MARINE TRAFFIC RISK ASSESSMENT FOR HONG KONG WATERS
(MARA STUDY)

Report Summary

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1   INTRODUCTION

1.1   Background

1.1.1   The "MARAD Strategy Study" completed in 1997 outlined a blueprint for the future usage of Hong Kong waters and forecast marine risks, based on the planning framework at that time. However, since its completion many changes in the Hong Kong Special Administrative Region (HKSAR) planning context have occurred and increasing cross-boundary links and Mainland port development are rapidly reshaping the local marine risk environment.

1.1.2   To readdress the future marine risks implicit in these developments, the Marine Department (MD) has commissioned BMT Asia Pacific Ltd. (BMT) to conduct the "*Study on Marine Traffic Risk Assessment for Hong Kong Waters*", the "MARA Study".

1.1.3   The Study Area is shown in Figure 1.1.

Figure 1.1 Study Area, HKSAR Waters

1.2 Study Objectives

1.2.1 The overall goal of the MARA Study was to assist MD in the planning and regulation of marine traffic activities in the Hong Kong waters. Specifically, the objectives of the MARA Study were to:

- Conduct a comprehensive analysis of marine traffic activities (2003) within HKSAR waters by capturing the latest traffic activity via field surveys;

- Develop a marine traffic risk assessment simulation model;

- Establish the existing Baseline (2003) and future marine traffic risk levels for the Benchmark years 2006 & 2011, and

- Assess the adequacy and efficiency of the existing mitigation and control systems, and develop supplementary measures to tackle the risks, if required.

1.3 Study Organisation

1.3.1 The Study was commissioned by the Marine Department in May 2003, directed by a Steering Group and co-ordinated by a Working Group. Technical Papers were produced throughout the Study, documenting the findings at each stage, these were examined within the Working Group and reviewed by the Steering Group. Papers summarizing the progress and findings of the Study were presented at the Provisional Local Vessel Advisory Committee (PLVAC), Pilotage Advisory Committee (PAC) and Port Operations Committee (POC).

1.4 Report Structure

1.4.1 This Executive Summary summarises the key tasks, results and recommendations of the MARA Study, and is structured in the following manner:

Chapter 2: Study approach and key tasks

Chapter 3: Phase I - Comprehensive Assessment of Traffic Activity

Chapter 4: Phase II - The Marine Traffic Model

Chapter 5: Phase III - Development and testing of risk control measures, and

Chapter 6: Summary and Conclusions of the Study

2   STUDY APPROACH AND KEY TASKS

2.1   Introduction

2.1.1   The MARA Study has adopted the Formal Safety Assessment methodology for the assessment of risks and control mechanisms. This methodology has five principal steps:

(1)   *Identification of Hazards* (What is the distribution of hazards?);

(2)   *Assessment of Risk* (How bad and how likely is the risk and hazard to life?);

(3)   *Risk Control Options* (How can matters be improved?);

(4)   *Cost Benefit Assessment* (What would be the likely cost/improvement?), and

(5)   *Recommendations* (What actions should be taken?).

2.2   Study Process

2.2.1   The Study process was divided into three main phases, as illustrated in Figures 2.1 & 2.2:

Phase I –   Comprehensive assessment of present/future traffic activity;

Phase II –   Development and application of marine traffic risk assessment model to map present and future risk levels, and

Phase III –   Review, development and testing of available risk control measures to improve key conflict areas.

Figure 2.1 Phase I – Data Collection
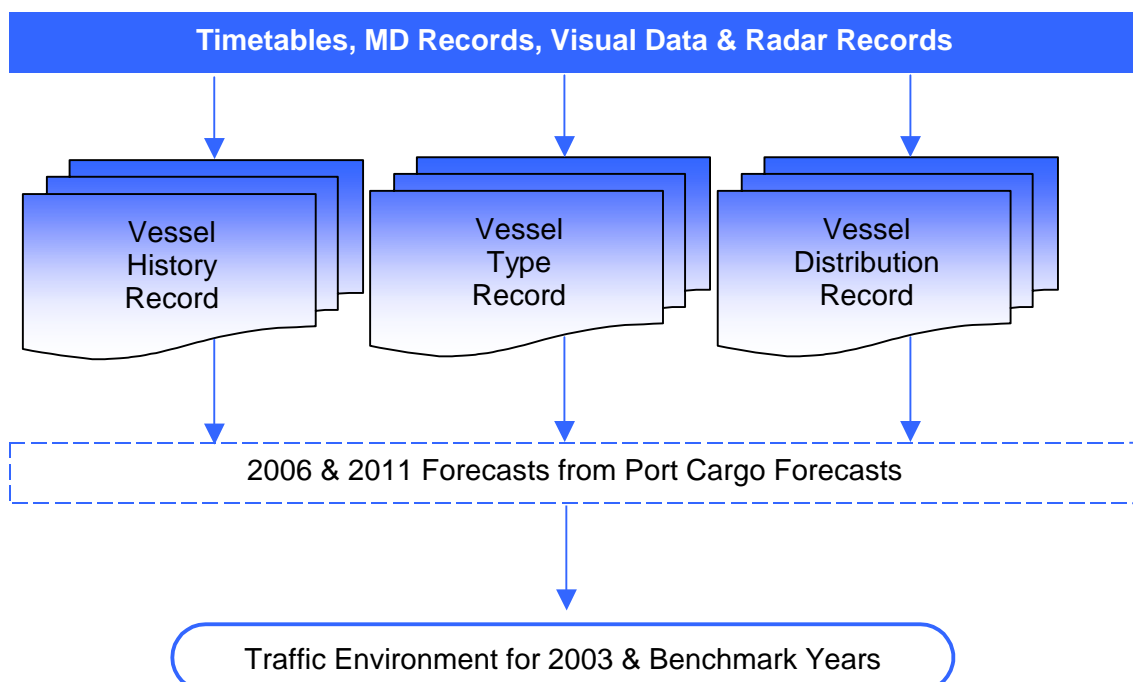
Figure 2.2 Phase II & III – Risk Forecasting & Mitigation Options

