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The marine electronic highway and routeing scheme along the west coast of India and Sri Lanka : feasibility study : "aiming towards a sustainable maritime transportation system"

Sellakkannu I. Abul Kalam Azad
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WORLD MARITIME UNIVERSITY

Malmö, Sweden

**THE MARINE ELECTRONIC HIGHWAY AND
ROUTEING SCHEME ALONG THE WEST COAST
OF INDIA AND SRILANKA – FEASIBILITY STUDY**

“Aiming towards a Sustainable Maritime Transportation System”

By

SELLAKKANNU I. ABUL KALAM AZAD

India

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 AFFAIRS

(MARITIME SAFETY AND ENVIRONMENTAL ADMINISTRATION)

2014

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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.

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ABSTRACT

Title of Dissertation: **The Marine Electronic Highway (MEH) and routeing scheme along the West coast of India and Sri Lanka – Feasibility study.**

Degree: **Master of Science in Maritime Affairs**

For centuries, ships have enjoyed the freedom of navigation at sea. However, the situation has changed, over the years, from the introduction of voluntary traffic separation, in the beginning of 20th century, to the implementation of mandatory ship's routeing measures, Vessel Traffic Services (VTS) and Ship Reporting Systems (SRS) in many parts of the world, under the auspices of IMO, to enhance safety.

The dissertation is a study, to examine the need for the establishment of traffic management solutions along the West coast of India and Sri Lanka, to identify the critical areas of the coastline which require urgent attention because of traffic density as well as environmental sensitivity and to propose suitable solutions to manage the shipping traffic in this region safely and effectively.

Furthermore, it is a study on the feasibility of implementation of Marine Electronic Highway system along-with futuristic e-Navigation concepts as an overarching solution for this region, similar to the IMO led pilot project being implemented in the Straits of Malacca and Singapore. Moreover, it has revisited the historical evolution of Maritime Traffic Management (MTM) solutions till date. Emerging trends have also been reviewed.

The study has undertaken the exercise of collection and analysis of traffic statistics, traffic density and traffic patterns for this region. The Analysis revealed that the establishment of a Traffic Separation Scheme, precautionary areas and coastal Vessel Traffic Services (VTS) combined with a Ship Reporting System, in the identified critical areas, will reduce the risk of collisions and groundings in this region.

Thereafter, the draft layouts of the Traffic Separation Scheme for these areas were designed in accordance with the IMO criteria and forwarded to the stakeholders for comments. The comments received were collated, evaluated and the necessary modifications suggested by the mariners have been incorporated in the proposed routeing measures.

Additionally, the architecture for the proposed Marine Electronic Highway system for this region has been conceptualized. Key deliverables of the system have been identified considering the needs of India and Sri Lanka. Gap analysis was conducted between the existing infrastructure vis-à-vis the components of the proposed system.

Lastly, some recommendations are made to the authorities underlining the feasibility of the proposal and way forward towards the establishment of routeing measures, VTS and SRS in this region as a first step, followed by the establishment of the Marine Electronic Highway system.

KEYWORDS: Traffic management, MEH, e-Navigation, Ship's Routeing, TSS, VTS, SRS.

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List of Abbreviations

ADB	Asian Development Bank
AIS	Automatic Identification System
AMSA	Australian Maritime Safety Agency
AtoN	Aids to Navigation
BA	British Admiralty
CBD	Convention on Biological Diversity
COMSAR	Sub-committee on Radio Communications and Search and Rescue
CPEES	Centre with Potential for Excellence in Environmental Science
DGLL	Directorate General of Lighthouses and Lightships, India
DGPS	Differential Global Positioning System
DGS	Directorate General of Shipping, India
ECDIS	Electronic Chart Display and Information System
EC/EU	European Commission / European Union
EGC	Enhanced Group Calling
EMIO	Environmental Marine Information Overlays
EMPS	Environmental Management and Protection System
EMSA	European Maritime Safety Agency
ENC	Electronic Navigational Charts
ENVIS	Environmental Information System
ESI	Environmental Sensitive Index
GEF	Global Environmental Facility
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigational Satellite System
GPA	Global Programme of Action
GT	Gross Tonnage
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IBS/INS	Integrated Bridge System/Integrated Navigation System
ICAO	International Civil Aviation Organization
ICMAM	Integrated Coastal zone and Marine Area Management
ICT	Information and Communication Technology
IGP&I	International Group of Protection and Indemnity Clubs
IHO	International Hydrographic Organization
IMCO	Inter-governmental Maritime Consultative Organization
IMO	International Maritime Organization
INCOIS	Indian National Centre for Ocean Information System

ISPS	International Ships and Port Facilities Security Code
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature
IUMI	International Union of Marine Insurance
KSCSTE	Kerala State Council for Science, Technology & Environment
KYSTVERKET	Norwegian Coastal Administration
LRIT	Long Range Identification and Tracking System
MARAD	Maritime Administration
MARIN	Maritime Research Institute Netherlands
MEH	Marine Electronic Highway
MEHSOMS	Marine Electronic Highway in Straits of Malacca and Singapore
MEPA	Marine Environment Protection Authority of Sri Lanka
MEPC	Marine Environment Protection Committee
MMD	Mercantile Marine Department, India
MOEF	Ministry of Environment and Forests
MSC	Maritime Safety Committee
MSI	Maritime Safety Information
MTM	Maritime Traffic Management
NAIS	Indian National Automatic Identification System Chain
NAV	Sub-committee on Safety of Navigation
NCSR	Sub-committee on Navigation, Communications and Search and Rescue
NDC	National Data Centre
NHO	Indian National Hydrographic Office
RADAR	Radio Detection and Ranging
SIP	Strategy Implementation Plan
Sjofartsverket	Swedish Maritime Administration
SMA	Swedish Maritime Administration
SOLAS	International Convention on Safety of Life at Sea
SOMS	Straits of Malacca and Singapore
SRS	Ship Reporting System
STRAITREP	Ship Reporting System in the Straits of Malacca and Singapore
SW	South-West
TSS	Traffic Separation Scheme
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
USCG	United States Coast Guard
UHF/VHF	Ultra High Frequency / Very High Frequency
VTS	Vessel Traffic Services

Chapter 1 - Introduction

1.1 Background and rationale

In the era of globalization, maritime transport remains indispensable for the growth of world trade. To keep the wheels of economy rolling, it is essential to maintain shipping as a safe and reliable means of transport at all times. Although, shipping is a most environmental friendly mode of transport among others, in terms of energy efficiency, operational pollution and threat of pollution from ships due to accidents is still a cause of concern for the international maritime community. Lloyds Register world casualty statistics indicates that there is a steady improvement in the safety standards of shipping in the past century in terms of total loss of ships (Cardiff University & Allianz, 2012). Though, the technological advancements in ship design and construction have played a key role in improving safety standards, the positive influence of regulatory regime for the shipping industry, developed under the ambit of IMO, cannot be underestimated.

Nevertheless, even today navigational accidents such as collisions and groundings continue as the maximum contributor to the accidents in maritime transport, leading to huge amount of losses and claims (EMSA, 2011). Furthermore, these incidents pose major threats to the marine environment. Oil spill statistics released by the International Tanker Owners Pollution Federation (ITOPF) Limited (2014) indicates that, during the period 1970-2013, 50% of large¹ spills happened while the vessel was underway at sea, out of which 59% were caused by collisions, allisions and groundings. Hence, Baldauf et al (2011) rightly argue that collision and grounding are the two critical maritime operational risks in the field of maritime safety.

¹ Incidence of oil spills greater than 700 tonnes are classified as large oil spills. Source: (ITOPF, 2014)

Therefore, realizing the significance of navigational safety and its effect on marine environment, IMO (2013) has included the safety and efficiency of ‘Maritime Traffic Support and Advisory system’ as one of the goals, within the evolving concept of the Sustainable Maritime Transport System.

Many shore-based safety systems which have been incorporated in SOLAS, over the years, by IMO (2014) for maritime traffic management, namely Ship’s routing schemes, Vessel Traffic Services (VTS) and Ship Reporting System (SRS), have significantly contributed towards the reduction of navigational accidents, within the areas covered under such systems (EfficienSea, 2012). Yet many accidents are occurring throughout the world at frequent intervals. It is always comfortable to conclude that 80 percent of maritime accidents are contributed by human error, as shown in certain studies in the past. Subsequent to one such study by Baker & Seah (2004) it is argued “50% of maritime accidents were *initiated* by human error and another 30% of accidents were *associated* with human error.” In contrast, safety scientist Reason (1997) argued “human error is not a cause, it is a consequence,” therefore he suggested that the identification of human error should be the beginning of any accident investigation rather than the end in itself.

Although, there are many contributing factors which lead to navigational accidents, one important reason is the absence of traffic management, perhaps ineffective management, especially in areas with very high traffic density, triggered by the growing number of the world’s fleet. A definition and functions of vessel traffic management and its historical evolution are explained in the Chapter-2. The tonnage of the world shipping fleet has doubled to 1.14bn GT as in March 2014 from 2001, and it is projected that both the number of vessels, and tonnage, will continue to grow, at least until 2024 (IGP&I, 2014). Consequently, more and more sea areas are becoming vulnerable due to the steady increase in shipping traffic over the years. In order to meet the traffic demands, it is an undeniable fact that, many States have implemented excellent traffic management solutions including routing schemes, VTS, SRS, recommended routes etc. within their jurisdiction. Conversely in some

other States, vessel traffic management, in areas beyond the port limits is not being given the due attention it deserves, even though the volume of ships passing through their waters is very high, posing serious threats to safety and the marine environment.

The reason for the above inadequacy can partly be attributed to the fact that many States did not have any mechanism for monitoring the traffic along its coast in the past. However, the introduction of the Long Range Identification and Tracking (LRIT) system for monitoring shipping traffic up to 1000 nm from the coast and establishment of Automatic Identification System (AIS) Stations along the coast in the recent past helped many States, especially India, to continuously monitor the traffic along its coast (Singh Suman, 2009). Moreover, it created awareness to the maritime authorities, not only about the maritime traffic patterns and traffic density along the coast, but the potential risks to the marine environment and the coastal communities as well.

In this respect, it is to be noted that traditionally, merchant ships trading between the Middle East and the Far East region follow the route (Appendix-1) which normally passes along the West coast of India and the South coast of Sri Lanka because of its geographical location (Hydrographer of the Navy, 1987). In view of increasing trade, the number of ships passing through this region has been increasing steadily over the years (Pandya, Herbert-Burns, & Kobayashi, 2011). Furthermore, the growing number of incidents of piracy off Somalia and in western parts of Arabian Sea, in the past five years forced the entire shipping traffic to pass very close to the West coast of India to avoid any pirate attacks (DGS, 2012). Numerous fishing boats of smaller size also operate in this region.

India has witnessed five incidents of collisions between merchant ships and fishing vessels and two incidents of grounding in this region between 2009 and 2013, because of many reasons, especially increasing shipping traffic (DG Shipping, 2014a). In order to prevent such collision incidents and to avoid any threat of pollution due to grounding, the Indian Maritime Administration (MARAD) has initiated discussion with other stakeholders, in the past few years, to establish

suitable traffic management systems covering the critical areas of the Indian coast. However, it was recognized that there is a compelling need to undertake a detailed study of the traffic patterns, traffic density, risks, etc. to establish an internationally acceptable traffic management system for coastal traffic.

Since the author, being associated with Indian MARAD, was aware of this issue, it was decided to take up this challenging task of study on establishment of traffic management system for the critical areas, starting with the West coast of India. However, realizing the fact that our close neighbouring country, Sri Lanka, also faces the same problems and concerns because of its geographic location and traffic patterns in the region, it was considered prudent to include the Sri Lankan coast also in the study, to achieve the coherent solution to the problem, which will be beneficial for both nations.

Although the primary objective of the study was to analyse the traffic pattern and to propose suitable traffic management solutions such as routing scheme, VTS and SRS for the region, the literature review revealed that any futuristic solution on coastal traffic management should consider both maritime safety as well as marine environmental protection simultaneously (Sekimizu, 2003). Therefore, it was decided to include the concept of the Marine Electronic Highway (MEH) as an overarching solution, as part of the study, taking into account the developments in e-Navigation (IMO, 2012b). MEH is an IMO led project being implemented in the Strait of Malacca and Singapore, which integrates both maritime safety systems as well as marine environmental protection systems with the help of Information and Communication Technology (ICT), in order to help decision making on-board and ashore (IMO, 2006). The concept of the MEH, e-Navigation and current trends are detailed in the Chapter-3.

Therefore, this dissertation will be a starting point to achieve the goals of traffic management along the West coast of India and South coast of Sri Lanka, with a futuristic outlook, utilizing the latest technological developments in the field of e-Navigation. Furthermore, this study, being focussed on a critical navigational stretch,

next only to the Malacca strait, will surely help the IMO, for commencing the subsequent phases of the Regional MEH project, originally envisaged for covering the entire oil and gas transportation routes (IMO, 2006). Simultaneously, it also embraces the concepts of IMO (2013) towards a Sustainable Maritime Transportation System, which aims to contribute towards Sustainable² Development Goals of the United Nations. This is because of the goals identified by IMO, under the heading of ‘Maritime traffic support and advisory systems,’ specifically states “consideration should also be given for further expansion of traffic information systems such as the Marine Electronic Highway concept” (IMO, 2013).

1.2 Research Objectives

The aim of the research is to first study the maritime traffic pattern, traffic density, potential risks due to increasing traffic and the vulnerability of the region between the West coast of India and South coast of Sri Lanka. Thereafter, the objective is to study the possible traffic management solutions for the area within the ambit of SOLAS and IMO guidelines, to minimize the risks of navigational accidents towards safety and marine environmental protection. Lastly, the objective is to study the feasibility of establishment of a Marine Electronic Highway (MEH) system, which may include appropriate routeing measures between the West coast of India and South coast of Sri Lanka, beyond or at the outer limit of territorial waters, in order to guide and regulate the ever increasing shipping traffic in this region.

The dissertation also aims to provide a roadmap to the Indian Maritime Administration, in order to establish such a system together with our neighbouring country Sri Lanka. Moreover, this research targets to collect traffic statistics, identify critical areas, analyse the traffic flow and design the suitable routeing scheme for this region. Also it aims to apply the concept of MEH in the region, similar to the Strait of Malacca and Singapore, in order to ensure sustainable maritime transportation, through establishment of safe navigational systems, for the present as well as

² Sustainable development is defined as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987).

anticipated future traffic. (Marine Electronic Highway, 2014) The long term goal of the thesis is to address the future needs of shipping traffic in order to ensure safety of navigation and prevention of accidents / marine pollution in this environmentally sensitive region.

1.3 Methodology and Scope

The procedure adopted for the dissertation has been broadly derived from the Formal Safety Assessment (FSA) process recommended by the IMO for introduction of any new regulatory requirements. FSA consists of five steps namely identification of hazards, evaluation of risk factors, devising risk control options, cost benefit assessment and recommendations for decision making (IMO, 2002). Realizing the fact that the detailed FSA is a highly technical and complex process, this study has covered the essential elements of FSA in a simplified manner except the cost benefit assessment, which is beyond the scope. The dissertation can be divided into three distinct parts. The first part covers the literature review on the subject, which is theoretical in nature. The second part covers the practical aspects of collection and analysis of traffic statistics, identification of traffic patterns and traffic density, collection and analysis of accident statistics and design of the routeing scheme for the critical segments of the region. The final part involves the consultation process with the stakeholders about the proposed traffic management solutions for the area and to conceptualize the road map to proceed further towards the establishment of MEH system. Details of each part are enumerated hereunder.

The literature review of the dissertation covers a wide range of topics ranging from well-established maritime traffic management solutions such as routeing schemes, VTS and SRS to the evolving concepts of MEH and e-Navigation. The articles written by many experts in the journal of navigation and other journals, since 1970 which are relevant, have been studied to understand the historical development of traffic management and the current trends within the maritime industry. Moreover, several guidelines adopted by IMO through Assembly resolutions and resolutions of Maritime Safety Committee (MSC) and Marine Environment Protection Committee

(MEPC), providing criteria and methodology for establishment of VTS, SRS and routing measures have been used as principal guidance documents for this study.

Furthermore, relevant information and documents from the website of IMO, IALA, EMSA, USCG, European Commission, Ministry of Shipping, Ministry of Environment and Forests, Directorate General of Shipping, Directorate General of Lighthouses and Lightships, Marine Electronic Highway Strait of Malacca and Singapore (MEHSOMS) and e-Navigation portals have been used to understand the concepts and to derive the necessary information for the dissertation. Also the project reports of the World Bank have been studied in detail to appreciate the status of the MEH project from its conception to final implementation (World Bank, 2006).

Simultaneously, efforts have been initiated to get the maritime traffic statistics for the region, also called as traffic survey (Fujii & Toyodo, 1971), which is a must for making any meaningful study on traffic management. Although there were statistics available regarding the number of ships transiting through the Malacca Strait, which gives some indication about the traffic in the region, no study or report was available which could give any reasonable information about the ships transiting through this region. Therefore, the author has decided to conduct the traffic survey directly using the live data feed from the Indian LRIT National Data Centre (NDC) and the National Automatic Identification System (NAIS) Chain data centre situated in Mumbai. The author has also obtained the kind consent of the authorities for accessing the live feed of data centres using web access, without which this study could not have been possible.

Utilizing the access given to the live data feed, the initial assessment of traffic data, traffic pattern, traffic density in the region has been completed by monitoring the traffic for at least 2-3 hours every day between July and August 2014. Moreover, the author has also analysed the past traffic patterns, using the historical data, randomly for few days of years 2012 and 2013 stored in the LRIT System (DGS, 2014). In this respect, a study by Aarsæther & Moan (2009) for estimating navigation patterns from AIS and another study by Silveira et al (2013) for characterising marine traffic

patterns and collision risk off Portugal using AIS data, guided the author's approach in the analysis of traffic patterns from AIS data. However, the main difference between these studies and the present study is that the analysis has been carried out directly using live feed instead of analysis of AIS historical data with the help of computer software.

However, during the actual monitoring of traffic flow using the National LRIT and NAIS data, few shortcomings have been encountered. The LRIT system, on certain days, has given the accurate traffic information, in terms of position and course of all the ships up to 1000 nm from Indian coast which includes the Sri Lankan coast also. Nonetheless, during most of the period the LRIT system was providing the data related to Indian flag ships only, due to the costs involved in continuous monitoring of all the ships within the LRIT range. Another shortcoming of LRIT data is that the ships position information was being recorded only every six hours. Therefore, live data from NAIS was used simultaneously to analyse the traffic patterns. However, the limitation of NAIS is that it can monitor traffic up to a maximum of 20-25 nm only. Moreover, the absence of an AIS base station in Sri Lanka created a void in effective traffic analysis around its coast (DGLL, 2014).

In order to bridge the gap in traffic analysis around the Sri Lankan Coast and to validate the observations made using LRIT and NAIS, the author has obtained a one month subscription for commercial AIS service provider 'Fleetmon' for viewing combined AIS data from both Satellite AIS and Terrestrial AIS of entire Indian Ocean (FleetMon, 2014). Subsequently, the traffic data was collected from 'Fleetmon' for a period of 15 days in the months of August and September 2014. Although the position information provided by 'Fleetmon' is delayed by 12 hours, it adequately served the purpose of this dissertation. It also helped to calculate the accurate number of ships fitted with AIS and types of ships passing through the region every day, which can be extrapolated for a period of one year.

Lastly, for identification of critical areas and to design a traffic lane based on the historical traffic information, the AIS density map of one whole month of August

2013, for the area surrounding Indian coast, was obtained from a leading service provider of Satellite AIS services (exactEarth, 2014). The data from the AIS density map was analysed using a Geographic Information System (GIS) Software QGIS. Based on the analysis, critical areas of heavy traffic density have been identified along the West coast of India and Sri Lanka, where management of traffic is essential. Furthermore, traffic analysis revealed that TSS can be the ideal solution for these areas.

Subsequently, ships information, mainly position and course, of around 100 ships within the critical areas have been plotted on the navigational charts published by British Admiralty. Using this information, a draft layout of Traffic Separation Scheme was prepared on the chart, according to the guidelines and criteria established by the IMO (2013) in Ship's Routeing guide. Thereafter, the draft layout of TSS was also plotted in Electronic Navigational Charts (ENC) of the region using open source ECDIS software 'openCPN,' to verify the adequacy of layout in comparison with the actual traffic flow in the region being monitored using the LRIT, NAIS and 'Fleetmon' data. Consequent to the monitoring of the traffic flow in the region, a final layout of TSS for the critical areas have been prepared.

During this intervening period, the author has obtained the casualty statistics, pertaining to the Indian coast for the past five year period between 2009 and 2013, as well as the detailed investigation reports of some of the major navigational accidents occurred in the region from the Indian MARAD for the purpose of study (DG Shipping, 2014a). These statistics and reports clearly establish the compelling need for advanced traffic management solutions for the region. Similarly, the details regarding the environmental sensitivity of the region, current environmental management information system and the livelihood of coastal communities and their vulnerability have been collected from the government sources through internet and studied for this dissertation.

Since the IMO guidelines mandates that the consultation with the stakeholders is a must for establishment of any routeing measures, a detailed questionnaire was

prepared to obtain the feedback and comments about the proposed TSS and other traffic management solutions for this region. The questionnaire along with the chart section showing the layout of TSS in the critical areas was forwarded to the stakeholders such as MARAD, Coast Guard and especially the mariners sailing in the region, for obtaining their comments and suggestions about the planned TSS. Even though the questionnaire was technical in nature, the author has received enthusiastic responses from the mariners on-board and ashore. A total of 47 completed questionnaires from the stakeholders have been received. The feedbacks received from the stakeholders regarding the need for the TSS, layout of the TSS and the need for the coastal VTS and other services were collated and evaluated. Some of the respondents have also given valuable suggestions to improve the design of TSS, which have been considered prudently for modification of the proposed layout of the TSS.

Lastly, the mind mapping method was used to conceptualize the all-encompassing Marine Electronic Highway system for the region which can integrate all the traffic management solutions being considered such as TSS, VTS and SRS and the environmental management system. Although the concept and basic framework of the system have been adopted from MEH project being implemented in the Strait of Malacca and Singapore, the new MEH architecture has been designed in a manner which will be suitable for this region, considering the latest developments in e-Navigation. During this process, the details of all the existing shore-based safety systems in the region such as AIS base stations, DGPS beacons, Racons and lighthouses along the coast have been identified and listed as part of the study. Similarly, the availability of ENCs for the region and the extent of coverage have been examined.

Moreover, the existing methods of issuance of Maritime Safety Information (MSI) such as navigational warning systems and meteorological services, search and rescue services, oil spill management and oceanographic services available for the region have been studied (NHO, 2012) (INCOIS, 2014) (ICG, 2010) (ICG, 2010a).

Thereafter, a gap analysis was carried out to identify the shortfalls between the proposed components of MEH system and the existing infrastructure. Based on the gap analysis, at the end, the study has produced some recommendations for development of additional infrastructure which are required and further roadmap for the creation of a MEH system covering the entire region from the South coast of Sri Lanka to the West coast of India.

Whilst analysing the maritime traffic patterns and traffic density along the coast of India, it has been observed that traffic density is high throughout the navigational stretch along the West coast of India from Cape Comorin, especially up to New Mangalore and within the environmentally sensitive Lakshadweep islands (exactEarth, 2013). Furthermore, most of the tankers to and from the Persian Gulf were observed to be navigating within the region throughout the year. Therefore, the need for establishment of appropriate traffic management solutions for these remaining areas also cannot be ignored. However, this dissertation has limited its focus only to the most critical areas to achieve maximum benefits. Nevertheless, it will be most appropriate to extend the scope of the study to the remaining areas as well in the near future.

Chapter – 2 Evolution of Traffic management in Shipping

2.1 Introduction to vessel traffic management

Ever since maritime trade began, mariners have always enjoyed the freedom of navigation at sea. This tradition was reinforced during early seventeenth century, by the famous Dutch jurist and philosopher Hugo Grotius, in his highly acclaimed book *Mare Liberum*, meaning the ‘freedom of the seas.’ In this book he argued and presented justification for the right of unimpeded navigation across the seas (Borschberg, 2006). For centuries, it was totally up to the Master of the ship to choose the best possible route to reach the destination safely. Although the shortest and more direct route remains the main criteria (Pla, 1978), often it was influenced by the favourable weather conditions, ocean currents and the routes which have been followed in the past. In the modern shipping practices of 20th century, the UK Admiralty publications like Ocean Passages for the World, Sailing directions and routeing charts have played a substantial role in guiding the mariners about the route planning for the intended voyage (Hydrographer of the Navy, 1987).

However, the freedom of unregulated navigation has started to change in the past century due to increasing traffic and growing concern over the marine environment. As per Lloyds Register Fairplay (2010) world fleet statistics, since 1900 total number of ships tripled and the Tonnage of ships increased from 29 million tons GT to phenomenal 958 million tons GT in 2010, which clearly reflects the enormous increase in shipping traffic. Gold (1983) argues that subsequent to World War II, our perception of the ocean has changed and he says “it is now viewed not only as a space to be traversed, but also as a resource to be conserved and as a natural environment to be preserved.” Therefore, he justified that because of current

navigational issues; rights of transit, freedom of navigation, etc. have to be balanced against environmental considerations (Gold, 1983).

Accordingly, three methods of traffic management evolved over the years, such as Ship's routing measures which include Traffic Separation Schemes (TSS), Ship Reporting Systems (SRS) and Vessel Traffic Services (VTS). Whilst the routing measures are passive in terms of communication, cost effective and preventive in nature, SRS and VTS interact directly with the ships for exchange of information which may as well provide for control of traffic from shore (IMO, 2014). Although, these traffic management regulations diminish the traditional authority of the Master to decide on the route, the main purpose of these regulations are for enhancing the safety of navigation and for the protection and preservation of marine environment from ship-source pollution. Three decades ago Gold (1983) wrote "there is a clear trend towards ocean regulation, and it can be predicted that the full control of traffic at sea will, within a comparatively short period of time, be as commonplace as traffic control in the skies." Now it appears that his prediction will become reality soon.

IMO has recognized and adopted the aforementioned traffic management solutions as voluntary measures and issued several guidelines beginning 1960s-70s. However, as the technology evolved these guidelines have been revised through several Assembly resolutions and the voluntary nature of traffic regulations gradually transformed to mandatory, over the years, to meet the changing circumstances, increasing risk of traffic and the needs of member States. As on date, Regulation 10, 11 and 12 of SOLAS Chapter-V, revised in 2002, covers all the three vessel traffic management solutions discussed above with mandatory regulations for worldwide implementation. IMO has also developed detailed guidelines and provisions for the establishment of necessary services by the member States for vessel traffic management (IMO, 2014).

Vessel Traffic Management is defined as "*the set of efforts (measures, provisions, services and related functions) which, within a given area and under specified circumstances, intend to minimize risks for safety and the environment, whilst*

maximizing the efficiency of waterborne and connecting modes of transport” (TECHNISEC, 2000). Westrenen & Praetorius (2012) have explained the function of vessel traffic management is to guarantee safe and efficient traffic flows through the four main activities, namely “monitoring traffic status, ensuring separation, routing traffic and capacity planning.” However, this explanation can be applied only to VTS’s. In recent years, the term ‘Maritime Traffic Management’ is being used by IMO and the European Commission, in author’s opinion, to cover the larger spectrum of activities, such as overall planning and guidance of maritime traffic for a wider area of the coast, the emergency response, search and rescue and oil spill management etc. in addition to vessel traffic management (EC, 2013) (IMO, 2014a).

Nevertheless, Praetorius (2014) stated that the maritime traffic management can be assumed as a large, socio-technical system, the ship-VTS system, incorporating all the services offered by VTS as well as the services offered through the ports such as pilotage service, tug service etc. Presently it appears from the literature that there is no standard definition is available, for the term Maritime Traffic Management to the best of author’s knowledge. However, considering the context in which it is being used by the Global / Regional agencies, the author is of the view that its scope extends well beyond the ports. Additionally, the concept of dynamic and proactive route planning, termed as Sea Traffic Management (STM), is currently being developed under the EU project MONALISA 2.0 (Motorways and Electronic Navigation by Intelligence at Sea), as part of a futuristic e-Navigation solutions (Sjofartsverket, 2012). Hereafter, historical evolution of vessel traffic management regulations with relevant details are enumerated in succeeding paragraphs.

