2000

VTS [vessel traffic services] in the Singapore strait : an investigation into mandatory traffic control

Mohammed Segar Abdullah
World Maritime University

World Maritime University
Malmö, Sweden

VTS IN THE SINGAPORE STRAIT: AN INVESTIGATION INTO MANDATORY TRAFFIC CONTROL

By

MUHAMMAD SEGAR ABDULLAH
Republic of Singapore

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE

in

MARITIME ADMINISTRATION AND ENVIRONMENTAL PROTECTION

2000

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

…………………………….

Muhammad Segar Abdullah

Date: 21 August 2000

Supervised by:

Capt. Sven-Åke Wernhult

Lecturer, Maritime Administration and Environmental Protection

World Maritime University

Internal Assessor:

Dr. Proshanto K. Mukherjee

Course Professor, Maritime Administration and Environmental Protection

World Maritime University

External Assessor:

Capt. Kjell Grahn

Visiting Lecturer

World Maritime University

DEDICATION

To my inspiration in life, my wife Fatimah and my children for their constant support and forbearance in the quest for this degree.

To my mother, brother, sister, sister-in-law and Mary Abraham for their support and encouragement.

ACKNOWLEDGEMENTS

I am grateful to the Director-General of the Maritime and Port Authority of Singapore, Mr Chen Tze Penn for giving me the opportunity to pursue this post graduate degree.

A special word of gratitude to Capt. Khong Shen Ping, Ms Lee Chin Neo, Capt. Mark Heah Eng Siang and Mr Michael Tang for their support and encouragement.

In the writing of this dissertation, I owe a debt to more people than there is space to name and thank - those who have assisted me in many ways and those whose books, journals and articles that I have read. But a special of word of thanks to:

- Course Professor P K Mukherjee for his encouragement to excel and sharing his vast experience and knowledge in maritime law;
- Professor J R F Hodgson, Capt. S-Å Wernhult and Mr Max Mejia for their guidance and patience in the supervision of this dissertation;
- Capt. Francis Wee, Capt. Wilson Chua, Capt. Sangam and Mr Parry Oei for their advice, inputs and comments;
- Mr William Seow, Mr Roger Teo and PSA Marine pilots for providing valuable feedback;
- Commander Rod Johnson and Mr Eric Musson of UK, Maritime Coastguard Agency for their information on Dover Strait and CNIS;
- MPA officers, Peggy Koh, Sandra Wee and Kamalanathan for producing the relevant chartlets;
- WMU library staff, Susan Wangeci Eklow and Cecilia Denne for their invaluable assistance in searching for reference materials; and
- Authors and commentators of the various textbooks, journals and articles which I have read. Their names and works are duly acknowledged in the bibliography.

Finally, I would like to thank "ALLAH" for making this long and difficult journey possible.

ABSTRACT

Title of Dissertation: **VTS in Singapore Strait - An Investigation into Mandatory Traffic Control**

Degree: **Master of Science in Maritime Administration and Environmental Protection**

This dissertation investigates mandatory traffic control in the Singapore Strait using the Singapore Vessel Traffic Information System (VTIS) as a model. The three littoral States *i.e.* Singapore, Indonesia and Malaysia have introduced many safety measures to enhance safety of navigation in the Singapore Strait. In addition, the Maritime and Port Authority of Singapore has established VTIS to provide information and navigational assistance to shipmasters, as well as warnings when there is a potential risk of close quarter situations.

The development of vessel traffic service (VTS), the types of VTS and their significant contributions to safety of navigation are discussed. Also, the effectiveness of the safety measures that have been implemented in Singapore Strait is examined. To further enhance the safety of navigation in the Singapore Strait through VTS, a definition for the shore-based control - mandatory traffic control is proposed. There are similarities in the air traffic service (ATS) and vessel traffic service. The principles and concepts of ATS are examined to identify the areas in which VTS differs and suitable solutions are provided to address these concerns for a shore-based control by VTS.

The development of new navigational tools such as ECDIS, ENC, DGPS/DGLONASS and AIS transponder which will enhance safety of navigation are evaluated to facilitate shore-based control. A comparative analysis between Dover Strait, Channel Navigation Information Service and Singapore VTIS identifies the common problems faced by VTS authorities and the need for further control measures. Shipowners, shipmasters, pilots and shipping organisations have valid concerns. Some of the issues related to mandatory traffic control are controversial and can be resolved at appropriate IMO forums.

Introducing mandatory traffic control is a complex and long drawn process and the importance of Singapore Strait can be overstated. Hence, in the final chapter a number of recommendations are made to enhance safety of navigation with ultimate aim to achieve shore-based control by VTS.

KEYWORDS:

Air traffic service

AIS transponder

Channel Navigation Information Service

DGPS/DGLONASS

ECDIS

ENC

Mandatory traffic control

Maritime and Port Authority of Singapore

Shore-based control

Singapore Strait

Singapore VTIS

Vessel traffic service

TABLE OF CONTENTS

Appendices

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIS	Automatic identification system
ARPA	Automatic Radar Plotting Aid
ATC	Air traffic controller
ATS	Air traffic service
BAFEGIS	Baltic Sea Ferry Guidance and Information System
BIMCO	Baltic and International Maritime Council
CNIS	Channel Navigation Information Service
COLREG	Convention on the International Regulations for Preventing Collisions at Sea, 1972 as amended
CPS	Vessel-Conflict Prediction System
DGLONASS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DOD	Department of Defence, United States
DSC	Digital Selective Calling
ECDIS	Electronic Chart Display and Information System
ECS	Electronic chart system
EEZ	Exclusive economic zone
ENC	Electronic navigational chart
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
IAIN	International Associations of Institutes of Navigation
IALA	International Association of Lighthouse Authorities
IAPH	International Association of Ports and Harbours
ICAO	International Civil Aviation Organization
IFSMA	International Federation of Shipmasters' Association
IHO	International Hydrographic Organisation
IMCO	Inter-Governmental Maritime Organisation

IMO	International Maritime Organisation
IMPA	International Maritime Pilots' Association
IPS	Institute of Policy Studies, Singapore
ISM	International Safety Management
LNG	Liquefied natural gas
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978, as amended
MCA	Maritime and Coastguard Agency of United Kingdom
MPA	Maritime and Port Authority of Singapore
MSC	Maritime Safety Committee, IMO
RCDS	Raster chart display system
SA	Selective availability
SATSA	Swedish Air Traffic Services Academy
SIGTTO	Society of International Gas Tanker & Terminal Operators Ltd
SIPS	Ship Identification and Positioning System
SOLAS	International Convention for Safety of Life at Sea, 1974, as amended
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as revised in 1995
TSS	Traffic separation scheme
UNCLOS	United Nations Convention on the Law Of the Sea, 1982
VLCC	Very large crude carrier
VTIS	Vessel Traffic and Information System
VTS	Vessel traffic service
WGS-84	World Geodetic System, 1984

Chapter 1

Introduction

The Secretary-General of the International Maritime Organization, O'Neil (1999) said that:

> the oldest tradition of the sea - that the authority of the ship's master should be paramount - may no longer be valid in a world that is becoming dominated by new technology. I think that we should ask ourselves if the time has not come to question this approach and to empower the shore authorities, in certain cases, to order ship to take whatever action is necessary to avoid an accident.

The principle purpose of this dissertation is to examine whether there are merits in the S.G.'s call to empower shore-based authorities, such as vessel traffic service (VTS) authority, to introduce mandatory traffic control. In civil aviation, positive control of aircraft by ground-based air traffic controller is accepted. The concepts and principles adopted by civil aviation could be introduced to vessels within the coverage of VTS.

This study investigates mandatory traffic control in Singapore Strait using the Singapore VTIS as a model. The Straits of Malacca and Singapore are among the world's busiest sea lanes and important waterways for domestic and international trade. Over the years, the three littoral States, Indonesia, Malaysia and Singapore have implemented many measures to improve the safety of navigation in the straits.

In 1990, Maritime and Port Authority of Singapore (MPA) established the Singapore Vessel Traffic Information System (VTIS) to enhance safety of navigation by providing navigational and traffic information to shipmasters, as well as warnings when there is a potential risk of close quarters situations or groundings. MPA has been continuously upgrading the VTIS with the latest state-of-the-art marine surveillance, communication and information system. Experience has shown that, in spite of the timely information and warnings provided by the VTIS, shipmasters took inadequate actions which resulted in collisions and groundings.

In 1997, the risk of major environmental and ecological disaster became a reality when the loaded tanker EVOIKOS spilled 28,500 tonnes of oil in the Singapore Strait after a collision. In 1998, the car carrier HUAL TRINITA and container vessel EVER GLORY collided in the west bound lane of the TSS. The car carrier was severely damaged and a few compartments were flooded. In 1999, the loaded bulk carrier GRACIOUS collided with the unladen tanker LULA 1 in the east bound lane of the TSS. The bulk carrier's bow and No. 1 cargo hold were severely damaged and had to be towed by the stern to a safe anchorage.

The MPA statistical record indicates that there were 49,107 and 141,523 vessel arrivals in the year 1989 and 1999, respectively. The traffic has increased by almost three folds in the last decade. With this escalating trend, the potential risk of major maritime disaster in the Singapore Strait cannot be ruled out. The objectives of this dissertation are as follows:

(a) To examine the effectiveness of improvements made to enhance the safety of navigation in the Singapore Strait;
(b) To define Mandatory Traffic Control;
(c) To identify the areas of Vessel Traffic Service system that need to be enhanced for shore-based control;
(d) To identify the emerging new technology that could be harmonised with the shore-based systems in VTS to enhance the navigational safety of ships;

(e) To examine the pros and con of shore-based control;

(f) To identify the essential requirements and measures that should be in place for mandatory traffic control in the Singapore Strait; and

(g) To make suitable proposals and recommendations to enhance safety of navigation in Singapore Strait through VTS.

The order of presentation is arranged in a logical sequence to focus and attain the desired objectives of this dissertation. In Chapter 2, the development of vessel traffic service (VTS), the various types of VTS and the legal status of VTS in the international conventions will be discussed. The safety measures that have been implemented in Malacca and Singapore Straits and their contribution to safety of navigation will be evaluated. The need to further enhance the safety of navigation through VTS will be discussed. Also, a suitable definition of mandatory traffic control for the purposes of this study will be proposed.

Introduction of new technology and rapid advancement in various maritime fields have overcome many major obstacles. Chapter 4 will focus on the functional capabilities, contributions and limitations of new navigational tools that could be effectively used by shore-based facilities and ships to enhance safety. The four main navigational tools that will be evaluated are Electronic Chart Display and Information System (ECDIS), electronic navigation chart data format; Differential Global Positioning System & Differential Global Navigational Satellite System (DGPS&GLONASS); and Automatic Identification System (AIS) transponders.

Shore-based control is totally a new concept to maritime industry. In Chapter 6, the pros and cons of introducing the various types of shore-based control will be evaluated. And in Chapter 7 using Singapore Strait as a model, the various essential requirements and measures that should be established, prior to the introduction of mandatory traffic control, will be proposed.

Mandatory traffic control may not be the ultimate solution and without problems to control maritime traffic in congested and restricted waterways. Hence, in Chapter 8, other alternative measures to mandatory traffic control will be explored to further enhance safety of navigation in Singapore Strait. The final Chapter 9 will outline the conclusion and recommendations based on the analysis of previous chapters.

Chapter 2

Vessel Traffic Services

2.1 Background of VTS Development

Every maritime nation has a duty to improve and maintain a safe port; to promote maritime safety; and protect the marine environment. The world's first harbour control radar was installed at the end of Victoria Pier, Douglas, Isle of Man, in February 1948. In July 1948, a port radar system was established at the Port of Liverpool. This was installed in particular, for the interest of the safety of ships and for the shipowners to turn around the ships quickly. This system was the stepping stone and an eye-opener, which pioneered the European Vessel Traffic Services.

Over the centuries, shipping has been the major means of transportation of cargoes and passengers, and it will continue to support world commerce and tourism. In order to transport cargoes from one port to the other, ships have to navigate accurately, safely and expeditiously. In the beginning, coastal States/Maritime Authorities provided aids to navigation such as lighthouses, lightvessels, beacons and buoys to assist the vessels to navigate safely in and around their coastal waters, approaches to and into their ports.

As shipping increased, the vessels increased not only by numbers but also in size and speed. Thus, the maritime nations improved the aids to navigation by increasing the numbers of navigational lights and adding audible aids such as fog warning devices. With the birth of the electronic age, electronics and satellites supported navigational aids were developed such as Decca Navigator, Loran A, Loran C, Omega and Global Positioning System (GPS) to enhance the vessel's position fixing system.

The straits, channels and fairways for navigation were highly utilised. Therefore, further enhancements were required to improve the management of vessel traffic. Hence, various passive techniques were introduced as follows:

(a) Traffic separation schemes;
(b) Inshore traffic zones;
(c) Precautionary zones and recommended directions of traffic flow;
(d) Routeing measures; and
(e) Speed limitation.

These passive techniques improved the safety of navigation and regulated the movement of vessels, similar to that of the road traffic system such as road dividers, highways, dual carriageways, traffic junctions for crossing and turning. However, the significant problem of congestion at the approaches to port and narrow fairways was of concern. Also, the number of ships carrying dangerous cargoes was increasing and the congestion caused delays. These delays in shipping movements not only increased the cost of maritime traffic and port operations but also increased the probability of accidents. This endangered life at sea, property and the marine environment.

There is a need to monitor the movements of vessels in the port and approaches thereto. Also, shipping needs information, advice and instructions. Hence to meet these demands, an interactive service that would organise the movement of vessels, minimise the risk of accidents, protect marine environment and maximise port efficiency was developed. This service is known as vessel traffic service.

Authorities using the VTS systems experienced improvements in safety of navigation, efficiency in port operations and reduction in marine environmental pollution. With developments in the information and computer technologies, there are now more than 500 VTS operational systems around the world with several distinct operating concepts.

2.2 Types of VTS

There are basically two broad types of VTS and they are categorised as a Coastal VTS or Port or River VTS. The Coastal VTS is established to facilitate the safe and expeditious passage of vessels traversing through the coastal waters or straits used for international navigation. Normally in these areas, the density of maritime traffic is high and there is a sensitive marine environment. The passage through these areas may also be difficult due to geographical constraints, numerous offshore explorations and crossing traffic to neighbouring or adjacent coastal States.

The Port or River VTS is established to assist the safe movement of vessels entering or departing from ports and to improve the efficiency of the port. This type of VTS is widely used by river ports to facilitate vessels which are restricted or hampered in manoeuvring. The following are some examples of the two types of VTS:

(a) Port or River VTS

- The Thames River Navigation Service (Gravesend)
- The Port of Gothenburg Control Area
- The Integrated Traffic Regulation Centre of Marseilles-Fos
- The Port of Rotterdam Vessel Traffic Management System
- The Bremerhaven Marine Traffic Surveillance Centre
- The Mississippi River VTS

(b) Coastal VTS

- The Channel Navigation information Service (Dover)
- The Aarhus Vessel Traffic Centre (The Sound and The Belt)
- The Singapore Vessel Traffic Information System
- The Malaysia Vessel Traffic Information Service

2.2.1 Types of Service provided by VTS

In general, there are 3 types of service provided by VTS Authorities. They are information service, navigational assistance service and traffic organisation service.

The information service enables shipmasters to obtain essential information to assist in the shipboard navigational decision-making process. This information include the positions, intentions and destinations of vessels in the VTS sector; the meteorological and hydrological conditions; status of aids to navigation; movement of deep drafted vessels, vessel restricted in ability to manoeuvre, unwieldy tows; and traffic congestion at pilot boarding grounds.

The navigational assistance service is provided to vessels which have encountered defects, deficiencies or difficulties in navigating due to for example meteorological circumstances. Hence, the VTS would provide navigational information such as course and speed made good by the vessel; position of the vessel in relation to the channel or fairway; positions and identities of vessels in the vicinity; and warnings to individual vessels. This assistance is provided at the request of the shipmaster.

The traffic organisation service regulates the movement of vessels by forward planning to prevent congestion and developments of dangerous situations within the VTS area. This service includes the adoption of a mandatory reporting system, establishment of routeing systems, designating speed limit zones and operating a system of traffic clearances in respect of priority of movements. Any instruction issued to vessel should be result oriented and the details of execution are left to the shipmaster.

2.3 Legal Status of Vessel Traffic Service

There are sufficient provisions in the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS) and United Nations Convention on the Law Of the Sea, 1982 (UNCLOS) to regulate maritime traffic. There should be a clear mandate in these provisions to include VTS.

The SOLAS Regulation V/8-2, which came into force on 1 July 1999 states that the VTS contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment, adjacent shore areas, work sites and offshore installations from possible adverse effects of maritime traffic. Also, VTS may be established when the contracting Government is of the opinion that the volume of traffic or the degree of risk justifies such services. But no VTS should prejudice the rights and duties of governments under international law and VTS may only be made mandatory in sea areas within the territorial seas of a coastal State. Therefore, the coastal State, which provides a vessel traffic service, has a key safety mandate and obligation to fulfil within its territorial seas.

There are no explicit provisions for mandatory VTS in the UNCLOS. However, UNCLOS has provided coastal States with legal rights to regulate the safety of navigation and maritime traffic. Coastal States may also establish mandatory sea lanes, traffic separation schemes and navigational and safety aids to protect the marine environment from pollution caused by vessels. In the Article 43 of the UNCLOS for the straits used for international navigation, there are provisions for user States and States bordering the strait by agreement to co-operate in the establishment and maintenance of necessary navigational and safety aids or other improvements in support of international navigation.

The coastal States in their exclusive economic zone (EEZ) have jurisdiction with regard to the protection and preservation of the marine environment. Although Article 58, para 1 of UNCLOS accords the principle of freedom of navigation in the EEZ, Article 58, para 3 of UNCLOS states that States shall have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the State, *etc*. Also it is important to take note that in Article 211, para 5 of UNCLOS, the coastal States in respect of their EEZ may adopt laws and regulations for the prevention, reduction and control of pollution from vessels which should conform to the generally accepted international rules and standards.

Finally, in the EEZ, coastal States have jurisdiction and also, may establish reasonable safety zones and appropriate measures to ensure the safety of navigation and the safety of artificial islands, installations and structures.

It can be reasonably argued that the provisions in SOLAS and UNCLOS provide an umbrella under the term regulate maritime traffic for the establishment of VTS systems within the territorial sea, straits used for international navigation and in the EEZ. It was well commented by Gold (1984) that the lack or absence of adequate VTS systems in areas where such systems would undeniably contribute to maritime accident prevention, or mitigate the adverse effects if incidents or casualties, could be seen as a violation of the Convention's strict legal requirements.

2.4 Safety Measures Implemented in Singapore Strait

The Straits of Malacca and Singapore are two of the busiest waterways in the world and are together approximately 500 nautical miles in length. Daily about 600 different types of ship use these straits. There are loaded tankers up to 22 metres draft confined to deep water routes, bulk carriers and tankers in ballast hugging the coastline and container vessels, hard pressed to arrive just in time at the terminals, cruising at high speed. There are liquefied petroleum and chemical tankers feeding the main refineries in the region. There are regional ferries and cruise vessels crossing the straits to promote Asean culture and tourism. There are also traditional sailing vessels, pleasure craft, fishing vessels and slow moving barges under tow with unpredictable courses.

There are numerous wrecks and shoal patches which were unconfirmed or reported only in approximate positions. In the Malacca Strait the predominant current is about 1 to 1.5 knots and in some localities the speed of flow increases to 5 knots. In the Singapore Strait, a tidal rate of 6 knots can be expected at some locations. The Straits are located in a tropical region subjected to the North East and South West monsoons with occasional thunderstorms and squalls. Heavy rain is experienced all round the year and the visibility is restricted during this general short duration of rainfall. Visibility in the straits is also regularly affected by the prolonged period of thick haze which may reduce the visibility to less than 1 kilometre.

The grounding of Japanese tanker TOKYO MARU on 4 April 1967 triggered the era of implementation of safety measures in the Straits of Malacca and Singapore. This incident occurred just shortly after the TORREY CANYON disaster on 18 March 1967. The tanker TOKYO MARU with a draft of 16.37 metres ran aground off the coast of Tg. Medan, Indonesia. Fortunately, the nature of the sea bottom was sandy and a major oil pollution disaster was averted. However, the real awakening began after the Japanese tanker SHOWA MARU carrying about 228,679 long tons of crude oil with a draft of 19.8 metres ran aground in the Singapore Strait on 6 January 1975. The tanker spilled about 8,000 tones of crude oil. After this accident, the three coastal States (*i.e.* Indonesia, Malaysia and Singapore) implemented safety measures to improve the safety of navigation and protect the marine environment in the Straits of Malacca and Singapore.

2.4.1 Routeing System

In May 1981, the IMO adopted Routeing System came into force in the Malacca and Singapore Straits. This Routeing System was the effort of the Tripartite Technical Experts Group comprising members of Indonesia, Malaysia and Singapore. The system comprises three (3) traffic separation schemes at the One Fathom Bank, The Singapore Strait and the Horsburgh Lighthouse Area. These schemes are shown in Appendix 1.

