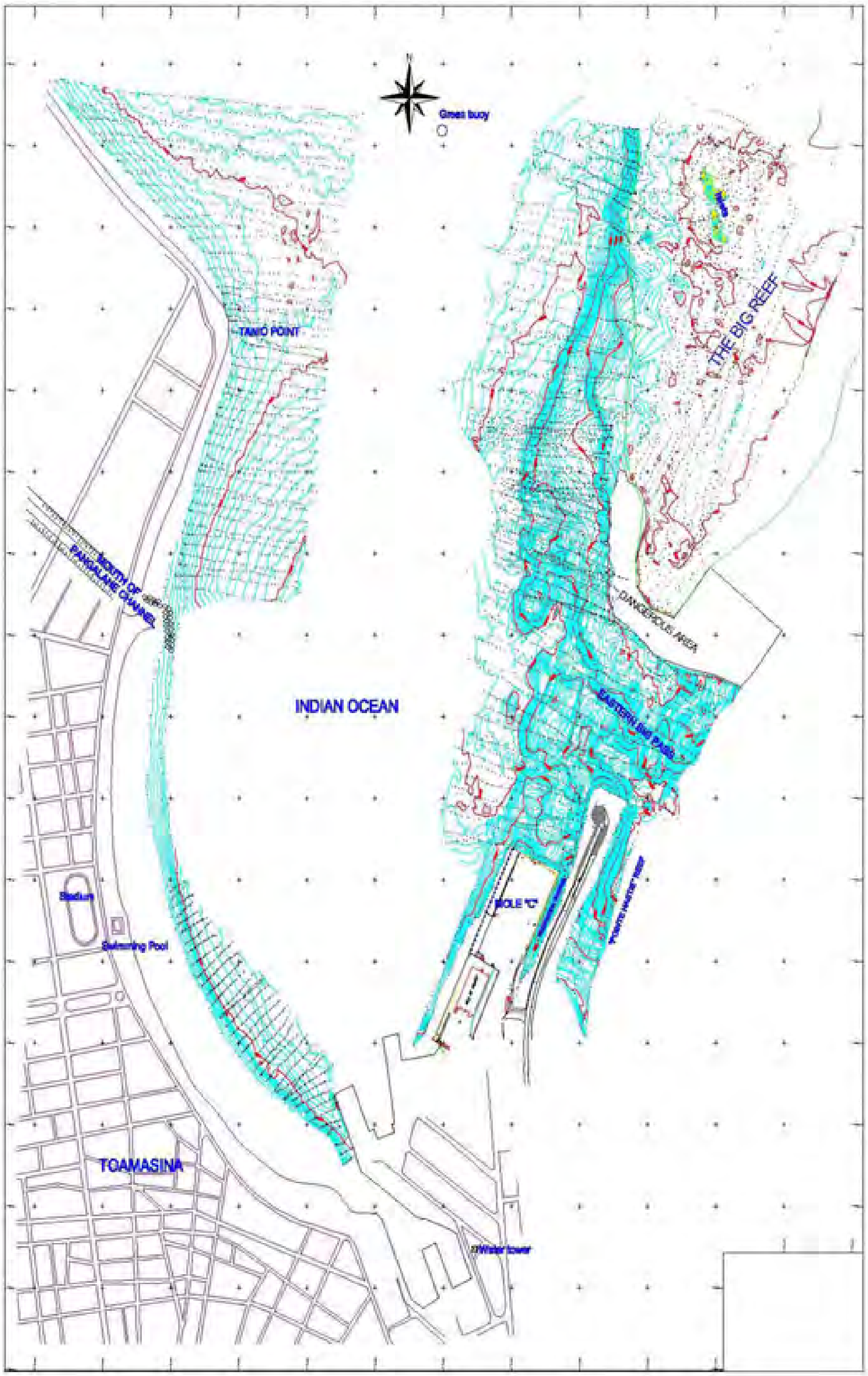
Appendix for Chapter 2

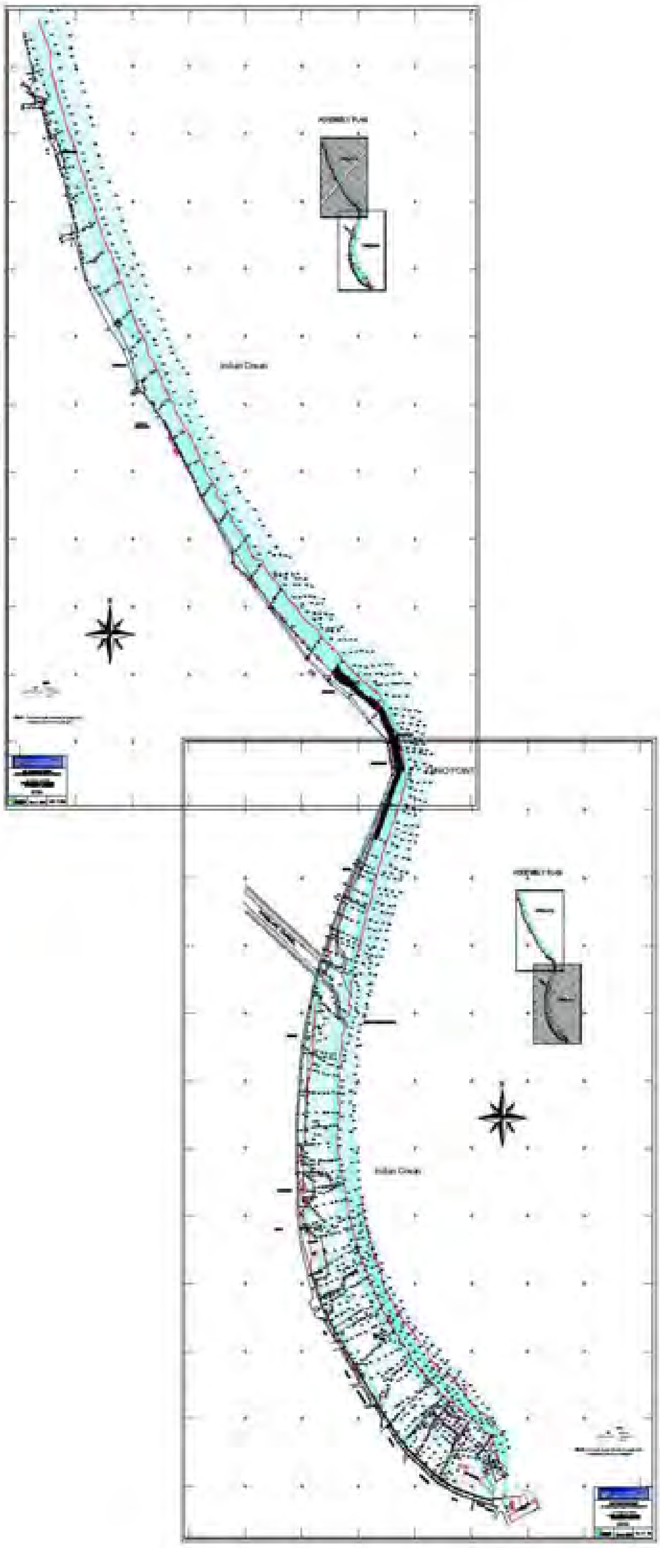
Natural Conditions and Field Surveys

(1) Bathymetric Survey Results



Bathymetric Survey Results

(2) Shoreline Survey Results



Shoreline Survey Results

(3) Topographic Survey Results

Topographic Survey Results

Appendix for Chapter 3

Cargo Demand Forecast

A3-1 Container Cargo Movement in the Indian Ocean Region

1) Container Throughput

The following figures show the recent 10 years movement of container throughput of major ports in the Indian Ocean region. In the figure, Manila port was added for reference since the port is operated by ICTSI which the parent company of Toamasina's MICTSL.

Figure A3-1-1 Locations of the Surrounding Country's Ports

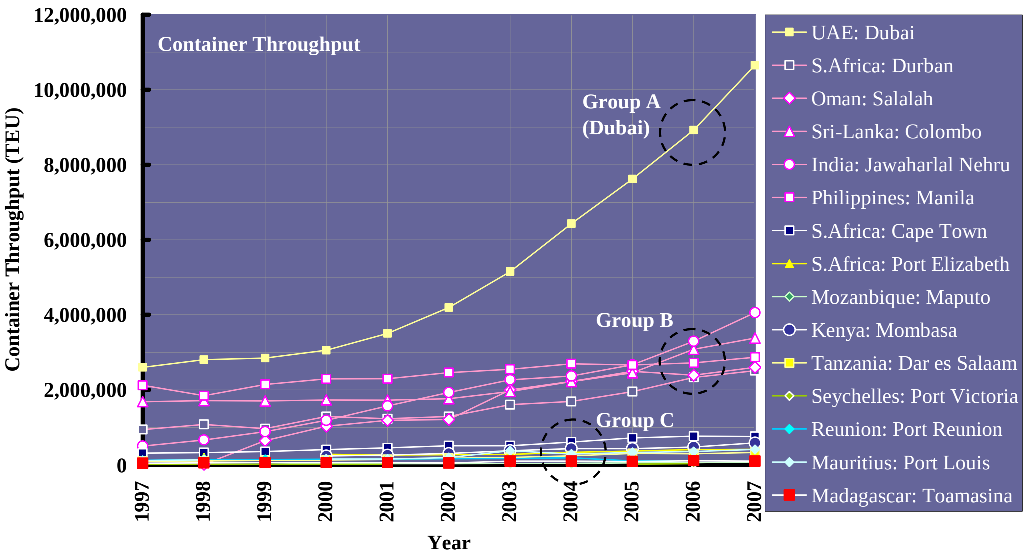


Figure A3-1-2 Container Cargo Throughput of Surrounding Country's Ports (1)
(source : ci-online)

As an attempt, these ports were divided into three groups. Group A contains only one port Dubai in UAE, whose range of throughput is over 10 million TEU. Group B contains Durban (S.Africa), Salalah (Oman), Colombo (Sri-Lanka), Jawaharlal Nehru (India), and Manila (Philippines) whose range of throughputs are in 2-4 million TEU. Group C contains Toamasina as well as other African ports whose range of throughputs are in less than 1 million TEU.

Comparing three groups, all ports positioned in the range less than 3 million TEU in 1997, whereas during these 10 years Dubai has taken off exceptionally by its strategy of trans-shipment business for surrounding countries. Looking at group B, all are national prime port of each country. It is noticed that Salalah and Colombo extended their throughput by the trans-shipment business in which the rate of growth is more than the growth of domestic economy. Jawaharlal Nehru and Durban have the characteristics that they extended the throughputs based on the strong domestic growth of economy while their trans-shipment ratio are rather lower than the others. It is also noticed that the gap between group B and group C seems becoming wider during these 5 years. Toamasina Port positions in group C, whose growths are lower and failed to take off during these 10 years.

The following figure shows the details of group C ports. In the group C, Cape Town, Mombasa, Port Elizabeth, Port Louis and Dar es Salaam are growing gradually, while other ports including Toamasina the rate of growth are lower.

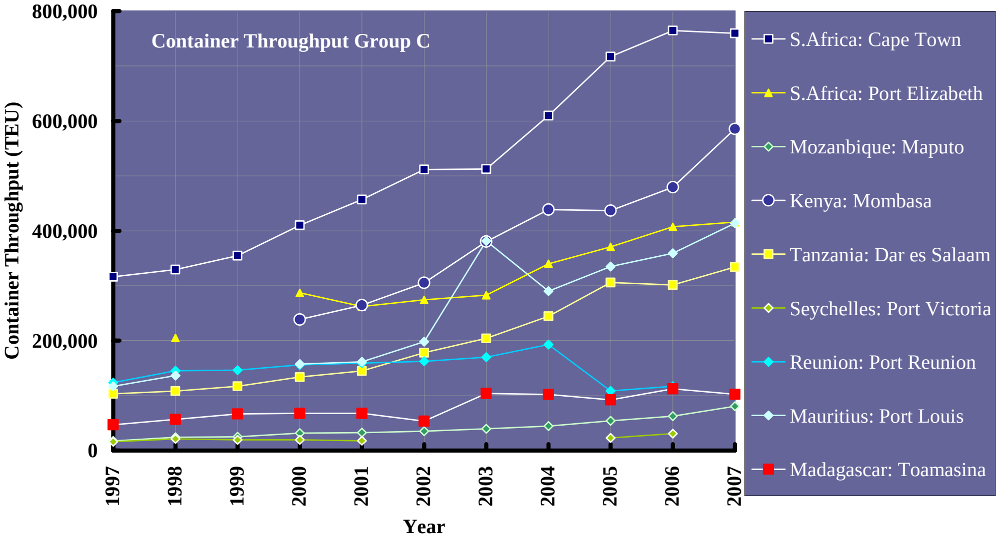


Figure A3-1-3 Container Cargo Throughput of Surrounding Countries (2)
(source : ci-online)

2) Container Vessel Rout

The following Table shows the regular sea-line container and car carrier services connecting to Toamasina port in 2007 and their vessel particulars. There are 1 car carrier's rout and 4 container regular routs for Toamasina port. In 2007, Toamasina port received 48 services of car carriers and 182 services of container lines. The size of vessels are in the range of 660 - 2,500 TEU capacities for container carriers.

Table A3-1-1 Container Vessel Routs Connect to Toamasina Port (2007)

NO	ROUT	VESSEL NAME	FLAG	TYPE	DWT	GT	NT	LOA	LBP	B	Dr	Dep	Cars	TEU	BOX WIDTH	REF PLUG	SPEED	YEAR	OPERATOR	SERV FREQ
RT-1	(CAR CARRIER) JAPAN - OCEANIA - AFRICA - EUROPE	MORNING ROSE	NIS	VC	15,603	45,007	13,502	194.04	180.02	32.31	9.02	21.16	5,250	173	0	0	18.00	1980	HOEGH AUTOLINERS	48
		HOEGH TROPICANA	NIS	VC	12,003	33,359	10,008	180.02	167.75	29.27	8.50	12.55	3,550	173	0	0	17.50	1980		
		HOEGH TRACER	NIS	VC	12,961	33,236	10,338	180.02	167.01	29.24	8.82	12.37	3,640	173	0	0	17.50	1981		
		HOEGH ASIA	BAH	VC	21,484	56,835	19,776	199.90	190.00	32.26	10.02	13.95	6,100	-	0	0	20.50	2000		
		HOEGH TREASURE	BAH	VC	21,199	58,684	17,606	199.90	190.38	32.26	10.02	22.20	6,100	-	0	0	19.50	1999		
		AUTO ATLAS	KOR	VC	23,069	52,422	17,216	199.52	189.24	32.26	10.02	21.04	5,193	-	0	0	18.00	1988		
		EURO SPIRIT	LIB	VC	15,483	46,346	13,904	188.00	178.00	31.20	9.11	30.90	4,095	-	0	0	19.00	1998		
		ATLANTIC SPIRIT	LIB	VC	16,165	47,287	14,678	190.02	180.02	33.25	8.93	13.31	4,838	170	0	0	19.50	1987		
		UNIVERSAL SPIRIT	LIB	VC	13,025	39,948	11,984	173.53	164.01	30.48	8.92	12.37	4,435	-	0	0	19.50	1985		
		KIWI AUCKLAND	NOR	VC	13,295	37,841	11,352	175.01	166.02	28.81	8.52	13.01	4,250	-	0	0	18.00	1985		
		HOEGH DETROIT	NOR	VC	15,921	68,169	25,239	229.00	220.00	32.29	9.00	19.93	6,545	-	0	0	20.50	2006		
		HUAL DURBAN	PAN	VC	18,381	59,217	17,766	199.90	192.00	32.26	9.61	35.80	6,402	-	0	0	19.50	2004		
		JINSEI MARU	JAP	VC	17,435	58,117	17,435	198.60	188.00	32.20	9.67	14.30	5,582	-	0	0	19.00	1990		
RT-2	SALALAH - EAST AFRICA	OLIVIA	LIB	FC	20,416	14,936	7,500	167.07	156.77	25.00	9.80	13.40	-	1,452	10	105	19.00	1995	MAERSK LINE	52
		ATLANTIC TRADER	ANT	FC	22,024	16,165	9,227	167.97	156.00	26.70	10.82	14.40	-	1,600	10	200	19.00	1996		
		OCEAN TRADER	ANT	FC	22,250	16,165	9,227	168.37	156.00	26.70	10.82	14.40	-	1,600	10	200	19.50	1996		
RT-3	HONGKONG - SINGAPORE - AFRICA	MOL MONO	PAN	FC	29,304	24,724	16,814	199.88	190.00	30.50	10.27	16.40	-	2,011	12	200	20.00	1999	MOL	52
		MOL SASSANDRA	PAN	FC	28,879	25,497	10,638	193.90	184.00	32.20	10.27	16.40	-	2,135	13	200	20.00	1999		
		MOL NIGER	PAN	FC	29,277	24,724	10,814	199.88	190.00	30.50	10.27	16.40	-	2,011	12	200	20.00	1999		
		MOL VOLTA	PAN	FC	28,917	25,497	10,638	193.90	184.00	32.20	10.27	16.40	-	2,135	13	200	20.00	1999		
		MOL OUEME	PAN	FC	29,266	24,724	10,814	199.88	190.00	30.50	10.27	16.40	-	1,697	12	200	20.00	1999		
		MOL SATISFACTION	ANT	FC	33,843	25,705	12,028	208.10	197.09	29.80	11.40	16.40	-	2,526	12	394	22.00	1999		
		MOL SUNSHINE	ANT	FC	33,917	25,535	12,454	199.80	187.90	29.80	11.55	16.50	-	2,476	12	400	22.00	2000		
		MOL DREAM	ANT	FC	33,900	25,361	12,733	207.40	195.40	29.80	11.40	16.40	-	2,460	12	400	22.00	2001		
RT-4	MADAGASCAR - MAURITIUS	MSC LONGONI	ANT	FC	8,015	6,704	3,557	132.60	123.40	19.20	7.22	9.20	-	660	7	75	17.00	2003	MSC	26
RT-5	ASIA - EAST AFRICA	KOTA AKBAR	SING	FC	22,257	17,738	6,334	176.68	164.00	27.07	10.03	14.60	-	1,267	10	100	18.50	1993	PIL	52
		LONDON TOWER	LIB	FC	23,884	17,651	8,135	182.84	170.00	28.00	9.53	14.00	-	1,500	11	133	19.00	1994		
		KOTA MAWAR	ANT	FC	22,494	16,266	8,739	179.70	167.26	25.30	9.94	13.50	-	1,660	10	170	19.50	1994		
		KOTA MANIS	LIB	FC	22,426	16,191	8,719	179.29	167.72	25.30	9.94	13.50	-	1,524	10	120	19.00	1994		
		KOTA ANGGUN	SING	FC	23,842	17,652	8,156	182.83	170.00	28.00	9.53	14.00	-	1,454	11	100	19.00	1999		
		KOTA HAPAS	HK	FC	18,889	13,491	7,314	159.53	150.00	25.00	9.22	12.80	-	1,100	10	150	18.50	2002		

Source: MDS, Lloyd's Resister

The car carriers for RT-1 are circulating Japan and the countries in Oceania, South-east Africa including Toamasina, Middle East and Europe. This rout is mainly to supply cars manufactured in Japan to these countries. Service frequency for this line is about once a week.