Phase II

Phase III

Route Mapping & Vessel Activity

Decision Making and Recommendations

Marine Traffic Model ← Refine the Model

2003 Baseline Validation

Model Accuracy NOT Acceptable

Model Accuracy Acceptable

2006 and 2011 Benchmark

Risk Control

Scenario testing of risk management options

Adopt for Risk Assessment

Is the risk acceptable? — *No* →

Yes

Cost-Benefit
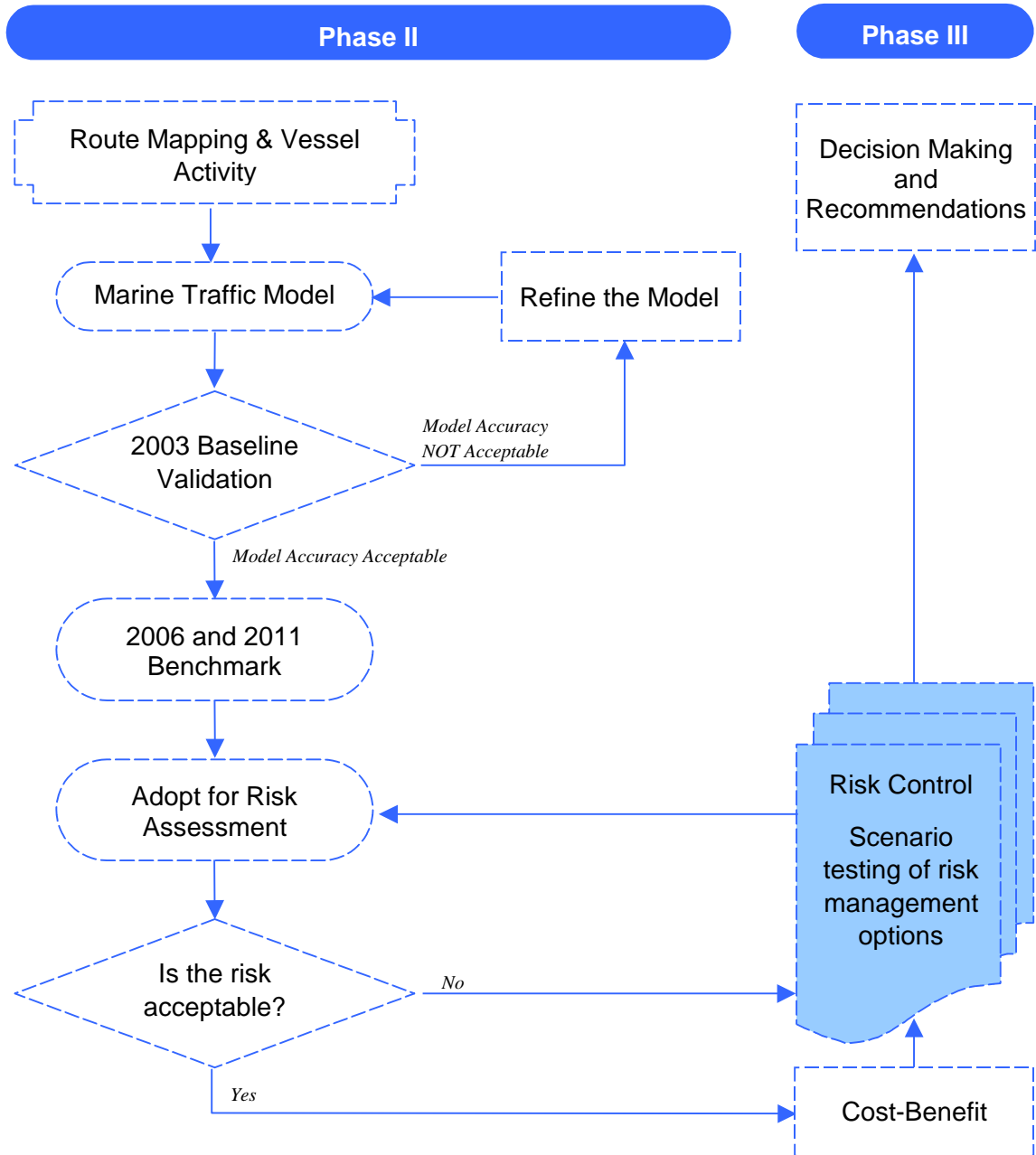
3   PHASE I – COMPREHENSIVE ASSESSMENT OF TRAFFIC ACTIVITY

3.1   Introduction

3.1.1   This section describes the scope of the survey activity undertaken within the MARA Study.

3.2   Baseline Marine Traffic Activity

3.2.1   The goal of the traffic activity survey was to develop a comprehensive representation of marine traffic in HKSAR waters by blending a variety of data, as illustrated in Table 3.1:

Table 3.1 Available Vessel Data Sources

Data Source	History	Path	Type
Timetabled schedules	Yes	No	Yes
MD vessel arrival/departure records	Yes	No	Yes
Digital capture from MD radars	Yes	Yes	Yes (from size)
Visual surveys	Yes	No	Yes

Timetabled Schedules

3.2.2   Figure 3.1 identifies the hourly activity of scheduled services in HKSAR waters, most frequently associated with ferry operations.

*Figure 3.1 Hourly Traffic Pattern of Scheduled Ferry Services*
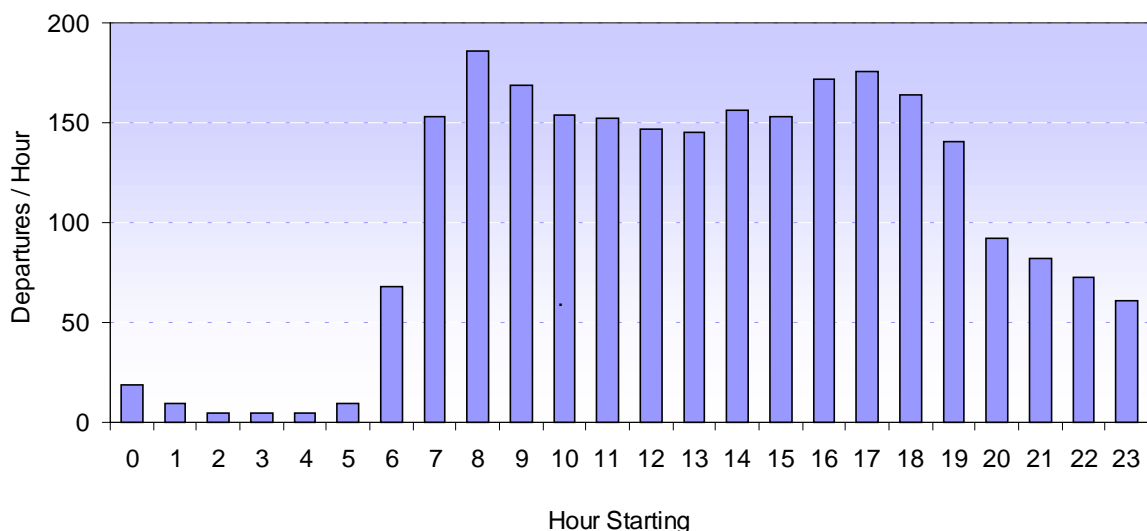
3.2.3   Two peaks of the ferry activities can be identified at around 08:00 and 17:00 respectively. In general most of the ferry activity is condensed between the periods from 07:00 – 19:00. Very limited ferry services are provided between 00:00 - 06:00.

3.2.4   MD's database of the arrival/departure data of Ocean-going and Rivertrade vessel activity for 2001 & 2002 was examined to identify short and long-term traffic patterns. The average hourly arrival and departure patterns of the Ocean-going vessels are illustrated in Figure 3.2:

Figure 3.2   *Average Hourly Distribution of Ocean-going Vessel Arrivals/Departures*
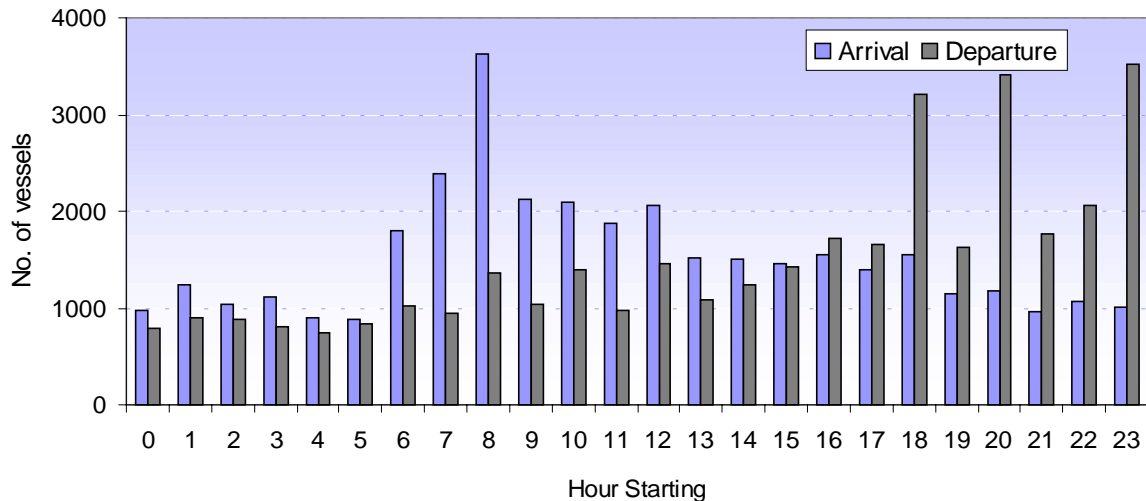
3.2.5   The peak vessel arrival period is from 06:00 to 12:00; the high departure activity within hours starting 18:00, 20:00 and 23:00 may be a function of reporting.