Raja Malik (1998) commented that after the implementation of the traffic separation schemes, there was no serious accident reported. It appeared that the traffic separation scheme had been effective in curbing accidents within its limits. In the Singapore Strait, the traffic separation schemes regulated the traffic flow by separating the east bound and west bound traffic.

2.4.2 Rules for Vessels Navigating Through the Straits of Malacca and Singapore

The rules for vessels navigating through the Straits of Malacca and Singapore which has been adopted by IMO, came into force in May 1981. These rules are published in the IMO Ships Routeing (1991). These are associated rules and recommendations which define vessels of draught 15 metres or more to be deemed as deep draught vessels, and tankers of 150,000 dwt and above to be deemed as a very large crude carriers (VLCC). The focus of these rules is more for the deep draught vessels and VLCCs. Some of the unique key provisions in these rules include the requirement for a minimum under-keel clearance of at least 3.5 metres, a designated deep water route, no overtaking in the deep water route, a speed restriction of 12 knots and a voluntary ship reporting system for deep draught vessels.

This set of rules for deep draught vessels was an appropriate safety measure that ensured that shipmaster's carried out a thorough passage planning exercise prior to transiting the Straits of Malacca and Singapore. The designated deep water routes, the requirement for under-keel clearance and the speed restriction were aimed at minimising the potential risk of pollution from such ships and protecting the marine environment of coastal States.

2.4.3 Extension of Traffic Separation Schemes

In 1992, there were three serious collisions in this area, between passenger vessel ROYAL PACIFIC and fishing vessel TERFU No.51, between naval vessel USS INGERSOLL and coastal tanker MATSUMI MARU and between loaded tanker NAGASAKI SPIRIT and container vessel OCEAN BLESSING. A number of lives were lost and coastal States sustained environmental damages. These incidents occurred outside the existing traffic separation scheme in Malacca Strait.

The extended traffic separation scheme adopted by IMO came into force on 1 December 1998. The One Fathom Bank traffic separation scheme was extended so as to join with the existing traffic separation scheme at Pulau Pisang as shown in Appendix 2. An inshore traffic zone and a deep water route off Tanjong Medan were also established. A total of seven precautionary areas, *i.e.* three in the Malacca Strait and four in the Singapore Strait traffic separation schemes, were introduced. Also, consequential amendments were made to the Rules for vessels navigating through the Straits of Malacca and Singapore, and has been adopted by IMO.

The extended scheme brought about an orderly flow for traffic transiting the straits. The inshore traffic zone segregated the coastal traffic from the through traffic. The precautionary areas alerted the shipmasters of the cross traffic areas, especially the areas where high speed ferries cross. This enabled the shipmasters to maintain a maximum state of manoeuvring readiness. In a survey conducted by the Society of

International Gas Tanker & Terminal Operators Ltd (SIGTTO) in early 1999, 94% of their masters replied that the revised TSS had made the transit through the straits easier and the most of the traffic observed these rules.

2.4.4 Mandatory Reporting System - STRAITREP

The mandatory ship reporting system known as the STRAITREP was also adopted by IMO and came into force on 1 December 1998. The objectives of the STRAITREP are to enhance the safety of navigation, protect the marine environment, facilitate vessel movements, support Search and Rescue operation and oil pollution response operation. To facilitate the seamless operation of the STRAITREP nine (9) sectors were established in the Straits of Malacca and Singapore as shown in Appendices 3 & 4.

For shipmasters, the STRAITREP has reduced unnecessary voice communications, provided a one step reporting procedure for vessel traversing the straits and an easy identification of vessels calling or leaving ports in the area. From the perspective of the VTS or Ship Reporting System Authorities, it provided a first hand bird's eye view of all the vessels moving in the sector or area. The Malaysia and Singapore Authorities electronically exchange information on all vessels participating in the STRAITREP, thus reducing voice communication and the VHF channel is easily accessible for information. This reduced communication translates into closer monitoring of vessels' movement and timely information and advice to shipmasters to avert a close quarter situation.

2.4.5 Surveys of Shoals and Wrecks

The navigational charts that were available in the 1960's were inadequate for large vessels navigating in the Straits of Malacca and Singapore. These charts were based on the hydrographic data obtained before World War II. Japan's energy source was from oil and about three-quarters of the imported oil was transported through the Straits of Malacca and Singapore. Japan was very concerned over the safety of their ships navigating through these straits. Hence, with the co-operation of the 3 coastal States, the Malacca Strait Council was established in 1968. A series of hydroraphic surveys was carried out from 1968 to 1978. The product of these surveys was the establishment of a Common Datum Charts and removal of four shipwrecks that were found along the navigational channel in the straits.

At the request of the three coastal States the Japanese Government agreed to a joint re-survey of the straits in 1996. The objective was to review and revise the existing ship routeing system as well as to update the navigational charts. In addition, the results of the surveys served as a platform for the electronic navigational chart (ENC) database. The survey was completed in March 1998. It confirmed that the critical areas and the dangerous/unconfirmed shoals and wreck that were investigated, do not affect the extended traffic separation schemes.

The coastal States and Japanese Government have relentlessly contributed to the safety of navigation in the Malacca and Singapore Straits. It would be worthy to note at this point of time that the user States other than Japan have not been forthcoming in their contribution, although there are provisions in Article 43 of the UNCLOS for agreements to co-operate in the establishment and maintenance of navigational and safety aids or other improvements in aid of international navigation.

2.4.6 ECDIS and DGPS

The importance of the Straits of Malacca and Singapore for the international shipping and the three coastal States cannot be overstated. It is essential that the strait is kept free of obstructions and safe for navigation at all times. With the changes brought about by the developments of computer technology, information technology and communication infrastructures, new navigational aids and aids to navigation have been established.

The Electronic Chart Display and Information System (ECDIS) is the technology of the future that will further enhance navigational safety world-wide, including the Singapore Strait. Singapore has invested in the production of electronic navigational chart (ENC) data and has developed the infrastructure to support the Differential Global Positioning System (DGPS) broadcast service to be used with ECDIS.

The benefit of DGPS integration with ECDIS for shipmasters is that there is precise real-time navigational information available round the clock regardless of the visibility or weather conditions. Navigating officers are relieved of the manual chore of plotting positions on the charts. Moreover, ECDIS provides automatic route monitoring, anti-grounding mechanism and anti-collision alert when coupled to Automatic Radar Plotting Aids (ARPA). In the busy waterways like Singapore Strait, this technology will assist shipmasters greatly in the decision-making process.

2.5 Safety of Navigation in Singapore Strait further Enhanced through VTS

Over the years, the three coastal States, Indonesia, Malaysia and Singapore have progressively and continuously implemented many safety measures to enhance the safe movements of vessels in the Straits of Malacca and Singapore. However, in spite of the implementation of such safety measures there is still a significant potential risk of major environmental and ecological disaster in these Straits.

In 1997, the laden tanker EVOIKOS and light VLCC ORAPIN GLOBAL collided in the Singapore Strait traffic separation scheme. The tanker EVOIKOS spilled 28,500 tonnes of fuel oil and made history as Singapore’s Worst Oil Spill

Disaster. It took about a month for the Maritime and Port Authority of Singapore to clean-up this massive oil spill at an estimated cost of S$13 million.

In 1998, the car carrier HUAL TRINITA and the container vessel EVER GLORY collided in the west bound lane of the traffic separation scheme. The car carrier was severely damaged and a few compartments were flooded. Subsequently, in 1999 the laden bulk carrier GRACIOUS and the unladen tanker LULA 1 collided in the east bound lane. Ironically in all these incidents, the Singapore VTIS provided timely information and warnings of the potential risk of collision to the vessels. However, despite this service, shipmasters took inadequate actions.

The Singapore VTIS provides information service and navigational assistance service, and has a bird's eye view of the relative positions of all vessels, their identities, track and speed. Hence, one option that could be further exploited by VTS Authority to prevent incidents is to introduce the traffic organisation service including instructions which are result-orientated. The requirements for this type of service have been discussed in paragraph 2.2.1.

The second option is to introduce mandatory traffic control, which is totally a new concept for VTS. For mandatory traffic control, VTS authority should be empowered to instruct the shipmasters to take appropriate actions, not limiting to result oriented action only, to avoid any close-quarter situations. This concept would raise many controversial issues and encroach into the traditional role of shipmasters and pilots for safe navigation. However, before deliberating on these issues such as legal responsibility, liability, when it should be applied and if so to what degree, the mandatory traffic control has to be defined.

2.6 Definition of Mandatory Traffic Control

For the purposes of this study, mandatory traffic control shall be defined as:

Mandatory traffic control means the regulation and control of the movement of vessels in a designated area of an approved shore-based VTS adopted by the Organisation.

The term control means any instruction given by VTS authority to a vessel, when it is apparent that the action (or lack of it) being taken by a vessel to avoid a close-quarter situation is inadequate, inappropriate or otherwise not in compliance with the International Regulations for Preventing Collisions at Sea. Such instructions may include course alterations or changes in speed.

Chapter 3

Comparisons Between Air Traffic Service and Vessel Traffic Service

3.1 Background

In Chapter 2, the types of vessel traffic service (VTS) and the concepts that are provided have been discussed. Similar to VTS, civil aviation authorities provide air traffic service (ATS). The paramount importance in the airline industry is the safety of passengers. There are similarities between ATS and VTS.

The International Civil Aviation Organization (ICAO) (1981), Rules of the Air has defined air traffic services as a generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service, area control service, approach control service or aerodrome control service. Both the ATS and VTS provide information service, advisory service and instructions, if necessary in defined sectors or areas. Therefore, there are similarities in the services provided by the ATS and VTS. In some aspects ATS differs from VTS. In this chapter, some comparison between the ATS and VTS in respect to the following will be drawn:

(a) Rules of Air and Sea;
(b) Types of Service;
(c) Guidelines and Criteria for ATS and VTS;
(d) Qualification and Training of operators;
(e) Relationship between ATS and Pilot vs VTS and Shipmaster; and
(f) Legislation governing the operators.

3.2 Rules of the Air

The ICAO (1981), Rules of the Air is in many aspects conceptually similar to the IMO (1990), International Regulations for Prevention of Collisions at Sea, 1972 as amended (COLREG). Some of the similarities are that the pilot-in-command is responsible for the operation of aircraft and shall have final authority as to the disposition of the aircraft. The rules for avoidance of collisions cover the right-of-way of an aircraft in a head-on situation, converging situation, overtaking situation and cruising levels. The lights to be displayed and signals with regard to distress and urgency are similar.

In the rules of the air, a submission of a flight plan is mandatory prior to operating any flight, including flights provided with air traffic control service, flights within or into designated areas, flights along designated routes and flights across international borders. Some of the key information submitted in the flight plans are estimated times at flight information region, cruising levels, cruising speed and route to be followed. Similarly, in a traffic organisation service provided by VTS, there is provision for the submission of a VTS sailing plan. Despite these similarities there are more collisions at sea than in the civil aviation. The statistics of collisions are shown in Table 1.

Table 1 – Statistics on Collisions

Year	No. of Collision Incidents at Sea	No. of Collisions between Aircraft
1990	21	1
1991	36	1
1992	25	1
1993	20	0
1994	16	0
1995	17	0
1996	29	1
1997	23	0

Source: Lloyds Register, (1990 – 1997) & http://www.airsafe.com. (2000, Mar)

Most of the collisions at sea occurred near the coast or within the coastal waters. Critics argue that aircraft manoeuvres and ship manoeuvres are not similar. Aircraft have three-dimensional freedom of manoeuvres, while vessels are restricted to two-dimensional freedom of manoeuvres. The aircraft could turn left, right, increase or decrease its altitude and moreover the air space is invariably free of obstructions. Whereas, the vessel's lateral movement is restricted due to close proximity of land, shoals and hazards.

Having noted the similarities between the rules of the air and sea, as well as the limitation and constraints, there are some areas in which maritime and port authorities could further improve to reduce the risks of maritime incidents. To address this, it is necessary to focus on how aviation authorities regulate and control air traffic so as to enhance the safety of air navigation without hampering freedom of passage.

3.3 Air Traffic Service

The ICAO (1978), International Standards and Recommended Practices for Air Traffic Service, pertains to the establishment of airspace, units and services necessary to promote a safe, orderly and expeditious flow of air traffic. These standards and practices have been established to ensure that flying on international air routes is carried out under uniform conditions designed to improve the safety and efficiency of air operation. The important aspect of these standards and recommended practices are that they not only apply to the airspace over the contracting State but also to airspace wherever the contracting State accepts the responsibility of providing air traffic services such as over the high seas or in space of undetermined sovereignty.

The objectives of ATS and VTS are similar i.e. to prevent incidents, expedite and maintain an orderly flow of traffic and provide advice and information useful for the safe and efficient conduct of navigation. The main difference between the ATS and VTS is that in civil aviation the contracting State must determine where the air traffic service will be provided, while for the coastal State, VTS is an option. It is also important to note that in civil aviation a State, by mutual agreement, may delegate to another State the responsibility for establishing and providing air traffic service extending over the territories of the former. It can be reasonably argued that air traffic service is a mandatory requirement imposed upon the contracting State.

3.4 Guidelines and Criteria for VTS

The IMO (1997b), Guidelines and Criteria for VTS, provides guidance to a coastal State or competent authority for the planning of VTS. The need to manage traffic should be carefully investigated and determined by analysing casualties, assessing risks and consulting local user groups. The guidelines further suggest that VTS is appropriate in areas where there exists high traffic density, traffic carrying hazardous cargoes, conflicting and complex navigational patterns, difficult hydrographical, hydrological and meteorological elements, a record of maritime casualties, *etc*.

Similarly, ICAO (1978), International Standards and Recommended Practices for Air Traffic Services, states that the need for air traffic service shall be determined by consideration of the types of air traffic involved, the density of air traffic, the meteorological conditions and such other factors as may be relevant. It also includes examples where there may be a need for air traffic services and one such example is that open stretches of water, mountainous, uninhabited or desert areas might necessitate the provision of air traffic services even though the amount or frequency of operation is extremely light.

A careful study of the guidance provided in IMO (1997b), Guidelines and Criteria for VTS, in particular the reasons to establish VTS, one could deduce that almost every port in the world and straits used for international navigation can justify the establishment of a VTS. However, it is not mandatory for coastal States to provide VTS, and if provided it may only be made mandatory in sea areas within a State's territorial waters. In civil aviation, aircraft enjoy freedom of passage too, but every international airport and civil aviation authority provides ATS to control and regulate air traffic within their airspace and up to the flight information region.

3.5 Guidelines on Qualification and Training of VTS Operators

There are more than 500 VTS systems in operation around the world and the services offered vary from a simple broadcast of navigational information to navigation related instructions. There are no formally recognised qualification, entry requirements and standards of training for VTS operators. IMO's investigation confirmed that the entry requirements vary between countries ranging from personnel without nautical knowledge to personnel with certificate of competency or pilot's licence. Also, recognised by IMO was that there was no fully defined standard of training to achieve the levels of knowledge and skill of the operators. This could be one of the reasons why shipmasters are reluctant to accept the advice of shore authorities to avoid an accident.

At the International Association of Lighthouse Authorities (IALA) (1996) symposium, it was concluded that international standards should be set for VTS personnel. VTS Authorities should also provide facilities for training to achieve these standards and institute measures to maintain it. IALA agreed to develop suitable training and certification standards.

IMO, being aware that a number of governments and international organisations have requested guidance for VTS and also recognising that the use of differing VTS procedures may cause confusion to shipmasters, adopted a resolution, IMO (1997c), to provide guidelines on recruitment, qualifications and training of

VTS operators. These guidelines and framework laid the foundation for the IALA to develop a comprehensive document on standards for training and certification of VTS personnel. Also, IALA undertook to establish model courses for training and certification, guidance on the recruitment of VTS personnel and a model for operational job descriptions.

The IALA completed its recommendations on Standards for Training and Certification of VTS personnel and submitted the document, IALA (1998a), to the IMO, Maritime Safety Committee (MSC). Tremendous efforts have been made by IALA to expedite the recommendations for the training and certification of VTS personnel. Also, the high level of expertise from the members of VTS Committee contributed significantly in developing these standards.

These recommendations were well structured and duly recognised the importance of achieving a professional standard among VTS personnel globally, comparable to seafarers and maritime pilots. These covered every aspect of VTS personnel, categorising them as operators, supervisors, managers or instructors. There is also provision for proper selection and recruitment including aptitude and medical tests. The requirements for annual assessment and revalidation ensure that professional competency is continuously maintained. It is very similar to the code established in the IMO, International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), as revised in 1995, stipulating clearly the requirements for competence; knowledge, understanding and proficiency; methods of demonstrating competence; and criteria for evaluating competence. In addition to these standards, IALA has now also completed the model courses for VTS operators and On-the-Job Training programme. The model course for VTS supervisors should be completed shortly.

A close observation of the training manual for air traffic controllers reveals that the provisions, structure and methodology of the standards for training and certification are conceptually similar except for the functional differences. It is interesting to note that it is not a prerequisite to be a seafarer or an aircraft pilot to be trained as a VTS operator or an ATS controller.

The IMO, 72nd Session of the Maritime Safety Committee[1] has approved to promulgate the IALA recommendations on Standards for Training and Certification of VTS Personnel through a circular to draw the attention of the VTS authorities. In author's opinion, it would have been much more appropriate, if these standards have been made mandatory and incorporated in the IMO, STCW. This would have ensured that VTS authorities complied with the standards and that there were sufficiently trained, qualified and competent personnel to manage the VTS. This would also have boosted the shipmasters confidence and enhanced the VTS operator and shipmaster relationship.

3.6 Legal Considerations – Relationship between ATC and Pilot Vs Relationship between VTS and Shipmaster

3.6.1 Relationship between ATC and Pilot

The Rules of the Air states that the pilot-in-command shall have final authority as to the disposition of the aircraft, and be responsible for the operation of the aircraft. However, in practise we know that aviation pilots comply with the instructions given by air traffic controllers (ATC).

Feedback obtained from air traffic controllers in Singapore indicates that the relationship between the ATC and the pilot is established by means of a flight plan. This flight plan is similar to a negotiated contract which binds the ATC and pilot. The pilot has a duty to maintain this plan unless he has valid reasons to depart from

[1] IMO, Report of the Maritime Safety Committee on its Seventy-Second Session, dated 31 May 2000, pp 32.

it. In the event that the ATC considers at a certain point of time during the flight that the aircraft may encounter a close quarter situation, or the separation distances may be affected, he may propose a modified plan. The pilot may reject the plan but normally it is resolved rapidly by both parties agreeing to a satisfactory plan.

The role of the ATC is to monitor the flight, acknowledge pilots' reports, and provide clearances for landing, taxiing, taking off, ascending and descending. The ATC may also accelerate or delay flights to maintain the necessary separation distance between any two planes. The ATC may also indicate the pre-determined procedures to achieve safety of aircraft, and pilots will normally follow these instructions. Discussion[2] has confirmed that ATC issue instructions such as change of courses, speeds, heights or rates of descent to pilots when there is potential conflict between aircraft or when the separation passing distance between the aircraft would result closer than that stipulated. These instructions are given to aircraft flying within the controlled airspace and must be complied with by aircraft pilots. For example, Swedish and British ATCs carry out such positive controls and there are sufficient provisions in their regulations to take action against the pilots for any non-compliance. Therefore, it is the ATC that proposes the modified plan and pilot executes the desired course of actions.

The internationally recognised certification and training standards for air traffic controllers has fostered a good relationship between pilot and ATC in the discharge of their respective responsibilities. Moreover, under the ICAO (1978), States, which are parties, have a duty to provide air traffic services. Hence a very high standard of professionalism and competency of ATC is maintained by civil aviation authorities.

[2] Author during the field trip to Swedish Air Traffic Services Academy (SATSA) on 16 Mar 2000, discussed positive controls by ATC with Director of SATSA. A former adviser to the Director-General of Swedish Civil Aviation Authority, confirmed that Swedish ATC issue instructions to pilots when there is potential conflict between aircraft or when the separation passing distance between aircraft would result closer than stipulated.

3.6.2 Relationship between VTS and Shipmaster

Strictly, the role of VTS is clearly defined as to provide information and advice. The shipmaster or pilot is responsible for the safe navigation of the vessel. The VTS has no authority to encroach or disturb the traditional relationship between master and pilot. It is traditionally accepted that the vessel's manoeuvre shall be executed from the bridge of the vessel by the master or pilot. However, there are exceptions to such practices. In the Port of Rotterdam, during adverse weather, shore-based pilotage assistance, often called remote pilotage, is accepted by shipmasters who are entering harbour or proceeding to a suitable location to embark the pilot.

