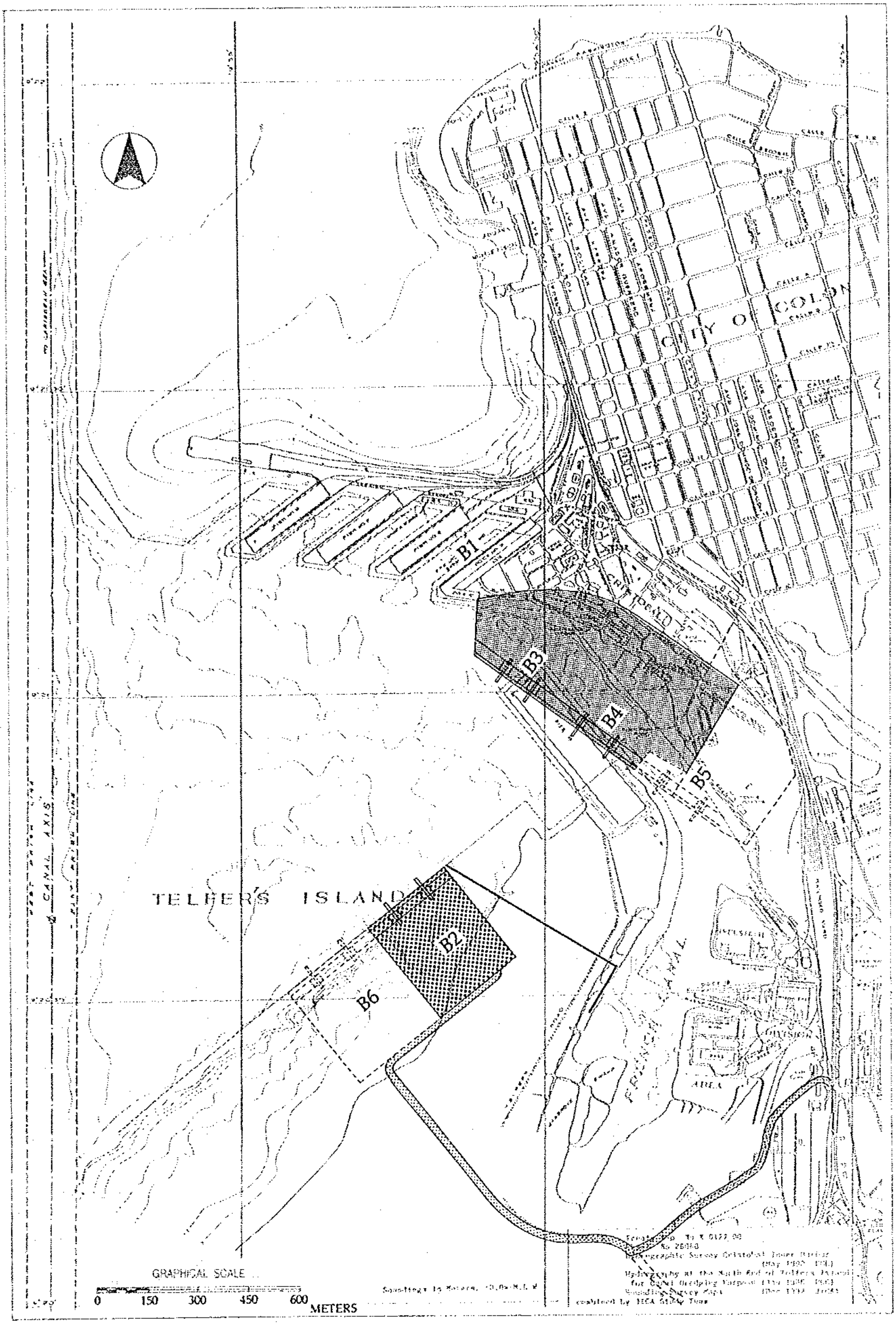


Figure 3-2-5 Alternative Site-F(d)

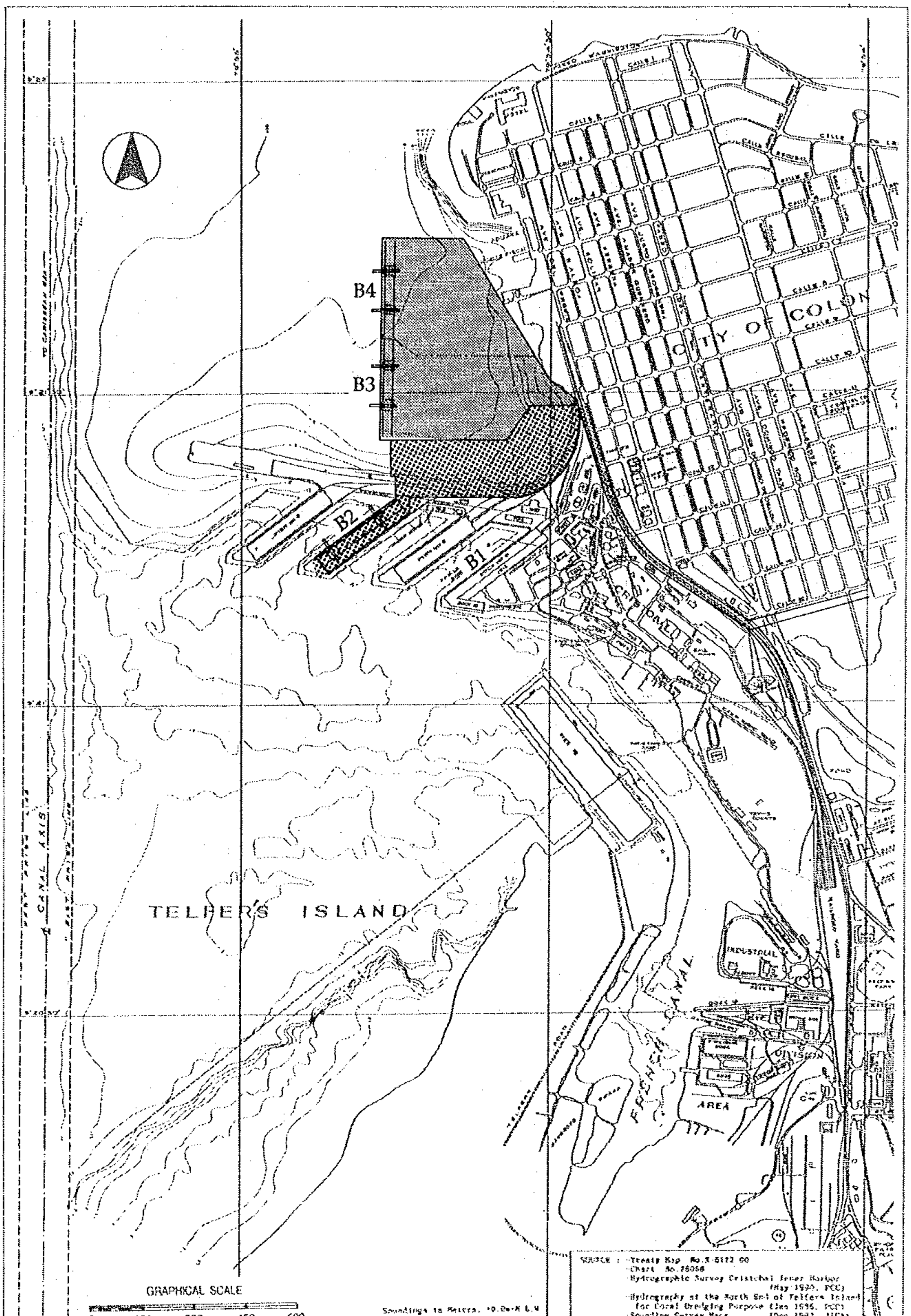


Figure 3-2-6 Alternative Site-C

There may exist a hard rock layer (Gatun Rock Formation) exists at a shallow depth (around 8 m) on the south side of Pier No.16, and it might cause a high construction cost.

For all these alternatives, Pier No.16 will be demolished. In place of bunkering facilities on Pier No.16, a new marginal pier for bunkering service will be constructed along the south side line of excavated area in case of Alternative F(b) and F(d). In case of Alternative F(c), detached pier will be constructed next to new container terminals in Telfers Island.

3.2.3 West Side of Colon (Site-C)

Container berths and yard will be constructed in the water area on the west side of Colon City by a large scale reclamation. In the short term plan, a container yard is constructed on the backside of the mole by reclamation utilizing the existing Pier No.7 as a container berth equipped with two container cranes.(Figure 3-2-6) For the long term master plan stage, reclamation will be expanded and two new container berths will be constructed at the end of the reclaimed land area.

The merits of this alternative are:

* Existing piers are utilized efficiently.
* Initial investment for the short term plan can be reduced.

On the other hand, there are many demerits to this alternative as follows:

* The working rate of the container berths which will be constructed in the long term plan will be affected by the prevailing northern wind and induced wave in dry season in particular.

* Since this area is situated next to the existing city area, there is no room for future expansion on the land area. All the facilities must be located on the reclaimed land area. The water depth in front of the berth is rather shallow, and a large amount of dredging work will be necessary. The volume of dredging greatly varies by design ship size.

* The geo-technical condition of this site is not good, and supporting layer is relatively deep. It is necessary to conduct some soil improvement works.

* For the post master plan stage, there is no room for the additional two container berths and terminals envisioned as future expansion. Those berths will be constructed in another place and investment cannot be concentrated in one site.

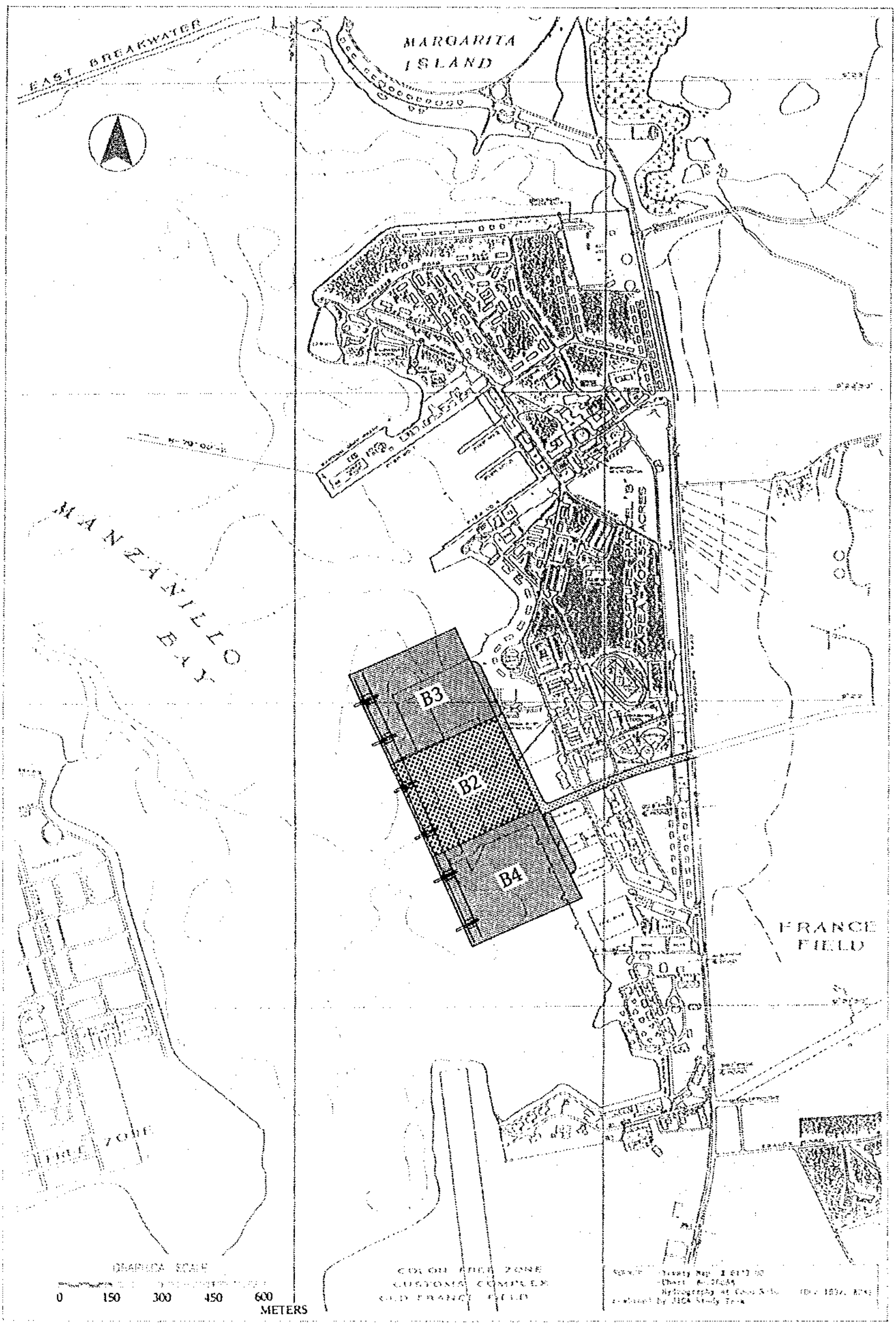


Figure 3-2-7 Alternative Site-CS

3.2.4 Coco Solo Area

Container terminals will be constructed utilizing the open space in the Coco Solo which was formerly used as a hydroplane base port in World War II (Figure 3-2-7). It is necessary to reclaim in order to secure necessary space for the long term plan. This site is closest to the French Field Area of Colon Free Zone,and this can be the great advantage of this alternative. Since water area is shallow, a great amount of dredging work will be necessary. It makes the construction cost, for the short term plan in particular, very expensive compared to the other alternatives.

3.2.5 Comparison and Evaluation of the Alternatives

(1) Reliability

Container cargo handling is said to be sensitive to the movement of container vessels. Berth utility largely depends on the wind and waves. It is necessary to keep the wave height in front of quay wall less than 0.5 m.

Generally speaking, the Limon Bay Area is well protected by the breakwaters from the wind and waves of the Atlantic Ocean. The waves that invade through the entrance of the breakwater will easily dilute into minor ones by deflection at the coastal line. The only thing that should be considered is the wind wave which will be induced by the strong north wind. The area in the Cristobal Basin is protected by the mole double hold. Coco Solo Site is also protected by Colon Island. The only site that can be affected by the wind and waves is West Colon Area. The workability of the container berths at Site-C will be less than that of another sites.

(2) Rough Estimate of Construction Cost

The construction costs for each Alternative are roughly estimated in Chapter 11.

Site-T : construction cost is most inexpensive
Site-F : construction cost differs by alternatives
slightly more expensive than Site-T
Site-C : construction cost in short term plan is most inexpensive
construction cost in long term plan is most expensive
Site-CS : construction cost in short term plan is very expensive
construction cost in long term plan is slightly higher than Site-T

(3) Space Utilization and Future Expansion

Site-T : abundant with undeveloped wide space
Site-F : well organized development with existing terminal
Site-C : just in front of the city area
Site-CS : many buildings still remain on the back side

(4) Water Area Utilization

Site-T : enough depth, anchorage area "F"
Site-F : enough depth
Site-C : relatively shallow
Site-CS : shallow, adverse effect on the water quality

(5) Accessibility

Site-T : easy to access the main road, necessary to construct an access road
Site-F : existing road can be used, countermeasure for congestion is necessary
Site-C : access road must be constructed, separation from existing traffic is necessary
Site-CS : existing road can be used, widening and reconstruction is necessary

(6) Effect on Existing Port Function

Site-T : independent, all existing functions are valid
Site-F : bunker facilities (Pier No.16) must be removed
Pier No.10 will be abandoned
Site-C : existing pier will be reconstructed as a container berth
Site-CS : storage area for imported vehicles must be removed

(7) Overall Evaluation

As indicated in the "Overall evaluation" in Figure 3-2-8, Site-T is selected as the best alternative for the placement of container terminals.

3.3 Strategy on Development Process

The best alternative of the site for container terminals was selected as Site-T in previous section, however, their priority order can be changed if basic conditions change.

Basic criteria for selecting alternative of terminal allocation and process of construction are as follows.

1. It is preferable to form continuous berths at as early a stage as possible.

2. Container berth should be appropriately separated from the access channel of Panama Canal to some extent in order to avoid confusion and interaction with transit vessels of Panama Canal.

3. Container berths should be constructed from the inner bay side because it is necessary to have future flexibility for constructing a deeper berth when necessary.

Evaluation of Alternative Sites for Container Terminals

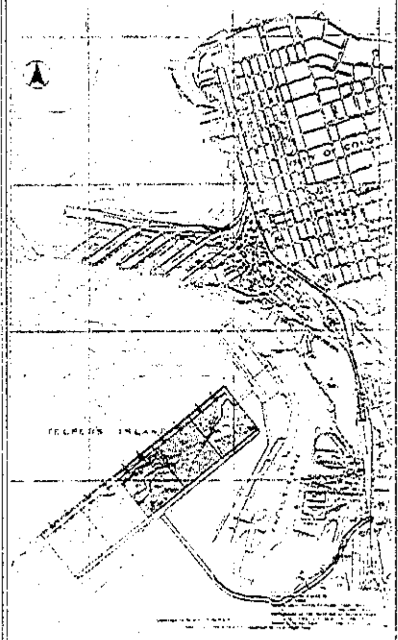
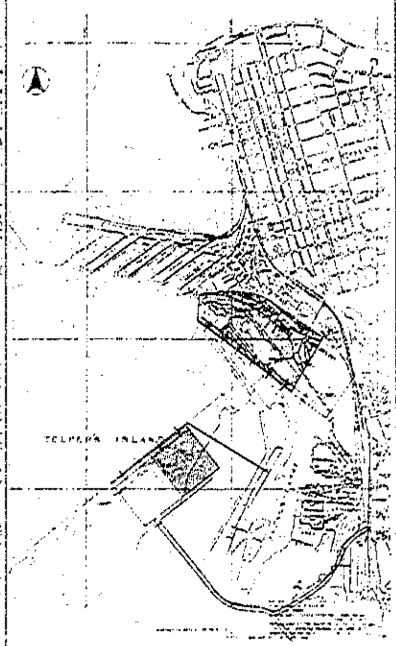
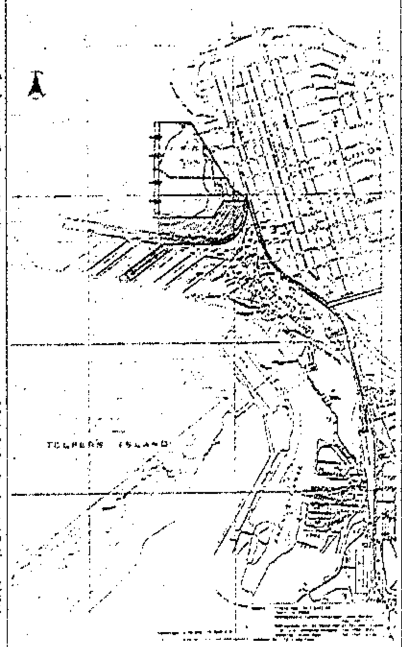
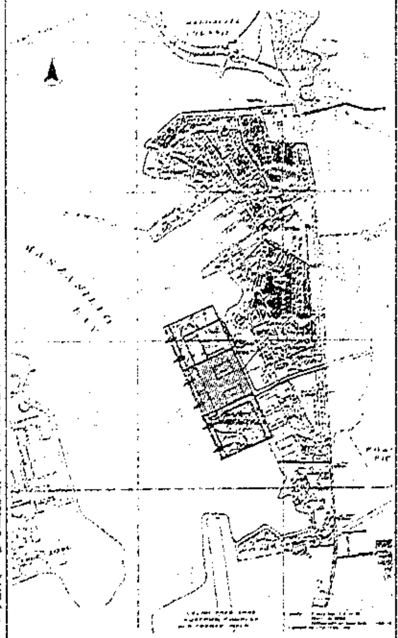
		ALTERNATIVES			
		Telfers Island (T)	French Canal (F)	West Colon (C)	Coco Solo (CS)
PLAN					
EVALUATION	RELIABILITY	A	A	C	A
	CONSTRUCT. COST	A	B	C	C
	SPACE UTILIZATION	A	A	C	C
	WATER AREA UTI.	B	A	B	C
	ACCESSIBILI.	A	A	C	A
	EFFECT ON EXIST. FUN.	A	C	B	B
OVERALL EVALUATION		A	B	C	C

Figure 3-2-8 Evaluation of Alternative Sites for Container Terminals

4. It is important to start construction at a less inexpensive site in order to raise maximum funds to proceed with next step of the project.

The major issues affecting the scenario for development are as follows.

1. The most important issue is whether Telfers Island can be used as a container terminal site. When and what part is available for use.

2. Possibility to removing Industrial Division of PCC.

3. Necessity for integrating terminal function to the existing container terminal

The alternatives of step wise process for development are explained in Figure 3-3-1.

In case that Telfers Island is not available or largely delayed for container terminal use, Alternative-C is the sole option for developing container terminals at the port of Cristobal. However, an access road to the navigation control center which is presently planned to be used exclusively by PCC might be a fatal obstacle for this plan. Serious negotiation will be necessary.

For the terminal layout of the Master Plan, there are three alternatives. In the first alternative, front area of ship repair facilities of PCC will be excavated to open water. In case that the area of Telfers Island available for container terminal is limited and area close to Panama Canal cannot be used, this alternative offers a good option because it has the longest water front line for construction of container berths. If the PCC's Industrial Division is largely expanded and a wider water area is needed in front of the facilities, this alternative is the sole option that could meet the requirement. Main part of container terminals will be efficiently integrated to Cristobal Port Area. However, construction cost is uncertain at this point.

This alternative needs a lot of excavation. Judging from geo-technical data presently available for planned excavated area, there may exist a shallow hard rock layer. Hard rock layers greatly affect excavation cost. It is definitely necessary to investigate geo-technical condition in more detail before proceeding with this alternative. Two additional berths should be constructed at the same time in this alternative.

The second alternative is that one terminal is constructed at Cristobal Area and the other at Telfers Island. Pier No.16 and its base part will be partly demolished to make space for ship operation. This alternative inevitably leads to Alternative F(b). Alternative bunkering berth will be prepared utilizing the remainder of Pier No.16. This alternative has a good balance of terminal capacity between Cristobal and Telfers.