2.2 Development of ship’s routeing measures

Exploration of literature on the subject revealed that initially, the traffic separation and traffic routing were proposed in 1847 based on weather routing, and in 1855, it was proposed to assign separate lanes for steamers sailing in north Atlantic in opposite directions. Although this proposal was examined by the 1889 Washington Maritime Conference no decision was taken then to implement the proposal (Beattie,

1978). Subsequently, in 1898, the first voluntary traffic separation routes were established by the passenger shipping companies operating ships in the north Atlantic route, on the basis of “gentlemen’s agreement,” for safety reasons. Furthermore, Beattie (1978) explained that traffic separation was adopted systematically by the ship-owners ‘Lake Carriers Association’ in Great Lakes, Canada, consequent to the loss of 22 ships due to collisions between 1900 and 1910. He further explains that feasibility and success of these voluntary traffic routing systems in preventing collisions, was reflected in the International Convention for the Safety of Life at Sea, 1960 (SOLAS). The 1960 Safety convention acknowledged the practice of following recognized traffic routes in converging areas on both sides of the North Atlantic, which helped in preventing collisions and therefore recommended governments to influence owners of all the passenger ships to follow the recognized routes (IMO, 2013)

Gold (1983) narrates that many proposals for establishment of one-way traffic lanes near the Europe were initiated in the mid-1950s but little was done immediately. In 1961, a joint group was formed, consisting of the institutes of navigation of the Federal Republic of Germany, France and United Kingdom, to study the applications of traffic separation in the congested Dover Strait. A study by this group discovered that over 96 percent of mariners surveyed favoured traffic routeing in those waters. Consequently their studies resulted in submission of proposal for separation of traffic using traffic lanes in the Dover Strait as well as for certain basic principles of ship’s routeing. These proposals were accepted by Maritime Safety Committee of the then IMCO. Immediately thereafter in 1967, two main through traffic lanes and two inshore traffic zones were established in the Dover Strait as voluntary routeing schemes (Squire, 2003). Gold (1983) describes this as the first modern application of traffic separation in the world.

Because of its early involvement, beginning in the 1960s, IMCO became the right forum for further development of traffic separation and routing. Subsequently in the 1970s, IMCO has developed the guidelines and adopted the Assembly resolutions

detailing the principles and methods of application of traffic separation around the world, which led to establishment of traffic separation in many congested areas (Beattie, 1978). In 1971, IMCO Assembly adopted an amendment to SOLAS 1960, by which member States recognized IMCO as “the only international body for establishing and adopting measures on an international level concerning routing” and it states that selection of routes “will be primarily the responsibility of the governments concerned.” This resolution was given the mandatory effect by means of reference in the 1972 Collision regulations (Lee & Parker, 2007). In order to ensure compliance with traffic routing measures and create deterrence, the IMO Assembly adopted a further resolution which recommended governments to make it an offence for ships violating the traffic separation schemes (Gold, 1983).

Thereafter in 1973, detailed ‘General provisions pertaining to Ships routeing’ were adopted by the IMCO Assembly vide resolution A.284(VIII), providing guidelines to the member States towards the establishment of routeing measures, which have been amended regularly to meet the changing requirements during that period. The importance of routeing, the responsibility of contracting governments in establishment and implementation of routeing schemes, the role of the Organization in approving such schemes and the need to follow the guidelines being adopted by the IMCO in this regard have been reinforced through adoption of Regulation V/8 of SOLAS 1974 (IMCO, 1974). This regulation was amended subsequently. Gold (1983) explains that by 1979, more than 100 traffic separation schemes were approved by IMCO and many others were created unilaterally. Currently, the guidelines which are being followed globally for the establishment of ship’s routeing are emanating from an original IMO Resolution A. 572(14) adopted in 1985, ‘General Provisions on Ship’s Routeing’ which is being reviewed and updated by MSC at regular intervals (IMO, 2013).

SOLAS regulation V/10 on Ship’s Routeing, revised in 2002, stipulates that the ship’s routeing systems adopted and implemented in accordance with the guidelines and criteria developed by the IMO are recommended for use by all ships. It also

states that such systems may also be made mandatory for use by all ships or specific categories of ships or ships carrying certain cargoes and ships shall use such mandatory routing system in accordance with the relevant provisions of the system. Additionally it specifies that IMO is the only international body recognized for developing guidelines and criteria for ship's routing systems on an international level. Furthermore, it requires that the States should submit the proposal to IMO for adoption of routing systems, taking into account the General Provisions on Ship's Routing adopted by the Organization (IMO, 2014).

These provisions adopted by IMO (2013) affirms the overall objective of routing measure is to "improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited by restricted sea-room, the existence of obstructions to navigation, limited depths or unfavourable meteorological conditions." Moreover, it explains the criteria for many routing measures such as Traffic Separation Schemes, two-way routes and recommended tracks. Additionally, it provides the guidelines for selecting and marking the areas which need to be avoided, inshore traffic zones, roundabouts, precautionary areas, deep-water routes and archipelagic sea lanes. Details of all the adopted routing systems are being published periodically in IMO publication 'Ship's Routing' (IMO, 2013). Since, one of the main objectives of this dissertation is to develop a proposal for establishment of routing measure along the West coast of India and Sri Lanka; the criteria established by IMO have been used for designing the Traffic Separation Schemes, the details of which are given in the Chapter-6.

2.3 Vessel Traffic Services

Unlike ship's routing measures, the Vessel Traffic Services (VTS) requires information exchange between ship and shore and active involvement of shore personnel (VTS Operator) in monitoring and managing the traffic with the help of Radar, VHF and other equipment's installed ashore and on-board. The guidelines for VTS adopted by IMO (1997), vide resolution A.857 (20), defines VTS as "a service implemented by a Competent Authority, designed to improve the safety and

efficiency of vessel traffic and to protect the environment. The service should have the capability to *interact with the traffic* and to *respond to traffic situations* developing in the VTS area” (IMO, 1997).

The evolution of VTS can be traced back to mid-20th century. Whilst the traffic routing was gaining its due importance the availability of commercial radar and radio post World War II, led to the installation of first radar station at port of Liverpool in 1948, in order to facilitate boarding of pilots at the entrance. As Hughes (1998) explained, Liverpool radar station can be considered as a forerunner for development of VTS in the Europe. Later in 1951, radar and VHF were first installed in port of Long Beach in the USA to simplify port operations, which some ports followed slowly. Consequently, with the help of radar and VHF, ports could monitor the ship movements in all weather conditions on real-time basis, which over the years evolved as shore-based traffic surveillance systems (Hughes, 1998).

Consequent to the *Torrey Canyon* disaster in 1967, the importance of VTS in enhancing safety of navigation near the ports was recognized by the IMO in 1968 through adoption of a resolution A.158 (ES.IV) ‘Recommendation on Port Advisory Systems.’ This resolution recommended the governments to consider setting up of port advisory services in the ports handling dangerous cargoes and in the areas of high traffic density (IMO, 1969). Likewise, collision involving tankers *Arizona Standard* and *Oregon Standard* in San Francisco bay in 1971 resulted in massive oil pollution and created widespread public criticism in USA. This led to the adoption of the US Ports and Waterways Safety Act, 1972 (PWSA) which mandated USCG to establish and operate VTS in critical areas (USCG, 2014).

Hughes (1998) argued that VTS did not get due international recognition for its role in navigation safety, traffic efficiency and environmental protection for many years till 1985, only when IMO adopted resolution A.578 (14) with detailed guidelines on VTS. These guidelines emphasized that VTS can be useful and highly appropriate for the port approaches, in areas of high traffic density, narrow channels, within environmentally sensitive regions and for ports handling dangerous cargoes. It also

reiterated that final decisions relating to navigation and manoeuvring of the vessel rests fully with the ship's master (IMO, 1969). Although many ports were started establishing VTS as per the IMO guidelines, it was remained only as voluntary service, due to the absence of any mandatory regulation concerning VTS. However, the major oil spill occurred in U.S due to *Exxon Valdez* disaster in 1989 resulted in enactment of Oil Pollution Act (OPA) by the USA. The OPA 90 mandated the USCG to make ships participation in VTS compulsory, which subsequently paved the way for adoption of new SOLAS Regulation on VTS by IMO in 1997 (USCG, 2014). Concurrently the IMO has also adopted the revised Guidelines for VTS through an Assembly resolution A.857 (20), which is still in force.

Regulation V/12 of SOLAS (2014) on VTS states that contracting governments “undertake to arrange for the establishment of VTS where, in their opinion, the volume of traffic or the degree of risk justifies such services” and also urges the States to follow the guidelines developed by IMO for implementation of VTS. Moreover, the regulation categorically states that VTS service can be made mandatory only within the territorial waters of the coastal State. Furthermore, it mandates that States shall strive to ensure participation of ships flying their flag in VTS's established in accordance with this regulation (IMO, 2014).

Although SOLAS regulation states that VTS can be made mandatory only within the territorial waters of Coastal State, in the recent past IMO has adopted some VTS which covers the areas beyond the territorial waters, as part of either a mandatory SRS or for ensuring compliance with the mandatory Ship's routing schemes adopted by the IMO. Great Belt VTS (Denmark), Sound VTS (Denmark/Sweden) and Vardoe VTS (Norway) are some of the examples adopted by IMO which cover the areas beyond the territorial waters (IALA, 2009). In this regard, IALA has also issued a Guideline no.1071 on 'Establishment of Vessel Traffic Services beyond Territorial Seas' (IALA, 2009). Coastal VTS being proposed in subsequent chapters of this dissertation can be established by the India and Sri Lanka based on this guideline.

The IMO Guidelines for VTS, A.857 (20), explains the need for distinction between port or harbor VTS, which primarily concerned with traffic in and out of port, and Coastal VTS, which mostly concerned with traffic passing through its area to ensure compliance with TSS. According to the IMO guidelines, there are three types of services namely *information service, navigational assistance service and traffic organization service* may be provided by VTS. Whilst some VTS may only provide information services whereas the others may provide either two or all the three services, depending upon the VTS capability, VTS coverage area and the volume of traffic. The Guidelines also states “the efficiency of a VTS will depend on the reliability and continuity of communications and on the ability to provide good and unambiguous information” (IMO, 1997).

Although VTS requires active involvement of VTS operator in traffic management, the IMO guidelines clearly states that any instruction being issued by VTS to vessels should be *result-oriented* only, leaving the details such as course or speed alteration only to the master or pilot on-board ship. Furthermore, it reiterates that the final decision regarding the maneuvering and navigation of the vessel remain with the Master (IMO, 1997). Therefore, the effectiveness of the VTS purely depends upon the qualification, training and experience of VTS personnel. Allen (2009) explained that the VTS personnel have the ability to assist in preventing maritime casualties because of their skills and experience. Nonetheless at times they may also contribute to casualties, directly or indirectly, due to improper or lack of professional training as evidenced in the collision between vessels *Audacity* and *Leonis* at the entrance to the River Humber, UK in 2007 (Marine Accident Investigation Branch, 2008). Hughes (1998) argued that many VTS operators are engaged in duties with no clear guidance from the employers about their role, which leads to complications. Moreover, he argued that the main anomaly in the system is that there is no standard internationally accepted qualification or certification for VTS operators, unlike Air Traffic Controllers who have internationally recognized qualification, though both are involved in highly specialized and critical job (Hughes, 1998).

In order to remedy these shortcomings and to ensure minimum standards, IALA has developed Standards for training and certification of VTS personnel (Recommendation V-103) and associated model courses, which have been endorsed by IMO and MSC/Circ.1065 issued to that effect in 2002 (International Maritime Consultancy, 2014). Furthermore, IALA is playing an important role in developing standards for VTS equipment's and operational procedures for VTS. It also publishes comprehensive VTS manual every four years, which serves as a reference document for VTS. Moreover, World VTS guide being published by IALA along with other industry organizations provides detailed and useful information about VTS area to the shipmasters (IALA, 2014a). However, in authors experience the inadequate compliance with IALA requirements for VTS equipment's, shortage of qualified VTS personnel and training and qualification of VTS operators are still a cause of concern in some States, as evidenced from the investigation report of collision between MSC Chitra and MV Khaleejia-3 within the Mumbai port (DGS, 2011).

Furthermore, in the field of Vessel Traffic Services, although VTS is the only term mentioned in SOLAS and IMO guidelines, there are many names being used in different ports which cause confusion to the shipmasters. Hughes (1998) describes Vessel Traffic Management System (VTMS), Vessel Traffic Information Service (VTIS), Vessel Traffic Management Information System (VTMIS), Mobile VTMIS (MOVIT) and Vessel Traffic System (VTS) are all the acronyms being used by manufacturers to describe their products based on the technical capability. Although some systems may have more advanced capability than the other the common theme among all the system should be VTS. But it is also a fact that different ports have different kinds of systems with many add-on services to suit their specific requirements (Hughes, 1998).

Nevertheless, many research projects were conducted in the previous decade within the European region to enhance the services of VTS with the help of advancements in technology including AIS. The earliest EU project on VTS was COST 301 – 'Shore Based Marine Navigation Aid Systems,' conducted between 1983 and 1986.

It gave recommendations for a coordinated European approach to VTS, which includes dynamic allocation of space for a vessel within the defined sea areas, efficient use of sailing plan in space allocation within the areas of heavy traffic, use of software for evaluation of traffic behaviour and training programme for VTS operators (CORDIS-EU, 1998). This project led to further projects in the EU which developed Regional Traffic Management System. Furthermore a study was made on a Vessel Traffic Management and Information System (VTMIS) (TECHNISEC, 2000). Another European project, among others, was POSEIDON (Project On integrated VTS, Sea Environment and Interactive Data On-line Network) conducted between 1996 and 1999. This project had developed Vessel Traffic Management and Information Services for “achieving interoperability of VTS and improving safety and efficiency of maritime traffic.” It created a strong basis for implementation of integrated VTMIS by all the users in the European Maritime Community (CORDIS-EC, 1999). These projects created a basis for development of advanced systems and solutions for VTS.

2.4 Ship Reporting Systems

Evolution of routeing measures and VTS has been explained in previous paragraphs. Similarly, the concept of the Ship Reporting System (SRS) using radio communication can be traced back to first voluntary reporting system AMVER (Originally known as Atlantic Merchant Vessel Emergency Reporting System) established by USCG in 1958. The purpose of this reporting system is to identify the ships which are near an area of distress using the position information being sent by ships at regular intervals. It facilitated the Search and Rescue (SAR) of many distress incidents and actively contributed in saving many lives at sea. Since AMVER has evolved over the years due to advancements in technology and its worldwide coverage it changed its name to ‘Automated Mutual assistance Vessel Rescue System’ (AMVER) and it is still functioning as a voluntary service (USCG, 2013). Subsequently, in similar lines of AMVER, Australian Ship Reporting System

(AUSREP) was established in 1973 by Australia to meet their obligation on Search and Rescue (SAR) (AMSA, 2012).

The spate of tanker accidents and serious pollution incidents in the late 1960s and 1970s encouraged establishment of SRS by other states as well for meeting several objectives not only of SAR but also for traffic services, weather forecasting and prevention of pollution. Whilst SRS like AMVER and AUSREP are covering the wide ocean area for the main objectives of SAR, many other VHF based reporting systems were being established to monitor the traffic around the coast and to monitor the ships approaching port as a complementary system for routing measures and VTS (Glansdorp, 1976). Gold (1983) described the Eastern Canadian Traffic Regulation System (ECAREG) established in 1976 by the Canadian Coast Guard was the most advanced coastal vessel traffic reporting system at that time and the model was adopted subsequently by other States as well.

The need for establishment of SRS by States and the details of reports to be transmitted have been incorporated first in the International Convention on Maritime Search and Rescue in 1979 (IMO, 2000). The mandatory requirement for reporting of any pollution incidents at sea stipulated under the MARPOL-73 has also been incorporated in SRS by the States. In order to bring uniformity in the reporting formats and to avoid multiple reporting by ships, IMO has adopted resolution A. 531 (13) – General Principles of Ship Reporting Systems in 1983 and urged the Member States to follow these principles while implementing SRS (IMO, 1983). These principles have been amended subsequently by IMO through many assembly resolutions A.598 (15) and A.648 (16) and the latest being A.851 (20).

Although SRS have been implemented in many areas of the world, mostly on voluntary basis, the concept of mandatory SRS primarily meant for vessel traffic management and marine environment protection introduced only in 1994 through adoption of new SOLAS regulation V/8-1- Ship Reporting System (IMO-MSC, 1994). Simultaneously IMO has also adopted resolution MSC.43 (64) stipulating the ‘Guidelines and Criteria for Ship Reporting Systems’ and therein, recommended the

governments to take into account these criteria when proposing to establish SRS. Subsequently, using this regulation and guidelines States has established many SRS with the approval of IMO for efficient traffic management within their jurisdiction.

The SOLAS regulation –V/11 on Ship Reporting Systems, revised by IMO (2014) in 2002, states that if a SRS has been developed as per the guidelines and adopted by the IMO, then it “shall be used by all ships or certain categories of ships or ships carrying certain cargoes in accordance with the provisions of each system.” It also states that IMO is the recognized body for development of guidelines, criteria for SRS and for adoption of SRS. Moreover it stipulates “SRS shall have the capability of interaction with the ships and the ability to assist ships with information when necessary.” Furthermore, it mandates that the master of a ship shall comply with all the reporting requirements of SRS. Also this regulation specifies that the participation of ships in SRS shall be free of charge to the ships concerned (IMO, 2014). Therefore, any governments planning to establish SRS shall comply with this regulation as well as the guidelines and criteria established by the IMO.

The guidelines and criteria for SRS adopted by resolution MSC.43 (64), as amended, states that adoption of any SRS by IMO should be considered, only when there is a proven need to address the traffic issues in the region for “the improvement of the safety of lives at sea, the safety and efficiency of navigation and/or to increase the protection of marine environment” (IMO-MSC, 1994a). It also states that a SRS may or may not be operated as part of a vessel traffic service. Furthermore the criteria specify that the communication between a ship and shore authority should be limited to only essential information to meet the objectives of the SRS and the communication system should be able to facilitate exchange of information between ship and shore. It also states that the reliability of communication system should be ensured and wherever possible non-verbal communication should be encouraged. Moreover, it require a shore based authority to be provided with adequate staff, infrastructure and communication equipment’s to ensure functioning of the system. The criteria for SRS also specify the factors to be taken into account whilst planning

for establishment of such system and the procedures to be followed for submission of proposals to the IMO. Lastly, it also provides the guidelines for implementation of SRS and the criteria for assessment of proposals for adoption and review by IMO (IMO-MSA, 1994a). It is to be noted that MSA reviews this criteria at regular intervals and it has been subsequently amended by resolution MSA.111 (73) and MSA.189 (79), but the key elements are remaining same. Details of mandatory reporting system given in Ship's Routing guide indicates that, in many cases areas covered under a SRS also has routing measures and VTS (IMO, 2013).

In recent years many mandatory SRS beyond territorial waters have been established by member States which are also adopted by IMO, apparently because of SOLAS regulation which restricts that the use of VTS can be made mandatory only within territorial waters of coastal state. Similarly, many adopted routing measures includes areas well beyond territorial waters (IMO, 2013). In this respect, Hughes (2009) stated in his recent article that many mandatory SRS areas are being operated from VTS centres. He also explains that confusion may arise to the master because of use of call sign such as VTS for reporting positions in mandatory SRS areas. Furthermore, he asserts that VTS procedures are being used in some of the mandatory SRS areas. Therefore he concludes "A VTS Centre managing a mandatory SRS, albeit in international waters, can be likened to a coastal VTS" and such centre may also provide one of the VTS services (Hughes, 2009). Hence, in coming years many SRS may start providing services of VTS, for enhancing safety and protection of marine environment of coastal region.

2.5 Role of latest systems AIS and LRIT in traffic management

Traditionally, the shore based systems for vessel traffic management such as VTS and SRS have primarily relied upon the Radar, VHF and other radio communication equipment's onboard ships and ashore including Global Maritime Distress and Safety System (GMDSS) for ship-shore communication. Accordingly, the area of coverage of traffic management regulations were being limited to VHF and Radar ranges. However, the introduction of Automatic Identification System (AIS) onboard

ships from 2002 onwards has extremely simplified the operation of traffic management by shore based authorities. Because AIS being a terrestrial broadcast system operates in VHF frequency, it continuously (maximum interval of 2s to 6m) transmits the PNT (Positioning, Navigation and Timing) information with positive identification of ship to shore authorities as well as to ships within the AIS range. If AIS is connected to the Radar or ECDIS then the ship details can be readily seen by any operator ashore or onboard ships, which can be utilized not only for effective traffic monitoring but for security purposes as well (SMA, 2004).

As per SOLAS regulation V/19, AIS (Class A) needs to be fitted onboard all the cargo ships of 300 GT and above and all the passenger ships irrespective of size (IMO, 2014). Considering the usefulness of AIS, many States have imposed the requirement of fitment of at least Class B AIS on smaller vessels and fishing vessels also. Class B AIS has limited functions but sufficient enough to transmit position information. For example, all Indian vessels of over 15NT but less than 300 GT are required to be fitted with Class B AIS (DG Shipping, 2013). Furthermore, many coastal States have started establishment of AIS base station networks along the entire coast, which facilitates them to monitor the shipping traffic all along the coast, much more than the areas covered under VTS or SRS. Consequent to Erika disaster European Commission has issued a directive 2002/59/EC for establishing a Community vessel traffic monitoring and information system for monitoring the shipping traffic across the EU (EUR-Lex, 2002). Based on this directive many European countries for example, Norway, Sweden and Denmark have established the AIS network along the coast, for continuous monitoring of shipping traffic for enhancing safety, security and protection of marine environment (Kystverket, 2011). Although, terrestrial AIS network provides complete picture of shipping traffic along the coast, it has the restriction up to a maximum of 20-25nm from the coast due to VHF range limitations.

Further to AIS, another important development in the maritime traffic monitoring in the previous decade, mainly for security purposes, is the implementation of Long

Range Identification and Tracking (LRIT) system of ships through SOLAS regulation V/19-1 from 2008. This regulation requires cargo ships of 300 GT and above and passenger ships irrespective of size engaged on international voyages, to be fitted with a system to automatically transmit ship's identity, position, date and time for tracking through LRIT infrastructure (Figure-1). The LRIT system consists of Ship Satellite terminal, Inmarsat Satellite Communication/Application Service Provider (CSP/ASP), National Data Centres (NDC) and International LRIT Data Exchange (IDE) (IMO, 2014). The National Data Centres (NDC) mainly collect, store and provide LRIT information to all the users through the internet network. Similarly, the main function of the IDE is the routing of messages between various NDCs and functions as a communication hub for the LRIT System (EMSA, 2014).

Under the SOLAS regulation, contracting governments are entitled to receive LRIT information for security, safety and marine environmental protection purposes about ships of their own flag from any part of the world. Furthermore, States can also receive information from ships anywhere in the world, which are bound for the ports in own State and the ships of any flag which are navigating or positioned within 1000 nm from the coast. However, it clearly states that governments shall bear the costs towards the position information being requested and received by them (IMO, 2014).

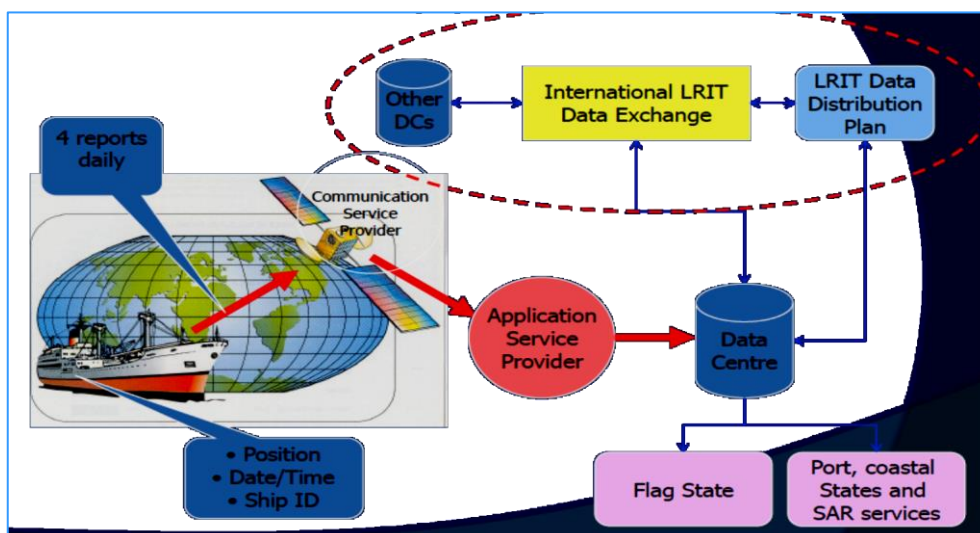


Figure 1: LRIT System Architecture. Source: (Yasnikouski, 2013)

LRIT is a satellite based, real-time tracking and reporting system of ships which can provide enhanced maritime domain awareness of the region. Therefore, subsequent to the adoption of regulation on LRIT, States have established the National Data Centres (NDC) and made agreement with Satellite communication service providers for receipt of LRIT information. Normally ships positions are received every six hours. However there is a facility for increasing the frequency of positions with shorter intervals up to 15 minutes (USCG, 2014b). Since LRIT information are being received through Satellite communication, existing communication equipment on board ships under GMDSS was sufficient enough to meet the SOLAS requirements, in some cases with little modifications. Since this regulation did not require any new equipment on board ships, it was implemented very quickly by 2009 (IMSO, 2011).

Upon implementation of LRIT system, all the States could identify and monitor the traffic up to 1000 nm from their coast. It provided the much broader picture of the marine traffic including traffic density and traffic patterns etc. which was not available anytime in the past. This system helped the States to monitor the traffic not only for security purposes but also for SAR situations and to identify and track the ships involved in oil pollution or accidents etc., even beyond the Exclusive Economic Zone of the State. Another important security feature of LRIT system is that the position information of the ships cannot be accessed by any outsiders other than the authorized governmental agencies; therefore commercial confidentiality such as trading pattern of ships etc. can be strictly maintained (USCG, 2014b). Although LRIT system can provide the better picture of the marine traffic, system is not being used by the member States regularly for monitoring the traffic because of the cost involved for obtaining positions of ships of another flag and the availability of other means such as Satellite AIS.

Moreover, the recent technological developments in the field of satellite-based AIS coverage revolutionized the vessel traffic monitoring across the world. Even though many private companies like 'exactEarth' and 'ORBCOMM' have already started providing AIS data from satellite to the users for commercial purpose, the strategy

for taking advantage of this technology is still being discussed at the IMO. The technology for reception of VHF/UHF signals using Low Earth Orbit (LEO) satellites is a recognized technology already being used in many commercial applications. Therefore, satellite detection of AIS has developed rapidly in recent years. Presently the shortcomings in the Satellite AIS technology is that the ships position data is delayed by around 90 minutes depending upon the number of satellites available for covering a particular area (Carson-Jackson, 2012).

Nevertheless, Norway has already launched its AIS satellite in 2010 and started monitoring the traffic in the ocean areas beyond Norway. Norwegian satellite passes over the sea areas near Norway and receives AIS information from ship traffic every 90 minutes. This satellite traffic information is being forwarded to Maritime Traffic Control Centre in Vardö, Norway and other agencies such as RCC for the purposes of traffic monitoring, search and rescue and oil spill response (Kystverket, 2011). Therefore, it is certain that the Satellite AIS technology, in coming years, will improve the Maritime Domain Awareness (MDA)³ well beyond the existing boundaries with minimal cost (Carson-Jackson, 2012).

³ Maritime Domain Awareness (MDA) is generally defined as: “The effective understanding of any activity associated with the maritime environment that could impact on the security, safety, economy or environment of a nation.”