In the case of VTS, even if a VTS operator possess specialised knowledge, and is an experienced pilot or a master mariner with command experience and with local knowledge, his instructions are viewed as interfering with the traditional role of the master. At the author's request a survey was conducted by PSA Marine pilots on vessels that call the Port of Singapore and frequently transit the Singapore Strait. A total of 20 shipmasters responded to the survey and without exception opposed VTS operators giving instructions regarding to ship manoeuvres. Shipmasters agreed that VTS had an overall picture of the traffic situation and with the latest updated information, VTS was in a better position than they were. However, the main concern of shipmasters in accepting the instructions from a VTS operator in close quarter situations were:

(a) the liability issues in the event of an accident; and

(b) the standard of training and level of competency of VTS operators in collision avoidance.

3.7 Legal Liability

The most important and controversial issue associated with the VTS system, is the liability aspect. Who is to be blamed when things go wrong? While the need for VTS, and the valuable contribution it makes to the safety of navigation, is recognised and accepted, the question of assignment of liability in the event of an accident is highly controversial.

The main debate is concentrated on, what is the extent of the liability of the VTS Authority when it is shown that the authority has been negligent or has committed an error. Basically, it is up to the authority to decide how much or how little liability it is prepared to accept for operations under its control. Although it has often been attempted, a State cannot legislate itself out of all liability[3]. In the event that an accident occurred due to instructions given by VTS operator, maritime laws of liability would be applicable. However, suits against governments are never easy. To avoid liability, VTS authorities are very clear in the types of service they provide. VTS operators do not provide instruction to shipmasters or pilots.

In civil aviation, although the pilot-in-command is responsible for the operation of aircraft, he complies with the instruction given by air traffic controller (ATC). Thus, a civil aviation authority, or other government authority or agency, which usually employs ATC is liable for civil action against negligent acts. In Australian National Airlines Commission v. The Commonwealth of Australia and Canadian Pacific Airlines[4], the Australian High Court heard a case involving the

---

[3] The HERMES [1969] 2 Lloyds Law Rep. 347 (Canada Exchequer Court), where the Conservancy Authority (the Crown) was unable to limit its liability owing to actual fault or privity with respect to damage and loss caused by misalignment of a leading light. The front light of a pair of leading lights had been moved by ice pressure over a period of years and the Conservancy Authority had failed either to undertake remedial action or to warn ships of the misleading character of the lights. As a consequence of this misalignment, the HERMES was close to the south bank of the channel. This caused a bank suction effect which resulted in HERMES sheering off-course and colliding with a ship proceeding in the opposite direction.

[4] [1977] 2 LMCLQ 204.

collision of two aircraft on a runway. The aircraft belonged to Australian National Airlines and Canadian Pacific Airlines, and the Commonwealth of Australia was the employer of the air traffic controller. The judge found that the airline pilots were equally at fault for the accident but that the air traffic controller was more at fault than either of the pilots. Each of the airlines was liable for 30% of the damages and the Commonwealth of Australia was liable for the remaining 40% of the damages.

In summary, there are many similarities between air traffic service and vessel traffic service. However, there are some areas in which maritime industry lack behind civil aviation. These should be addressed as follows:

(a) The standard for training and certification of VTS personnel should be made mandatory and included in the STCW to have an international standard so as to enhance the relationship between the VTS and Shipmaster;
(b) Pilots and ATCs have responsibilities for the safe navigation of aircraft. Therefore, the traditional law of the sea, recognising shipmaster as the sole judge of actions needed for the safety of his ship may no longer be valid;
(c) Civil aviation authorities are liable for the actions of their ATCs. Hence, IMO, IALA, VTS authorities, shipowners and shipping industry should work closely to establish a legal regime for VTS liability; and
(d) VTS could be made mandatory beyond coastal States territorial sea, EEZ and undetermined sovereignty including areas where VTS authority accepts responsibility. In civil aviation such provisions are available.

Chapter 4

Development of Technology to Enhance Safety of Navigation

4.1 Modern Technology

The introduction of any new technology involves in overcoming major obstacles. Rapid advancement in technology, particularly in the areas of information technology, satellite navigation and telecommunications, has led to continuous improvement in navigational aids. Many navigational equipment and navigational aids have been developed to enhance safety, security, effectiveness and efficiency of maritime transportation. This chapter focuses on some of these technologies that would further enhance the safety of navigation when applied or used by ships and VTS. The functional capabilities and contributions to the safety of navigation including the limitations of the following navigational tools would be evaluated:

(a) Electronic Chart Display and Information System (ECDIS)
(b) ENC data format
(c) Differential Global Positioning System & Global Navigational Satellite System – (DGPS & GLONASS)
(d) Automatic Identification System (AIS) transponders

4.2 Electronic Chart Display and Information System - ECDIS

The ECDIS has emerged as a promising navigational aid to maritime navigation. It is not just an electronically generated replica of a paper chart capable of displaying ship's position at a faster rate than manual plotting. The human error contributes up to 80% of accidents at sea (Chua, N.F. 1999). The resultant of fatigue and illness, loss of concentration, workload and stress were the contributing factors to the human error. ECDIS could assist to reduce the navigational workload, improve safety and efficiency of shipboard operations.

The ECDIS is a powerful integrated navigational tool, designed primarily for use in confined and congested waters. It is a real-time geographic information system that is capable of integrating different navigational positioning systems and ship equipment with the electronic navigational chart (ENC). For example, when ship's equipment such as radar and automatic radar plotting aid are superimposed on a single display system, it would provide position monitoring capabilities and collision avoidance detection. It has features to warn the mariners of any imminent danger so that they could have sufficient time to react. It enables mariners to do things that were previously not possible and also to do it safely, such as the use of low visibility transits in confined waters. The ECDIS also enables one mariner to pass on the knowledge to another. For example, navigational information pertaining to a certain voyages could be maintained and shared within the fleet from the ECDIS voyage information and passed on to other vessels for preview. Hence, sharing of this information would greatly increase the safety of future voyages undertaken by other vessels within the fleet.

It has been demonstrated in Great Lakes by installing ECDIS in almost all large bulk carriers that the prudent use of ECDIS could reduce levels of risk and increase the operational safety. Chua, N.F. (1999) commented that the collaboration between Canadian Hydrographic Service and Canadian Steamship Lines in the implementation of ECDIS on the latter's fleet was a success. Canadian Steamship Lines reported that there were improvement in safety, increase in profits and decrease in insurance premium. Bligh (1998) highlighted the benefits of ECDIS fitted on P&O Nedlloyd new ships. Some of these key benefits were as follows:

(a) ISM and STCW requirements for passage planning were met in a more timely and cost efficient manner;
(b) Accurate, clear and constantly updated charts;
(c) Navigating with the pilot onboard could be properly monitored;
(d) Recorded information could be replayed later as a useful training aid; and
(e) Integrated radar information.

However, some of the potential problems were the ability to delete data, reliability of information fed into the ECDIS, need to overcome the failure of the equipment whereby ships will not have charts to navigate and the importance of skill and proper training in ECDIS.

ECDIS not only benefits shipowners and navigators. It could also play an active role in shore-based navigational aids. At present VTS centres are changing from synthetic chart overlay to ECDIS to cover their areas of responsibility. In the near future VTS systems would make use of navigational safety broadcast services. In these so-called "Silent VTS systems", the location and movement of all vessels within the VTS area of responsibility would be broadcast as an overlay to a ship's ECDIS display using a standard format and protocol. In addition, the VTS centres would also be able to send recommended or mandatory route changes to be displayed on the ship's ECDIS and vice versa the ship could also transmit the planned route to VTS centres.

The knowledge of height of tide and strength of tidal stream are essential element in safe navigation. Often mariners have to rely on tide tables and broadcast from port authorities. The Maritime and Port Authority of Singapore has initiated the development of a tidal overlay on the ECDIS. This information would enable shipmasters, pilots and the Singapore VTS centre to plan the approach through the channels. Tidal information would be transmitted from the network of the newly installed real-time digital tide gauges and current meters around the Singapore waters. Other navigation related information would also be available on real-time basis through the VTS system such as updating of charts, automated notices to mariners, weather warnings and ice coverage downloaded via digital links.

4.3 Electronic Navigational Chart (ENC) Data Format

The International Hydrographic Organisation (IHO) in Monaco maintains copies of charts issued by the member States. There are about over 20,000 different charts covering various regions and in different languages. The primary objective of IHO is to comment on variances on chart construction. IHO consistently works towards to achieve standardisation in the specifications, symbols, styles and formats used for nautical charts. These are governed by the Charts Specification of the IHO and Regulations of the IHO for International Charts. The biggest challenge to IHO is to develop a common, worldwide chart series that would be produced to a single set of agreed specifications for use by international shipping.

There is also a need for survey data to be charted on common datum. Currently, there are hundreds of different chart datums and this is a serious problem. Mariners had failed to realise that in the past as they approach a harbour or port, navigating visually or with regional navigational systems they had automatically shifted to the usage of local chart datum. However, the GPS navigation system is based on a World Geodetic System, 1984 (WGS-84) datum, and it is essential to adjust the GPS value to the local datum. Unfortunately, in many cases this correction to local datum is not known to all mariners. Given this backdrop, one can imagine the problem mariners would face, if the ENC data formats were also not standardised.

Hence, IHO established the ENC standards in 1997 and it is known as the IHO Transfer Standard for Digital Hydrographic Data, S57-Edition 3. Also, included in these standards, as appendices were the ENC Product Specification and Object Catalogue which specifies the ENC objects that are to be displayed in the ECDIS to guide manufacturers. It should be noted that S57 Standards is a general transfer standard and not a display format. Hence, ENCs have to conform to the ENC product specification irrespective of their origin. Different ECDIS would work in different ways, however it is for the ECDIS manufacturer to translate the S57 Standards data to an internal format suitable to his equipment.

Due to the delays in providing the relevant international standards for ENC and the data, the use of electronic chart systems (ECS) using commercial data has increased over the past few years. ECS by definition is not intended to be a chart and it was difficult to ensure that they are not used. It was here that the raster chart display system (RCDS) entered the navigational arena and a number of hydrographic offices started producing them. Also, the unavoidable delay in extensive ENC coverage, there were calls for RCDS to be recognised officially in the absence of ENCs. RCDS has good track record and gathered positive reports from mariners. However, certain organisations are still opposed to the RCDS concept.

The "duel-fuel" philosophy was initiated by providing shared trials to fill up the gap or areas by RCDS where ENCs are not available. One such example is the trial between Singapore and Hong Kong and between ports in Europe. Participating vessels use ENCs in Singapore and Hong Kong and the official RCDS in Rotterdam, Felixstowe and its approaches. The ENCs by Singapore and Hong Kong are among the first to be produced that conform to the ENC product specification.

4.4 DGPS/DGLONASS

Global Positioning System (GPS) is a satellite-based global navigation system created and operated by the United States Department of Defense (DOD). It was originally intended solely to enhance military defence capabilities. However, it has been expanded to provide highly accurate position and timing information for many civilian applications.

It can be simply stated that GPS is based on twenty-four satellites in six orbital paths that circles the earth twice each day at an inclination angle of approximately 55 degrees to the equator. This constellation of satellites continuously transmits coded positional and timing information at high frequencies in the 1500-Megahertz range. GPS receivers with antennas are located in positions to pick up these satellite signals and use the coded information to calculate a position in an earth co-ordinate system. GPS is the most accurate worldwide all-weather navigation system, but not free from errors. One of the significant errors in this system is the intentional degradation of the satellite signal by the DOD. This intentional degradation of the signal is known as selective availability (SA) and is intended to prevent adversaries from exploiting highly accurate GPS signals and using them against the United States or its allies. This error in conjunction with poor satellite geometry could limit GPS accuracy to 100 metres at 95% of the time and up to 300 metres at 5% of the time. Fortunately, this error could be reduced or eliminated through a technique known as "Differential."

Differential Global Positioning System (DGPS) works by placing a high-performance GPS receiver (reference station) at a known location. Since the receiver knows its exact location, it could determine the errors in the satellite signals by measuring the ranges to each satellite using the signals received and comparing these measured ranges to the actual ranges calculated from its known position. The difference between the measured and calculated range is the total error. This error data for each tracked satellite is formatted into a correction message and transmitted to GPS users. These differential corrections are then applied to the GPS calculations, thus removing most of the satellite signal error and improving the accuracy to $\pm$ 5 metres. GPS is adequate for general navigational applications, however for mariners demanding precision services, DGPS is the ideal choice. DGPS is widely use in seismic surveying, hydrographic surveying, offshore construction vessels, dynamically positioned vessels, fast ferry autopilots and vessels navigating in confined waters.

Global Navigation Satellite System (GLONASS) is the Russian developed equivalent of the GPS. Its operation is similar to that of GPS System. The primary difference is that the satellite signals are not degraded by any form of selective availability (SA) and the system performance for civilian receivers will meet the requirement for horizontal position accuracy of $\pm$ 45 metres at 95% of the time. The drawback of this system is that in the current Russian economic situation, the priority of maintenance is low and there are only 15 operational satellites out of a full constellation of 24 satellites. This results in the system having inadequate number of satellites to calculate vessel's position. GLONASS accuracy is not suitable for navigation in harbour entrances and confined water without augmentation. Also, it does not provide instantaneous warning of system malfunction. However, with the augmentation i.e. the application of differential correction, the Differential GLONASS (DGLONASS) can enhance the accuracy to $\pm$ 10 metres at 95% of the time and offer integrity monitoring. Unfortunately, no similar differential processing techniques as that of DGPS has been made available for GLONASS. However, processing software is available for better accuracy of GLONASS.

There are some concerns on the over-dependence on the GPS technology. Although the United States had given its commitment to continue maintaining the GPS, it may be wiser not to rely on the status quo arrangement of free access. A pro-active approach should be adopted to prevent over-dependence on GPS and the possible alternative is the use of the Russian system, GLONASS. In spite of the IMO acceptance of the GLONASS as an approved satellite navigation system, the number of GLONASS products in the market is limited. The reluctance of equipment manufacturers to produce GLONASS or dual GPS/GLONASS receivers have raised concern on funding to maintain the system in the longer term. However, it could be counter-argued that if more equipment were manufactured and sold then the chance of long-term survivability of GLONASS would increase.

DGPS when integrated with ECDIS can provide 24-hour real-time positioning to prevent grounding incidents. These features could be effectively used in confined waters like the Malacca and Singapore Straits and in ports, especially during periods of poor visibility like haze and night-time. DGPS is an essential navigational equipment which complements the use of ECDIS and provides continuous and accurate positions. In this respect, Maritime and Port Authority of Singapore (MPA) has set up facilities to broadcast differential corrections in October 1997. The DGPS corrections to be applied to receivers are transmitted in the medium frequency (MF) band on 298 kHz. These corrections are transmitted free of charge by MPA to the shipping community and the public. These corrections could be received at a distance of at least 200 km from Singapore.

4.5 Automatic Identification Systems (AIS)

The VTS Committee of IALA including experts from IAPH, IAIN, IFSMA and IMPA undertook a study in 1988-1989 on the possible application of a transponder system which would permit ships to be identified and tracked when approaching, entering or sailing within a VTS area. An IALA (1990) paper outlining the requirements for ship identification, polling, tracking and automatic reporting system to operate in conjunction with VTS was submitted to the IMO Sub-Committee on Safety of Navigation. The initial focus was on ship-to-shore data exchange in support of vessel traffic management such as VTS. Subsequently, this transponder concept expanded to encompass the additional requirement for ship-to-ship data transfer to assist in collision avoidance. Hence, two VHF radio based transponder techniques emerged as follows:

(a) a transponder based on digital selective calling (DSC) protocols, using VHF channel 70; and

(b) a broadcast system, universal automatic identification system known as AIS using self-organising time division multiple access techniques.

4.5.1 Digital Selective Calling System

The Digital Selective Calling (DSC) system was primarily utilised to provide a transponder to exchange data from ships to shore on VHF channels. These transponders supported the shore-based identification, tracking and monitoring of vessels. Interrogation or polling has to be performed when a ship enters the VTS area. This technology proved attractive to several nations, as VHF DSC channel 70 has been designated for Global Maritime Distress and Safety System (GMDSS). Most of the European nations, North America and Japan have chosen Area A1 and A2 under GMDSS implementation arrangements. Thus, all ships operating in these area and coastal stations would be fitted with VHF DSC equipment. Also, this type of transponder could be implemented relatively quickly. Several such systems have been implemented in United Kingdom and United States. For example, the monitoring of ferries crossing the Dover Straits by the Channel Navigation Information Services (CNIS) and the Valdez (Alaska) VTS.

However, drawbacks of these systems were that radar detection was still necessary to initiate polling process and VTS operator intervention is frequently required. The capacity for message to be transmitted on VHF channel 70 was limited and sharing of this channel limited the transponder's rate of update. Hence, the DSC transponder did not receive the final endorsement from IMO on the performance standards.

4.5.2 Universal Automatic Identification System

The universal AIS was initially called the ship-ship, ship-shore (4S) system which originated from the Swedish manufacturer. This is a broadcast transponder operating on VHF maritime mobile band. It is capable of sending ship information such as identification, position, course, speed and other necessary information not only to shore but also to other ships. This AIS could handle multiple reports at a faster rate with the use of self-organising time division multiple access technology and ensured reliability during robust ship-to-ship operation. This system was also backward compatible with DSC systems, thus allowing shore-based GMDSS systems to establish AIS operating frequency channels, identify and track vessel equipped with AIS. A resolution, IMO (1998a) on the Recommendation on Performance Standards for an Universal AIS System was adopted at the IMO, 69th session of the Maritime Safety Committee in May 1998.

In busy waterways of harbours, ports, rivers, narrow channels and congested waters the continuous identification of vessels is essential for safety of navigation. Some of the benefits of AIS to shipmasters and VTS are as follows:

(a) Real-time tracking of own ship on ECDIS display with DGPS positions, course made good and speed made good;
(b) Presentation of predicted track when manoeuvring;
(c) Data recording of vessels tracks;
(d) Able to receive DGPS corrections from base station;
(e) Continuous broadcast of own ship's dynamic, static and voyage related data to other ships and VTS centre;
(f) Send and receive short message to and from VTS and other ships;
(g) Non-existent of radar based tracker problems such as target swapping and degradation due to sea clutter and weather;
(h) Higher update rate of tracks compared to radar tracks;
(i) Extension of VTS surveillance beyond normal radar range in EEZ and for Search and Rescue operations;
(j) Reduction of voice communication;
(k) Local navigational warnings;
(l) Local aids to navigation status;

With such significant benefits from the use of AIS, it is unlikely that AIS would render either radar or voice communications obsolete. For the start, non-

SOLAS vessel would not be required to be fitted with AIS. Many older SOLAS vessels will delay the installation of AIS, since there have been proposals to have provision in the SOLAS regulation for Administrations to exempt ships which will be taken permanently out of service within 2 years after the date of implementation. Hence, radar would remain the only detection and tracking system capable of handling all targets. Moreover, with the radar target broadcasting application, VTS radar would be retained. The radar target broadcasting is the process of converting radar targets to AIS targets and transmitting it to ships in the VTS area. This allows all ships fitted with AIS to view all targets held by VTS radar including targets from their own radar.

The use of AIS, as mentioned earlier, would reduce voice communication and minimise manual functions of VTS operators. However, it would still be necessary for exchange of information to vessels not fitted with AIS. Also, voice communication would be required in emergency situations and for immediate confirmation or acknowledgement when navigational assistance is provided.

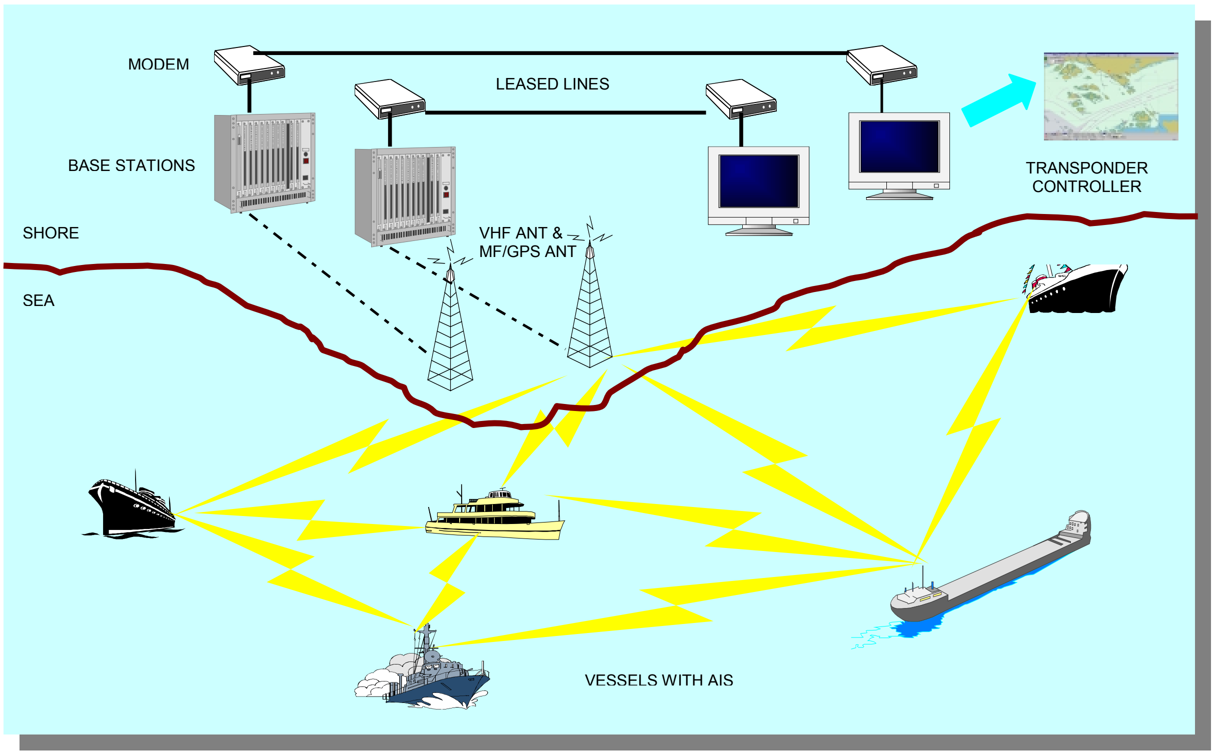
4.5.3 Singapore's Experience in AIS Transponder Technology

A pilot test of the AIS transponder, known as Ship Identification and Positioning System (SIPS) was conducted in Singapore from April to June 1999. The objectives of this pilot test were to evaluate the applicability, suitability and the effectiveness of tracking of vessels in the port waters and Singapore Strait. The operational and technical performance of the AIS transponder was based on IMO's recommended performance standards.