The third alternative is to construct three consecutive terminals at Telfers Island. This option has large future flexibility which leads to any of Alternatives F(a), F(b), F(c) and T in the Post Master Plan Stage. This is the most recommendable alternative at the

Time Stage	Present	Short Term Plan	Long Term Plan		Post Master Plan
Target Year	1991	2000	2010		2020
No. of Container Berth	1	2	3	4	6
Alternatives for Sequence of Container Berth Construction					

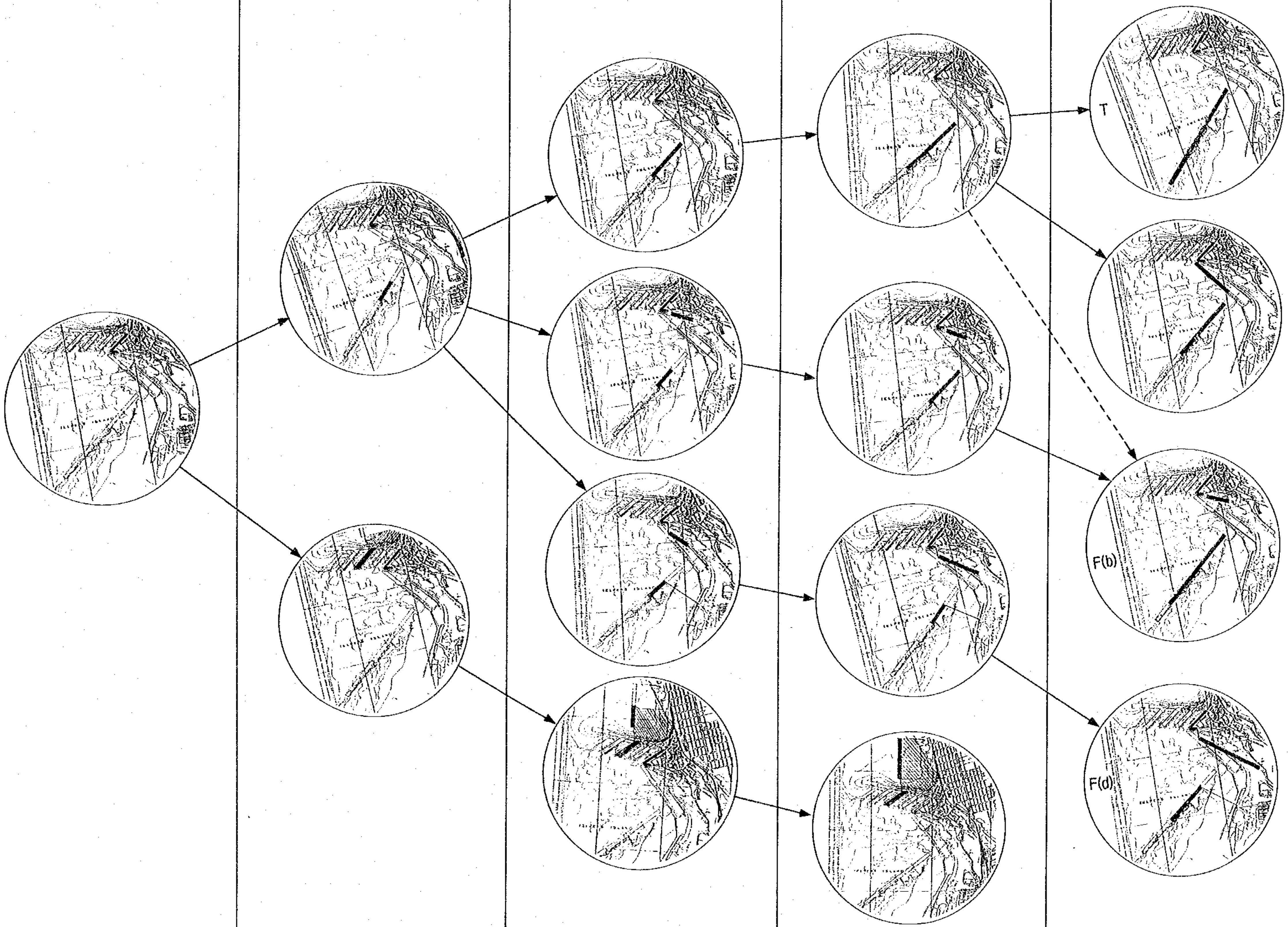


Figure 3-3-1 Alternative of Step Wise Development Process of Container Terminals

Master Plan Stage. In this alternative, the second terminal should be constructed inside of the previous one to keep flexibility for second alternative mentioned above and to cope with future possibility for upgrading berth dimension.

The most important precondition at Post Master Plan stage is the possibility of removing PCC's repair facilities in Mt.Hope area. If removal of PCC's repair facilities becomes possible at an early stage, the best alternative can be changed to Alternative F(a) with a total reclamation of French Canal Area. If the utilization of repair facilities become low and the size of ships entering these facilities become small, Alternative F(c) will be the most reasonable option. For these two alternatives, new bunkering facilities have to be prepared at remaining coastal line of Telfers Island or at another appropriate area. The last and most probable alternative at present is Alternative T. In this alternative, all of the existing functions will not be affected. However, since the last berth is close to the navigation channel of Panama Canal, careful arrangement will be necessary for construction of facilities and operation of vessels. The recommended Short Term Plan and Master Plan are most flexible to any change of future precondition.

3.4 Plan for Allotment of Port Function and Utilization of Facilities

In this section, the basic policy for the allotment of port function and the utilization of port facilities are described on the basis of the best alternative selected in the previous section.

For the first, functional allotment among Telfers, Cristobal, Coco Solo and Bahia Las Minas is examined. Basic policies for functional allotment are as follows;

* Utilize existing facilities as much as possible so long that efficiency is not greatly affected

* Port functions are concentrated to improve efficiency of terminal operation and investment as long as possible

On the basis of these two basic policies, functional allotment of each area is assumed as below;

1) Bahia Las Minas

The port of Bahia Las Minas will be exclusively used for handling dangerous cargo in the long term stage because it has no room for expansion or improvement. Container handling is shifted totally to other ports. However, because of capacity strain it will continue to treat container cargoes at present level in short term stage.

2) Coco Solo Norte

Container handling at the port of Coco Solo Norte has largely increased in recent years. However, it is largely due to the capacity constraint of Cristobal and overall capacity is restricted by its poor port facilities. Container cargo volume handled at this port will not greatly increase in the long run, even if it grows rapidly at present.

3) Telfers Island

On the Telfers terminals, high priority is laid on the effective operation and swift cargo handling, and total volume of container cargo handled at these terminals is intentionally limited to the level of around 160 thousands TEUs for one berth.

4) Cristobal

Existing container terminal in Cristobal is in the position of inter-complementary between Telfers terminals. In the short term stage, it treats the same volume of cargo at present which seems to be the maximum volume available on sacrifice of some degree of handling efficiency even though some rehabilitation work is conducted. In the long term stage, high efficiency of cargo handling of the same level with new container terminals will be attained by full rehabilitation and procurement of new handling equipment and decreasing total volume of container cargo handled.

The majority of container cargo is handled at Pier No.9 and 10 at present. In the long term stage, all container cargoes are handled at these two berths, because these berths can attain high efficiency due to their good location next to the container yard. However, in the short term stage, Pier No.7 will handle more than the present volume in order to cope with the capacity constraint.

Based on the basic concept above, allocation of container cargoes to each port and berth is assumed as shown in Table 3-4-1 and Figure 3-4-1.

All new container terminals will be constructed in the Telfers Island Area. Consequently, no drastic reconstruction will be conducted in existing port area. The main target of this port is container cargo handling. The ratio of large sized full container vessel will increase gradually and steadily. New container terminals on Telfers mainly accommodate these vessels with maximum efficiency. This makes the port attractive, thus increasing its competitiveness with competing ports around the Caribbean Sea.

Existing container terminal will be rehabilitated and modernized without excessive investment. It will complement new terminals and will accommodate various types of vessels. Container yard will be expanded on both land side and water side. Cargo

Table 3-4-1 Allocation of Containers

(Thousand TEUs)

		Laden				Empty	Total
		Import	Export	Tranship	(Reefer)		
1991	Bahia Las Minas	22	8			15	45
	Coco Solo	5	3			6	13
	Cristobal						
	No.6	4	3			6	13
	No.7	10	9			9	28
	No.8	1	1			1	3
	No.9	40	6			30	76
	No.10	15	6			9	30
	Others					7	13
	Sub Total	76	25			62	163
	Total	103	35	(4)		83	221
2000	Bahia Las Minas	22	8	0		15	45
	Coco Solo	7	5	0		8	20
	Cristobal						
	No.6	0	0	0	0	0	0
	No.7	16	6	1		12	35
	No.8						0
	No.9	45	16	5	(4)	34	100
	No.10	14	5	1		10	30
	Sub Total	75	27	7	(4)	56	165
	Terlfers						
	No.1	69	25	9	(5)	59	162
	No.2	-	-	-		-	-
	No.3	-	-	-		-	-
	Sub Total	69	25	9	(5)	59	162
	Total	173	65	16	(9)	138	392
2010	Bahia Las Minas	-	-	-	-	-	0
	Coco Solo	4	2	0		5	11
	Cristobal						
	No.6	0	0	0	0	0	0
	No.7	0	0	0	0	0	0
	No.8	0	0	0	0	0	0
	No.9	46	16	23	(3)	35	120
	No.10	12	4	6	0	8	30
	Sub Total	58	20	29	(3)	43	150
	Telfers						
	No.1	61	23	23	(3)	48	155
	No.2	61	23	24	(3)	49	157
	No.3	61	23	24	(4)	49	157
	Sub Total	183	69	71	(10)	146	469
	Total	245	91	100	(13)	194	630

( ) : Included in other items

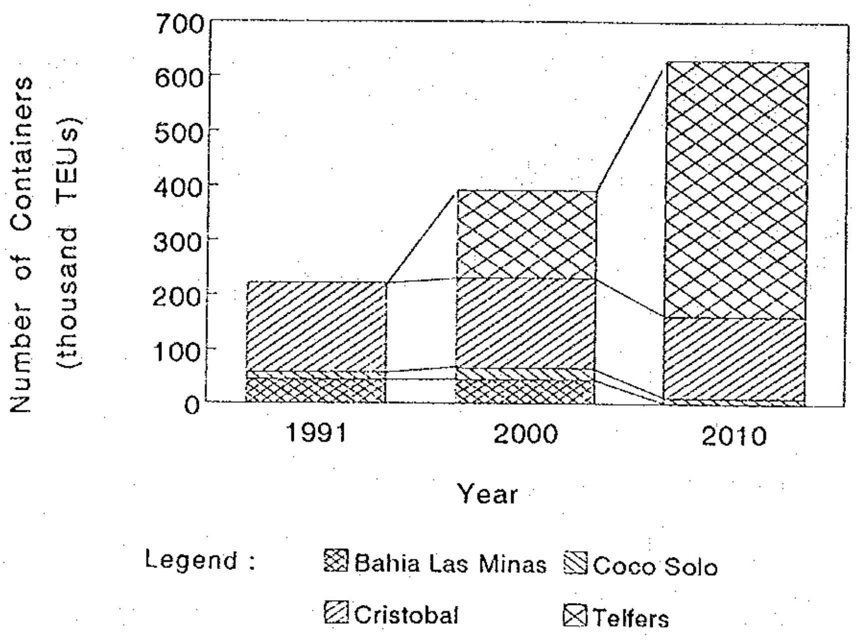


Figure 3-4-1 Allocation of Containers by Terminal

handling equipment will be replaced or newly deployed in order to improve cargo throughput.

Transhipment container cargo will increase sharply, and cargo traffic between the container terminals will also increase. A port highway connecting container terminals will be necessary.

Ro-Ro type cargo handling is mainly operated at the port of Bahia Las Minas at present. Economic handicap is essentially imposed on Ro-Ro type vessels due to their low loading efficiency compared to full container vessels with progress of world wide development of container cargo handling facilities. Judging from the progress of port development in middle and south American countries, however, Ro-Ro operation will be continued for the feeder service somewhere close to the port of Cristobal even after termination of container cargo handling at the port of Bahia Las Minas in Master Plan stage. On the other hand, specific berth facilities for Ro-Ro operation such as ramp are not needed due to small tidal range in the Port of Cristobal. Further, the construction of a new Ro-Ro facility is being carried out by private sector in Co-Co Solo. Therefore, berthing facilities exclusively used for Ro-Ro operation will not be planned in Cristobal or Telfers Container Terminal.

The bunker facilities of Pier No.16 will maintain its function in the future. Since the structural condition seems to have some difficulties, some rehabilitation and re-enforcement will be necessary. The basic configuration and function will not change. In order to cope with the increasing bunker demand, the function of this pier will be concentrated in bunkering. General cargo handling which has been conducted at this pier will be transferred to other existing finger piers.

CHAPTER 4 DEVELOPMENT PLAN OF NEW CONTAINER TERMINALS

For the consecutive container berths which were selected as the best alternative in Chapter 3, the necessary number, scale and physical layout plan were examined.

4.1 Necessary Number of Container Berths

The necessary number and scale of container berths and terminals is investigated and decided. The number of berths is decided on the basis of a preliminary cost and benefit analysis. The evaluation of benefit is estimated only for the decrease of ship waiting time.

4.1.1 Estimation of the Distribution of Ship Waiting Cost

(1) Distribution of Vessel Type and Size

Almost all of the large size vessels calling at Cristobal are full container ships or Ro-Ro type ships. Figure 4-1-1 shows time trend of the average ship size of full container type and Ro-Ro type. The average ship size had been gradually increasing, and has become stable at 15,000 G.T., which is considered to have 900 TEU capacity.

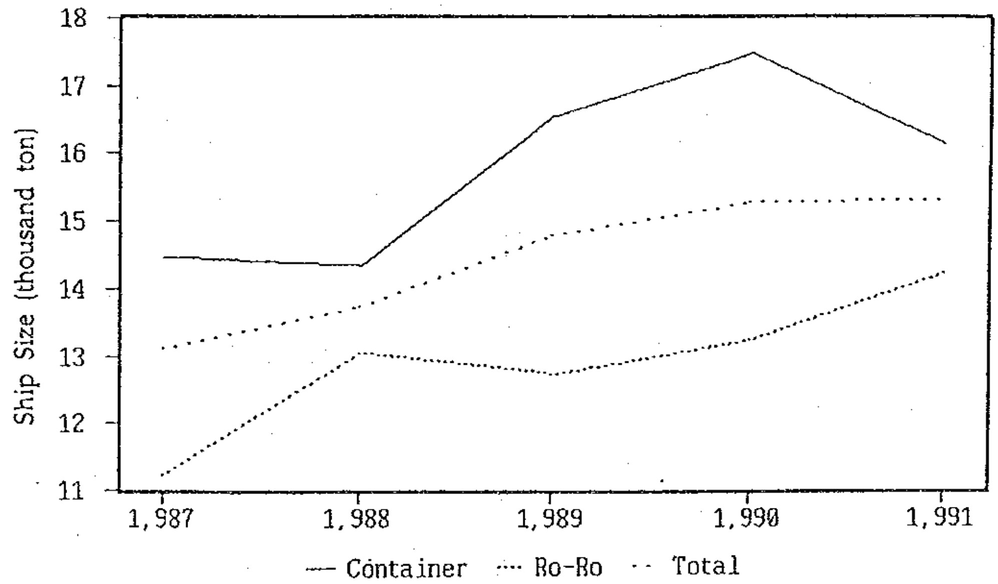


Figure 4-1-1 Time Trend of Average Ship Size

Investigating the data of the number of laden containers which were loaded or unloaded by each full container or Ro-Ro ship which called at Pier No.9 of Cristobal Port in the year of 1991, the average number of containers is around 300 TEU. Since the average ratio of laden containers among all containers is around 60 %, 500 TEU on average is treated by one ship. (There are no direct data indicating total number of loaded and unloaded containers for one ship).

According to the increase of average ship size, the average number of containers treated by one ship will also increase according to the increase in the role of the port of Cristobal in world wide maritime container transportation. In the year 2000 and 2010, average ship size and average volume and number of containers in TEUs and Units handled for one ship are forecasted as follows.

Target Year	2000	2010
Average Ship Size (G.T)	16,000	17,000
Average Ship Size (DWT)	19,000	20,000
Average Container Volume (TEU)	700	900
Average Container Number (Units)	467	600

The ratio of 20 ft containers to 40 ft containers will remain almost the same as at present as no significant tendency to change its proportion has been observed. Above calculation is based on the assumption that it will not change even in future.

The projected container cargo volume and number of ships at Pier No.9 and new berths in the year 2000 and 2010 are shown below.

Target Year	2000	2010
Container Volume Handled (TEU)	262,000	589,000
Number of Ship Calls (/year)	654	374

(2) Ship Arriving Pattern

Using the ship arriving data of the year 1991 at the port of Cristobal, the distribution pattern of the number of ships which arrive in one day was examined as shown in Figure 4-1-2. It was confirmed that the ship arriving pattern is Poisson type.

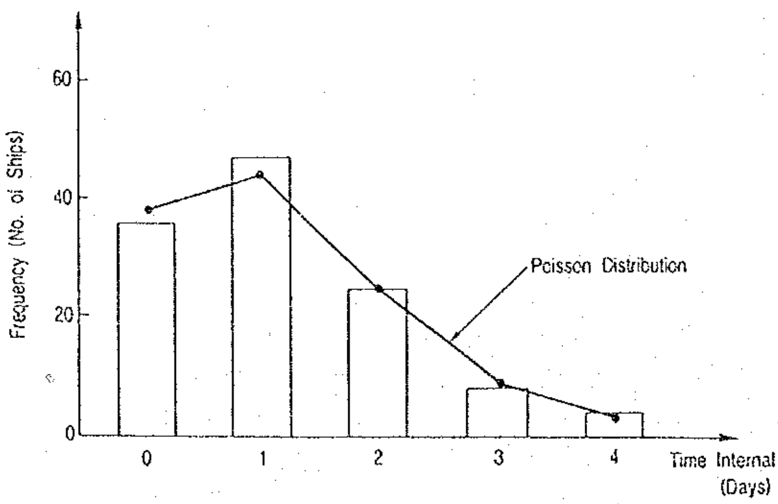


Figure 4-1-2 Ship Arriving Pattern

(3) Distribution Pattern of Service Time

The service time distribution should be examined on the bases of the cargo handling time for the same number of containers instead of the distribution of berthing time itself because the number of containers treated by individual ship differs very much due to the wide variation of ship size and the berthing time doesn't represent service level. Since such service time data is limited at the port of Cristobal, only data from twenty one ship were available to use for the check of service time distribution. It fits 7th degree Erlan distribution as shown in Figure 4-1-3. With sufficient data, it is expected to fit with the second degree Erlan distribution.

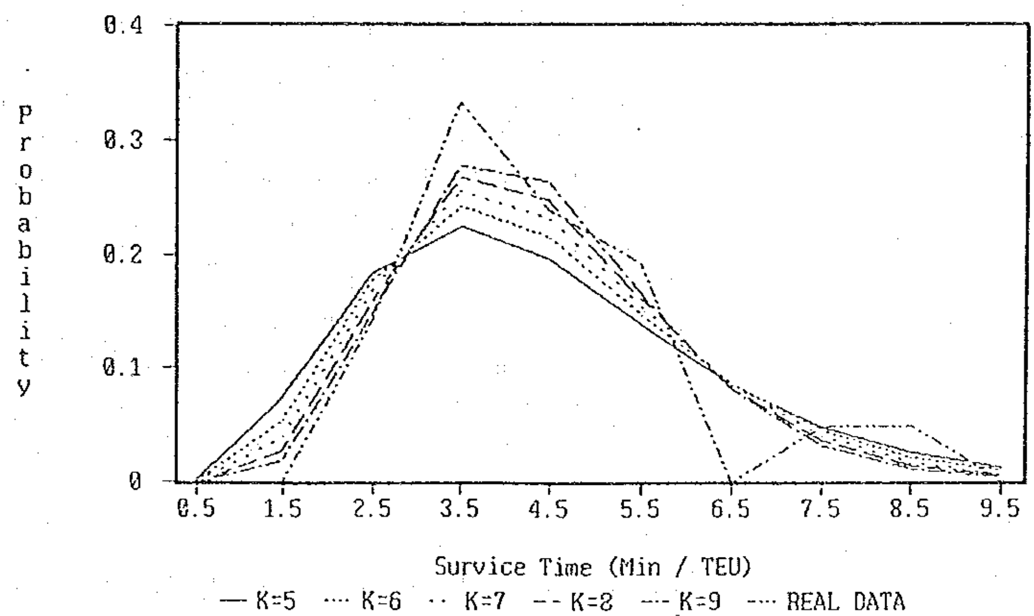


Figure 4-1-3 Service Time Distribution

The average berthing time in 1991 for full container ships and Ro-Ro ships was around 28 hours.

For the calculation of the necessary number of berths, theoretical staying time is assumed as follows:

Specification of container cranes	:	30 units/hour = 45 TEUs/hour
Efficiency	:	0.8
Cargo handling time	:	600/(2*30*0.8) = 12.5 hour
Operation hours	:	16 hours/day
Preparation time before and after the cargo handling	:	5 hours/ship
Redundancy time	:	0.5 day/ship
Staying time in port	:	(12.5+5)/16+0.5 = 1.59 days

Average staying time in the year 2010 is estimated as 1.6 days.
In the same way, average staying time in 2000 is estimated as 1.4 days.
Accordingly, future average staying time is significantly shortened due to improved cargo handling efficiency.

4.1.2 Estimation of Ship Waiting Time Cost and Terminal Construction Cost

In this section, calculation of ship waiting cost and terminal construction cost is shown. Ship waiting cost is calculated for the average ship size and average waiting time which is investigated in the next section. The average ship size is assumed to be 20,000 DWT with a capacity of around 1,000 TEUs in 2010 and its economic ship cost is estimated as around 15,000 $/day for this size container ship including fuel cost of waiting time. In the same way, average ship waiting cost is estimated for the year 2000 as 14,000 $/day. All of the ship cost is not necessarily borne by the Panamanian economy. Virtually all of these ship are owned by foreign shipping companies and their effect on the Panamanian economy will take place in an indirect manner. The contribution ratio is difficult to determine theoretically, however, it is usually estimated as 50 %.

For the construction cost of new container terminal, it is estimated in the case that the terminal will be constructed on Telfers Island. Construction cost including cargo handling equipment is roughly estimated as 80 million dollars.

Annual maintenance cost of the terminal facilities is assumed as 1 % for civil works and 5 % for mechanics. So, total maintenance cost will be 2 % of total construction cost.

Annual operation cost including personnel cost basically depends on the volume of cargo handled in the terminal, and does not differ significantly. Accordingly operation cost is not considered in this analysis.