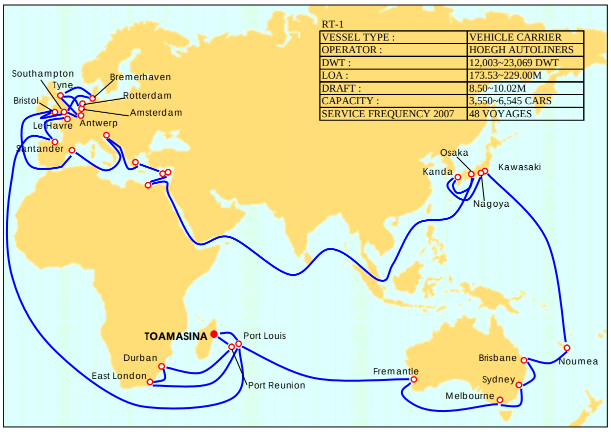


Figure A3-1-4 RT-1 (Car Carrier)

RT-2 is operated by Maersk Line and distributing trans-shipment containers from Salalah port in Oman to the east African island countries. It is noted that the Salalah port is fully managed by APM Terminals and the regional base port of Maersk Line. Service frequency for this line is once a week.

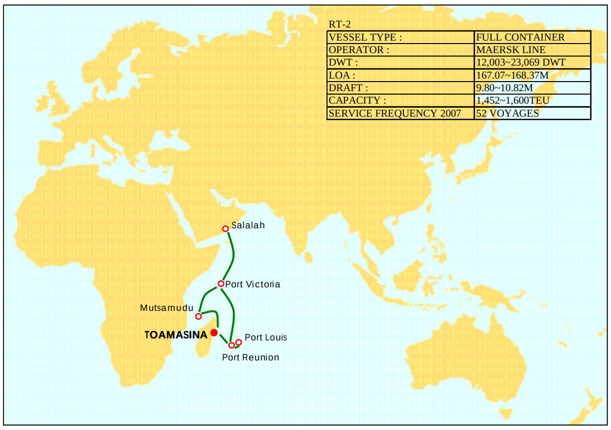


Figure A3-1-5 RT-2

RT-3 is operated by MOL and connecting Hong Kong· Singapore and African countries, which is supposed to distribute trans-shipment containers to these regions through the Asian big-2 ports. Service frequency for this line is once a week.

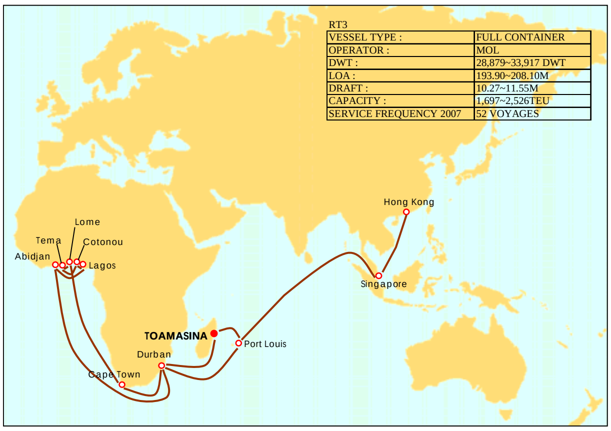


Figure A3-1-6 RT-3

RT-4 is the regional line operated by MSL and connecting Mauritius: Port Louis and Madagascar Toamasina. The size of the vessel is 660TEU which is a little smaller than other lines. Service frequency for this line is once in two weeks.

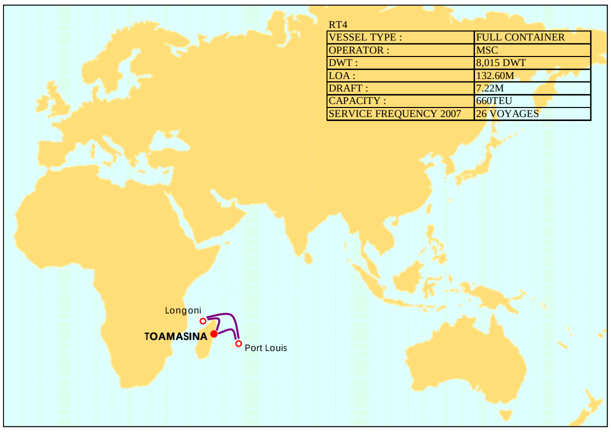


Figure A3-1-7 RT-4

RT-5 is operated by PIL and connecting China, Singapore, Colombo and African countries, which is supposed to distribute trans-shipment containers from Asian major ports to African countries. Service frequency for this line is once a week.

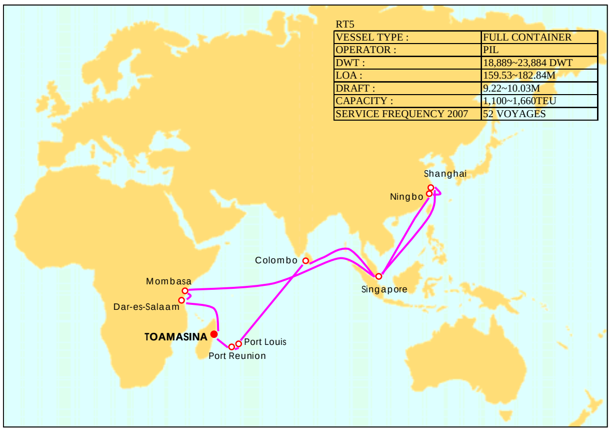


Figure A3-1-8 RT-5

The overview of these container regular lines shows that the major regional hub-ports connecting to Toamasina are Salalah, Colombo, Singapore and Hongkong.

In addition, it can be found that all the routs passing Toamasina also stop in Port Louis of Mauritius. Port Louis is located closed by Toamasina in the Indian Ocean region, and has the similar geographical condition, i.e. the island country. The container throughput of Port Louis is approx, 40 thousand TEU which is four times as that of Toamasina port. The next figures show the container lines connecting to Port Louis which do not stop in Toamasina port. It is noticed that Port Louis has 12 routs more than Toamasina and is playing a role of regional trans-shipment hub port.

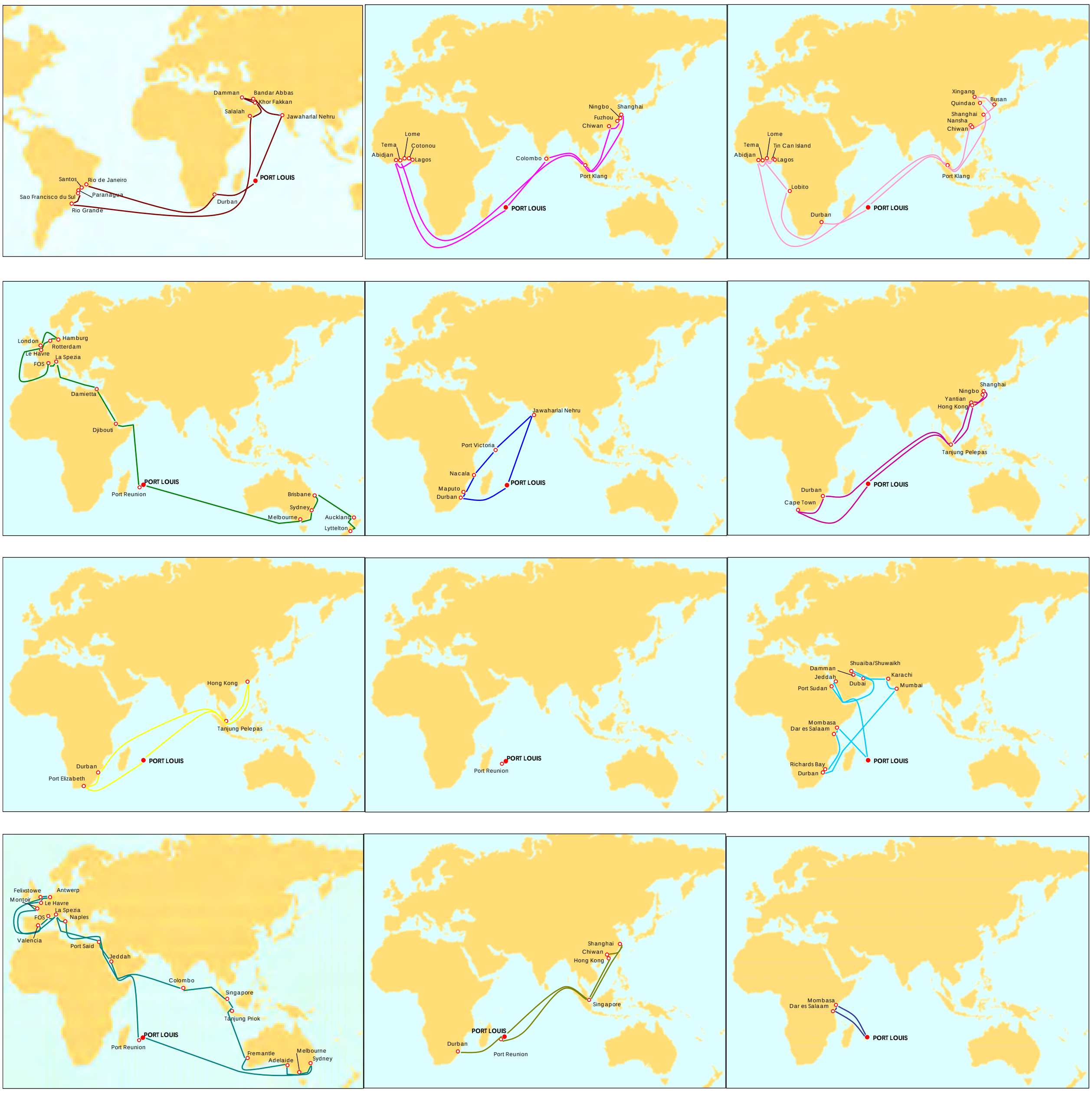


Figure A3-1-9 Container Vessel Routs Connect to Port Louis (2007)

A3-2 Demand Forecast of Container Cargo and Verifications

(1) Demand Forecast of Container Cargo

The following figure shows the container throughput data of Toamasina Port in the period from 1990 to 2008. As an initial attempt, a secondary degree's curve using least-square method was drawn on the chart (blue dotted curve). The curve shows good fitting along the all data plots which have gradual curvature whose end is going up-ward. In order to evaluate optimum annual growth rate, three curves were drawn assuming growth rates, 8%, 10% and 12% taking the throughput figure in 2005 as the basic point. The standard deviations of these three curves are as follows.

Figures of Standard Deviation	1) Growth Rate 8%	132 (Thousands TEU)
	2) Growth Rate 10%	100 (Thousands TEU)
	3) Growth Rate 12%	140 (Thousands TEU)

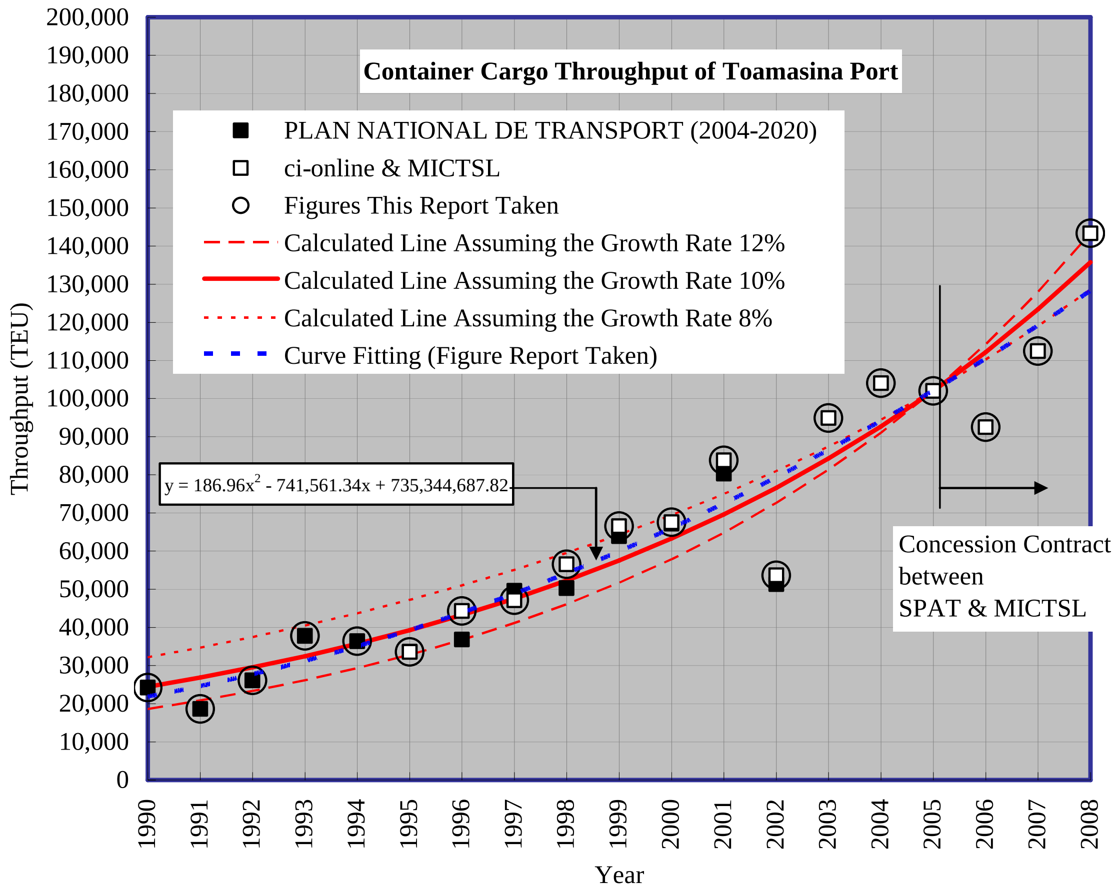


Figure A3-2-1 Optimum Curve for Container Cargo Demand Forecast

As the result of these simple analyses, the curve of 10% annual growth shows the best fitting taking the data of past 18 years. As the conclusion of the report, proposed demand forecast of container throughput takes 10% annual growth. However, in order to consider rather wide fluctuations of the past data, 12% growth as the 'aggressive scenario' and 10% growth as the 'conservative scenario' are also proposed.

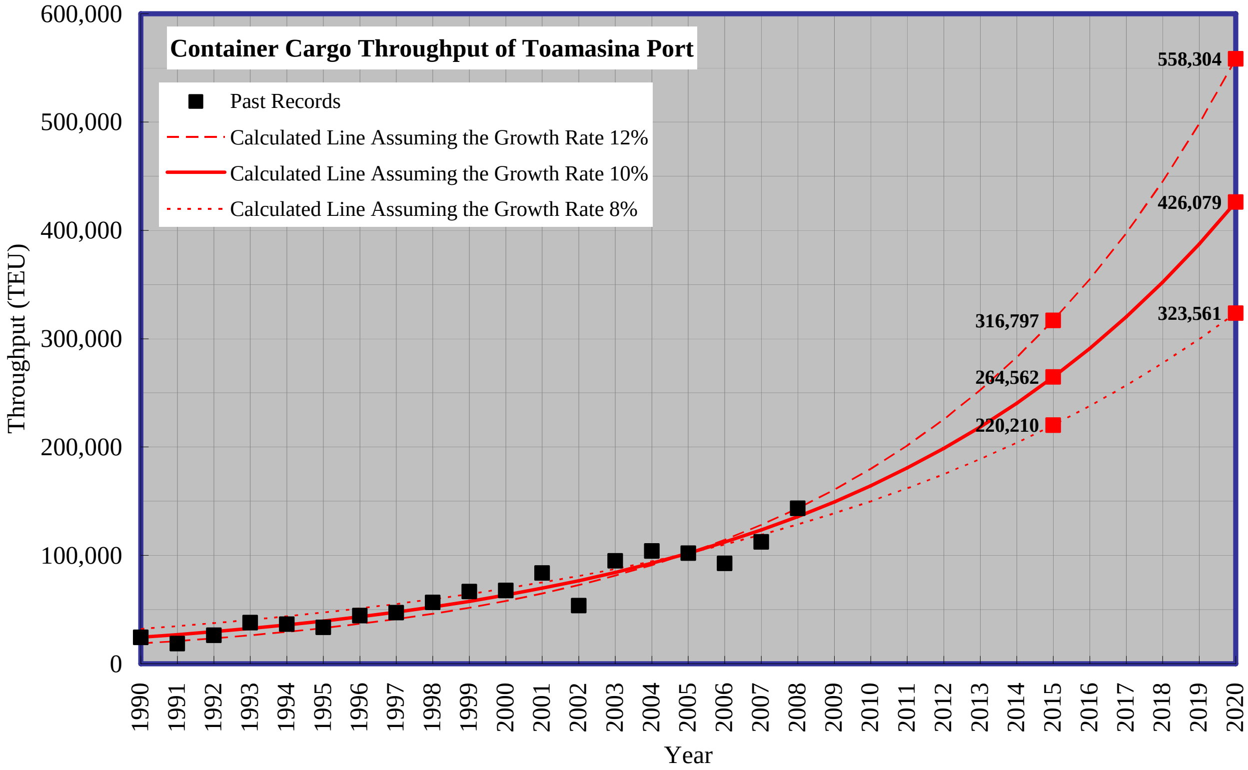


Figure A3-2-2 Demand Forecast of Container Cargo Throughput

The following table shows the prediction figures in 2015 and 2020 for each scenario. Taking the proposed scenario, the container throughput in 2015 and 2020 will reach 264,562 TEU and 426,079 TEU respectively.