CHAPTER 3 – Concept of the Marine Electronic Highway and E-Navigation

3.1 Background

As explained in the previous chapter, over the years, IMO has adopted several regulations on vessel traffic management under Chapter-V of SOLAS, which facilitated the member States to establish Ship's routing measures, Ship Reporting Systems (SRS) and Vessel Traffic Services (VTS) in areas of high traffic density in order to enhance the safety of navigation and protection of environment (IMO, 2014). Studies conducted by many agencies have confirmed with certainty that these vessel traffic regulations contributed significantly towards reduction of shipping accidents in areas of high risk (Cockcroft, 1978) (EfficienSea, 2012a). However, it is also a fact that the maritime industry still encounters few high profile accidents, albeit less in numbers, at regular intervals. Realizing the fact that shipping traffic is increasing steadily, due to increasing transport demand, also recognizing the consequences of accidents involving oil, chemicals and other hazardous substances which are being carried in large quantities in recent years because of 'economies of scale' (Stopford, 2009), some of the countries have adopted additional measures with the help of latest technologies. One example is the continuous monitoring of shipping movements within European waters through 'SafeSeaNet' programme using AIS, mainly with the aim of preservation of marine environment (EMSA, 2010) .

Similarly, the concept of the Marine Electronic Highway (MEH) was evolved in the Canada in early 1990s for integration of ECDIS and AIS to provide real-time exchange of information between ship and shore, since many ships operating in the St. Lawrence River then, were fitted with these latest navigational equipment's. Due to rapid advancement in Information and Communication Technology (ICT),

utilizing the basic concept of MEH, USA and Canada had jointly established the Great Lakes-St. Lawrence Seaway System, which transmits the information on available water depth, tide and traffic information to ships on real time basis (Research and Traffic Group, 2014). Since more and more new ships have been fitted with ECDIS in the last decade and the fitment of AIS was made mandatory through SOLAS beginning 2002 (IMO, 2014), IMO in collaboration with Singapore, Malaysia and Indonesia, the three littoral States of Straits of Malacca and Singapore (SOMS), has decided to implement the Marine Electronic Highway IT system in the one of the busiest waterways of the world (Sekimizu, 2003). However, the further advancement of ICT in the recent years and adoption of amendments to SOLAS in 2009 which requires the mandatory fitment of ECDIS over a period of 2012 to 2018 encouraged the IMO to progress swiftly towards ‘e-Navigation’ for ensuring, inter-alia, the seamless flow of information between ship and shore (IMO, 2014).

3.2 Marine Electronic Highway (MEH)

The MEH is an IT system which integrates marine environmental management and protection system (EMPS) with vessel traffic management and navigational information (Figure-2) for supporting the decision-making on-board and ashore.

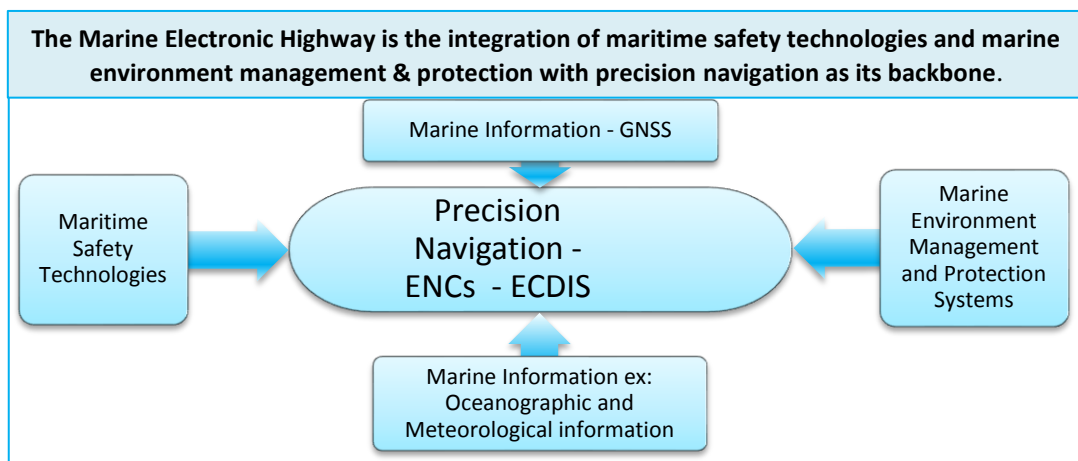


Figure 2: The Marine Electronic Highway IT System. Concept is from IMO. Source: Author

This system has been designed to provide the vessel traffic management information, real-time ship to shore communication, large scale resolution environmental forecasts using Environmental Marine Information Overlays (E-MIO) and large scale

electronic charting information for ships using the marine electronic highway and the shore authorities (MEHSOMS, 2014).

The functionality of the system depends upon the availability of precise position information using DGPS broadcast stations, set up of AIS shore stations along the coast, creation of EMPS, VTS in key areas with radar coverage, establishment of ship's routing measures and Ship Reporting Systems (SRS), fitment of AIS and ECDIS on-board ships (GEF, 2003). A functional diagram of IMO's MEH system is depicted in Figure-3.

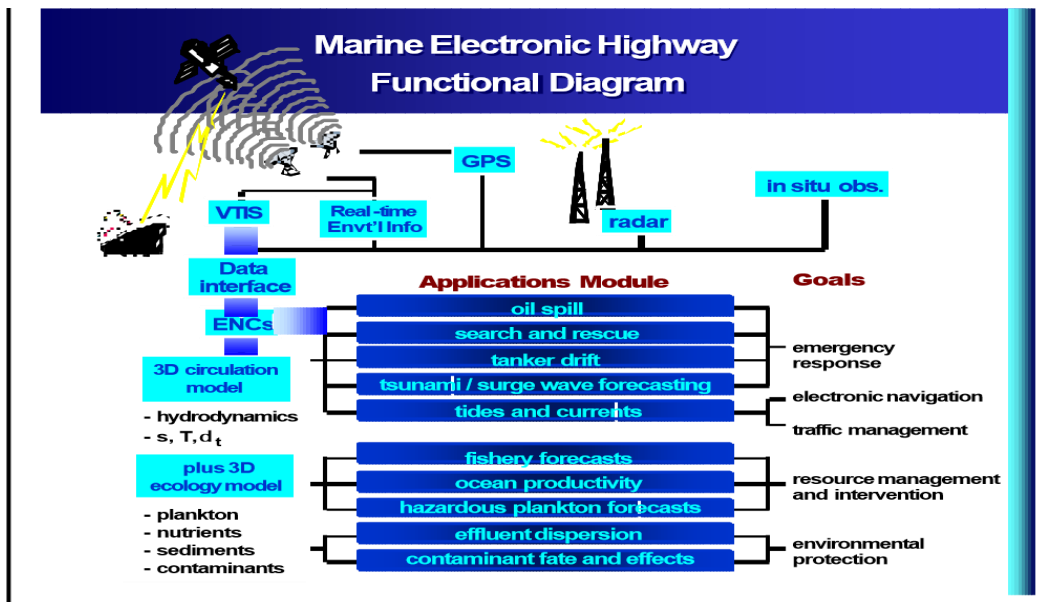


Figure 3: MEH Functional diagram showing system integration and flow of information across various platforms. Source: (IMO, 2001)

Therefore, for providing real time marine safety information, in addition to vessel traffic information by VTS, it is necessary to install tidal and current monitoring equipment's along the coast and offshore meteorological observation stations. Moreover, it is vital to carry out the high resolution hydrographic survey of critical areas for updating ENCs with the latest information towards implementation of the MEH system. Similarly as part of EPMS, environmental sensitive mapping of coastal areas and development of oil spill trajectory and dispersion model needs to be completed for the MEH regions (GEF, 2003). Finally using AIS, ECDIS and present

day information and communication technologies MEH data centres will be able to provide all the relevant information to maritime users with minimal verbal communication and to respond to any emergencies effectively using real time 3-D information on sea surface, seabed and water column. Furthermore, all the MEH information can be displayed in a user-friendly design that can be accessed by all the relevant agencies such as MARAD, Navy, Coast Guard and State Environmental agency through the dedicated web portal (MEHSOMS, 2014).

3.3 MEH project in the Straits of Malacca and Singapore

Because of its unique nature, as a vital narrow shipping lane with highly congested traffic and environmental vulnerability, the Straits of Malacca and Singapore (SOMS) were chosen to implement the MEH as a pilot project by IMO in collaboration with the three littoral states of Indonesia, Singapore and Malaysia. In the first Phase, the MEH demonstration project is being implemented for a critical 300 km stretch of the Strait, as a joint project of the Global Environmental Facility (GEF), the World Bank and the IMO. Upon successful completion of its demonstration, in the second phase, the MEH system was planned to be implemented across the full length of the Strait by the littoral states (Sekimizu, 2003). The map showing the coverage area of MEH project is given in Appendix-2. The objectives of MEH system in SOMS are to improve the efficiency of marine transport through the Straits by reducing the frequency of ship collisions and groundings in the congested traffic lanes and to reduce the negative environmental effects due to accidents and illegal discharge of marine pollutants from ships by effective monitoring and tracking of ships navigating through the Straits (GEF, 2003).

Another important reason for selecting SOMS for this project was the existence of modern electronic navigational aids such as DGPS stations in Singapore and Malaysia, publication of electronic charts for the Singapore Strait and effective implementation of vessel traffic management services within the Straits for many years. Singapore has been operating comprehensive computer and radar based VTS since 1990 for the Singapore Strait, which has significantly contributed in reduction

of accidents in the past two decades (Maritime Institute of Malaysia, 2013). Similarly the Malaysia has commissioned a radar based VTS system in 1998 covering portion of the Malacca Strait. Furthermore, the mandatory ship reporting system “STRAITREP” is being implemented by littoral states since 1998, which covers the key stretch of SOMS (World Bank, 2006). Therefore, the MEH project was envisaged to integrate all the data from existing traffic management services and the new environmental and meteorological services in order to present the information in a user-friendly manner to all the stakeholders using a standard format of ENC layers.

The implementation of MEH project in SOMS commenced in 2006 subsequent to the approval of project and signing of grant agreement between GEF/World Bank and IMO (IMO, 2006). This project had total five components namely;

- a) system design, coordination and operation;
- b) MEH system development including bathymetric surveys;
- c) fitment of equipment’s on board and testing of system;
- d) Marine Environment Protection system and
- e) dissemination of information and evaluation of the system;

and IMO took up the task of managing all these components. The project was primarily funded by GEF through IMO and it was originally expected that cost of some elements of the project such as installation of ECDIS on-board ships will be borne by the ship-owners. The remaining cost was required to be contributed by the three littoral states and it was also planned to complete the project in five years period i.e. by 2011 (World Bank, 2006).

However, due to several operational reasons, the MEH demonstration project was completed only in May 2013, rather with partial achievement of its planned objectives. The ‘final implementation and results report’ of the project released by the World Bank (2014) describes the outcome of the project as “moderately unsatisfactory,” since all the planned objectives could not be achieved even after a delay of two years. According to this report, the main reason for the limited success of the project is due to the poor response from the ship-owners in fitment of ECDIS

on-board ships and consequently the poor participation in trials of the system and the delay in conduct of bathymetric surveys of the intended area due to cost escalation (World Bank, 2014).

Nevertheless, some of the key components of the project such as the establishment of MEH data centre in Batam, Indonesia, development of environmental marine information overlays, data interchange between the ship and shore using ECDIS and AIS, development of web portal for MEHSOMS for the benefit of end users and integration of the backup data centres in Singapore and Malaysia with regional data centre have been successfully completed (World Bank, 2014). Consequently, in August 2012, IMO has formally handed over the functioning Batam MEH IT system to the Indonesia for completion of remaining activities towards the development of full scale MEH system for the entire strait, through the co-operation among the littoral states (IMO, 2012). Another significant achievement is that the littoral states, realizing the environmental and safety benefits, have jointly decided to scale up the MEH system, for the full operational status for the use of mariners, which was the primary objective of the pilot project (World Bank, 2014).

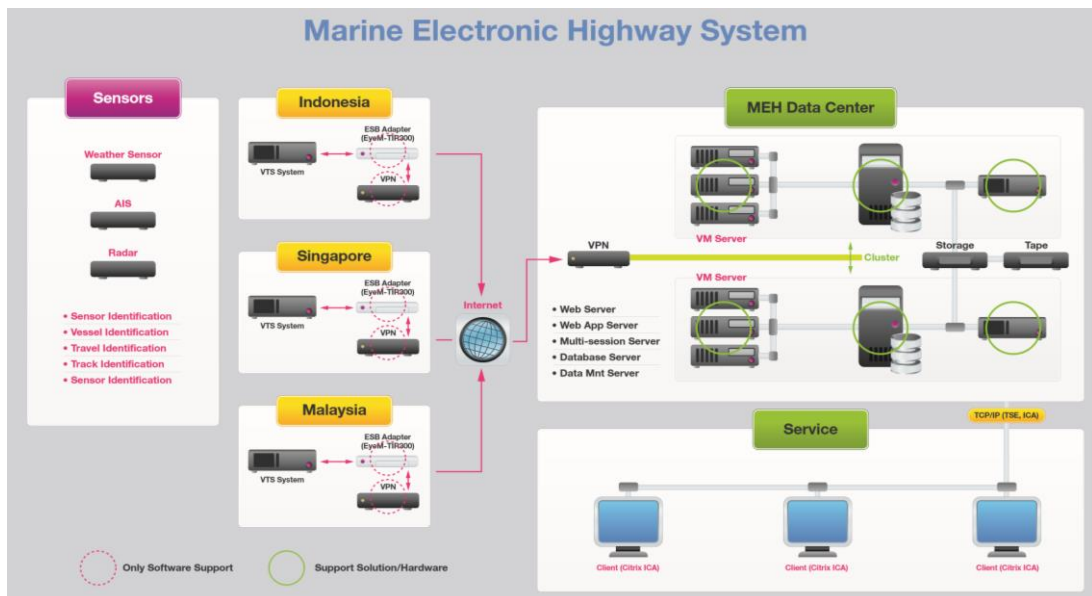


Figure 4: Architecture of MEH System of Straits of Malacca and Singapore. Source: (IMO, 2012a)

The layout of the MEH showing the vital systems and its linkages with other systems and data centre of SOMS is depicted in Figure-4. As on August 2014, MEHSOMS states that data integration between MEH Indonesia and the data centre has been completed and further demonstration of the system is in progress (MEHSOMS, 2014).

3.4 Background of e-Navigation

E-Navigation is an IMO led concept aimed to harmonize, standardize and enhance the performance of marine navigation systems and related shore-based support services based on the ‘user needs’ (IALA, 2014). It came to the forefront consequent to the work programme (MSC 81/23/10) submitted by the member States; to be precise, Japan, Marshall Islands, Netherlands, Norway, Singapore, UK and USA, in 2005 to the IMO. Through this proposal, they called for the development of standards and long term strategy towards effective utilization of existing and new electronic navigational tools, in a holistic and organized manner in order to reduce navigational accidents, errors and failures to achieve the overall aim of safety at sea and protection of the marine environment (IMO-MSC, 2005).

The compelling need for development of such an e-Navigation strategy, as stated in their proposal, was the unorganized development and introduction of the several electronic navigational systems, for use on-board ships, such as AIS, LRIT, ECDIS, IBS/INS, GMDSS and DGPS within a short span of 5 to 10 years, though some are mandatory, while remaining are not. While all those equipment’s definitely benefited the mariners in their navigational duties, it also created the problem of differing standards of equipment’s, several forms of display and poor placement of the equipment within the navigating bridge, due to constraints in retrofitting. Hence the proposal clearly stated “if the timely action is not taken, the disadvantages of pursuing uncoordinated individual technologies will outweigh the potential benefits that together they could deliver” (IMO-MSC, 2005).

On the other hand, several new measures were introduced for vessel traffic management, such as reporting requirements for VTS and SRS, Pre-Arrival Notification (PANS) for ISPS and numerous other reporting requirements by several port authorities created the onerous administrative burden on the watch keepers, over and above their normal navigational duties. The problem was further aggravated due to increasing shipping traffic, faster turnaround of vessels in port and drastic reduction in the manning scale in the past decade. Therefore, it was felt necessary to standardize the existing and new navigational tools and to utilize the advancement in technology, especially ship-shore satellite communication and modern navigational tools such as ECDIS and AIS for presenting the navigational information precisely, depending on the user needs. Moreover, it was envisioned to facilitate seamless flow of information between ship and shore, to avoid multiple forms of reporting, thereby reducing administrative burden of ships officers (Nautical Institute, 2014).

Realizing the importance of the issues presented before them, Maritime Safety Committee (MSC) of the IMO, in 2006, has decided to include “Development of an e-Navigation strategy” as a high priority item within the work programmes of NAV and COMSAR sub-committees with a target completion date of 2008. Upon extensive deliberations by the sub-committees about the available technologies, user needs and the intended outcome of e-Navigation, “*Strategy for the development and implementation of e-Navigation*” was prepared and submitted to MSC 85, which it had approved in 2008 and subsequently, directed the sub-committees to prepare an implementation plan as a high priority item for realizing this strategy (IMO-MSC, 2008). Although IMO is the lead agency for developing and implementing the e-Navigation concept, other international organizations such as IALA and IHO are also playing major role towards roll-out of this concept. IALA being the competent agency for Aids to Navigation (AToN), through its e-Navigation committee, is leading the development work of e-Navigation architecture for shore-based systems and ship-shore interface. IALA together with IHO is also supporting the IMO in development of Common Maritime Data Structure (CMDS), based on the IHO S-100 standard, which has been agreed for use in e-Navigation (IALA, 2014).

E-Navigation being an evolutionary and dynamic concept, there has been numerous ideas and discussions about what can be achieved by it, realistically and which of the user needs to be incorporated under e-Navigation, in the recent past. At the same time, incremental innovation happened in the field of ICT, encouraged experts in the maritime industry to include all possible solutions within the ambit of e-Navigation. In this background IMO, in 2009, has entrusted Norway to co-ordinate the work of development of '*e-Navigation Strategy Implementation Plan (SIP)*' through its sub-committees. Accordingly, *correspondence group on e-Navigation* established by IMO, chaired by Norway, has been relentlessly working on finalising the e-Navigation concepts, solutions and way forward, till date (Kystverket, 2014).

Concurrently, technology providers in collaboration with the research institutions and maritime administrations, mainly of Scandinavian countries and European Union (EU), have established several research projects, referred to as e-Navigation test beds, mainly ACCSEAS (Accessibility for Shipping, Efficiency advantages and Sustainability), EfficienSea (Efficient, Safe and Sustainable Traffic at Sea) and MONALISA (Motorways and electronic Navigation by Intelligence at Sea) to demonstrate the technical capabilities and the future potentials of e-Navigation concept (IALA, 2012). Furthermore, many conferences, seminars and workshops have been conducted by the interested stakeholders to brainstorm the e-Navigation possibilities, in many parts of the world. After many months of discussion and experiments, *correspondence group on e-Navigation* finalized the *Strategy Implementation Plan (SIP) for e-Navigation* and submitted to the IMO sub-committee NCSR in June 2014, which validated the SIP and forwarded to MSC 94, scheduled in November 2014, for approval (Kystverket, 2014). This SIP for e-Navigation, if approved, will definitely provide a roadmap for implementation of e-Navigation in coming years.

3.5 Definition, user needs and key elements of e-Navigation

The definition of e-Navigation developed by IALA's e-NAV committee and approved by IMO is as follows:

'e-Navigation is the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment' (IMO, 2007a).

This definition clearly indicates that the uniformity and harmonization in display and communication of navigation information are the key elements in e-Navigation and the main purpose is to enhance berth to berth navigation and related services. The e-Navigation aims to reduce the navigational errors and accidents through transmission and display of positional and navigational information using *electronic formats*. It also aims to use the up-to-date ENC's to facilitate route, position and other information, making full use of ENC's and GNSS (Hagen, 2014). Moreover, the aim of e-Navigation, as Patraiko (2007) explains "is to join the ship's bridge team and VTS team to create a unified navigation team that would achieve safer navigation through shared tactical information."

Considering the increasing trend in the number and nature of collisions, groundings and associated costs in the past decade, the shipping industry and IMO have realized the "clear and compelling need to equip the master of the vessel and those ashore responsible for the safety of shipping with modern, proven tools to make maritime navigations and communications more reliable and user-friendly" (Kystverket, 2014). It is anticipated that e-Navigation will be able to provide these tools with the help of advanced technology.

The *vision of e-Navigation* adopted by IMO (2008) primarily focusses on three elements, i.e. enhancement and up-gradation of navigational systems on-board, enhanced standards for shore-based vessel traffic and related services and communication infrastructure providing seamless flow of information between ship and shore. Key components of e-Navigation are depicted in figure-5 (Hagen, 2014).

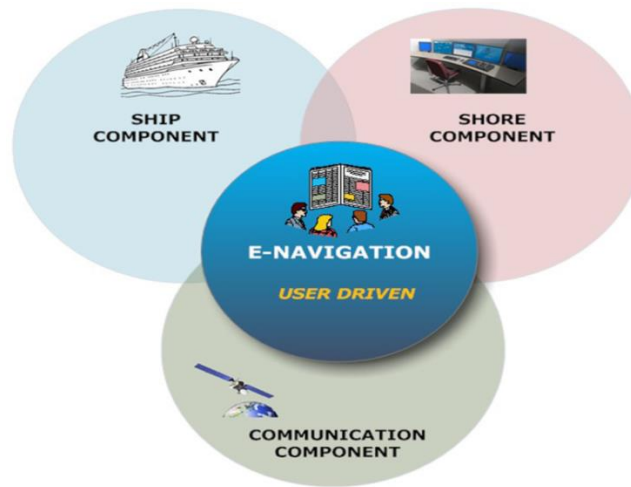


Figure 5: Key Components of e-Navigation. Source: (Hagen, 2014)

Moreover, e-Navigation strategy approved by IMO (2008) emphatically states that any development under this concept should purely be on ‘user-driven’ not ‘technology-driven.’ Therefore, this strategy enumerates several high level user needs of both the shipboard and shore-based personnel, inter alia,

- a) Common maritime information/data structure;
- b) automated and standardized reporting functions;
- c) effective and robust communications;
- d) human centered presentation needs for navigation displays;
- e) integrated alert management systems;
- f) effective human machine interface to reduce “single person errors” considering ergonomic principles;
- g) resilient data and system integrity and
- h) provisions for several analysis functions to support decision making

of bridge team as well as shore authorities. These high-level user needs are intended to be met by elements of the e-Navigation (IMO-MSC, 2008).

In order to accomplish the identified user needs, IMO’s e-Navigation strategy (2008) explains, many key strategy elements such as overall system architecture (figure-6), accurate position fixing systems with redundancy, worldwide coverage of the ENCs, performance standards for standardization of equipment’s and suitable communication technologies which have to be developed. Similarly, human element

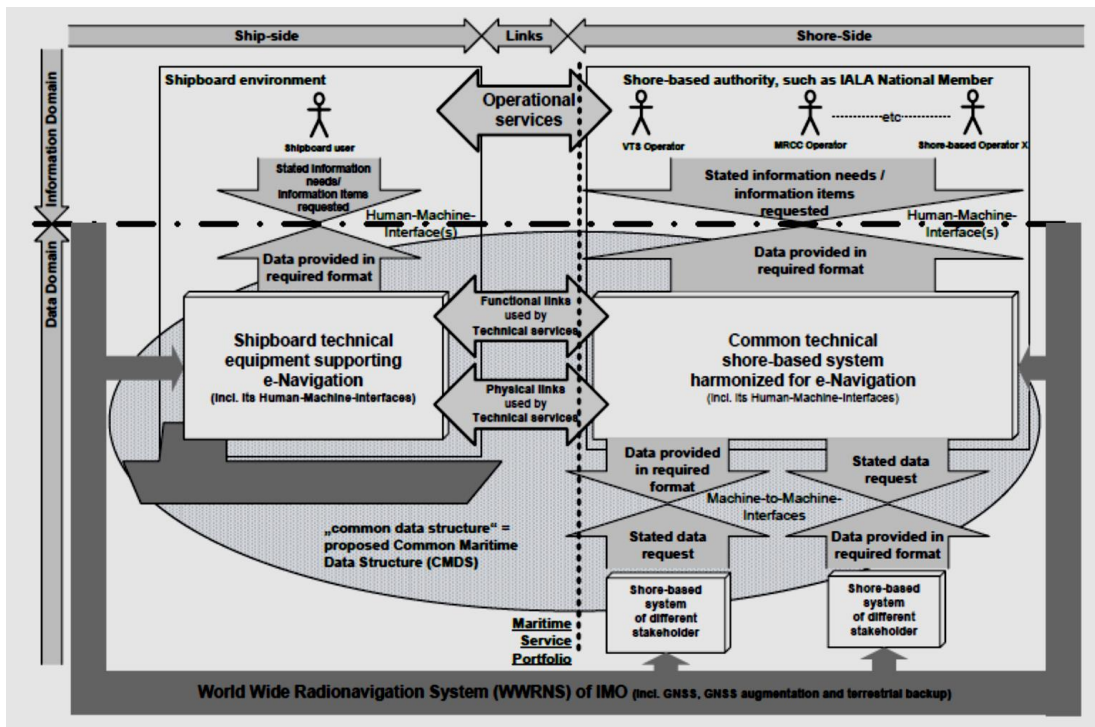


Figure 6: Overarching e-Navigation architecture. Source: (IMO, 2014b)

issues of training as well as competency, Scalability to all kinds of vessels, amendments to conventions and legislations have also to be addressed. These developments can be initiated subsequent to cost-benefit analysis of various solutions available and gap analysis on regulatory, operational and technical issues relating to e-Navigation (IMO-MSC, 2008). Hence, the *correspondence group on e-Navigation* over the years, has not only conducted the gap analysis of user needs of e-Navigation vis-à-vis technological capabilities, but carried out the cost-benefit analysis of several e-Navigation solutions as well, in order to finalize the SIP for e-Navigation.

3.6 E-Navigation Strategy Implementation Plan by IMO

The e-Navigation Strategy Implementation Plan (SIP) endorsed by the NCSR sub-committee of IMO in 2014, has primarily focussed on implementation of five prioritized e-Navigation solutions and gave the road-map to IMO to make e-Navigation a reality. Although many possible e-Navigations solutions were being examined and successfully tested in recent years, based on the user needs and cost-

benefit analysis, for initial roll-out, it was decided to start with five high priority e-Navigation solutions which are as follows:

- “Improved, harmonized and user-friendly bridge design (S1);
- means for standardized and automated reporting (S2);
- improved reliability, resilience and integrity of bridge equipment and navigation information (S3);
- integration and presentation of available information in graphical displays received via communications equipment (S4); and
- improved communication of VTS Service Portfolio” (IMO, 2014b).

While the solutions S1 and S3 promote the workplace standards by better design of lay-out and navigational equipment’s, the remaining three solutions are focussed on seamless flow of information between all the users on-board and ashore. Each of these five prioritized solutions has been further divided into many sub-solutions to facilitate the process of development of guidelines and standards towards the implementation. In order to implement these solutions, the *correspondence group on e-Navigation*, using Formal Safety Assessment (FSA) methodology, has identified and listed several tasks for each sub-solutions and expected deliverables, in the SIP, with specific time line for each tasks, in order to complete all the identified tasks during the planned period of 2015-2019 (IMO, 2014b).

Furthermore, the SIP recommended to the MSC 94, to incorporate all the identified tasks in the high level action plan of the IMO to complete the work as per the implementation schedule. The SIP also invites all the member States to actively participate in the process, to complete all the identified tasks, so that industry can start designing products and services to meet the e-Navigation solutions (IMO, 2014b). The SIP has also recognized all the possible functions of shore-based services which can be provided in harmonized way using e-Navigation, as Maritime Service Portfolios (MSP). There are sixteen MSPs, which have been identified in the SIP, inter alia, Vessel Traffic Services, Maritime Safety Information Services, Pilotage Service, Maritime Assistance Service, Meteorological information service, Chart correction service and SAR services. Moreover, six different areas of

coverage, such as port areas, coastal areas, open sea, polar areas, etc. have been identified for delivery of MSPs using e-Navigation. The SIP also recommends for establishing a dedicated ‘website’ for implementation of e-Navigation by IMO and developed a plan to create awareness about the developments in the field of digital navigation through consistent campaigns and wide publicity (IMO, 2014b).