4.1.3 Optimum Number of Container Berths

Optimum number of container berths is decided in a manner that minimizes the total cargo handling cost. Existing berth at Pier No.9 is treated as 1 berth having the same throughput with newly constructed terminals. Among the components of total cost, ship waiting cost and terminal construction cost depend on the number of berth. These two kinds of cost will be calculated for each of the alternatives of the number of berths and the alternative with the least total cost is selected as the best alternative.

In order to calculate average waiting time, "Queuing Theory" is applied as shown in Table 4-1-1. This result indicates that it is impossible to cope with the demand with one berth in 2000 and with three berths in 2010. In this analysis, the distribution of service time is assumed as 2-degree Erlan distribution.

Table 4-1-1 Optimum Number of Container Berths

Target Year	2000			2010		
No of Berth	1	2	3	3	4	5
No. of Ships	374	374	374	654	654	654
Berthing Time (day)	1.4	1.4	1.4	1.6	1.6	1.6
Berth Occupancy Ratio	1.43	0.72	0.48	0.96	0.72	0.57
Wating Time Ratio	*****	0.83	0.09	*****	0.31	0.07
Total Waiting Time (day)	*****	435	47	*****	324	73
Daily Ship Cost ($/day)	14,000	14,000	14,000	15,000	15,000	15,000
Annual Waiting Cost (thousand $/year)	*****	3,042	330	*****	2,433	549
NPV (million $)	*****	28.6	3.1	*****	22.9	5.2
Cost Difference (million $)		*****	25.5		*****	17.7

In the next step, total cost is compared among each alternative. To make things simple, the construction is assumed to be accomplished in the first year. Ship waiting cost and operation and management cost appear after service begins and last during the project life time. It is assumed that the service begins in the second year and that the project life is 30 years. These costs must be evaluated as a Net Present Value (N.P.V.) in the first year. Discount rate is assumed as 10 %. On this condition, N.P.V. of ship waiting cost is calculated as follows;

NPV of ship waiting cost = Annual ship waiting cost * 0.5 * 9.4
NPV of O/M cost = Construction cost * 0.02 * 9.4

For the Short Term Plan:

Total Number of Berth	1	2	3
Construction Cost (million $)	80	160	240
NPV of O/M Cost (million $)	15.7	31.3	45.1
NPV of Ship Cost (million $)	*****	28.6	3.1
Total Cost (million $)	*****	220	288

**** unrealistic large value

For the Master Plan:

Total Number of Berth	3	4	5
Construction Cost (million $)	240	320	400
NPV of O/M Cost (million $)	45.1	60.2	75.2
NPV of Ship Cost (million $)	*****	22.9	5.2
Total Cost (million $)	*****	403	480

**** unrealistic large value

These results indicate that two berths (one existing berth and one new berth) are most appropriate for the short term plan stage, and four berths (one existing berth and 3 new berths) are most appropriate for master plan stage.

4.2 Cargo Handling Systems

The most suitable cargo handling system is selected among various kinds of handling systems. There are three typical types of systems: Chassis System, Straddle Carrier System and Transfer Crane System. There also exist many kinds of variations of these systems. The main characteristics of these three systems are explained as follows:

(1) Chassis System

Under this system, containers are directly unloaded onto chassis using a portainer or a shiptainer. After the containers are placed on chassis, they are pulled to the container yard by a tractor.

The advantages of this system are:

- containers can be moved out speedily at any time
- container yard does not require heavy-duty pavement
  probability of container damage will be reduced

On the other hand, disadvantages are:

- the same number of chassis are required as there are containers
- a vast container yard is needed

(2) Straddle Carrier System

Under this system, containers are unloaded directly onto the apron using a crane, and are then moved to the container yard using a straddle carrier.

The advantages of this system are:

- the crane's operation time can be reduced
  container yard can be smaller than that of chassis system

On the other hand, disadvantages are:

- the number of times the containers are handled will be increased
- the container damage rate increases due to the increased handling times

(3) Transfer Crane System

Under this system, containers are unloaded directly onto chassis, moved to the container yard, and then stacked in a few layers by transfer crane.

The advantages of this system are:

- the utilization of land space is more efficient than that of the other systems
- It is easy to automate and/or computerize this system

On the other hand, disadvantages are:

- it may take a lot of time to remove the stacked containers, particularly those in the bottom layers
- total amount of handling and damage may increase
- the path of the transfer crane must be determined and specially reinforced

(4) Selected System

A tire-mount transfer crane system was selected as the most suitable system considering total area required, total amount of initial investment and ease of operation and management.

The required terminal area by different cargo-handling systems is summarized on the condition of a new container terminal of a short term plan in Table 4-2-1. In order to get an image of the scale, preliminary layout image of main facilities for each alternative is shown in Figure 4-2-1 to 4-2-3 in the same scale.

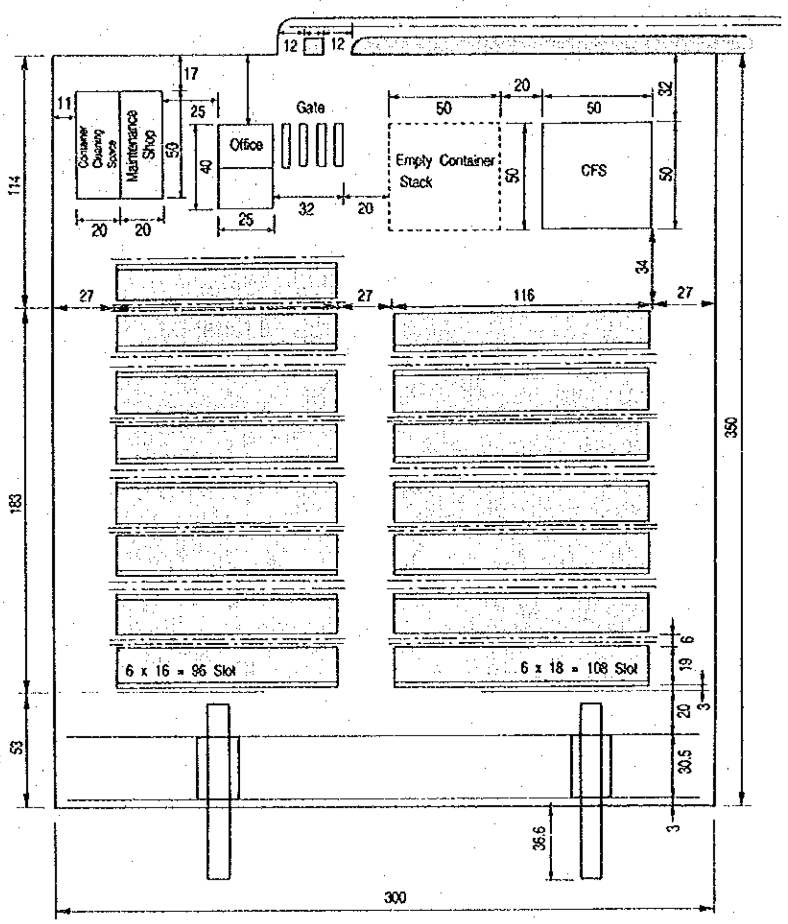


Figure 4-2-1 Short Term Plan Transfer Crane System

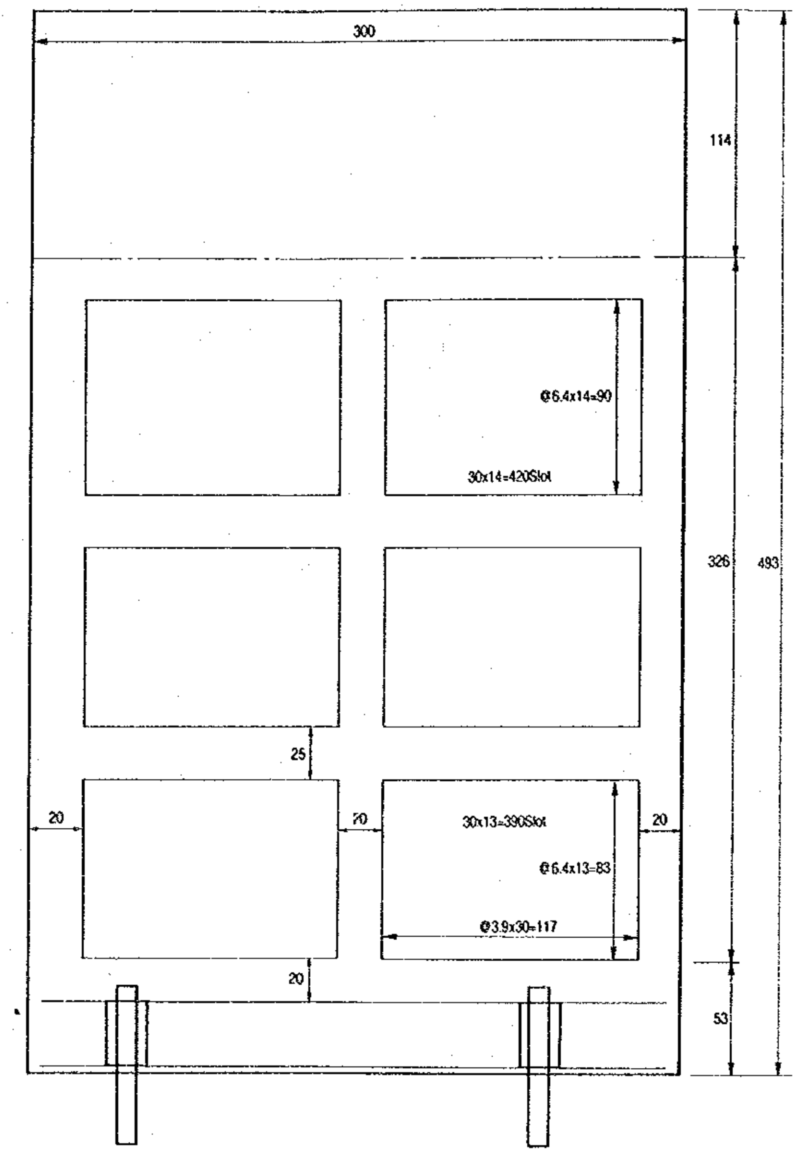


Figure 4-2-2 Straddle Carrier System

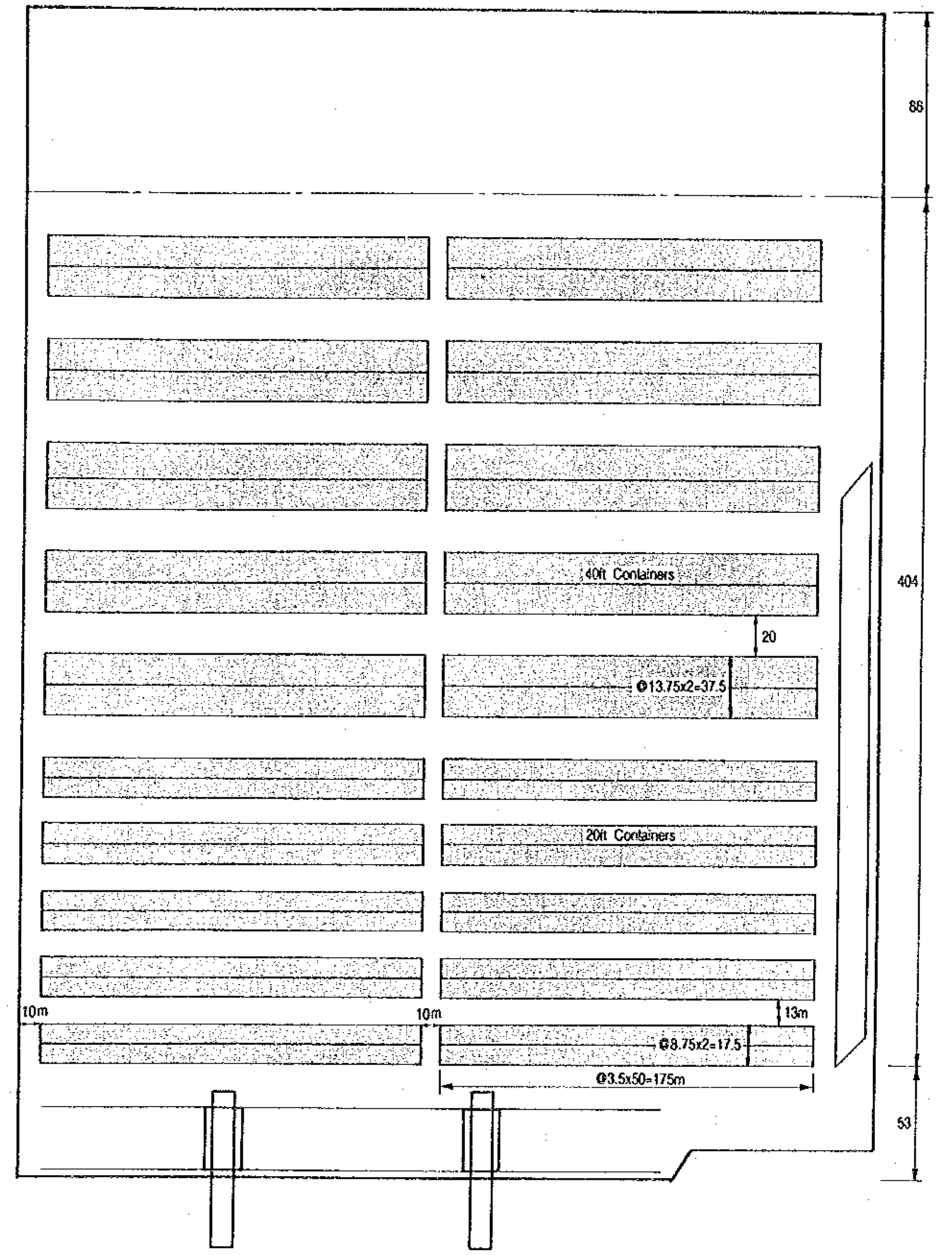


Figure 4-2-3 All Chassis System

Table 4-2-1 Required Terminal Area by Different Cargo-handling Systems

Unit: m^2

Cargo-handling System	Transfer Crane	Straddle Carrier	All Chassis
Total Area (Length x Width)	105,000 (300 x 350)	147,900 (300 x 493)	217,200 (400 x 543)
Marshaling Yard Sub-total Slot Area Others (Length x width)	 54,900 26,900 28,000 (300 x 183)	 97,800 59,900 37,900 (300 x 326)	 161,600 96,250 65,350 (400 x 404)
Apron (Lenth x Width)	15,900 (300 x 53)	15,900 (300 x 53)	21,200 (400 x 53)
Backyard Sub-total CFS Head Office Reair Shop Others (Length x Width)	 34,200 2,500 1,000 1,000 29,700 (300 x 114)	 34,200 2,500 1,000 1,000 29,700 (300 x 114)	 34,400 2,500 1,000 1,000 29,900 (400 x 86)

As the chassis system requires a very wide area, nearly 22 ha for one terminal, it seems impossible to secure such a wide space in Telfers Island considering post master plan stage.

Straddle carrier system needs a relatively wide space and frequent maintenance, however, it is not easy to secure such a back-up system in Panama.

Tire mounted transfer crane system is recommendable as the best alternative.

4.3 Required Scale and Quantity of Port Facilities

4.3.1 Container Berth

(1) Design Ship Size

Existing port facilities are designed for the maximum size ship which can transit the Panama Canal, that is to say, Panamax Type. All piers have a depth of more than 12 m and channel and basin are also maintained more than 12 m. Almost all full container ships and Ro-Ro vessels of Panamax size calling at the port of Cristobal transit the Panama Canal. There is little possibility that the over Panamax type vessels will call at Cristobal without transit of the Panama Canal in future considering major world wide shipping routes. The design ship size depends on the dimensional restrictions of the canal facilities.

Even though the study of alternatives to the Panama Canal is ongoing, the restriction of the size of transit vessel will not change at least until 2010, and perhaps, the expanded canal will not be in service before 2020. Accordingly, there is no rationale for over Panamax type vessel calling at Cristobal. Accordingly, it is appropriate that the design ship size is decided based on the dimensions of Panamax type vessels.

(2) Berth Dimension

The maximum size vessel currently calling at the port of Cristobal regularly is "TEXAS" which is a Ro-Ro vessel with a dimensions of 262 m in length, 32.3 m in width and 11.0 m in usual draft entering this port. It usually calls at this port on the way from Los Angeles to Miami. The maximum draft of the vessel which can transit the Canal is limited to less than 39.5 ft (12.04 m), and waterways and basins are generally designed as 42 ft (12.73 m) deep in consideration of the extent of oscillatory motion of the ship due to the natural conditions such as waves, winds and tidal currents, and the trim. Consequently, it seems appropriate that the water depth of the new berths is kept as 13 m.

If the Panama Canal is reconstructed and Over Panamax type vessels become able to transit the Canal, deeper berths will be required in this port. In order to cope with such a situation anticipated in future, it is recommended to have a flexibility for future expansion by designing the berths to be deepened up to 14 m.

The necessary berth length for the Panamax type vessel is usually estimated as below;

$$289.6 \text{ m} + (32.3 \text{ m} \times 1.7) = 344.5 \text{ m}$$

The second item is due to the necessity for mooring. Since calling of Panamax type vessel is not so frequent even in the short term plan stage, the berth length can be reduced by installing mooring bits out of the end of the berth. In case of long term plan stage, frequency of the calling of Panamax type vessel will increase, however, the restriction will be alleviated because of formation of three continuous berths. Accordingly, the berth length is decided as 300 m for both short term plan and long term plan. It is also possible to extend berth length up to 350 m as long as all new berths are designed to be deepened up to 14 m afterward.

(3) Container Crane

Existing container cranes at Pier No.9 are designed for Panamax type vessels and there seems to be no problem with their mechanical specification. Container cranes of new berths shall have equivalent or better specifications than that of existing cranes. Considering the world wide trend of up-sizing of container cranes, the major specifications of the cranes are decided as follows;

Rated capacity (under the spreader)	:	41 MT(Metric Tonnage)
Outreach	:	36.6 m
Rail span	:	30.5 m
Back reach	:	15.0 m
Main hoist speed/Loaded	:	50 m/min
Main hoist speed/Spreader	:	120 m/min

4.3.2 Container Yard Facilities

(1) Marshalling Yard

Required storage number of containers in the marshaling yard (Ml) is calculated as follows;

$$Ml = My \times Dt \times p / Dy$$

where: My : Annual container throughput (TEUs/year)
Dt : Average dwelling time (days)
p : Peak ratio
Dy : Annual operating days (days/year)

Required number of ground slots (Ns) is calculated as follows;

$$Ns = Ml / H$$

where: H : Average stacking height (layers)

Ns is calculated as 1,495 for the year 2000 and 4,185 for the year 2010 as shown in Table 4-3-1. Average dwelling time is assumed on the basis of the actual observation data in the container yard.

Table 4-3-1 Required Storage Capacity of New Container Yards

Target Year 2000	Unit	Laden				Empty	Total
		Import	Export	Reefer	Tranship		
Annual Container Throughput (My)	TEUs	65,000	24,000	5,000	9,000	59,000	162,000
Average Dwelling Time (Dt)	Days	6.0	2.8	5.0	3.5	6.0	5.4
Required Storage Number (M1)	TEUs	1,449	250	93	117	1,315	3,223
Stacking Height	Layers	2.0	2.0	1.5	2.0	2.5	2.2
Required Ground Slots	Slots	724	125	62	59	526	1,495
Target Year 2010							
Annual Container Throughput (My)	TEUs	175,000	67,000	10,000	71,000	146,000	469,000
Average Dwelling Time (Dt)	Days	6.0	2.8	5.0	3.5	6.0	5.1
Required Storage Number (M1)	TEUs	3,900	697	186	923	3,254	8,959
Stacking Height	Layers	2.0	2.0	1.5	2.0	2.5	2.1
Required Ground Slots	Slots	1,950	348	124	462	1,301	4,185

In actual yard planning, container storage area is planned to have 1,524 slots in Short Term Plan and 4,620 slots in Master Plan including some amount of redundancy.

(2) Container Freight Station

Required area of CFS (S) is calculated as below;

$$S = (W \times D \times p) / (w \times r \times T)$$

where:
W : Cargo volume treated in CFS (ton)
D : Average dwelling time (days)
p : Peak ratio
w : Average stacking weight on unit area in CFS (ton/m^2)
r : Effective use ratio of floor area in CFS
T : Annual operating days (days/year)

The ratio of LCL containers is very low in general and decreasing annually. It is around 5 % in 1991 and assumed to be at the same level in future. W is estimated as follows;

Target Year	2000	2010
Number of laden containers except tranship and reefer (TEUs)	89,000	242,000
Unit cargo volume (ton/TEU)	7.14	7.14
LCL cargo ratio (%)	0.04	0.04
W : LCL cargo volume (ton/year)	24,562	69,115

Another parameters are assumed as follows;

D = 10 days, p = 1.5, w = 1.0 ton/m^2, r = 0.6, T = 250 days

On the assumption above, S is calculated as follows;

Target year	2000	2010
S : Required space of CFS	2,456 m^2	6,911 m^2

The required number of bays (Nb) can be checked by;

$$Nb = (N \times p) / (n \times T \times b)$$

where : N : number of containers through CFS (Units/year)
n : average number of containers which can be treated in one bay (Units/day)
b : bay occupancy ratio

Parameter n and b are assumed as below;

n = 3 Units/day
b = 0.5

Target Year	2000	2010
Number of Containers (Units)	2,373	6,453
Number of Bay	10	26

Since the necessary length of the bay is usually from 3.5 m to 3.75 m, required length of CFS is 37.5 m in 2000 and 97.5 m in 2010. Accordingly, the area of CFS is decided as 2,500 m^2 (50 m x 50 m) in 2000 and 7,000 m^2 (50 m x 140 m) in 2010.

(3) Maintenance Shop

The size of the maintenance shop depends on such factors as the rates of container damage, the type and number of cargo-handling vehicles and machines to be used in the terminal. Considering other examples, following dimensions are assumed;

Area : 1,000 m^2 (40 m x 25 m)/ berth
Height : 10 m
Width of the space in front of the maintenance shop : more than 10 m

(4) Terminal Office Building

The area of the terminal office is decided from the number of persons working in the terminal. Based on past experience, it is assumed that around 150 persons work at one terminal. Required floor area for one person is usually set as 10 sq.m. Accordingly, required floor area is 1,500 m^2. In case that half of the office is two stories, necessary area of terminal office is 1,000 sq.m for one terminal. It is located next to the terminal gate.

(5) Terminal Gate

Terminal gate is set up near access roads, and in the center of the container yard. Gate facilities are generally made up of two truck scales and 4 gate lanes per berth.