Table A3-2-1 Demand Forecast of Container Throughput of Toamasina Port

	Assumed Growth Rate	Present Figure 2008 (TEU)	Forecast of Container Cargo Throughput 2015 (TEU)	2015 Growth	2020 (TEU)	2020 Growth
Conservative Scenario	8.0%	143,307	220,210	54%	323,561	126%
Proposed Scenario	10.0%		264,562	85%	426,079	197%
Aggressive Scenario	12.0%		316,797	121%	558,304	290%

(2) Verification by Several Methods

With respect to the demand forecast on the container throughput, several methods have been proposed in the past literatures. Hereinafter verifications were tried applying the theoretical methods.

1) Verification by Population & GDP

Container throughput of a country is generally linked to its magnitude of GDP and population. The following figure shows an attempt to explain the relationship between GDP-per-capita and container throughput per unit population using various countries data.

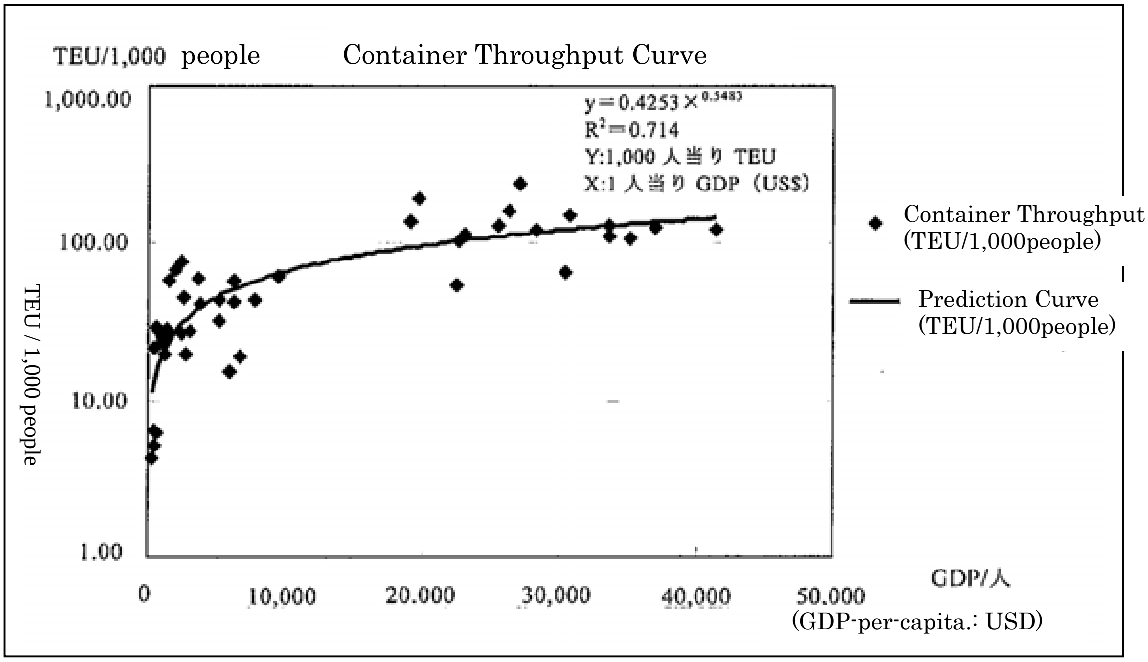


Figure A3-2-3 Theoretical Curve Showing Relationship between GDP Per-capita. and National Container Throughput per 1,000 Population (OCDI 2006)

The prediction curve is expressed by the equation,
$Y = 0.4253\ X^{0.5483}$
where,
Y : Container Throughput per 1,000 Population (TEU/1,000 Persons)
X : GDP Per-capita. (USD).

Applying the equation to the figure of Madagascar; 392 USD/capita. (2007 IMF), the container throughput of Madagascar is calculated as,

$Y = 0.4253 \times (392)^{0.5483} =$ 11.236 TEU/1,000 people
As population of Madagascar in 2007 was 19.7 million, the estimated container throughput is,
11.236 x 1,970 = 22,134 TEU.

In general, the error of this equation is large in the range of GDP-per-capita less than 10,000 USD. The actual container throughput of Toamasina port in 2007 was 112,427 TEU which shows the figure 5 times larger. The following figure shows the errors on the equation are large if we apply the other neighboring countries data to the equation.

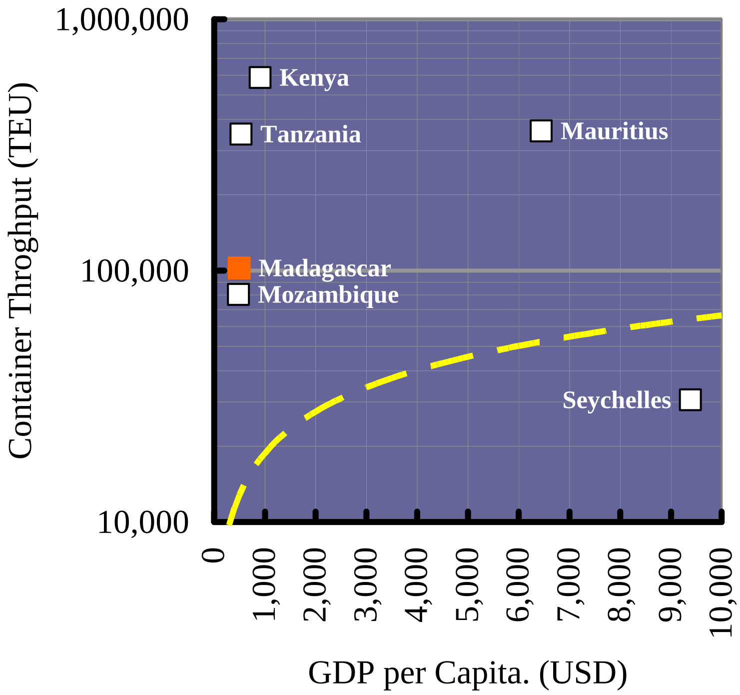


Figure A3-2-4 Application of Projection Curve

2) **Verification by GDP Growth Rate**

The method of direct forecast the container growth rate linked by GDP growth rate using the following formula has been applied in many past forecast documents.
(Container Growth Rate) = E x (GDP Growth Rate)

The following figure shows the plots of Madagascar and neighboring countries using the data of 2004-2007. From figure it is noticed that the plots of S. Africa, UAE, and India are distributed along the line E=2.0, which shows that the container growth rate usually double of GDP growth rate. These countries hold the larger ports of group A or group B discussed in section 3-2-1 which handle more than 2 million TEU.

On the other hand, other African countries including Madagascar have very large fluctuations in data plots. The figure shows the difficulty to apply this method to the forecast for Madagascar port.

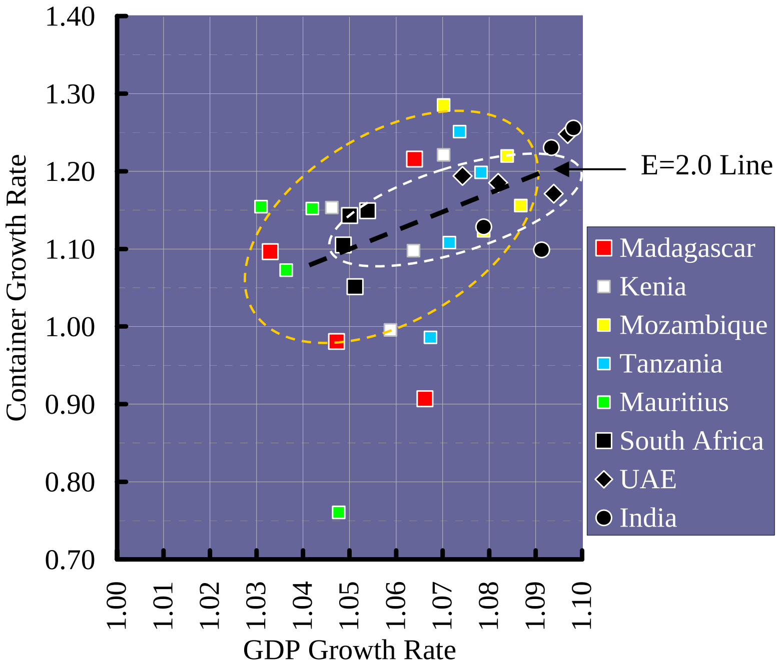


Figure A3-2-5 GDP Growth Rate and Past Container Growth Rate

3) Verification by Import, Export Cargo Tonnage

In general, there is a trade imbalance with import containers predominating during early years of container operations in developing countries since few of those countries are able to provide sufficient containerized export cargo to fill the available import containers. Therefore the number of empty containers being loaded in such countries are very high.

The following Table shows the import/export cargo volume structure of Toamasina port. From the table it is observed, import cargo volume shares 70%, where the aforesaid trade imbalance is observed. Looking at ratio of full container, 68% is considered to be low figure, for example, compared with the figure of Durban port in S. Africa 75% in 2008.

As the third verification method, import tonnage is focused because container cargo throughput is thought to be dependent on the growth of import volume considering the trade imbalance of Madagascar and the import volume should have closer relation to national consumption as well as GDP caused by economic activities in the country.

Table A3-2-2 Import/Export Cargo Volume Structure of Toamasina Port

Year	Cargo Volume of Ocean-going Vessel					Container Cargo Volume				Ratio Container	Ratio Full Container	Tonnage per TEU	
	Import		Export		Total		Full	Empty	Total			Full	All
	(ton)	(%)	(ton)	(%)	(ton)	(ton)	(TEU)	(TEU)	(TEU)	(%)	(%)	(ton)	(ton)
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬
2003	—	—	—	—	—	897,579	62,172	32,675	94,847	—	66%	14.4	9.5
2004	1,011,564	71%	406,184	29%	1,417,748	950,000	68,741	33,565	102,306	67%	67%	13.8	9.3
2005	926,089	74%	330,458	26%	1,256,547	777,357	78,948	37,667	116,615	62%	68%	9.8	6.7
2006	863,750	74%	305,564	26%	1,169,314	616,799	63,835	28,694	92,529	53%	69%	9.7	6.7
2007	1,105,396	66%	558,163	34%	1,663,559	1,245,588	77,162	35,263	112,425	75%	69%	16.1	11.1
Average		71%		29%						64%	68%	12.8	8.6

note)
1) Import/export cargo volume in tonnage of ocean-going vessel excludes cargo volume of coastal & short coastal vessels.
2) Ratio container shows the figures calculated : ⑩ = ⑥ ÷ ⑤
3) Ratio full container shows figures calculated : ⑪ = ⑦ ÷ ⑨
Source : Rapport d' Activite Portuair 2004~2007 APMF

The Figure A3-2-6 shows the movement of import/export figures of Toamasina which include general cargo and container cargo, excluding liquid cargo. The growth curve fitting shows that 7-8% growth seem to be suitable to forecast import cargo tonnage. Figure A3-2-7 shows the extended curve to 2020. Import cargo volume in 2020 were estimated as,

Growth Rate 7% : Import cargo 2,567,000 ton for 2020
Growth Rate 8%: Import cargo 3,239,000 ton for 2020.

Assuming the ratio of container ver. total cargo 68% will remain the same till 2020, container import tonnage are estimated,

Growth Rate 7% : Import container cargo 1,746,000 ton for 2020
Growth Rate 8% : Import container cargo 2,203,000 ton for 2020.

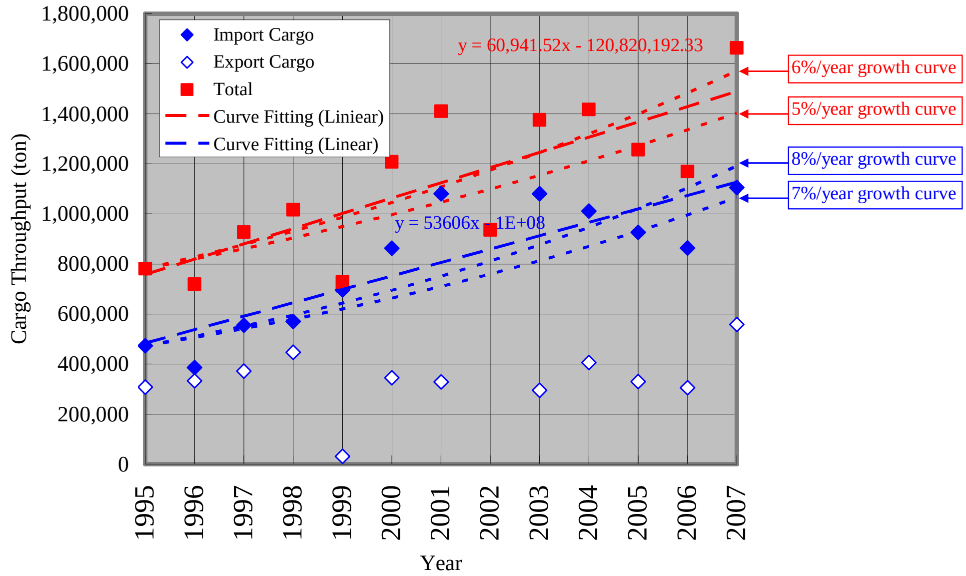


Figure A3-2-6 Import/Export Cargo Volume of Toamasina Port (source : APMF)

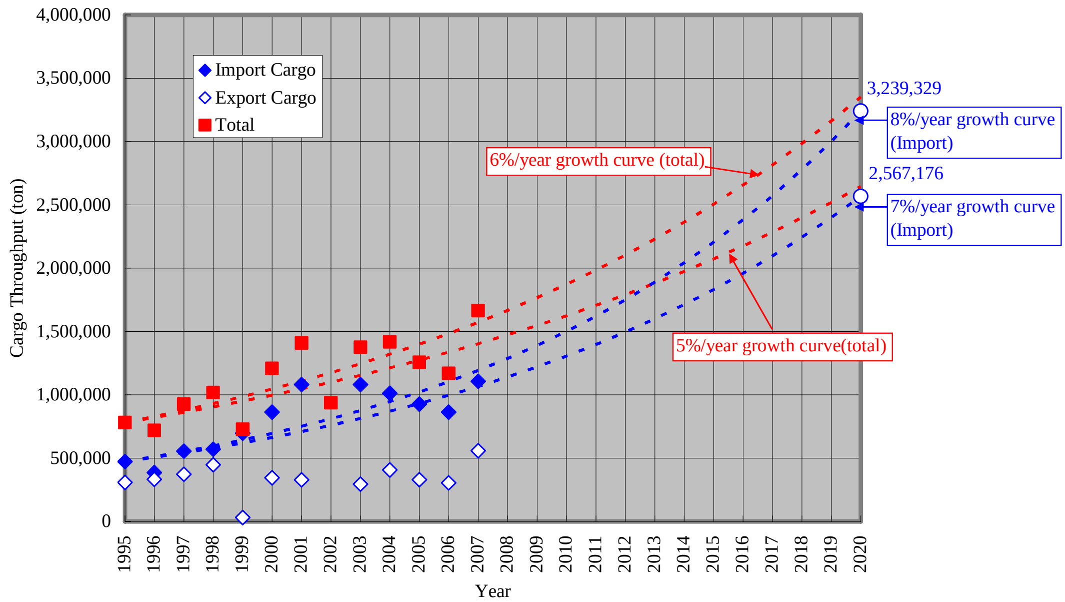


Figure A3-2-7 Forecast of Import Cargo Volume of Toamasina Port (source : APMF)

Further assuming total container throughput is double of import volume as export containers are less than import, and assuming average unit tonnage per TEU is 12.8 ton, total container throughput is estimated as follows.

Growth Rate 7% : Container Throughput 273,000 TEU for 2020
Growth Rate 8% : Container Throughput 344,000 TEU for 2020

Although many assumptions are contained in this figure, the figure of growth rate 8% shows the similar range to the “conservative scenario” proposed in Table A3-2-1

A3-3 Cargo Forecast of Particular Commodities

1) Import Cargo Forecast

Fore the purpose to estimate present and future forecast import/export volume, several statistics were referred. In general, the different statistics shows different figures, thus it looks difficult to judge a unique prediction. Hereinafter, all available statistical data are plotted in one graph, and tendency of cargo volume is discussed.

a) Rice

The Figure A3-3-1 shows the statistical data plot of rice import volume of Toamasina port. JETRO study referred mainly custom statistics, SMMS referred their own records, APMF data was made based on the report by SPAT.

Rice is the biggest import commodity of Toamasina port. It is noted that rice consumption per person of Madagascar is approximate 130 kg (nearly double of Japan), 10% of them owes to import rice. The most of import rice for Madagascar is through Toamasina, as the national custom statistics indicates the similar figures of JETRO study figures. Major import embarkation countries are, Pakistan (64%), India (28%), and USA (3%) based on 2007 custom data.