3.7 Impact of E-Navigation on future MEH Projects

The MEH project of SOMS was conceived almost a decade ago based on the available technology at that time. However, during the past decade, enormous enhancements happened in the field of ship-shore communication, due to revolution in the ICT. Even the e-Navigation concept which was conceived in 2006-2008, changed phenomenally over the years, which led to development of SIP, only in 2014 (IMO, 2014b). While both the MEH and e-Navigation, aims to achieve the similar deliverables, especially in areas of ship-shore communication, e-Navigation concept, is much more comprehensive and encompasses all the aspects of navigation including user-friendly bridge design and all types of ship-shore services (MSPs).

Currently, MEH of SOMS is being used as one of the test bed for demonstrating the use of universal S-100 data standard of IHO, for providing e-Navigation solutions. A workshop conducted in 2012 by the Norwegian Coastal Administration, Maritime and Port Authority of Singapore and MEHSOMS successfully demonstrated the possibility of transmission of MSI from shore to ship via AIS VHF data link, using S-100 data standard. The report (NAV 58/INF.4) submitted by Norway to the IMO about the outcome of this workshop, concludes that there are lot of synergies between the MEH and e-Navigation and recommends that future development of MEH should consider merging of MEH infrastructure with emerging technologies using S-100 framework and MEH should incorporate all the aspects of e-Navigation including systems, architecture to utilize its maximum potential (IMO, 2012b). Therefore, it is unambiguous that any future MEH project, as proposed in this dissertation, should build on the demonstrated capabilities of e-Navigation.

Chapter – 4 Analysis of traffic between the West coast of India and South coast of Sri Lanka

4.1 Global trends on Seaborne trade and Maritime traffic

Shipping is referred to as derived demand, because the growth of shipping is directly related to the growth in world trade. The Trade and Development Report 2014 released by UNCTAD (United Nations Conference on Trade and Development) states that the world economy is still in the doldrums, because even after six years of global financial crisis, the economy has not revived to its full potential yet. From a growth rate of 2.3 percent in 2012 and 2013, the global economy is projected to increase moderately to 2.5 to 3 percent in 2014, however, recovery remains weak. Consequently, the international trade remains lack lustred because growth in trade has been hovering around only 2 percent since 2012 (UNCTAD, 2014).

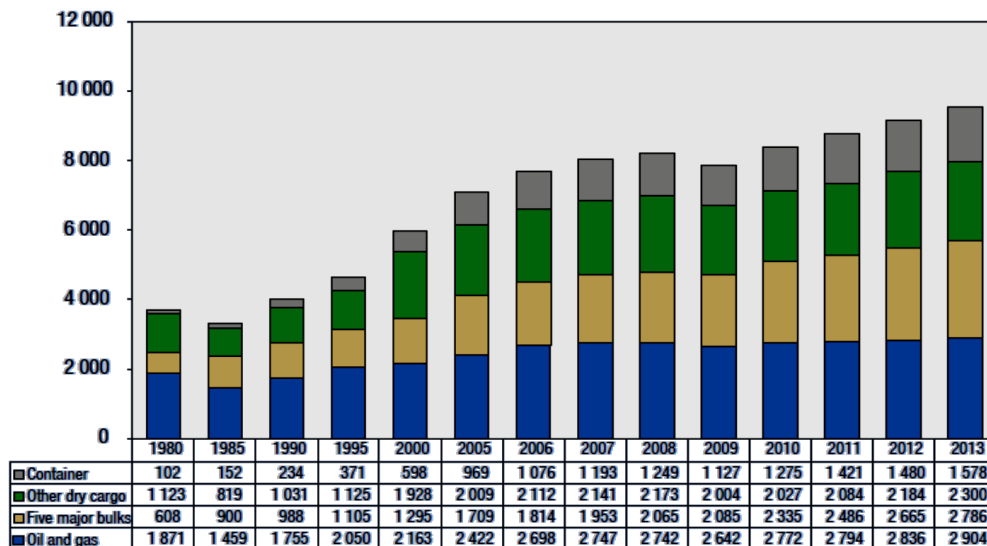


Figure 7: International seaborne trade, millions of tonnes loaded Source: UNCTAD Review of Maritime Transport, 2013

In view of this, although the international seaborne trade increased in 2012, it remains susceptible to risks facing the world economy. However, due to the rise in China's domestic demand and the increased trade in certain sectors, the international seaborne trade achieved a growth of 4.3 percent in 2012, which is better than the world's economy. As in 2012, seaborne trade has increased to a level of 9.2 billion tons of goods (loaded) worldwide, with oil cargoes occupying around 30% of trade (figure-7) with the remainder being dry cargoes (UNCTAD, 2013).

In contrast, despite the slowdown in the economy, the world tonnage continues to increase steadily, leading to overcapacity of the fleet during the period since 2008. The Review of Maritime Transport, 2013 published by UNCTAD (2013), reports that the shipping fleet has more than doubled since 2001 and reaching 1.63 billion deadweight tons (figure-8) as of January, 2013. The figure-8 clearly depicts the spurt in the growth of bulk carriers, container ships and other cargo ships, since 2005, compared to oil tankers.

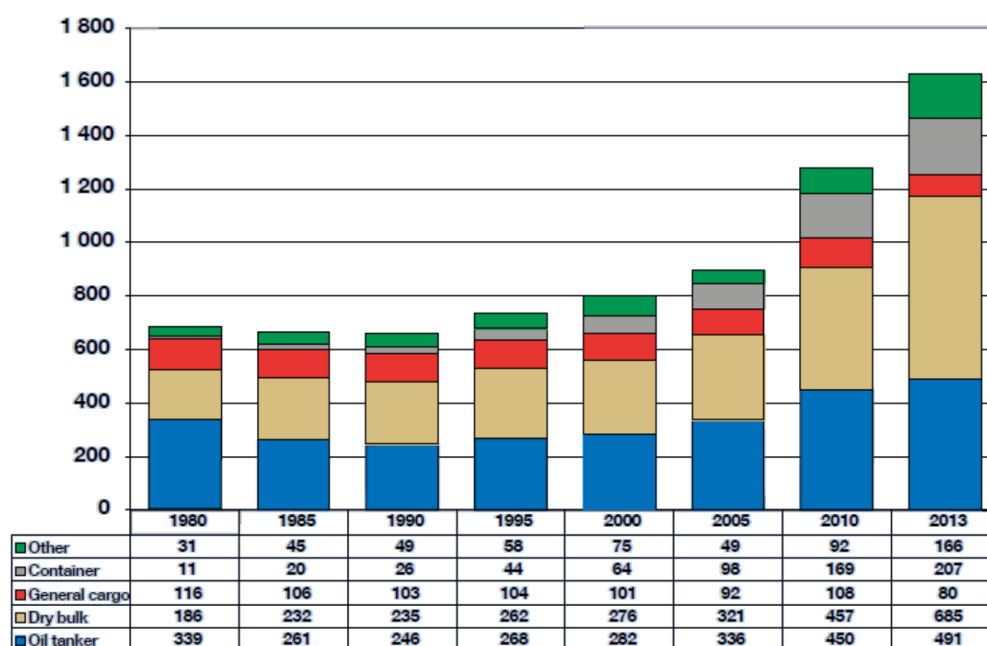
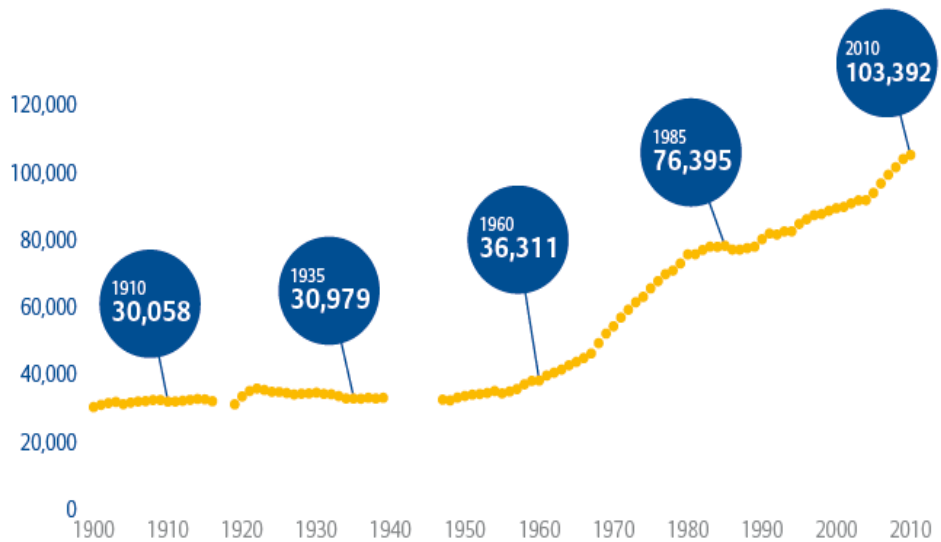


Figure 8: Growth of World Merchant Fleet (1980-2013) by vessel types in millions of Dead weight tons. Vessels >100 GT are included. Figures represent beginning of years. Source: (UNCTAD, 2013)

Similar to the increasing trend in shipping tonnage over the years, the Lloyds Register World Fleet statistics show that the number of ships have also increased

three times since 1960 and standing at over 100,000 in 2010 (figure-9) (Cardiff University & Allianz, 2012). Hence, the current trend indicates that the number of ships, as well as shipping tonnage, will continue to increase in the coming years,

World fleet size by number of ships: 1900-2010



Source: Lloyd's Register Fairplay, World Fleet Statistics 1900-2010

Figure 9: World fleet size by number of ships from 1900 to 2010. Source: (Cardiff University & Allianz, 2012)

at least until 2024 (IGP&I, 2014). This fact implies maritime traffic will also rise in all parts of the world, and more so in the congested shipping lanes.

4.2 Statistics of ships traffic data around the Indian Sub-continent

The literature review revealed that to date, no specific study has been conducted to find out the maritime traffic data around the Indian Sub-continent. Therefore, to begin any traffic management solutions, establishing the statistics of shipping traffic for that region is vital. In order to obtain a realistic estimate of shipping traffic in this region, the author has collected traffic data with the help of live feed and historical data from the Indian LRIT National data center (NDC) as well as using the live feed of the Indian National AIS chain. Data from the Indian NDC during the year 2013 has shown that at any instant, around 2700 vessels were operating within a 1000

nautical miles range and around 1050 vessels were operating within 500 nautical miles range of the Indian Coast. These numbers represent only those vessels of 300 GT and above, which are required to be fitted with LRIT. Moreover, the data from LRIT had also shown that within the specific coastal area being studied under this dissertation, i.e. between the South coast of Sri Lanka and the West coast of India, at any time, around 300 vessels are operating along the coast (DGS, 2014). Although, these numbers from LRIT have given some indication of the traffic density, it could not provide any accurate statistics regarding the number of ships transiting through the region in a particular period.

Therefore, it was necessary to adopt a methodology for counting the actual number of ships transiting the region in any day, so that data can be extrapolated for longer periods. Initially, using the live feed of the National AIS chain, the author has counted the number of ships transiting along the West coast of India to be precise off Kolachel, for a period of six hours. This exercise was repeated for five consecutive days at the beginning of August 2014. This process has revealed that on average 35 to 40 ships are crossing off Kolachel in a period of six hours. Even if we consider a minimum limit, it indicates that around 140 ships are transiting every day, which accounts for 51,100 ship transits every year. Since this data has been obtained using a smaller sample with a limitation on the AIS coverage area, another method was also adopted to estimate the ship transits in this region with the help of commercial satellite AIS services.

In this method, utilizing the 'Fleetmon' satellite AIS tracking service, the actual number of ships present in the critical navigational stretch of one day sailing distance (336nm) i.e. from the South coast of Sri Lanka to the West coast of India (figure-10), was counted every day for a period of 15 days. The reason for selecting the navigational stretch of 336 nm for one day is based on the fact that any ship transiting this region with a speed of 14 knots cannot stay within this stretch, for more than 24 hours. Also, the 14 knots speed was considered as an average speed for several categories of ships transiting through the region, using the AIS live data.

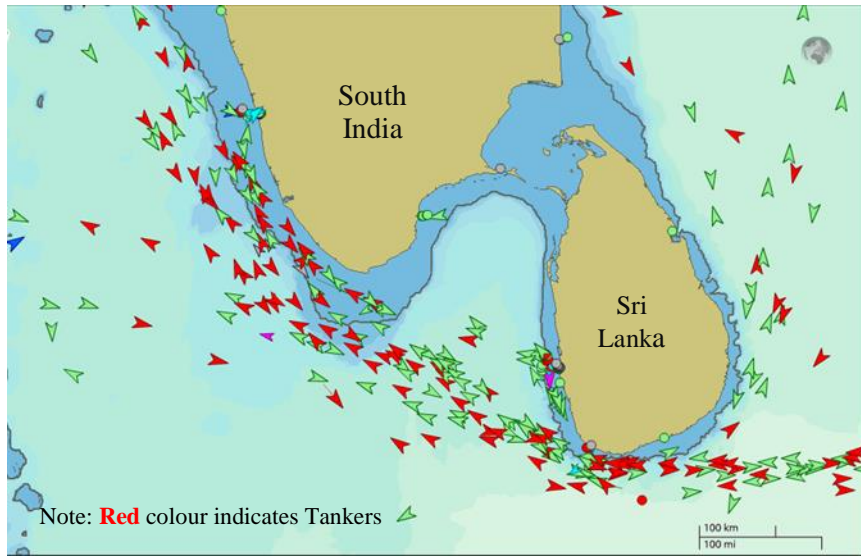


Figure 10: Shipping traffic between the SW coast of India and South coast of Sri Lanka, as seen from Satellite AIS display. Dated: 23rd Aug 2014. Source: (FleetMon, 2014)

Moreover, the ships count was made for all ships as well as for tankers separately. The result of this observation is illustrated in the bar chart (figure-11). This data collection process was conducted for 15 days using the Satellite AIS service, and has revealed that on average, 160 ships of all types, including 68 tankers but excluding fishing vessels, are transiting through this region every day (FleetMon, 2014).

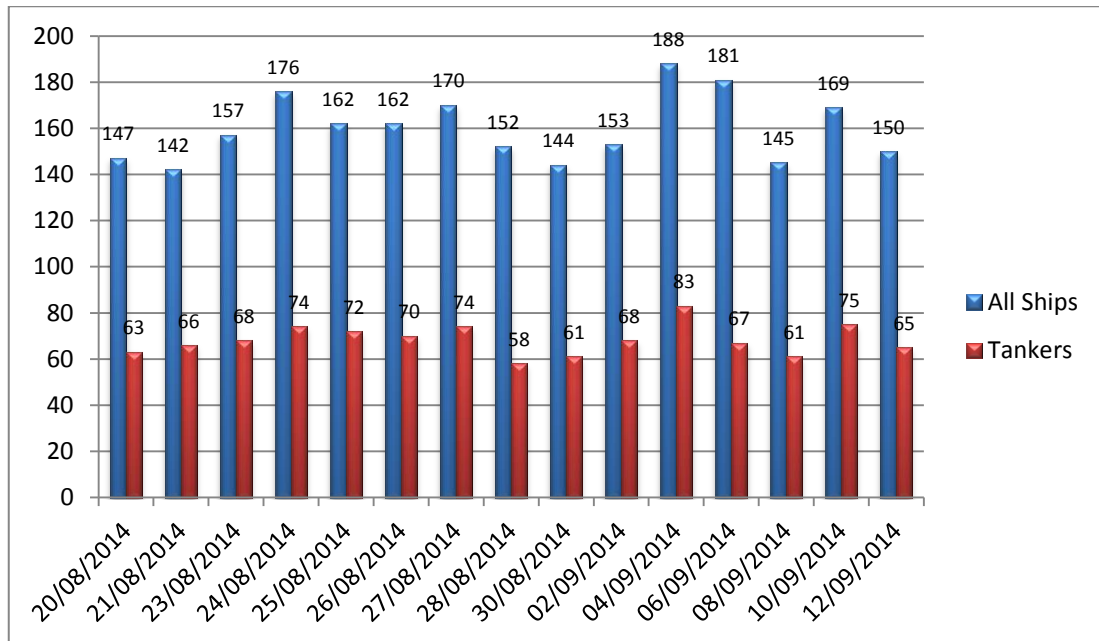


Figure 11: Chart showing the number of ships present within a navigational stretch of 336 nm. i.e. one day sailing distance at a speed of 14 knots. Source: Author

Consequently, it shows that the total of 58350 ship transits, including 24820 tanker transits are passing through this navigational stretch in one year. At this point, it is to be noted that the data represents only the ships transiting through the region and does not include the smaller harbor crafts operating within the ports and fishing vessels.

From the statistics collected above, in order to visualize the traffic concentration of this region in perspective, a comparison is made with the busiest shipping lanes of the world i.e. the Dover Strait and Singapore Strait. The Maritime and Coastguard Agency (2014) of the UK has reported that over 400 commercial vessels use Dover Strait every day. Similarly, the STRAITREP statistics (Appendix-3) released by the Marine Department of Malaysia, show that a total of 77973 ships transited through the Strait in the year 2013, which means around 215 ship transits every day (Straitrep, 2014).

Although, 160 ship transits per day in this region is significant, but less than the traffic in Singapore Strait, the main difference is that at present, the traffic in the region is moving in a haphazard manner without any traffic management, compared to the well-established traffic management in the Singapore Strait over many years. Moreover, despite the availability of sufficient sea room, many ships are navigating closer to the coast because of the shorter distance and traditional route, which increases the traffic density in the region, similar to the narrow straits (DGS, 2014). Although the above mentioned traffic statistics was collected diligently using sample survey method, some margin of error cannot be ruled out due to the possible overlapping of ships from one day to another day due to the variation from the average speed and change in the number of ships in different months.

A news article from Sri Lanka in 2010, reported that, quoting from the head of the Marine Environment Protection Authority, around 350 vessels were passing the South coast of Sri Lanka every day (Sunday Times, 2010), which could not be substantiated by this study. Furthermore, the traffic in this region is highly correlated to the traffic in the Strait of Malacca and Singapore (SOMS). Many studies have projected that the shipping traffic through the Strait will increase steadily in the

coming years. Rusli (2011) stated that by the year 2024, shipping traffic in the SOMS is being estimated to increase to 122,640 transits annually, based on the report by the Maritime Institute of Malaysia. Moreover, a study conducted by the Nippon Foundation in 2007, has projected that by 2020, the number of ships transiting through the Straits would increase to 141,000 which will be almost 80% more than the present level (Japan Association of Marine Safety, 2008). Therefore, according to the estimates given for SOMS, the number of ship transits through this Indo-Sri Lanka region also will increase correspondingly in coming years.

4.3 Analysis of the traffic pattern between the South coast of Sri Lanka and the West Coast of India

The next important step after estimating the traffic density is the analysis of existing and historical traffic patterns for the establishment of suitable traffic management solutions for the region. Since, the IMO guideline on ship's routing specifically states that any traffic management should closely follow the established traffic patterns in the region (IMO, 2013). In order to meet this requirement the author has studied the traffic pattern for a period of two months using the live data of the Indian LRIT NDC and the Indian National AIS chain, and for a period of one month utilizing the commercial Satellite AIS service 'Fleetmon.' As part of the study, the author has recorded and analysed the tracks, which include the identity of ships, positions, courses steered, speed maintained and course alteration points of over 100 ships transited within the navigational stretch between the South coast of Sri Lanka and the West coast of India. The observation of traffic has revealed that in general, shipping traffic between the Far East and Middle East follows the recommended routes (Appendix-4) given in the Ocean Passages for the World (Hydrographer of the Navy, 1987). The current traffic pattern, as seen in Satellite AIS live display, is depicted in figure-12 (FleetMon, 2014).

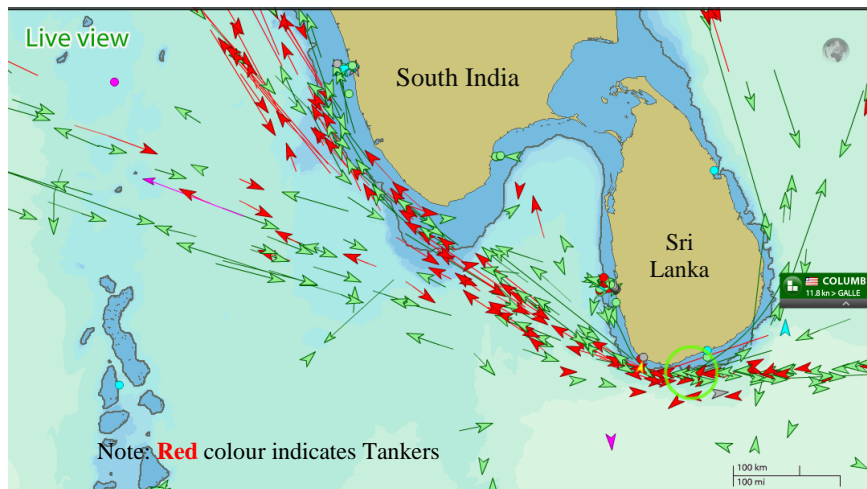


Figure 12: AIS live display depicting the ship's traffic pattern between the West coast of India and South coast of Sri Lanka as on 24th August 2014. Source: (FleetMon, 2014)

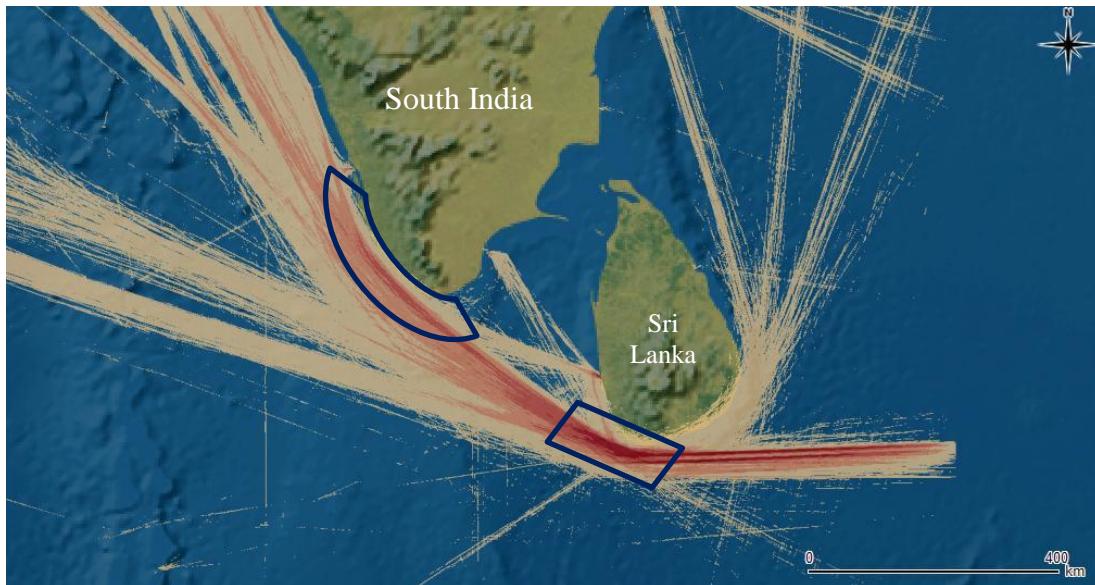
As can be realised in figure-12, from the South coast of Sri Lanka, predominantly there are two routes which occupy the major portion of the west bound traffic in this region. The first route is for ships destined either for ports on the West coast of India or for the Persian Gulf region. Ships following this route are normally navigating along the West coast of India up to a latitude of 13 degrees north; thereafter vessels alter their course towards their destination. Due to the topography of the West coast of India, the traffic slightly moves away from the coast upon crossing Kollam. Therefore, on this route, high traffic density with more risk of 'head-on' encounters among vessels following opposite courses, have been observed between Cape Comorin and Kollam. Moreover, it was observed that there is some convergence of traffic off Cape Comorin since ships sail to/from Colombo and Tuticorin to join the route along the SW coast of India. This creates the risk of crossing encounters in this region, which also needs to be suitably addressed. Another major concern in this area is that some ships are found navigating dangerously close to the coast, which has led to groundings in the past. Therefore, traffic management in this area should also aim to maintain the passing vessels at a safe distance from the coast, because of environmental concerns.

The second important route is for the ships bound towards the Gulf of Aden. After crossing Galle in Sri Lanka, the ships destined for Red Sea ports normally head

towards the eight degree channel and thereafter directly towards the Gulf of Aden. However, during the observation of past traffic, it was noticed that many ships are sailing towards the Indian Coast for a considerable distance before they alter their course towards the Gulf of Aden; this because of piracy concerns. However, recently with the help of armed guards on board, the traffic pattern for the Gulf of Aden has started to change in a normal way i.e. through the eight degree channel. This study has indicated that approximately one-fourth of traffic from the South coast of Sri Lanka or vice versa, passes through the eight degree channel and remaining three-fourth navigates along the Indian coast. Since the eight degree channel is very wide, and the traffic numbers through the channel are reasonable, this study did not foresee any immediate problem for this route.

The westbound traffic from the South coast of Sri Lanka has been analysed in previous paragraphs. Similar hazards exist for the eastbound traffic also, i.e. whilst navigating from the West coast of India and from the eight degree channel towards the South coast of Sri Lanka. The traffic observation of the entire area has clearly shown that the most critical point in this navigational stretch is the area off Galle, Sri Lanka. There is major concern for traffic noticed in this area because of the convergence of heavy traffic from three directions and vice versa. Moreover, the problem has been compounded in this area, since each ship is making alterations towards their destination in different positions; this because of the absence of traffic management. This creates the severe risk of crossing encounters in addition to head-on and overtaking encounters in this region, i.e. within 24nm range off Galle harbour. Although there is a Traffic Separation Scheme off Dondra Head, which is around 30 nm east of Galle, the study has shown that 35 percent of the ships transiting through this region were not using this TSS; instead they were passing further south of the TSS due to safety concerns (FleetMon, 2014) (exactEarth, 2014). Furthermore, it has also been observed that as a departure from their normal routes, many ships are coming very close to Galle harbour for logistics services, mainly for embarking and disembarking the private armed guards due to the piracy menace off Somalia (FleetMon, 2014) (ICOC-PSP, 2012). Since this is a temporary

phenomenon, it was not given consideration for establishing the routeing scheme, which is a long-term issue. Although collision risk assessment using quantitative analysis is important for maritime traffic management (Jeong, Park, & Kim, 2012), this study has adopted qualitative method based on the recent accidents and the prevailing traffic patterns in this region because of its unique nature.



■ >100 ships ■ 51-100 ships ■ 26-50 ships ■ <25 ships per sq.km

Figure 13: AIS density plot for the month of August 2013. Source: (exactEarth, 2014)

Hence, the overall traffic observations have clearly indicated the most critical areas, such as off Galle and the area between Cape Comorin and Kollam, for initiating the traffic management solutions within this navigational stretch. Moreover, the AIS density plot obtained from the commercial Satellite AIS service provider ‘exactEarth’ for the previous year i.e. for the month of August 2013, has also confirmed that the traffic density was very high in these critical areas (figure-13). Therefore, in order to avoid the collision risks, as well as grounding risks due to unregulated traffic, the establishment of Traffic Separation Schemes (TSS) in these critical areas appears to be a cost effective solution, which can be implemented as soon as possible. Moreover, with the help of the AIS density plot obtained from ‘exactEarth’ (see also Appendix-5) the location and alignment of TSS has been

identified. Further details regarding the design of the TSS layout for this region have been explained in Chapter-6.

Additionally, the traffic analysis along the West coast of India has shown that the traffic density remain considerably high along the entire West coast, especially up to New Mangalore and through the Lakshadweep islands because of oil/gas trade route. Therefore, detailed study of the shipping traffic in remaining areas also needs to be undertaken, subsequently, for establishment of necessary routeing measures. Furthermore the India has also established, since 2008, some routeing measures such as safety fairway through the offshore development area, off Mumbai and recommended routes in the Gulf of Kutch for improving the safety of navigation in these congested waters, along the West coast. However, these routeing measures have not been submitted to IMO, yet for adoption, therefore it remains as recommendatory for foreign flag ships (National Hydrographic Office, 2008). Hence, if the necessary steps are taken by India to make it as an IMO approved routeing scheme to ensure its universal acceptance then it will surely enhance the safety of navigation around the Indian sub-continent.