The SIPS comprised of a shore-based controller, a base station and 10 units of AIS transponders. The controller site was located at the Singapore Vessel Traffic Information Centre and linked to the base station via telephone lines. The AIS mobile transponders were installed on board vessels operating regularly from

Singapore such as cruise vessel, passenger ferry, container vessel and coastal tanker. It operated on two internationally approved AIS frequencies *i.e.* 161.975 MHz and 162.025 MHz. The system enabled vessels fitted with AIS transponders to transmit identity, position, speed, course and other voyage related information automatically to the control centre and to all participating vessels. The system could also transmit short messages from the control centre to the transponders, and vice-versa, via the transponder base station. Other features included an installation of DGPS beacon receiver at the AIS base station site to receive DGPS corrections from the Reference Station. The DGPS corrections were then transmitted from the base station via the AIS data link to the AIS fitted vessels. The schematic diagram of the infrastructure set-up is shown in Figure 1.

Figure 1: Schematic Diagram of Pilot Test Infrastructure



Source: Lim, Y.G. (2000, Jan).

The result of the pilot test indicated that the performance of the SIPS was satisfactory. The coverage test showed that the system could provide a good and reliable radio coverage within the port and Singapore Strait. The AIS playback system indicated that vessels tracking performance were good and logged at regular intervals. For vessels that were tracked by both the AIS and radar system, it was noted that AIS could maintain the vessel's tracks continuously even when two vessels came close to each other, while the radar tracks merged and were lost. The field transponders proved to be reliable after exposing to harsh tropical marine environment. The result of this pilot test was submitted to the IMO Sub-Committee on Safety of Navigation in September 1999.

In the next phase of the pilot test, Maritime and Port Authority of Singapore, would integrate the AIS base station with VTS. The tracked information from the AIS would be send to the VTS Multi-Sensor-Tracker and integrated with the radar tracks. This would ensure that only one unique track is displayed in the VTS surveillance system. Also, incorporated in the VTS, would be the capabilities to send and receive text messages; and visual displays to selected vessels or all vessels fitted with transponder and ECDIS terminal.

4.5.4 European Countries Experience in AIS Transponder Technology

Sweden and Finland have advanced very far in the development and implementation of AIS for vessels. Finland has successfully completed the Poseidon Project funded by European Union. Sweden has in the meantime successfully commenced with the installation of a network of base stations for AIS along its coastline. Finland will set-up its own network of base stations before the end of 2001.

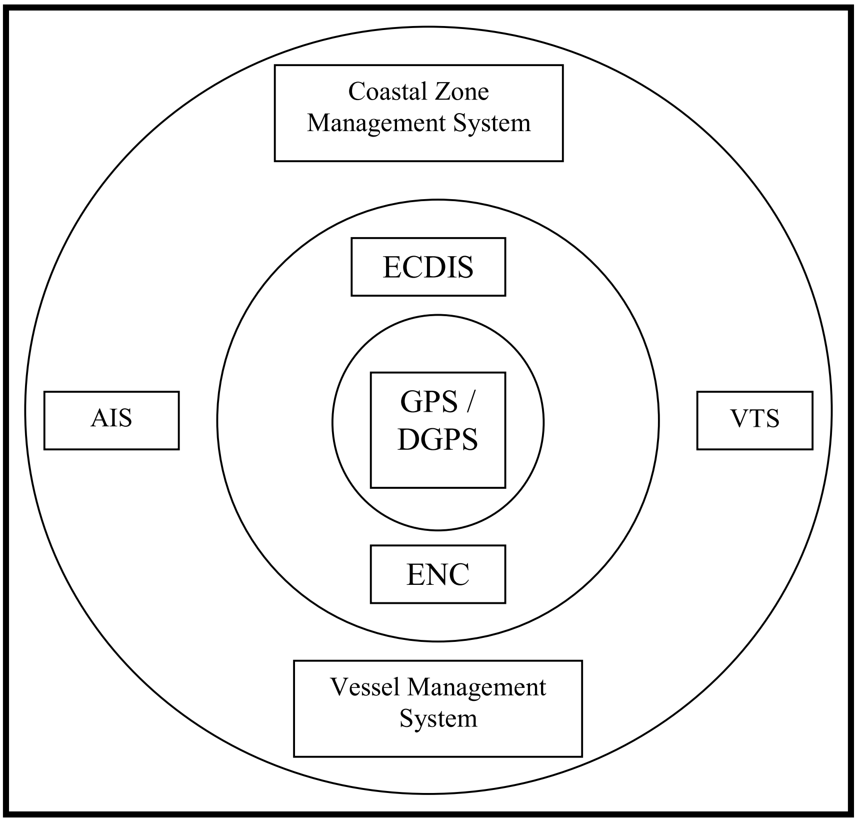
Another, successful pilot project conducted in June 1997 by the maritime administrations of Sweden and Germany was the Baltic Sea Ferry Guidance and

Information System (BAFEGIS). This project successfully demonstrated the use of AIS in conjunction with ECDIS and an information paper was submitted to IMO.

With the number of successful projects, the IMO Maritime Safety Committee is expected to approve the mandatory carriage of AIS transponders at its 73rd session in Dec 2000. All ships of 300 gross tonnage and upwards engaged on international voyages, all ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with AIS transponders. The implementation schedule will commence in July 2002 and will be completed not later than July 2008.

It is envisaged that in the near future, the integration of ECDIS, ENC, DGPS and AIS would form a core system to significantly enhance the safety of navigation and reduce marine incidents. Vessel traffic services, vessel management system and coastal zone management system would also effectively use this application. The schematic diagram in figure 2 shows the inter-relationship between the core system and other applications.

Figure 2: The "Core System" to enhance safety of navigation.



Chapter 5

A Comparative Analysis between Dover Strait VTS and Singapore VTS

5.1 Background

The Dover Strait and Singapore Strait are among the busiest shipping lanes in the world. Statistics from the United Kingdom, Maritime and Coastguard Agency shows that in 1999 there were about 70,688 vessel movements through the Dover Strait. Also, there were about 150 cross-channel ferry movements per day between the ports of United Kingdom, France and Belgium.

Similarly, for the year 1999, statistics from Maritime and Port Authority of Singapore indicates that there were 141,523 vessel arrivals in the Port of Singapore through the Singapore Strait. There were about 29,000 vessels transiting the strait without calling at the Port of Singapore. Also, included in the vessel movements were 120 cross-strait ferry movements per day between Singapore and Indonesia.

Vessel Traffic Services were introduced in the Dover Strait and Singapore Strait in 1972 and 1990, respectively. In this chapter, the comparative analysis between these two VTS systems will focus mainly on the following:

(a) the need for VTS system in the Dover Strait and Singapore Strait;
(b) roles and responsibilities of VTS Authorities;
(c) difficulties faced by these VTS systems; and
(d) analysis and comments by the author.

5.2 Need for VTS Systems in the Dover Strait and Singapore Strait

In 1960 and 1961, the number of collisions in the Dover Strait due to human error reached a level that could no longer be accepted by the coastal States. The United Kingdom, France and Germany undertook a comprehensive study and proposed a separation of traffic in the Dover Strait to the then Intergovernmental Maritime Consultative Organisation (IMCO). This study pioneered the introduction of an internationally recognised Traffic Separation Scheme (TSS) in the Dover Strait in 1967. Unfortunately, as it was on a voluntary basis, no procedures were established to ensure compliance, when navigating in the TSS.

In early 1971, a series of disasters struck in the Dover Strait. On 11 January 1971, a Peruvian cargo vessel PARACAS collided with a Panama registered tanker TEXACO CARIBBEAN. The tanker exploded and sank, and nine lives were lost. One of the causes of the incident was due to the cargo vessel PARACAS, which proceeded through the west bound lane, instead of the recommended east bound lane. The following day *i.e.*12 January 1971, the German cargo vessel BRANDENBURG hit the wreck of the TEXACO CARIBBEAN and sank. More lives were lost in this incident. Subsequently, on 28 February 1971, the Greek cargo vessel NIKI hit both these wrecks and also, sank with the entire crew onboard. A total of 49 lives were lost in this disaster.

In response to this disaster, preventive measures were taken to enhance safety of navigation in the Dover Strait by the then, IMCO. The key safety measures were the development of general principles of ships' routeing and the revision of the collision regulations, in particular, to include the conduct of navigation in the TSS. However, the United Kingdom, Department of Trade, then responsible for maritime safety, concluded from the above incidents that TSS in the Dover Strait was inadequate without surveillance and other information service. Hence, radar was installed at the St. Margaret's Coast Guard Station near Dover, and a surveillance system known as Channel Navigation Information Service (CNIS) was introduced in

1972. Since 1972, the United Kingdom, France and Netherlands have continuously enhanced safety in the Dover Strait through IMO and upgraded the surveillance systems with the latest technology. The area of radar coverage for the surveillance system in the Dover Strait is shown in Appendix 5. A summary of enhancements implemented in the Dover Strait is shown in Table 2.

Table 2 - Enhancement to Safety and Surveillance Systems in Dover Strait

Year	Enhancement
1972	• Revised International Regulations for Preventing Collisions at Sea was formulated at IMO; • IMO recommended that member States take action against their vessels which proceed against the direction of the TSS which were adopted by IMO; • Channel Navigation Information Service (CNIS) was established; and • UK regulation was amended to include that it was an offence for UK vessels to proceed against the direction of flow in a TSS.
1973	• France established radar surveillance and information service from Cap Griz Nez; and the Anglo-French Safety Navigation Group was formed.
1976	• CNIS radar coverage was enhanced by installation of new and longer range radars at St Margaret's Bay and Dungeness.
1977	• Revised International Regulations for Preventing Collisions at Sea came into force.
1979	• CNIS moved to the new operation centre at Langdon Battery at Dover; and • Voluntary system of Ship Movement Reporting known as "MAREP" was established.
1981	• Passage Planning Guide for mariners in the form of Admiralty chart No.5500 for English Channel was introduced.
1982	• CNIS commissioned the Automated Tracking and Data Processing System; and • Dover Strait TSS was aligned with the Casquets TSS and a larger separation zone was drawn to safeguard fishing grounds.
1983	• Netherlands initiated the Deep Draught Planning Guide for vessels with draught between 20.7 metres and 21.4 metres.

1985	• Standardised the arrangements in the Dover Strait, Casquets and Ushant TSS with regard to Information Service Broadcast and VHF Channels.
1989	• Amendments to Rule 8 and 10 of the International Regulations for Preventing Collisions at Sea were introduced.
1999	• CNIS upgraded the surveillance system with new technology and extended the radar coverage of Dover Strait; and • Mandatory Ship Reporting System known as "CALDOVREP" was introduced.

In Chapter 2, attention was drawn to the number of safety measures that were implemented by the coastal States (*i.e.* Indonesia, Malaysia and Singapore) to enhance the safety of navigation in the Malacca and Singapore Straits. Some of these measures are the establishment of an IMO adopted ship routeing system, rules of navigation in the Malacca and Singapore Strait, enhancement to aids of navigation, and mandatory ship reporting system.

Following closely on the developments in the IMO to enhance the safety of navigation, the Singapore Authority was aware and acknowledged that the general surveillance of shipping movements in the ship routeing system, including the establishment of cases of contravention, was only possible with the aid of radar system. Also, without the surveillance of movements of vessels in the Straits, ships, which contravened the TSS, would not sometimes be detected until and after an accident had occurred. Although, the situation in the Singapore Strait improved with the implementation of the ship routeing system, accidents could still occur and result in the following consequences:

(a) Pollution by oil and chemicals could affect the marine life, beaches, other vessels and seaward structures. Also, noxious chemicals escaping as a result of accidents such as collisions or groundings could be dangerous to people on the water and ashore. In addition, vast manpower and other resources would be required to remedy pollution damages.

(b) The width of the narrowest point in the Singapore Strait TSS that is used for navigation is about 0.7 nautical mile (1330 metres), and a serious accident could block the strait either fully or partially. Hence, there is little room to provide for an alternative route and the time required to clear the obstructions would take weeks. Therefore, ships calling at Singapore would have to be routed through the port waters and this would increase the risk of accidents within the port.

(c) With promotion of the tourism industry, passenger traffic across the Strait has increased over the years. Larger ferries are now capable of carrying about 250 passengers, and their lives would be at risk if a serious collision were to occur.

Prior to the establishment of VTS, port authority worked with only VHF radio communication and a simple database system. Therefore, the exact locations of ships were unknown and there was no real-time picture of the traffic situation. In 1988, the number of vessel arrivals was 44,855 and it was projected to increase by about 10% annually. It was recognised that increase in traffic would have an impact on navigational safety and port efficiency. Hence, a monitoring system was required to enhance the safety of navigation, protect the marine environment and facilitate the movement of vessels.

In 1990, Singapore commissioned a multi-radar system (*i.e.* five radars), known as the Vessel Traffic Information System (VTIS) to monitor vessel traffic in the Strait of Singapore. In 1995, another four radars were added to the existing system to monitor the port waters. The area of radar coverage for the surveillance system in the Strait of Singapore is shown in Appendix 6.

5.3 Roles and Responsibilities of CNIS and Singapore VTIS

Both the CNIS and Singapore VTIS operate on the basic principle of non-intervention. The roles of CNIS and VTIS are to monitor traffic in the strait, provide traffic information, navigational assistance and response to marine emergencies. Traffic information on vessels' positions, intentions (if known) and destinations are collected, recorded and disseminated to specific vessels on request for the purpose of safety of navigation. Additionally, general information is given to all vessels through radio broadcasts. This information includes warnings on restricted visibility, malfunctions of aids to navigation, obstruction in the traffic separation schemes, movements of deep draft vessels and unwieldy tows.

As real-time traffic information is available, specific navigational information is only provided to a shipmaster only upon request to assist him to better assess the situation concerning his vessel and the surrounding traffic or environment. Operators of both VTSs exercise great care to avoid the direct or tacit apportionment of blame, or issuing of direct or tacit steering instructions. However, in the case of Singapore VTIS, when two vessels are seen converging on each other without taking avoiding action, they would be warned by VTIS operators. The warning is given to individual vessels and comprises information about course, speed and relative position of the vessels. Also, a vessel that is observed to be heading towards shallow water would be warned and advised to take corrective action.

The unique responsibilities that both VTS have assumed include the observation of possible contraventions of maritime law, in particular, the contravention of Rule 10 of the COLREG and the pursuant of appropriate actions against any such vessel. Vessels that contravene Rule 10 of the COLREG and do not call at Authority ports would be reported to the vessel's Flag State to take appropriate action. In May 1999, CNIS operators observed the vessel WINTER STAR contravening Rule 10 of the COLREG. All vessels in the vicinity were warned and evidence of contravention using radar plots and statements were documented. The enforcement arm of the UK Authority met the vessel on arrival in the UK port. The unfortunate master was taken to court and was fined £10,000.

The Dover Strait is a strait used for international navigation. The implementation of 12-mile territorial sea brings the narrowest section of the Dover Strait under the territorial jurisdiction of United Kingdom and France. Hence, procedures have been established between the two countries with respect to the reporting of infringements and follow-up actions. Whilst the management of the Dover Strait is an international venture, the French are given primacy when considering vessel movements on their side of the median line. Likewise, the Singapore Strait is also used for international navigation and within the territorial jurisdiction of Singapore and Indonesia. Both countries have established similar procedures and Singapore initiates any necessary measures regarding contravention of TSS rules.

5.4 Difficulties Encountered by CNIS and Singapore VTIS

The operation of VTS is not without its problems. Although mandatory ship reporting systems have been implemented in the Dover Strait and the Singapore Strait, there are some vessels that do not participate in the reporting system, either because of ignorance or a blatant disregard for the need to report. Also, small craft, by virtue of their size, do not carry VHF radio and are not required to report. Thus, VTS operators are unable to identify all the targets that are tracked by radar and unable to respond to shipmasters when asked for information about a vessel that has not been identified. Hence, without the benefit of a radar transponder, it is virtually impossible to identify radar tracks beyond doubt.

Linguistic constraints create another significant issue in the operation of both VTSs. While most communications are conducted professionally with IMO Standard Marine Communication Phrases; difficulties are still encountered with ship's officers from non-English speaking countries. This results in information transfers being erratic and misleading. Radio traffic density and cross communications are also encountered when several vessels communicate simultaneously. To minimise VHF congestion, the Singapore Strait is divided into three sectors and each sector has an assigned VHF channel. However, CNIS maintains a single frequency of VHF operation to ensure that no important message would be missed either by the operator or transiting vessel.

5.5 Analysis

Generally, both the CNIS and Singapore VTIS have many similarities in the need for VTS, roles and responsibilities, and difficulties encountered in providing such a service. The summary of the comparative analysis is shown in Table 3.

Table 3: A Summary of Comparative Analysis.

Dover Strait - CNIS	**Singapore Strait - Singapore VTIS**
Need for VTS • Reduce marine incidents - arising from the sequence of disasters in 1971; • Inadequate surveillance of TSS; and • Protect the marine environment;	Need for VTS • Prevent marine incidents as any major oil or chemical pollution would affect the Port of Singapore; • Inadequate surveillance of TSS; • Protect the marine environment; and • Increase in vessel traffic.
Roles and Responsibilities • Monitor traffic in the Strait; • Provide traffic information; • Provide navigational warnings; • Provide navigational assistance when requested; • Respond to marine emergencies; • Observe contravention of TSS rules and report to enforcement unit; and • Non-intervention in the execution of vessel manoeuvres.	Roles and Responsibilities • Monitor traffic in the Strait; • Provide traffic information; • Provide navigational warnings; • Provide navigational assistance when requested; • Respond to marine emergencies; • Observe contravention of TSS rules and report to enforcement unit; • Non-intervention in the execution of vessel manoeuvres; and • Provide warning when it is apparent that there is a risk of collision or grounding and when inadequate actions are being taken by the vessels concerned.

Difficulties Encountered	Difficulties Encountered
• Some vessels do not participate in Mandatory Ship Reporting System; • Identifying radar tracks due to radar limitations; • Linguistic constraints; and • Radio traffic density and cross communication.	• Some vessels do not participate in Mandatory Ship Reporting System; • Identifying radar tracks due to radar limitations; • Linguistic constraints; and • Radio traffic density and cross communication.

Authorities of CNIS and Singapore VTIS have been continuously upgrading their VTS systems with the latest state-of-the-art technology and have significantly contributed in the enhancement of safety of navigation in the Dover Strait and Singapore Strait, respectively. The last five years' statistics indicate a gradual increase in vessel movements in the Dover Strait and Singapore Strait. The statistical record of vessel movements is shown in Table 4. The last three years' statistics of contravention of TSS rules, and marine incidents in both the straits are shown in Table 5 and Table 6, respectively.

Table 4: Statistics of Vessel Movements in the Straits of Dover and Singapore

Year	Dover Strait	Singapore Strait
1995	46,487	104,014
1996	50,458	117,723
1997	56,406	130,333
1998	63,840	140,922
1999	70,668	141,523

Source: Dover Strait - UK Maritime Coastguard Agency (Courtesy of Rod Johnson)
Singapore Strait - Maritime and Port Authority of Singapore (Port Master's Dept.)

Table 5: Statistics of Contravention of TSS Rule in the Straits of Dover and Singapore

Year	Dover Strait	Singapore Strait
1997	266	51
1998	261	37
1999	244	18

Source: Dover Strait - UK Maritime Coastguard Agency (Courtesy of Rod Johnson)
Singapore Strait - Maritime and Port Authority of Singapore (Port Master's Dept.)