(6) Stacking Yard

Stacking yard for the empty containers is kept in the vacant space of the terminal. However, this area may not be sufficient to house all empty container stacking. It is necessary to reserve sufficient area around the terminal in order to prepare stacking yards afterwards in accordance with the increase of demand.

(7) Transfer Cranes

Tire mount type transfer cranes with a span of 23 m (for 6+1 row) and a height of four layers clearance are deployed in the marshaling yard. This is the most general type recently used throughout the world. There are two major categories of cargo handling in marshalling yards. One is to or from quay side and the other is to or from the outside of the terminal through the gates. Transfer cranes are used for both types of cargo handling. Those two handling operations may take place independently and simultaneously. Average handling capacity of a transfer crane is assumed at around 18 units/hour. To correspond with the handling capacity of two container cranes (40 units/hour), more than three transfer cranes are necessary for the former operation. For the latter operation, the necessary number of transfer crane is calculated as follows;

Target Year	2000	2010
Annual throughput of containers except transhipment (Units)	102,000	265,300
Number of containers treated in one hour (Units)	66	172
Number of Transfer Cranes	4	10

Gate operating days and hours are assumed as 250 days and 8 hours respectively. Peak ratio is assumed as 1.3.

Since each terminal can be operated independently, seven transfer cranes are required for one terminal in total. An example of basic assignment of transfer cranes for each kind of slot in Short Term Plan is shown as follows;

	Number of rows assigned to one crane	Number of cranes
Export Containers	1	1
Import Containers	2	3
Empty Containers	2	2
Others	2	1
Total	7	7

(8) Chassis and Tractors

Required number of Chassis largely depend on the way of cargo handling. It varies from 10 to 40 for one berth. On the other hand, the number of tractors is usually from 10 to 12. For the purpose of cost estimation, numbers are assumed as 16 for chassis and tractors.

(9) Basic Layout of Major Facilities

Basic layout of major facilities in container terminals is proposed in Figure 4-3-1 for the long term plan. Smooth expansion from the layout of the center terminal in short term stage shown in Figure 4-2-1 is taken into consideration as much as possible.

Three continuous Panamax type container berths will be constructed along the coastal line of Telfers Island. Container cranes should be able to move to the next terminal in order to allow flexible assignment of cranes to berths.

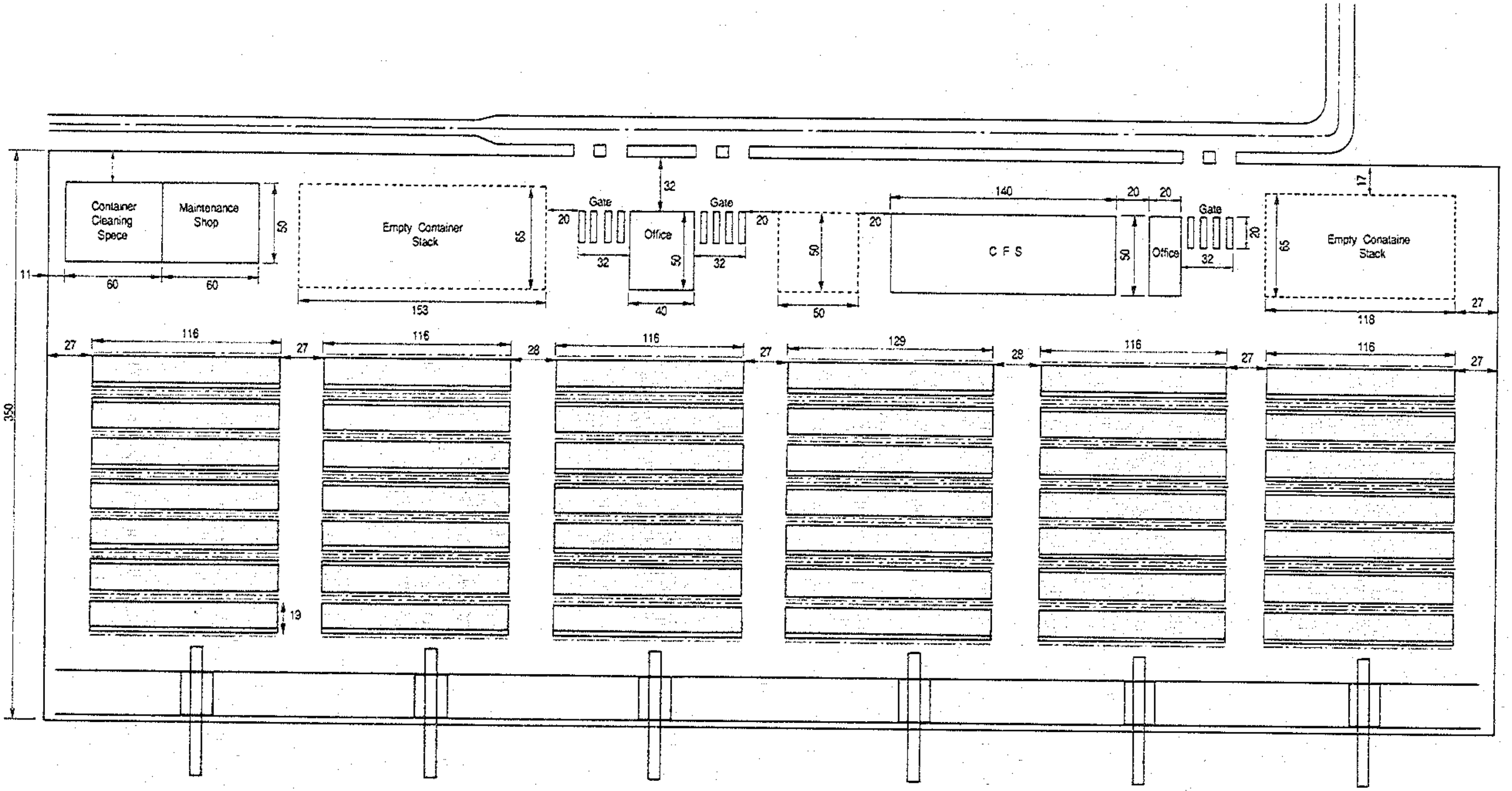


Figure 4-3-1 Basic Layout of Major Facilities (2010)

In marshalling yard, a comprehensive tire mount transfer crane system is introduced. Inner access space should be kept wide enough for smooth transportation of containers. At the back side of the marshalling area, 2.0 ha of open space in total for tentative empty container stacking and chassis parking will be provided. Empty containers will be gathered by each shipping company and densely stacked up to four layers. Top-loaders will be used for handling empty containers at these open space. Next to the maintenance shop, container cleaning spaces with area of 3,000 sq. m is provided.

At the back side of container terminals, access road with four lanes is provided keeping enough distance (more than 8 m) from terminal boundary in order to reserve space for possible future introduction of access railroad.

4.3.3 Waterways and Basins

Waterways and basins with calmness and sufficient space and depth must be secured for smooth anchorage, smooth ship operation and cargo handling.

Access navigation routes should be provided from both the northward and southward direction because many of the container vessels that call at Telfers container terminals transit Panama Canal before or after berthing. Considering limited effect of waves and current, access waterways will secure width of 150 m which is the same as the Panama Canal navigation channel.

In front of the terminals a sufficient water area for turning of the bow of ship should be secured. The area of turning basin should exceed the area of a circle with the radius of the overall length of the design ship in case that tugboats are expected to be used for ship maneuvering. Accordingly, an area with a radius of 300 m is secured as a turning basin.

Vessels are expected to anchor in front of wharves with their bow pointing north-east, namely starboard berthing. The way of ship departure differs by direction of destination. In case of south bound, ships have to turn to the opposite direction. As a result, water area shown in Figure 4-3-2 will be required for ship operation and can be secured within Cristobal Basin. However, there are many other vessels that call at existing piers. Arrangement and justification of water area use between new container berths and existing berths, especially Pier No.16, will be necessary.

Water depth of these water areas should be kept more than -13 m. Since the entire area of Cristobal basin is kept more than -12 m at present, total amount of dredging volume for providing and maintaining waterways and basins is small. It is practical to make the water depth more than -13 m for the entire Cristobal Basin for the purpose of flexible use of water area.

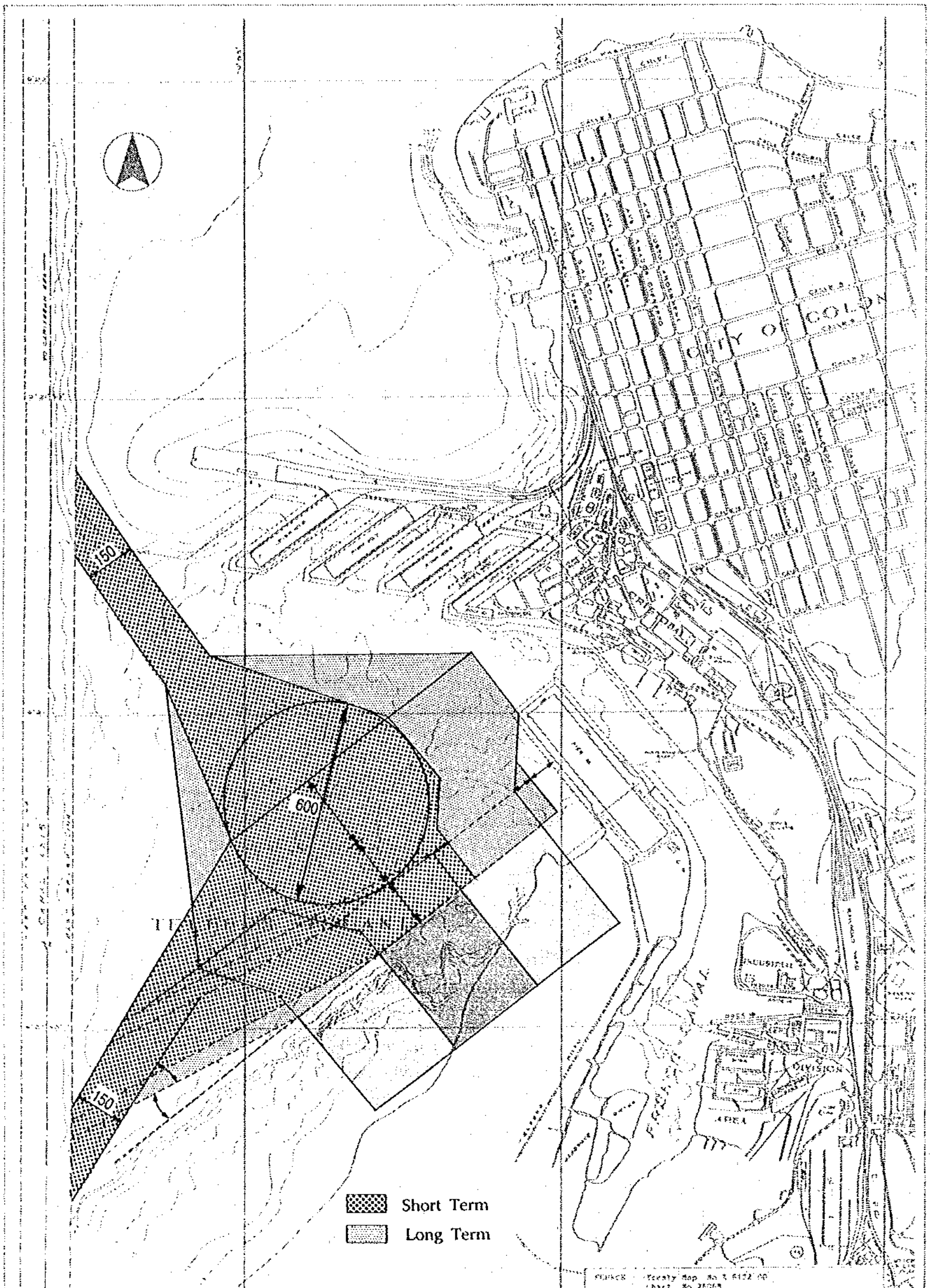


Figure 4-3-2 Waterways and basins for New Container Terminals (Master Plan)

CHAPTER 5 MODERNIZATION PLAN FOR EXISTING CONTAINER TERMINAL

5.1 Improvement Plan for Operation

5.1.1 Container Handling System

There are many handling methods at container terminals throughout the world including chassis system, straddle carrier system, transfer crane system, forklift (top-loader) system and others.

The most suitable handling system for the terminal will be selected. The items to be considered are as follows:

a) Land utilization
b) Height of stack
c) Efficiency of container crane
d) Working hour for taking in/out container
e) Damage ratio of container
f) Required skill of driver
g) Term for training of driver
h) Maintenance cost
i) Running cost
j) Required skill for repair
k) Amount of investment (machinery)
l) Amount of investment (container yard)
m) Scale of repair shop
n) Experience of handling
o) Automation of operation

The results of the comparison of handling systems are as shown in Table 5-1-1.

As can be seen from the following comparison considering the actual circumstances at the port of Cristobal, in selecting these systems, it is important to consider the condition of cost factors (initial, running and maintenance) and ordinary operation.

Transfer crane system is superior from the view-point of cost and operation and recommended to be adopted in the target year of 2010. Concerning the target year of 2000, both systems,transfer crane and forklift, are recommended same as at present.

Table 5-1-1 Comparison of Handling Systems

	Chassis system	Stradle carrier system	Transfer crane system	Forklift System (Top -loader)
(a) Land utilization	large	medium	small	large
(b) Height of stack	low	medium	high	medium
(c) Efficiency of container crane	low	high	long	high
(d) Working hour for taking in/out container	short	medium	long	medium
(e) Damege ratio of container	low	high	medium	high
(f) Required skill of driver	low	high	medium	high
(g) Term for training of driver	none	long	medium	short
(h) Maintenance cost	small	large	medium	large
(i) Runnig cost	low	high	medium	high
(j) Required skill for repair	low	high	medium	high
(k) Amount of investment (machinery)	medium	small	large	small
(l) Amount of investment (container yard)	medium	large	medium	small
(m) Scale of repair shop	small	large	-	medium
(n) Experience of handling	none	none	yes	yes
(o) Automation of operation	low	medium	high	medium

5.1.2 Computer System

(1) Outline of Computerization

At the port of Cristobal, the container handling operation is managed by inventory card and computer-based container terminal operation has not yet started.

Computerized yard location planning and stowage planning are both popular in many container terminals in different parts of the world. From the historical view, the degree and extent of computerization has generally been as shown in Table 5-1-2.

Table 5-1-2 Degree and Extent of Computerization

	Approximate annual	Terminal office	Yard opreation
Level 1	-60000TEUs	manual	manual
Level 2	60000-150000TEUs	computerized	manual
Level 3	150000TEUs-	computerized	computerized

Almost all the container terminals in the world have reached Level-2. Some in Europe, USA and Japan have been proceeding toward Level-3. The annual container handling volume at the port of Cristobal has reached Level-3.

(2) Introduction of Computerized Container Operation system

As mentioned above, the port of Cristobal should introduce a computerized container operation system.

Since it will be difficult to quickly introduce the total computer system mentioned below, it will thus be necessary to start with a small scale computer system in the target year of 2000, which has the following functions:

a) Promoting the stacking plan.
b) Determining container storage positions.
c) Determining re-handling when unloading containers.
d) Promoting the shift plan in the yard.
e) Promoting the sequence plan of ship loading/discharging.
f) Controlling the yard map.

However, the development of small scale computer system should take into consideration the possibility of extending component of system before further development system.

The total computer system is introduced in the target year of 2010, and the basic concept of this system is divided into following three systems.

1) Terminal Control System

This system includes the following two major programs:

a) Marshalling yard control program
Function: Determination of export container locations.
Determination of import container locations.
Determination of change of locations; instruction and revision.
Storage container list inclusive of container locations and status.

b) Gate control program
Function: In-bound container control.
Out-bound container control.

2) Terminal Planning System

This system includes the following three major programs:

a) Loading schedule program
Function: Inputting and filing the number of loading containers and their

status from a specific vessel.
Preparing preliminary plans, a bay plan, a stowage plan, a schematic plan, a sequence checklist, etc.
Finalization/revision of preliminary plans.
Calculation of weight, height of center of gravity of the ships, cargo combinations, monitoring and others.
Monitoring of operation

b) Discharging schedule program
Function: Inputting and filing the number of containers discharged and their status from a specific vessel.
Preparing preliminary plans a schematic plan, a sequence checklist and rehandling list.
Monitoring of operation.

c) Program for optimal handling equipment procedure.

3) Documentation System

This system finalizes all the information processed and/or developed in systems described previously. Preparing documentation to submit to the parties concerned and filing the necessary information for port statistics can be carried out with this system.

The outline of the total computer system in each for area as a whole can be referred in Figure 5-1-1(1)-(4) and 5-1-2.