3.2.6   The average monthly arrival and departure patterns of Ocean-going vessels are illustrated in Figure 3.3:

Figure 3.3   *Average Monthly Distribution of Ocean-going Vessel Arrivals/Departures*
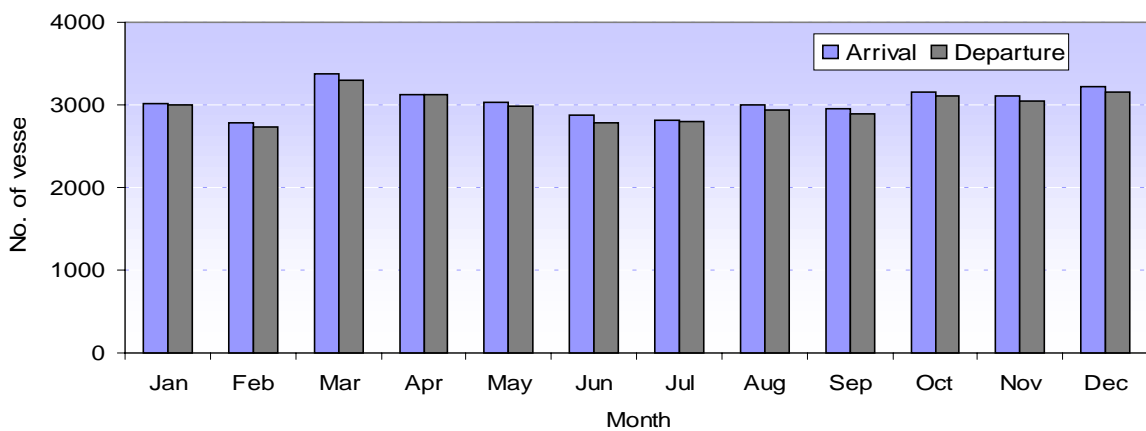
3.2.7   It can be identified that the arrival and departure frequency during June, July, and August, the key months of MARA Study survey activity, has a rate of approximately 96% annual average levels.


Digital Capture from Marine Department Radars

3.2.8   A significant survey resource was made available with the recent upgrade of MD's radar system to a digital format. This data potentially held the exact timing, position, speed, heading, length and beam of all vessels within HKSAR waters. BMT collected and analysed the digital vessel data over a 12-day period. The data was sampled on the following basis:

- Minimum route length 5,000m, and
- At least one vessel per day on each route, except Ocean-going vessels for which all routes with frequency greater than 0.2 per day, and some specific routes, were selected.

3.2.9   Figure 3.4 illustrates the centreline of 1,000 routes initially identified from this analysis:

Figure 3.4   Centrelines from Initial Track Analysis
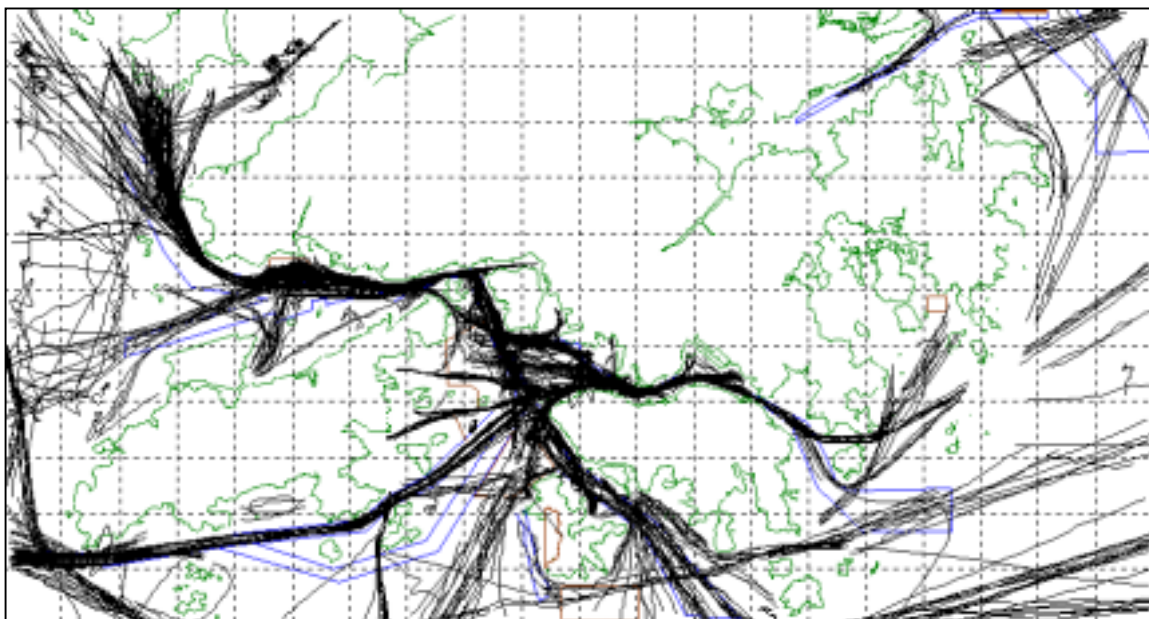
3.2.10   These routes were then sorted to establish:

- Which routes could be consolidated into a single route;
- Which routes crossed radar shadows and could be joined together, and
- Which routes could be discarded without compromising the integrity of the model.

3.2.11   Following this exercise 545 routes were retained within the model.

Visual Data

3.2.12   It was recognised that the deletion of shorter route elements had stripped significant traffic from the model. In order to ensure that the traffic levels within the model were consistent with HKSAR waters activity a widescale visual survey was conducted. Eight sites were selected for the installation of CCTV cameras; the sites and directions of the survey are illustrated in Figure 3.5:

Figure 3.5   Visual Survey Sites
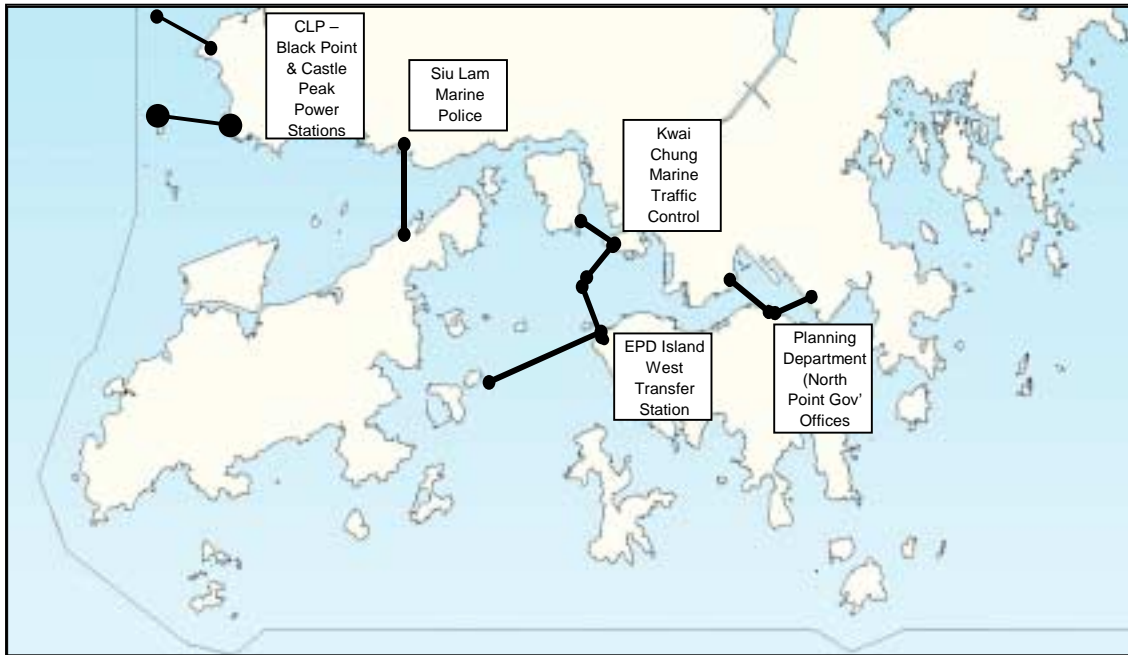
3.2.13   24 days of surveys between June – September was undertaken. Vessels identified in the surveys were categorised into twelve classes for the purposes of analysis, Figure 3.6 illustrates a summary of all activity recorded (distribution of vessel classes) during the visual surveys.