Chapter – 5 Vulnerability of the region due to recent casualties and its impact

5.1 World Casualty Statistics – Major causes and trends

An analysis of the casualty statistics for the past 100 years, by the Cardiff University, indicates that there is a decline in total losses⁴ of ships, over the years. Lloyd's Register world casualty statistics illustrates that the number of ship losses have decreased steadily from one ship loss in every 100 ships in year 1910 to one ship loss in every 670 ships as at 2010, which bolsters the overall image of shipping industry (Cardiff University & Allianz, 2012). However, it is to be borne in mind that whilst the total loss of ships reached a low level of 138 ships in 2013 (IHS, 2014), the consolidated number of all the shipping casualties, which includes the serious and very serious casualties, for the same year stood at enormous 2596 incidents (Allianz Global, 2014). This indicates that, although the numbers of shipping casualties are very high, the total losses of ships remain low due to inter alia, improved ship design, stability and strength of ships. Therefore, an analysis of casualty statistics, which includes both total loss i.e. very serious and serious casualties of ships, can only provide a clear indication about the major causes of shipping casualties.

Furthermore, the statistics reflect that if we analyse the causes only for the total losses of ships, foundering of ships occupies the major portion of 73%, followed by grounding, fire, collision and others in 2013, similar to the previous years (Allianz Global, 2014). In contrast, if we examine the combined statistics of both the total loss and serious loss of ships for the period of 1999-2013 (figure-14), collisions and groundings combined occupy the major share of 46% compared to other types of casualties (IUMI, 2014). Furthermore, the analysis of casualties occurred during the

⁴ Total losses refer to propelled sea-going merchant ships of not less than 100 GT which, as a result of being a marine casualty, have ceased to exist, either by virtue of the fact the ships are irrecoverable or have subsequently been broken up. They are considered as very serious casualties (IHS, 2014).

period between 1999 and 2013, carried out by the International Union of Marine Insurance (IUMI), shows (figure-14) that in terms of total number of casualties, the percentage of collisions and groundings combined increased from 41% during the period of 1999-2003 to 46% in the period of 2009-2013. Therefore it clearly

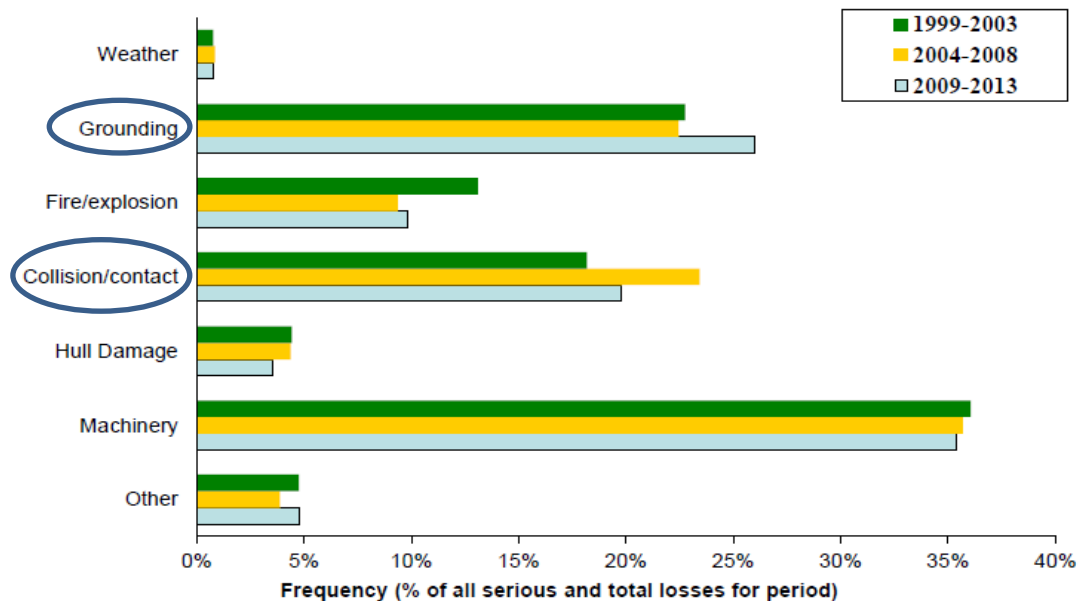


Figure 14: Percentage of all serious and total losses of ships (>500 GT) by cause during the period 1999-2013. Total losses as reported by Lloyd’s list. Source: (IUMI, 2014)

reflects that the percentage of navigational accidents i.e. collisions and groundings have increased in the past fifteen years, despite tremendous advancements in the navigational safety systems on-board and ashore. Hence it is incumbent upon all the stakeholders to analyse the root-causes of navigational accidents thoroughly and to implement necessary corrective and preventive measures, including efficient maritime traffic management systems, to reduce the potential risks of such accidents.

5.2 Statistics of navigational accidents around the Indian coast

Similar to the world-wide trend, the Indian coast has also witnessed many navigational accidents during the past five year period of 2009-2013 because of several reasons which includes increased maritime traffic in the past decade. The casualty statistics of the Directorate General of Shipping (2014a) indicate that a total

of 34 collision incidents and 43 groundings (Table-1) occurred within the Indian waters during this period.

Table-1: Statistics of Navigational accidents within Indian waters for the period of 2009-2013
Source: Author; based on the casualty statistics of the DG Shipping, India

Type of Casualty	2009	2010	2011	2012	2013	Total
Collision	7	9	3	4	11	34
Grounding	8	7	15	5	8	43
Total	15	16	18	9	19	77

A detailed analysis of these navigational incidents illustrates that, out of 34 collision incidents, 14 incidents occurred within the port area and approaches, 9 incidents occurred along the Indian coast and the remaining 11 incidents were collision with fishing vessels i.e. hit and run cases. Moreover, within these 34 collisions, 8 incidents of collision occurred within the VTS areas of the ports (Figure-15).

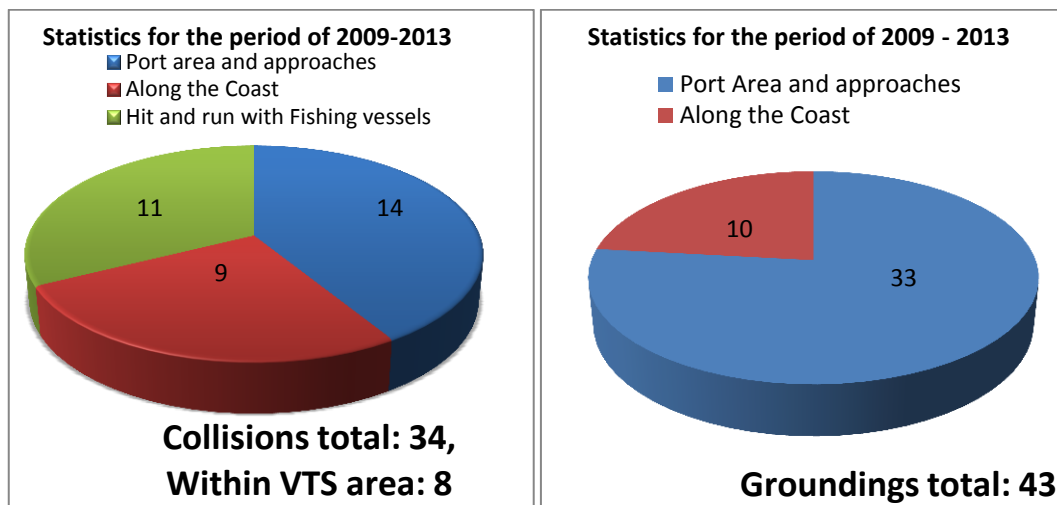


Figure 15: Statistics - Breakup of collision and grounding incidents in Indian waters. Data obtained from the DG Shipping. Source: Author

On the other hand, out of 43 groundings, total of 33 groundings occurred within the port area and approaches and remaining 10 vessels were grounded (figure-15) along the Indian coast (DG Shipping, 2014a). From the above mentioned statistics it is sufficiently clear that Indian waters are highly vulnerable to navigational accidents. More specifically, five incidents of collision between merchant ships and fishing vessels and two incidents of groundings occurred within the critical area, are being

studied by this dissertation i.e. off the South West coast of India, during the period of 2009-2013. These incidents have resulted in loss of lives of fisherman and oil spill within this region (DG Shipping, 2014a). Furthermore, few incidents of oil and chemical pollution have occurred within the Sri Lankan waters as well in the recent past. In 2006, an oil pollution incident, due to failure of hull and subsequent foundering of cargo ship had occurred in the South coast of Sri Lanka, whilst the vessel was on her way from Rangoon to Mumbai (MEPA Sri Lanka, 2014). Some of these major incidents are analysed in the subsequent paragraphs.

5.3 Analysis of navigational accidents off the SW coast of India

The casualty investigation reports of three navigational accidents occurred off the SW coast of India in the recent past and are summarised and analysed as follows:

a. Collision between *M.V. Izumo*, Flag: Panama and Indian fishing boat '*Al Amin*' off Kerala coast on 16.01.2013 (MMD, 2013).

The report of Preliminary Inquiry conducted by the Indian Mercantile Marine Department (MMD) (2013) states that one of the fishing vessels reported to the authorities in Kerala coast, that they saw one merchant vessel collided with motorised fishing boat '*Al Amin*' during daylight hours, while engaged in fishing, off Calicut. Also they had taken the photographs of merchant vessel using their mobile phone. Consequently, fishing boat sank and three fisherman of that boat jumped into the water and immediately they were rescued by other fishing boats in the region. They also reported to the police that the merchant vessel involved in the incident neither stopped after the collision nor gave any assistance in rescue of those fishermen. Based on the reported information, the authorities had immediately identified, *M.V. Izumo* sailed out from Kandla bound for Singapore, was in that position, at that time reported by fishing vessel, using AIS tracks and LRIT data. Subsequently, the merchant vessel was directed to Kochi for the purpose of casualty investigation (MMD, 2013).

Casualty investigation revealed that the merchant vessel ‘*Izumo*’ was navigating through the area of dense fishing traffic, at the time of accident and the second officer, who was on watch, told the investigating authority that his vessel had five close quarter situations with fishing boats during his watch but did not realize any collision with fishing boats. However, circumstantial evidences available have *prima facie* established collision between fishing boat ‘*Al Amin*’ and *M.V. Izumo*. Recommendations given in the report, states “where concentration of fishing boats are known, it is unwise to navigate through the area.” Moreover, it also gave a recommendation inter alia to update the information given in Admiralty Sailing Directions about the areas of heavy fishing traffic especially off Alleppey, Kollam and Calicut of Kerala Coast, by the authorities concerned (MMD, 2013). However, in view of many such incidents as explained under the casualty statistics, it is certain that if proper traffic management tools are not being implemented then recurrence of such incidents cannot be avoided.

b. Collision between *M.V. Prabhu Daya*, Flag: Singapore and Indian fishing trawler *Don-1* off Kerala coast on 01st March 2012 (MMD, 2012)

The report of Preliminary Inquiry conducted by Indian MMD (2012) states that owner of a fishing vessel received a phone call from fisherman, at the midnight on 1st March 2012, informing him that unknown merchant vessel collided with *Don-1* whilst they were engaged in fishing off Alleppey and five fishermen from the trawler were missing and boat sank. Thereafter, the owner had alerted the authorities about the incident and lodged complaint with the Kerala police. Immediately, the law enforcement authorities sprang into action and have identified merchant vessel ‘*Prabhu Daya*’ bound for Singapore from Goa, was exactly at the location of the incident, at that time reported by fisherman, with the help of the Indian LRIT National Data Centre. Subsequently, the vessel was diverted to the nearest port Chennai for investigation (MMD, 2012).

On the following day of the incident, Master of the vessel raised an alarm to the SAR authorities stating that the second officer, who was on duty at the time of alleged

collision, is missing from the ship, while sailing towards Chennai. Later, he was rescued by the Sri Lankan fishing boat and brought ashore. Also, it was confirmed that five fishermen of ill-fated *Don-I* lost their lives due to the collision with merchant vessel. Detailed investigation carried out by the authorities have confirmed with certainty that *M.V. Prabhu Daya* had indeed collided with fishing trawler around midnight on the day of the incident. The investigation report confirms that second officer during that night had experienced heavy fishing traffic in that region. Also, he was altering courses to keep the fishing traffic clear of the vessel. However, whilst altering courses to clear one fishing vessel, the vessel collided with that trawler. At that time, the report stated, the second officer was suspecting a collision with trawler, because the bright light of the trawler went missing immediately thereafter. Though he called the Master on the bridge subsequently, the vessel was not stopped immediately, to verify whether the vessel collided with fishing trawler or not and to rescue the lives of fishermen on that trawler (MMD, 2012).

The safety investigation of this incident has given many recommendations to the authorities about the navigational practices of merchant vessel, compliance with COLREGS, training of fisherman, standards of fishing trawlers, limitation on fishing areas etc. One of the recommendation states that in coastal waters and in areas of high density fishing traffic, merchant ships have to keep safe distance possible from the coast. Furthermore, it specifically recommended that “traffic studies may be undertaken by state maritime administration in the area and necessary change to the routing and buoyed system, if any may be proposed” (MMD, 2012).

Despite the fact that many fishing vessels operating in the region does not have adequate navigational and communication equipment to operate beyond territorial waters, as a first step, it is necessary to guide the huge fleet of merchant vessels passing through the region, with the help of suitable traffic management system, so that fishermen can be familiarized with the route of merchant vessels. Such a system will not only help avoiding collision incidents with fishing vessels but the collisions between merchant vessels as well. This dissertation is a step towards meeting the

recommendations given by the safety investigation authorities, in order to avoid any such collision incidents and loss of lives of fishermen around this region and for protection of the marine environment.

c. Grounding of *M.V. Mirach*, Flag: Panama, on 29th March 2011, off Kolachel, South Tamil Nadu coast (MMD, 2011).

The report of preliminary investigation by MMD (2011) states that bulk carrier *M.V. Mirach* carrying iron ore fines, on her laden voyage, with maximum draft of 10.25m, from Visakhapatnam to Karachi, ran aground near a submerged “crocodile rock” off Muttam lighthouse, on 29th March 2011 at 1800 hours. This grounding incident resulted in damages to ship and oil pollution in that area. Major pollution from bunker oil tanks was averted due to immediate arrival of Salvage team on-board. Subsequently the vessel was abandoned and all crew members were safely evacuated from the ship. Eventually the vessel sank in that position. The investigation revealed that the subject vessel was navigating very close to the coast i.e. 3.5nm and passing navigational dangers such as rocks with a distance of 1nm. Master of the vessel did not provide any instructions to the navigating officer about safe passing distances from the coast or navigational dangers. The report has also indicated many shortcomings in navigational practices, passage planning and lack of bridge team management which resulted in grounding (MMD, 2011).

Furthermore, the investigation report has given many recommendations to the authorities for prevention of such grounding incidents along the coast. One such recommendation clearly states “VTS may be considered to be installed at few strategic locations in Southern coast of India to monitor passing vessels” (MMD, 2011). Therefore, upon analysing the traffic patterns in this region, a Traffic Separation Scheme has been proposed for this area, not only to separate opposing streams of traffic but to keep the passing traffic at a safe distance from the coast as well, in this dissertation. Moreover, based on the recommendation of investigating officer, establishment of Coastal VTS, off Kolachel is being proposed in the dissertation as part of the overall Marine Electronic Highway system for the region.

Finally, it is amply clear that the analysis of even few navigational incidents as above, demonstrates the compelling need for establishment of suitable Maritime Traffic Management solutions for this region.

5.3 Environmental sensitivity of the region

India has a long coastline of 7517km and is blessed with beautiful beaches, a vast network of backwaters, estuaries, lagoons, creeks and a variety of sensitive ecosystems like mangroves, coral reefs, sand dunes, sea grass beds and wetlands. Some of these ecosystems are the breeding grounds and nurseries of different kinds of fishes, gastropods and crustaceans (Sa, 2010). The bio-diversity of the coastal areas especially the Gulf of Mannar, Gulf of Kutch, Andaman and Nicobar and Lakshadweep islands are significantly high. More than 5000 species of marine flora and fauna have been recorded within the coastal waters of India (ICMAM, 2010). The area being studied for this dissertation covers only the Kerala coast, South Tamil Nadu coast in India and Southern coast of Sri Lanka. Any oil spill in these areas due to shipping casualties and tank cleaning operations of oil tankers immediately affects the habitats, beaches and the livelihood of people dependent on coastal resources and causes irreversible damages to the bio-diversity of the region.

A study on sensitive coastal marine areas of India by Integrated Coastal and Marine Area Management (ICMAM) Project Directorate (2010) states that the coastal zone of Kerala is very unique because of its direct links with lagoons, backwaters and canals very close to the coast. Also the sea off Kerala coast is a major productive zone for marine fish. Therefore, the report concludes that the entire 580km long coastal stretch of Kerala has high utility for fishing, navigation, boating and tourism; hence the whole coast needs protection from oil spills. Moreover, this study has reported that oil spill risk for the coast is moderate to high because of adjacent shipping lane (ICMAM, 2010). Furthermore, because of its unique location Kerala has 28 mangrove sites (figure-16) which are very rich in species diversity and environmentally sensitive (KSCSTE, 2007). Reji & Pawels (2013) argued for a marine oil spill trajectory modelling and Environmental Sensitive Index (ESI)

mapping of the Kerala coast with a reasoning that any major spill resulting from collision, stranding and other marine casualties could affect several areas around the Kerala coast and threaten the entire marine life in the inter-tidal zones, fisheries, sea birds, recreational beaches and tourism.

Similarly the coast line of Tamil Nadu is around 1076km long and stretches along Bay of Bengal, Gulf of Mannar and Arabian Sea. It has coral reefs in the Rameshwaram, Gulf of Mannar (figure-16) and well developed mangrove forests in three places along the coast (CPEES, 2010). Although the coast extends to Bay of Bengal, for the purpose of this dissertation, more emphasis is being given to south Tamil Nadu coast i.e. around Kanyakumari (Cape Comorin) and Gulf of Mannar area because of prevalent maritime traffic pattern in the region. The coast line of Tamil Nadu is also highly sensitive to environment because of features like mangroves, coral reefs, mud flats, sand dunes, marine parks, salt marshes, Turtle nesting grounds, Horse shoe crab habitats, sea grass beds, nesting grounds for birds and archaeological important heritage sites existing throughout the coast (ENVIS Tamil Nadu, 2006).

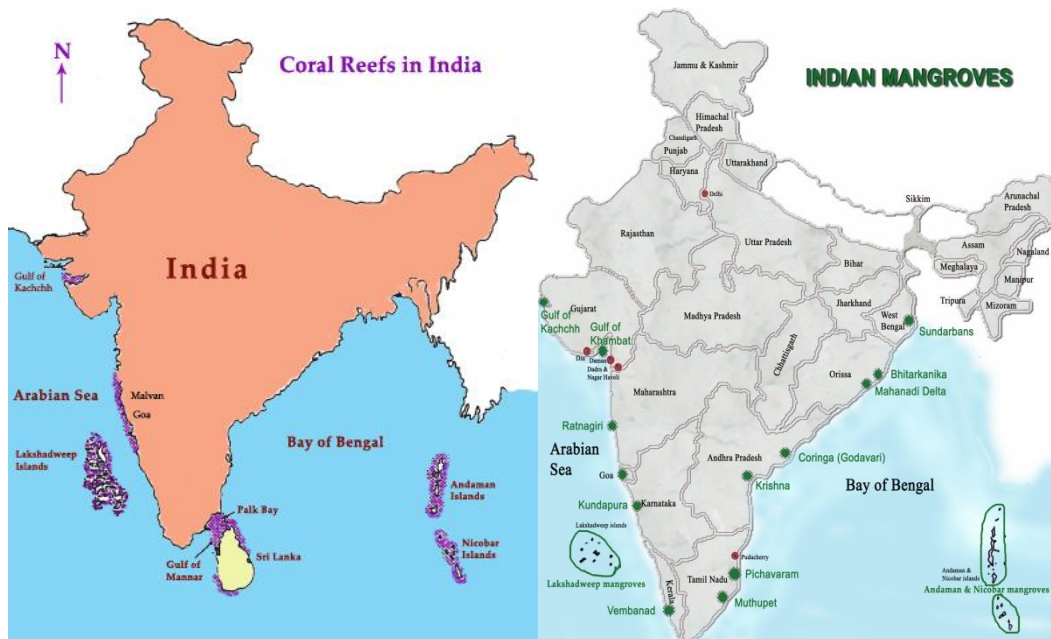


Figure 16: Map showing coral reefs and mangroves in India Source: (CASMBENVIS, 2014)

More specifically, the Kanyakumari being the southernmost point in mainland India attracts large number of tourists from India and abroad. The coastal waters of Kanyakumari are being used regularly for bathing by tourists. Therefore, any oil spill in the area will damage the appealing view of beaches and prohibit bathing by tourists. Hence, a study by ICMAM (2010) reports that oil spill risk is 'high' for Kanyakumari region, because many oil tankers pass very close to the coast every day. Furthermore, the report states that oil spill risk near Tuticorin area is 'very high' because of pearl banks, coral reefs and chank beds situated in adjoining areas.

The most important environmentally sensitive region, which might be affected because of any marine casualty in the adjoining area, is the Gulf of Mannar situated between India and Sri Lanka (ICMAM, 2010). Gulf of Mannar covers an area of approximately 10,500 square-km with 21 small islands within it. It is one of the biologically richest coastal regions in Indian sub-continent and it has been declared as the first 'Marine Biosphere Reserve' in the entire South and South East Asia. It has also been declared as 'priority area' by the international agencies engaged in the field of conservation of Marine Protected Areas (ENVIS Tamil Nadu, 2006).

The state of environment report of Tamil Nadu (2003) illustrates that the Gulf of Mannar is "rich in seaweeds, sea grass, coral reef, pearl bank, sacred chank beds, fin and shellfish resources, mangroves and number of endemic species and endangered species including the Dugong dugon commonly referred to as the sea cow." It also reports that around 3600 species of flora and fauna have been known to exist within this Marine Biosphere Reserve. Moreover, Gulf of Mannar region has a total of 117 species of coral belonging to seven genera. Therefore, this region is called as 'biologist's paradise' (MOEF, 2003). The coral reef also houses abundant varieties of fish and supports the livelihoods of around 150,000 fisher folk in the area (UNDP, 2014). Because of the environmental sensitivity of the region, a study by ICMAM (2010) concludes that even though main shipping lanes and oil tankers routes are little far away from the Gulf of Mannar, the risk of oil spill is 'very high' because of consistent wind direction in June to September, which might rapidly spread the oil

spill towards this region, in case of any shipping casualties in the nearby shipping lanes.

In addition to the environmentally sensitive region of the West coast of India and Gulf of Mannar, this dissertation also covers the coast of Sri Lanka, since majority of the shipping traffic is passing through the Sri Lankan waters. Being a tropical island nation, with large coastline and continental shelf, Sri Lanka is gifted with rich variety of coastal and marine resources, which are highly associated with the nation's economy. The country has a variety of coastal habitats (figure-17) such as lagoons, estuaries, pristine beaches, mangroves, salt marshes, coral reefs and sea grass beds which supports the coastal fisheries and tourism industry (ADB-IUCN, 2002).

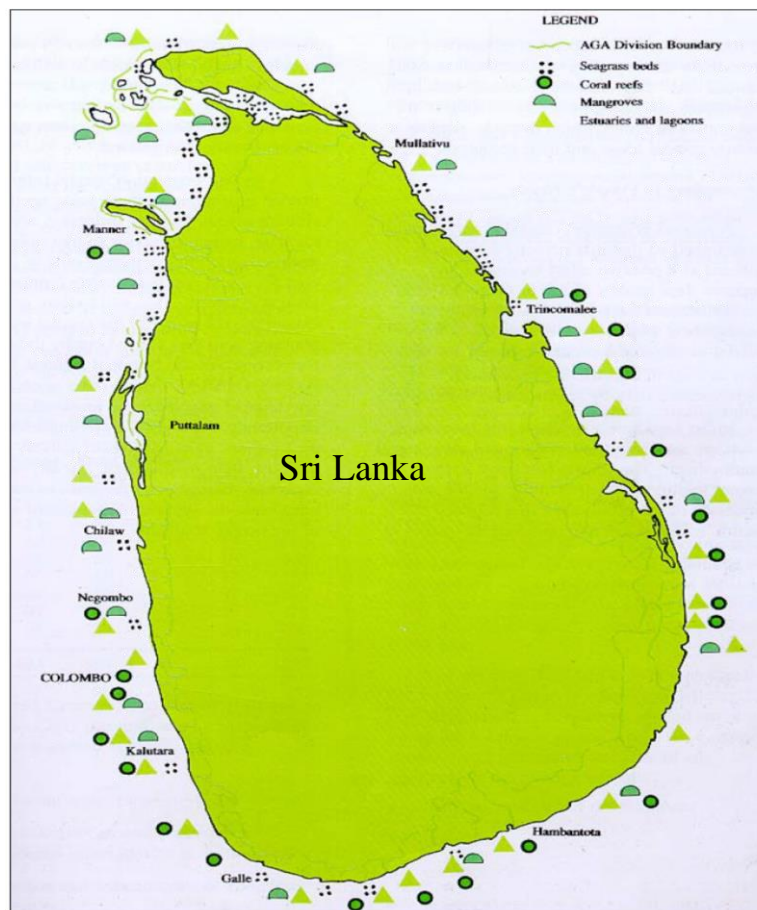


Figure 17: Map depicting the location of significant coastal habitats in Sri Lanka Source: (ADB-IUCN, 2002)

Furthermore, Sri Lankan coastal waters are being considered as ecologically and Biologically Significant Areas (EBSA) because it is home to endangered species of turtles such as green turtle, leatherback turtle and hawksbill turtle and globally endangered marine mammals such as *Balaenoptera musculus* (blue whales) and *Dagong dugon* (Jayakody, 2012). Moreover, surveys conducted recently, off South coast of Sri Lanka by Priyadarshana et al (2014) have confirmed that highest number of blue whales was observed within the current shipping lanes off Dondra Head, with severe risk of ship strikes. The report submitted to Convention on Biological Diversity (CBD) by Sri Lanka (2012) stated that 38 species of marine mammals, 180 species of corals, 11 species of lobsters, 25 true mangrove species and 1800 species of marine fishes are living in the coastal waters of Sri Lanka. Also, the coastal wetlands support many of the wetland migratory birds.

The preservation of coastal environment is highly significant for the Sri Lanka, because 55% of country's population lives in coastal districts. The situation analysis report prepared by the Asian Development Bank (2002) states that oil spills from fleets of tankers passing along the South and West coast Sri Lanka, trading between the Gulf and the Far East, poses major hazard to beaches and sensitive coastal environment throughout the year. The coastal region is also affected by other pollutants dumped into the sea by hundreds of passing ships every day. Therefore, Gunasekera (2014) from Marine Environment Protection Authority (MEPA) argued that the coast of Sri Lanka is highly vulnerable to an oil spill risk, since "25 percent of world's oil transportation, which runs up to a quantity of 550 million tons per annum, pass via the Exclusive Economic Zone (EEZ) of Sri Lanka." Therefore, protection and preservation of marine environment of these sensitive coastal regions is highly challenging, because of dense shipping traffic passing through it without any monitoring and control.

5.4 Potential impacts on the environment due to shipping casualties

The coastal areas of the South West coast of India and Sri Lanka are environmentally sensitive due to its unique and fragile ecosystems, which have been explained in previous paragraphs. Moreover, the Indian coast is highly vulnerable due to its low-lying coastal area, high population density in the coastal belt, frequent occurrence of cyclones and high rate of environmental degradation on account of pollution. Also most of the people living in coastal area are highly dependent on the natural resources of coastal ecosystems (CPEES, 2010). Therefore, any major pollution incident from shipping casualties, for example grounding of Very Large Crude oil Carrier (VLCC) or collision involving oil tankers will become a catastrophe in this region. Such incidents will not only damage the ecosystems but destroy the livelihoods of millions of people surviving purely on coastal resources.

