage spaces, access roads etc are set out again in the fig. 5.

It is possible to analyse the weaknesses that characterise the terminal's function and see the bottlenecks that limit system productivity.

The use of the GIS MAP-INFO enables us to program the berth assignment and mooring according to the depth, the extent to which pier is used, etc . It is thus possible to know the situation in the quay ,particularly the productivity of the quay crane.

This phase which is shown schematically in fig.6 assigns the ship to the container terminal berth number according to scheduled arrival-departure, dwt, number of containers being loaded, ship length and width, draft etc.

To provide a complete view of all unitised traffic in the port, the terminals are numbered with the mooring assignment -noting ship physical parameters- as is set out again in fig.7 The GIS is here very useful because the port is subject to silting up.

Generally, moorings assignment follows operational functional procedures :

- the eastern pier with moorings 53- 54- 55 has deeper shoals and could accommodate mothers vessels with a draft up to 11 m ;
- the western pier with moorings 51 - 52 can accommodate mother vessels like those of the previous, with a draft up to 10m;
- Pollena pier, with moorings 56 - 57 -58, could accommodate ro-ro ships. It is a private terminal managed by the Messina shipping company;
- Granili pier, with moorings 45 to 50 , with shallow shoals , can receive only general cargo vessels with limited container number on board;
- Flavio Gioia pier with moorings 15-16 can essentially accommodate ro-ro ships for islands routes (Sicily and Sardinia) and is essentially managed by the state-owned shipping company Tirrenia, with a 9m shoal

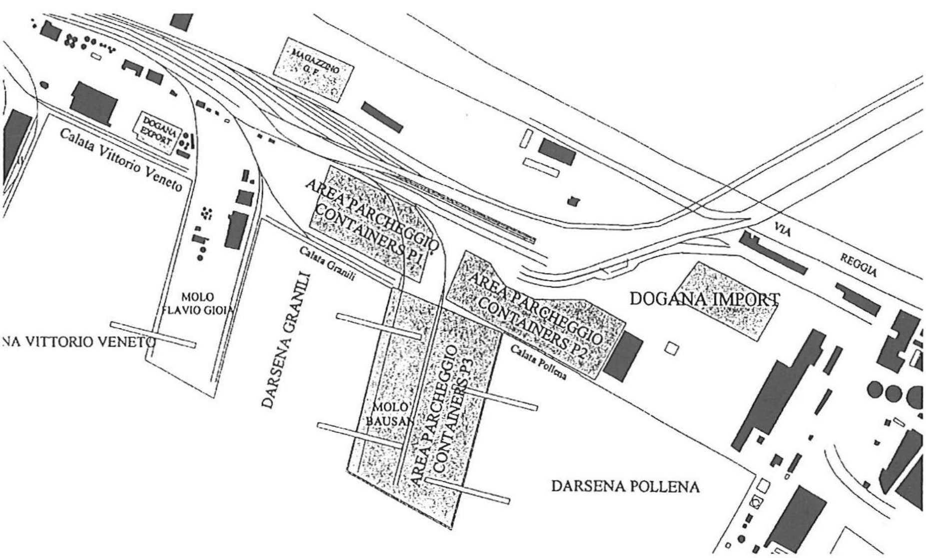


Fig. 5 The container terminal

With information in advance about the shipment of hazardous goods, it is possible to program the arrival and related berth, the stay at terminal , the mechanical equipment involved, loading/discharging operations and the container stacking area.