Figure 3.6   Distributions of Vessel Classes
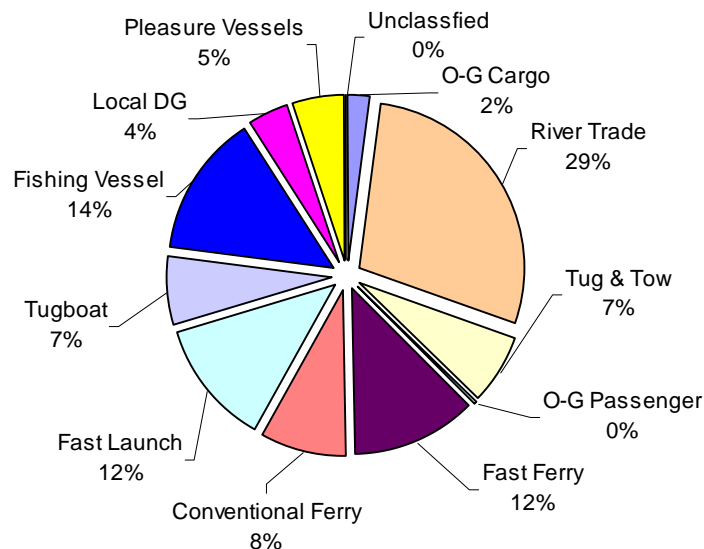
Note: O-G Passenger 0.28%, Unclassified – 0.05%

3.2.14   Following the traffic surveys vessel activity on the routes identified from the radar data was factored, based on the comparative gate and class volumes. Figure 3.7 illustrates a representation of the factored model traffic versus survey data for the gate at Siu Lam.

Figure 3.7 Comparison of MARA Model with Visual Survey at Siu Lam
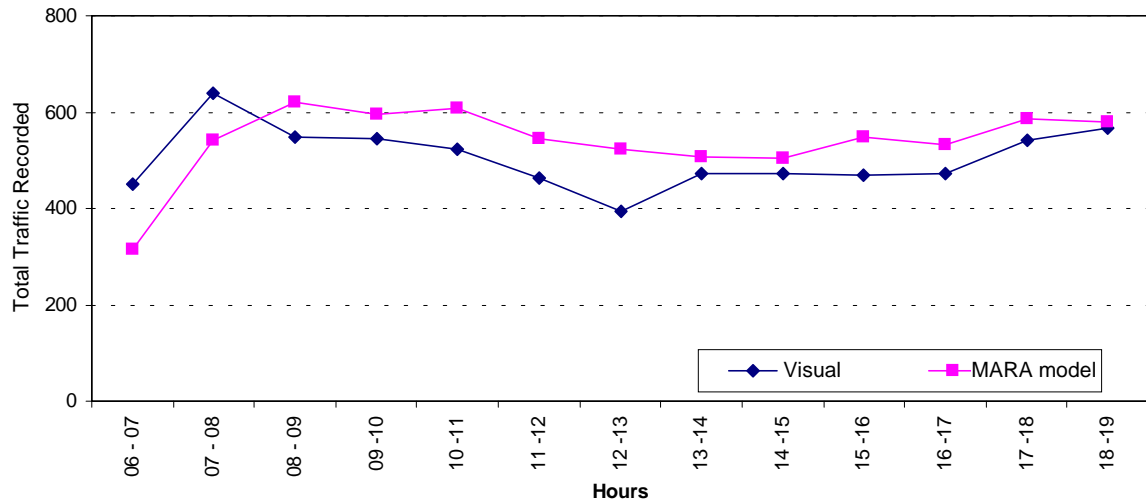
3.2.15   In general the MARA model maps the surveyed data well and slightly over-represents the traffic by approximately 5 – 6 % at each gate. This correlation was considered acceptable in the light of the annual patterns identified in Figure 3.3. Figure 3.8 summarises the consolidated traffic activity mapped within the MARA model for 2003.

Figure 3.8 Baseline Traffic Activity within MARA Model
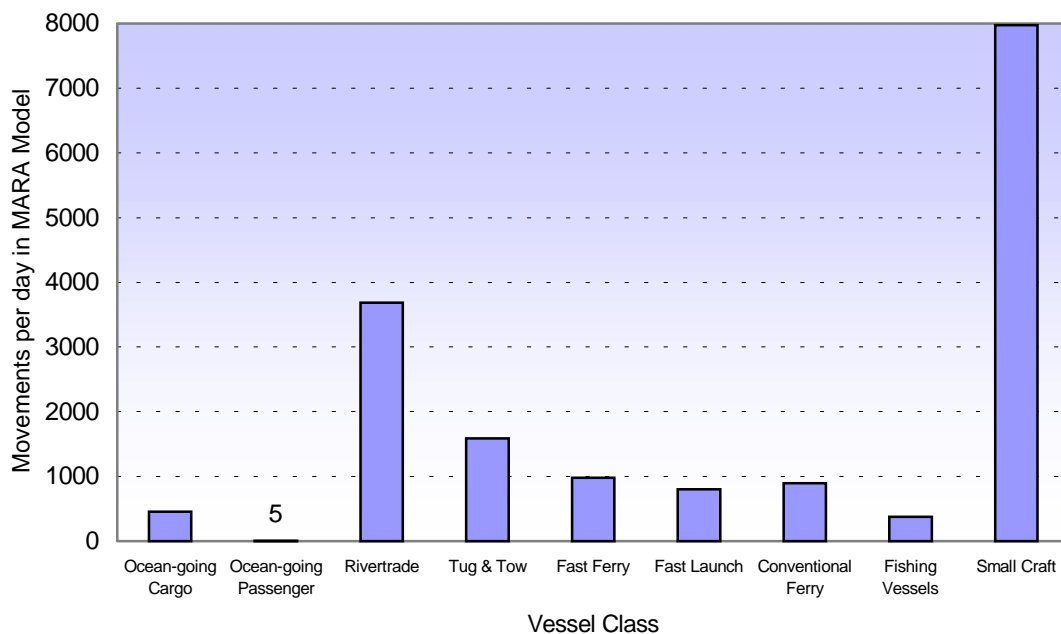
3.3   Baseline Hazards

3.3.1   The average annual distribution of all reported marine incidents, (developed from data for 2001 to 2003), is shown in Figure 3.9. Incidents are concentrated at Yau Ma Tei, South West of Tsing Yi Island, the Western Harbour and Tuen Mun.