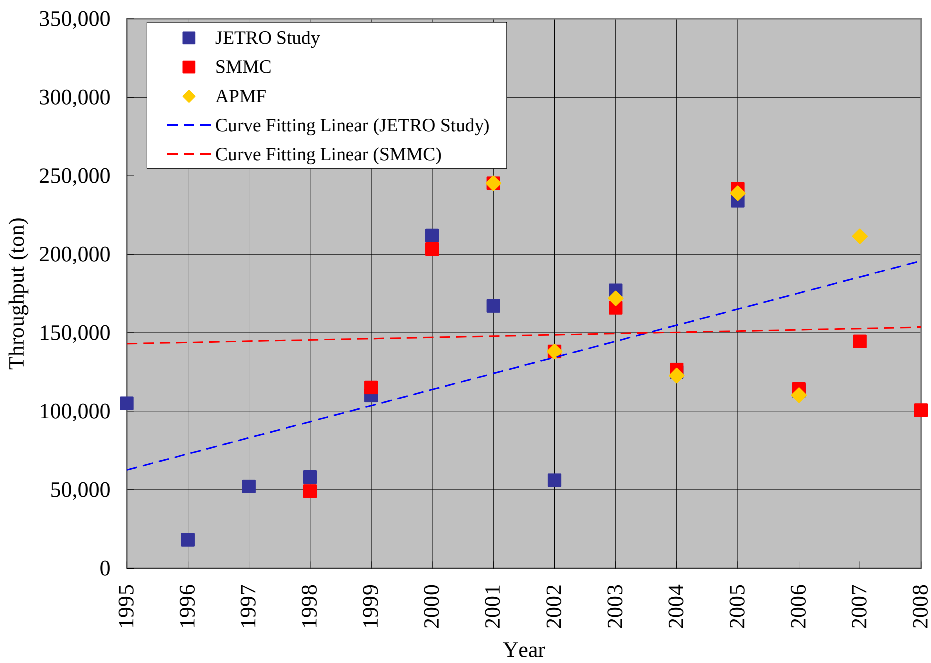


Figure A3-3-1 Rice Import Throughput of Toamasina Port

Although the annual figures have wide fluctuation, the import volume is roughly 150,000 tons every year. One reasons of this fluctuation is thought to be that the national production volume of rice is not stable and required import varies every year. On the other hand, the Government holds a policy to increase crops of rice as it is the staple food of Madagascar.

In view of form of cargo, the most of import are in the form of dry cargo (rice bags) presently. However the cargo is able to be containerized in general. If the containerization will be progressed in future, general cargo volume will be decreased and shifted to the container cargo.

b) Cement

In Toamasina port, Holcim (Madagascar) S.A. has the bagging plant and storage warehouse in front of quay wall of More C1. The most of cement are imported in the form of dry bulk where the quay wall is facilitated for air-pumping and pipeline unloading.

The Figure A3-3-2 shows the statistical data plot of cement import volume of Toamasina port. Major import embarkation countries are, Indonesia (62%), China (24%), and Pakistan (7%) based on 2007 custom data. Though data are fluctuated, the tendency of import volume is the gradual increase. Reasonable curve fitting taking JETRO Study data shows the annual increase of 14,000 tons.

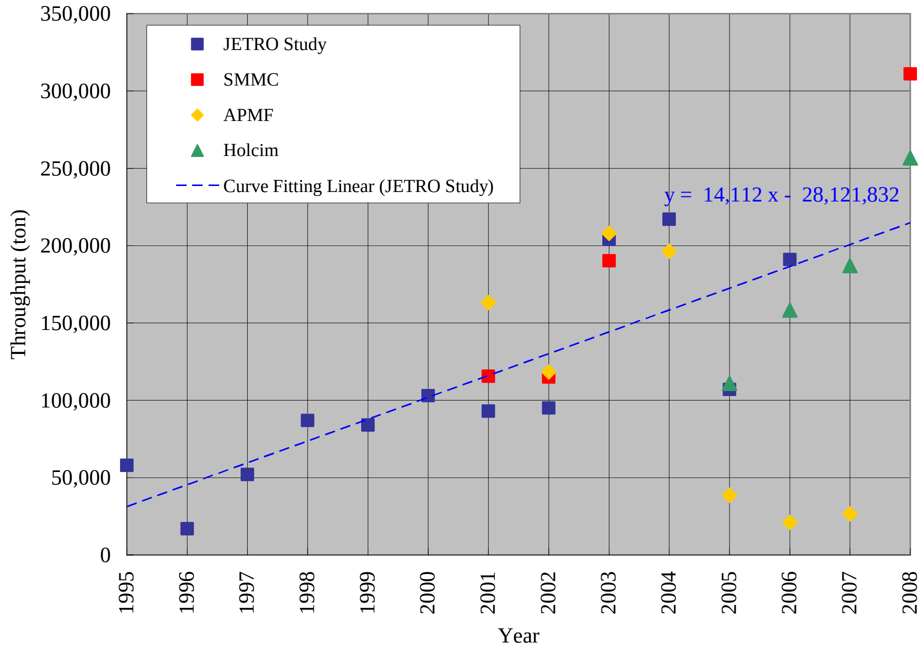


Figure A3-3-2 Cement Import Throughput of Toamasina Port

Cement consumption generally depends on the construction market growth. As recent GDP growth is approximate 7%, future demand of cement import will be increased according to the national economy growth.

It is pointed out that the cement is also one of the commodities which can be containerized similar to rice import. However Holcim (Madagascar) S.A. is operating the bagging plant in approximate 50% of full capacity now, which allows more import in the form of dry cargo. It is foreseen that the increase of cement dry cargo will be continued.

c) Wheat

In Toamasina port, MANA Madagascar has the factory for processing wheat and producing flour. MANA is founded in 2007 merging the similar factory in the same port. Wheat is imported in the form of dry cargo, which is unloaded from the bulk carrier vessel by bucket and hopper then moved to the factory storehouse using belt conveyor mounted in front of quay wall Mall C1. The all produced flour is sold to domestic market, in which 60% for Antananarivo, 20% for Toamasina city, and 15~20 % is transported to other region by feeder cargo vessels.

The Figure A3-3-3 shows the statistical data plot of wheat import volume of Toamasina port. All data scattered in wide fluctuation, thus future forecast using these data is difficult. In accordance to the interview to management of MANA, production in 2008 was 100,000 tons and national consumption is increasing.

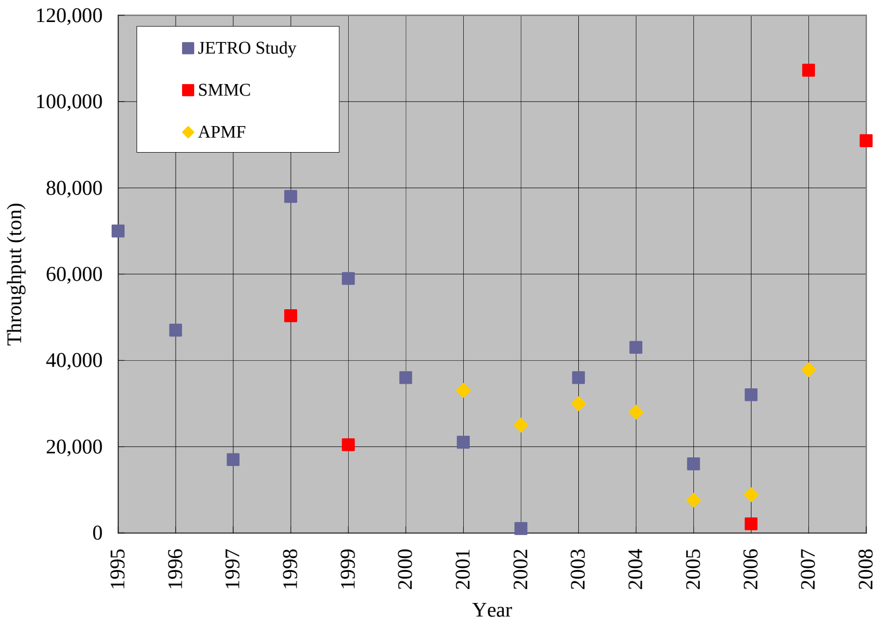


Figure A3-3-3 Wheat Import Throughput of Toamasina Port

As a new business, MANA is expanding its factory and plans to export flour to oversea. The planned volume of export is 50,000 tons per year and it will be commenced in 2009. When the plan launched successfully, throughput of wheat and flour in Toamasine will be predicted approximately 200,000 tons.

2) Export Cargo Forecast

a) Litchi

Lichi is one of the main export items in Toamasina port. The harvest season is from November till Dicember. During the season, the lichi is exported by leefer cargo ship or by packed in reefer containers. According to the information provided by MICTSL, approximately 50% is loaded to reefer ship and the rests are for reefer container.

The Figure A3-3-4 shows the statistical data plot of lichi export volume of Toamasina port. Export volume in 2007 was roughly 20,000tons. All data scattered in wide fluctuation. The reason of the fluctuation might be the unevenness of crop each year. However it is observed in the figures that the export volumes have a tendency to increase.

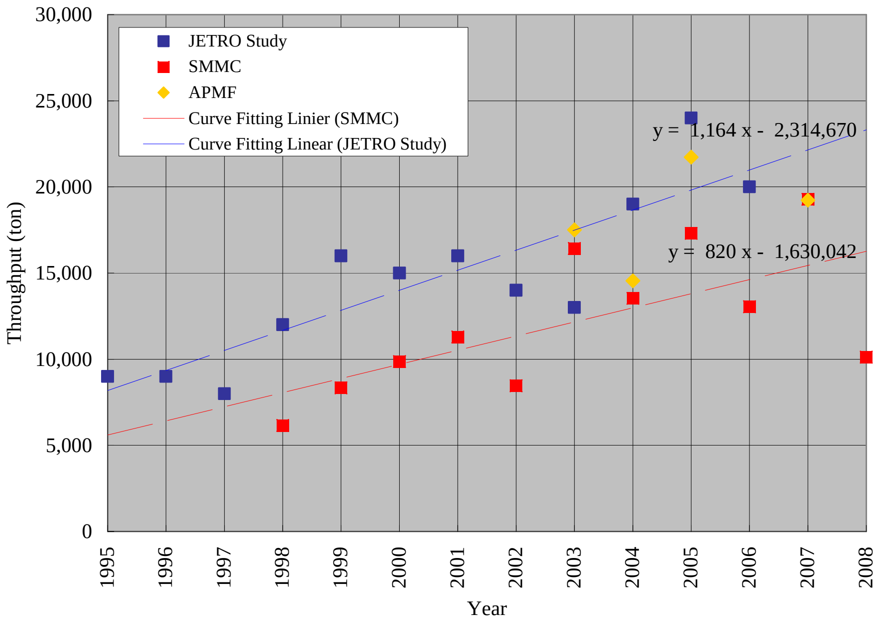


Figure A3-3-4 Lichi Export Throughput of Toamasina Port

b) Chromium Ore

Chromium ore is also one of the main export items in Toamasina port. There is a stock area of the ore in the port owned land, and these stockpile is transported to quaywall for every vessel arrrival. Usually the ore is loaded to the bulk cargo ship, but sometimes exported with packed in the container upon order received.

Recent annual figures of export shows apploximately 100,000tons. The data scattered in wide fluctuation, thus future forecast using these data is difficult.

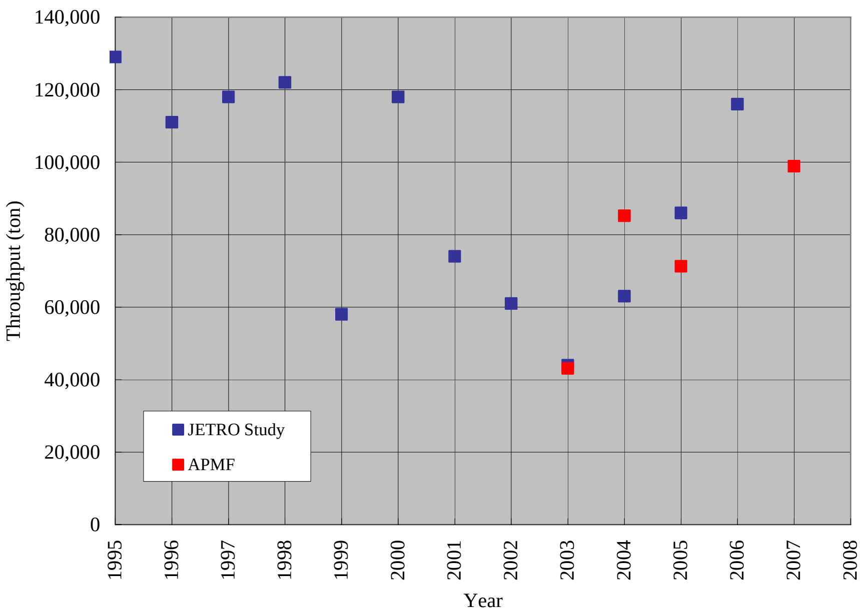


Figure A3-3-5 Chromium Export Throughput of Toamasina Port

Appendix for Chapter 4

Port Planning

A4-1 Cost Comparison of Alternative Layouts

(Plan-1)
An original plan to meet the 2020 demand is indicated in Fig A4-1.
The end of the quay will be utilized for berthing (-14x185), although the length is not sufficient to accommodate ships of 50,000 DWT.
The water area behind the breakwater will be reclaimed and utilized for the marshalling and the stacking of containers. The aim of the plan is to realize smooth traffic and quick handling at the quay side. However, to utilize the area, overtopping waves need to be prevented. The crown height of the breakwater should be sufficient and stable enough to handle the waves generated in a cyclone. Accordingly, the crown height of the breakwater should become +11.0m above datum level, and the wave dissipating blocks (50t-Dolos) will be used at the front slope of the break water.
The stock yard for containers will be located on the plane of Hastie reef, in addition to the quay site. The planned area is shallow and calm under normal sea conditions. However, during a cyclone, a huge wave mass will run on the surface of the reef flat and collide with the shore protection at great speed. It may destroy the shore structure and wash it away. To protect the shore and prevent overtopping of water, the blocks (2t-Tetra Pod) will be placed on the surface of the shore protection.
The pavement of the container yard is made of reinforced concrete to support the heavy lifts with full container loads.

(Plan-2)
Plan-2 is indicated in Fig A4-2.
To reduce the cost, the quay at the end of the C4 is withdrawn. Bulk and other goods will be handled at C1, C2. The belt conveyer for the chips will be installed at the C1-C2 quay. The basin in front of the C1-C2 berth will be deepened. The reclamation area on the Hastie reef is reduced to half of that of the original plan.

(Plan-3)
Plan-3 is indicated in Fig A4-3.
To decrease the cost, the idea of reclaiming the area behind the breakwater is abandoned. This makes it possible to lower the crown height of the breakwater. The idea of improving the existing breakwater is also abandoned.
The structure for the shore protection on the Hastie reef is changed to a temporary one, because it is located in shallow water and easy to repair.
The pavement is changed to the asphaltic concrete from reinforced concrete. However the filling material will be the stones of non-sorted grade and will have sufficient bearing capacity.

(Plan-4)
Plan-4 is indicated in Fig A4-4.
To reduce the cost for the breakwater, the alignment of the breakwater is bent so that the location of the breakwater may pass the -15m depth.
Owing to the odd shape of the container yard, the quay alignment is also changed so that the back yard will have sufficient space.
However, the cost for the breakwater became higher than that of Plan-3, because the back yard and the break water touched together. The crown height of the breakwater should be high enough to prevent the over topping.

The costs for each alternative are indicated in Table A4-1.

Table A4-1 Cost for the Alternatives

Plan	Cost: EURO million	Remarks
Plan-1	333	+Annex berth, Filling behind, 26ha reclamation
Plan-2	233	Without Annex berth, Filling Behind, 10ha reclamation
Plan-3	196	Without Filling behind, 10ha reclamation
Plan-4	219	Bent Breakwater