Table 6: Statistics of Collisions in the Straits of Dover and Singapore

Year	Dover Strait	Singapore Strait
1997	7	8
1998	2	4
1999	2	3

Source: Dover Strait - UK Maritime Coastguard Agency (Courtesy of Rod Johnson)
Singapore Strait - Maritime and Port Authority of Singapore (Port Master's Dept.)

Collisions and contraventions of TSS rules continue to occur, in spite of the international effort to enhance shipboard equipment with modern technology; introducing safety rules, guidelines and regulations; and establishing international standards for training and certification for seafarers. The introduction of mandatory ship reporting systems *i.e.* CALDOVREP and STRAITREP in 1999 in both straits has significantly reduced the number of contraventions of TSS rules. However, in the article entitled, COLREGS Concern (2000) highlighted the increase in the number of contravention of TSS rules in the Dover Strait. Also, some viewed that the CNIS system was under strain at present and feared that it would be worse in the future.

Currently, both VTS authorities provide information service and navigational assistance service. These VTS authorities should consider the traffic organisation service as recommended in the IMO resolution (1997b) and the proposal made by O'Neil (1999) to have more shore control of ships through mandatory traffic control. The arguments for and against these measures will be evaluated in the succeeding chapters.

Chapter 6

Shore-based Control of Vessel Movements in Singapore Strait

"To keep ships afloat and to keep ships apart -
Is that a role of a VTS or the responsibility of the shipmaster?"
C J Parker

In spite of the implementation of numerous safety measures and types of service provided by the Singapore VTIS, there is still a significant potential risk of a major environmental and ecological disaster in the Singapore Strait. This is illustrated by the occurrence of the three (3) consecutive incidents in 1997, 1998 and 1999, which were highlighted in Chapter 2. Also, the increase in contravention of TSS rules and incidents in the Dover Strait were highlighted in Chapter 5. The VTS authorities are in a dilemma. When there is an increase in contravention or incidents, VTS is blamed for not taking sufficient preventive measures. On the other hand, shipowners, shipmasters, pilots and shipping associations have strongly opposed any proposal to have more shore-based control of ships through VTS.

VTS authority could further enhance the safety of navigation in the Singapore Strait and in this chapter the following shore-based control options will be evaluated:

(a) Pro-active control *i.e.* traffic organisation service; and
(b) Active control *i.e.* mandatory traffic control.

6.1 Traffic Organisation Service

Traffic organisation service is an another type of service that could be provided by VTS. It is important to note that the information service and navigational assistance could be provided independently. However, the traffic organisation service includes both information and navigational assistance services. The effective management and forward planning of vessel movements would prevent congestion and development of dangerous situations in the VTS area. This service includes the adoption of a mandatory reporting system, establishment of routeing systems, designating speed limit zones and operating a system of traffic clearances in respect of priority of movements. Any instruction issued to vessel should be result-orientated and the details of execution are left to the shipmaster. In providing this service, the VTS area could also be divided into sectors.

6.1.1 Pros and Con of Traffic Organisation Service

The principal argument in favour of the traffic organisation service is that the shipmaster and pilot are responsible for the safe navigation of the vessel. The freedom of navigation for vessels transiting the strait is not impeded. Therefore, it is favourable to shipowners. There is no issue of liability to VTS authority, as long as specific instructions with regard to vessel manoeuvres are not issued. Port and VTS authorities can carry out forward planning for arrival and departure of vessels to prevent congestion at the approaches to port and the strait

The argument against this service or control is that shipmasters sometimes take inadequate action to avoid collisions, in spite the timely information, warnings, and leaving the details of execution of manoeuvres to the vessel. For example, in the collision incident between the laden tanker EVOIKOS and the light VLCC ORAPIN GLOBAL on 15 Oct 1997, both vessels were warned. The VLCC ORAPIN GLOBAL was overtaking another vessel at a speed of about 12 knots, by navigating on the wrong lane of the TSS. The tanker EVOIKOS was attempting to cross the

TSS to proceed to the pilot station. Several warnings were given to both vessels by VTS but the action taken by both shipmasters were inadequate to avoid the collision. In regulating traffic, the decision-making process is always left to the shipmaster.

In the Maritime Accident Reporting (MARS), (1999) it was reported that a vessel due to call at the port of Singapore was advised while navigating in the Singapore Strait that the berthing time was amended. The shipmaster had an option to proceed to pilot station as scheduled or to a holding anchorage. Instead the master decided to reduce speed and loiter in the vicinity of the deep water route in the Singapore Strait. Timely warning by the VTS to a laden VLCC and a LNG carrier avoided a close-quarter situation. The comment from the shipmaster of the LNG carrier was that the traffic control was quick to tell us we were standing into danger, but not so quick to order the vessel, which caused it, to clear the TSS until her pilot time. Critics blame the Port and VTS authorities for poor planning and scheduling. In the author's view, the decision to take such an action was based more on commercial interest rather than safety of navigation (*i.e.* the vessel would incur additional pilotage and anchorage dues). The consequence of taking such an action is seldom realised by a shipmaster who does not have an overview of traffic situation in the Singapore Strait.

6.2 Mandatory Traffic Control

This is totally a new concept to improve maritime safety, which has been successfully implemented in the civil aviation field. In Chapter 2, for the purposes of this study, mandatory traffic control was defined as follows:

> Mandatory traffic control means the regulation and control of the movement of vessels in a designated area of an approved shore-based VTS adopted by the Organisation.

The term control means any instruction given by VTS authority to a vessel, when it is apparent that the action (or lack of it) being taken by a vessel to avoid a close-quarter situation is inadequate, inappropriate or otherwise not in compliance with the International Regulations for Preventing Collisions at Sea. Such instructions may include course alterations or changes in speed.

6.2.1 Pros and Con of Mandatory Traffic Control

The arguments for the introduction of mandatory traffic control are that, with the rapid advancement of information technology, satellite navigation and telecommunications, VTS has more information than shipmasters or pilots. The mandatory ship reporting system coupled with the mandatory carriage of AIS transponders would enable VTS to have the position, identity, radar track, speed and intended route of all vessels. The principle of shore-based control has been successfully accepted by civil aviation which was discussed in Chapter 3. In spite of the result-orientated instructions issued by VTS operators, shipmasters sometimes take inadequate action to avoid close-quarter situations.

The most important argument against mandatory traffic control is the controversial legal issue *i.e.* liability aspect. The main debate is concentrated on what is the extent of the liability of the VTS Authority when it is shown that the authority has been negligent or has committed an error. The Baltic and International Maritime Council (BIMCO) (2000), executive committee's response to introducing mandatory control was that empowerment of a shore authority to instruct shipmasters to execute manoeuvres is a contentious issue and shore authorities should be prepared to assume liabilities from the result of such instructions.

At the author's request a survey was conducted by PSA Marine Pilots on vessels that call the Port of Singapore frequently. Some of the pertinent comments from shipmasters and pilots, in addition to the legal liability issue were that the responsibility for safe navigation ultimately rests on the bridge of ships. The argument behind this was that ships have the best tactical information and can make the best decisions. VTS operators would not have the appreciation of a vessel's manoeuvring characteristics and capabilities. Other concerns were that the standard of training and level of competency of VTS operators in collision avoidance was inadequate. Radar target identification problems could not be totally resolved, as non-SOLAS vessels, coastal vessels, small craft and pleasure craft were not required to carry AIS transponders. It was further argued that the Singapore Strait is also used for international navigation and freedom of transit passage should not be hampered. Mandatory VTS should be limited to territorial sea.

6.3 Evaluation of Shore-based Controls

Traffic organisation service is suitable for forward planning, scheduling and regulating vessel movements to prevent congestion. From the previously mentioned two incidents in paragraph 6.1.1, result-orientated instructions are unable to prevent close-quarter situations. The arguments and concerns against the mandatory traffic control are valid but not unsolvable. If these issues and concerns were addressed satisfactorily, then the mandatory traffic control could be accepted.

6.3.1 Liability Aspect

If the need for VTS and the valuable contribution it makes to the safety of navigation is readily recognised and accepted, the question of assignment of liability in the event of an accident is highly controversial. A State cannot legislate itself out of all liability and this was illustrated in Chapter 3, in the cases of The HERMES[5] and Australian National Airlines Commission v. The Commonwealth of Australia and Canadian Pacific Airlines[6]. In the event that an accident occurred due to

[5] [1969] 2 Lloyd's Law Rep 347 (Canada Exchequer Court)
[6] [1977] 2 LMCLQ 204.

instructions given by VTS operator, maritime laws of liability would be applicable. However, suits against governments are never easy.

Precedents have been set in the transfer of liability to ships. For instance, in many jurisdictions, pilotage authorities have been permitted to limit their liabilities to a level where it is not worthwhile to litigate against pilots. Also, contracts of towage services transfer all liabilities to the tow. If, the liability is to be borne by the VTS authority, naturally the authority would need to take out insurance coverage and the cost would eventually be passed on to the shipowners. VTS is another navigational service provided by government to support the efficient operation of shipping at a reasonable cost. Similar fears were expressed by the maritime industry in the 1950s, when radar was fitted to ships. The issue was then liability of radar-assisted collision. It was well commented by Gold (1998) that it appears that those who oppose VTS, or are at least reticent about it, are quite prepared to exaggerate possible legal problems.

Lengthy debates on the liability of VTS may not be necessary, the legal and underwriting sector of the shipping industry is capable of absorbing VTS into maritime jurisprudence. The final execution of a manoeuvre, even if it was an instruction by VTS authority, still remains with the shipmaster. The other factor that should be taken into consideration is that ships are permitted to limit their liability under the international conventions[7].

6.3.2 Responsibility of Navigation ultimately lies on the Bridge of Ships

The shipmaster and pilot on board the vessel are in better position and have the full control of the vessel. Also the shipmaster knows his ship's manoeuvring characteristics, limitations and capabilities. Remote piloting is being practised in Germany, Belgium and Netherlands. Active pilots man the VTS and provide remote pilotage. Shipmasters comply with shore-based pilots' instructions to execute the

---

[7] Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC). International Convention on Civil Liability for Oil pollution Damage, 1992 (CLC). Future HNS Convention.

manoeuvres safely. Therefore, the principle of control need not be on the vessel but the timely and safely execution of the manoeuvre have to be carried out by shipmaster. Similarly, in the civil aviation, the pilot-in-command is responsible for the aircraft, but the ground-based air traffic controllers exercise positive control. The VTS operators must be adequately qualified, competent and trained to carry out such functions. The turning circles, transfer, advance and stopping distances of vessels vary in different conditions. This information as well as any peculiarity of the vessel could be provided to the shore authority in advance.

Hence the issue at hand is to define the respective roles, responsibilities and the liability aspects in areas where shore-based control is established. As for the VTS operators, the VTS authorities must ensure that the systems in place are of the highest standards, operated by well-trained and competent personnel in accordance to international standards. In addition, to the usual deterrent of termination of service, VTS operators should be subjected to the same criminal liabilities, fines, imprisonment, suspension or cancellation of certificates that normally applies to pilots and shipmasters.

6.3.3 Radar Target Identification

It is essential to have positive identity of all vessels and their intentions before providing positive control. With the mandatory carriage requirement of AIS transponders, the target identification problem should be resolved. The drawback is that it is only applicable to SOLAS vessels. However, with the radar broadcasting technology, VTS would be capable of identifying all vessels and providing that information to vessels fitted with AIS transponders. As explained in Chapter 4, radar target broadcasting is the process of converting radar targets to AIS targets and transmitting the information to ships in the VTS area. This allows all ships fitted with AIS to view all targets held by VTS radar including targets from their own radar.

6.3.4 Freedom of Transit Passage

UNCLOS and SOLAS provide an umbrella under the term regulate maritime traffic for the establishment of VTS systems within the territorial sea, straits used for international navigation and in the EEZ. This has been discussed in Chapter 2. The IMO (1997d), SOLAS regulation 8-2 permits VTS to be made mandatory in sea areas within a State's territorial sea. Hence, from a safety point of view, if VTS could contribute to the safety of navigation in the territorial seas, then it should be equally beneficial to extend it beyond the territorial sea. The conventions on COLREG and International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978, as amended (MARPOL 73/78) are not limited to territorial sea. The goal in regulating and controlling traffic movements is to ensure that international waterways are safe and available for international shipping traffic and should not be construed as impeding transit passage. Civil aviation has recognised the importance of providing air traffic service beyond the contracting State's airspace. Hence, provision has been made by ICAO for contracting States to accept responsibility for providing air traffic service beyond it's airspace such as over the high seas or space of undetermined sovereignty.

In summary, there are merits as well as drawbacks in introducing traffic organisation service and mandatory traffic control. Some of these drawbacks could be overcome by technology. The contentious liability and responsibility issues could be addressed in an appropriate international forum by applying the principles used by airline industry. The traffic organisation service and mandatory traffic control complement each other. In large and narrow waterways such as the Singapore Strait and the Dover Strait, traffic organisation service should be used to regulate traffic for efficient vessel movements and reduce congestion. In areas within these waterways, which have been identified as potential high risk areas where traffic organisation service is unable to prevent incidents, then mandatory traffic control should be considered.

Chapter 7

Implementation of Mandatory Traffic Control in Singapore Strait

"System Theory - When a component is added to a system,
there is a qualitative change in the system as a whole"
Seaways, June 1999

7.1 Implementations prior to the introduction of Mandatory Traffic Control in the Singapore Strait

In the previous chapter, it was established that mandatory traffic control could be introduced, provided the issues that are of concern have been resolved satisfactorily. Hence, to effectively introduce mandatory traffic control in the Singapore Strait, a number of essential requirements and measures need to be addressed and implemented. This chapter focuses on the following:

(a) Mandatory carriage of ship equipment;
(b) Shore based equipment and performance standards;
(c) Qualification and training standards for VTS personnel;
(d) Revision of the ship routeing system in Singapore Strait;
(e) Designate the area to be under mandatory traffic control;
(f) Changes to international conventions and collision regulations; and
(g) Legislation and liability

7.2 Mandatory Carriage of Ship Equipment

Singapore VTIS must be able to identify all vessels accurately and continuously in all types of weather condition before providing information or instructions. This should be achieved by the mandatory carriage of universal AIS transponders by all vessels. The capabilities and benefits of the AIS transponder were discussed in Chapter 4. The mandatory carriage requirement of AIS transponders by SOLAS vessels is being finalised in IMO. The proposed phase-in implementation schedule is expected to commence in July 2002 and be completed by July 2008. The SOLAS vessels are all ships of 300 gross tonnage and upwards engaged in international voyages; all ships of 500 gross tonnage and upwards not engaged in international voyages; and all passenger ships irrespective of size. These requirements would not cover all ships using the Singapore Strait.

The Maritime and Port Authority of Singapore's statistical record for 1999 indicates that about 13% of the vessel arrivals were less than 300 gross tonnage. Although, the record of marine incidents for the last three years (i.e. 1997, 1998 and 1999) indicates that all the vessels involved in collisions were above 300 gross tonnage, the smaller vessels navigating in the Singapore Strait still need to be positively identified. These smaller vessels are mainly coasters and tugs towing aggregate barges plying between the coastal States (*i.e.* Singapore, Indonesia and Malaysia). Hence, the coastal States have to address this issue. Since these smaller vessels report to VTIS centre and are identified, a radar broadcasting system could be incorporated into the existing VTS system. This system would allow ships fitted with AIS transponders to view and identify these smaller vessels through the VTS radar system.

7.3 Shore Based Equipment and Performance Standards

Currently, there are no performance standards for the VTS radar system and shore based equipment. Kruuse, T. (2000) recommends that performance standards for VTS radar systems, VTS equipment and related systems should be developed. Also, for the purpose of shore-based control, the VTS system has to be reliable, accurate and available around the clock.

In January 2000, the Maritime and Port Authority of Singapore commissioned its second VTS centre, which was developed at a cost of S$15 million. This centre is equipped with an integrated state-of-the-art marine surveillance, communication and information system. It combines the capabilities of various cutting edge systems, including the sophisticated radar-based VTS system. This new system is able to track up to 5,000 vessels in real-time. The existing VTS centre is being upgraded and would be linked to the second VTS centre. In normal operation, the two centres will take charge of separate operational areas. The centres will provide mutual back up for each other and be capable of taking over the other centre's operational areas. Wilson F. E. (2000) commented that the Singapore VTS system should be one of the six international models to be used for VTS testbeds for regional modelling.

Singapore has successfully completed the pilot test of the AIS transponder and details of the test are highlighted in Chapter 4. The next phase of the test is to integrate the AIS base station with the VTS system. The first phase of mandatory carriage of a AIS transponder on a vessel is proposed to come into force in July 2002. Therefore, the AIS base station, infrastructure and network to provide coverage in Singapore Strait needs to be operational by this date.

7.4 Qualification and Training Standards for VTS Personnel

Since 1990, the Singapore VTS operators have undergone comprehensive theoretical and practical hands on training in the VTS operations. The MPA has incorporated the recommendation of the IALA on Standards for Training and Certification of VTS personnel - IALA (1998a), in its training programme for VTS operators. Also, most of these operators have obtained tertiary education in the fields of maritime studies. The VTS supervisors are experienced master mariners or harbour pilots, adequately trained in VTS systems and operations, under the present concept. A number of supervisors have also been trained in Canada and have participated in various overseas VTS workshops and seminars.

Shore-based control, especially the mandatory traffic control is totally a new concept, which gives instructions to shipmasters or pilots to achieve a desired result, to avoid a close-quarter situation, or specific instructions for course alteration or changes in speed. Hence, the current training standards for VTS operators and supervisors may not be adequate for mandatory traffic control.

A computer-based system has been developed to assist VTS supervisors and shipmasters to identify potential close-quarter situations. MPA, in collaboration with Nanyang Technological University in Singapore, has developed a system, which extracts the real-time radar tracks of vessel from the VTS system to predict potential conflicts of vessels at variable time horizons and issue warnings when such conflicts are predicted. This system is known as Vessel-Conflict Prediction System (CPS). This system is now being further enhanced to incorporate the relevant rules from the COLREG; safety distance to pass danger areas taking into consideration the real-time input of the tidal stream; general manoeuvring characteristics and stopping distances of various types of vessel; and depth of water and sea room available for manoeuvring. This system will also be able to compute and offer several suitable options to the VTS supervisor. Shipmasters could also have access to this information through their AIS transponders. However, with such a computer based system, MPA will need to customise a comprehensive training programme including simulation training for VTS supervisors to ensure that they are well versed in international collision regulations and able to give precise and clear instructions to shipmasters or pilots so as to avoid close-quarter situations.

7.5 Revision of the Ship Routeing System in Singapore Strait

The traffic separation scheme (TSS) in the Singapore Strait between south of Raffles Lighthouse and south of St John's Island is narrow. The width of the westbound lane in this section is narrower than the eastbound lane. The eastbound lane includes a deep-water route with a controlling depth of 23 metres for the movement of deep draught vessels. The detailed dimensions of these lanes are provided in Appendix 7. This stretch of water is heavily utilised by many vessels arriving, departing and crossing the TSS lanes in order to call at the Port of Singapore. Moreover, regional ferries and VLCCs often cross the TSS lanes to proceed to neighbouring countries and single buoy mooring facilities, respectively. Hence, it is potentially a high risk area. Loaded tankers navigating through the deep-water route often keep very close to the traffic separation zone to have sufficient manoeuvring room and to avoid shallow waters. This might result in a loaded tanker straying into the opposite westbound lane thereby creating a head-on situation with vessels proceeding in the westbound lane.

To further enhance safety of navigation, streamline the traffic flow and facilitate mandatory traffic control, the traffic separation scheme in this area should be revised. The areas where depths are less than 23 metres in the eastbound lane adjacent to the deep water route should be dredged. Subsequently, both the lanes should be widened and straightened to minimise a series of course alterations when navigating in this stretch of water. The estimated quantity to be dredged is 500,000 cubic metres. The initial cost of dredging varies from S$50 million to S$100 million, depending on the nature of the material to be dredged (*i.e.* soft or hard material). It would be a huge financial burden for the coastal States to fund this project.

Currently, MPA provides VTS services free-of-charge. There is provision in Article 43 of UNCLOS for user States and States bordering the strait by agreement to co-operate in the establishment and maintenance of necessary navigational and safety aids or other improvements in support of international navigation. The IPS/IMO,

(1999) proposed a user pays system for states to defray maintenance costs in the Straits of Malacca and Singapore. One proposal was to establish a fund and managed by an international entity, which should include the littoral States, the IMO, major user states and others. It was suggested that burden sharing might be more agreeable and users to include flag states, exporting and importing countries, shipowners, insurance companies and major oil companies. Another proposal was that the existing fund known as Revolving Fund to which Japan contributes and managed by the three littoral States could be modified and widened to accept contributions from others. Therefore, the three coastal States may have to initiate a forum to obtain contributions from user States. The proposed revision of TSS and the areas to be dredged are shown in Appendix 8.