Figure 3.9   Average Annual Incident Distribution (2001 - 2003)
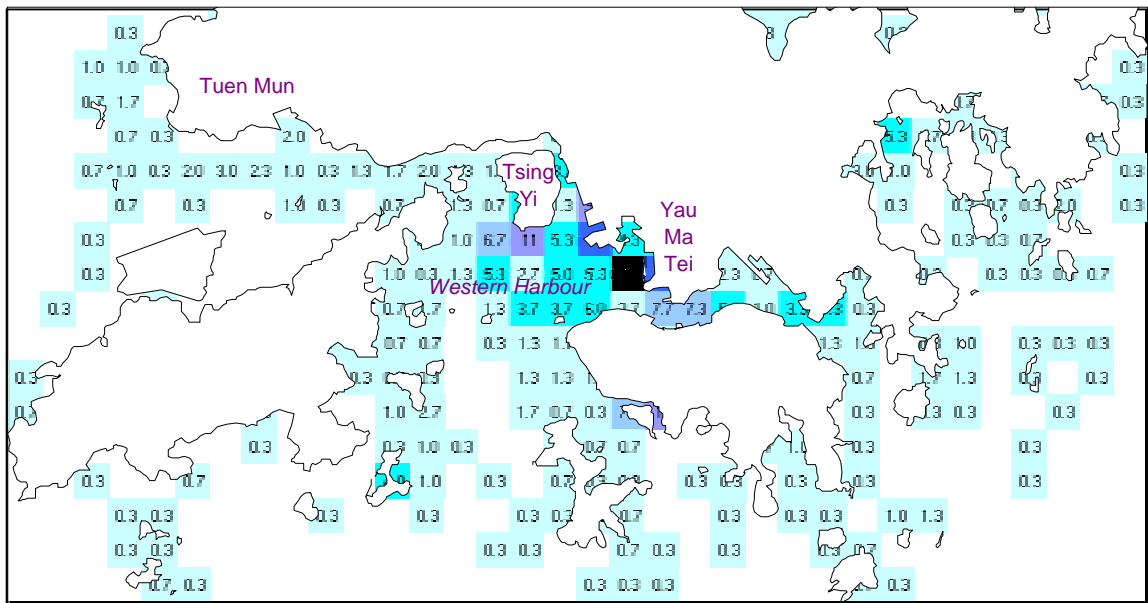
3.3.2   Figure 3.10 illustrates the distribution of incident types. It can be noted that almost 70% of all accident recorded were collisions or contacts, with stranding/grounding accounting for 10%.

Figure 3.10 Average Distribution of Incident Types (2001 - 2003)
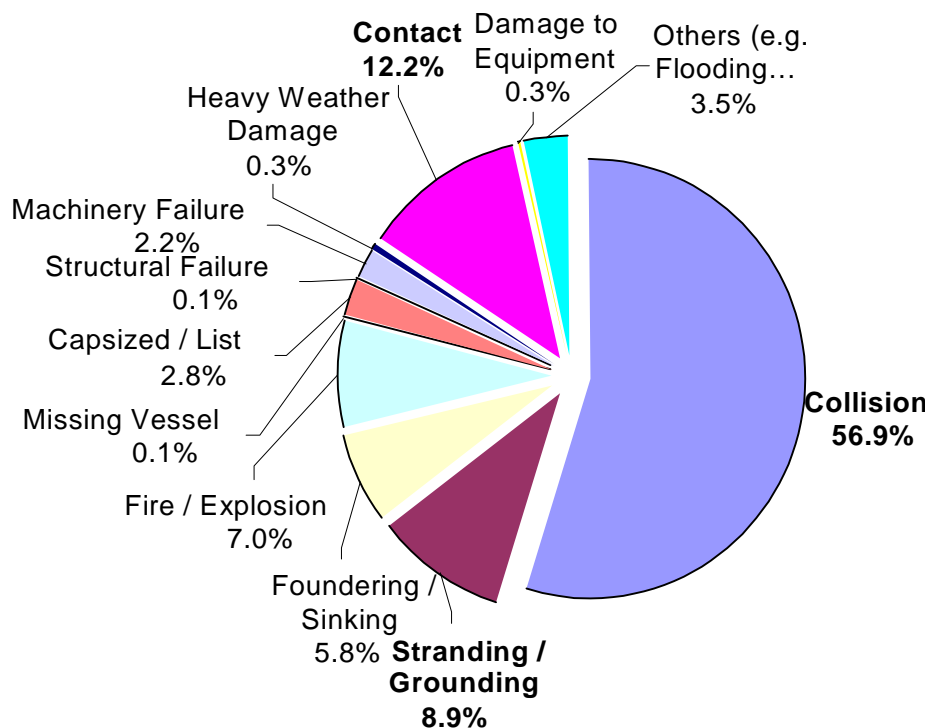
3.3.3   Figures 3.11 & 3.12 illustrate the distribution of vessel incidents:

Figure 3.11   Vessel Types Involved in Incidents
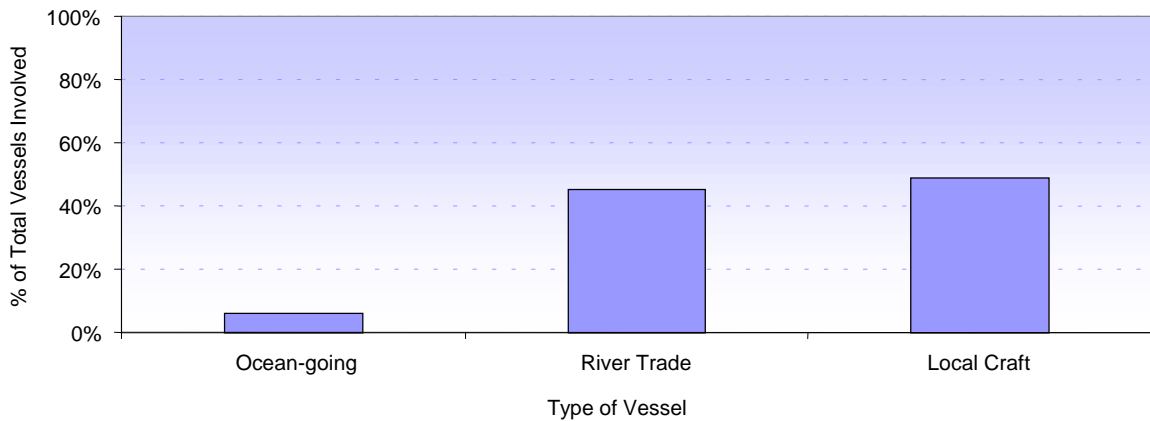
Figure 3.12   Vessels in Collisions, by Gross Registered Tonnage (GRT)
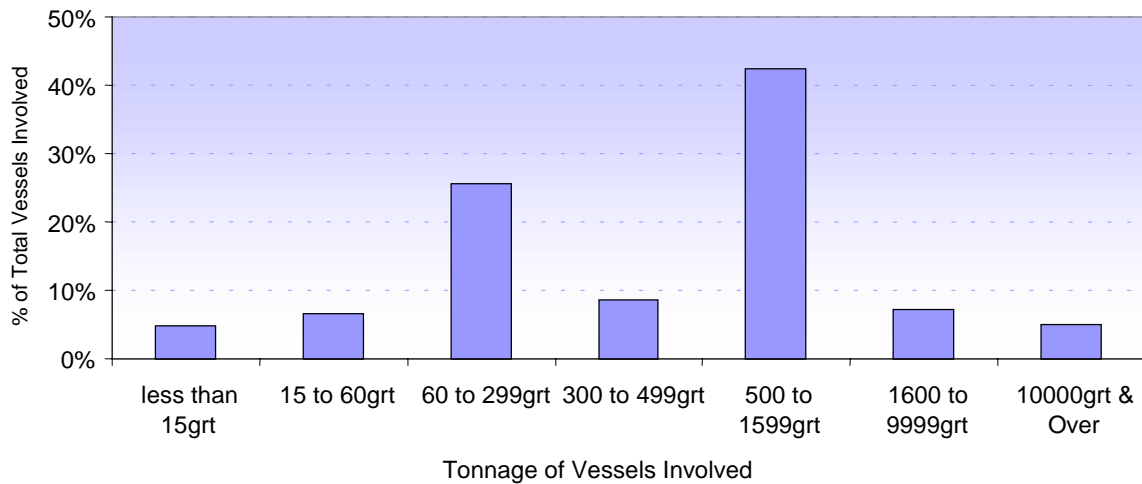
3.3.4   A statistical analysis of environmental factors has been conducted to identify if there is any correlation between collision incidents and poor visibility, high winds, adverse weather, strong currents and rough seas; however, none has been identified with significance.