(1) Receiving

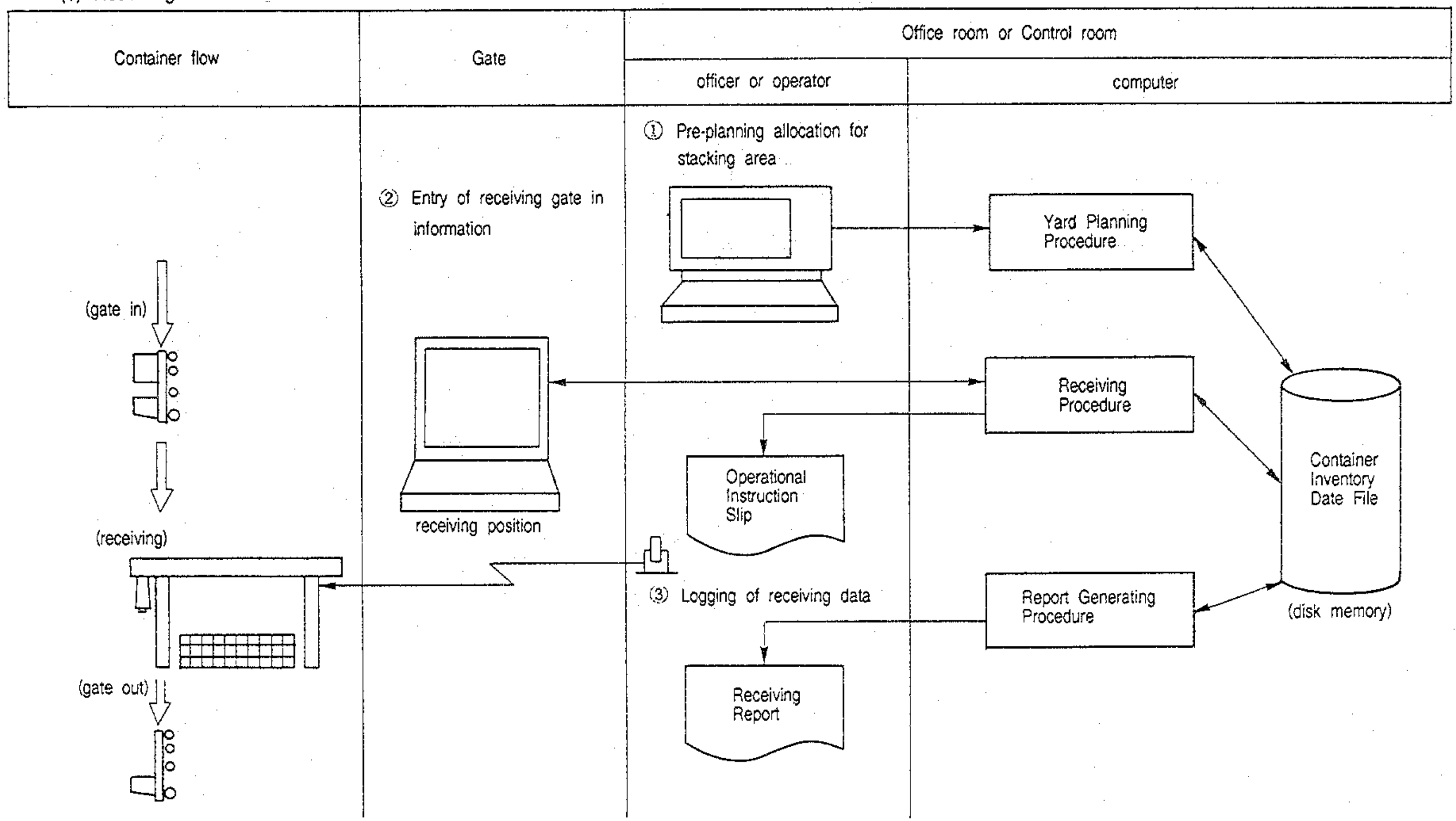


Figure 5-1-1(1) Gate Control Program

(2) Delivery

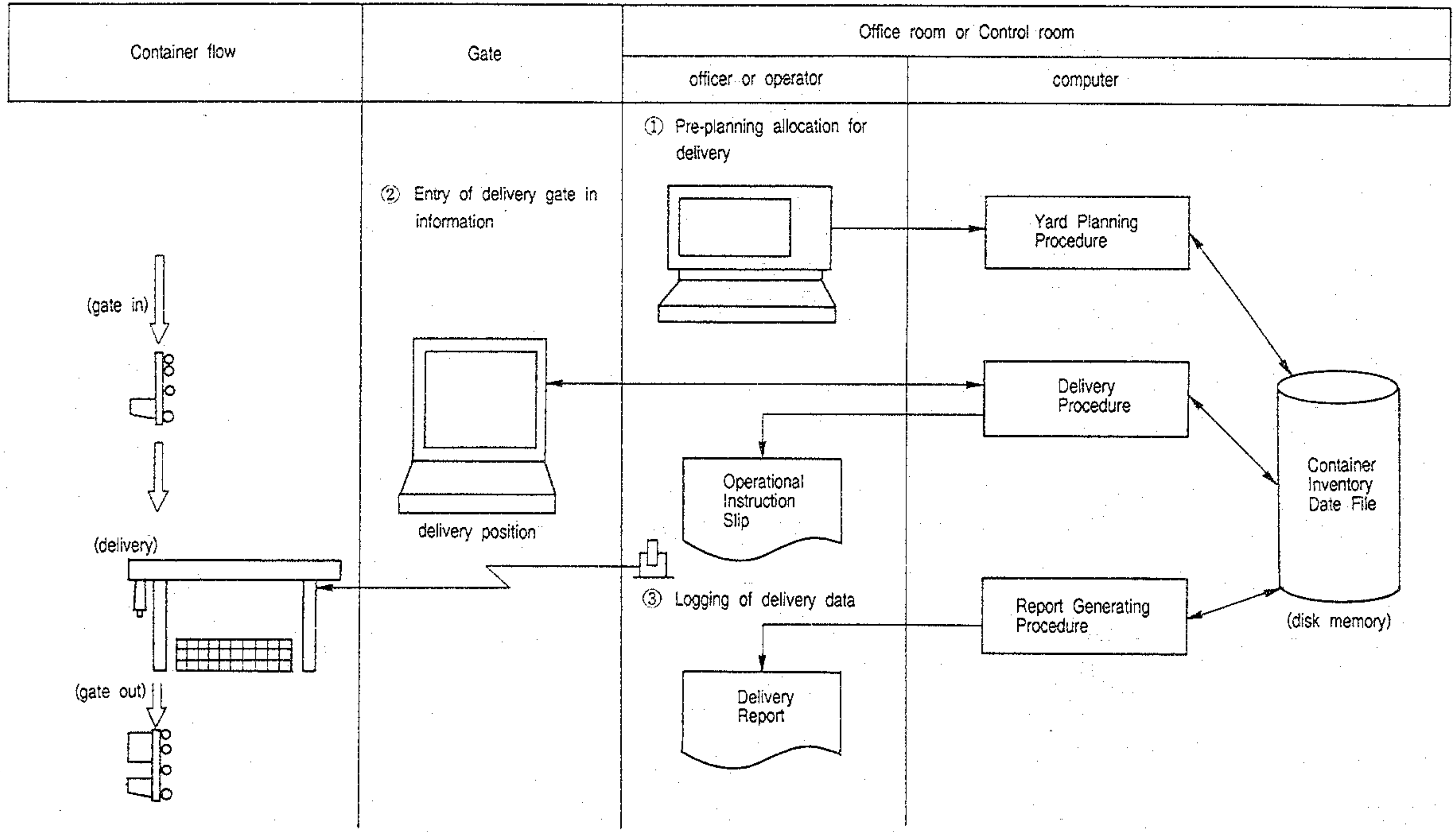


Figure 5-1-1(2) Gate Control Program

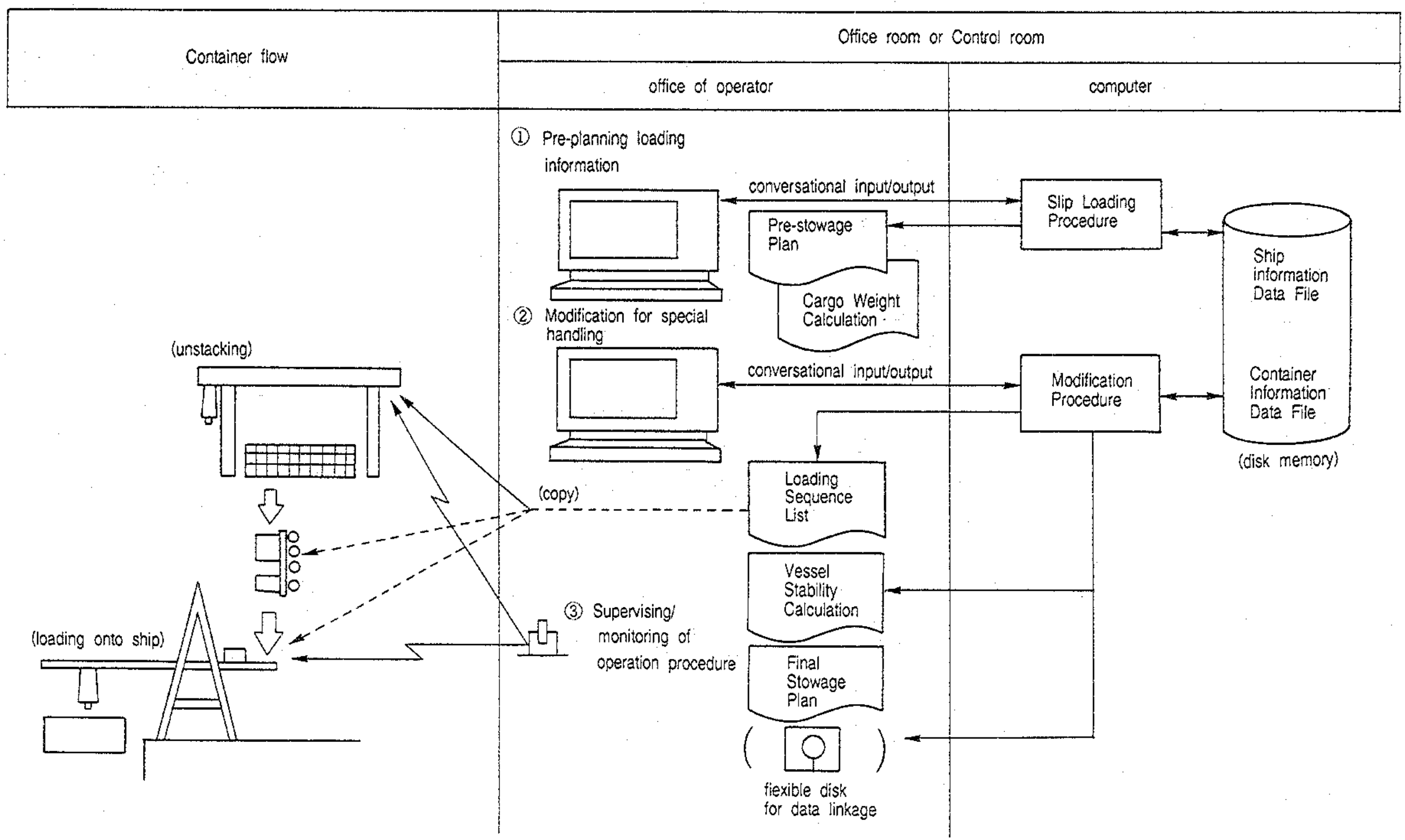


Figure 5-1-1(3) Loading Schedule Program

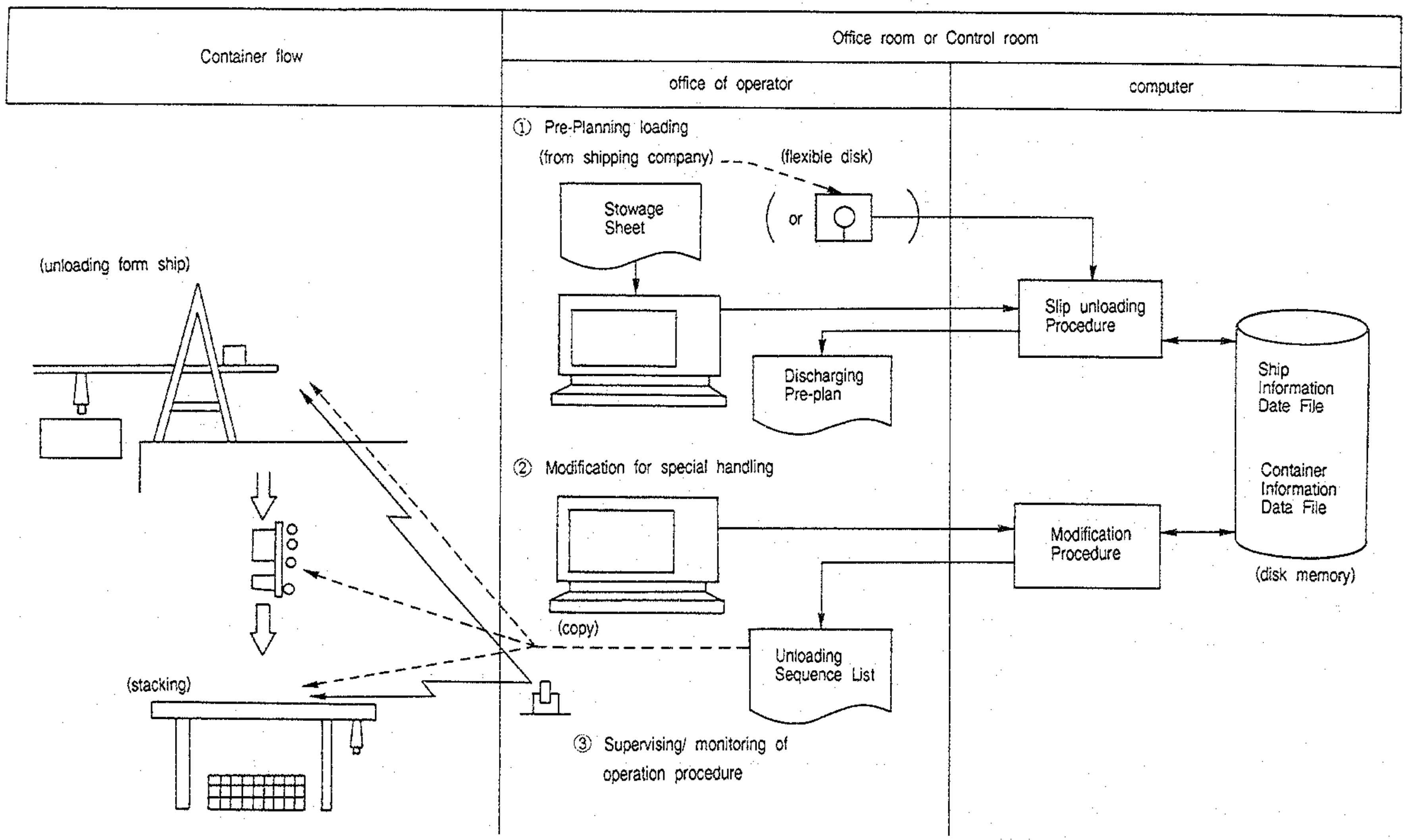


Figure 5-1-1(4) Discharging Schedule Program

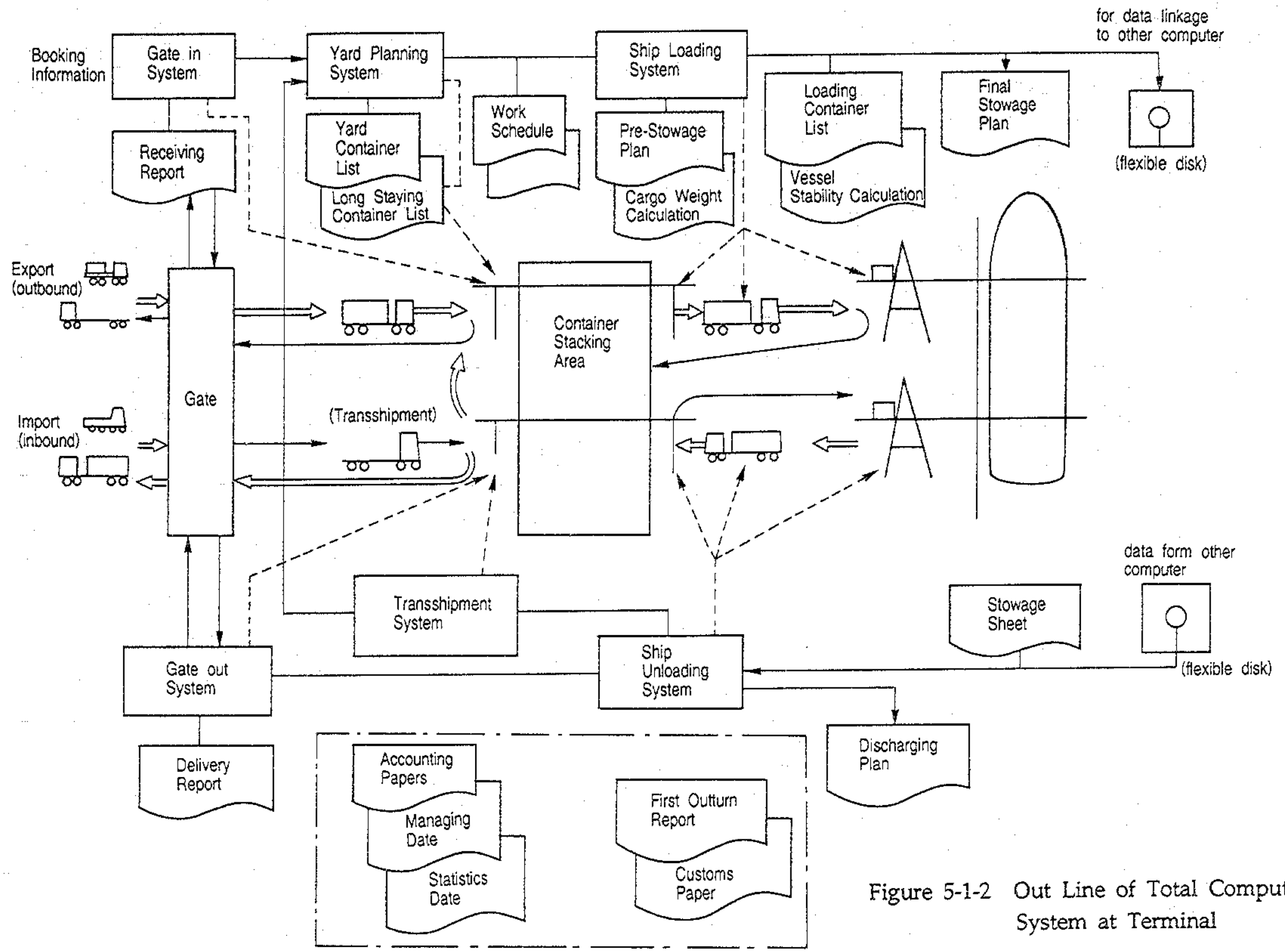


Figure 5-1-2 Out Line of Total Computer System at Terminal

5.1.3 Maintenance and Repair System

(1) Present Conditions

There is one building in the port area used for maintenance and repair facilities for cargo handling equipment which includes a workshop and office. The cargo handling equipment owned by APN totals 94 units. Thus all cargo handling equipment will have to be maintained, inspected and repaired on a regular basis.

The present workshop can provide sufficient space for these activities in the target year of 2000 and 2010.

The main problem concerning maintenance and repair is the low ratio of operation days of handling equipment as shown in Table 5-1-3.

Table 5-1-3 Operation Days Handling Equipment

November.1992

	Total number of equipments		Available working equipments		Working ratio
	Unit	Available working days	Unit	Actual working days	(%)
Trasfer crane (20')	1	30	0	0	0.0
Trasfer crane (40')	1	30	1	30	100.0
Top-loader	7	210	3	16	7.6
Forklift	44	1320	34	643	48.7
Tractor	24	720	15	443	61.5
Chassis	14	420	8	225	53.6

Source: APN
Notes: This table was made based on APN's data by Team

The low ratio of operation days of handling equipment seem to be due to the following reasons:

1) Insufficient Supply of Spare Parts

Insufficient supply of spare parts means that old spare parts are used for a long time, which accounts for the frequent breakdown of equipment.

2) Old and Useless Equipment

As mentioned in section 8.1, Part I, there is a plethora of old and useless equipment. APN does have procurement plans for cargo handling equipment but does not have any replacement plan or disposal plan.

3) Lack of Preventive Maintenance System

All maintenance and repair works are carried out by the port, however, preventive maintenance such as monthly and annually checks are not performed. Preventive maintenance is to check and repair equipment before it breaks down or its function deteriorates, and to avoid breakdowns and ensure its original function.

4) Lack of Training

The port of Cristobal has a large quantity of large scale cargo handling equipment. In order to keep this equipment in good condition, high levels of technology and skill are required in terms of both maintenance and repair. However, APN has not been providing training.

5) Lack of Proper Maintenance and Repair Works Records and Data

APN keeps many kinds of records of maintenance and repair works. However, there are no proper records for analysis of all the actual records and data.

(2) Improvement Plan

The main purpose of maintenance and repair is to keep equipment in good condition thereby increasing productivity of handling equipment by minimizing trouble during container handling operation.

The main points of the improvement plan for the above mentioned items are outlined as follows:

1) Procurement of Spare Parts

The insufficient procurement of spare parts is due to lack of budget. It is necessary to consider a systematic purchase scheme based on the analyzed consumption of spare parts as soon as possible. A skilled expert is necessary to carry out the analysis.

2) Planning of Replacement Plan or Disposal Plan

Replacement and/or disposal is considered less important than the procurement plan from the point of view of budgetary requirements. However, replacement plan or disposal plan are more important than procurement plan in terms of having the appropriate amount of cargo handling equipment and also in terms of maintaining cargo handling equipment in an economical fashion.

3) Implementing Preventive Maintenance System

Preventive maintenance is to check and repair equipment before it breaks down or its function deteriorates, and to avoid breakdowns and ensure its original function. On the other hand, corrective maintenance is a passive form of maintenance which restores the original function of the equipment by carrying out repairs after the trouble.

4) Training of Personnel

The necessity of training of APN personnel is described in the next section.

5) Introduction of Computerized Maintenance and Repair

Records related to maintenance and repair can neither be analyzed nor utilized sufficiently. Thus a computerized maintenance and repair system should be introduced at the level of personal computer.

Since the port of Cristobal was returned thirteen years ago, APN has been executing repairs and maintenance works by itself. However, as most of the machines and tools at the workshop are becoming superannuated, APN needs to reinforce its maintenance ability.

The following machines and tools should be replaced:

(a) All types of dissolving and assembling tools.
(b) Measuring tools.
(c) Rust removers, painting tools.
(d) Handling machines.
(e) Machinery.

Including the above instruments, the necessary maintenance instruments are as shown in Table 5-1-4. Moreover, as a movable repair shop truck, one four-ton truck equipped with necessary repairing instruments should be provided.

Table 5-1-4 Necessary Repair Instrument

Instrument	Quqntity	Remarks
Hot Water Pressure Washer	1 unit	Body, Engine Steam Wash
Compressor with Engine	1 set	Compressed Air Supply
Electric Bench Grinder	1 unit	For Paintig, Holding
Air Sander	1 unit	〃
Big Hammer	3 units	〃
Oxygen Welding Set	3 sets	〃
Dynamic Power 10-ton	1 set	〃
Hand Tool Set	5 sets	Assembly and Disassembly
Impact Wrench	2 sets	〃
Portable Lubricator for Grease	1 unit	〃
Bench Vise with Bed	2 units	〃
Electric Bench Drill	1 unit	〃
Portable Electric Drill	1 unit	〃
Pipe Wrench 450	3 units	〃
Monkey Wrench 4502	3 units	〃
15-ton Press	1 unit	〃
Portable Working Light	5 sets	〃
Parts Cleaning Basin	1 set	〃
Welder and Register	1 set	〃
Chain Block	1 set	〃
Welder with Engine	2 sets	〃
Hydraulic Jack 10-ton	3 units	Hydraulic Jack
Garage Jack 5-ton	2 units	〃
Micro Centimeter Counter	2 sets	〃
Variou Tools	1 set	Tire Repair
5-HP Compressor	1 set	〃
Total	49 pack.	

5.1.4 Training

(1) Operators

A part of the open yards should be set aside for a special course for these operators explaining the basics of dynamics, mechanics and electricity.

(2) Mechanical Engineers

Mechanical engineers who have graduated from a technical college and entered Mechanic Dept. should be sent overseas to the firms which produce the equipments that is used at the port. The engineers will be in a position to gain maintenance and repair experience first hand at the maker's factories.

APN should invite a special expert maintenance engineer who is familiar with all types of port equipment to teach maintenance and repair work to the mechanical engineers at the port of Cristobal.

(3) Maintenance and Repair Workers

Time lost due to mechanical trouble may reduce cargo handling efficiency, extending staying time in the port and increasing costs. A regular maintenance system is necessary to prevent untimely breakdown of crucial equipment.

The special expert mentioned above should also prepare a training curriculum for general maintenance and repair workers including:

a) Hands on practical maintenance and repair training.
b) Lectures on the basic principal of dynamics, mechanics and electricity.

5.2 Improvement Plan for Facilities

5.2.1 Required Scale of Storage Facilities

(1) Container Yard

1) Calculation of Storage Volume

The required storage number of container is calculated by the following formula:

$Ml = (My \times Dw / Dy) \times P$

where Ml : Required storage number of containers (TEUs)
My : Annual container throughput (TEUs)
Dw : Average dwelling days (days)
Dy : Operating days (310 days)
P : Peak ratio (1.3)

The required storage number of containers is calculated as shown in Table 5-2-1.

Premises for calculation are as follows:

a) Dwelling time in container yard (CY) and container freight station (CFS)

At present, in spite of the free storage periods (5 days) and a lot of valuable cargoes, the average dwelling time of imported container is 8.9 days. As this is rather longer compared with the other ports (Lazaro Cardenas, Mexico: 5 days, Colombo, Sri Lanka: 6 days), many of the shipping agents are sometimes dissatisfied with APN. Therefore, this figure is assumed to reduced to 6 days both for 2000 and 2010.
Exported container is assumed to maintain the present level, that is 2.8 days both for 2000 and 2010.
The present average dwelling time of empty containers is 7.3 days, and will be maintained in both 2000 and 2010.
Reefer containers (or refrigerated containers) are assumed to be 5 days both for 2000 and 2010. And transhipment containers are set at 3.5 days both for 2000 and 2010.
The dwelling time in the CFS is set at 7 days both for 2000 and 2010.

b) Stacking height of containers

Import/export containers, excluding loaded reefers, could be stacked at three layers height in the container yard. However, operationally, it is desirable to stack 2.5 high on an average basis. Therefore import container is set at 2.5 both for 2000 and 2010, however, export container is set at 2.1 both for 2000 and 2010 the same as the present level.

The stacking height of tranship containers is set at 2.5 in 2000 and 2.0 in 2010 on average.
The stacking height of reefers is set at 1.5 both for 2000 and 2010.
As for empty containers, 3.5 both for 2000 and 2010, the same as the present level.

c) Required number of ground slots

Sl = Ml / L
where Sl : Required number of ground slots (TEUs)
Ml : Required storage number of containers (TEUs)
L : Stacking height of containers (TEUs)

The results of the calculation are shown in Table 5-2-1.