7.6 Designate the Area to be under Mandatory Traffic Control

The eastbound lane of the TSS in Singapore Strait is about 90 n.miles and the westbound lane is about 80 n.miles. Freedom of navigation in the straits must be maintained and not all areas within the Singapore Strait are narrow, congested and necessarily require mandatory control. It would be appropriate to identify and designate the area that should be under the mandatory traffic control. A formal safety assessment should be carried out to identify the narrow waterways which are congested, highly utilised and incident prone areas.

In 1997, MPA carried out an in-house project to reduce traffic risks in the Singapore Strait and port waters. From the empirical data, it was identified that the high risk areas in the TSS of Singapore Strait were between south of Raffles Lighthouse and south of Changi Beacon. This area is marked as sector 8 in Appendix 4. The recent collision incidents in the Singapore Strait highlighted in the Table 6 occurred within this area. Also, along this sector there are five pilot disembarkation grounds, four pilot boarding grounds and two precautionary areas to facilitate cross traffic. For the start, it is proposed that the sector 8 of the STRAITREP operational area should be designated for mandatory traffic control (refer to Appendix 4). It is important to take note that this sector is not entirely within the territorial sea of Singapore.

7.7 Changes to International Conventions

7.7.1 SOLAS Chapter V

The Singapore Strait is a strait used for international navigation, bordered by three coastal States with multi-jurisdiction and monitored by Singapore VTIS. Although Singapore VTIS could establish traffic organisation service, it would not have the necessary power to implement mandatory traffic control in the Singapore Strait beyond its territorial sea.

IMO would need to amend SOLAS Chapter V, Regulation 8-2 to include that a State may by mutual agreement, delegate to another State the responsibility for establishing a mandatory VTS to cover its territorial sea. Also, contracting Governments should refer such agreements to IMO for adoption, and masters of ships must comply with the requirements for VTS systems adopted by IMO. It should be noted that similar provisions have been included for air traffic services in ICAO (1978).

7.7.2 International Regulations for Preventing Collisions at Sea

Currently, there is no special rule in the Convention on the International Regulations for Preventing Collisions at Sea, 1972 as amended (COLREG) that provides details of conduct of vessel in the area under the control of VTS system. However, there is provision in the COLREG, Rule 1(b) that states:

> Nothing in these Rules shall interfere with the operation of special rules made by an appropriate authority for roadsteads, harbours, rivers, lakes or inland waterways connected with the high seas and navigable by seagoing vessels. Such special rules shall conform as closely as possible to these Rules.

There is also provision in COLREG, Rule 10 for conduct of vessels navigating in a traffic separation scheme adopted by IMO.

IMO should amend the COLREG, Rule 1 to include that mandatory traffic control by VTS may be adopted by the Organisation for the purpose of these Rules. A new Rule 10-1 should be developed, similar to COLREG, Rule 10 for the conduct of vessels in areas designated as mandatory traffic control by VTS. This rule should include that a master of vessel shall comply with directives given by VTS for the safe navigation of vessels such as to proceed along a designated route, alteration of course, or changes in speed to avoid close-quarter situations. Also, provision for a master to depart from this rule in order to avoid any immediate danger or collision.

These amendments to conventions would ensure that there are unified rules for mandatory traffic control and enhance the relationship between VTS operator and shipmaster.

7.8 Legislation and Liability

The legal issues are perhaps the biggest hurdle that needs to be resolved, and necessary legislation formulated, prior to the implementation of mandatory traffic control. The VTS regulations should clearly define the area of jurisdiction of the VTS authority; the types of vessel to which these regulations apply; the standards for training and certification of VTS personnel; the relationship between VTS personnel and shipmasters or pilots; and the penalties for non-compliance of regulations. The legal liability of a VTS authority, VTS personnel, shipmasters and pilots, in the event of an accident due to mandatory traffic control, should be determined and legislated.

It is essential that the requirements and measures discussed above be implemented for the successful establishment of mandatory traffic control in the Singapore Strait. The requirements, such as shore based equipment; mandatory carriage of ship equipment; and standards for training and certification of VTS personnel, are already in place, or can be implemented in the near future by the VTS authority. Coastal States' co-operation and agreement are required for the revision of the ship routeing system. At the international level (initiated by IMO) amendments to SOLAS regulations and COLREG are required, along with compliance by shipmasters. Also, the liabilities of VTS, and a mechanism for funding the establishment of navigational aids in straits used for international navigation, have to be addressed.

In summary, it may be seen that introducing mandatory traffic control in Singapore Strait would be a complex and long drawn process, which would require a number of issues to be resolved locally, regionally and internationally.

Chapter 8

Alternatives to Mandatory Traffic Control in Singapore Strait

8.1 Alternate Measures

A number of measures have to be in place prior to the implementation of mandatory traffic control in the Singapore Strait. These have been discussed in Chapter 7. Issues such as amendments to IMO conventions and VTS liabilities might require extensive deliberation in IMO by member States before being adopted. Moreover, the call to introduce mandatory traffic control has not received international support and recognition. Therefore, alternative measures should be put in place to further enhance safety of navigation in the Singapore Strait.

These alternative measures should include the increase use of VTS safety benefits without encroaching into the traditional role of shipmaster and pilot. Some of these measures that would enhance the safety of navigation and the relationship between VTS and shipmaster/pilot are as follows:

(a) Pilotage service;
(b) VTS sailing plans and
(c) Pro-active management by VTS (*i.e.* traffic organisation service)

8.2 Pilotage Services

For centuries, pilots with local knowledge have assisted shipmasters to guide vessels in and out of ports and in waters where shipmasters were unfamiliar or considered hazardous. In 1968, IMO recognised the importance of employing qualified pilots and adopted a resolution, IMO (1968) to provide recommendations on pilotage. This resolution recommended that Governments establish pilotage services to improve safety of navigation and to define the types of ships for which compulsory pilotage would be applicable. Since 1968, IMO has continued to adopt resolutions, which encourage the use of deep-sea pilotage services in certain areas. A summary of these resolutions is shown in Table 7.

Table 7 - IMO Resolutions on the use of Pilotage Services

IMO Resolution	Summary of Recommendations
Resolution A.480(IX) adopted in 1975	Use of qualified deep-sea pilots in the Baltic.
Resolution A.486(XII) adopted in 1981	Use of deep-sea pilots in the North Sea, English Channel and Skagerrak.
Resolution A.579(14) adopted in 1985	Certain oil tankers, all chemical carriers and gas carriers and ships carrying radioactive material using the Sound should use pilotage services.
Resolution A.620(15) adopted in 1987	Ships with a draught of 13 metres or more should use the pilotage services established by Coastal States in the entrances to the Baltic Sea.
Resolution A.668(16) adopted in 1989	Use of pilotage services in the Euro-Channel and IJ-Channel (in the Netherlands).
Resolution A.710(17) adopted in 1991	Ships of over 70 metres in length and all loaded oil tankers, chemical tankers or liquefied gas carriers, irrespective size, in the area of Torres Strait and Great North East Channel, off Australia, to use pilotage services.

Source: IMO (1998b). IMO and the safety of navigation, Focus on IMO.

In the general provision of rules for vessels navigating through the Straits of Malacca and Singapore, IMO (1991), it is stated that all deep draught vessels and VLCCs navigating within the traffic separation scheme are recommended to use the pilotage service of the respective countries when they become available. The pilotage services of the littoral States have so far been limited to the ports, harbour and approaches thereto of the respective States. Since these rules came into force in 1981, vessel movements in the Straits have significantly increased. In the last decade, vessel arrivals in the Port of Singapore through the Singapore Strait have increased by almost three fold (*i.e.* 49,107 arrivals in 1989 to 141,523 arrivals in 1999).

Internationally, it is recognised that in appropriate circumstances competent deep-sea pilots can make an effective contribution to the safety of navigation in confined and busy waters such as the North Sea, English Channel and the Skagerrak. Hence, it would be appropriate for the three coastal States (*i.e.* Singapore, Indonesia and Malaysia) to establish a Pilotage Commission and develop rules and regulations for deep-sea pilotage service in the Straits of Malacca and Singapore. The council of the European Communities has set the precedent by establishing a North Sea Pilotage Commission. Establishing recognised deep-sea pilotage services not only contributes to the safety of navigation, but also ensures that adequately qualified deep-sea pilots by a competent authority of the coastal State provide these services. In addition, an IMO resolution could be adopted to recommend member States to take all necessary and appropriate measures to encourage ships entitled to fly the flag of their State to make use of this recognised deep-sea pilotage service.

This would aid shipmasters, particularly of deep draught vessels who are less familiar with the Straits and restricted by tidal windows to maintain an under keel clearance of 3.5 metres. However, compulsory pilotage in the Straits should be avoided so that vessels would continue to enjoy the right of transit passage and freedom of navigation. Moreover, any delays in pilotage service would cause congestion, increase shipowners' operating cost and hamper the safe passage of deep draught vessels.

8.3 VTS Sailing Plans

The IALA (1998b) recommends that a VTS sailing plan is an essential instrument for traffic organisation service and a major source of information to the VTS. This plan should include the estimated time of arrival in the VTS area and certain critical points where cross traffic is expected or areas where ships join or leave the Port of Singapore to transit the Singapore Strait. This would facilitate the streamlining and regulation of traffic flow, and provide an early warning to VTS operators and shipmasters on anticipated traffic situations. Also, VTS operators could provide early warnings to vessels, if there was any significant departure from the sailing plan, or an amendment to sailing plan was required due to special circumstances.

STRAITREP, a mandatory ship reporting system has been implemented in Malacca and Singapore Straits. Therefore, additional information that is required by VTS could be incorporated in the mandatory ship reporting system. The appropriate reporting format for such additional information is provided for in the resolution IMO (1997a). Hence, incorporating a VTS sailing plan with mandatory ship reporting requirements would not cause any inconvenience to shipmasters. In fact, there is an existing voluntary ships' reporting scheme for deep draught vessels and unwieldy tows to broadcast eight hours before entering certain critical areas in the Malacca and Singapore Straits.

8.4 Pro-active Management by VTS (Traffic Organisation Service)

The Singapore VTIS provides information service and navigational assistance service. An alternative option to mandatory traffic control that should be considered by Singapore VTIS is the pro-active management or traffic organisation service. The traffic organisation service has been discussed in Chapter 2 and Chapter 6, respectively.

The coastal States (*i.e.* Singapore, Indonesia and Malaysia) have established ship routeing system, mandatory ship reporting system and speed limits of 12 knots for deep draught vessels navigating in a designated deep water route in the Malacca and Singapore Straits. The additional information that is required for the VTS sailing plan could be incorporated into the mandatory ship reporting system as discussed in paragraph 8.3. The MPA has also developed a Vessel-Conflict Prediction System (CPS), which was highlighted in Chapter 7 that could predict potential conflicts of vessels at variable time horizons and issue warnings when such conflicts are predicted. Thus, Singapore VTIS has, in one way or the other, the necessary elements in place to establish the traffic organisation service in the Singapore Strait.

Currently, MPA regulates traffic movement within the port and provides channel clearances for vessel to proceed and depart from terminals. Operating one of the busiest ports and largest container terminals in the world, Singapore has the necessary capabilities and experience. Thus it could provide traffic organisation service in the Sector 8 of the STRAITREP operational area of the Singapore Strait (refer to Appendix 4). The main advantages of providing traffic organisation service are that it would not encroach into the traditional role of shipmaster/pilot. The responsibility remains with shipmaster/pilot to decide on the appropriate action to avoid a conflict. The controversial liability issue would not be a major obstacle for implementation of this service. The drawback of this service is that it can only be made mandatory within a State's territorial sea. However, 13 out of the 15 collision incidents that occurred in the last three years (refer Table 6 in chapter 5) were within the Singapore territorial sea.

Implementations of deep-sea pilotage service and traffic organisation service are relatively easier than the mandatory traffic control. It would be well supported by shipowners, shipmasters, pilots and maritime industry as the responsibility and liability issues remain status quo. Moreover, these measures would serve as a platform and would not affect the future implementation of mandatory traffic control. However, the coastal States still have to bear the consequences of an incident, if the shipmaster or pilot takes inadequate action to avoid it. Safety of navigation is of paramount importance in all navigable waters. VTS is established to enhance safety of navigation. Therefore it may not be prudent to restrict VTS mandatory application only within the territorial sea.

Chapter 9

Conclusions and Recommendations

"Maps, machines and man complement each other to ensure safety of navigation"
Capt. Mark Heah, 2Deputy Director/PortMaster, MPA

9.1 Conclusions

The importance of the Singapore Strait cannot be overstated. The IMO and the three coastal States, *i.e.* Singapore, Indonesia, and Malaysia have implemented many safety measures, including VTS in the Singapore Strait. The Singapore VTIS plays a major role in the safety of navigation by providing information, navigational assistance, advise and warnings to vessels. However, major incidents have not been averted. With the growing trend in vessel arrivals and the environmental sensitivity of the area, there are valid concerns about safety in the Singapore Strait. The existing safety measures that have been discussed in Chapter 2 may not be adequate. Collisions and contravention of TSS rule continue to occur, in spite of the international effort to enhance shipboard equipment and modern technology. This has been discussed in the comparative analysis between Dover Strait VTS and Singapore VTS in Chapter 5. Singapore VTIS could further enhance safety of navigation by providing shore-based controls, such as traffic organisation service and mandatory traffic control.

The application of new technology to ships and VTS, and their contributions to enhance the safety of navigation have been evaluated in Chapter 4. For effective mandatory traffic control, the essential navigational tools are ECDIS, ENC, DGPS and AIS Transponders. The integration of this equipment will form a core system and reduce marine incidents. Other computer-based system such as Vessel-Conflict Prediction System is essential to assist VTS operators in the decision-making process.

Shipowners, shipmasters, pilots and maritime associations preferred traffic organisation service than mandatory traffic control. These were because of the strong sentiment that responsibility of ship navigation lies with the shipmaster/pilot; VTS operators would not have the appreciation of vessel's manoeuvring characteristics and capabilities; and the controversial legal liability aspects of VTS. Mandatory traffic control is a new concept in maritime safety. Positive control has been successfully introduced in civil aviation. The maritime industry could learn from their experience and adopt the principles and concepts of ATS.

In civil aviation, the relationship between ATC and aircraft pilot has been enhanced and the responsibilities are being shared. This was made possible through an internationally unified standard for training and certification of air traffic service personnel. Similarly, the existing standards for training and certification of VTS personnel should be made mandatory to foster better relationship between VTS personnel and shipmaster.

The main concern in introducing mandatory traffic control is the liability aspect. The legal liability issues have been amicably resolved in airline industry. Shipping industry is capable of absorbing VTS into the maritime jurisprudence. Precedents have been set in the transfer of liability to ships, such as liability of pilot and towage services. IMO and IALA should initiate an appropriate international forum to discuss and resolve the extent of liability of VTS authority and VTS operator for negligent act.

Mandatory VTS is being restricted to within the territorial sea. There should not be a boundary or limitation for safety of navigation and protection of marine environment. Once again, precedents have been set. For example, COLREG are applicable in all navigable waters and MARPOL 73/78 regulates discharge of oil beyond territorial sea. Also, in civil aviation, air traffic service can be extended beyond the contracting State's airspace including over the high seas or in space of undetermined sovereignty provided it accepts the responsibility. Safety of navigation should have priority over freedom of passage and mandatory VTS should be extended beyond territorial sea. As discussed in Chapter 7, IMO should amend the SOLAS Chapter V, Regulation 8-2 to include mandatory VTS in straits used for international navigation. Also, the COLREG should be amended to include rules for conduct of vessels in IMO adopted mandatory traffic control, VTS schemes.

In evaluating the pros and cons of traffic organisation service in Chapter 6, two incidents were highlighted. These incidents indicate that result-orientated action may not be suitable in certain stretch of navigable waterways in the Singapore Strait which are narrow, restricted and congested. The master of the vessel who encountered the close-quarter situation commented that Singapore VTIS should have ordered the vessel to keep clear of the TSS.

It can be reasonably concluded that in the Singapore Strait, two types of shore-based control should be introduced. Traffic organisation service should be used to regulate traffic for efficient vessel movements and reduce congestion. Mandatory traffic control should be implemented in navigable waters within the strait, which are narrow, congested and have been identified as potential high risk areas. A total and practical approach has to be taken to enhance the safety in Singapore Strait. The revision of the ship routeing system in the Singapore Strait and deep-sea pilotage services would also improve safety and contribute to the effectiveness of mandatory traffic control.

9.2 Recommendations

The next step for Singapore VTIS is to progress from providing passive service to active service, to enhance safety of navigation in the Singapore Strait. Introducing shore-based control, especially mandatory traffic control is a long drawn process, which would require regional and international co-operation. The Singapore VTIS and the Singapore Strait would be an appropriate model that could be used internationally to establish mandatory traffic control. The Maritime and Port Authority of Singapore (MPA) should participate actively in the international fora to resolve the issues in establishing mandatory traffic control by VTS. Concurrently, safety requirements and measures should be implemented that would continue to enhance safety of navigation and facilitate mandatory traffic control. The recommendations are in two phases.

9.2.1 Phase 1 - For Traffic Organisation Service (Pro-active Management)

The Singapore VTIS Authority should designate Sector 8 of the STRAITREP operational area for traffic organisation service (refer to Appendix 4) and continue to provide information and navigational assistance service in the Sectors 7 and 9.

The Singapore VTIS Authority should enhance the existing Vessel-Conflict Prediction System (CPS) or develop a computer-based system for forward planning of vessel movements to prevent congestion and development of dangerous situations in the designated sector for traffic organisation service.

The Maritime and Port Authority of Singapore with the co-operation of the Indonesian and Malaysian authorities, should incorporate a VTS sailing plan in the mandatory ship reporting system requirements.

The three coastal States should establish a Malacca and Singapore Straits Pilotage Commission, similar to that of the North Sea Pilotage Commission and provide deep-sea pilotage services in the Straits of Malacca and Singapore. The three states should also work closely to adopt an IMO resolution to recommend that member States take all necessary and appropriate measures to encourage ships entitled to fly their flag to make use of this recognised deep-sea pilotage service.

9.2.2 Phase 2 - For Mandatory Traffic Control

The IALA Standards for Training and Certification of VTS Personnel are not adequate for the concept of mandatory traffic control. The Singapore VTIS Authority should customise a comprehensive training programme including simulation training for VTS supervisors to ensure that they are well versed in COLREG and able to give precise and clear instructions to shipmasters or pilots so as to avoid close-quarter situations.

The AIS transponders would enable to identify all vessels accurately and continuously. The first phase of mandatory carriage of AIS transponders on vessels is proposed to come into force in July 2002. Therefore, Singapore VTIS should establish the AIS base stations, infrastructure and network to provide coverage in the Singapore Strait by this date. Also, the radar broadcasting system, which was discussed in Chapters 4 and 7 to identify small vessels should be incorporated into the existing radar tracking system by July 2002.

Based on the empirical data, the Sector 8 of the STRAITREP operational area should be designated for mandatory traffic control. However, the Singapore VTIS

Authority should carry out a formal safety assessment to determine the appropriate sector or area for mandatory traffic control.

The SOLAS Regulation 8-2 and COLREG have to be amended to provide the mandate for mandatory traffic control. Also, the legal liability regime for VTS authority and VTS personnel has to be developed. It is recommended that IMO and IALA initiate an international forum to establish the liability regime and subsequently amend the relevant conventions. MPA should actively participate in these forums.

After the establishment of internationally recognised liability regime for VTS, the MPA should incorporate this regime into their relevant national legislation and regulations for the VTS authority and the VTS personnel.

The revision of ship routeing system in the Singapore Strait is an essential element for the effective operation of mandatory traffic control. There would be a huge financial burden for the three coastal States in this revision. Hence, the three coastal States should continue to work closely on the users pay principle to establish a fund for Malacca and Singapore Straits by an international entity for the necessary maintenance of navigational and safety aids or other improvements in support of international navigation.

Mandatory traffic control is a controversial issue and the conclusions and recommendations drawn may be bold. Shipowners, shipmasters and pilots would have many arguments against the introduction of mandatory traffic control. All issues and concerns can be addressed and resolved. Technology is so advanced that it is virtually possible to control many things remotely. It is up to the users to determine the extent of control that should be exercised. Those who oppose it should look at it objectively to enhance safety of navigation than exaggerate the possible traditional responsibilities and legal problems.

BIBLIOGRAPHY

Aircraft Collisions (1990-1997). Available: http://www.airsafe.com. (2000, Mar)

Andreasen, C. (1994). The IHO, Electronic Charting and the Changing Relationship to Ports, International Hydrographic Review, Monaco, LXXI, (2). Monaco: IHO.

BIMCO Executive Committee. (2000). Owners Cool on Extending VTS Responsibility. NUMAST Telegraph, Mar 2000, 33 (2), 16.

Bligh, S.E. (1998). ECDIS: What are the potential benefits for the Shipowner and Professional Navigator, International ECDIS Conference, Oct 1998, Singapore, (pp 29 – 41). Singapore: LLP (Singapore).