3.3.5   Almost 60% of collisions involve damage solely to the vessels involved, with 20% of incidents resulting in no reported damage. Approximately 80% of all collisions (where personnel were affected) resulted in injuries, with 20% reported with fatalities/missing persons. Summary data for the last decade identifies an average injury rate of 11% and a fatality rate of 2%, given a collision.

3.3.6   It is also identified that collision frequency, with respect to Ocean-going and Rivertrade arrivals is on a consistent downward trend – reflecting improvements in shipping management and operation. However, there is, for both injury and fatalities, an apparent trend of increasing frequency given an incident. This may be a function of increased vessel size, speed and crew/passengers potentially at risk.

3.4   Future Marine Traffic Activity

Historic Trends and Traffic Growth

3.4.1   Data from the HKSAR *Port Cargo Forecasts 2000/01* formed the foundation of the cargo traffic forecast as they take account of macro and local economic drivers. Passenger vessel activity has been referenced to the patronage forecasts conducted by the Transport Department while MD's *Assessment of Typhoon Shelter Space Requirements 2002-2021* provided the principal reference for development of future local vessel growth. Multiple forecasts have been conducted and a whole "family" of results has been used to develop the realistic upper bound growth limits for 2006 & 2011.

Figure 3.13   Traffic Forecast Methodology
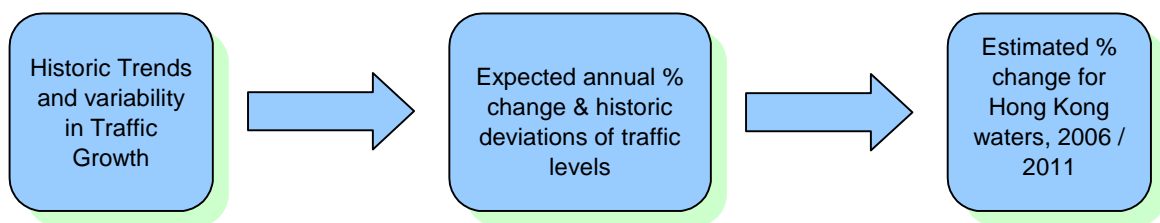
3.4.2   The present trends in Ocean-going and Rivertrade vessel size has been incorporated in the analysis to take account of the increasing consolidation of cargo in larger ships. Consideration was also given to the impact of reclamations, cross-boundary services, port facilities, shipping trends and key Mainland projects on the forecasts.   Table 3.2 summarises the traffic adjustments adopted within the model:

Table 3.2 Traffic Volume Adjustments adopted for Benchmark Years

Vessel Class	2003 - 2006	2003 - 2011
Ocean-going Cargo	+7%	+7%
Ocean-going Passenger	+54%	+264%
Rivertrade	+3%	-12%
Tug & Tow	+3%	-12%
Fast Ferry	+6%	+14%
Fast Launch	-3%	+3%
Conventional Ferry	-9%	-14%
Fishing Vessels	-4%	-17%
Small Craft (Tugboat / Local DG vessels / Pleasure Vessels / Unclassified)	+13%	+19%

Note: Rounding errors apply

Broadly speaking a rise in traffic is forecast to 2006 with decreasing levels of growth, or reductions in some classes between 2006 and 2011.

3.5   Summary

3.5.1   An extensive survey campaign has been conducted for the MARA Study including:

- Review of Timetabled Vessel Data;
- Analysis of 2001 & 2002 Ocean-going vessel activity records;
- Visual Surveys at 8 sites over 24 days each, and
- Analysis of Digital Radar Capture of 12 days.

3.5.2   The nature and distribution of incidents associated with marine traffic has been examined. It is identified that collisions are the dominant incident type, and most frequently occur between the Rivertrade vessels (container, general cargo and Tug & Tows) with GRT less than 1,600 tonnes. A weak correlation has been found between marine environmental conditions and incidents.

3.5.3   A review of future traffic activity has identified modest growth rates for the dominant vessel classes from 2003 to 2006 & 2011.

4 PHASE II – DEVELOPMENT AND APPLICATION OF MARINE TRAFFIC RISK MODEL

4.1 Dynamic Marine Traffic Simulation Model

4.1.1 BMT's "DYMITRI" dynamic marine traffic simulation model (the Model) was adopted as the principal tool for the examination of marine traffic collision risk for the Baseline and Benchmark years.

4.1.2 Each vessel is developed as an autonomous agent within the Model and constantly scans the waterspace ahead of its intended course. Should another vessel be navigating on a course with the potential to cause a collision an avoidance manoeuvre is taken. In general any avoidance manoeuvres adheres to the Steering Rules of the Collision Regulations (ColRegs). However, these may be over-ridden in special circumstances governed by the classes of the respective vessels, some classes being assumed to give way to others by virtue of their relative sizes, regardless of the specific demands of the ColRegs. The number and nature of avoiding actions has been identified as directly proportional to the frequency of collision incidents.

4.1.3 The following key data was compiled together for the Model:

- Coastline geometry;
- Traffic routes;
- Traffic volume and type, and
- Navigation characteristics.

4.1.4 The validation procedure for the strategic model is illustrated in Figure 4.1:

Figure 4.1   Validation Procedure
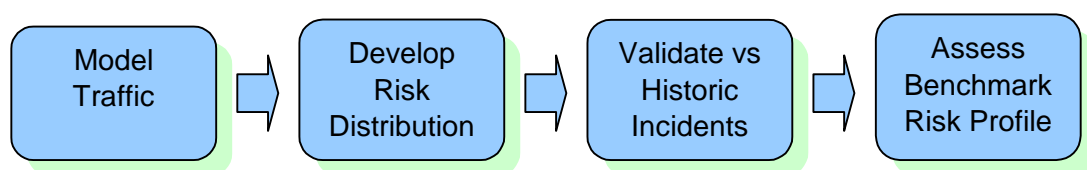
4.1.5 The collision validation was conducted for all collision incidents, excluding those in Typhoon Shelters (TS), which are mainly contacts and minor in nature. The distribution of other incidents (grounding, fire etc) was developed from historic patterns. For the purposes of the MARA Study it was decided to adopt a series of specific correlation factors to convert the anticipated collisions predicted from model output to actual collisions in HKSAR waters.

4.2 **Baseline and Benchmark Risks**

Table 4.1 and 4.2 summarise the collision and "other" incident for Baseline (2003) and Benchmark (2006 & 2011) year forecasts. A feature of the forecast is that historic improvements in safety for collisions and "other" hazards have been introduced to account for the consistent benefits in safety gained by improved ship design, traffic management, port operation and control.