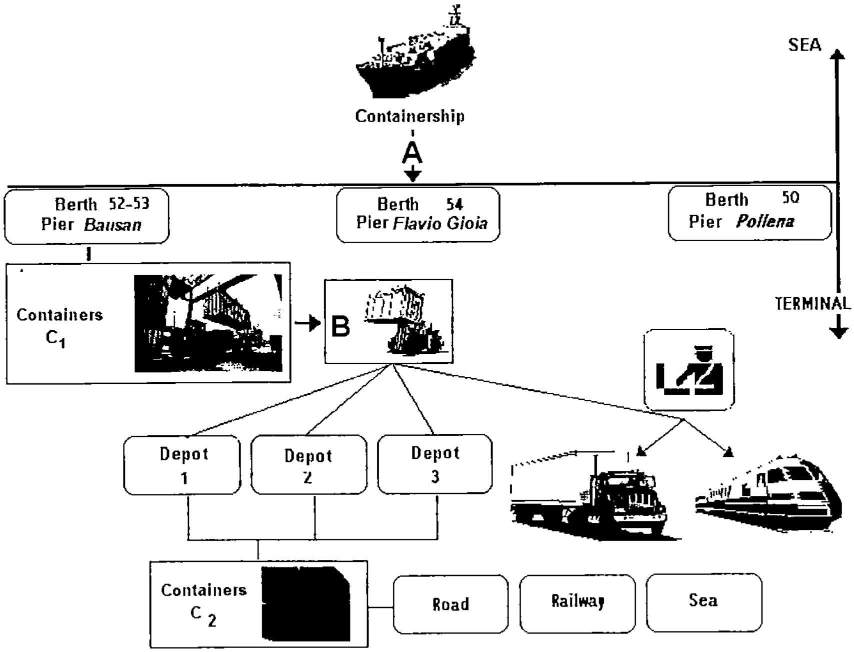


Fig.6 Container cycle

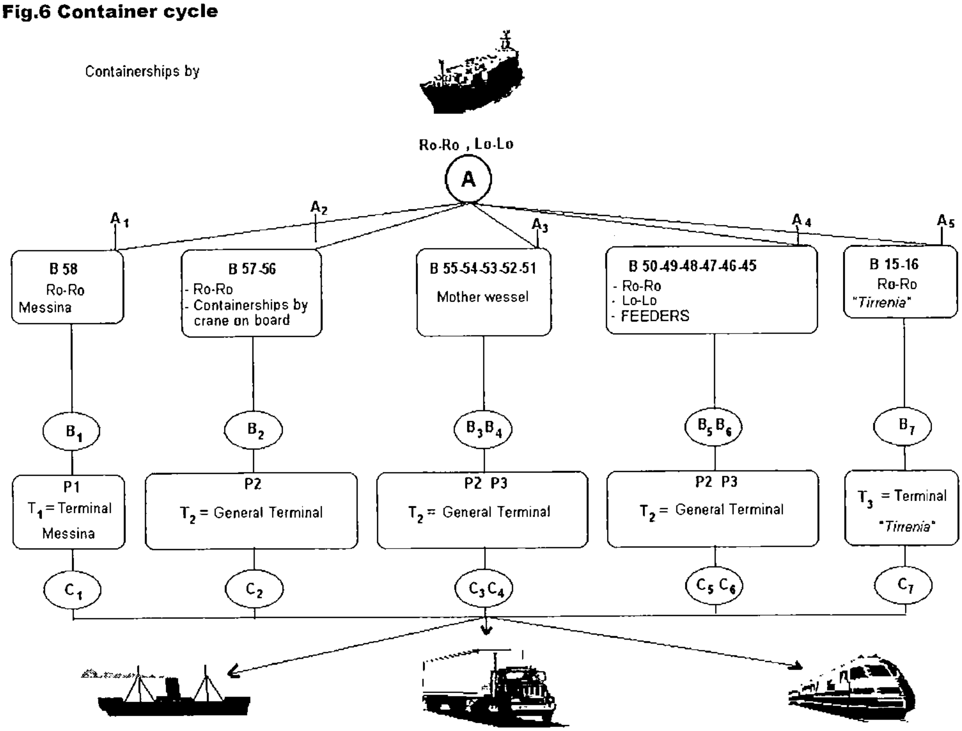


Fig.7 Unitised traffic terminals with the number of mooring

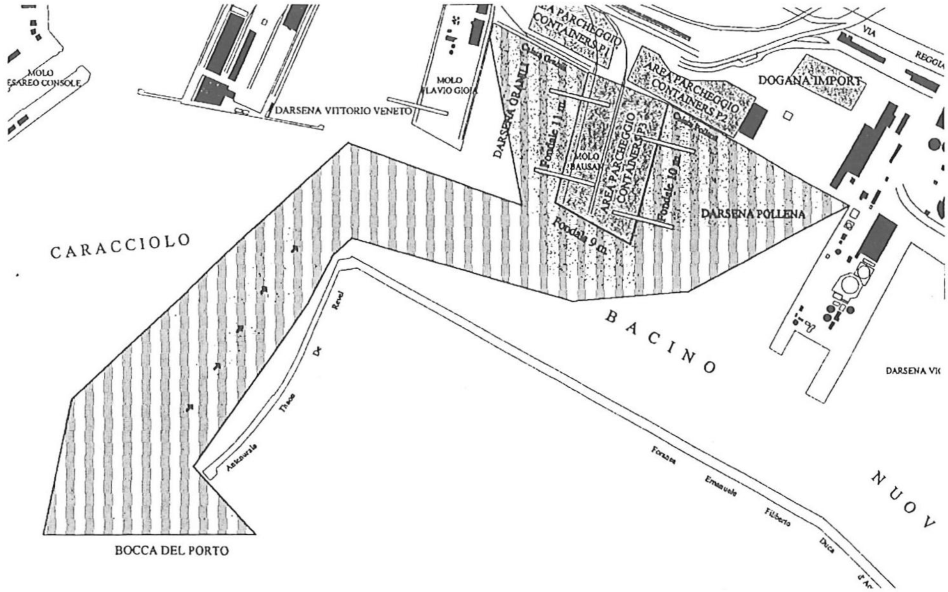


Fig 8 Sea accessibility to the container terminal

Shipping movements can usually be shown by this framework :*vessel data* (vessel name,- voyage number in and out, service type), *vessel time*(planned arrival, pilot on board, gangway ashore, custom cleared, vessel unberthed), *working time vessel*(labour on board, first lift ,last lift ,labour ashore), *operational delay* (crane breakdown, unlashing, etc)..

It is possible to represent with the GIS map ,in fig. 8 ,sea accessibility with the mooring system of the container terminal, both western and eastern quays of the Bausan pier, equipped with two portainers for each side.

The terminal includes the Granili pier which could be used for occasional loading/discharging of shipments. The containers can be immediately cleared by import/export customs and loaded onto lorries and ready for departure.

Quay equipment

The equipment of the terminal essentially consists of tractors , trailers, , forklift with sprider 30 - 45 tons., forklift from 3 - 7 tons for stacking .The terminal has 50 electric sockets for refrigerated containers ,where goods are stored at a constant temperature. The quay cranes are 4 Paceco portainer, over pananax, with a maximum range of 50 tons, more than sufficient to handle a full container.

	Loading/Unloading (min)	%
Trailer (n.3/portainers)		
Total cycle time	9.5	100
Stacking time(overall)	4.0	42
Control time	0.5	6
Handling time	4.0	42
Idle time	1.0	10

Fig.9 Performance indicators of the container terminal (source by CONATECO)