Table 5-2-1 Required Storage Capacity in Container Yard

	Unit	Laden Container				Empty	Total
Target Year 2000		Import	Export	Reefer	Tranship	Cot.	
Annual Container Throughput (My)	TEUs	72,000	26,000	4,000	7,000	56,000	165,000
Average Dwelling Days	Days	6.0	2.8	5.0	3.5	7.3	
Required Storage Number (Ml)	TEUs	1,812	305	84	103	1,714	4,018
Average Stacking Height	Layers	2.5	2.1	1.5	2.5	3.5	
Required Ground Slots	Slots	725	145	56	41	490	1,457
Target Year 2010							
Annual Container Throughput (My)	TEUs	56,000	19,000	3,000	29,000	43,000	150,000
Average Dwelling Days	Days	6.0	2.8	5.0	3.5	7.3	
Required Storage Number (Ml)	TEUs	1,409	223	63	426	1,316	3,437
Average Stacking Height	Layers	2.5	2.1	1.5	2.0	3.5	
Required Ground Slots	Slots	564	106	42	213	376	1,301

(2) Container Freight Station (CFS)

The required area for the CFS is calculated in the same manner as warehouse, according to the formula below:

A = (Mc x Dw x P) / (w x r x Dy)
where A : Required floor area of CFS (m2)
Mc : Annual handling volume of container cargo through CFS (tons)
Dw : Dwelling time at CFS (days)

P : Peak ratio (1.3)
w : Volume of cargoes per unit area (1.3 tons/m2)
r : Utilization rate of CFS floor (0.5)
Dy : Operating days of CFS (250 days)

Using the premises mentioned above, the required area of the CFS is calculated as follows:

Year of 2000: A = (47,000 x 7 x 1.3) / (1.3 x 0.5 x 250)
= 2,630 m2
Year of 2010: A = (42,000 x 7 x 1.3) / (1.3 x 0.5 x 250)
= 2,350 m2

The capacity of the existing CFS is about 6,300 m2, thus no additional CFS will be required.

5.2.2 Required Scale of Handling Equipment

The container volume to be handled at the existing piers in the target years are as follows:

	2000	2010
Pier No. 7	35,000	-
Pier No. 9	100,000	120,000
Pier No.10	30,000	30,000
Total(TEUs)	165,000	150,000

(1) Gantry Crane

Two quay-side gantry cranes have already been installed on Pier No.9. The required number of gantry cranes in the target year of 2010 is calculated by the following formula:

Nc = My / Ec x O x H x Dy x (1 + r)
where Nc : Number of crane
My : Annual container throughput (TEUs)
Ec : Handling productivity of crane per hour (Box)
O : Berth occupancy rate
H : Working hours per day
Dy : Working days per year
r : Ratio of 40 footer

The result of calculation of required number of crane is as follows:

Nc = 120,000 / 20 x 0.6 x 16 x 310 x (1+0.37)
= 2 cranes

(2) Transfer Crane and Top-Loader

As mentioned in section 5.1, both transfer crane and top-loader systems are adopted at the terminal in the target year 2000, while in the target year 2010 only transfer crane system will be utilized.

The required number of transfer crane and top-loader is calculated from the total handling volume of containers as follows:

a) Handling volume at pier.
b) Handling volume at yard, which is calculated by the following formula:

$Hv = Mc \times (1 + r) / (Dy \times h) \times P \times Er$

where Hv : Handling volume at yard (TEU/hour)
Mc : Annual handling volume of container (TEUs)
r : Ratio of 40 footer container
Dy : Annual operating days of gate (250 days)
h : Operating hours per day at gate (8 hours)
P : Peak ratio (1.3)
Er : Handling ratio between transfer crane and top-loader (transfer crane: 0.4, top-loader:0.6)

c) Average handling capacity of transfer crane and top-loader is assumed 18 TEU/hour, respectively.

The results of the calculation are shown in Table 5-2-2.

Table 5-2-2 Required Number of Transfer Crane and Top-Loader

		Unit	Target Year	
			2000	2010
Handling Volume at Pier	No. 7	Boxes/hour	12	-
	No. 9	Boxes/hour	40	40
	No.10	Boxes/hour	12	12
Handling Volume at Yard	Transfer Crane	Boxes/hour	31	71
	Top-Loader	Boxes/hour	47	-
Total Handling Volume	Transfer Crane	Boxes/hour	57	123
	Top-Loader	Boxes/hour	85	-
Required Number	Transfer Crane	Units	3	7
	Top-Loader	Units	5	-

(3) Chassis

The required number of chassis for shipping is calculated by the following formula:

$N = (Tc/Tm) \times n$

where N : Required number of chassis
Tm : Minimum cycle time of the crane

n : Number of crane
Tc : Cycle time, which is calculated by the following formula:
Tc = Tl + Tu + 3600 x S / V
where Tl : Average loading hours (Sec.)
Tu : Average unloading hours (Sec.)
S : A round-trip distance (Km)
V : Running speed (Km/hour)

The required number of chassis for CFS is calculated by the following formula:

N = Mc x 1.3 / (Dy x h x 60 x 0.75 / t)
where N : Required number of chassis
Mc : Annual handling volume of containers through CFS (2000: 6,500 TEUs, 2010: 5,900 TEUs)
Dy : Annual operating days of CFS (250 days)
h : Operating hours per day (8 hours)
t : Cycle time (45 min.)

According to the result of the calculation, 4 units of chassis are required for both year 2000 and 2010.

The results of the calculation are shown in Table 5-2-3.

Table 5-2-3 Required Number of Chassis

Target Year 2000	Tl	Tu	S	V	Tc	Tm	n	N (Unit)
No. 7	20	30	2.0	10	780	360	2	4
No. 9	20	30	1.3	10	528	100	2	11
No. 10	20	30	1.3	10	528	360	2	3
CFS								4
Sub-total								22
Total (includ. 15% spare)								25
Target Year 2010								
No. 9	20	30	1.3	10	528	100	2	11
No. 10	20	30	1.3	10	528	360	2	3
CFS								4
Sub-total								17
Total (includ. 15% spare)								20

(4) Tractor

The required number of tractors for the each target year is the same as number of chassis (excluding number of spare chassis), thus 22 units are required for in the target year 2000 and 17 units in the target year 2010.

(5) Forklift

1) CFS

The required number of forklift for CFS is calculated by the following formula:

$$N = Mc \times 2 \times 1.3 / (Dy \times h \times p)$$

where N : Required number of chassis

Mc : Annual handling volume of containers through CFS (2000: 47,000 tons, 2010: 42,000tons)

Dy : Annual operating days of CFS (250 days)

h : Operating hours per day (8 hours)

p : Handling productivity (10 tons/hour)

The required number of forklift is 6 units for the target year 2000 and 5 units for the target year of 2010.

2) Others

The required number of forklift for general cargoes at the piers and warehouse is calculated by the same formula mentioned above.

Mc : 426,000 tons (2000), 596,000 tons (2010)

Dy : 310 days, h: 12 hours, p: 15 tons/hours

The required number of forklift is 20 units for the target year 2000 and 28 units for the target year of 2010.

(6) Specification of Gantry Crane and Transfer Crane

The main specification of cranes mentioned above is as follows:

1) Gantry Crane

The existing gantry cranes are replaced in the years 2000 and 2002, respectively; replacement plan is mentioned in following section 5.3. The main specifications of new gantry cranes are almost the same as the existing gantry cranes.

a) Hoisting capacity: 41 tons under spreader
b) Outreach: 37 m
c) Span: 22.555 m
d) Backreach: 12.2 m
e) Total lifting height: 45 m
f) Lifting height above rail: 30 m
g) Lifting height under rail: 15 m
h) Power source: Supplied from outside

i) Approximate working speed:
- Hoisting speed with 41 tons load: 50 m/min.
- Hoisting speed with no load: 120 m/min.
- Trolley traversing speed: 150 m/min.
- Travel speed: 46 m/min.

2) Transfer Crane (Tire Mounted)

a) Hoisting capacity: 30.5 tons under spreader
b) Span: 23.47 m
c) Lift (9'6" containers 4 high): 14.94 m
d) Approximate working speeds
- Hoisting speed with 30.5 tons load: 17 m/min.
- Trolley traversing speed: 35 m/min.
- Travel speed: 90 m/min.

(7) Required Number of Handling Equipment

The cargo handling equipment required in each target year is shown in Table 5-2-4

Table 5-2-4 Required Number of Handling Equipment

Equipment	Capacity	Unit	Target Year	
			2000	2010
Gantry Crane	41 tons	No.	2	2
Tranfer Crane	30.5 tons	No.	3	7
Top-Loader	40 tons	No.	5	0
Tractor		No.	22	17
Chassis	20'/40'	No.	25	20
Forklift	2-4 tons	No.	26	33

5.2.3 Other Facilities

(1) Gate

The required number of truck lanes is calculated by the following formula:

N = (Mc x p / Dy x H) x (S / 60)
where N : Required number of truck lanes
Mc : Annual handling volume of containers (2000: 165,000 TEUs, 2010:

150,000 TEUs)

p : Peak ratio (1.3)

Dy : Annual operating days (250 days)

H : Operating hours per day (8 hours)

S : Necessary procedure time per truck (3 min.)

The required number of truck lanes is 5 lanes for the target year of 2000 and 4 lanes for the target year 2010.

Considering some necessary equipment, two truck scales should be equipped at the gate.

(2) Terminal Office

The required area for the terminal office will depend on the method of operation and other factors. Assuming around 10 m2 of required floor area per person and considering some allowance for uncertainty, around 1000 m2 of terminal office will be required in the target year 2010.

(3) Others

1) Repair of Damaged Containers

On the assumption that about 10 % of the total containers received at the terminal will be damaged, a container repair yard of around 1,000 m2 is required in the target year of 2010.

2) Fumigation of Containers

The container terminal will need a fumigation yard in the target year of 2010. Assuming that 5 % of loaded import container have to be transferred to an exclusive yard for fumigation and considering 5 days of dwelling time, a fumigation yard of around 400 m2 is required.

3) Washing and Cleaning Containers

For washing and cleaning of empty containers at the container terminal in the target year of 2010, an required area of 200 m2 is planned.

4) Customs Inspection

Based on the actual situation, the loaded import container for local distribution should be checked at terminal by Customs, thus a Custom inspection yard of about 300 m2 is planned in the target year of 2010.

5) Others

Necessary facilities such as an electric station, an oil station, parking areas for yard tractor-chassis, etc. are included in the facility layout in the target year of 2010.

Figure 5-2-1 and 5-2-2 show the layout of container yard in the target year of 2000 and 2010.

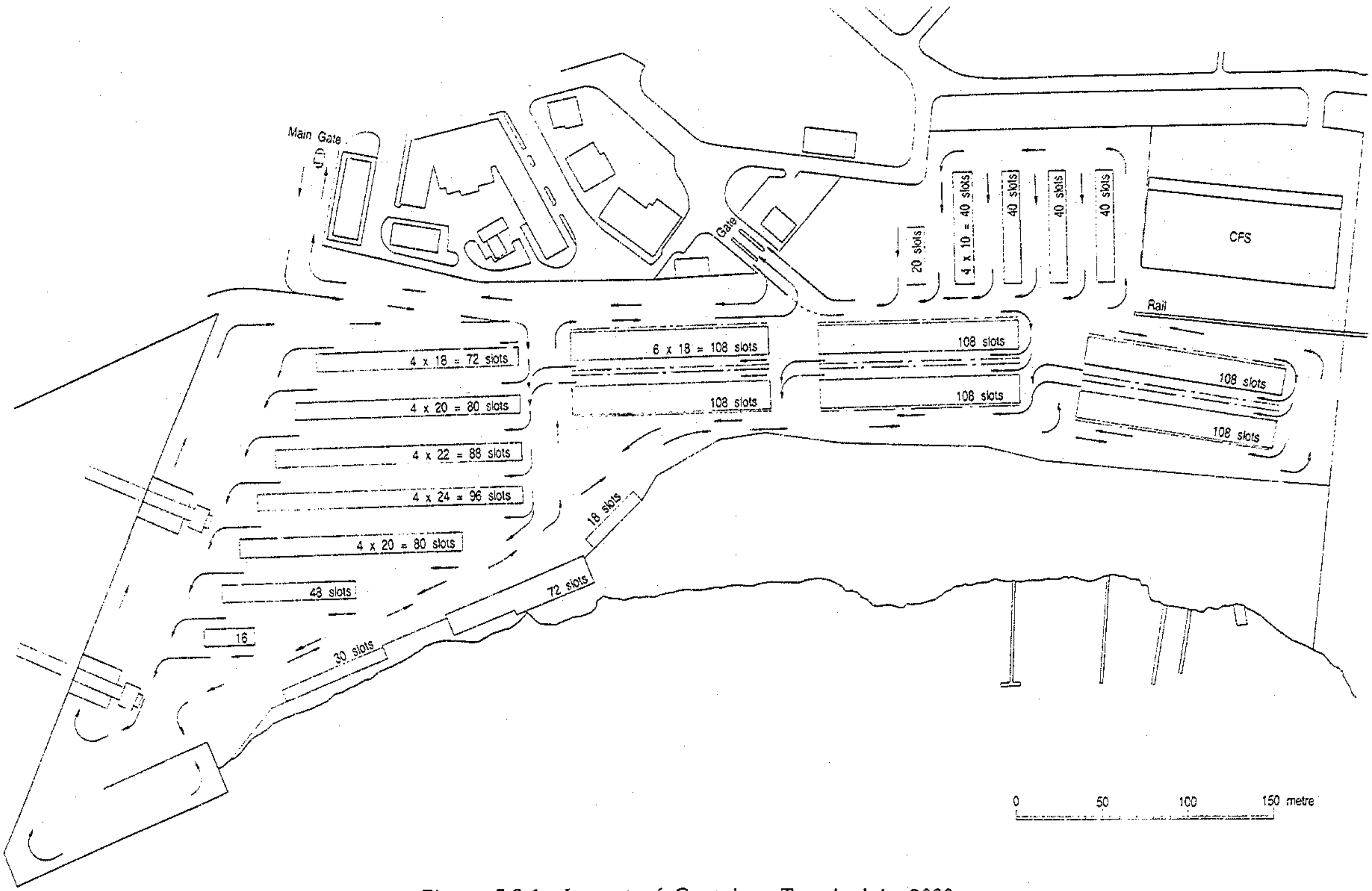


Figure 5-2-1 Layout of Container Terminal in 2000

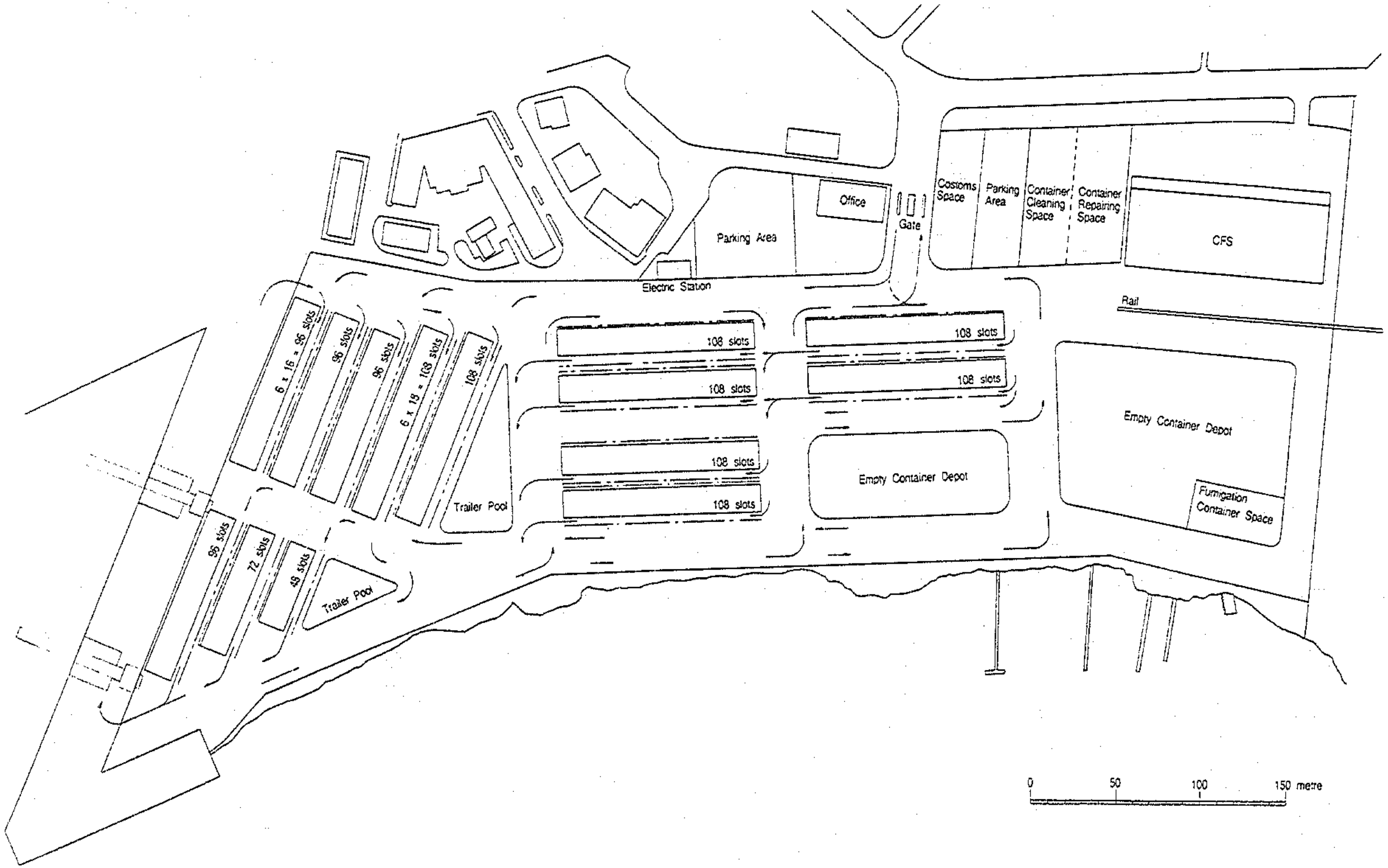


Figure 5-2-2 Layout of Container Terminal in 2010

5.3 Stage Plan for Modernization of Existing Container Terminal

The stage plan for modernization of the existing container terminal with a target year of 2010 should naturally be executed in gradual stages.

Concerning the existing handling equipment, the replacement and disposal period is set from the average service life considering the economical life time and present circumstances of the port of Cristobal as follows:

- Gantry crane: 15 years
- Transfer crane: 15 years
- Top-Loader: 8 years
- Forklift: 8 years
- Tractor: 8 years
- Chassis: 5 years

Table 5-3-1 shows the time period required for each stage and main work being undertaken.

Table 5-3-1 Stage Plan for Modernization of Existing Container Terminal

1. Cargo Handling Equipment

Equipment		Purchased year	Exist.	1994/1998 Requir.	1994/1998 Proc.	1994/1998 Repla.	1999/2000 Requir.	1999/2000 Proc.	1999/2000 Repla.	2001/2003 Requir.	2001/2003 Proc.	2001/2003 Repla.	2004/2008 Requir.	2004/2008 Proc.	2004/2008 Repla.	2009/2010 Requir.	2009/2010 Proc.	2009/2010 Repla.
Gantry crane				2	0	0	2	1	1	2	1	1	2	0	0	2	0	0
		1984	1						1									
		1986	1									1						
Trasfer cranec				3	3	2	3	0	0	7	4	0	7	0	0	7	3	3
		1990(1968)	1			1												
		1990(1968)	1			1												
Top-Loader				5	3	3	5	2	2	0	0	0	0	0	0	0	0	0
		1981	3															
		1984	1			1												
		1987	1			1												
		1988	1			1												
		1991	2						2									
Forklift				26	26	26	26	0	0	33	7	1	33	25	25	33	0	0
	2-tons	1989	6															
	4-tons	1980	5															
	4-tons	1984	4															
	4-tons	1985	5															
	4-tons	1989	13															
	4-tons	1990	9															
	8-tons	1985	1															
	10-tons	1985	1															
Tractor				22	22	22	22	0	0	17	7	7	17	10	10	17	0	0
		1981	3															
		1983	1															
		1984	4															
		1985	6															
		1989	10															
Chassis			9	25	25	14	25	25	25	20	0	0	20	20	20	20	20	20

2. Civil Works and Others

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Civil works																	
Demolition and pavement	──	──						──	──								
Building																	
Office & Gate									──								
Introduction of computer																	
Personal computer	──																
Small scale computer system						──											
Total computer system																──	

CHAPTER 6 MODERNIZATION PLAN OF EXISTING PIERS

6.1 Future Requirement of Conventional Berth

6.1.1 General Cargo Berths

All the conventional cargo will be handled at existing piers No.6 to No.8. In the short term stage, 35 thousands TEUs of container cargo, which corresponds to 50 container or Ro-Ro vessels, will also be handled at these piers.

According to the future demand forecast, the number of cargo vessels which call at these existing piers for the purpose of cargo handling are as follows;

Target Year	2000	2010
Mix Type Ship	453	519
Solid Bulk	12	16
Liquid Bulk	2	2
Container	50	0
Total	517	537

The majority of these ships are mix type. Average ship size is forecasted as 10,000 GT (15,700 DWT), and daily ship cost is assumed as 13,000 dollars. In order to find an average berthing time of the conventional type ships of this size, actual data of the berthing time of these sized ships (28 ships in 1991) was analyzed. The distribution of berthing time is shown in Figure 6-1-1, and average berthing time is 40 hours.

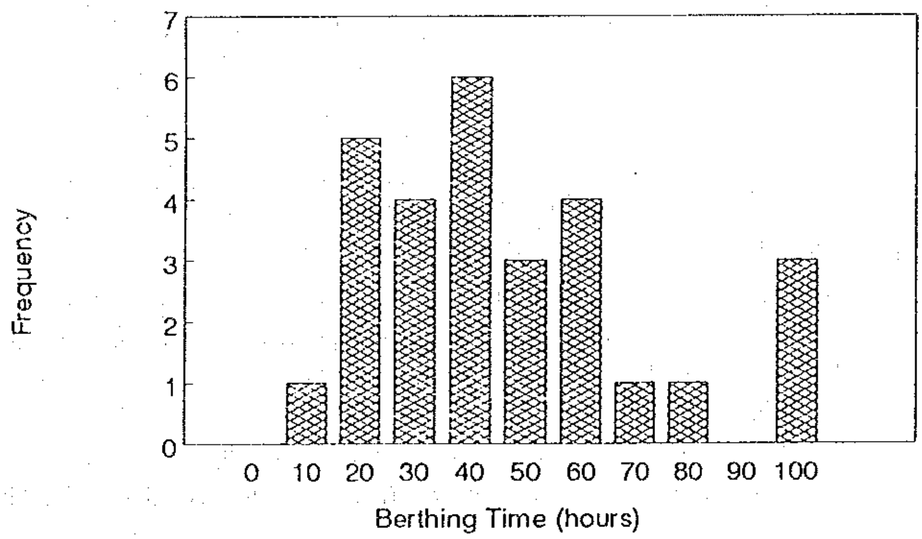


Figure 6-1-1 Frequency Distribution of Berthing Time
(Pier No.6 and 7,1991)

Ship waiting cost for each alternative number of berths is estimated in Table 6-1-1. There is a big difference in NPV of annual ship waiting cost between the cases of three berths and four berths. Practically, no waiting time is expected in case of five berths. In the Short Term Plan stage, five berths will be fully available even if the use of south side berth of Pier No.8 is limited due to the busy occupation of Pier No.9 by Panamax size container vessels. The number of berths in the Short Term Plan stage is sufficient. In the Long Term Plan stage, four berths are fully available. Since average waiting time for the case of four berths is acceptable in the Long Term Plan stage, there is no need to construct additional berths. Berth waiting condition will be fairly alleviated if berth allocation is flexibly arranged including passenger berth at Pier No.8. For peak time, Pier No.8 is expected to be available for ad hoc base cargo handling besides the function of passenger terminal.