Chua, N.F. & Chen, Y.K. (1999). The Development of Electronic Chart Display and Information System (ECDIS) – The Singapore Experience. Singapore Maritime & Port Journal, 39 - 42.

Clarke, J.P. (1988). Worldwide Availability of Official Electronic Charts, International ECDIS Conference, Oct 1998, Singapore, (pp 105 – 110). Singapore: LLP (Singapore).

COLREGS Concern (2000). NUMAST Telegraph, Feb 2000, 33, (2), 16.

Corbet, A.G. (1989). Development of Vessel Traffic Services: Legal Considerations, Maritime Pollution Management, 16, (4), 277-292.

Cuyvers, L. (1986). The Strait of Dover, 8. The Netherlands: Martinus Nijohff Publishers, Dordrecht.

Gold, E. (1984). The New Law of the Sea and Vessel Traffic Services. Vessel Traffic Services, 5, 179-181.

Gold, E. (1988). Who is to blame when things go wrong?, Seaways, Oct 1988, 5 -7.

Hughes, T. (1999). Vessel Traffic Services. Seaways, Sept 1999, 9-11.

International Association of Lighthouse Authorities (IALA) (1990). Requirements for a ship identification, polling, tracking and automatic report system to operate in conjunction with VTS. NAV 36/18/3, 6 June 1990. London: IMO

IALA (1996). 8th International Symposium on Vessel Traffic Services: Port of Rotterdam VTS '96, 15-20 Apr 1996, Rotterdam. Rotterdam: Author

IALA (1998a). IALA Recommendations on Standards for Training and Certification of VTS Personnel. IALA Recommendation V-103, May 1998. France: Author.

IALA (1998b). Vessel Traffic Manual. France: Author

International Civil Aviation Organization (ICAO) (1978). International Standards and Recommended Practices – Air Traffic Services, Annex 11 of the Convention on International Civil Aviation, (7th ed.). Montreal: Author.

ICAO (1981). International Standards– Rules of Air, Annex 2 of the Convention on International Civil Aviation, (7th ed.). Montreal: Author.

International Maritime Organization (IMO) (1968). Recommendation on Pilotage, (Assembly Resolution A. 159(ES.IV). London: Author.

IMO (1990). International Conference on Revision of the International Regulations for Preventing Collisions at Sea, 1972, (1990 ed.). London: Author.

IMO (1991). Ship Routeing, (6th ed.). London: Author.

IMO (1997a). General Principles for Ship Reporting Systems and Ship Reporting Requirements, including Guidelines for Reporting Incidents involving Dangerous Goods, Harmful Substances and/or Marine Pollutants, (Assembly Resolution A.851(20)). London: Author.

IMO (1997b). Guidelines and Criteria for VTS, Annex 1, (Assembly Resolution A.857(20)). London: Author.

IMO (1997c). Guidelines on Recruitment, Qualifications and Training of VTS Operators, Annex 2, (Assembly Resolution A.857(20)). London: Author.

IMO (1997d). International Convention for Safety of Life at Sea, 1974. (1997 ed.) London: Author.

IMO (1998a). Performance Standards for a Universal Automatic Identification System (AIS), (Maritime Safety Committee Resolution MSC.74(69)). London: Author.

IMO (1998b). IMO and the safety of navigation, Focus on IMO, Jan 1998 (pp 12). London: Author.

IMO (2000). Report of the Maritime Safety Committee on its 72nd Session, May 2000, MSC72/23. London: Author.

Institute of Policy Studies (IPS) & IMO (1999). Funding and Managing International Partnerships. Navigational Safety and the Control of Pollution in the Straits of Malacca and Singapore, 14-15 Oct 1999 - Singapore. Singapore: IPS

Kruuse, T. (2000). Conference recommendations. VTS 2000 Symposium, Jan 2000, Singapore.

Lim, Y.G. (2000). Application of AIS Transponder Technology for the Port of Singapore. VTS 2000 Symposium, Jan 2000, Singapore, session 8, paper 1. Singapore: LLP (Singapore).

Lloyds Register, (1990 – 1997). World Casualty Statistics. London: Author

Maritime Accident Reporting (MARS) (1999). No: 982028. Safety at Sea International, Jan 1999, 26.

Muirhead, P. (2000). GPS and DGPS – An Introduction. Unpublished lecture handout, World Maritime University, Malmo, Sweden.

Neill, H.J. (1999). The Channel Navigation Information Service for the Dover Strait, Journal of Navigation, 43 (3), 331 -342.

Ng, W. K. (1998). Design and Implementation of A Maritime Conflict Prediction System, International ECDIS Conference, Oct 1998, Singapore, (pp 261–266). Singapore: LLP (Singapore).

O'Neil, W. (1999). Keynote Address. IPS-IMO International Conference on the Malacca and Singapore Straits, 14-15 Oct 1999, Singapore, pp. 2-3.

Plant, G. (1995). A legal analysis of mandatory ship traffic systems, Competing Norms in the law of Marine Environmental Protection, (11 – 29). London, The Hague: Kluver Law.

Raja Malik, (1998). Navigational Safety in the Strait of Malacca. Singapore Journal of International & Comparative Law,2, (pp 476 - 478). Singapore: National University of Singapore.

Segar, M.A. (1999). Mandatory Ship Reporting System. Singapore Maritime & Port Journal, 16 – 19.

SIGGTO (1999). Results of a survey of SIGGTO members transiting the Straits of Malacca and Singapore conducted from December 1998 to June 1999. London: Author.

The GPS/DGPS Revolution (1999). Seaways, Aug 1999, pp 3-7.

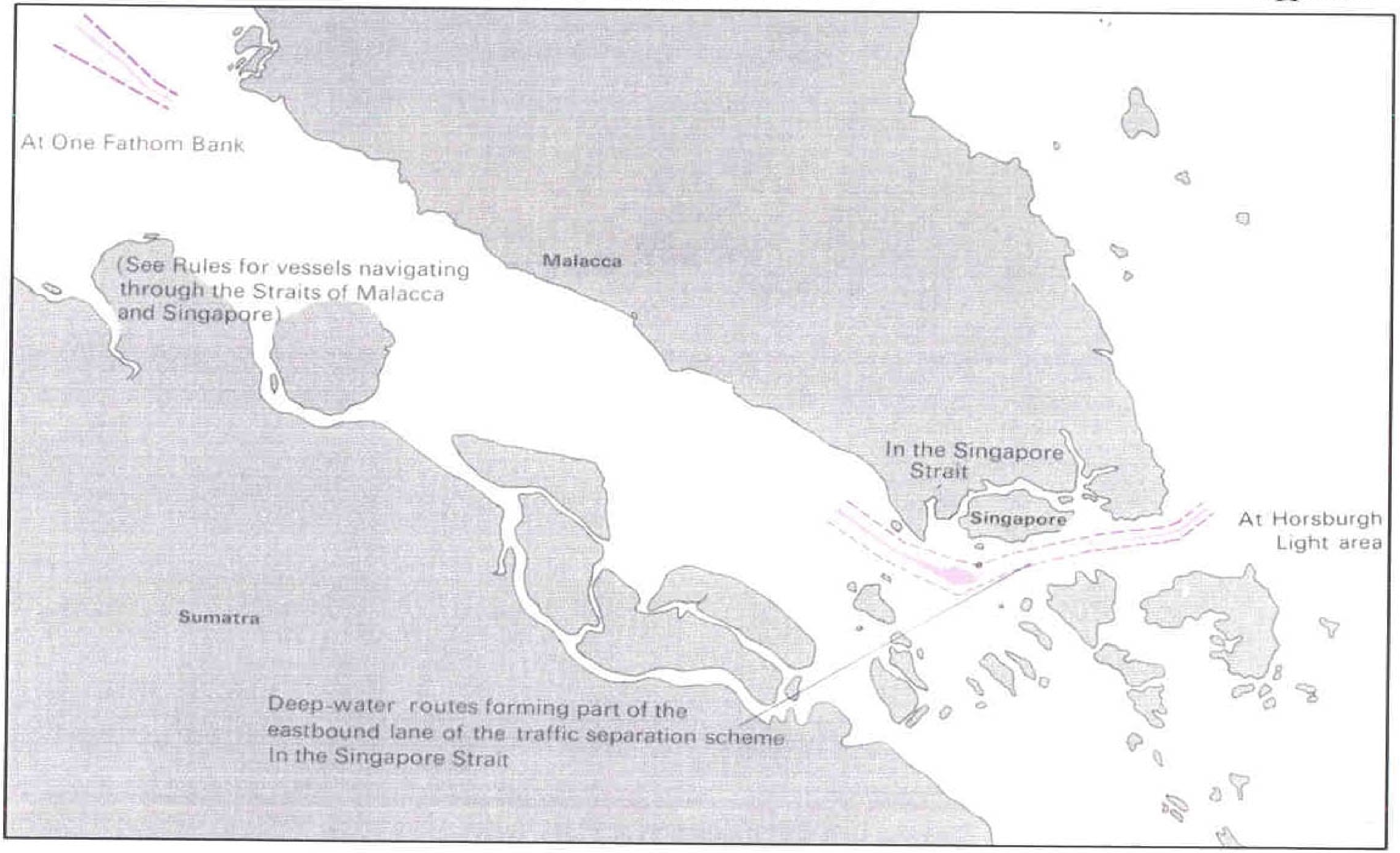
The Nordic Experience (1999). Safety at Sea International, Feb 1999, 12 - 14.

United Nation. (1982). United Nations Convention on the Law of the Sea. London: Author.

Wee, H. L. (1999). Revised Routeing System and Traffic Separation Scheme in the Malacca and Singapore Straits. Singapore Maritime & Port Journal, 7–15.

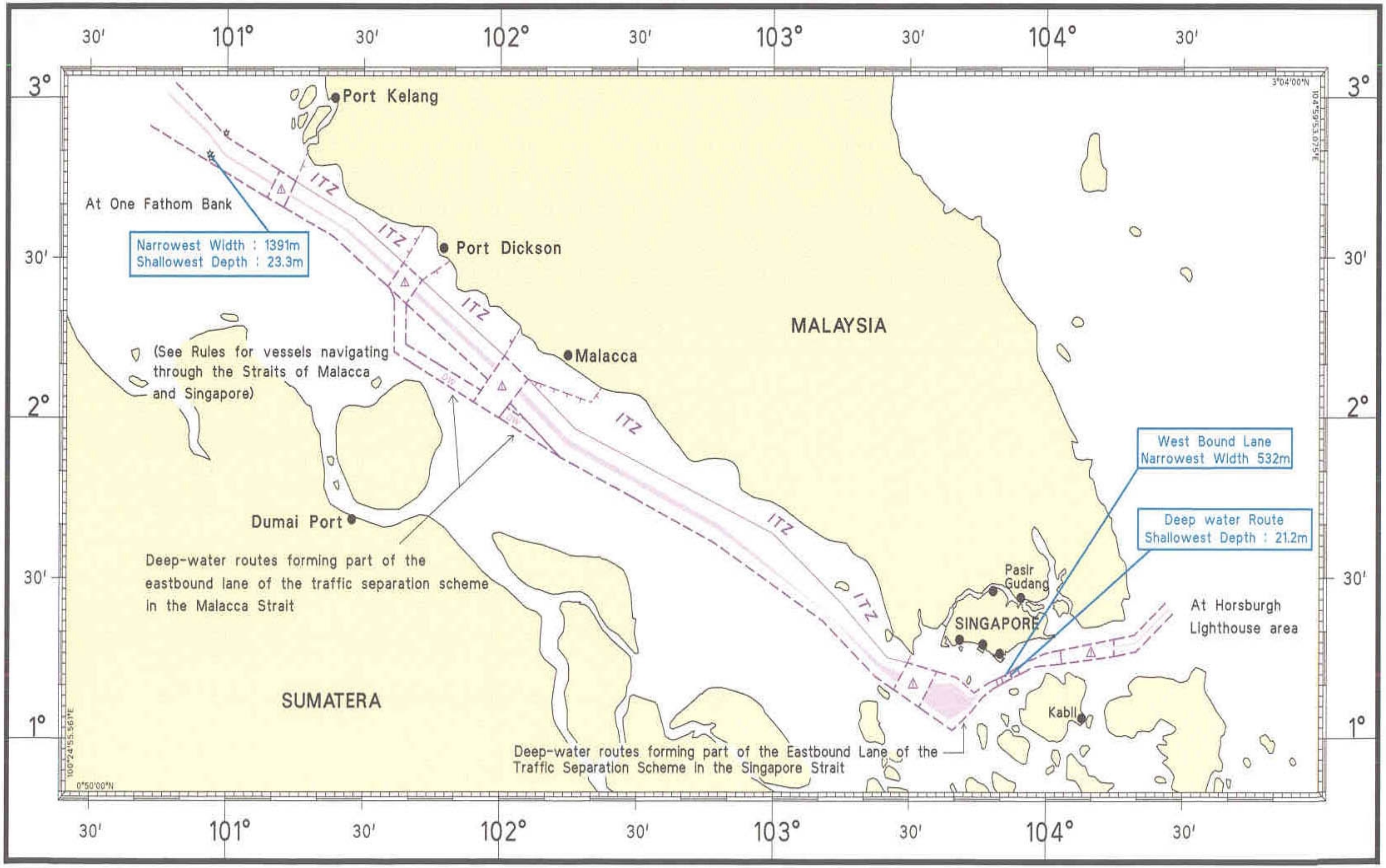
Wilson F. E. (2000). International VTS Testbeds Now for Developing a Globally Compliant Maritime Capability, VTS 2000 Symposium, Jan 2000, Singapore, session 4, paper 3. Singapore: LLP (Singapore).

Traffic Separation Scheme on Malacca and Singapore Straits, 1981



Source: IMO Ships' Routeing, 6th Edition, 1991 (pg V/1-1)

Extended Traffic Separation Scheme in Malacca and Singapore Straits, 1998

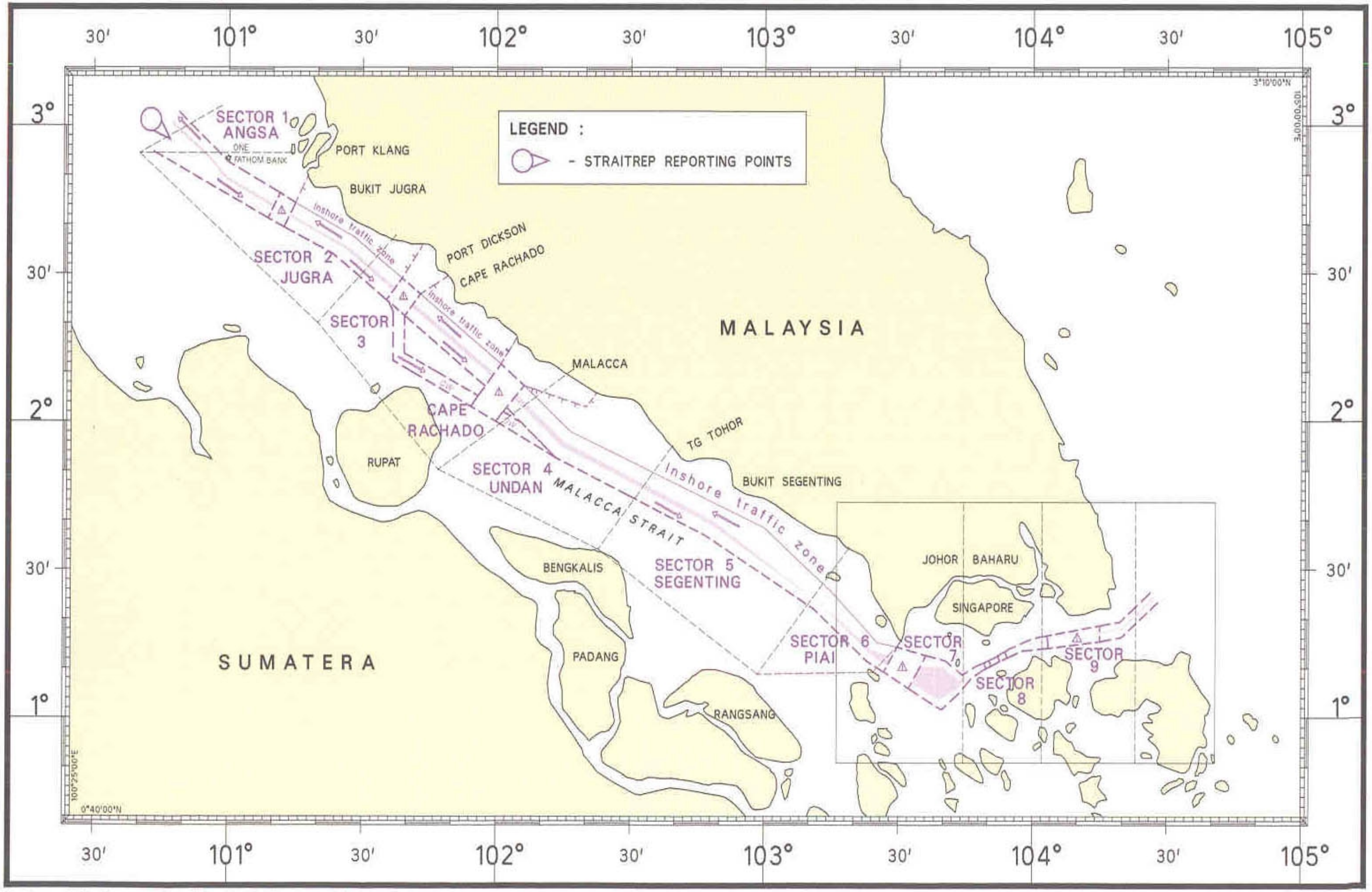


Courtesy of Maritime and Port Authority of Singapore, Hydrographic Dept.

POSITIONS IN WGS84

HY Code : AD0202798

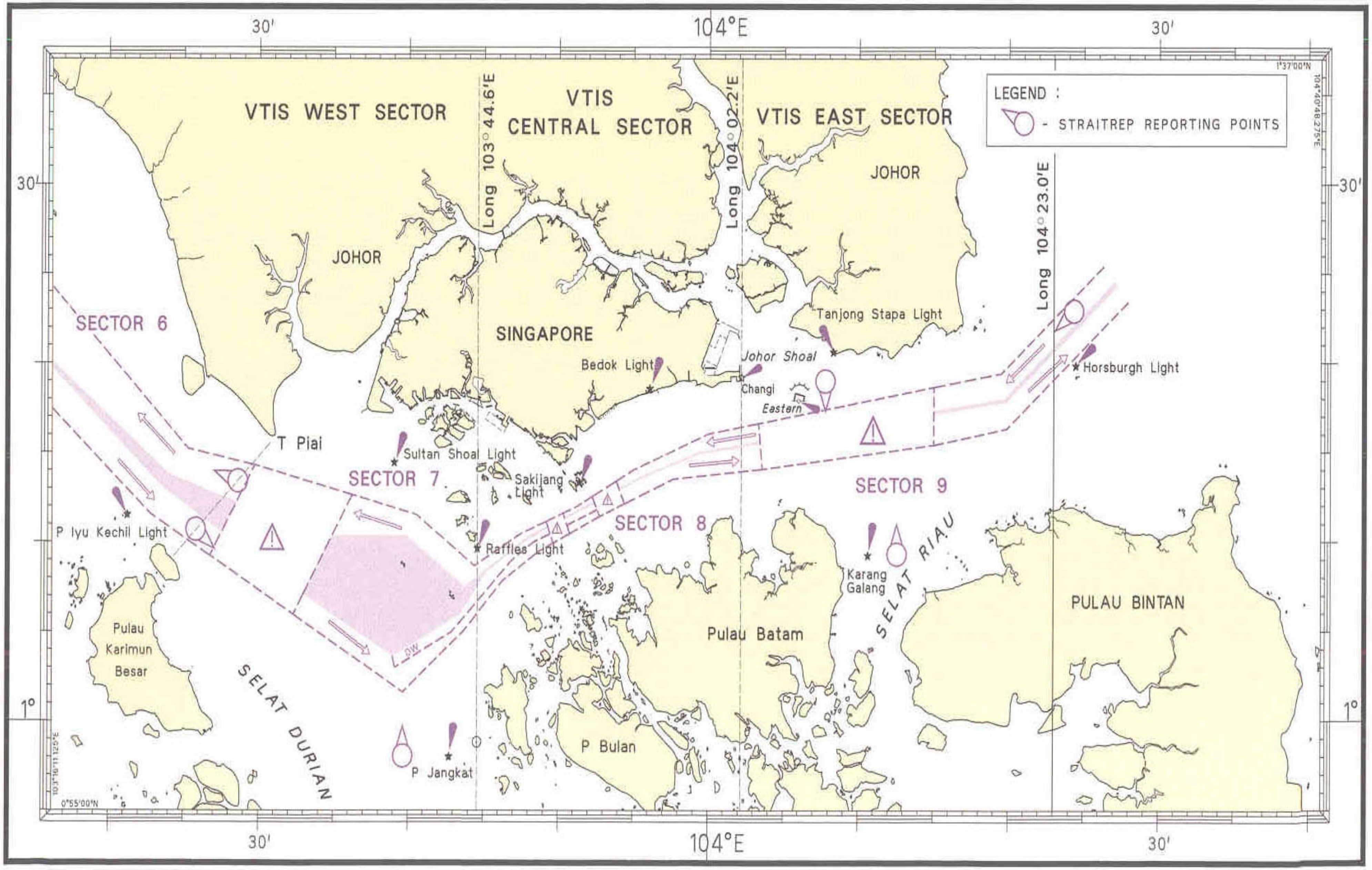
Mandatory Reporting System "STRAITREP" Operational Sector 1-7



Courtesy of Maritime and Port Authority of Singapore. Hydrographic Dept.