Table 4.1   Forecast Risk Environment (based on 2001 – 2003 validation data)

Scenario		2003 Baseline	2006 Benchmark Year		2011 Benchmark Year	
Collisions outside TS	Collision safety factor due to general improvement [1]	**1.0**	0.9	**1.0**	0.8	**1.0**
	Anticipated Collisions per year [2]	**185**	169	**188**	140	**175**
	% Change	**0%**	-8%	**+ 2%**	-24%	**-5%**
	Fatalities rate per collision [3]	**0.02**	0.04	**0.04**	0.05	**0.05**
	Anticipated Collision Fatalities per year	**4**	7	**8**	7	**9**
Collisions inside TS [4] & Other Incidents	Safety factor due to general improvement [1]	**1.0**	0.9	**1.0**	0.85	**1.0**
	Anticipated Incidents per year [3]	**171**	165	**183**	156	**183**
	% Change	**0%**	-3%	**+7%**	-9%	**+7%**
	Fatalities rate per incident [3]	**0.04**	0.04	**0.04**	0.05	**0.05**
	Anticipated Fatalities [3] per year	**7**	7 - 8	**8**	8	**9**
Total Incidents		**357**	334	**370**	296	**358**
Total Fatalities		**11**	14	**16**	15	**18**
Population at Risk per year		**130M**	135M	**135M**	140M	**140M**
Potential Loss of Life		**0.8×10^{-7}**	1×10^{-7}	**1×10^{-7}**	1×10^{-7}	**1×10^{-7}**

Note: Rounding errors apply
(1) – Developed from review of prior accident statistics
(2) – from DYMITRI model output results
(3) – projected from historic data.
(4) – Approximately 20 collisions per year within TS are included in these statistics.

4.2.1   The analysis identifies that overall collision levels will rise slightly and then drop as a result of continuous improvements of navigation practice and port management. When the addition of non-collision fatalities is included the risk level for HKSAR waters, in general is anticipated to remain relatively static over the next decade, and has the potential to fall if safety improvements are realised.

Table 4.2   Forecast Collision Range (excluding Typhoon Shelter) Frequency

Waterspace	2003 Baseline	2006 Benchmark Year		2011 Benchmark Year	
Safety factor due to general improvement	**1.0**	0.9	**1.0**	0.8	**1.0**
Deep Bay	**5**	5	**5**	4	**5**
Western Waters	**19**	17	**19**	14	**17**
Ma Wan & Approaches	**27**	27	**30**	20	**25**
Western Harbour	**19**	17	**18**	16	**20**
Yau Ma Tei & Central	**86**	77	**86**	65	**81**
Eastern Harbour	**11**	10	**11**	8	**10**
Southern Approaches	**16**	14	**16**	13	**16**
Eastern Waters	**2**	2	**2**	2	**2**
TOTAL	**185**	169	**188**	140	**175**

Risk Distribution in 2006

4.2.2   With few new facilities, the forecast pattern of collision distribution is similar to the 2003 Baseline. Total incidents are anticipated to increase at most by 5%, and may fall by 5% if future risk improvements mirror historic activity. Collisions are expected to vary between –10% to 0% variation from present levels. The collisions within the Yau Ma Tei, Western & Central Harbour area remain relatively high, and are anticipated to increase. An anticipated rise in fatality rates per collision is expected to increase the Potential Loss of Life risks for mariners and passengers in HKSAR waters. However the predicted risk level at 1×10^{-7} is well within acceptable levels.

Risk Distribution in 2011

4.2.3   Although a number of facilities will become operational by 2011, the overall marine traffic volume will reduce from the Year 2006 to 2011 due to consolidation of shipping activity. Collisions are expected to vary between –20% to 0% variations from present levels. Total incidents are anticipated to increase at most by 5%, and may fall by 15% if future risk improvements mirror historic activity.

4.3 Summary

4.3.1 In general the risk environment of HKSAR waters is anticipated to remain relatively static over the next decade, and has the potential to fall if safety improvements are realised. The Central Harbour and Yau Ma Tei areas maintain the focus of port activity and will experience the largest proportion of all incidents; while risks at Ma Wan, Western Harbour and Southern Approaches are not anticipated to rise significantly.

4.3.2 It is anticipated that in the future marine traffic risk management will be focussed on the management of fewer larger vessels that suffer hazards with more serious consequences than presently.

4.3.3 It has been identified that both present and future risk levels fall well within acceptable limits with respect to the standard of "Potential Loss of Life". This finding is consistent with the perception of marine safety in the region that, while busy, marine traffic activity is effectively regulated and generally safe.

5 PHASE III – REVIEW, DEVELOPMENT AND TESTING OF AVAILABLE RISK CONTROL MEASURES

5.1 Introduction

5.1.1 The Study has identified that for HKSAR waters as a whole, the overall marine traffic collision levels is not anticipated to rise, and has the potential to fall if safety improvements are realised. It is therefore necessary to identify where improvements can be made, so that the significant contribution to marine safety realised by MD's vessel traffic management system in the past are also gained into the next decade. The key areas where control is available are:

- Vessel Routing / Fairway alignment / Traffic Separation, and
- Speed Controls.

5.1.2 The review of marine traffic risks have identified the following key areas for risk control:

- Navigation in open waterways accounting for approx. 29% of all incidents, but almost all injuries/fatalities;
- Navigation in constrained typhoon shelters and port areas accounting for approx. 28% of all incidents;

5.1.3 A review of risk management initiatives has been conducted to seek to identify, on the basis of the risk assessment results, valuable risk control strategies for HKSAR waters. The following broad initiatives are recommended:

- Measures to minimise traffic risks within open waterways;
- Measures to minimise traffic risks within constrained waterways, and
- Specific traffic control measures for Western Waters and Yau Ma Tei / Central Harbour.

5.1.4 The effectiveness of the risk management practices can be capitalised by addressing the cost-benefit of the control measures. A quantitative cost-benefit assessment was conducted on the specific proposals using the MARA model and adopting a statistical cost of life for every fatality avoided of HK$33M.

5.2 Traffic Management in Open Waterways

5.2.1 It is anticipated that the HKSAR will face a requirement to provide safe access to the increasing size of vessels and volume increases of traffic transiting through Hong Kong to/from the Shekou Ports should the Tonggu Waterway not be constructed by 2011. While the inevitable increases in vessel size will ensure a consolidation of cargo in large vessels, water depths in the PRD limit the passage of the largest container ships; and container ship volumes have the opportunity to double on the transit route to the Shekou Ports. This doubling has not been modelled in the risk assessment, as the Tonggu Waterway is an assumed development – however its construction is not guaranteed.

5.2.2   At present the sectorised "hand-over" of Ocean-going vessels between Vessel Traffic Services (VTS) operators works efficiently and safely, however an increase in the number and size of vessels passing through the Ma Wan Channel and Western Harbour is expected to place increasing stress on the scheduling of vessels through their passage in Hong Kong waters. This increase will be accompanied by continuing high use of anchorages and developments at Container Terminal No. 9.

5.2.3   It is considered that there is a local requirement for a "Passage Plan Approval System" (PPAS) which would permit real time forecasting of marine traffic movements based on the current VTS situation updating the initial Vessel Traffic Management system (VTMS) information. Specifically the system would aim at:

- Predict traffic utilisation within fairways;
- Receipt and approval of passage plans, and
- Provide advice to vessel masters and pilots of potential vessel conflicts.