Table 6-1-1 Optimum Number of General Cargo Berth

Target Year	2000			2010		
No. of Berth	3	4	5	3	4	5
No. of Ships	517	517	517	537	537	537
Berthing Time (hr)	40	40	40	40	40	40
Berth Occupancy Ratio	0.79	0.59	0.47	0.82	0.61	0.49
Waiting Time Ratio	0.79	0.12	0.03	0.98	0.14	0.04
Total Waiting Time (day)	681	103	26	877	125	36
Daily Ship Cost ($/day)	13,000	13,000	13,000	13,000	13,000	13,000
Annual Waiting Cost (thousand $/year)	8,849	1,344	336	11,402	1,629	465
NPV (million $)	83.2	12.6	3.2	107.2	15.3	4.4
Cost Difference (million $)		70.5	9.5		91.9	10.9

6.1.2 Passenger Terminal

The numbers of passengers and passenger vessels have been decreasing in recent years mainly due to security reasons. In the year 2000, this situation will not dramatically change. However, it is expected that passenger traffic will increase up to 75,000 persons for one year according to demand forecast for the year 2010. Accordingly, the number of passenger ships will increase up to 183 ship/year. Average berthing time is assumed as 12 hours considering the typical pattern of cruse ships in Caribbean Sea. On this assumption, berth occupancy rate is 0.25 and average waiting time is 3 hours in case of one berth service. This seems acceptable, however, no waiting time is preferable for passenger service. Actually, berth waiting time can be significantly decreased due to the reasons below;

* Most passenger ships are operated in regular cycle, the schedule can be arranged or adjusted to avoid berth waiting.

* Passenger ships can berth at any other general cargo berth when passenger berth is occupied. The probability that all the general cargo and passenger berth will be occupied at the same time is very low.

Accordingly, one passenger berth is enough in the Long Term Plan.

6.1.3 Bunkering Berth

The number of ships which call at the port of Cristobal only for bunkering is forecasted as 663 in the year of 2000 and as 1,166 in the year of 2010. Current average berthing time of the vessels calling at Pier No.16 for bunkering is around 26 hours. It will not change so much even in the future and 26 hours is assumed as an average berthing time. Average size of ships which call at Pier No.16 only for bunkering in the year 1991 was 14,700 DWT and average daily ship cost of this size is approximately 12,000 US$. The total ship waiting time and cost are calculated in Table 6-1-2. Accordingly, three berths are necessary in the year 2000, and five berths are desirable in the year 2010.

Table 6-1-2 Optimum Number of Bunkering Berths

Target Year	2000			2010		
No. of Berth	2	3	4	4	5	6
No. of Ships	663	663	663	1,166	1,166	1,166
Berthing Time (hr)	26	26	26	26	26	26
Berth Occupancy Ratio	0.98	0.66	0.49	0.87	0.69	0.58
Waiting Time Ratio	*****	0.19	0.04	1.07	0.17	0.05
Total Waiting Time (day)	*****	136	29	1,352	215	63
Daily Ship Cost ($/day)	12,000	12,000	12,000	12,000	12,000	12,000
Annual Waiting Cost (thousand $/year)	*****	1,638	345	16,219	2,577	758
NPV (million $)	*****	15.4	3.2	152.5	24.2	7.1
Cost Difference (million $)		*****	12.2		128.2	17.1

**** unrealistic large value

The average size of vessels calling at Pier No.16 is 105 m long and 15 m wide, and required berth length is 130 m. Accordingly, the number of berths on Pier No.16 can cope with the future demand in 2010.

6.2 Existing Berths Improvement Plan

6.2.1 Pier No.6 and No.7

These two piers have ten berths in total, however, only one large sized ship can berth at each side of these piers. Accordingly, these piers are almost all occupied by general cargo handling including solid and liquid bulk cargo and shall be specialized for that purpose in the year 2010. In the Short Term Plan Stage, 35,000 TEUs containers are also handled and 50 container ships will call at these piers annually besides general cargo carriers.

In the Short Term Plan Stage, container cargo and automobiles comprise the major part of total cargo. These cargoes need a wide area (apron and yard). The present layout with a quay shed just behind the berth is not suitable and convenient for handling these types of cargo. Quay shed is partly demolished in Pier No.7 to prepare wide apron space, however, it is impossible to secure the space for container stacking close to the wharf.

The quay shed on Pier No.7 should be totally demolished in the early stage, because the structure of the roof of this quay shed is steel truss and can be easily demolished compared to other sheds hich are all concrete structure. Ship cranes are mainly used for container handling. No wharf crane is equipped, however, a mobile crane will be deployed to promote handling efficiency. This mobile crane can also be used at other piers.

Unloaded containers are preferable to be transported to container yards directly, however, it may take a long time for transportation of containers between pier and container yard due to congestion in container terminal when a large container ship berths at Pier No.9 for container cargo handling. If containers can be stacked behind berth, container handling efficiency will be highly improved. Soon after finishing container cargo handling at Pier No.9, stacked containers at Pier No.7 shall be transported to the container terminal. On the other hand, export containers are transported and stacked at the pier prior to ship arrival.

It is preferable that the capacity of container stacking area is able to accept all containers handled by one ship (700 TEUs in average). Since this stack is tentative, full containers as well as empty containers can be stacked with amall space between each containers.

Area use plan of Pier No.7 is shown in Figure 6-2-1. Apron width is secured as 19 m. In order to stack 700 TEUs of containers, stacking area of 6,400 sq.m wide should be secured. For night time cargo handling, lighting system is necessary. Location of lighting poles shall be carefully examined so as not to hinder cargo handling. Allotment of containers described here is only an example and not to be understood as fixed.

Handling of automobile needs wide space as well as container handling. In the Short Term Plan Stage, container cargo handling has higher priority than automobile handling.

Then, automobiles should be stacked out side of pier.

The majority of break bulk tranship cargo is automobile. The average unit weight is 1.45 MT in the recent nine years. It fluctuates year by year, but is almost stable in the long term basis. Accordingly future unit weight is supposed to be 1.45 MT. The number of vehicles handled is calculated as follows.

Target Year	2000	2010
Total Weight of Transhipment Break Bulk Cargo (MT/year)	108,000	163,000
Unit Weight (MT)	1.45	1.45
Total Number of Vehicles(/year)	74,500	112,400
Number of Vehicles (/day)	276	418
Required Parking Area (sq.m)	5,520	8,360

Required parking area for one passenger car is usually around 20 sq.m, and total area for vehicles handled for one day is 5,520 sq.m in the year 2000 and 8,360 sq.m in the year 2010 respectively.

In the Short Term Plan Stage, container cargo handling has higher priority than automobile handling. Then, automobiles should be stacked out side of pier. In the mole area close to Pier No.7, tentative stacking yard for automobiles (and empty containers) is secured.

To check the capacity of transit shed for general cargo handling, required area of a transit shed is estimated with necessary parameters as shown below.

Target Year	2000	2010
Cargo Volume Except Transhipment (MT/year)	435,000	615,000
Cycle Rate (cycle/year)	20	25
Utility Rate	0.5	0.5
Area Utility Rate (t/sq.m)	1.0	1.0
Required Area (sq.m)	10,875	12,300

The area of transit shed on Pier No.6 is 14,000 sq.m, and sufficient to handle the break bulk cargo except vehicles.

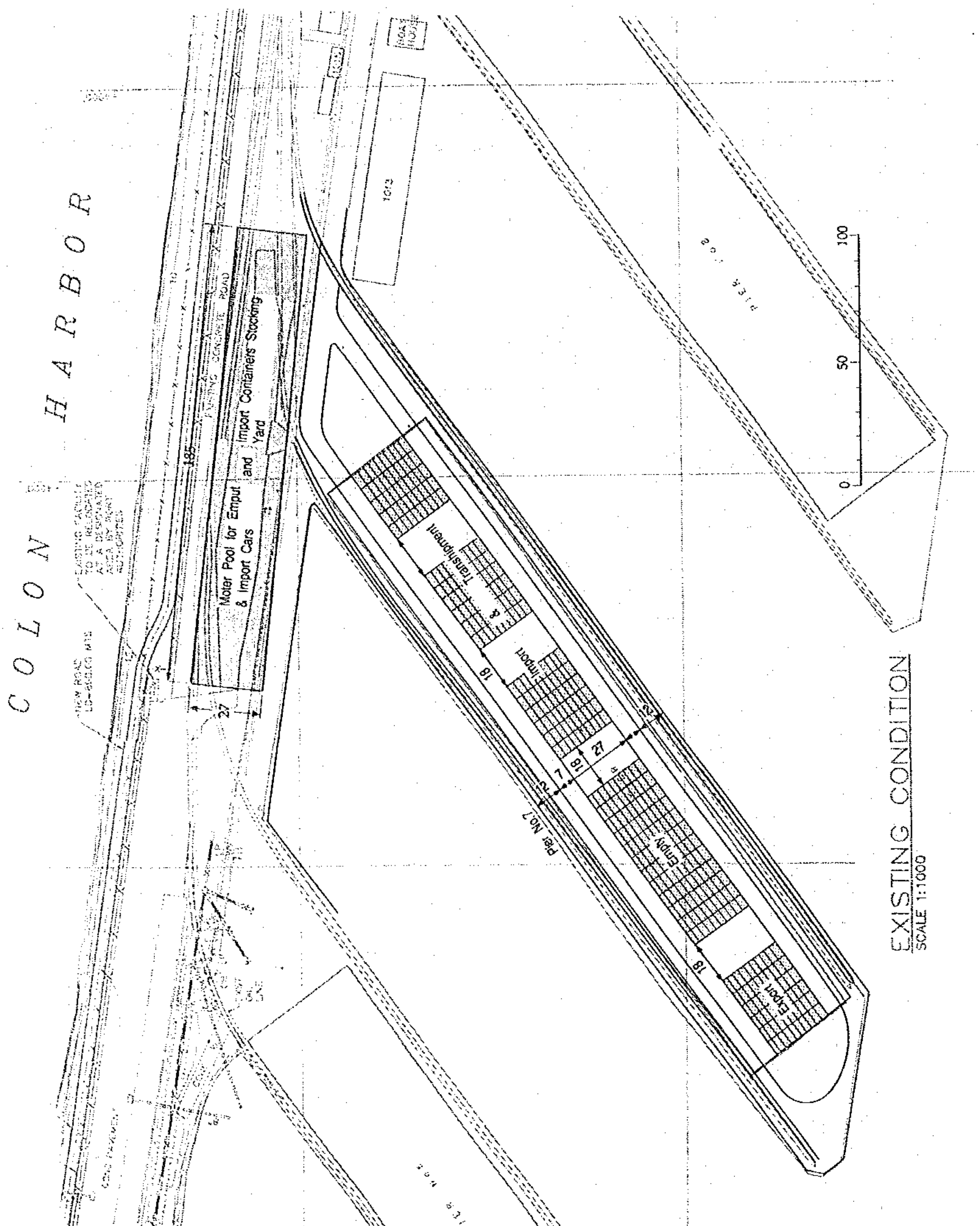


Figure 6-2-1 Area Use of Pier No.7

6.2.2 Pier No. 8

The Government of Panama is now promoting the rehabilitation of Panama Railroad. Prior to full scale rehabilitation for a large amount of container transportation, a small scale rehabilitation for passenger transportation for tourist use is expected to be realized in near future. Connected with passenger vessel, it will play an important role in revitalizing tourism in Panama. Pier No.8 is the only pier which has an active branch line of railroad, thus, this pier is most appropriate as the passenger terminal planned in the Long Term Plan. It can also be the most effective way for revitalization of utilization of Pier No.8 which has already been obsolete for modernized cargo handling such as container cargo transportation.

Since Pier No.9 will be highly occupied by large size container vessels, the use of south side berth of Pier No.8, facing Pier No.9, may be affected and limited to only small size vessels. North side of Pier No.8, which is less restricted in use, will be reformed as a passenger terminal.

Existing shed house is modified to passenger terminal building. Renovation of the quay shed will be limited to the least necessary scope. Passenger facilities at Pier No.8 are planned on the basis of shuttle bus system for passenger access to and from the city area in Colon. Passenger bridge connecting the terminal to outside the port area will not be included in the project accordingly.

Space utilization plan of Pier No.8 is shown in Figure 6-2-2.
Expected land access means to this terminal are railroad, bus and passenger car. A platform for passenger will be prepared around rail track well. Surrounding the platform, coach access way is located inside columns. In the space between columns and outer wall, terminal facilities are located. This terminal has functions of immigration and customs office, tourist information center, restaurants and coffee shops and shopping center which serves for passengers and crews. Required area for passenger terminal facilities is estimated as follows;

Passenger Terminal Facilities	Area (sq.m)
Terminal Office, Waiting Room, Baggage Office and Others *)	650
Customs and Immigration	200
Information and Tourist Office	300
Duty Free Shops (10 tenants)	1,400
Restaurants and Coffee Shops (3 tenants)	450
Total	3,000

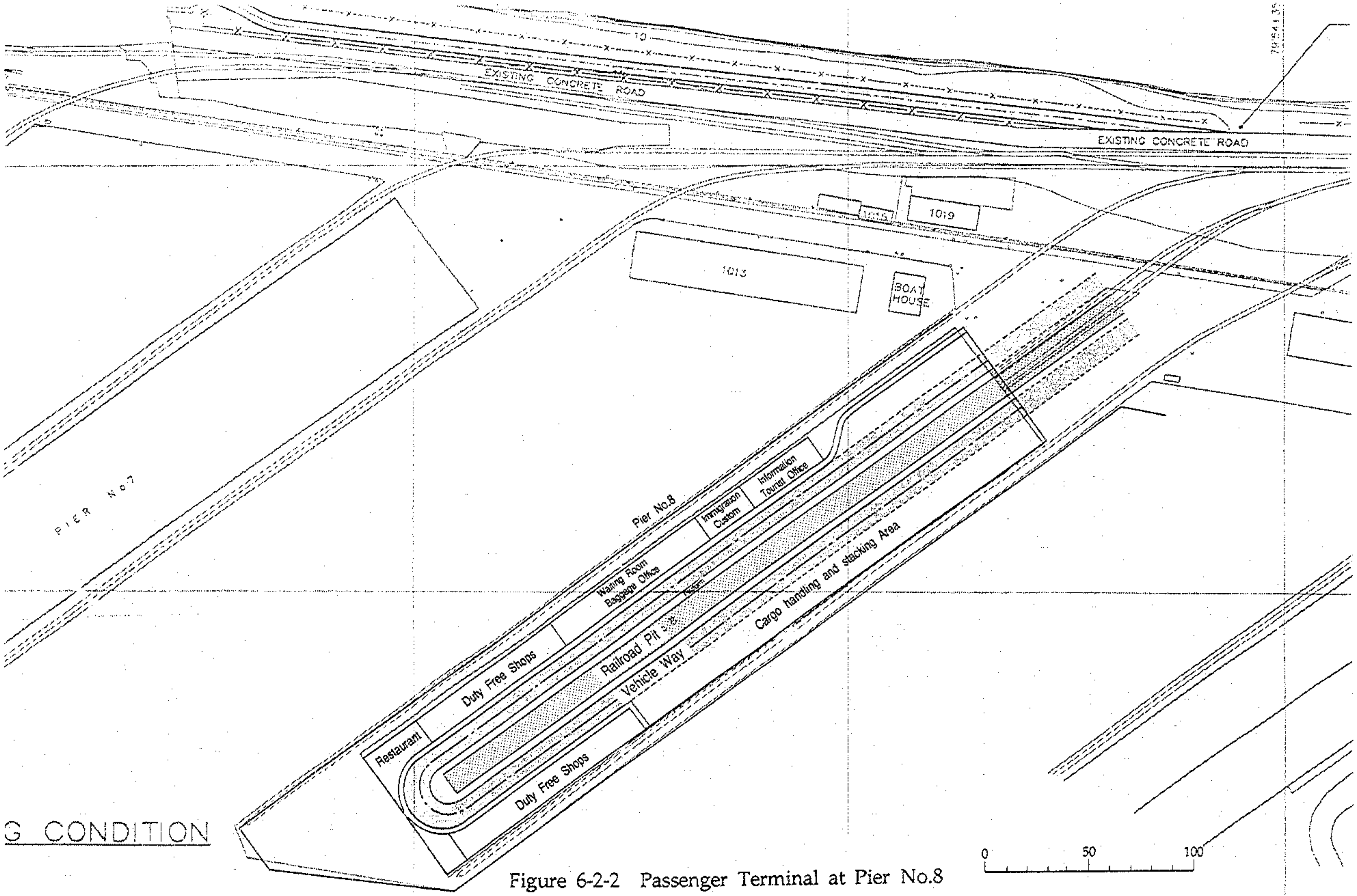


Figure 6-2-2 Passenger Terminal at Pier No.8

In this terminal, a wide area is allocated for duty free shops. Existing duty free shops in the port area will be integrated in this area. These shops serve for not only passenger but also crews and employees.

Besides these functions, cargo handling and stacking area is also kept in the shed house in order to cope with ad hoc demand of railroad transportation of cargo. This area can also be used as parking area.

Around this terminal, parking space for passenger and employee is required.

6.2.3 Pier No.16

There are five berths with bunkering facilities at Pier No.16. The number of ships which call at this pier has decreased in these ten years. It is expected to increase to the level of 900, however, it is still less than the number in the year of 1983. Accordingly, the demand in 2010 is still within the capacity of Pier No.16, as long as existing bunkering facilities can be maintained in good condition. Judging from the present situation of structural soundness, rehabilitation works will be necessary in the near future.

6.2.4 Mole Area

Mole area is an important space that connects each pier with gate or container terminal. The utilization of mole area greatly affects the efficiency of cargo handling activity at each pier. Present situation of utilization of mole area is not necessarily efficient or systematic. Mole area is not fully used at present.

At the end of the mole, a navigation control center of PCC is under construction. North side of the mole is planned to be used as an access road to the center exclusively. This road will be surrounded by a new fence and mole area use will be restricted. There is another area between Pier No.7 and No.8 in the mole exclusively used by PCC. This area is said not to be reverted until 2000.

The area of the branch line of railroad to Pier No.6 and No.7, which is no longer used, remains unpaved. Rail line is not maintained at all and branch line is not available for possible future use without total rehabilitation or reconstruction. It seems of no use to keep these lines as they are.

Building No.1014 presently used as a duty free shop also seems to be an obstacle for efficient use of mole area.

To secure smooth and efficient activities at each pier, a large area of back up space is needed at mole area. In the short term stage, open storage area with area of 4,860 sq.m (27 m X 180 m) for stacking automobiles and empty containers should be prepared north of Pier No.7 in addition to existing paved area in mole. Rail line will be buried and paved as shown in previous Figure 6-2-1.

In the Long Term Plan Stage, additional open storage area with area of 2,800 sq.m will be prepared after reversion of PCC's exclusive area and demolition of building No.1015 and No.1019. For the time being, this area would be reserved and used as a green park area until an additional open storage area becomes necessary. Around Pier No.8, parking area of 4,000 sq.m (with a capacity of 200 passenger vehicles) in total is prepared mainly for passenger and employee use. Surrounding area of the existing maintenance shop with area of 5,000 sq.m is exclusively used as maintenance area.

After demolishing Building No.1014, a parking area for chassis and cranes with area of 3,000 sq.m is prepared between Pier No.8 and No.9. Space with area of 6,000 sq.m at the north side of maintenance area is used as open storage area for multiple use such as stacking empty containers, chassis and cargo handling equipment. Land use plan of mole area is shown in Figure 6-2-3.

Mole area around Pier No.6 is also used as open storage area as it is. Quay side access road, which is 9 m wide at present, will be widened to 14 m between Pier No.7 and No.9. Newly recommended area use of mole is summarized as follows;

Function	Area(sq.m)	Notes
Open Storage Area	4,860	leveling,pavement
Reserved Area for Open Storage	2,800	leveling, pavement, demolish building
Parking	4,000	leveling, pavement
Maintenance	5,000	re-pavement
Chassis and Handling Equipment Stacking	3,000	demolish buildings, re-pavement
Open Area for Multiple Use	6,000	demolish buildings, re-pavement

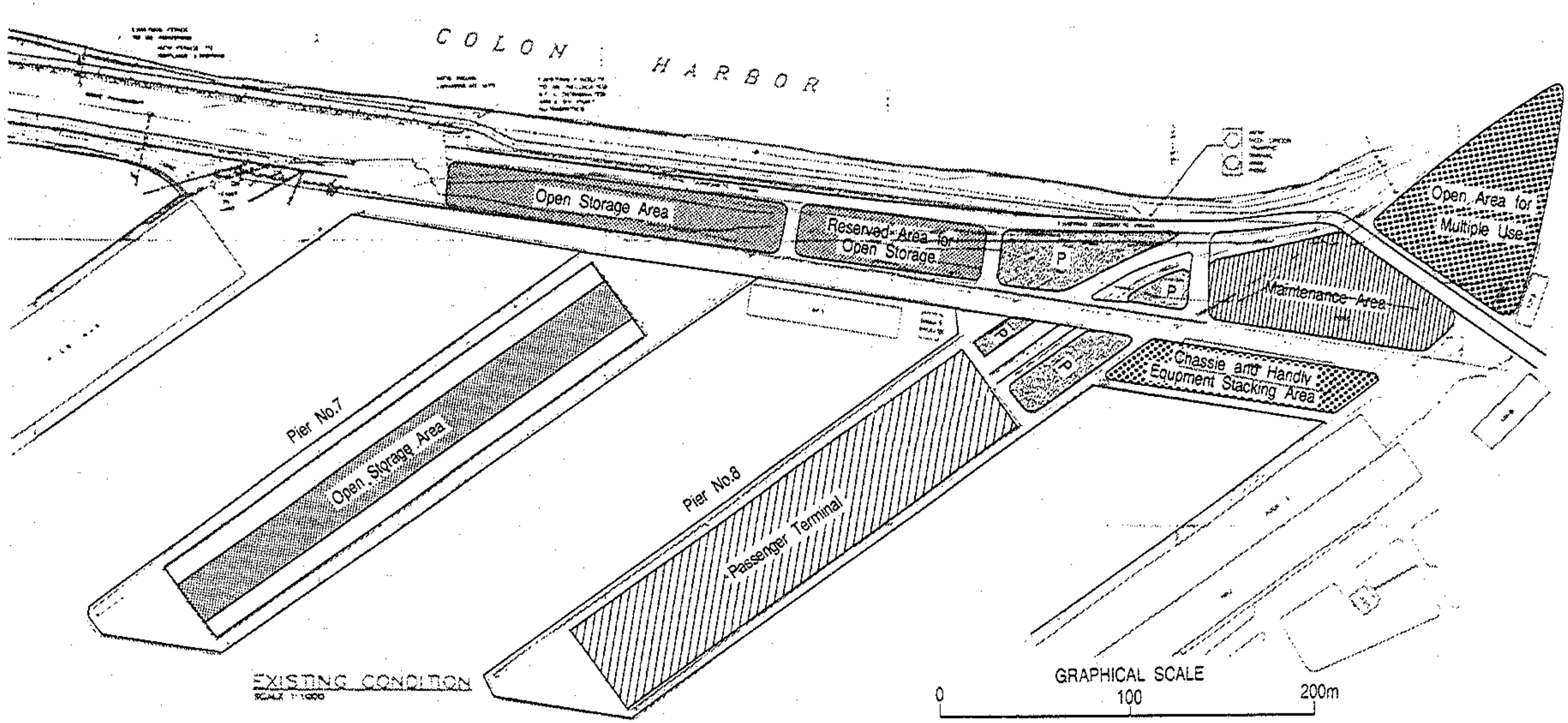


Figure 6-2-3 Land Use of Mole Area (Master Plan)

CHAPTER 7 DEVELOPMENT OF LAND TRANSPORTATION SYSTEM AND LAND USE PLAN OF SURROUNDING AREA

7.1 Demand Forecast of Port Oriented Land Transportation

In order to check the capacity of the land transportation system, port oriented land transportation demand is forecasted. Container cargo transportation demand and other cargo transportation demand are forecasted separately.