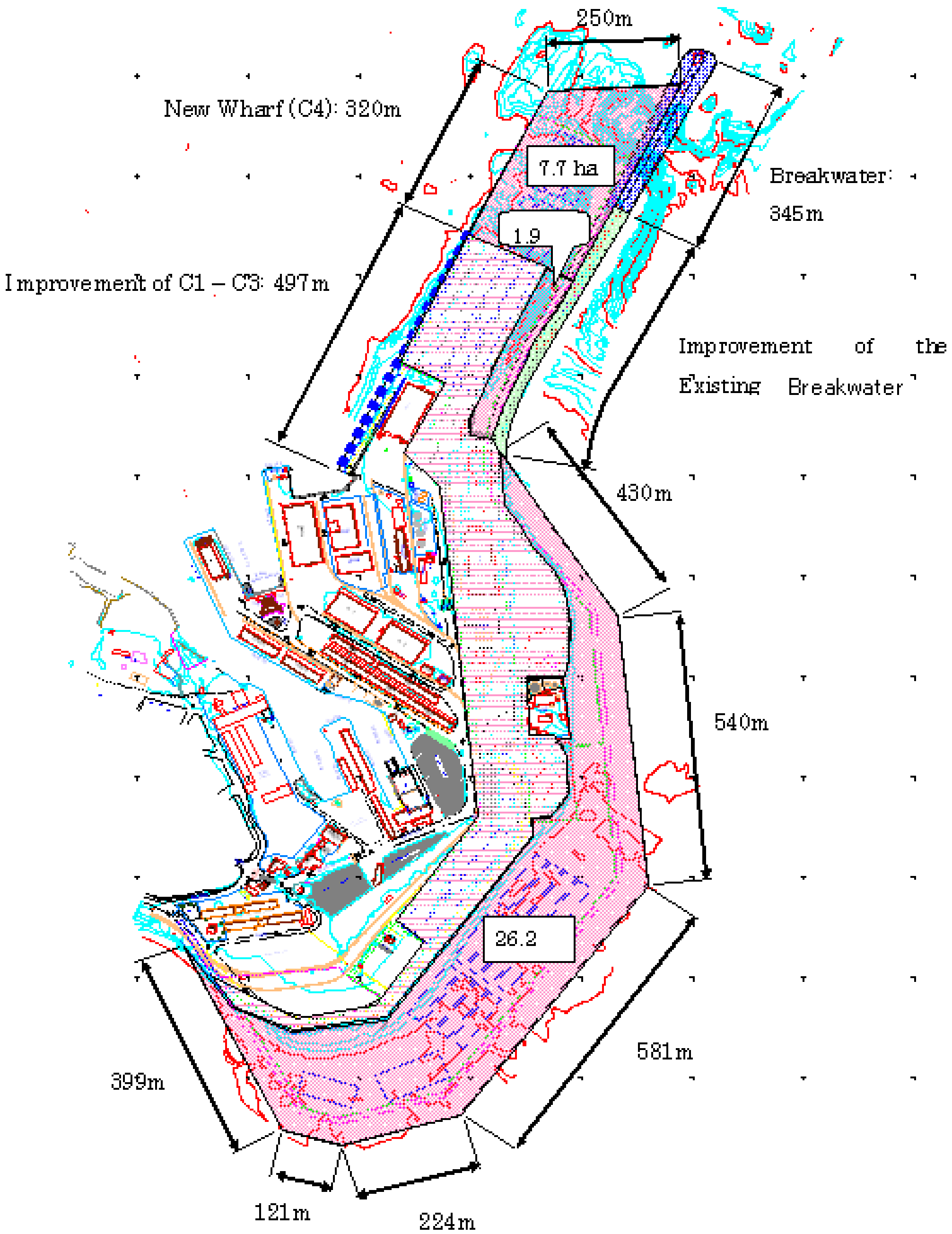
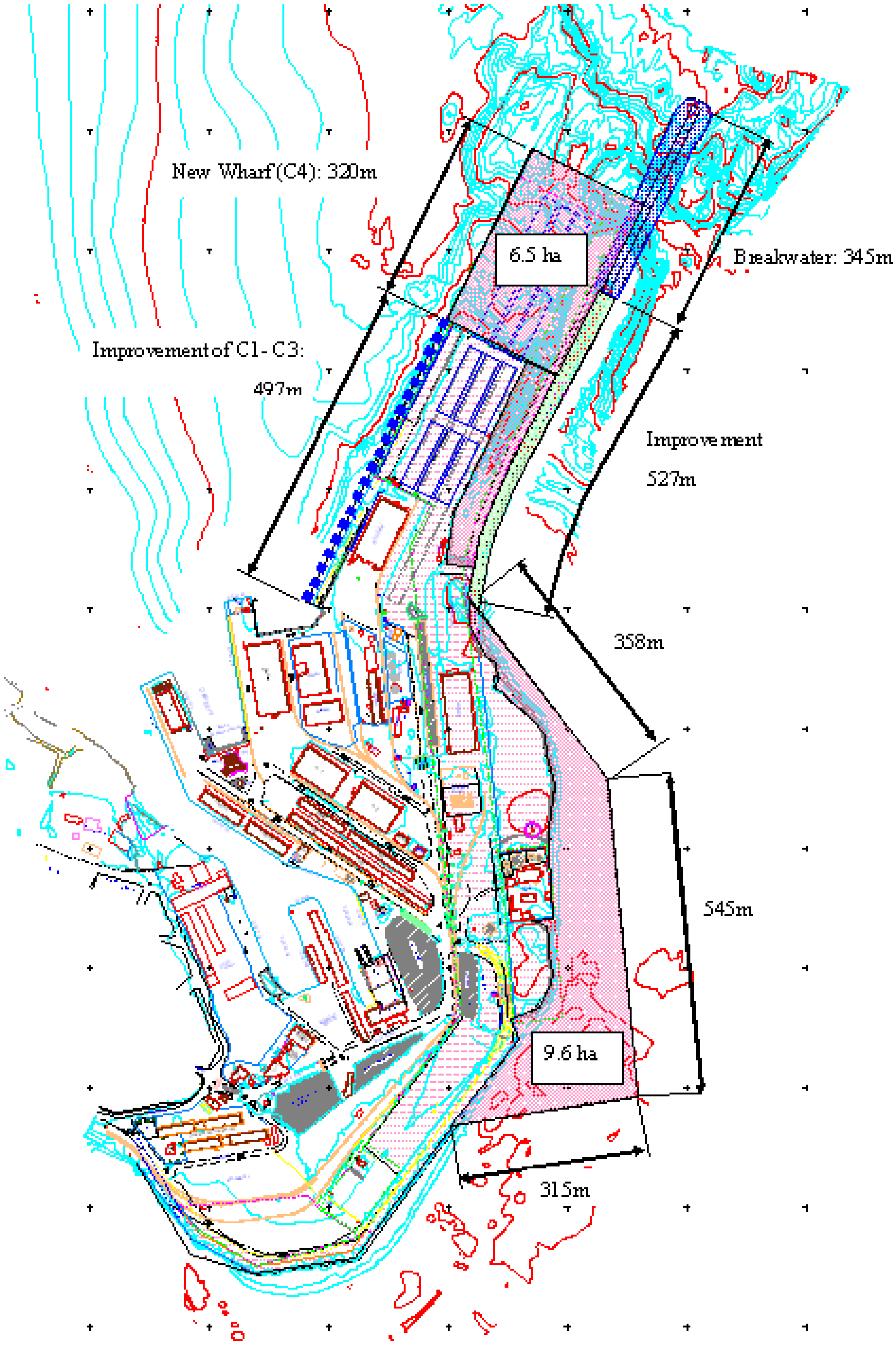


Fig A4-1 Plan-1



Gig A4-2 Plan-2

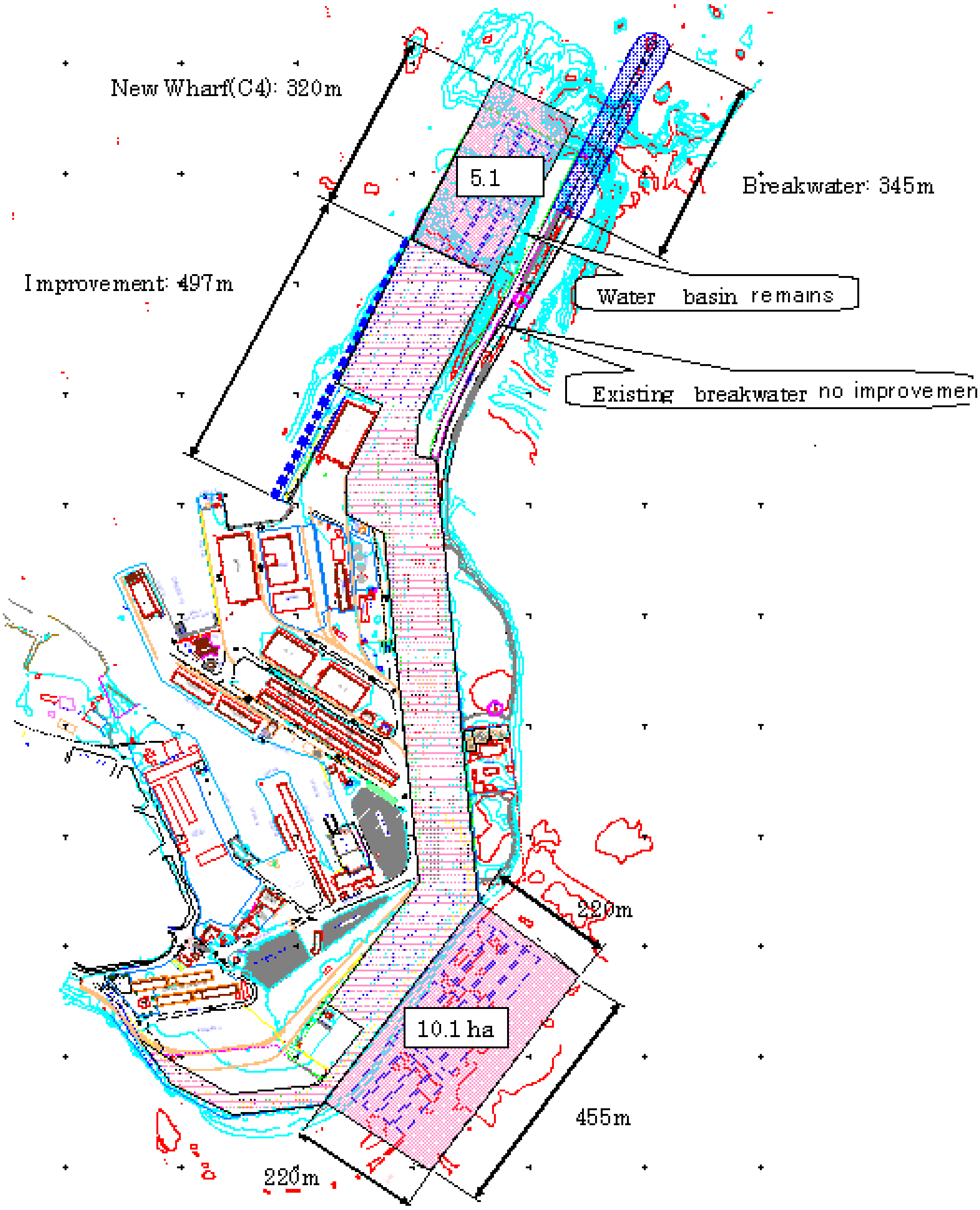


Fig A4-3 Plan-3

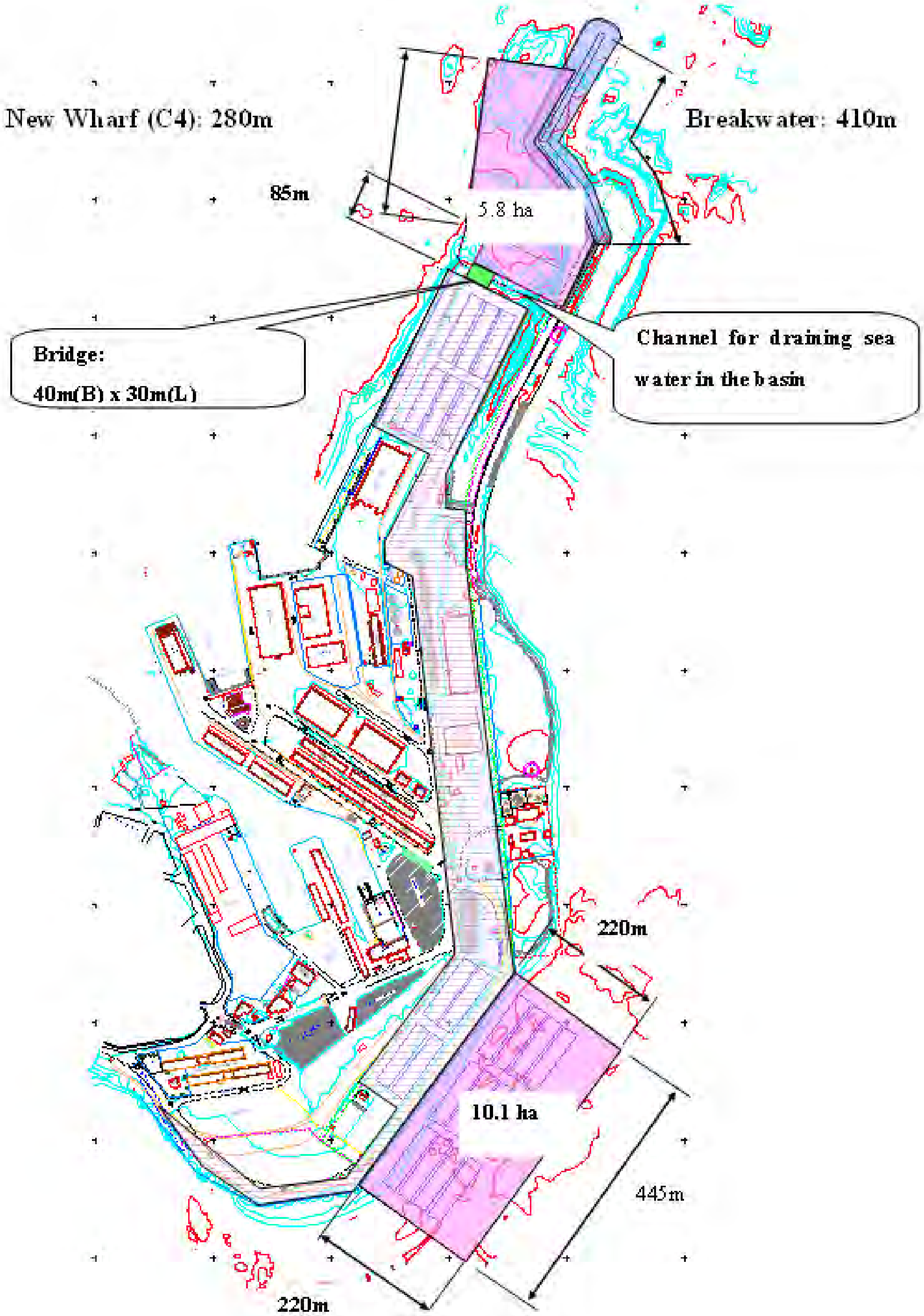
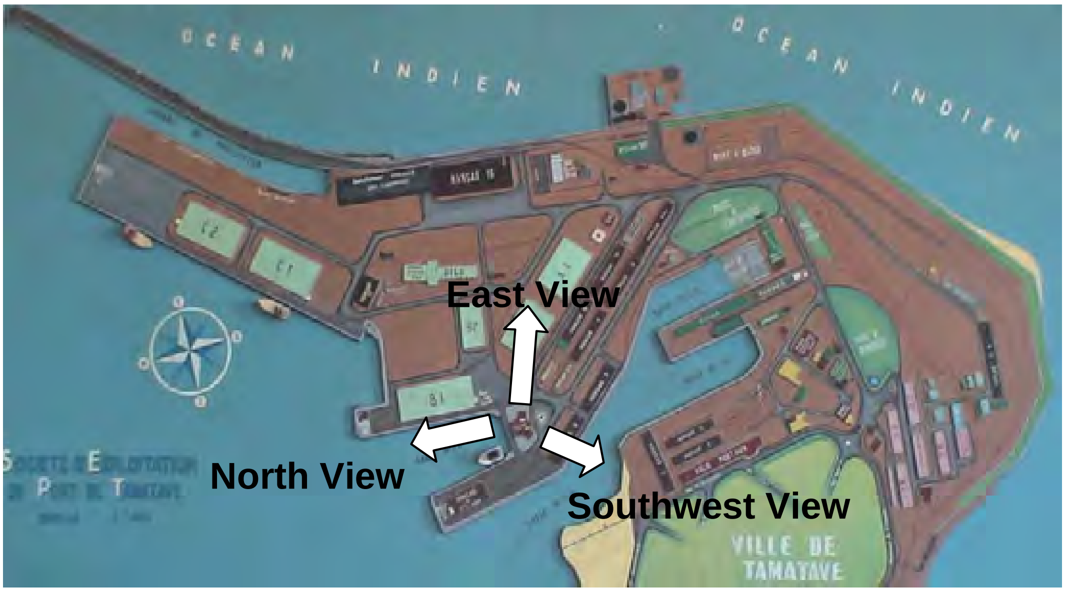


Fig A4-4 Plan-4

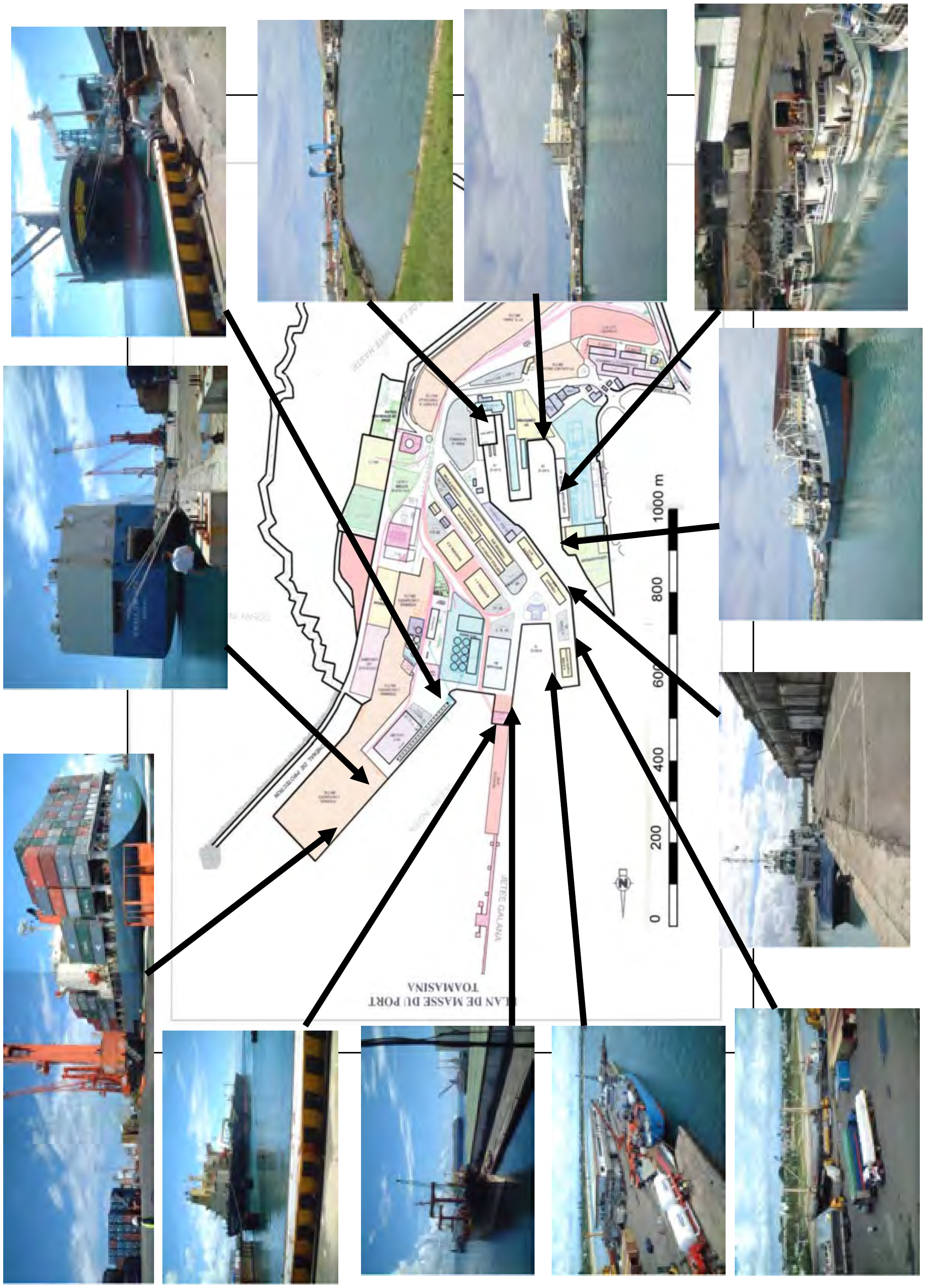
A4-2 Existing Situation (Photos)