HY Code : AD0200298

Mandatory Reporting System "STRAITREP" Operational Sector 7-9

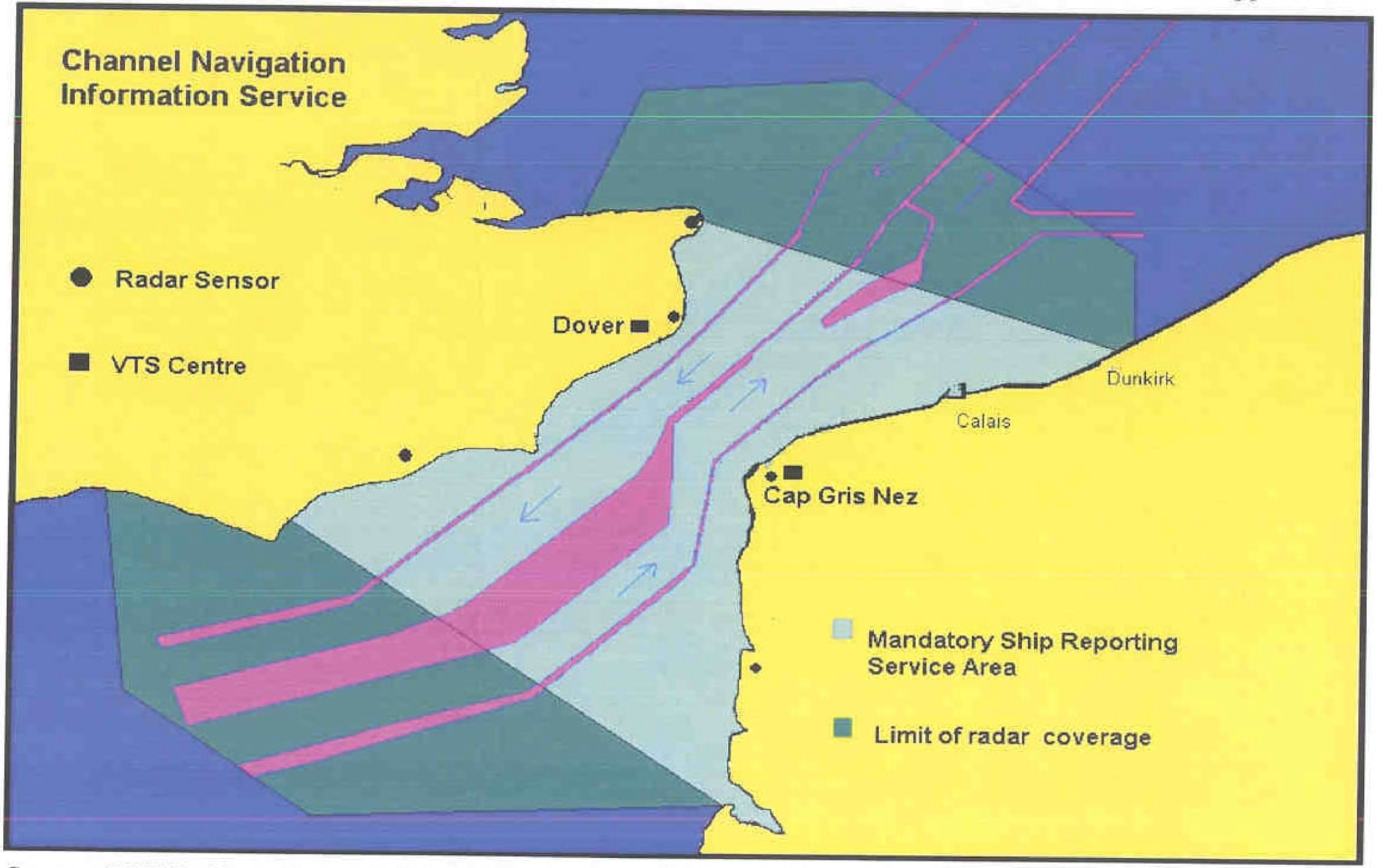


Courtesy of Maritime and Port Authority of Singapore, Hydrographic Dept.

HY Code : AD0200198

CNIS - Radar Coverage Area

Appendix 5

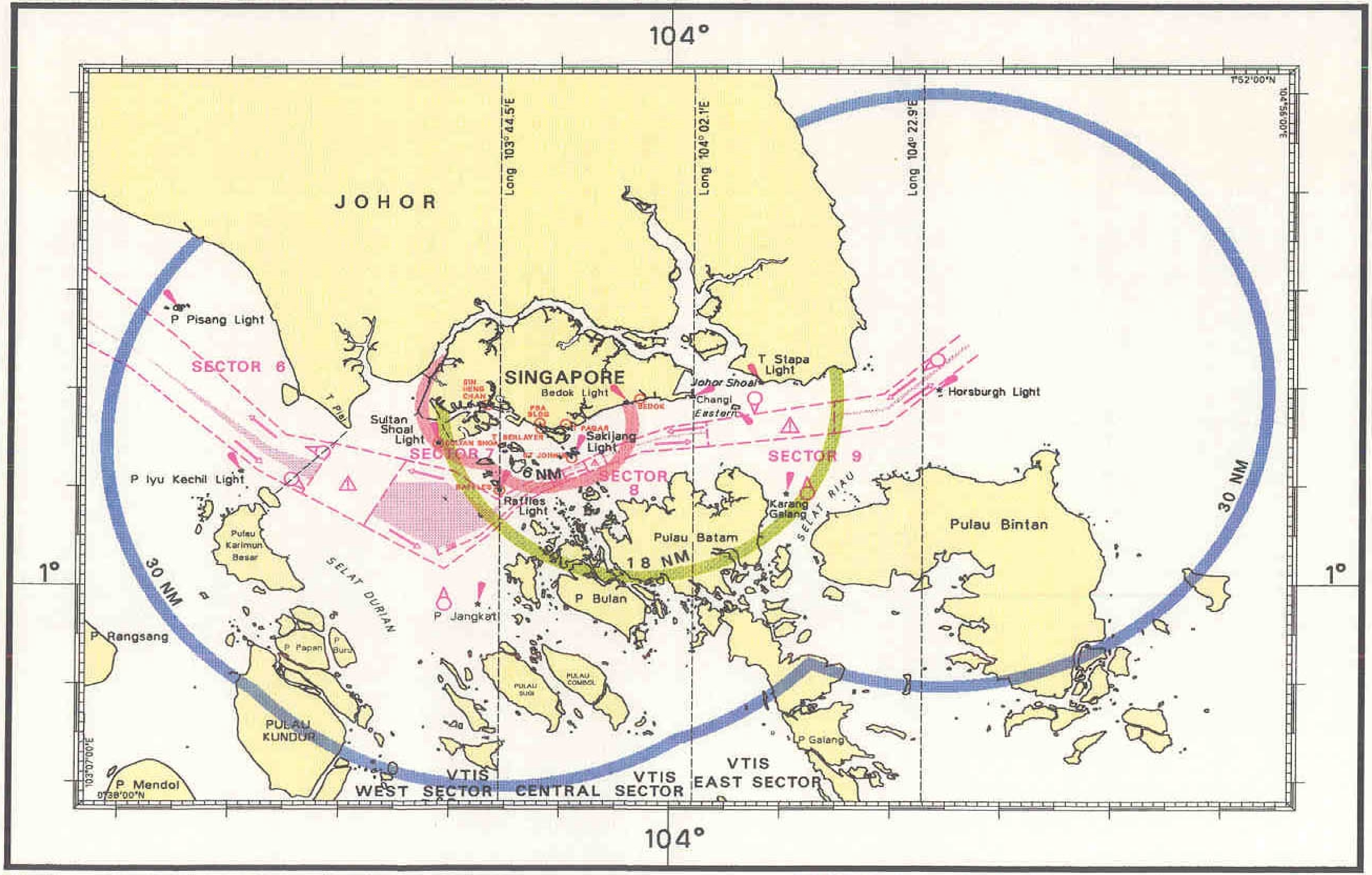


Source: UK Maritime Coastguard Agency (Courtesy of District Controller of CNIS, Mr. Rod Johnson)

Appendix 6

SINGAPORE STRAIT - VTIS RADAR COVERAGE AREA

Scale 1:1 050 000



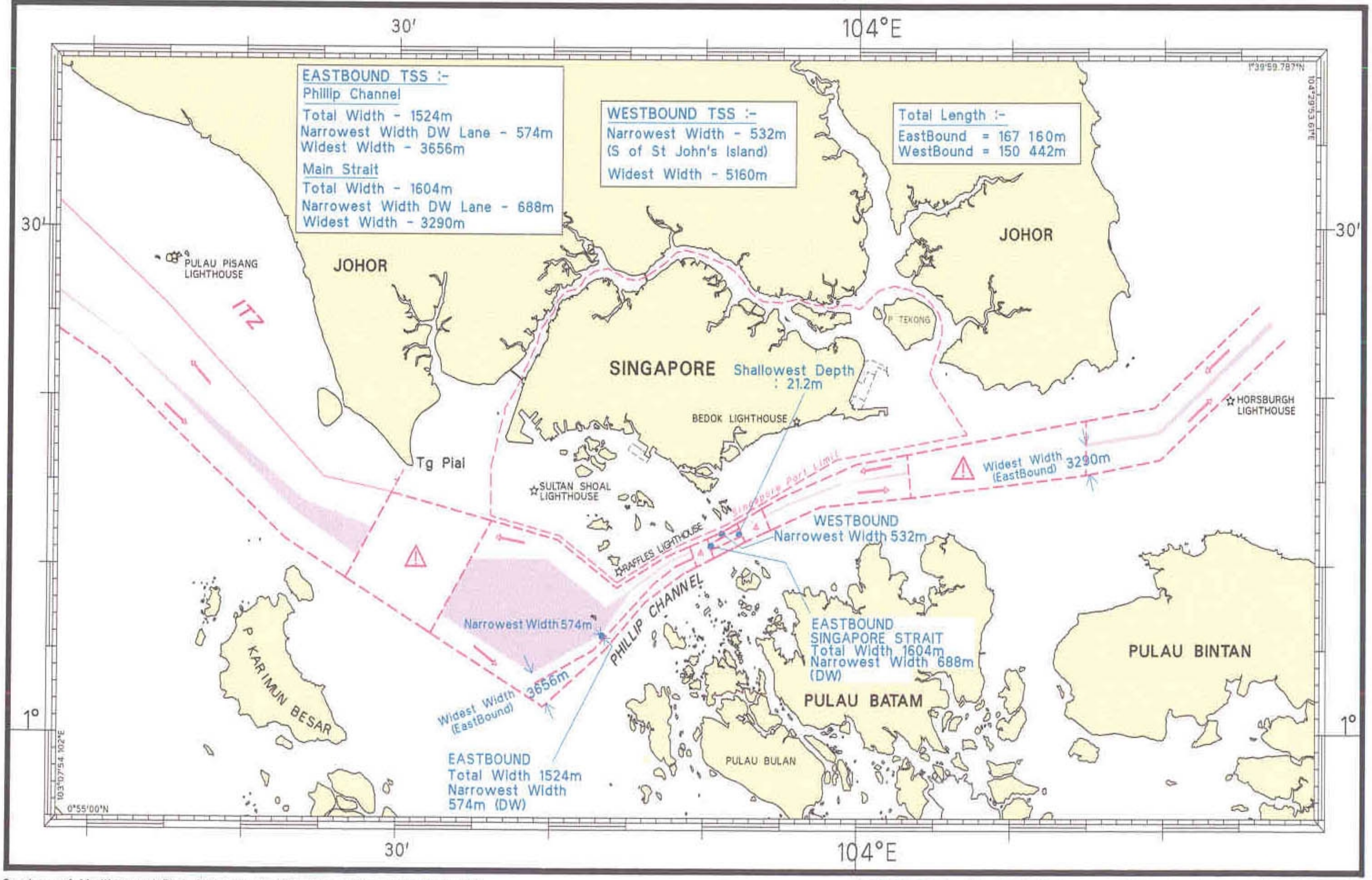
Courtesy of Maritime and Port Authority of Singapore. Hydrographic Dept.

POSITIONS IN WGS 84

HY Code AJ0302200

Detailed Dimension of Traffic Separation Scheme in Singapore Strait

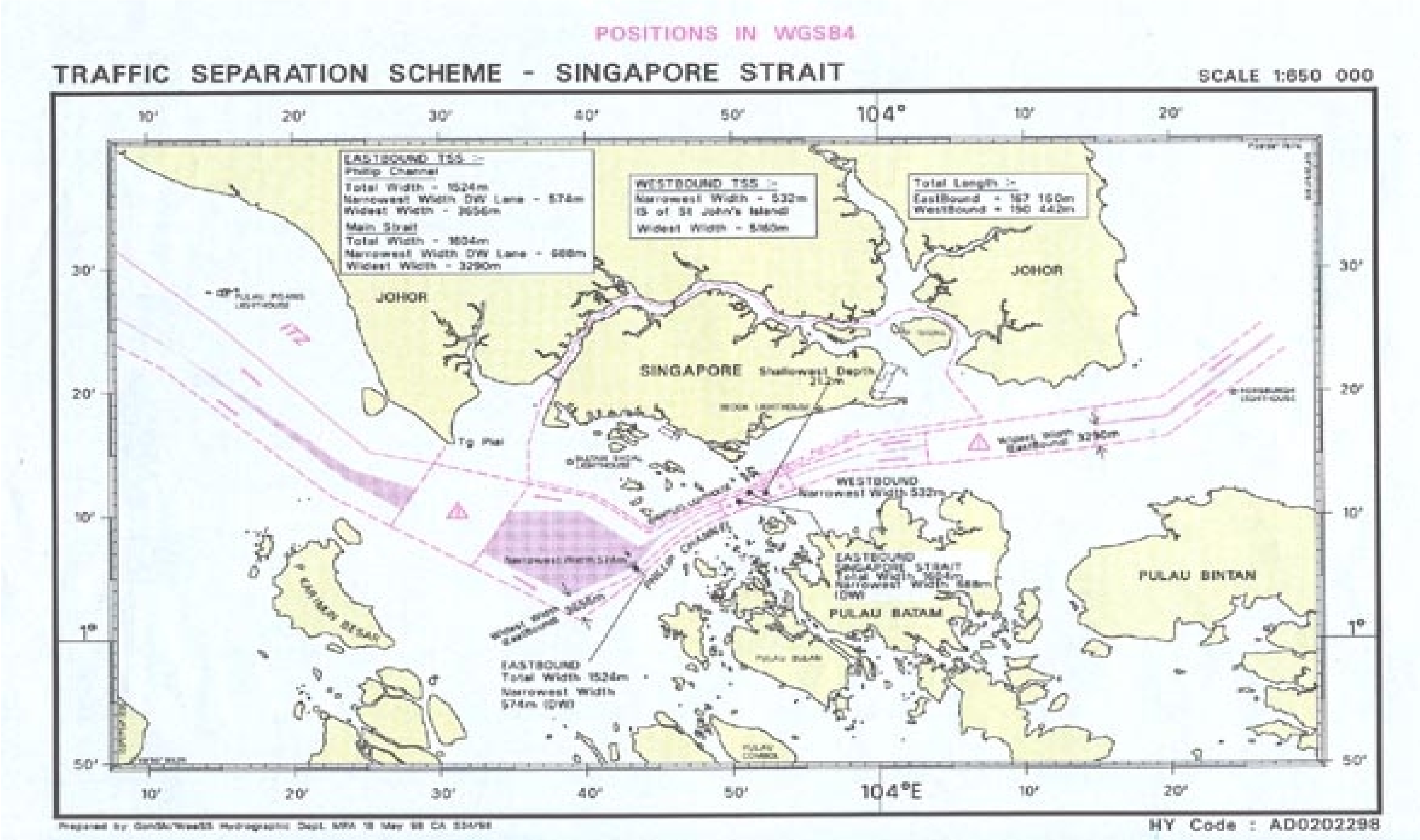
Scale 1:650 000



POSITIONS IN WGS84

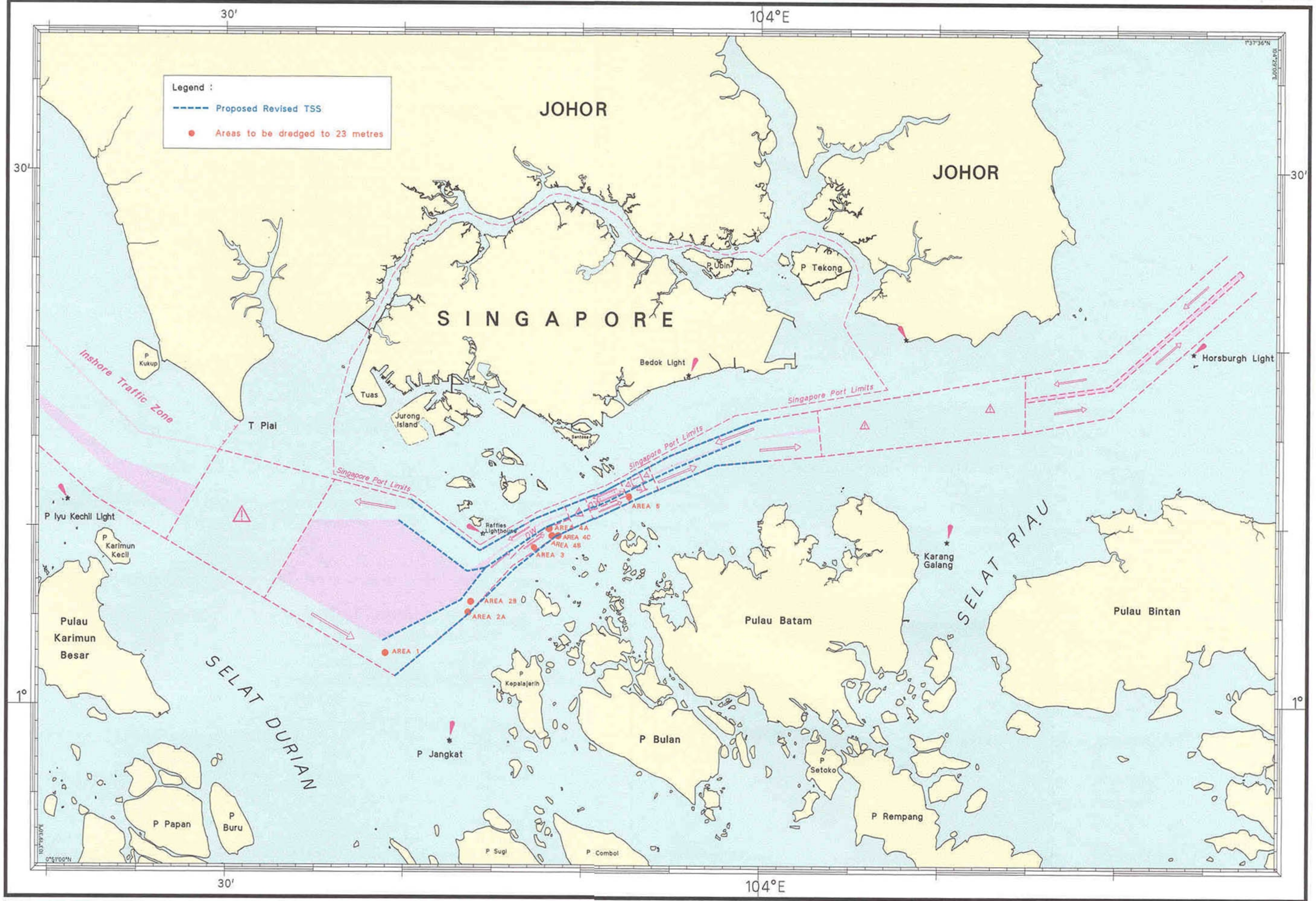
HY Code : AD0202298

Detailed Dimension of Traffic Separation Scheme in Singapore Strait **Appendix 7**



Proposed Revision of Traffic Separation Scheme and Areas to be Dredged in Singapore Strait

Appendix 8
Scale 1 : 370 000



Courtesy of Maritime and Port Authority of Singapore. Hydrographic Dept.

POSITIONS IN WGS 84

HY Code AD0201299