Statistics show that around 9.4 million people live in coastal districts of Kerala, out of which more than 1 million are fisher folks. Because of this, Kerala occupies the highest position in terms of marine fish production and produces 7.5 lakh tonnes every year (Kerala Fisheries Department , 2013). Similarly, around 29 million people live in coastal districts of Tamil Nadu and the state have around 9.15 lakh marine fishing population purely dependent on marine resources. They contribute to the marine fish production of around 4.3 lakh tonnes every year, for Tamil Nadu (Tamil Nadu Fisheries Department, 2013). Likewise, fisheries sector of the Sri Lanka has 2.7 lakhs fisherman and provides livelihood for more than 1 million people. The total fish production of Sri Lanka in the year 2013 was 5.2 lakh tonnes and it is growing steadily (Minsitry of Fisheries, 2014). Hence any oil/chemical spills in the region will directly affect 3 million fisher folks and indirectly affect the 50 million people living in coastal districts.

Furthermore, oil spills contaminates the commercially valuable fish and damages fish hatcheries in coastal waters, thereby directly affects the fishing industry. However, indirect losses due to imposition of fishing ban by States due to oil spills are very

high (Rai, Pandey, & Joshi, 2011). Furthermore, Rai et al (2011) explained that oil spills impacts the coastal ecosystem in variety of ways. Oil kills the plants and animals in the estuarine zone and settles on beaches and kills the organisms therein. It also settles on ocean floor and kills benthic organisms such as crabs and affects the inter-tidal organisms as well. Moreover, oil poisons algae, disrupts important food chains and decreases the production of edible crustaceans (ITOPF, 2011).

Similarly, the exposure to oil can damage the coral reefs and the marine organisms living in or around the reef. Salt marshes might also be damaged easily by the light oils. Even little amount of coating of oil in the mangrove roots can damage the mangrove completely. Although the negative effects of oil spill can be neutralized, it may take many years or decades for recovery of ecosystem to the normal condition (GPA, 2013). More than anything else, the pictures of oily beaches and oil soaked birds can generate more pressure from the public for taking some immediate action to prevent the pollution incidents. Nevertheless, oil harms the sea birds and marine mammals due to physical contact as well as toxic contamination. Oil spills also affects the human health either due to inhalation or touching of oil products and eating contaminated food (ITOPF, 2011). Furthermore, contamination of coastline by oil severely affects the tourism industry and affects few of the industries which are required to intake cooling water directly from sea. Therefore, oil spills due to shipping casualties affect wildlife, habitat and economy of the coastal regions and the health of persons involved (GPA, 2013).

Although it is not possible to attribute economic values to the coastal environment, for the purpose of cost-benefit analysis, some studies have calculated the economic value of the coastal resources based on the benefits it provides to the community. The value will definitely be different for the different ecosystems and it also varies from one country to another depending upon the living standards. A report on Integrated Coastal Zone Management Project by the World Bank (2010), states that no systematic study has been conducted so far about the economic benefits of coastal resources of India. However, it estimates that the mean economic value of coastal

resources of India is around US\$400,000 per kilometre of coastline per year, which amounts to US\$2.1 billion per year for the peninsular Indian coast. Similar estimates can be applied to the coast of Sri Lanka also, because of common ecosystems. These estimated values are based on the benefits to the people only and not the values to the environment itself, which cannot be quantified. Even if we only consider the values to the people and other economic benefits from tourism etc. of the coastal environment, the potential impacts of oil spills in the region can be phenomenal. Therefore, any effort to prevent such impacts, like maritime traffic management, will definitely contribute towards protection and preservation of the marine environment and help in ensuring sustainable development of the region.

Chapter – 6 Design of routeing measure as per IMO Criteria

6.1 Rationale for the routeing measure and IMO Criteria

The history of evolution of routeing measures and its objectives have been enumerated in Chapter-2. As explained therein, initially during the 1960-70s the purpose of routeing measures in many parts of the world, was to separate the opposing streams of traffic in areas of high traffic density. However, the development of ships with increasing draft and size, the prevalence of shallow water areas in critical navigational stretches and the rapid increase in volume of traffic in recent decades have necessitated the adoption of various kinds of routeing measures ranging from Traffic Separation Schemes (TSS), two way routes, deep water routes, inshore traffic zones, roundabouts to precautionary areas and mandatory Ship Reporting Systems (SRS), by IMO (IMO, 2013). Moreover, though the primary objective of Ship's Routeing is to enhance safety of navigation, the General Provisions on Ship's Routeing adopted by IMO (2013), simply termed as 'criteria' hereafter, describes that the routeing measures may also be used for achieving the aim of prevention and reduction of pollution or other damage to the marine environment due to collisions or groundings in or near areas which are environmentally sensitive. Therefore, increasing concerns over the marine environment have led to the adoption of additional routeing measures such as areas to be avoided, recommended routes, archipelagic sea lanes, etc.

As far as the navigational stretch between the South Coast of Sri Lanka and West Coast of India is concerned, there exists not only a serious danger to the safety of navigation but the marine environment as well, both of which have been explained in detail in Chapter-4 and 5. Therefore, there is an urgent need for the establishment of routeing measures, which are appropriate for meeting the specific requirements of

the region. The precise objectives of any routeing system, as stated in the Ship's Routeing guide by IMO (2013) "will vary depending upon the particular hazardous circumstances which it is expected to mitigate." Such circumstances may include some or all of the following:

- a. the separation of opposing streams of traffic in order to reduce the head-on situations;
- b. the reduction of dangers of collision between crossing traffic within the traffic lane;
- c. to simplify the traffic flow in areas of converging traffic;
- d. the organization of traffic flow in or around offshore installations;
- e. the organization of traffic flow near environmentally sensitive areas to keep the traffic at safe distance;
- f. the reduction of grounding risk by providing special guidance to vessels operating in shallow areas;
- g. the regulation or guidance of traffic near fishing grounds (IMO, 2013)

Considering the fact that the critical navigational stretch along the West coast of India and Sri Lanka has many of the above-mentioned hazards like head-on encounters, crossing situations, converging traffic, prevalence of fishing grounds and environmental sensitivity, as enumerated in Chapter-4 and 5, it will be prudent to establish TSS in critical junctions and to establish precautionary area in places where crossing traffic can be expected. Furthermore, for the purpose of protection of the marine environment it is also necessary to establish vessel traffic management tools such as coastal VTS combined with SRS and other route monitoring systems through the platform of the Marine Electronic Highway covering the entire region.

The criteria and guidelines for the establishment of ship's routeing measures adopted by IMO should be used as a primary methodology for the development of any such systems. SOLAS Regulation V/10 on Ship's routeing categorically states that IMO is recognized as the only international body, not only for the adoption of guidelines, criteria and regulations on routeing systems, but also for the approval of individual

ship's routeing systems being developed by the member States. It also specifies that contracting governments should ensure compliance with all the measures being adopted by IMO, concerning ship's routeing (IMO, 2014). Therefore all the principles and criteria stipulated in General Provisions on Ship's Routeing have been considered for designing the TSS in this region. Some of the key elements of the IMO Criteria for development of ship's routeing measures are explained in subsequent paragraphs.

General Provisions on Ship's Routeing adopted by IMO (2013), states that when planning to establish a routeing system in any area, States shall consider factors, inter alia, exploration and exploitation of living and mineral resources, prevailing traffic patterns and any expected changes in the traffic pattern within the area concerned, presence of fishing grounds, adequacy of aids to navigation, hydrographic survey and availability of nautical charts, weather conditions, tidal streams, currents and environmental sensitivity of the region. Furthermore, it requires States to consider, whether VTS or reporting service should be established or not, for areas covered under routeing systems. It also requires that Governments should have proper consultation with all the stakeholders such as mariners, port authorities, fisheries organization, authorities responsible for hydrographic surveys, aids to navigation and offshore exploration activities for establishing any routeing systems (IMO, 2013).

Furthermore, the design criteria established by IMO on ship's routeing specifically mentions that any proposed routes must follow the existing patterns of traffic flow as closely as possible, based on the traffic surveys and insists that course alterations along a route should be kept minimum; more so it should be avoided near the traffic convergence zones or where crossing traffic may be expected. It also states that the number of convergence areas and route junctions should be kept fewer and those should be separated from each other with wide margin. Moreover, the criteria requires that routes should be designed in such a way as to allow for efficient use of aids to navigation in the area and detailed hydrographic surveys of the area to be carried out to ensure sufficient depth is available for ships using these routes. It also

provides some flexibility, especially for designing the arrangement and length of routeing systems, being established to provide for an unobstructed passage through offshore exploration and exploitation activities (IMO, 2013).

Since, Traffic Separation Schemes (TSS) are the most suitable routeing measure for some of the critical areas within the region, it is obligatory to ensure compliance with specific design criteria for TSS provided in the Ship's Routeing guide (IMO, 2013), in addition to meeting the general criteria explained in preceding paragraphs. Accordingly, TSS shall be designed in such a manner to facilitate ships using the TSS to comply fully with the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS), as amended. Furthermore the criteria requires that if a routeing system has one or more TSS then each TSS should be considered separately by its own name for ensuring compliance with COLREGS. Moreover it necessitates limiting the coverage of TSS only to an extent of what is essential for enhancing safety of navigation in that area. Additionally, the General Provisions on Ship's Routeing by IMO (2013) specifies that the traffic lanes should be designed to make best use of the depths available in that area and the width of the lanes should be sufficient to cater to the anticipated traffic considering the traffic density and availability of sufficient sea-room. It also states that the separation zone should be given preference than a separation line to separate opposing streams of traffic in places where adequate sea-room is available. A similar methodology may be adopted between the inshore traffic zone and adjacent traffic lanes (IMO, 2013).

The design of TSS should also consider the availability of a position fixing means to ensure ships follow the traffic lane with full certainty. Although accurate position fixing is not a critical issue anymore on board ships because of the fully functional Global Navigation Satellite Systems (GNSS) worldwide and the availability of DGPS beacons around the coast, the criteria established by IMO (2013) categorically states that within the limits of TSS and its immediate approaches, there should be a possibility of fixing positions by *more than one means* during the day as well as at night time. It also states that the minimum width of the traffic lane and separation

zone should consider the accuracy of available position fixing methods in that region. Wherever possible, the criteria specifies that the width of separation zone should be not less than three times the transverse component of the standard error of the most suitable position fixing methods available therein (IMO, 2013).

Furthermore, if any routeing measure is being designed for traffic converging areas and route junction then it is vital to consider the definite criteria given in the Ship's Routeing Guide (IMO, 2013) for such areas. These criteria specify that the cardinal principle for designing routeing method for such areas is to avoid any possible source of confusion or ambiguity in application of COLREGS for ships navigating through route junctions or converging areas. This principle should be kept in mind whilst establishing the recommended directions of traffic flow within the route junctions. In particular, the routeing criteria of IMO (2013) specify that at route junctions following considerations must be applied:

- a. Encourage the crossing of traffic lanes at right angles as nearly as possible;
- b. Provide adequate sea room for vessels which are required to give way as per COLREGS;
- c. Enable a stand-on vessel to maintain a steady course as long as possible before reaching the route junction;
- d. Encourage the traffic not following the established route to avoid crossing at or near route junctions.

Finally, the criteria also specifies that routeing systems can be implemented for all ships or for ships carrying certain types of cargoes e.g. dangerous goods and it can be either made mandatory or recommendatory in nature. Additionally, it stipulates that all the routeing systems should be marked on navigational charts using suitable symbols and legends given in the guidelines (IMO, 2013).

6.2 Procedure adopted for design of routeing measures

Now it is very obvious that for the establishment of any routeing measure, States need to consider all the criteria specified in the General Provisions on Ship's Routeing. Key elements of these criteria have been explained in previous paragraphs.

Although this dissertation is an academic exercise, ultimately it intends to provide the necessary information towards the formulation of routing measures in the Indian Sub-continent, more specifically between the South Coast of Sri Lanka and the West Coast of India (figure-18). Therefore, it has been decided to adopt all the procedures and criteria stipulated by IMO to design the routing measures. As stipulated in the criteria, the first step towards establishment of routing measures is the analysis of traffic patterns and traffic density in the region, which have been enumerated in Chapter-4.

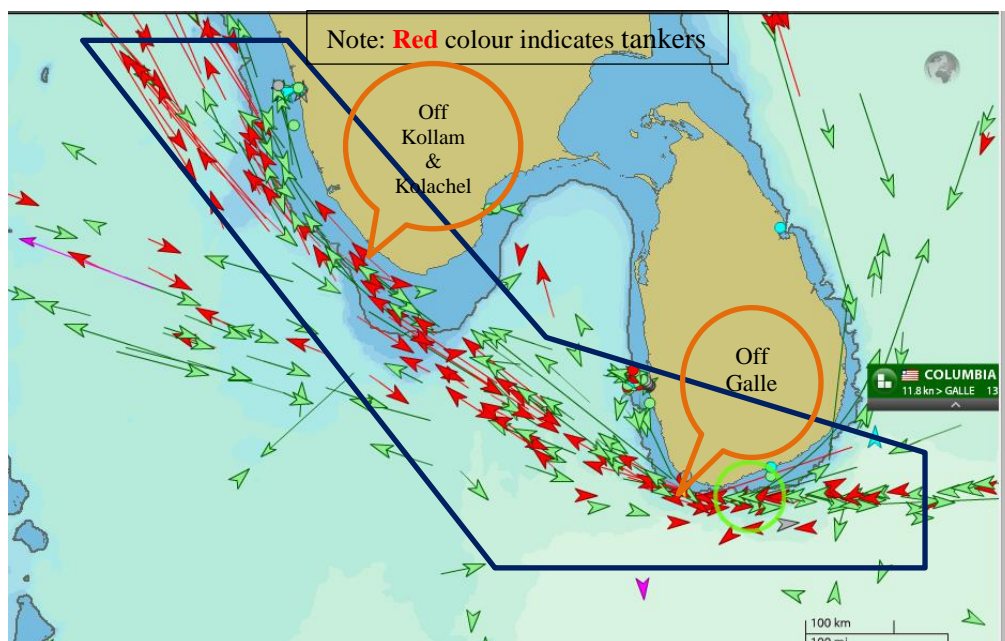


Figure 18: Shipping traffic pattern within the critical navigational stretch between the West coast of India and South coast of Sri Lanka from Satellite AIS data. Source: (FleetMon, 2014)

Upon the systematic analysis of traffic flow and density for more than two months using live traffic data from the Indian LRIT National Data Centre (NDC) and the National Automatic Identification System (NAIS) Chain system, three critical areas have been identified for the establishment of TSS within this region. These areas are off Kollam and off Kolachel in the South India and off Galle in Sri Lanka, which have significant risks of collision, grounding and subsequent pollution (figure-18).

Moreover, the navigational stretch between the South Coast of Sri Lanka and the West Coast of India has a traffic converging area and route junction off Galle, Sri

Lanka and off Kolachel, South India, so it is proposed to include a 'precautionary area' along with TSS in these locations, meeting all the criteria specified by IMO for such critical areas. The main purpose of TSS in these areas is not only to reduce the collision risks but to minimize the grounding risks as well. For this purpose, traffic lanes have been marked with appropriate safe distance from the coast because of the environmental sensitivity of the region. Paton (1982) argues "TSS's were not envisaged as a means of imposing an entirely artificial pattern of traffic flow, but rather to give greater order to an existing traffic situation." Therefore, it has also been ensured that the location of TSS and the direction of traffic flow do not alter the existing traffic patterns in the region.

Firstly based on the analysis of the traffic pattern as explained in Chapter-4, a preliminary sketch of traffic lanes was marked on the charts. Subsequently ships positions have been plotted, regularly on the charts, over a period of two months to confirm the traffic pattern. This has helped to prepare a draft layout of TSS in these regions, by comparing the design of several TSS shown in the Ship's Routeing guide. This approach was adopted based on the available information in the journal of navigation confirming that AIS position data have been used in several ways to analyse the traffic pattern within a defined area.

Aarsæther and Moan (2009) have revealed the method of deciphering AIS data to get the traffic statistics and traffic patterns from any area using computer software. Moreover, Willems et al (2009) through their research have demonstrated the possibility of geographical visualization of traffic patterns and traffic density using AIS data, as density maps, which can be used to identify the traffic lanes and anchorage areas etc. to support the operators of coastal surveillance systems and decision makers to get insights about the vessel movements along the coast. Recently Silveira et al. (2013) have successfully confirmed the use of AIS data to estimate the ship collision data off Portugal. They showed that AIS data can serve as the important information for evaluation of risks in maritime traffic, especially ship-to-ship collision risk (Silveira, Teixeira, & Soares, 2013).

Although there is a software available to use the AIS data in an efficient manner, considering the non-availability of historical AIS data for this region, time constraints and the cost implications in using software etc., author has taken the simplified and more pragmatic approach of analysing the traffic patterns, using manual plotting of the current data available for designing the TSS. However, for the purpose of quantitative risk assessment, if the complete AIS data is available, it is recommended to use the recently developed modelling software IWRAP (IALA Waterways Risk Assessment Programme) for estimating the frequency of collisions and groundings in the given region, which will also be helpful in selecting the appropriate routeing measures (IALA, 2014b).

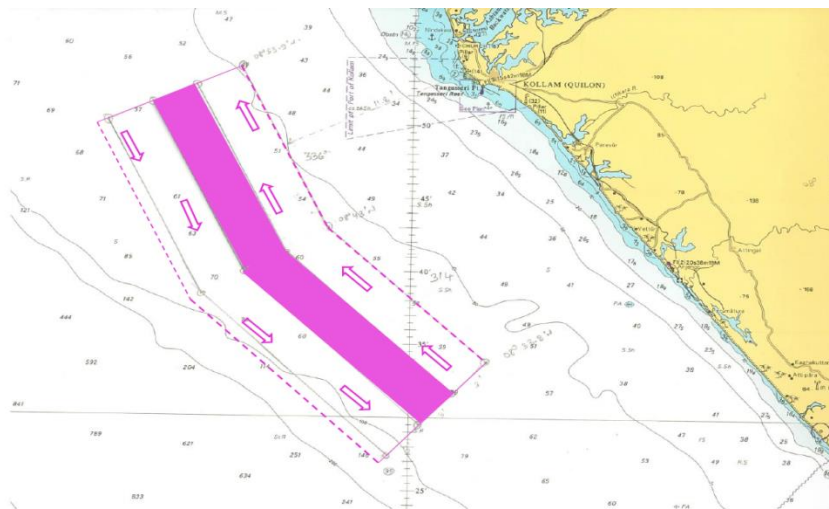
Another important element in designing the TSS is to decide about the width of traffic lanes and separation zones of each TSS. The IMO criteria do not provide any guidance about the width of the traffic lane. However, guidelines being used in the collision risk assessment of wind farms and offshore installations in the North Sea, based on an AIS study by the Maritime Institute of Netherlands (MARIN), states that the sea room of two ship lengths for each vessel is required in case of overtaking within traffic lane. Furthermore, the guideline recommends that a traffic lane which accommodates more than 18,000 vessels per year (considering maximum of 4 vessels overtaking side to side) with maximum size of 400 metres should have a width of minimum 3200 metres, i.e. 1.7 nm (Shipping Advisory Board North Sea, 2013). Therefore, this guideline has been given due consideration whilst designing TSS. In fact, to ensure sufficient sea-room, a width of minimum of 3nm has been considered for all the main shipping lanes and separations zones within the three proposed TSS in this area. Moreover, it has been observed from the Ship's Routeing Guide that many of the TSS established along the coast e.g. West of Scilly isles, off Cape Roca, etc. also has a width of around 3 nm for the traffic lane (IMO, 2013).

6.3 Design of TSS off Kollam in Kerala Coast

Upon analysis of traffic patterns along Kerala Coast, it has been observed that most of the ships both in NW bound and SE bound directions alter their course off

Kollam, because of the change in topography of the coast at Kollam. Since each of the ships plans their course alternations on their own, there is a significant collision risk in this area due to crossing encounter between ships, which has been noticed from the AIS chain display. Furthermore, it has also been observed that whilst many vessels navigate with a safe distance from the coast, some of the vessels navigate dangerously close to the coast, which increases the grounding risk. Therefore, the main purpose for deciding to establish the TSS off Kollam is to separate the opposing streams of traffic to avoid the head-on and crossing encounters as well as to keep the shipping traffic at a safe distance from the Coast.

The NW bound traffic lane of the TSS (figure-19) has been marked in a direction of 314 degree for 13 nm, thereafter direction of lane is altered to 334 degree for 13 nm. The width of this lane is of 3 nm. Similarly the SE bound traffic lane of the TSS is plotted in an opposite direction of 154 degree for 13 nm and thereafter direction altered to 134 degree for 13 nm. Since many of the loaded VLCCs are passing through this area the width of SE bound traffic lane is kept at 4 nm.



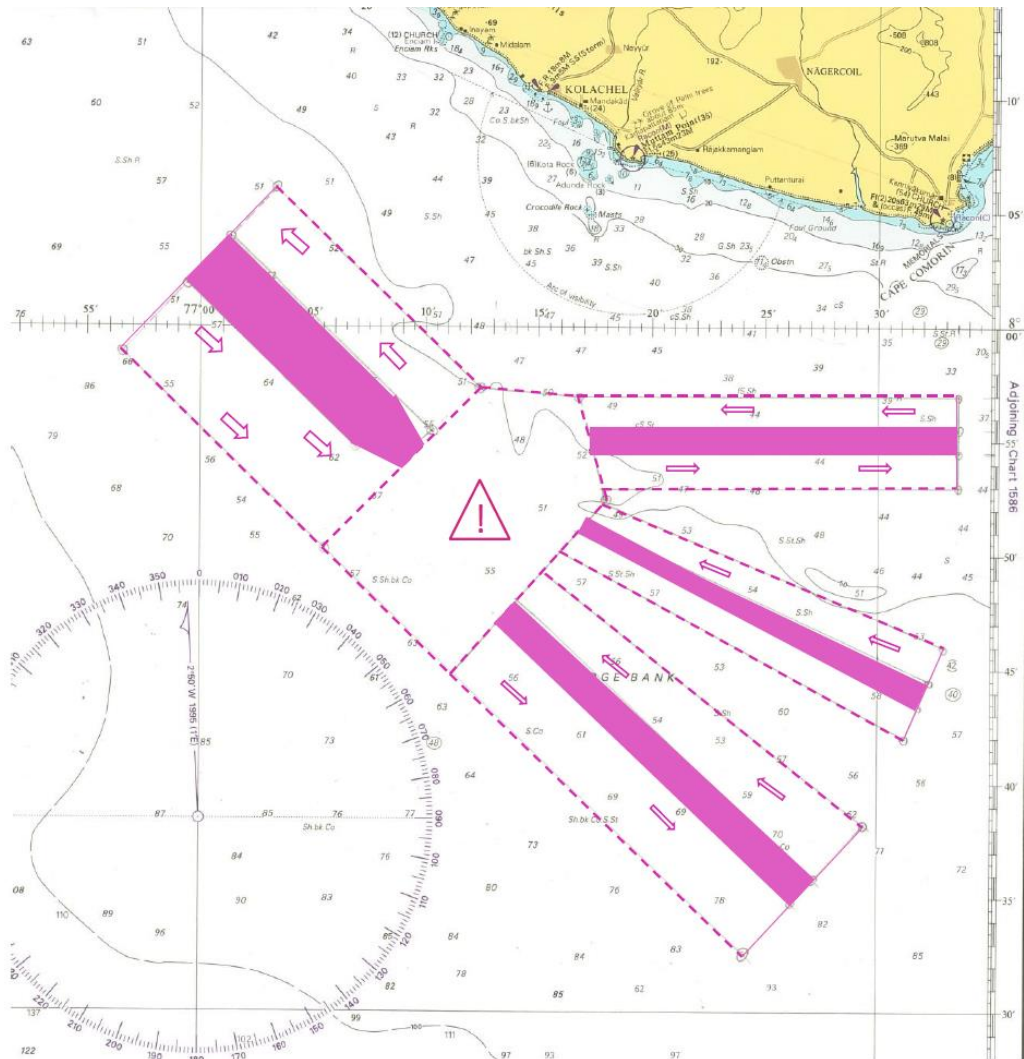
1) Proposed TSS off Kollam (Quilon) – Kerala Coast

Figure 19: British Admiralty chart section showing the proposed TSS off Kollam. Source: Author Tangasseri point light house can be used as a reference point for altering course while navigating through the TSS off Kollam (UKHO, 1986). Additionally, the topography of the area can be clearly identified on Radar because of its distinct

Radar conspicuous feature. Moreover, the width of the separation zone is maintained at 3nm throughout the entire TSS. Furthermore, there is sufficient depth available for navigation within the TSS, since entire TSS is placed outside 50m contour. Another important feature of this TSS is its distance from the coast. The NW bound traffic lane, which is closer to the coast, is marked at a distance of around 10 to 11nm from the coast. Although the main purpose of keeping the traffic lane at an appropriate distance is due to environmental concerns, it will also help to avoid encounters with traditional coastal fishing vessels, to a certain extent.

6.4 Design of TSS off Kolachel in Tamil Nadu Coast

The analysis of marine traffic patterns in the area near the southern most part of mainland India, i.e. Cape Comorin, not only revealed the heavy traffic around it but also showed the critical nature of this area due to the convergence of traffic from more than one directions and the divergence of traffic to more than one destination (DGLL, 2014). Therefore, the design of TSS off Kolachel (figure-20) is the most challenging in comparison with the design of TSS off Kollam and Galle.



2) Proposed TSS off Kolachel (South Tamil Nadu coast)

Figure 20: British Admiralty chart section showing the proposed layout of TSS off Kolachel.
Source: Author

This TSS covers almost the entire traffic to/from Persian Gulf, traffic along the West Coast of India, traffic to/from ports in the Gulf of Mannar, traffic to/from Colombo and traffic to/from the Far East and ports in the Bay of Bengal. Therefore, it serves as a route junction for shipping traffic in this region. The Northern part of the TSS is kept aligned in a direction of 314 - 134 degree, in order to facilitate the movement of traffic to/from the adjacent TSS off Kollam. However, the Southern part of the TSS

is divided into three parts to ensure smooth division of traffic towards Tuticorin, Colombo and Galle (figure-20). The direction of the traffic lanes have been designed to facilitate the movement of traffic towards their destination. Furthermore, a precautionary area has been included between the northern and southern parts of TSS to ensure smooth flow of traffic from one lane to another lane and crossing traffic.

Considering the fact that many loaded tankers are sailing towards Singapore from Gulf region, width of the outermost SE bound traffic lane is kept at 3 to 4 nm. However, the width of the traffic lanes towards Colombo and Tuticorin are kept at 1.5 to 2 nm due to less traffic in that direction compared to traffic towards Galle. Moreover, the width of the separation zone has been maintained as 3 nm in Northern part and 1.5 to 2 nm in the southern part because of multiple lanes in southern part. In addition, the traffic lanes have been designed to ensure sufficient depth is available within the TSS area. It is also proposed to cover this TSS area under Coastal VTS and Ship Reporting System, details of which has been discussed in Chapter-7.

Furthermore, this TSS area is covered by sufficient AtoN such as Muttam Point Light house and Cape Comorin Light house, which are very prominent. Also the RACON is fitted on both of these light houses to facilitate position fixing on-board ships by more than one means (UKHO, 1986). Additionally, the nearest traffic lane of the TSS towards the coast is kept at a safe distance of around 10 nm, to avoid any chances of grounding incidents near the coast. This is because as explained in Chapter-5, in the recent past one cargo vessel went aground in this region, thereby causing an oil spill and damage to the environment, since it was navigating very close to the coast (DG Shipping, 2014a).

6.5 Design of TSS off Galle in Sri Lanka

Investigation of marine traffic along the SW coast of India and Sri Lanka revealed that compared to other places, as discussed in previous paragraphs, the maximum of vessel traffic and traffic density is being consistently seen off Galle, Sri Lanka

(FleetMon, 2014). It is because of the simple fact that entire traffic from the Persian Gulf, Indian Coast and Gulf of Aden via the eight degree channel converges off Galle, which can be easily seen in figure-21, because of its location.