The potential of the portainer installed at the Bausan pier is sufficient to guarantee scheduled traffic volumes on condition that efficiency is at an acceptable performance level This means that it is necessary to avoid technical setbacks by controlling electrical equipment through continuous maintenance. As fig. 9 shows the container terminal is at low productivity levels .

Stacking and storage area

This area is one of the most important in the whole terminal so its connection to the central operative system is important, as is access to it ,the configuration, the total area and so on. The areas directly involved are: slots assigned to each shipping company, custom passage(gate), import/export customs, railway station etc. Optimisation should not only be achieved through management criteria but also equipment efficiency, better rotation to minimise the average stay and thereby reducing the stacking area. The uneconomic use of trailer for stacking causes an inevitably high number of in /out rotation shifts with consequent additional costs.

On the other hand this system has to be adapted to low traffic containers which require no capital intensity.

In the terminal there is also a railway station where trains can be formed. Rail transport has an advantage to costly haulage. Surely the advantage is in reduced external costs rather than lower private costs.

Rail/road transport of the containers

The terminal is equipped with a rail/road system with a high percentage (90%) of containers transported by road, with negative effects on the environment, due to congested urban traffic since the port is surrounded by an urban infrastructure. Fig. 10 shows land accessibility through a good motorway ramp and the maritime railway station ,directly connected to the national railroad system, which facilitates access/egress .It is important to facilitate the passage of lorries using the Granili pier, by good connections within the port.