1. General views



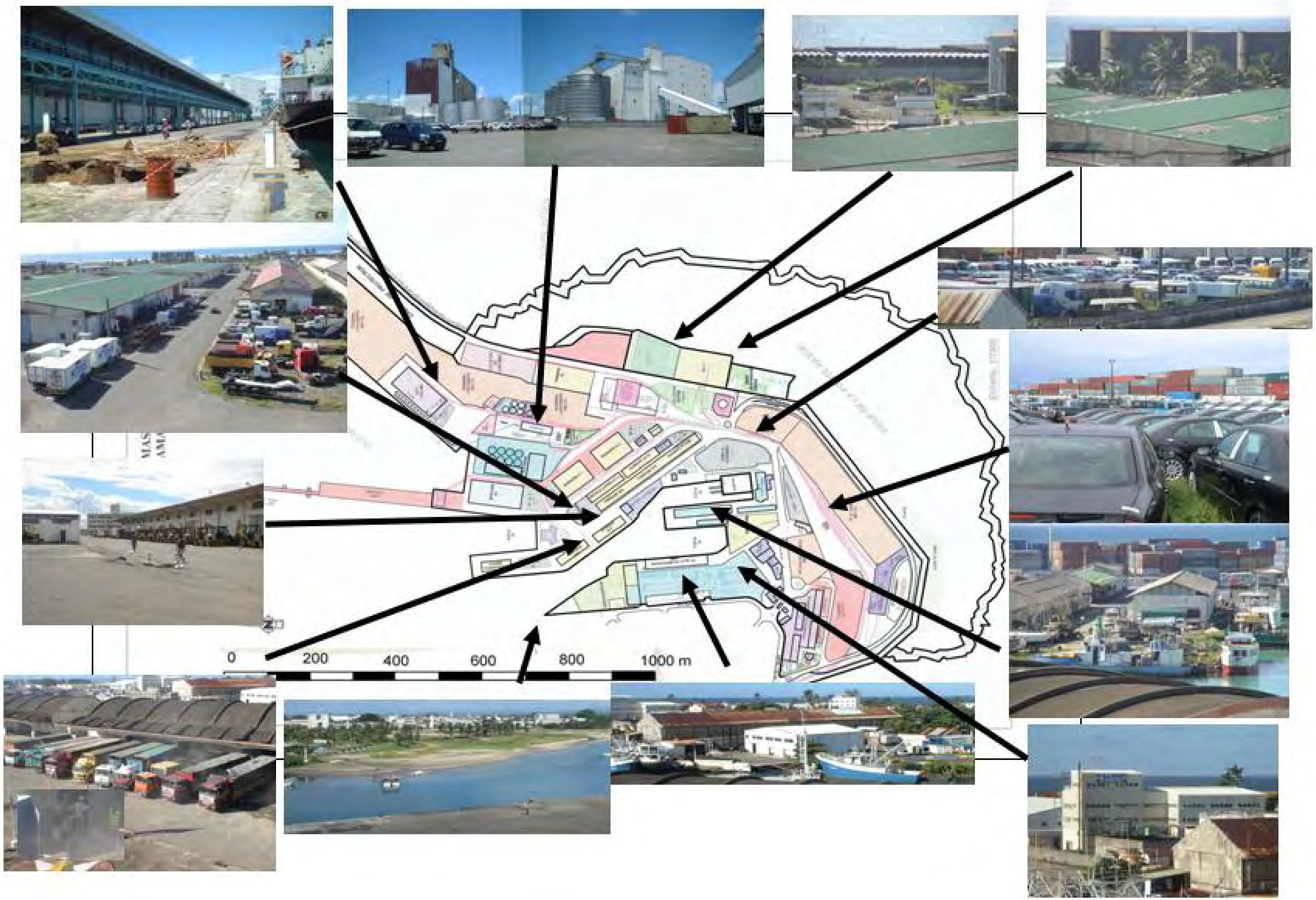
Toamasina Port View

General View of Toamasina Port

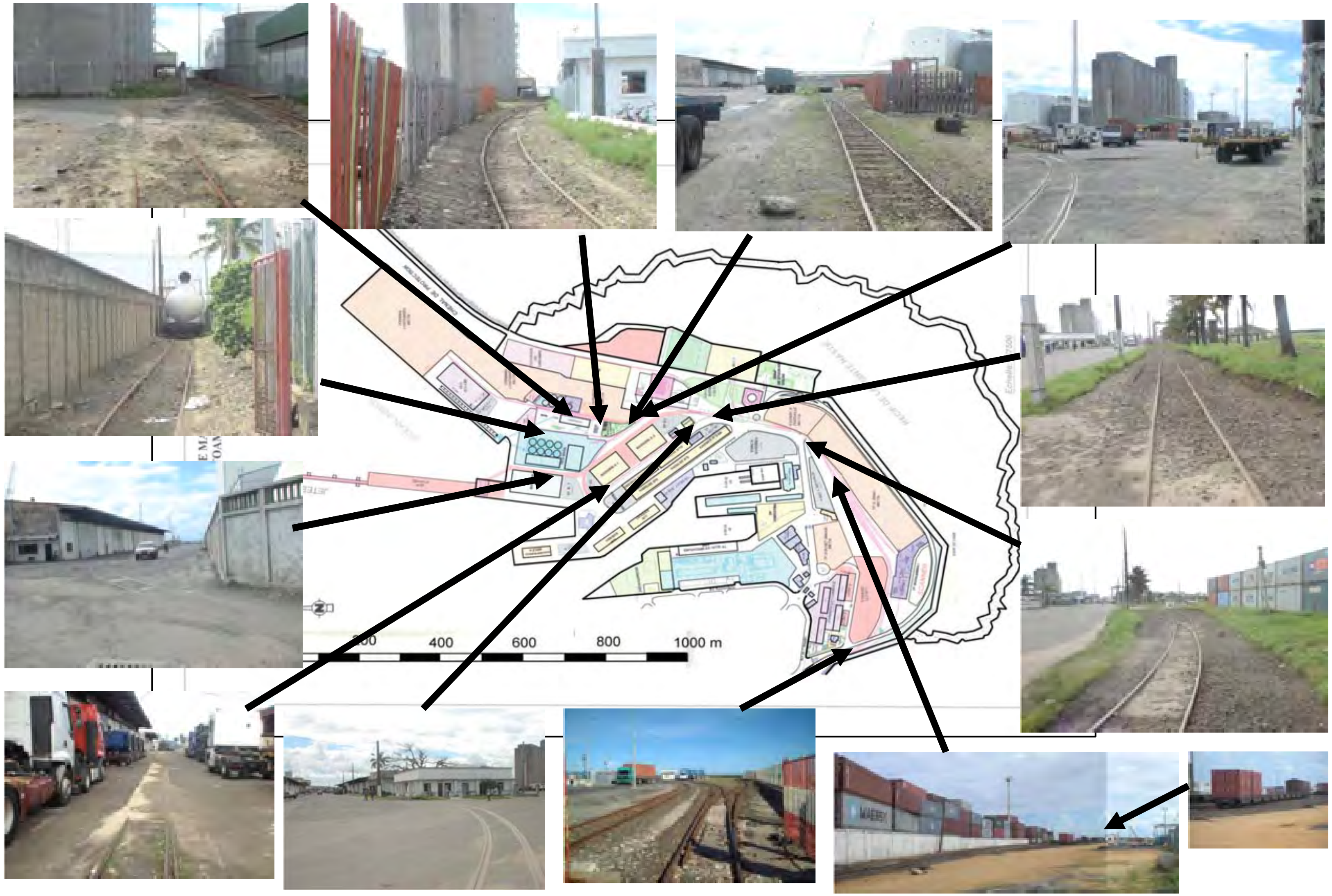

PLAN DE MASSE DU PORT
TOAMASINA
JETEES GALANA
0
200
400
600
800
1000 m

Wharves

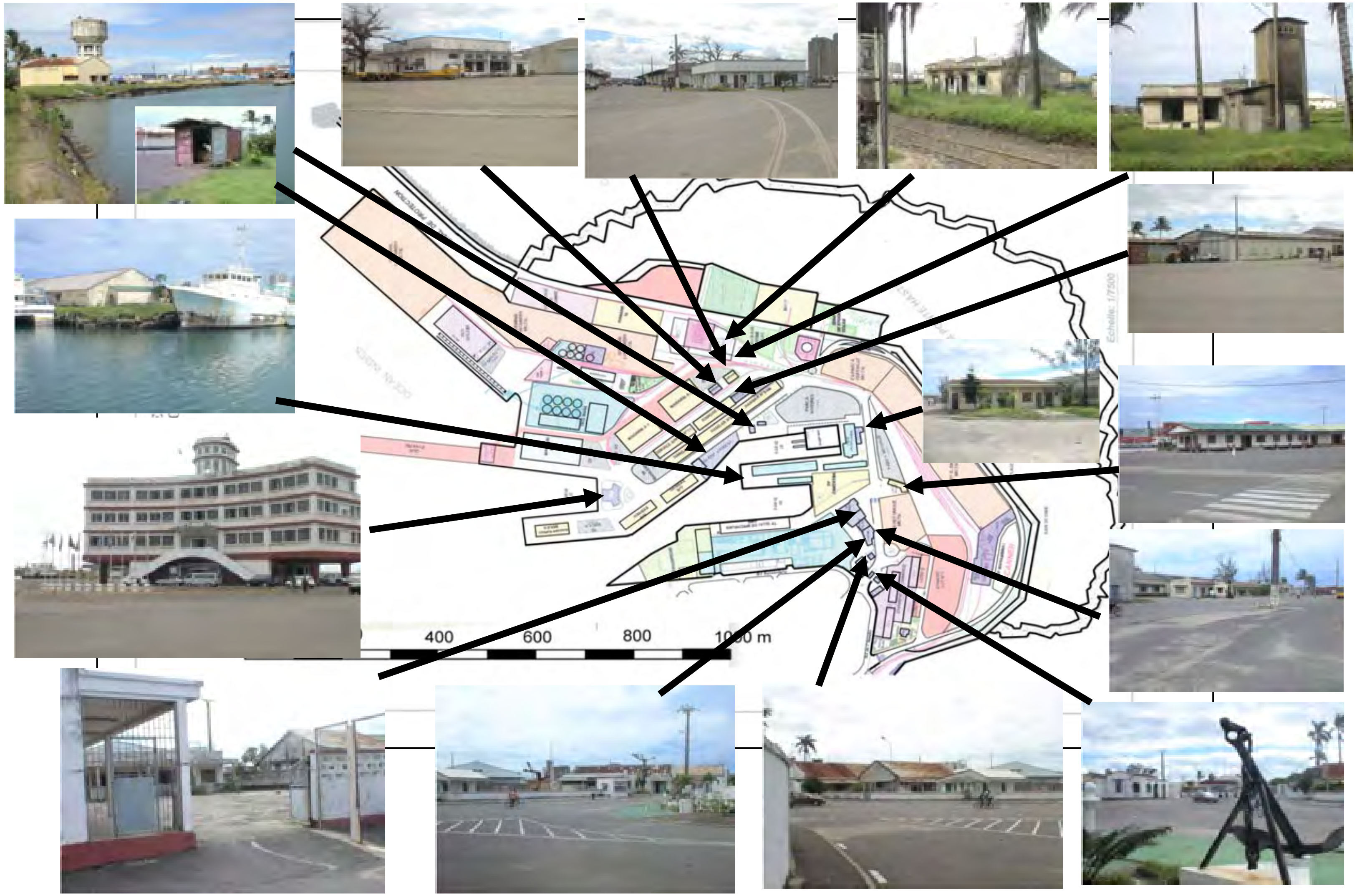
Container yards in the port area



Yard, storage and factories



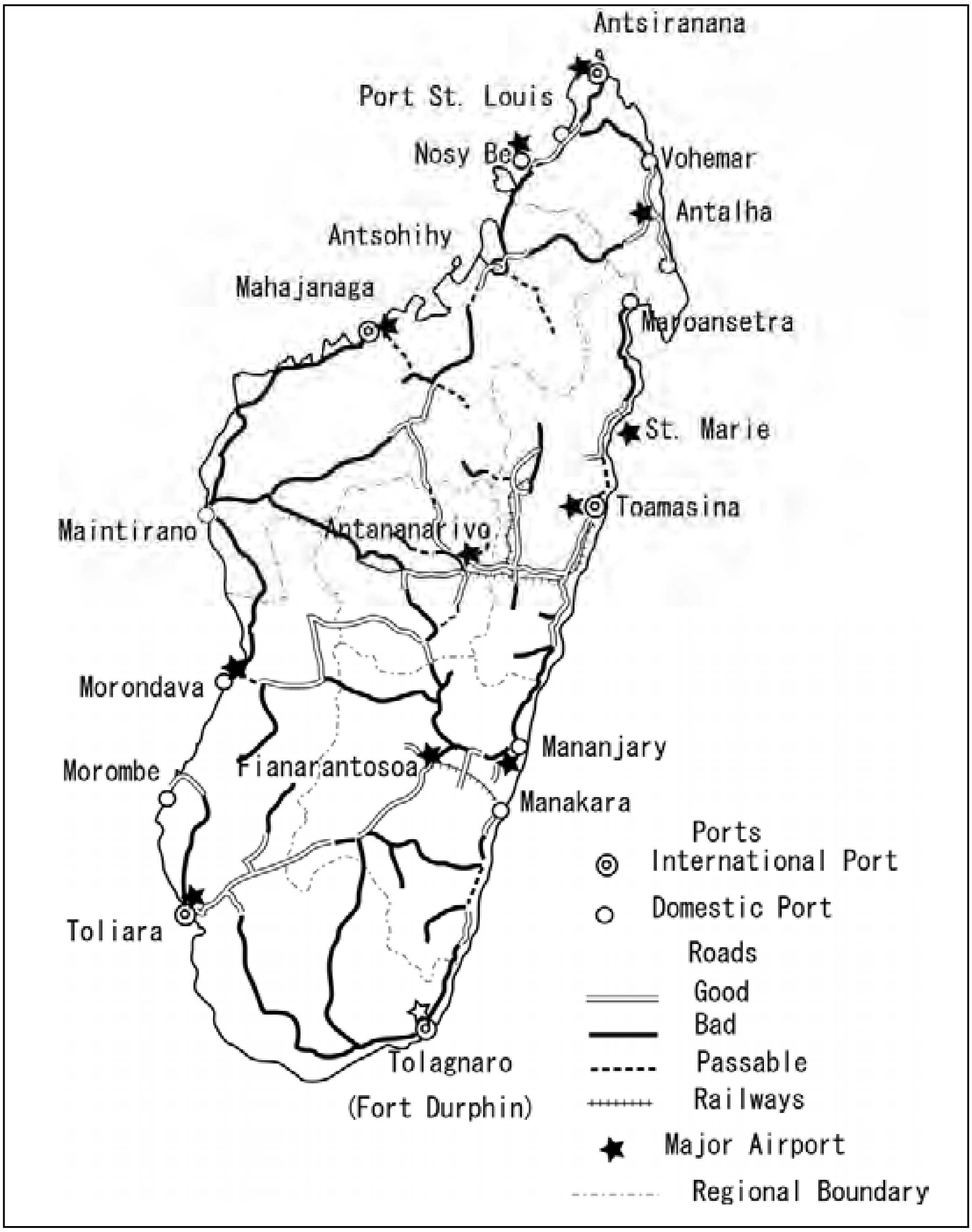
Raiways in the Port area



Office Buildings

A4-3 Transport Network of Madagascar

The existing transport Network of Madagascar is exhibited in **Fig. 1**. In the Fig. major airports, International and domestic ports, highways and railways are drawn. For the highways, the conditions are also shown.



Source: National Transport Plan, 2004, Edited by Study Team

Fig. 1 Transport Network of Madagascar

(1) Airports
There are 12 major airports. The international airport in Antananarivo is plying a role of the hub to provide regular service to major cities over the country.

(2) Railway
The railway between Antananarivo and Toamasina has been privatized, and Madarail is now operating freight trains between Antananarivo and Toamasina. Passengers trains are also operated between Toamasina and Andasibe, which is the halfway from the east coast to Antananarivo. Madarail has branch line from Andasibe to Ambatondrazaka. There is another railway line, which is state owned and providing service between Fianarantso and Manakara.

The freight trains service of Madarail are transporting containers and other general cargoes between Toamasina and Antananarivo. The travel time is about 24 hours. A train is composed of 20 wagons that carry container or general cargoes, especially, bagged cargoes. The freight service is once a day but Madarail has a plan to increase the service to three trains per day. At Antananarivo, Madarail has container depot that is operated by Madarail itself. Photo 1 shows the container freight train at the marshaling site near Toamasina Port.

Source: Study Team

Photo 1 Container Freight Train at the Marshaling Yard of Madarail

(3) Highway
As shown in Fig. 1.2.1, the road conditions are not good enough. Except the highway between Antantarivo and Toamashina, which is the busiest arterial highway, all the routs want improvement. Through an interview to an engineer of the Madagascar Highway Authority, it was found that the highways from Antatnanarivo to the northwest region covering Antsiranana, Vohemar, Mahajanaga, to the southwest region, Toliara and to the east region covering Toamasina and Manajary are good enough, while the highways going to Tolasgnaro (Fort Dauphin and the west, Morondava, Maintirano are bad and need improvement.