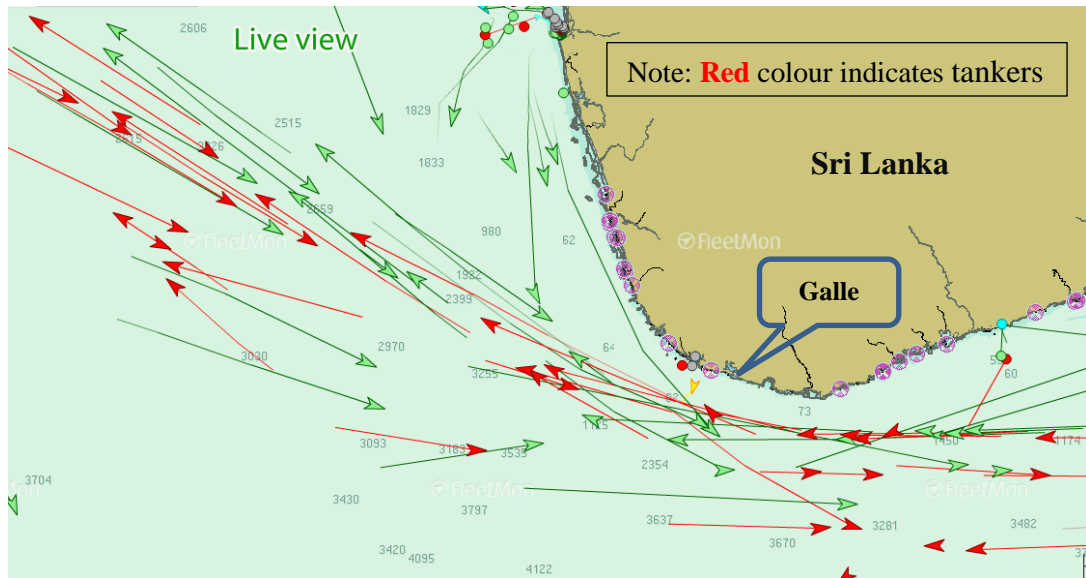


Figure 21: AIS display showing the traffic off Galle, Sri Lanka. Source: (FleetMon, 2014)

Since ships are converging from multiple directions, and all of them are altering their course after reaching Galle, it is vital to make traffic lanes which separate not only the opposing traffic but also to guide the vessels to make the course alteration uniformly in an appropriate position. Moreover, traffic lanes should be arranged in such a manner to ease the flow to/from an adjacent TSS off Dondra Head. Although this TSS off Dondra Head has existed for many years, traffic analysis indicates that many ships are not following the TSS, since there is no traffic management before or after the TSS to guide the traffic along the coast smoothly. However, there is a good chance that if the proposed TSS is introduced off Galle then many ships will be able to use the adjacent TSS due to its alignment with new TSS. The layout of the proposed TSS off Galle is depicted in Figure-22.

separation zone is maintained at 3 nm. Whereas, the east-bound traffic lane is marked with the larger width of 4 nm to facilitate the movement of laden tankers. The entire TSS area has sufficient depth for navigation of all the vessels. However, it will be necessary to carry out the bathymetric survey of Northern part of TSS to verify the depth, since there is a cautionary note on the chart states ‘less water reported’ near the TSS. Furthermore, for the purpose of position fixing by alternate means the Galle light house, which is very prominent, and the RACON at Galle may be used by vessels passing through this region (UKHO, 1986). As part of the Marine Electronic Highway project, it is also proposed to establish a Coastal VTS at Galle combined with SRS for the efficient management and monitoring of ever increasing shipping traffic in this region.

6.6 Aids to Navigation required for the proposed TSS

The IMO criterion specifically states the need for adequate aids to navigation in the areas covered under TSS to ensure ships are able to maintain their position within the appropriate lane. Moreover, it states “if there is doubt as to the ability of ships to fix their positions positively and without ambiguity in relation to separation lines or zones, serious consideration should be given to provide adequate marking by buoys” (IMO, 2013). However in the case of the three proposed TSS, as explained in previous paragraphs, the area is adequately covered by light houses and RACONs. Furthermore, AIS base stations installed along the coast will help the vessels to verify their positions. DGPS beacons along the coast will ensure accurate positioning using GNSS receiver on board ships. Therefore, the existing AtoN infrastructure will be sufficient to meet the IMO requirement for establishment of such routing measures.

Nevertheless, it will be prudent to establish the latest tools such as ‘Virtual AIS AtoN,’ also called as virtual markers, to identify the boundary of TSS and separation zone. Use of such ‘AIS AtoN’ has been successfully tested by the Danish Maritime Authority in their waters for various purposes like wreck marking, marking of TSS etc. by transmission of safety message from shore-based AIS stations (DMA, 2009).

These markers can be seen easily by the vessels using Radar or ECDIS with AIS input, similar to any other buoy or beacon. It will certainly simplify the flow of traffic within the TSS. Whilst virtual markers can assist the vessels fitted with ECDIS, there is also a compelling need to mark traffic lanes by suitable means for easy identification by fishing vessels operating in the region. The number and nature of marks necessary for identification of TSS by fishing vessels needs to be discussed thoroughly with the fishing community and subsequently markers to be installed at appropriate locations by DGLL.

6.7 Consultation with stakeholders regarding the proposed TSS

Upon designing the TSS, based on the analysis of traffic patterns and assessing the risks, the next important step, as stipulated in the IMO Criteria, is the need for consultation with the stakeholders about the proposed TSS. In order to meet the requirements to the extent possible, the author framed a questionnaire (Appendix-6) seeking comments and opinions about the proposed TSS off Kollam, off Kolachel and off Galle. The questionnaire was also intended to get opinions about the need for VTS in these areas. Since, the important stakeholders are the mariners sailing on board ships in these regions, a questionnaire, along with the British Admiralty chart sections showing the layout and location of TSS were been sent to the Indian National Ship-owners Association and Company of Master Mariners of India (CMMI) with a request to forward to ships for obtaining the marines suggestions and comments about the proposal. Furthermore, the same questionnaire had also been forwarded to the MARAD, Coast Guard, DGLL and other experienced master mariners ashore to obtain comments about the proposal.

Although, the responses were not many, a sufficient number of comments, totalling 47, were received from the stakeholder's on-board ships and ashore. However, the feedback received from the mariners revealed that each of them studied the issue carefully and gave their frank opinions and valued suggestions in order to improve the design of the TSS. Prior to analysing some of the general comments received

about the proposal, the overall opinion reflected by the mariners has been compiled and is presented as follows:

- I. Total number of comments received: 47
- II. Profile of the respondents by age group and their marine qualification:

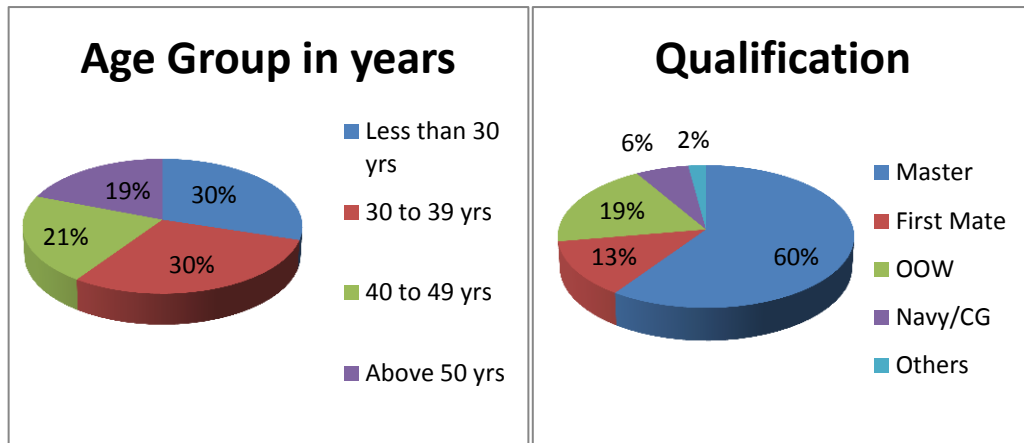


Figure 23: Profile of the respondents by age group and their qualification. Source: Author

The chart (figure-23) reflects that the comments were received from respondents of all the age groups, thereby incorporating the viewpoints of younger as well as senior persons of the maritime fraternity. Furthermore, the adjacent chart (figure-23) shows that 60 % of the feedback was received from master mariners, another 38% from deck officers at both the management and operational levels. Only one feedback was received from an engineer officer. Therefore, the qualifications of almost all the respondents clearly improved the usefulness and meaningfulness of the feedback exercise, which can definitely be relied upon.

- III. Profile of the respondents in terms of their experience in sailing around the coasts of India and Sri Lanka

Considering the fact that this feedback exercise mainly covers technical matters relating to maritime traffic management, it is vital to ensure that the respondents have adequate domain experience as well as the practical experience of sailing around the coasts of India and Sri Lanka, so that they can provide meaningful

suggestions on the questions being asked. Therefore, the questionnaire had also captured the local knowledge and experience of the respondents.

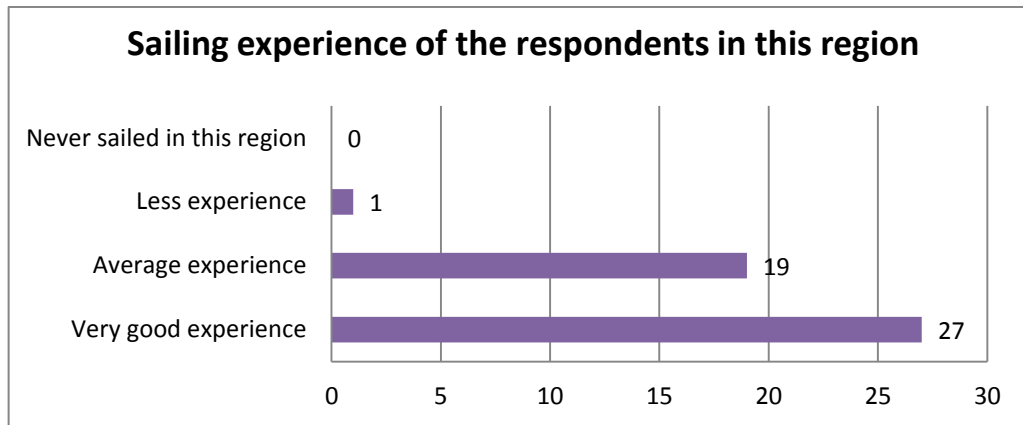


Figure 24: Chart depicting the profile of the respondents in terms of their experience Source: Author

The chart (figure-24) shows that out of 47 respondents, 46 respondents have confirmed about their sailing experience in this region, which includes 27 respondents with very good experience. Therefore, the feedback obtained from these respondents can be considered when arriving at any conclusion about the proposed traffic management solutions.

IV. General opinion of the mariners about the usefulness of the proposed TSS:

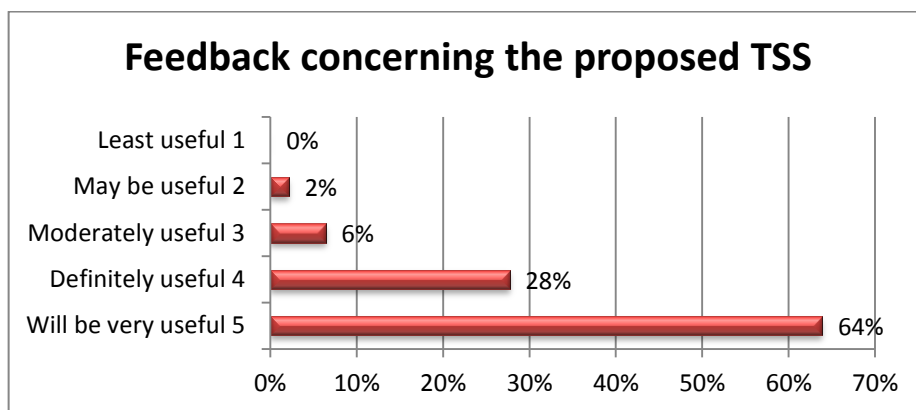


Figure 25: Chart depicting the opinion of the mariners about the proposed TSS. Source: Author

One of the central questions asked in the questionnaire concerned the opinion of the mariners regarding the three proposed TSS in this region. As shown in the chart (figure-25) the overwhelming majority of the respondents i.e. 98% have opined that

the proposed TSS will be useful, in a spotlight survey. Moreover, 92% have given very firm opinions, confirming that the TSS will definitely be useful for this region. In addition to this general question, specific comments were also asked about each of the TSS in the questionnaire. The responses given by the mariners in this regard are detailed hereunder.

V. Detailed comments on the proposed TSS off Kollam:

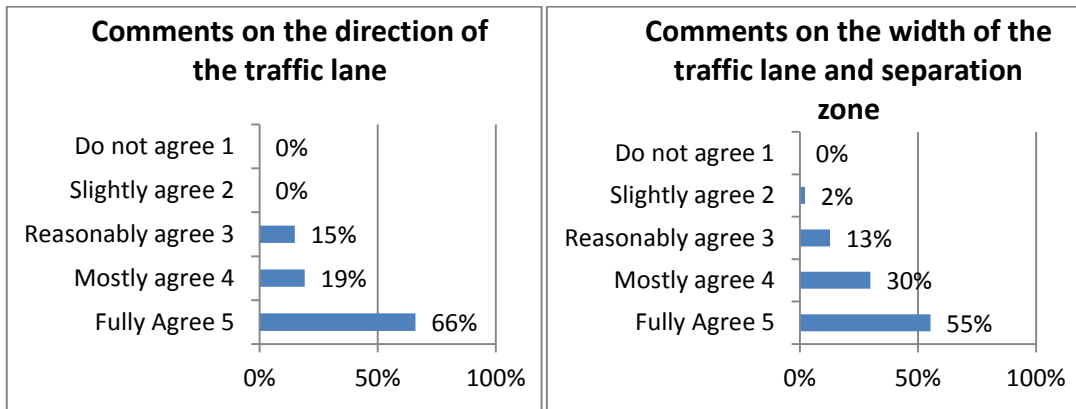


Figure 26: Feedback of the respondents about the proposed TSS off Kollam. Source: Author

As shown in figure-26, the majority of the respondents, i.e. more than 90%, have agreed with the direction of the traffic lane as well as the width of the traffic lane and the separation zone of the proposed TSS off Kollam. However, regarding the need for the coastal VTS, comments have reflected that there were differing views among the mariners. Although, 79% of the respondents (figure-27) have opined in favour of

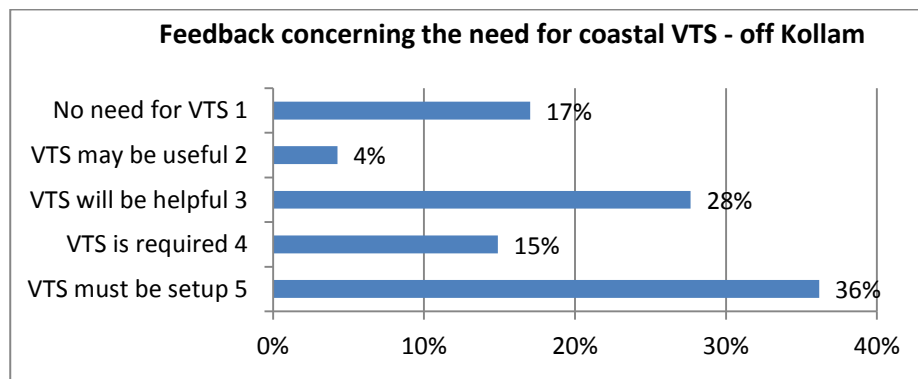


Figure 27: Feedback of the mariners about the need for VTS off Kollam. Source: Author

the coastal VTS, 17% of the respondents have given their firm opinion that there is no need for VTS in this area, which also has to be taken into consideration.

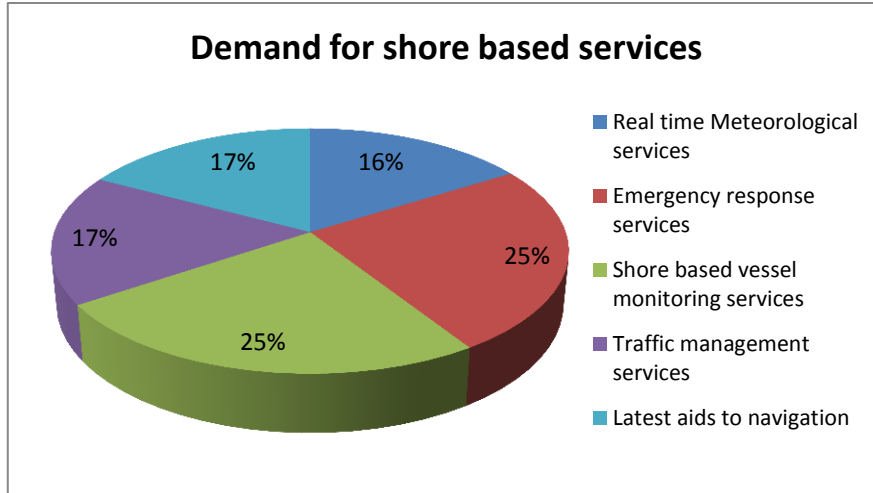


Figure 28: Suggestions given by the mariners regarding the shore-based services. Source: Author

Thereafter, for a question regarding the type of shore-based services required in this region, mixed responses were received from the mariners (figure-28). Whilst, 25% of the respondents gave a suggestion for shore-based vessel monitoring services and emergency response services in addition to search and rescue, 17% of them suggested for traffic management services and another 17% of the mariners favoured for the latest aids to navigation. The remaining 16% of the respondents have suggested for real-time meteorological services in this region. The respondents have given almost similar suggestions for the same question, in other areas as well.

VI. Detailed comments on the proposed TSS off Kolachel

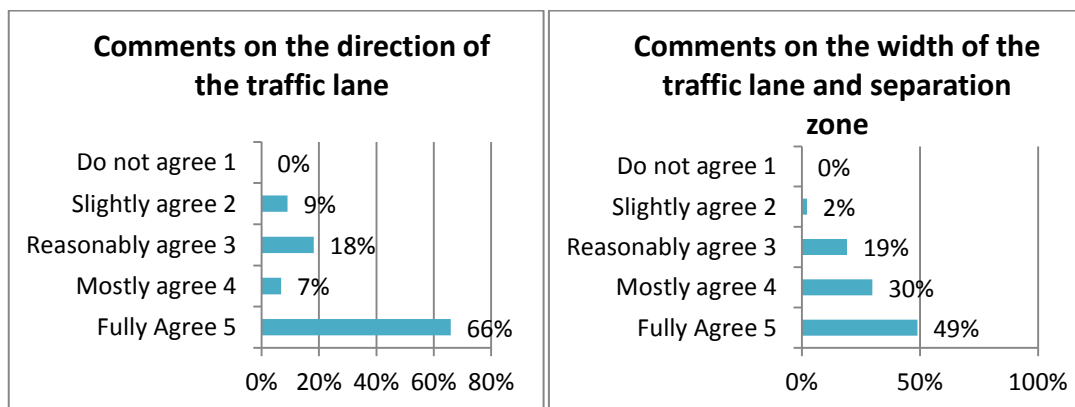


Figure 29: Feedbacks of the respondents about the proposed TSS off Kolachel. Source: Author

Similar to the TSS off Kollam, more than 80% of the respondents (figure-29) have agreed with the direction of the traffic lane as well as the width of the traffic lane and separation zone for the proposed TSS off Kolachel. However, some of the respondents have given their detailed comments suggesting an increase in the width of the traffic lane and the merger of three different lanes in the southern part of the TSS into two parts. They opined that by this merger, the width of the traffic lane can be increased. Since the suggestions given by the respondents are valid, the proposed layout of the TSS has been modified accordingly.

Furthermore, the respondents have given slightly differing responses regarding the need for a coastal VTS in this region. As shown in figure-30, although 11% of the respondents stated that there is no need for VTS, the majority of the respondents, i.e. more than 80% of them, opined that VTS would be useful for this area off Kolachel. Moreover, 40% of the respondents have given a firm opinion that a coastal VTS must be setup in this region.

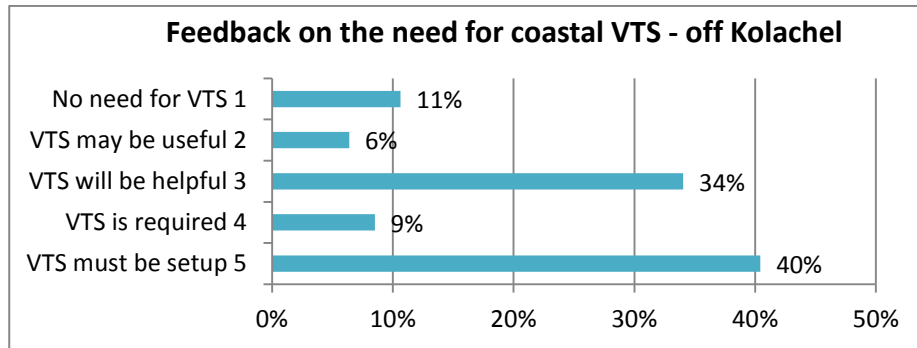


Figure 30: Feedback of the mariners about the need for VTS off Kolachel. Source: Author

VII. Detailed comments on the proposed TSS off Galle

The feedback received from the mariners has confirmed that the area off Galle in Sri Lanka is the most critical area in comparison to the other two areas as explained in the previous paragraphs. Regarding the proposed TSS off Galle, the vast majority i.e. more than 95% of the respondents (figure-31) have stated that they are in agreement

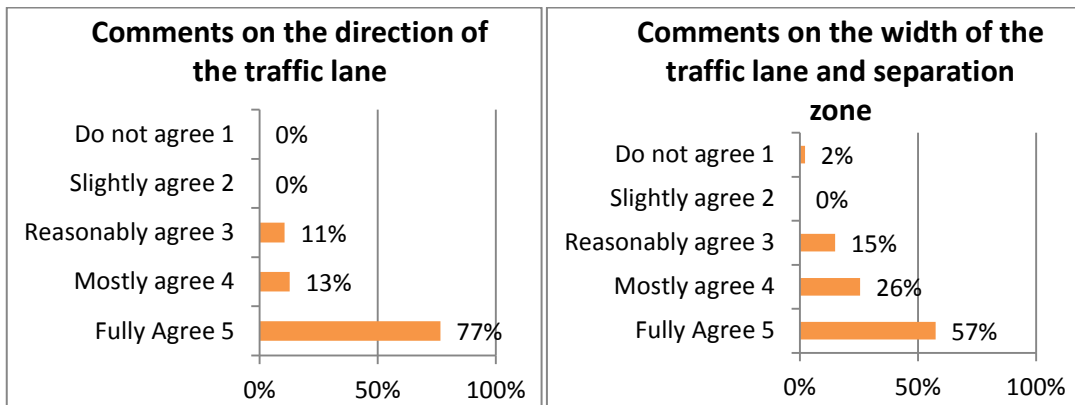


Figure 31: Feedback of the respondents about the proposed TSS off Galle. Source: Author

with the direction of the traffic lane as well as the width of the traffic lane and the separation zone. However, some of the respondents gave suggestions for minor modifications in the proposed TSS which have been incorporated in the lay out. Similarly, 91% of the respondents (figure-32) have opined that a coastal VTS will be useful for this region and only 9% have stated that there is no need for VTS.

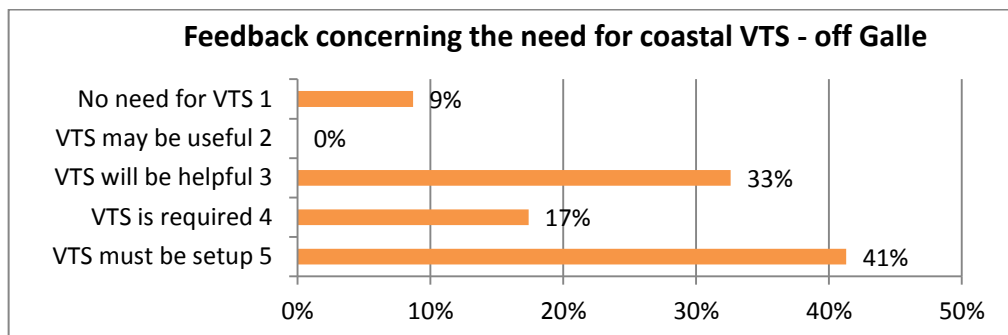


Figure 32: Feedback of the mariners about the need for VTS off Galle. Source: Author

Hence, this feedback exercise has undoubtedly demonstrated the compelling need for the establishment of traffic management solutions in this region. Moreover, the vast majority of the respondents have agreed with the proposed layout of the TSS and also confirmed the need for coastal VTS, to improve the safety of navigation in this critical navigational stretch between the South coast of Sri Lanka and the West coast of India. Nevertheless, some of the respondents have also expressed their concern regarding the heavy fishing traffic in this region, which are explained hereinafter.

VIII. Any other valuable comments received from the mariners

In addition to the general feedback about the proposed routing measures, many of the mariners have given very useful comments for improving the proposed layout of the TSS and increasing the width of the lane in some instances. Some of them have even given valid reasoning for making changes in the design of the TSS (Appendix-7). The comments received for modifying the layout of the TSS off Kolachel from more than six mariners are found to be very reasonable and valid. Therefore, the layout of the TSS off Kolachel, especially the southern part of the TSS, has been modified, as per the suggestions given by the mariners. The modified layout of the TSS is shown in Figure-33. Similarly, the layout of the TSS, off Galle has also been modified in view of the offshore activities being conducted in this area, as reported by some of the mariners. Accordingly, the position of the TSS has been shifted slightly southwards and a precautionary area has also been included. The modified layout of the TSS is depicted in figure-34. In addition, the layout of the TSS off Kollam has been slightly modified to include precautionary area within the TSS (figure-35), to facilitate crossing traffic to/from the port of Kollam and the nearby fishing harbour.

Furthermore, a few have suggested to include the 'Inshore Traffic Zone' in the areas landwards of the proposed TSS, which needs to be done by the Maritime Administration after consultation with the coastal states and the operators of the coastal shipping. Moreover, many of the mariners have commented on the heavy fishing traffic, and expressed their concerns regarding how the TSS lanes will be kept free of fishing traffic in this region. Some of them have even suggested training the fishermen, consulting with the fisheries department and with the fishermen association etc. A few of them have even expressed very sceptical views about the utility of TSS, since it will be difficult to control the fishing traffic in this region.

In view of the concerns expressed by the mariners, it is vital to have an awareness campaign and extensive consultations with the fishing industry, prior to finalizing the proposed TSS by the MARAD of India and Sri Lanka. However, considering the

long-term benefits of the proposed TSS and coastal VTS as confirmed by many of the mariners, an all-out effort is necessary to educate the fishermen community and empower them with the latest equipment like AIS, so that their lives, livelihood and the marine environment will not be at risk in the future due to the thousands of ships transiting through this region.

Some of the comments received are quoted herein to reflect the views of the mariners: (See Appendix-7 for further comments)

“Establishment of VTS to monitor TSS traffic will be a great help in shipping traffic and also to monitor fishing vessels. For easy monitoring of fishing vsl by VTS or other vsl, it is advisable to make necessary use of AIS by all fishing vsl in coast of India(For eg. in east china sea, yellow sea and south china sea all fishing vsl are fitted with AIS)” - Master of merchant ship ‘Maha Anosha,’ Five Stars Shipping

“The local fisher man has to be warned not to venture the TSS. TSS is good idea you can encourage your colleague to take it up for their region..... In year 1993/1994 we had a collision between SCI cargo vessel Ravidas with other Indian Ratnakar vessel. I had signed off from Ravidas before this incident and incident could have been avoided with TSS in place” - Master, Swiber offshore, Singapore

“Due to the more number of fishing boats are engaging in fishing, chances are that they will not mind your TSS. They will put their nets in the middle of TSS also.... As I am staying coastal area of Kerala KASARAGOD, I am suggesting the following: 01) A strict training to be given to the fisherman community regarding safety at sea. 02) Importance of LSA/FFA items to be explained to them. 03) Teach them strictly what is a TSS and to avoid fishing in TSS areas. 04) Kerala coast is always having fishing traffics due to availability of seasonal fish. 05) Before teaching fishermen the fisheries Dept. staff should trained and teach regarding safety at sea and the importance of TSS and their fitness to teach convince fisherman.” – Master, The Shipping Corporation of India Limited.