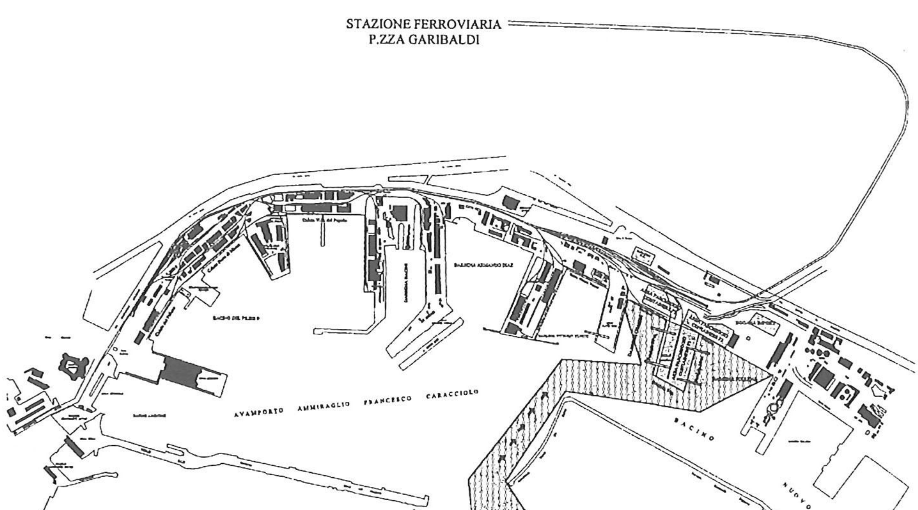


Fig.10 Rail accessibility

Has noted in the GIS, accessibility to the railway can be considered good because it is directly connected by a 4 km track to the Central railway station of Naples.

CONCLUSIONS

The following plan of the area, with the demolition of several structures and the relocation of the tracks, will make it possible to expand rationally in the future. Considering the low level of traffic and the private management of the terminal, investments in infrastructure have to be ruled out. However, reorganisation of the terminal is desirable to increase operational productivity, to minimise plant rigidities. It would be desirable to replace the trailer system by straddle carriers in order to reduce stacking costs. The terminal currently operates in an uneconomic way which can be summarised as follows:

1. Container groups by area:
    - Full container stacking in import- export area for shipping company and line;
    - Custom-cleared container export and import area;
    - Containers with hazardous goods stacked in area near motorway ramp (city boundary);
    - Empty containers not uniformly stacked.
2. Container shifts in storage spaces:
    - Twenty trailers are used according to necessity. For quay crane 3 trailers are assigned
3. Forklifts used:
    - Currently the concessionaire uses 15 forklifts for transfers to storage and stacking spaces;
4. Labour employed :
    - Currently labour is distributed in areas according to operational requirements.

Proposed reorganisation

There is an evident need to allocate storage spaces more effectively, allowing flexibility in terminal management, with a considerable increase in productivity. Detailed requirements can be summarised in the following three points:

- more areas are required for different function (import, export, hazardous goods, empty containers); the use of n.3 trailers for each crane is inefficient;
- there is a need to communicate in real time between all the operators involved in the transport cycle: terminal manager, forwarder, shipping company, port authority, maritime agent;
- a control centre is required to monitor all the logistic activities inside the terminal.

REFERENCES

Njikamp P., Rietveld P., (1994), **Information System for integrated Regional Planning**, North Holland.

Stopford M., (1997), **Maritime Economics**, Routledge London

Charlier J., (1990), **Ports and Hinterland Connections. Ports as Nodal Points in a Global Transports System**, Pergamon Press.

Bowen R. E., (1990), **The Role of Emerging Coastal Management .. Connections Ports as Nodal Points in a Global Transports System**, Pergamon Press.

Ibrahimi M.T, B.de Castilho, C.F. Daganzo, (1993), Storage space vs handling work in containers terminals, **Transportation Research**, n.278.

Evers J. and Koppers S., (1996) Automated guided vehicle traffic control at a container terminal, **Transportation Research**, n.30.

A.V, (1994) Understanding GIS-The Arcinfo Method, **Environmental Systems Research Institute** Redlands, CA.

Calogero V,.Monticelli M., Adams P, (1995), GIS in logistics and freight planning, **Proceedings PTRC Summer annual meeting .**

Maguire D. J..Smith R.C, (1995), GIS on the move : some transportation applications of GIS, **Proceedings PTRC Summer annual meeting**

Antenucci J.C., Brown K., Croswell P.L., Kevany M.J,.(1991), Geographic Information System. A guide to the technology, **Van Nostrand**, Reinhold, New York.

Sutton J,.(1996),Using GIS for regional transportation, **Proceedings PTRC Summer annual meeting** London.

Visser J.G.S., Maat K., (1996) A simulation model for urban freight transport with GIS **Proceedings PTRC Summer annual meeting** London.