7.1.1 Container Cargo Transportation Demand

(1) Transportation Demand between Container Terminals and Destination Areas

Major container transportation takes place between two container terminals (Cristobal and Telfers) and three major destination areas: Free Zone in Colon, Free Zone in France Field and Coco Solito, and Panama City and its surrounding area.

The origin and destination of container cargo through the ports of Cristobal is forecasted as follows;

(thousand TEUs)

Year	1991	2000	2010
Free Zone	138	263	365
Panama Domestic	55	98	154
US Army & Others	21	15	11
Transhipment	7	16	100
Total	221	392	630

It is assumed that transportation demand for each section of the Free Zone is in proportion to the area of the section. A large scale of expansion of the Free Zone is planned in several stages. Considering only the expansion plans which are regarded as certain at present, the future area of each section of the Free Zone is expected as follows;

Colon	69	ha
France Field	116	ha
Coco Solito	75	ha
Total	260	ha

The ratio between the area of Colon section and the area of other sections is approximately 1:3. The ratio of cargo volume seems almost the same level.

On the basis of these assumptions, container cargo flow is estimated as shown below;

(thousand TEUs/year) (Upper:2000, Lower:2010)

	Cristobal (Existing Terminal)	Telfers (New Terminal)	Coco Solo Bahia Las Minas	Total
Free Zone (Colon Area)	28 21	27 67	11 3	66 91
France Field Coco Solite	83 62	80 207	34 5	197 274
Panama City and Others	47 38	46 124	20 3	113 165
Sub Total	158 121	153 398	65 11	376 530
Transhipment	7 29	9 71	0 0	16 100
Total	165 150	162 469	65 11	392 630

This container cargo flow pattern is schematically shown in Figure 7-1-1.

Cargo flow in unit base is shown as follows based on the assumption that the number of 20 ft containers and 40 ft containers are almost the same.

(thousand units/year) (UPPER:2000,LOWER:2010)

	Cristobal (Existing)	Telfers (New)	Total
Free Zone (Colon)	19 14	18 45	37 59
Free Zone (France Field and Coco Solite)	55 41	53 138	108 179
Panama City Area and Others	13 25	31 83	62 108
Total	105 80	102 266	207 346

(2) Transportation Demand of Transhipment Container between Container Terminals

Transportation between different terminals may take place for transhipment cargo. Such transportation is preferable to be reduced as much as possible by giving berth priority to certain shippers. In the year 2010, 100,000 TEUs of transhipment containers are handled. Among them, there may exist tranship cargo transportation between Cristobal and Balboa taking advantage of improvement of container terminals in Balboa and

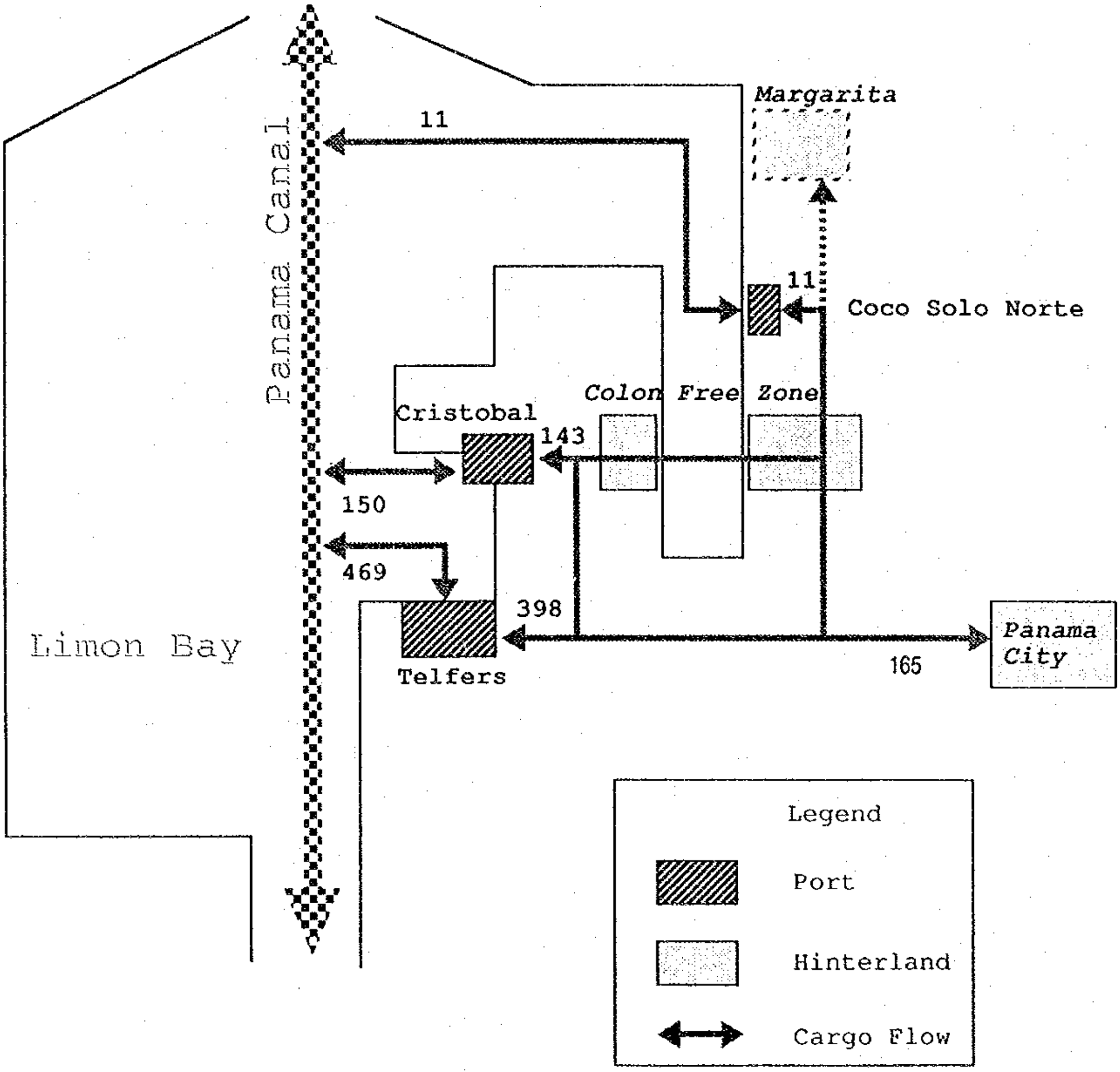


Figure 7-1-1 Container Cargo Flow in 2010 (thousand TEUs)

improvement of the transisthmian highway. However, total volume of transhipment cargo across the isthmus is not so large in volume at this time stage. Most of the transportation takes place between Cristobal and Telfers. If the berth of embarkation and disembarkation are selected randomly, 1/4 of the transhipment at Telfers will be handled at different berth of embarkation or of disembarkation. On this assumption, 18 (71 x 1/4) thousands TEUs (or 12 thousands units) of transhipment containers are transported between these two terminal areas.

In the same way, transportation demand in the Short Term Plan Stage is estimated as 3.5 thousand TEUs or 2.3 thousand units.

7.1.2 General Cargo and Bulk Cargo Transportation

The number of laden vehicles which carry port oriented bulk cargo is estimated as shown below. Based on the result of field survey by JICA (The Feasibility Study on the Improvement of the Panama-Colon Highway, 1993), unit weight carried by one vehicle is assumed as 4.0 for break bulk cargo and 5.0 for solid and liquid bulk cargo. This traffic mainly takes place between Panama City and Colon area. Transhipment cargoes are assumed to be treated within the port area.

Cargo Type	Break Bulk		Other Bulk	
Target Year	2000	2010	2000	2010
Total Cargo Volume (thousand ton/year)	435	615	125	164
Unit Weight (ton/vehicle)	4.0	4.0	5.0	5.0
Number of Laden Vehicle (thousand/year)	109	154	25	33

7.2 Land Transportation System

7.2.1 Modal Share

Land transportation to and from the Free Zone which is more than half of the total is naturally undertaken by road transportation. Cargoes to and from Panama City Area can be transported either by road or railroad. Railroad cargo transportation has sharply decreased in recent years and no future demand increase is expected without full scale rehabilitation of the facilities, rolling stocks and operation system. It seems difficult to perform full scale rehabilitation and revitalization until the year 2010, and it isn't realistic to expect railroad to play a major role. The role of railroad transportation is neglected in the Long Term Plan Stage.

In the Post Master Plan Stage, full scale service for transhipment operation between main lines will be realized at both ports of Cristobal and Balboa. Since transportation demand between the two ports will increase drastically, a modernization and revitalization of the railroad is indispensable as a major component of the Center Port.

7.2.2 Port Oriented Traffic Volume

Road traffic volume related to the container transportation is estimated on the basis of the unit number estimated in 8.1.1. All containers are assumed to be transported by one unit on chassis pulled by a tractor. In order to convert the number of containers to the traffic volume, the ratio of laden trailer and the ratio of related vehicle induced by container transportation are assumed as 0.5. Consequently, the ratio between traffic volume and the number of containers transported is;

(1+0.5) / 0.5 = 3

The traffic between the Colon Free Zone and Telfers container terminals is assumed to take a roundabout way via France Field in order to avoid congestion around Colon City. Annual traffic volume are shown below;

(Upper:2000, Lower:2010) (thousand vehicles/year)

	Cristobal	Telfers	Total
Free Zone (Colon)	57 42	- -	57 42
Free Zone (France Field and Coco Solite)	165 123	213 549	378 672
Panama City Area and Others	93 75	93 249	186 324
Total	315 240	306 798	621 1038

Traffic volume of transhipment containers between two terminal areas is calculated as 7 thousand for the Short Term Plan and 36 thousand for the Long Term Plan.

Traffic volume for bulk cargo to and from Panama City Area is 402 (134 x 3) thousand vehicles/year in 2000 and 561 (187 x 3) thousand vehicles in 2010. This traffic volume is schematically shown in Figure 7-2-1.

In order to check the capacity of each road section, annual traffic volumes shown above are converted to design hourly traffic volume. Parameters are assumed as follows;

Annual traffic days	350	days/year
Traffic hours	8	hours/day
Daily peak ratio	1.3	
Hourly peak ratio	1.4	

Design traffic volume related to the port activities for each segment of the road network around the port of Cristobal is shown in Figure 7-2-2.

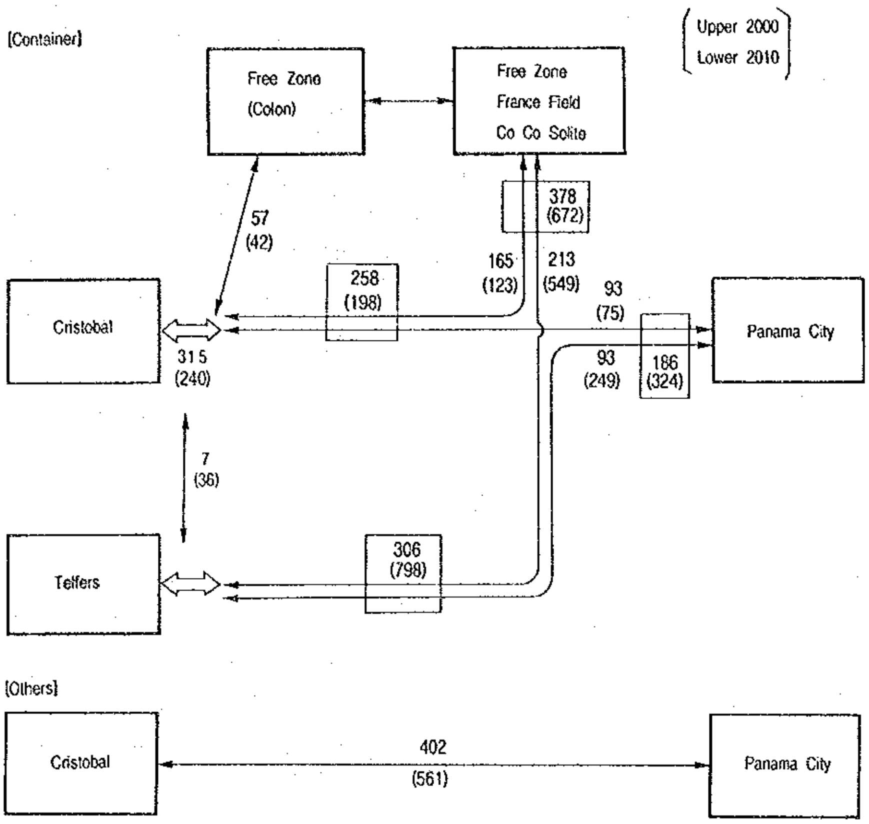


Figure 7-2-1 Port Oriented Traffic (1,000 Vehicles/Year)

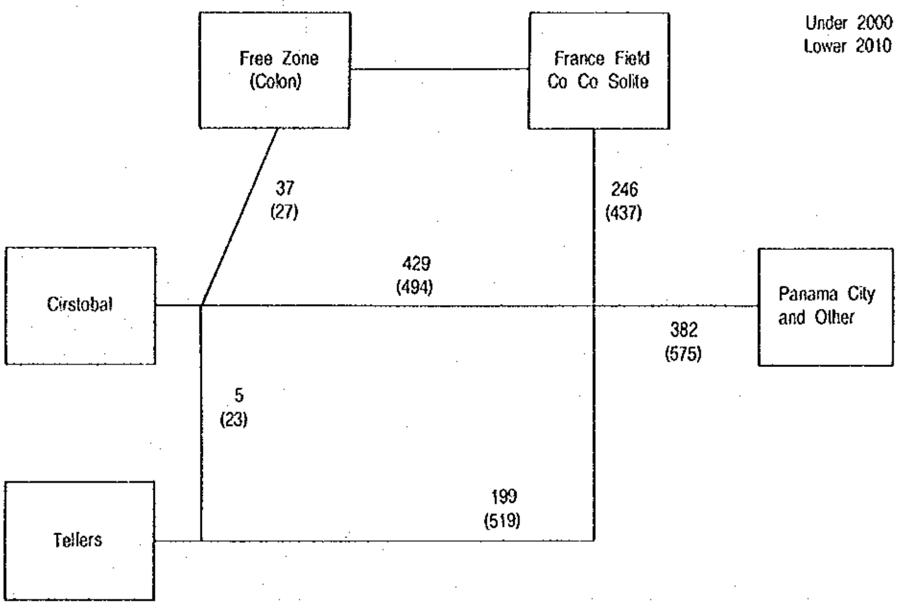


Figure 7-2-2 Port Oriented Traffic (Vehicles/Year)

The traffic volume of the Transisthmian Highway is 429 traffic/hour in 2000 and 576 traffic/hour in 2010. This traffic volume will largely affect the traffic condition, which is under congestion even now, and expansion of the capacity is urgently needed.

Randolph Road which branches toward France Field from the Transisthmian Highway also has a large traffic volume in the Long Term Stage. Full scale rehabilitation will be necessary considering its poor foundation and pavement.

The traffic volume from and to Telfers container terminals is around 500 vehicles/hour in the Long Term Stage. On the current road network, this traffic flows into Randolph Road and mixes with the traffic to and from the port of Cristobal. Since this traffic may cause heavy traffic congestion on Randlph Road, it is necessary to secure by-pass route from Telfers terminals to France Field and Panama City.

7.3 Development Plan of Road Network

7.3.1 Step-wise Scenario for Road Network Improvement

The road network connecting major points related with port activities is rather complicated and facilities are in poor condition. Since large scale developments will take place in Telfers Island and Coco Solite Area, traffic demand around these major points will greatly increase in the near future. To cope with this increasing demand, construction and formation of a circular shaped road network system (Figure 7-3-1) is preferable and recommended in future. The concept and step-wise scenario of each time stage is explained as follows and schematically shown in Figure 7-3-2.

(1) Present Situation

Many roads from major points access to the Transisthmian Highway which is the sole road connecting Colon and Panama City. Free Zone Areas are separated in two on both sides of the Folk River and access to the highway individually. There is no access road to Telfers Island Area.

(2) Short Term Plan Stage (2000)

Free Zones in Colon and in France Field will be connected by a bridge thereby providing easy access between each area. Access road to Telfers Island is constructed by improvement of Telfers Road and Limon Road. A short cut route for access to Randlpf Road from Telfers Island has been improved.

(3) Long Term Plan Stage (2010)

The traffic capacity of the Transisthmian Highway is increased by the rehabilitation and reconstruction. Route 16 from the highway to France Field is also improved and expanded. A new southbound access road from Telfers terminal to Boliver Highway

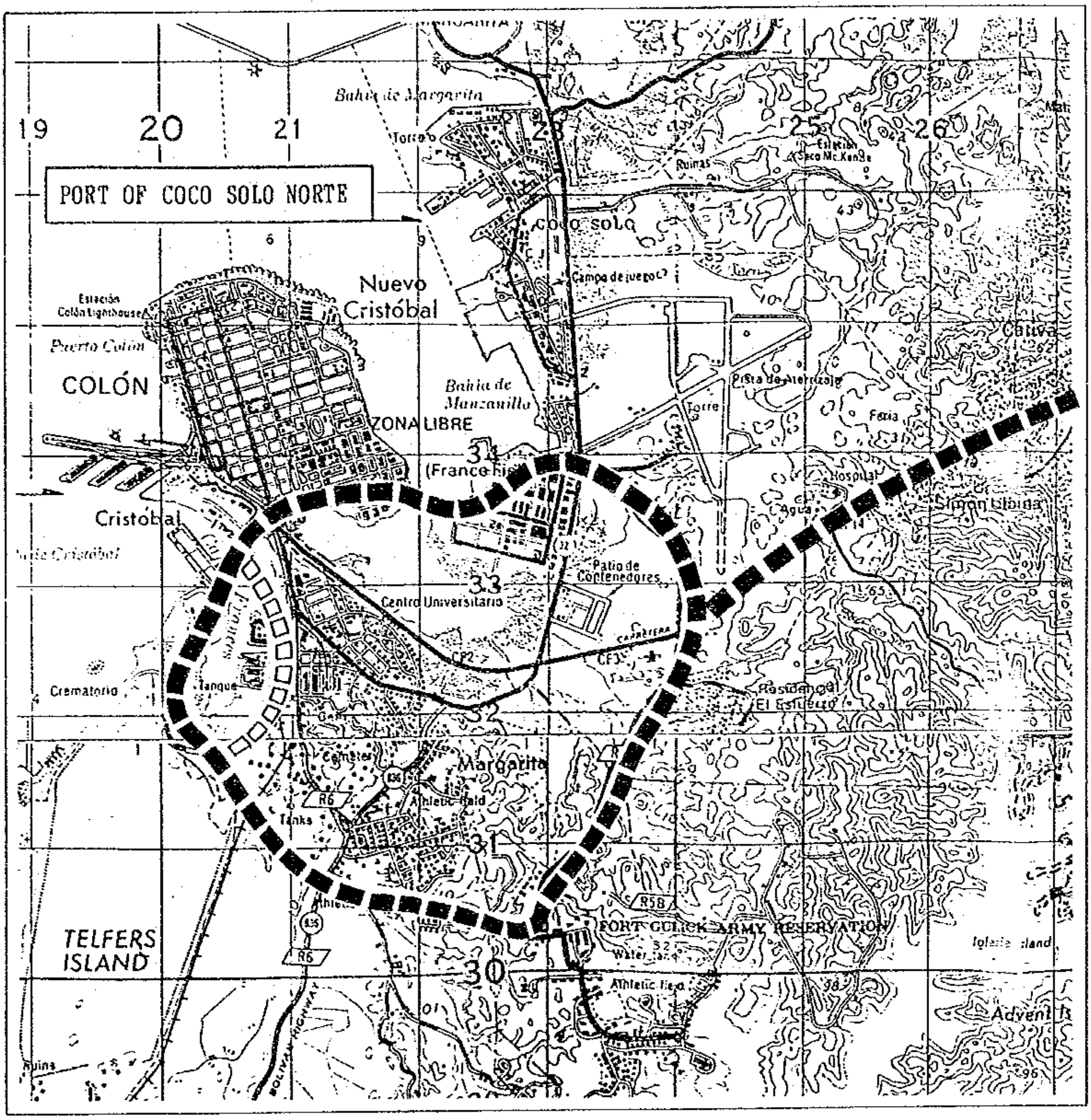


Figure 7-3-1 Circular Shaped Road Network