5.2.4   It is anticipated that the ships' passage plans will be received by Vessel Traffic Services (VTC) personnel and the initial information entered into the VTMS, as at present. As new vessels were introduced into the traffic system the computer would automatically evaluate the proposed passage plan and translate it into a ship definition and route which will be fed into PPAS to check for any conflicts during passage to the anchorage, berth, fairway or open sea. If a plan is rejected a series of improvement options, slower/faster speed, different arrival times, route variation will be defined and then tested, with a recommendation provided.

5.2.5   Considerations may be given for the development and implementation of a PPAS to manage the increasing proportion of larger vessels anticipated to pass through HKSAR waters should the construction of the Tonggu Waterway be delayed. It is anticipated that such a system will be required once traffic activity at Ma Wan reaches approximately 30 movements per day of vessels with greater than 200m LOA.

5.3   Traffic Management in Closed Waterspaces – Anchorage Management

5.3.1   An analysis of ocean-going arrivals to the Yau Ma Tei (YMT) anchorage for the years 2001 and 2002 has been conducted. The following features may be summarised from the data:

- An average of approximately 2,000 vessels arrive at the anchorage per year,
- All vessels are below 5,000 DWT, with almost 90% of vessels between 50 – 100m LOA, and
- Vessels are predominantly declared as full cellular container ships (approx. 58%) or conventional cargo (approx. 38%).

5.3.2   It is anticipated that if the mooring of larger Rivertrade and all OG vessels was restricted within the YMT anchorage and vessels relocated to Kellett Bank it would free up valuable anchorage space and provide the opportunity for better usage of the waterspace.

5.3.3   From the initial assessment of tracks and ocean-going activity, it is estimated that the density of the YMT anchorage would decrease by at least 15% upon implementation of this rule. As it is anticipated that Rivertrade vessels will grow in size and capacity up to approximately 2011, with

an average capacity of approximately 85TEU and length between 60 - 70m, it is estimated that a limit of 50m will prohibit the mooring of approximately 25 - 50% of all Rivertrade vessels. A cost benefit of approximately HK$7M per annum is identified for this action in the future.

5.4 Adequacy of Navigation Channels

5.4.1 A design review of key channel dimensions has been conducted with respect to the international guidelines. It is identified that while container ships are growing rapidly in size, the advent of 12,500 TEU vessels and larger may not appear before 2011.

5.4.2 The following recommendations are made with respect to channel dimensions:

- *Western Fairway* – No action is required prior to 2011, although if revised action is taken on the Northern Fairway it is recommended that the fairway layout in this location is reviewed;

- *Northern Fairway (North)* - It is recommended that a series of full bridge navigation simulations be conducted with the Hong Kong Pilots Association to review the requirements for fairway amendment on the arrival of larger container ships than the present 43m beam vessels. It is also recommended that field trials are conducted to identify the squat of large container ships accessing Kwai Chung to assist in the review of draft adequacy;

- *Northern Fairway (East)* - This fairway is considered adequate from a navigation standpoint for the vessels most regularly transiting the channel, and

- *Urmston Road* - The deep water channel between buoys CP4 and CP5 is considered insufficient for the two-way navigation of large container ships.

5.5 Specific Mitigation Measures

5.5.1 A series of specific marine traffic management measures has been tested in the Model to examine the benefit of traffic control in two principal marine risk areas:

- *Western Waters - Traffic separation in Urmston Road (with a central dividing buoy proposed).* It is identified that a single buoy provides too little traffic separation to gain benefits that are not undone on the re-convergence of vessels at either end of the separation. However, the investment in instilling navigation discipline at the critical western entrance to Hong Kong waters is considered worthwhile.

- *Western Waters - Traffic separation in Urmston Road (with a Fairway proposed).* It is identified from the simulation that the establishment of principal fairway enhances the safety environment within Western Waters generally, although it is estimated that the collision risks around the Tuen Mun Immigration Anchorages would increase 6%. However the significant dredging capital costs and patrol operations render this option unsuitable in the short to medium term.

- *Yau Ma Tei / Central Harbour - Enforcement of maximum speed limits of 10 knots within harbour areas (with exception of fast ferries),* Traffic adherence to the mandatory speed limits appears to offer a benefit of HK$10M per annum, However this must be set against an intensive and sustained patrol operation which will have similar cost.

- *Yau Ma Tei / Central Harbour - Wider Northern Fairway (double width) to minimise traffic interaction adjacent to Yau Ma Tei anchorage.* The potential benefits in spreading traffic across a wider Northern Fairway are not realised, as there is more risk to crossing traffic which is vulnerable to collisions from vessels running within the fairway.

- *Yau Ma Tei / Central Harbour - Shifted Northern Fairway (to south) to minimise traffic interaction adjacent to Yau Ma Tei anchorage.* The potential benefits in shifting traffic to a realigned Northern Fairway are not realised, as there is similar risk from the same traffic mix.

5.5.2   In summary, with the marginal increases in collision risk forecast for the Benchmark years of 2011 no risk control options have a clear cost-benefit. However it is considered that improved navigation discipline within western waters will be affected by installation of a single buoy.

5.6   Summary

5.6.1   It is proposed that future management measures are focussed on large vessels by the implementation of passage planning linked to risk assessment tools, enhancement of controls and reallocation of anchorage waterspace, and the management of specific waterspaces following testing within the MARA model.

6   SUMMARY AND CONCLUSIONS

6.1   Summary

6.1.1   The commissioning of the MARA Study by the Marine Department has provided a valuable opportunity to reassess the future risk profile of marine traffic in HKSAR waters, and to ensure that the anticipated risk levels in 2006 and 2011 are acceptable in the light of rapid changes within the local and regional planning context.

6.1.2   The adoption of the Formal Safety Assessment methodology has provided a structured approach to the evaluation of risks and cost-effectiveness of control measures.

6.1.3   An extensive survey campaign has been conducted for the MARA Study including a review of timetabled vessel data, analysis of Ocean-going vessel activity, extensive visual surveys and analysis of digital radar data. The nature and distribution of incidents associated with marine traffic has been examined. It is identified that collisions are the dominant incident type, and most frequently occur between Rivertrade vessels. A weak correlation has been found between marine environmental conditions and incidents. A review of future traffic activity has identified modest growth rates for the dominant vessel classes from 2003 to 2006 & 2011.

6.2   Conclusions

6.2.1   The Marine Department ensures the safety of navigation and efficiency of shipping activities in Hong Kong waters through comprehensive traffic management, harbour control, vessel traffic services, provision of mooring buoys and rigorous enforcement of international conventions.

6.2.2   In general the risk environment of HKSAR waters is anticipated to remain relatively static over the next decade, and has the potential to fall if safety improvements are realised. The Central Harbour and Yau Ma Tei areas maintain the focus of port activity and will experience the largest proportion of all incidents; while risks at Ma Wan, Western Harbour and Southern Approaches are not anticipated to rise significantly.

6.2.3   It has been identified that both present and future risk levels fall well within acceptable limits with respect to the standard of "Potential Loss of Life". This finding is consistent with the perception of marine safety in the region that, while busy, marine traffic activity is effectively regulated and generally safe.

6.2.4   It is anticipated that in the future marine traffic risk management will be focussed on the management of fewer larger vessels that suffer hazards with more serious consequences than presently. It is proposed that future management measures are focussed on large vessels by the implementation of passage planning, enhancement of controls and reallocation of anchorage waterspace, and the management of specific waterspaces following testing within the MARA model.

6.2.5   The improvement of marine traffic safety is an ongoing process and it is important that the findings of the MARA Study are continually reviewed and updated, to allow the determination of risk levels for individual waterspaces that will allow the Marine Department to effectively address the local marine planning issues.