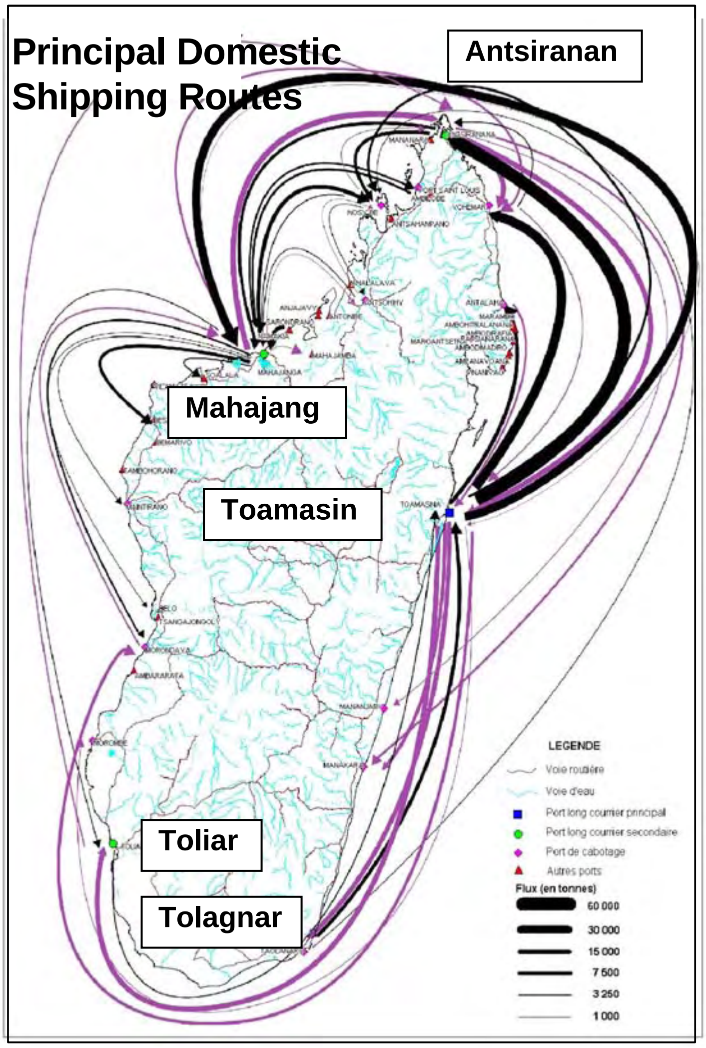
(4) Ports
Toamasina, Vohamar, Antsiranana, Nosy Be, Mahajanaga, Toliara and Tolagnaro (Fort Dauphine) Ports are called on by international ships, while other ports are serving for domestic shipping.

Of all the ports, Toamasina Port, which, of the national total volumes, currently handles about 80 % of cargoes, 75% of container cargoes, 50 % of other dry cargoes and 85% of petroleum, is playing a role of the distribution hub of the maritime transport in the country. domestic hub and considerable volumes of cargoed are transported to and from Toamashina.

Table 1 Features of ports in Madagascar

PORTS	Total Length (m)	Max. Depth (m)
ANTALAHA	68	2.8
ANTSIRANANA	418	8.5
ANTSOHIHY	185	–
MAHAJANGA	640	4.5
MAINTIRANO	66	5.0
MANAKARA	214	2.5
MANANJARY	157	1.5
MAROANTSETRA	–	–
MOROMBE	–	–
MORONDAVA	100	1.5
NOSY BE	374	5.0
PORT ST LOUIS	120	4.0
TAOLANARO	145	2.5
TOAMASINA	1020	12.0
TOLIARA	225	8.0
VOHEMAR	100	8.0

Source: National Transport Plan, 2004



Source: National Transport Plan, 2004

Fig. 2 Principal domestic shipping routes

A4-4 Port Development Policy & Plan

(1) The National Transport Plan 2004 – 2020

A study for the "National Transport Plan 2004-2020" was completed in 2004. The study covered land and maritime transportation, and, on the basis of the existing traffic analyses and the demand forecast, identified priority routes and ports for the development.

The plan proposed the development of a new deep sea port. The potential for the development of the following four ports were studied:

- Bay of Narinda ;

  The bay is located between Mahajanga and Antsiranana. The geography of the bay provides tranquil waterwrea without breakwater.
- Region of Maintirano and Region of Morondava ;

  These sites are located on the west coast between Mahajanaga and Toliara where no large ports exist. The sites are close to Antananarivo, Capital of Madagascar. A deep sea port, when it is completed in this region, would serve as the west gateway port of the country.
- Region of Manakara:

  The site is located on the east coast of Madagascar and at the intermediate point between Toamasina and Tolagonaro.Ports. The highway connecting to Antananarivo was already good.

The costs of the construction of these four ports were estimated. On the basis of the population of the hinterland and the construction cost per millions of the cargoes, the study concluded that Narinda Bay had the heist potential for the development (see Table 1.2.2..

Table 1.2.2 Cost of new deep sea ports in Madagascar

(The National Transport Plan 2004-2020)

PLAN NATIONAL DE TRANSPORT 2004-2020
COÛTS DE CONSTRUCTION DES NOUVEAUX PORTS

	Population Desservie en 2020		Potential traffic demand	Costs of construction of new ports	
	(Million hab)		in 2020		(million USD)
			(1000 t)		
		PART DE LA			Cost needed
	Population	Population		Ttotal cost	per million tons
					of traffic
	Dessservie (1)	Nationale (2)			
1. New Port in the Narinda Bay	4.8	18%	2,851	145	51
2. New Port in the Region of MAINTIRANO	1.1	4%	675	107	159
3. New Port in the Region of NARINDAMORONDAVA	4.1	16%	2,446	193	79
4. New Port in the Region of MANAKARA	7.2	27%	4,238	307	72

(1) : Population de la zone de compétitivité du port.
(2) : Population nationale estimée à 26,3 millions d'habitants en 2020.

Since the administration of the Republic of Madagascar has been changed and the of the new administration has not yet published, it is not sure whether the National Transport Plan 2004 – 2020 is remain as the policy guideline for the development of Highways and Port.. In the light of the current political situation of Madagascar, it is unlikely that the new administration will take the development of a deep sea port as one of the priority projects.

A4-5 Trucks in Toamasina City

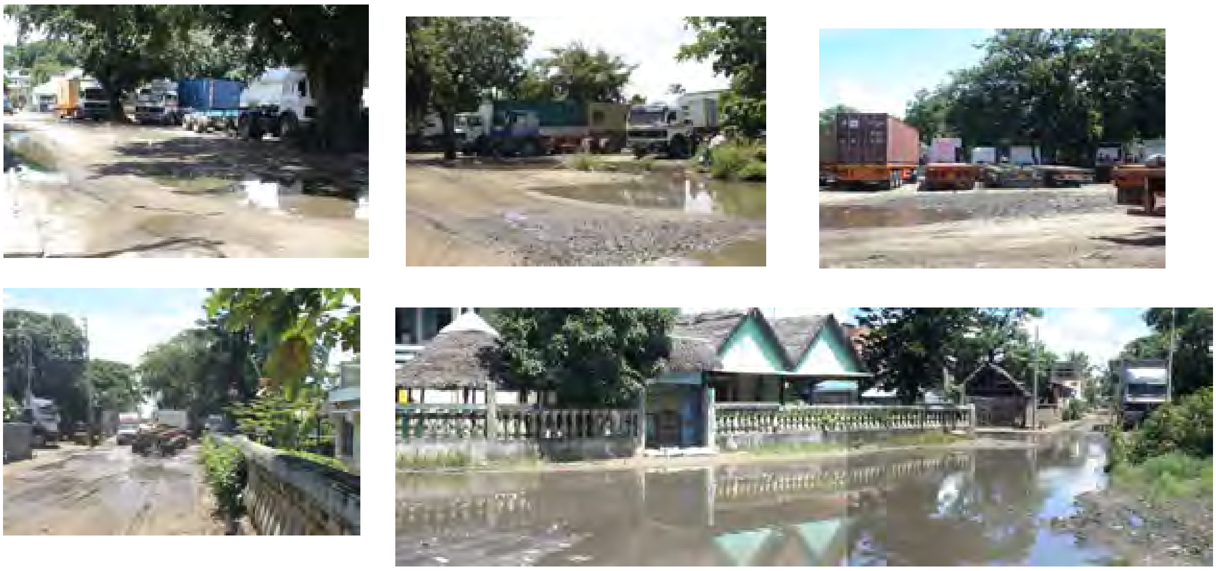
In accordance with the growth of the cargo volumes of Toamasina Port, the traffic volume of cargo trucks have been increasing. In addition to the traffic volumes along the main highways and boulevard, heavy trucks and full sided trailers are running on the narrow allies within the city area to deliver the good to private warehouses, which are located even within residential areas. In the areas close to the port, containers are handled on the streets and many trailers are parking everywhere of the city.

The passage of heavy truck has damaged all the roads in Toamasina City.

Photos 1 through 20 show the how deep the heavy trucks are intruding the city area.

Source: Study Team

Photo 1 Container depots that are occupying roads.



Source: Study Team

Photo 2 Truck parking without any facilities, which has made the road impassable except trucks

Source: Study Team

Photo 3 Trucks and trailers to and from warehouses inside residential areas

Source: Study Team

Photo 4 Parking trucks everywhere of the City

Source: Study Team

Photo 5 A full trailer is entering into an ally where those vehicles no heavier than 3.5 ton are allowed to pass

Source: Study Team

Photo 6 Damaged ally due to the traffic of heavy trucks and a bank protecting the house from the intrusion of water

It is expected that the cargo volumes at Toamasina Port will be doubles and tripled within the coming decades. Unless some actions are taken, the City of Toamasina is overwhelmed by heavy trucks**.**

Apart from the trucks, the development of railway marshaling yard out side of the port is generating another problem. The local community located other side of the railway is divided by the railway. The people living in the community are hard to cross the railway. So far the frequency of railway service has been not so much. However, once the Ambatovy is fully operational, trains will be passing this area every 15 minutes and the marshaling yard become very busy handling containers, petroleum products and general cargoes. The people of the community have to walk for long way to cross the railway. Photo 1.11.4-7 shows the present situation of the railway marshaling yard of Madarail and the people passing over a train there.

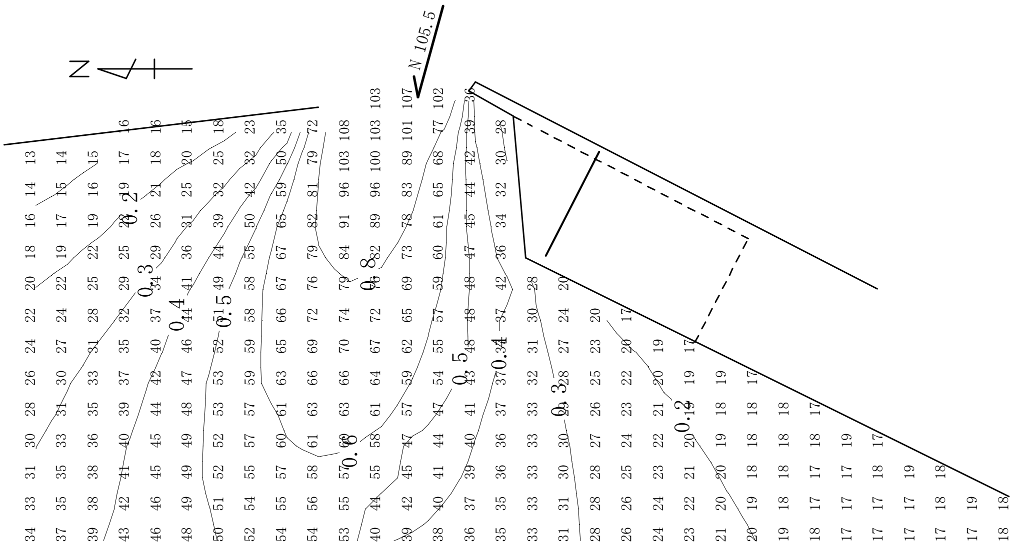
Source: Study Team

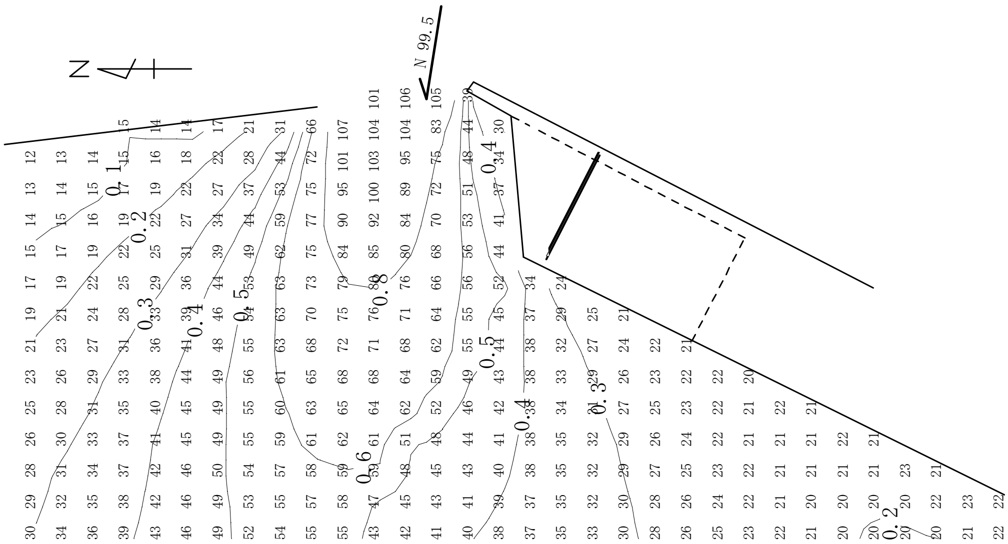
Photo 7　Situation at Madarail Marshaling yard and people crossing a train.

Appendix for Chapter 6

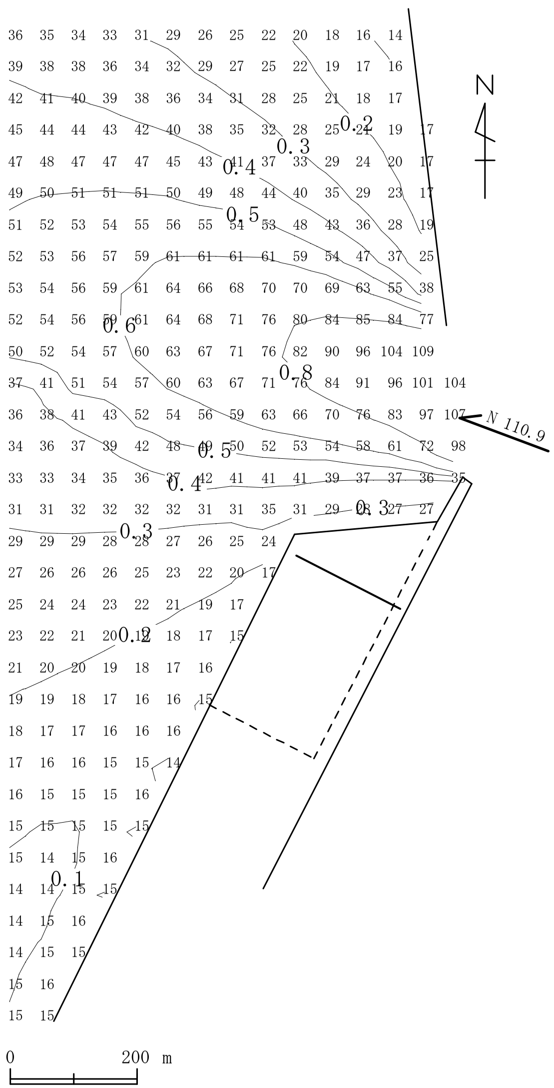
Engineering Aspects

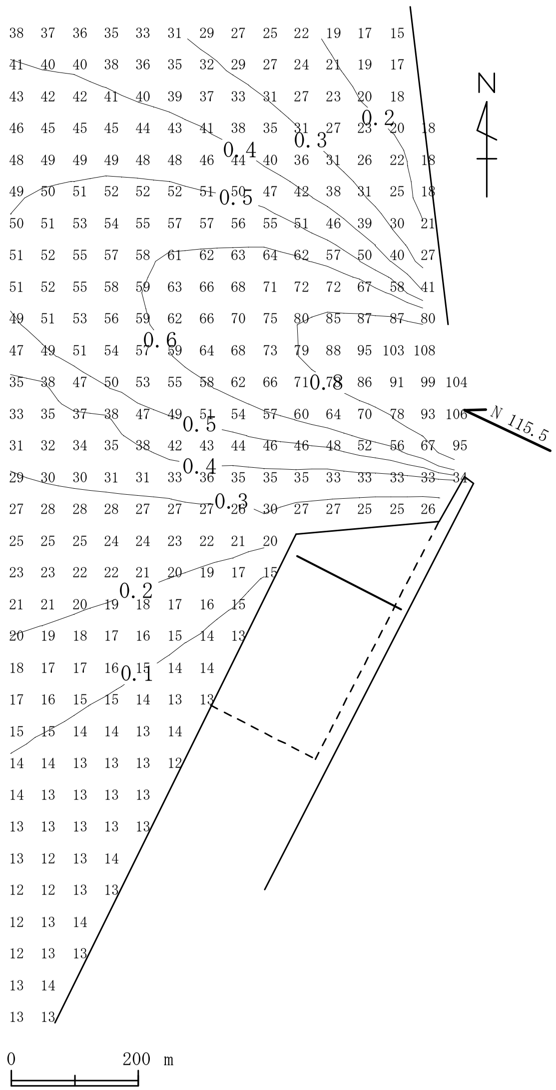
A6-1 Necessary Extension of Breakwater (Appendix for Section 6-1-2-1 (2))



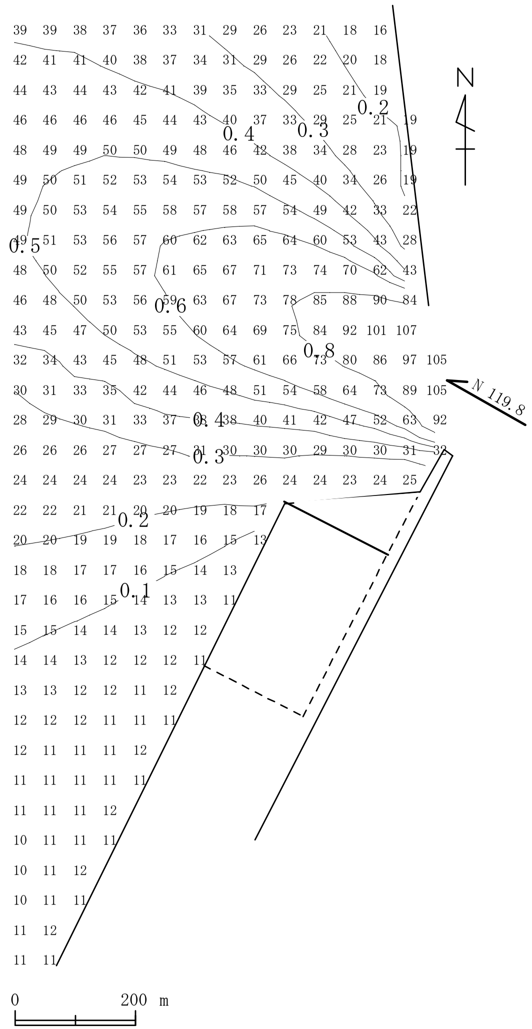


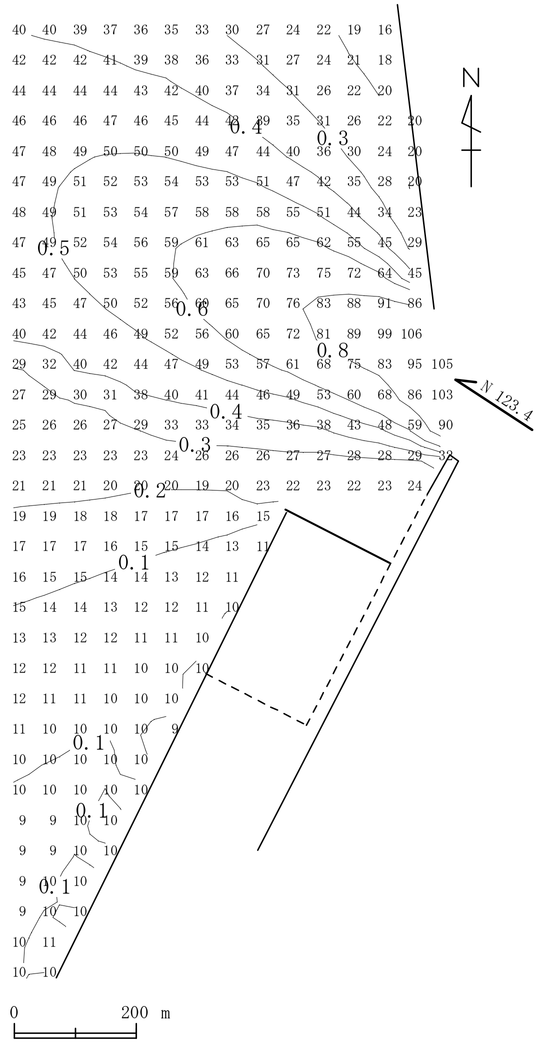
Wave Height ratio in Port (Wave direction: N99.5° & N106.6° (Section 6-1-2-1 (2))





Wave Height ratio in Port (Wave direction: N110.9°& N115.5°**(Section 6-1-2-1 (2))**





Wave Height ratio in Port (Wave direction: N119.8°& N123.4°(Section 6-1-2-1 (2))

A6-2 Input Data and Calculation Results of Analysis of Ship Waiting Time

A6-2-1 Ship Waiting Time of 2007

Table A6-2-1 shows the summary of ship arrival records of Toamasina in 2007. In the Table, ship sizes and berthing hours are indicated as the average figures of 2007.

Table A6-2-1 Summary of 2007 Ship Arrival in Toamasina Port

	Shiptype	Bulk/ General (1)	Bulk/ General (2)	Bulk/ General (3)	Container	Pass./ Ferry	Car Carrier	Tanker	Others	Total
Ship Types & Sizes	LOA(m)	60	130	150	160	110	200	130	45	
	B(m)	12	19	23	25	18	33	23	8	
	Draft(m)	3.5	8	10	10	6.2	10	9	2.5	
	DWT	1,300	10,000	20,000	20,000	3,500	20,000	20,000	-	
	Average Berthing Hrs	290.0	160.0	80.0	20.0	18.0	10.0	40.0	24.0	
Quaywalls	MOLE A WEST(AW)	49								49
	MOLE A EAST(AE)	40								40
	MOLE B WEST(BW)		35							35
	MOLE B POINT(BP)							54		54
	MOLE C1(C1)			38						38
	MOLE C2 (C2)				113	12	11			136
	MOLE C3 (C3)				114	12	11			137
	Other Small Craft Quays								832	832
	Total Shipcalls	89	35	38	227	24	22	54	832	1,321

(source: SPAT and OCDI ships database)

In accordance with the port regulation of Toamasina, the port operation runs 24 hours except that fuel tankers can enter into or depart from the port only in daytime. Speed limit in channel and basin is 5 knots. 1,500 MT or more sized vessels require port pilot on board to sail inside the port. From these conditions, it is clear that smaller crafts do not influence to the ship waiting hours because they can sail at any time. In the model, ships average speed is assumed at 3 knots considering the speed limit and reducing speed during their berthing and de-berthing. Input assumptions and the result of reproduction 2007 ship arrival records by the model are shown below.

Input Assumptions:

- Ship average speed is assumed at 3 knot.
- Ship waiting point is north offshore of the port near the channel mouth.
- Channel is one way pass.
- Small crafts can pass the channel using shallower rout during large vessel is passing the channel.
- Large vessels over 1,500 MT can pass the channel one by one.
- Tankers can pass the channel during daytime only.
- Bulk/general cargo vessels arrive at port in random frequency.
- Container cargo vessels arrive at port in equal frequency.
- Passenger ships or ferries come to port during tourism season, i.e., October – March, in equal frequency.
- Car carriers arrive at port in equal frequency.
- Operation days in a year are assumed at 309 days.

Table A6-2-2 Calculation Results of Ship Waiting Time for Reproduction of 2007 Ship Arrival Record in Toamasina Port

	Ship Waiting Time (days)	
	Max	Average
Bulk/General (1)	5.67	0.15
Bulk/General (2)	0.03	0.00
Bulk/General (3)	0.05	0.00
Container	0.04	0.01
Pass./Ferry	1.32	0.04
Car Carrier	1.41	0.02
Tanker	0.78	0.22
Others	1.16	0.32

Table A6-2-3 Calculation Results of Berth Occupancy Rate for Reproduction of 2007 Ship Arrival Record in Toamasina Port

	Berth Occupancy Rate (%)
MOLE A WEST(AW)	45.7
MOLE A EAST(AE)	37.4
MOLE B WEST(BW)	24.4
MOLE B POINT(BP)	28.0
MOLE C1(C1)	39.3
MOLE C2 (C2)	33.5
MOLE C3 (C3)	33.7

From calculation result, followings are read which express present ship waiting and berth occupancy conditions very well.

- Average ship waiting time for Container Ships is calculated 0.01 days, which expresses present condition that there are few waiting for container vessels.
- Berth Occupancy rate for Mole C2 and C3 is calculated 34%, which express present condition that real occupancy is nearly 30%.

A6-2-2 Future Ship Waiting Time

(1) The Case of the Project not Executed (Without Project Case)

In accordance with the result of demand forecast, growth ratio of container, bulk/general cargo and liquid cargo are 10%, 3% and 2% respectively.

If container traffic will be increased at 10% growth ratio, its throughput will be 426,000TEU in 2020. On the other hand, the capacity of port terminal is limited to approximately 200,000TEU due to limited space of existing container marshalling yard. In this report, it is assumed that the surplus container traffics over 200,000 TEU will be transported by smaller ships who has 500 TEU loading capacity so that shallower Mole A and B should be also used for their handling. These smaller ships are assumed to be shuttled between Toamasina and Port Louis using the service of transshipment at Port Louis. Details of these assumptions are discussed in the Chapter of Economic Analysis.

Table A6-2-4 shows the input data of the case of the project not executed (Without Project Case). Input assumptions are as follows.

- Bulk / general cargo vessels will increase at 3% growth ratio as mentioned in demand forecast.
- Container vessels will increase at 10% growth ratio. In 2012~2013, container throughput of the port will reach the maximum capacity 200,000. Further containers will be carried by smaller vessels and loaded or unloaded at any available quay-walls.
- Smaller vessels will handle containers by own ship gears. Average number of container boxes handled in one ship-call is assumed 500 TEUs. Average berthing time of these vessels is assumed 60 hours, i.e., handling speed is about 8 boxes per hour.
- Passenger ships, ferries and car carriers will remain same frequency in future. The forecast of these vessels are neglected in this report but this may give conservative results for container vessels' waiting time.
- Oil tankers will increase at 2% growth rate as mentioned in demand forecast. Tankers will use new jetty under construction as of 2009, which can accommodate larger tankers. Average ship size is assumed 30,000 DWT, thus ship-calls will reduce approximately 30%.
- Bulk carriers for on-going new projects, i.e., Ambatovy Project and Oji Paper Project are considered as additional ship-calls.
- Other small crafts will remain the same frequency, which has little influence to ship waiting time of container vessels.
- Operation days in a year are assumed at 309 days.

Table A6-2-4 Forecast of Ship Arrivals in 2020 for Without Project Case

	Shiptype	Bulk/ General (1)	Bulk/ General (2)	Bulk/ General (3)	Container	Container Small Vessels	Pass./ Ferry	Car Carrier	Tanker	Bulk Ambatovy	Bulk Oji Paper	Others	Total
Ship Types & Sizes	LOA(m)	60	130	150	160	100	110	200	130	210	210	45	
	B(m)	12	19	23	25	18	18	33	23	30	30	8	
	Draft(m)	3.5	8	10	10	6	6.2	10	9	12	12	2.5	
	DWT	1,300	10,000	20,000	20,000	5,000	3,500	20,000	20,000	48,000	50,000	-	
	Average Berthing Hrs	290.0	160.0	80.0	20.0	60.0	18.0	10.0	40.0	71.0	120.0	24.0	
Quaywalls	MOLE A WEST(AW)	44				134							178
	MOLE A EAST(AE)	44				134							178
	MOLE B WEST(BW)	43	36			10							89
	MOLE B WEST(New Berth)		12	24		40							76
	MOLE B EAST (Ambatovy)									71			71
	MOLE B New Oil Jetty								50				50
	MOLE C1(C1)			24		44					5		73
	MOLE C2 (C2)				200	44	12	11					267
	MOLE C3 (C3)				200	44	12	11					267
	Other Small Craft Quays											832	832
	Total Shipcalls	131	48	48	400	450	24	22	50	71	5	832	2,081

Table A6-2-5 and **A6-2-6** shows the calculation result. It shows that bulk cargo will suffer 0.82~3.65 days waiting time. Container vessels will have to wait 3.38 days in average. Berth occupancy of Mole C2 and C3 is forecasted 90% for the case.

Table A6-2-5 Calculation Results of Ship Waiting Time in 2020 for Without Project Case

	Ship Waiting Time (days)	
	Max	Average
Bulk/General (1)	17.60	2.09
Bulk/General (2)	18.11	3.65
Bulk/General (3)	5.50	0.82
Container	7.68	3.38
Container Small Vessel	14.48	1.28
Pass./Ferry	5.04	2.41
Car Carrier	5.51	2.63
Tanker	0.07	0.01
Bulk Ambatovy	0.09	0.00
Bulk Oji Paper	3.67	1.18
Others	1.13	0.02

Table A6-2-6 Calculation Results of Berth Occupancy Rate in 2020 for Without Project Case

	Berth Occupancy Rate (%)
MOLE A WEST(AW)	67.3
MOLE A EAST(AE)	66.6
MOLE B WEST(BW)	82.1
MOLE B WEST(New Berth)	80.6
MOLE B EAST (Ambatovy)	64.8
MOLE B New Oil Jetty	25.5
MOLE C1(C1)	66.3
MOLE C2 (C2)	89.6
MOLE C3 (C3)	89.7

(2) The Case of the Project Executed – One Lane Traffic (With Project Case)

Table A6-2-7 shows the input data of With Project Case. Input assumptions are as follows.

- Bulk / general cargo vessels will increase at 3% growth ratio as mentioned in demand forecast.
- Container vessels will increase at 10% growth ratio. Ship sizes will be increased at maximum 4,000 TEU (60,000DWT), and average 3,000 TEU (50,000DWT).
- Passenger ships, ferries and car carriers will remain same frequency in future. The forecast of these vessels are neglected in this report but this may give conservative results for container vessels' waiting time.
- Oil tankers will increase at 2% growth rate as mentioned in demand forecast. Tankers will use new jetty under construction as of 2009, which can accommodate larger tankers. Average ship size is assumed 30,000 DWT, thus ship-calls will reduce approximately 30%.
- Bulk carriers for on-going new projects, i.e., Ambatovy Project and Oji Paper Project are considered as additional ship-calls.
- Other small crafts will remain the same frequency, which has little influence to ship waiting time of container vessels.
- Operation days in a year are assumed at 345 days.

Table A6-2-7 Forecast of Ship Arrivals in 2020 for With Project Case

	Shiptype	Bulk/ General (1)	Bulk/ General (2)	Bulk/ General (3)	Container	Pass./ Ferry	Car Carrier	Tanker	Bulk Ambatovy	Bulk Oji Paper	Others	Total
Ship Types & Sizes	LOA(m)	60	130	150	290	110	200	130	210	210	45	
	B(m)	12	19	23	32	18	33	23	30	30	8	
	Draft(m)	3.5	8	10	13.5	6.2	10	9	12	12	2.5	
	DWT	1,300	10,000	20,000	50,000	3,500	20,000	20,000	48,000	50,000	-	
	Average Berthing Hrs	290.0	160.0	80.0	20.0	18.0	10.0	40.0	71.0	120.0	24.0	
Quaywalls	MOLE A WEST(AW)	47										47
	MOLE A EAST(AE)	47										47
	MOLE B WEST(BW)	37	36									73
	MOLE B WEST(New Berth)		12	16								28
	MOLE B EAST (Ambatovy)								71			71
	MOLE B New Oil Jetty							50				50
	MOLE C1(C1)			16						5		21
	MOLE C2 (C2)			16		12	11					39
	MOLE C3 (C3)				150	12	11					173
	MOLE C4 (C4)				150							150
	Other Small Craft Quays										832	832
	Total Shipcalls	131	48	48	300	24	22	50	71	5	832	1,531

Table A6-2-8 and **A6-2-9** shows the result of calculation. All vessels are distributed to the adequet berths and significant ship waiting is not observed. Average container vessels waiting time is estimated at 0.01 days from the result.

Table A6-2-8 Calculation Results of Ship Waiting Time in 2020 for With Project Case

	Ship Waiting Time (days)	
	Max	Average
Bulk/General (1)	7.78	0.49
Bulk/General (2)	11.44	0.55
Bulk/General (3)	4.32	0.36
Container	1.03	0.01
Pass./Ferry	0.95	0.21
Car Carrier	1.61	0.43
Tanker	0.13	0.01
Bulk Ambatovy	0.17	0.00
Bulk Oji Paper	2.20	0.46
Others	1.04	0.01

Table A6-2-9 Calculation Results of Berth Occupancy Rate in 2020 for With Project Case

	Berth Occupancy Rate (%)
MOLE A WEST(AW)	39.6
MOLE A EAST(AE)	39.6
MOLE B WEST(BW)	62.8
MOLE B WEST(New Berth)	37.2
MOLE B EAST (Ambatovy)	58.4
MOLE B New Oil Jetty	23.2
MOLE C1(C1)	21.6
MOLE C2 (C2)	18.5
MOLE C3 (C3)	38.5
MOLE C4 (C4)	34.6

(3) The Case of the Project Executed – Two Lanes Traffic (With Project Case)

At present, Toamasina port has 1-lane approach channel. For future, the case of 2-way traffic channel was analyzed. **Table A6-2-10** shows the input data of With Project Case (2-lane channel). The same input conditions of “(2) The Case of the Project Executed – One Lane Traffic” are applied to compare the effect of the change in channel.

Table A6-2-10 Forecast of Ship Arrivals in 2020 for With Project Case (2-Lane Channel)

	Shiptype	Bulk/ General (1)	Bulk/ General (2)	Bulk/ General (3)	Container	Pass./ Ferry	Car Carrier	Tanker	Bulk Ambatovy	Bulk Oji Paper	Others	Total
Ship Types & Sizes	LOA(m)	60	130	150	290	110	200	130	210	210	45	
	B(m)	12	19	23	32	18	33	23	30	30	8	
	Draft(m)	3.5	8	10	13.5	6.2	10	9	12	12	2.5	
	DWT	1,300	10,000	20,000	50,000	3,500	20,000	20,000	48,000	50,000	-	
	Average Berthing Hrs	290.0	160.0	80.0	20.0	18.0	10.0	40.0	71.0	120.0	24.0	
Quaywalls	MOLE A WEST(AW)	47										47
	MOLE A EAST(AE)	47										47
	MOLE B WEST(BW)	37	36									73
	MOLE B WEST(New Berth)		12	16								28
	MOLE B EAST (Ambatovy)								71			71
	MOLE B New Oil Jetty							50				50
	MOLE C1(C1)			16						5		21
	MOLE C2 (C2)			16		12	11					39
	MOLE C3 (C3)				150	12	11					173
	MOLE C4 (C4)				150							150
	Other Small Craft Quays										832	832
Total Shipcalls		131	48	48	300	24	22	50	71	5	832	1,531

Table A6-2-11 and **A6-2-12** shows the result of the calculation. From the result, 2-lane channel will give little effect on ship waiting time because the waiting time will be mainly governed by berth availability for the case of Taomasina port. However, more than 800 small ships are running without pilotage in Toamasina, which does not reflect on the ship waiting time calculation. These traffic might cause the danger in accident for the larger vessels in channel. Therefore it is said that 2-lane channel will be effective for safe port navigations.

Table A6-2-11 Calculation Results of Ship Waiting Time in 2020 for With Project Case (2-Lane Channel)

	Ship Waiting Time (days)	
	Max	Average
Bulk/General (1)	9.26	0.51
Bulk/General (2)	11.36	0.55
Bulk/General (3)	4.26	0.33
Container	0.94	0.01
Pass./Ferry	0.91	0.19
Car Carrier	1.55	0.40
Tanker	0.00	0.00
Bulk Ambatovy	0.00	0.00
Bulk Oji Paper	2.20	0.44
Others	1.04	0.01

Table A6-2-12 Calculation Results of Berth Occupancy Rate in 2020 for With Project Case (2-Lane Channel)

	Berth Occupancy Rate (%)
MOLE A WEST(AW)	39.6
MOLE A EAST(AE)	39.6
MOLE B WEST(BW)	62.9
MOLE B WEST(New Berth)	34.6
MOLE B EAST (Ambatovy)	58.4
MOLE B New Oil Jetty	23.1
MOLE C1(C1)	21.7
MOLE C2 (C2)	18.5
MOLE C3 (C3)	38.5
MOLE C4 (C4)	34.6