6.8 Modified layout of the proposed TSS based on the feedback

Upon analysis of the comments received from the stakeholders concerning the proposed layout of the TSS, it was noticed that some of the mariners have suggested for modification in the proposed TSS off Kolachel. The suggestion was mainly to merge the three separate traffic lanes provided in the Southern part of the TSS into two lanes, so that the width of the lanes can be increased. Therefore, considering the fact that the number of vessels destined to/from Colombo and Tuticorin from this area are not many, it was considered prudent to merge the three traffic lanes into two lanes, based on the suggestion given by the mariners. Accordingly, the proposed layout of the TSS off Kolachel has been revised (figure-33). The revised layout ensures minimum width of 3nm for all the traffic lanes. The geographical coordinates of the revised layout of the TSS have been given in Appendix-8.

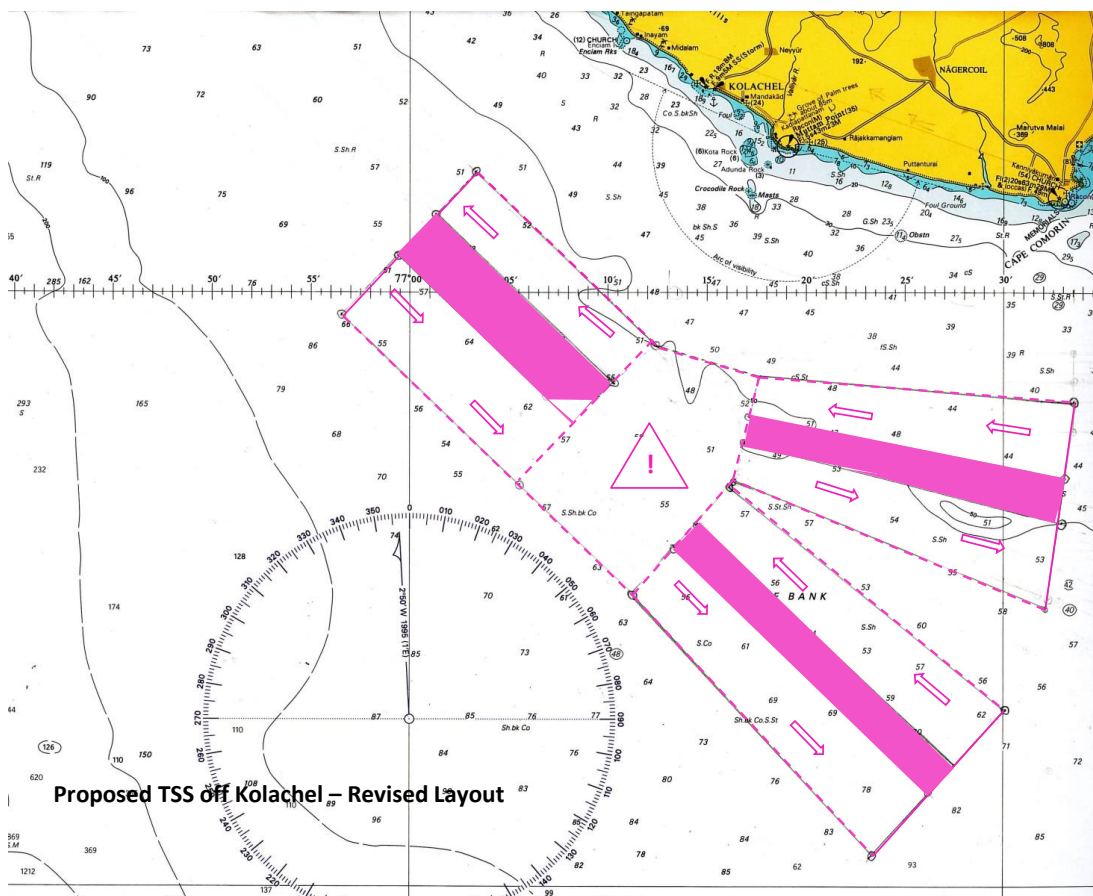


Figure 33: British Admiralty chart section depicting the revised layout of TSS off Kolachel.
Source: Author

Similarly, some of the mariners have given comments stating that many offshore activities are occurring off Galle harbour which needs to be considered in the layout of the proposed TSS off Galle. Moreover, few of them have suggested for increasing the size of the precautionary area in the Western part of the TSS, because of traffic convergence from many directions. In addition, many mariners have suggested for increasing the width of the traffic lanes in this area. Since all these suggestions and concerns raised by mariners are legitimate, the proposed layout of the TSS off Galle has been revised accordingly (figure-34). In the revised layout, a precautionary area has been included in the middle of the TSS, so that offshore activity can be carried out safely. Moreover, the width of the eastbound traffic lane has been increased to 5 nm to facilitate the transit of loaded tankers and the westbound traffic lane has been increased to 4 nm. However, it is also essential to shift the existing TSS off Dondra Head by 5 nm southwards, to align with the revised layout, at the time of implementation. The geographical co-ordinates of the revised layout of the TSS off Galle are given in Appendix-8.

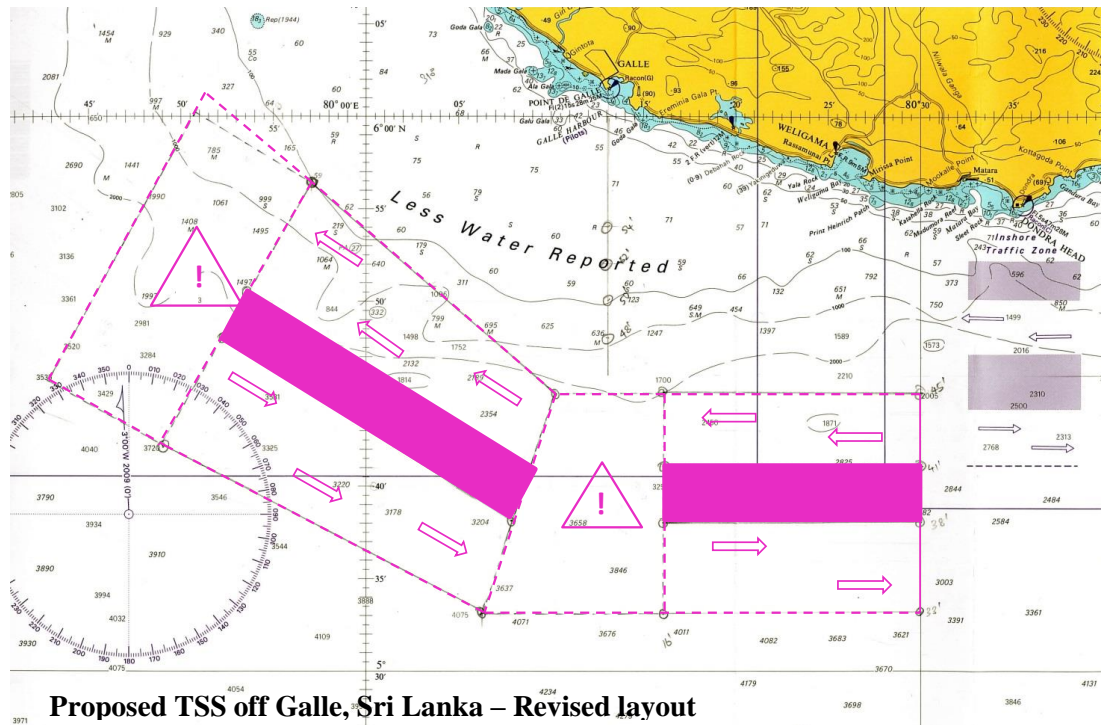


Figure 34: Chart section with the revised layout of proposed TSS off Galle, Sri Lanka. Chart is reproduced from UKHO. Source: Author

Lastly, the layout of the TSS off Kollam has also been modified slightly based on the comments received from some of the stakeholders. The revised layout (figure-35) includes a precautionary area within the Northern part of the TSS, to facilitate crossing traffic to and from Kollam port and nearby fishing harbor. The direction and width of the traffic lanes are kept same as it was proposed earlier. The geographical co-ordinates of the revised layout of TSS off Kollam are given in Appendix-8.

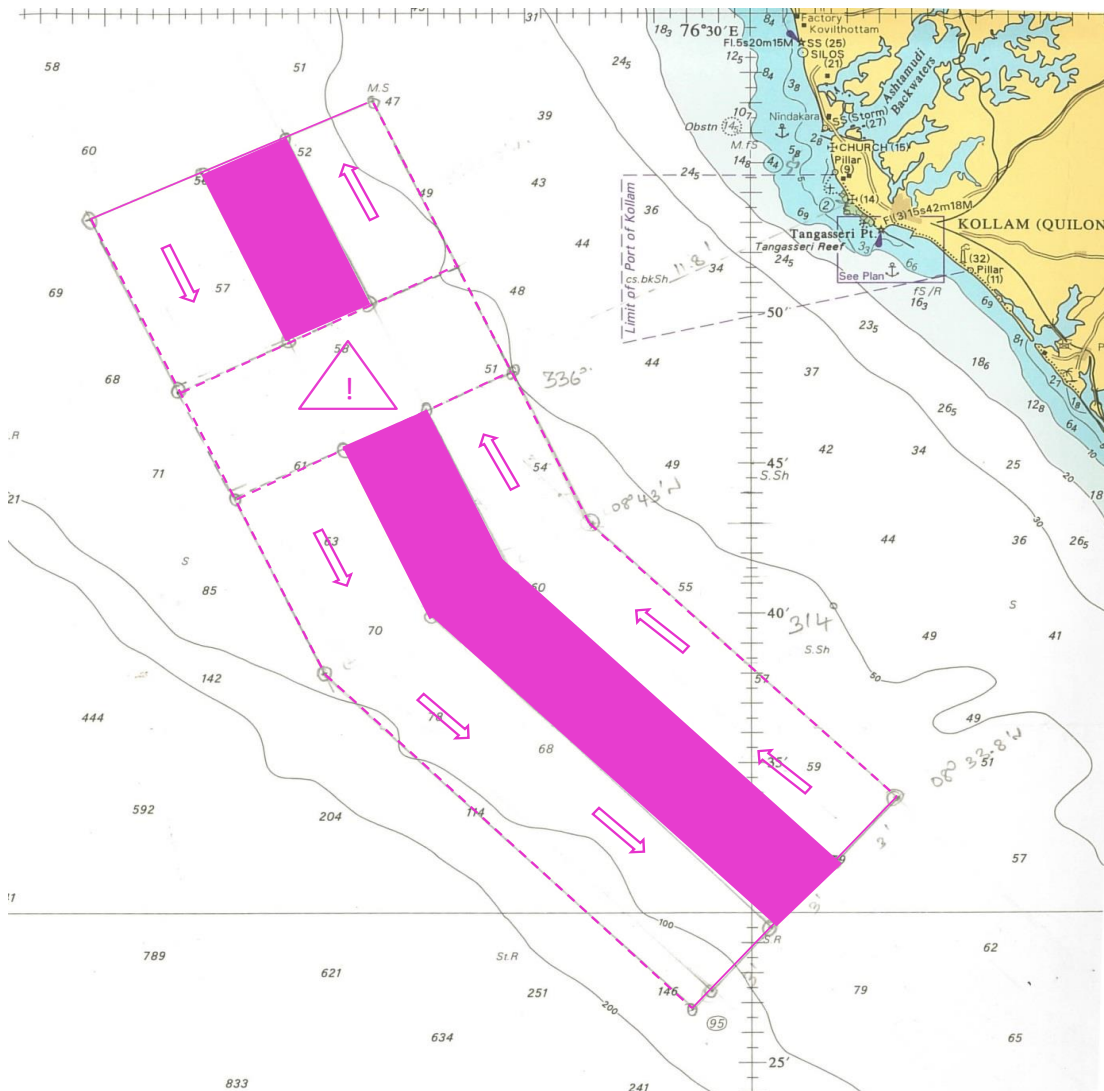


Figure 35: Chart section with the revised layout of proposed TSS off Kollam, India. Chart is reproduced from UKHO. Source: Author

Therefore, these revised layouts of the proposed TSS's incorporate the valid suggestions received from the key stakeholders.

Chapter – 7 Proposed Methodology for establishment of the Marine Electronic Highway in the region

7.1 Proposed deliverables of MEH along the West Coast of India and Sri Lanka

The concepts of MEH and its purpose have been enumerated in detail in Chapter-3, with reference to the first pilot project of IMO being implemented in the Straits of Malacca and Singapore (SOMS). The primary aim of MEH is to integrate the Maritime Safety Information, which includes, inter alia, vessel traffic information, and a marine environmental management and protection system and to present the information in a user-friendly manner to the relevant stakeholders for the purpose of decision making on-board ship and ashore (World Bank, 2006). However, the improvements in ICT over the years have broadened the scope of possibilities in navigation systems, especially ship-shore interface, which led to the development of e-Navigation solutions. Although e-Navigation Strategy Implementation Plan (SIP) provides a list of sixteen different services, relating to shore based functions, as Maritime Service Portfolios (MSP), all the services may not be required in all the sea areas. Hence many coastal States may provide a limited number of MSPs depending upon their capabilities and requirements within their region (IMO, 2014b).

In this regard, considering the environmental sensitivity and heavy traffic density being experienced in this region, it is required to provide the following minimum services (MSP) to ships through MEH data centre: VTS Information Services (MSP1); Maritime Safety Information Service (MSP5); Vessel shore reporting (MSP8); Maritime Assistance Service (MSP10); Meteorological Information Service (MSP14); real-time hydrographic and environmental information service (MSP15) and Search and Rescue Service (MSP16). As far as vessel traffic management, which includes SRS within the VTS areas, all the traffic information and communication

should be provided by VTS centres only. It is envisaged that MEH data centre will complement the VTS in traffic monitoring and facilitate electronic reporting of positions within the VTS sectors.

In addition to the abovementioned services to ships, MEH in its endeavour to enhance safety of navigation and protection of environment in the region should be able to assist, monitor the vessel traffic and to present the traffic situation to shore based enforcement authorities, for detecting any violations of national and international rules and regulations. Furthermore, MEH datacentre should be able to provide the details of oil spill movements and hazards to the coastal ecosystem using environmental Marine Information Overlays (MIO) by 3-D display. Also, the datacentre should be able to provide necessary real-time information to the Coast Guard on drift of crafts, persons, search patterns etc. during SAR operations. Moreover, authorities like the Coast Guard, Marine Environmental Protection agencies of coastal states and maritime administration should be able to view the information available in the MEH data centre using either the dedicated web portal or in the standalone display of ECDIS. Therefore, all these deliverables must be taken into account, while designing the architecture for the proposed MEH.

7.2 Architecture and Key components of proposed MEH

The architecture for the proposed MEH along the West coast of India and Sri Lanka has been designed using the existing framework of MEHSOMS. However, there is a need to modify and improvise the existing framework to meet the specific requirements of this region, taking into account the developments in the field of e-Navigation (IMO, 2012b). Since, designing an architecture for a new project is a conceptual exercise, the author, with his years of sailing experience and experience in handling of navigational aspects in Indian maritime administration, used the ‘mind mapping’ tool to identify and collate all the relevant stakeholders and their needs for executing this project. Mind mapping, was mainly used for visualization of all the relevant components of the project and the inter-relation between these components and stakeholders (Appendix-9).

Furthermore, using the same tool, author has also identified the required infrastructure for providing the intended services to the ships and to achieve the deliverables for the shore based authorities. While executing the mind mapping exercise, the author has also taken into consideration the existing aids to navigation and the services being provided by several agencies, mainly, Directorate General of Shipping (DGS), Directorate General of Lighthouses and Lightships (DGLL), Indian Coast Guard (ICG), National Hydrographic Office (NHO), Indian Meteorological Department (IMD), National Institute of Ocean Technology (NIOT), Indian National Centre for Ocean Information Services (INCOIS), Environment Information System (ENVIS) and National Coastal Zone Management Authority (NCZMA). Information obtained from the official websites of these agencies also definitely helped the author in designing the architecture for MEH (DGLL, 2013) (ENVIS Centre, 2014) (ICG, 2010) (INCOIS, 2014) (MOEF, 2003) (NIOT, 2013) (NHO, 2012). Overarching architecture of the proposed MEH project for this region is depicted in figure-36.

As shown in the figure-36, this MEH project is also centred on the co-operation between the two neighbouring States i.e. India and Sri Lanka, similar to MEHSOMS which involved three States. Since the concerns of both the States are common, in order to utilize the resources effectively for the sake of common good, this project intends to cover the most critical stretch of navigation, i.e. between the South Coast of Sri Lanka and West Coast of India, second only to SOMS. Although this project proposes to establish MEH data centre at strategic point of Cape Comorin i.e., southern most point of mainland India, its commissioning will be mainly depends on the establishment and functioning of the two proposed VTS, i.e. in Kolachel (India) and Galle (Sri Lanka). Furthermore, this MEH data centre should also be given input from AIS base stations, bathymetric data from hydrographic agencies, MSI from NHO, Meteorological data from Meteorological departments and environmental information from relevant agencies. Moreover, real time oceanographic information from INCOIS is central to meeting the objectives of Marine Electronic Highway.

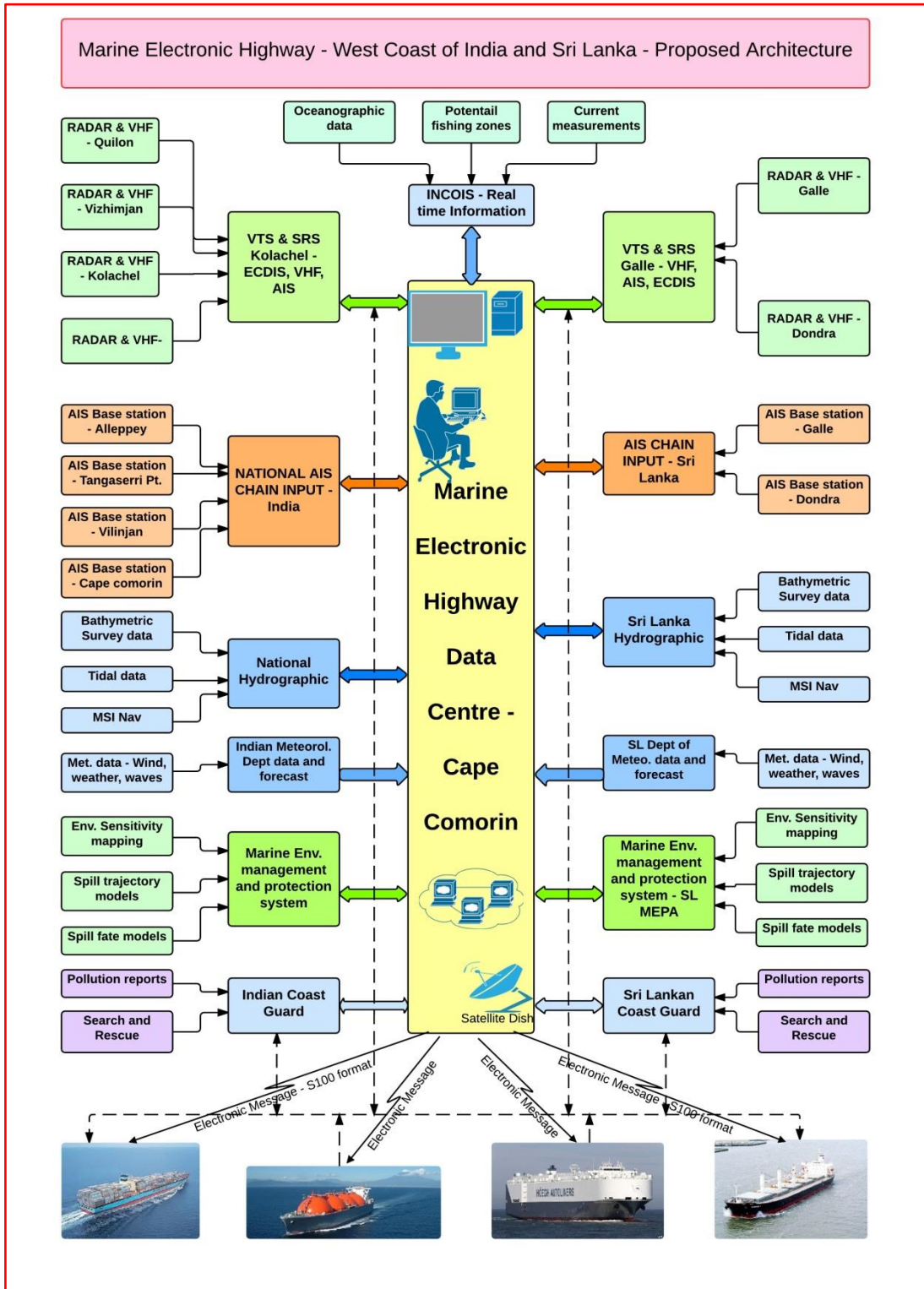


Figure 36: Overarching architecture of the proposed MEH along the West coast of India and Sri Lanka. Source: Author

The key components of the proposed MEH project described herein will be as follows:

1. **Vessel Traffic Services and SRS at Kolachel, India:** It is proposed to establish Radar and VHF antennas in four locations, i.e. Quilon, Vizhinjam, Kolachel and Cape Comorin, near the existing light houses to give feed to the VTS Centre at Kolachel. This VTS Centre can monitor the traffic within the TSS off Kolachel and Quilon. Furthermore VTS centre should be fitted with ECDIS, AIS, VHF and other systems necessary for vessel traffic management, including reception of electronic position reports from ships.
2. **Vessel Traffic Services and SRS at Galle, Sri Lanka:** In order to manage the heavy converging traffic in this region, it is proposed to establish Radar and VHF antennas in two locations, i.e. Galle and Dondra head, adjacent to the existing light houses to give feed to the VTS centre at Galle. This VTS also should be fitted with ECDIS, AIS, VHF and the other systems necessary for vessel traffic management, including reception of electronic position reports from ships.
3. **AIS Base stations:** Considering the fact that AIS is one of the important components of MEH, it is proposed to establish AIS base stations in the Sri Lanka at Galle and Dondra Head and connect them to MEH data centre for live feeding of AIS data. Similarly, AIS base stations which are already functioning at Alleppey, Tangaserri Pt., Vizhinjam and Cape Comorin in India needs to be linked to MEH data centre directly or through National AIS chain data centre at Mumbai.
4. **Hydrographic data and MSI inputs:** The Indian National Hydrographic Office has already produced ENC's for this region, which is an important requirement for roll-out of MEH. However, in order to keep the ENC's updated regularly, it is necessary to provide accurate bathymetric data and other hydrographic information in S-100 format to MEH data centre. Therefore the MEH data centre has to be linked to hydrographic offices of both India and Sri Lanka not only for updating ENC's but for the

promulgation of MSI as well. On the other hand, in view of sufficient depth available in areas of main shipping traffic, it will not be required to provide real-time depth information by this MEH. Nevertheless, detailed survey of the areas, especially in and around TSS, has to be completed during the implementation of this MEH project.

5. **Meteorological data inputs:** It is proposed to connect the MEH data centre with the meteorological departments of both India and Sri Lanka, to provide specific weather reports and forecasts for this area, using a graphical display on a 'need to know' basis, using the concept of e-Navigation.
6. **Environmental Information:** Since the primary aim of the MEH is to integrate the environmental information with maritime safety information, it is necessary to generate environmental sensitivity mapping data of this area into Marine Information Overlays using a standard format. Therefore, the MEH data centre should be linked to the environmental agencies of coastal states for obtaining this information. Similarly, the MEH data centre should incorporate 3-D Oil spill trajectory models and spill fate models software systems, for use by agencies, in case of any oil spill incidents.
7. **Search and Rescue services:** For the purpose of providing efficient SAR services, responsible agencies such as the Coast Guard should be linked with the MEH data centre.
8. **Real time Oceanographic data:** One of the key features of the MEH project is to provide real time information on currents, tides, wave parameters etc. Since, the Indian National Centre for Ocean Information System (INCOIS) already has the technology for providing this information on a real-time basis; it is proposed to link the INCOIS with the MEH data centre. Furthermore, information about the potential fishing zones may also be linked for transmission to users through the MEH platform (INCOIS, 2014).
9. **MEH Data Centre at Cape Comorin:** Since the central component of this project is the data centre, it should be provided with the necessary

infrastructure, hardware, software and qualified man power for the efficient functioning of MEH system 24/7, throughout the year.

10. **Communication network:** In order to ensure the smooth operation of the MEH system, it is necessary to set up a dedicated high speed communication network for voice and data, between all the components. Furthermore, wireless communication and satellite communication facilities using latest technology must be incorporated in the MEH IT system for the uninterrupted communication between ship and shore.

In summary, all of these ten components are vital for the establishment of the MEH system in this region. In order to implement the project in a time bound manner, it is critical to start the work on each of these components simultaneously. However, it is also an important fact that the fitment of ECDIS as per the SOLAS timeline i.e. by 2018 (IMO, 2014) and high speed communication equipment on board ships is necessary concurrently, for a full scale demonstration of MEH system.

7.3 Existing Infrastructure of Aids to Navigation in the region

India and Sri Lanka have both established many Aids to Navigation (AtoN) along their coasts for the benefit of mariners and fishermen. The Directorate General of Light Houses and Lightships (DGLL), being the authority responsible for AtoN in India, establishes and maintains lighthouses, light vessels, buoys, beacons and RACONs all along the Indian coast. Since electronic position fixing systems and AtoN are becoming increasingly popular throughout the world, DGLL has set up DGPS beacons at 23 locations around India which provides complete coverage for the Indian coast. Specifically, DGPS beacons situated at Minicoy, Azhikode and Pandian Thivu can provide precise positions in major part of Indian region covered under the proposed MEH Project (DGLL, 2013).

Furthermore, DGLL has launched National AIS Chain in 2012 with the help of Swedish company SAAB, which provides complete coverage of Indian Coast, using 74 AIS base stations located in the lighthouses along the coast. All the base stations

Moreover, many lighthouses and RACONs functioning along the Indian coast, as shown in figure-38 and famous light houses at Dondra Head and Galle in the South coast of Sri Lanka will be able to provide mariners with alternate means of position fixing, whilst navigating in this region.

7.4 Gap analysis towards establishment of MEH in the region

Once the architecture for the proposed MEH has been drafted and identification of the key components has been done, then the next logical step would be to carry out the gap analysis between the required infrastructure vis-à-vis the existing AtoN infrastructure within the MEH coverage area. Although some of the gaps like the establishment of two new VTS's combined with SRS are clearly identifiable, it is important to carry out the analysis of missing elements, as shown below (Table-2) to cover the proposed spectrum of the MEH Project:

Table-2: Gap analysis towards establishment of MEH in the region. Source: Author

<i>Sr. No.</i>	<i>Essential components of MEH project as per the planned architecture</i>	<i>Existing infrastructure which can be used for the MEH</i>	<i>Actions needed to fill the gap for executing the project</i>
1	New VTS Centre combined with SRS at Kolachel with four Radar and VHF stations	None	To be established completely.
2	New VTS Centre combined with SRS at Galle with two Radar and VHF stations	None	To be established completely.
3	AIS Base stations at Alleppey, Tangaserri point, Vizhinjam and Cape Comorin	AIS base stations are functioning at these locations	None
4	AIS Base stations at Galle and Dondra head, Sri Lanka	None	To be established completely.
5	Bathymetric survey data and ENC's for the area	ENC's for the entire area is available	ENC to be updated upon detailed survey of areas within TSS.

6	Promulgation of MSI	MSI being promulgated through EGC	Software to be developed for transmission of MSI in graphical format
7	Promulgation of Meteorological data	Meteorological information is being promulgated through EGC and Radio.	Software to be developed for transmission of MSI in graphical format
8	Environmental Sensitivity mapping of the area	Part of the area has been completed.	Detailed mapping has to be carried out for the entire area for production of E-MIOs.
9	Development of spill trajectory models and spill fate models	None	To be developed fully for the area in the required format.
10	Real-time Oceanographic information and potential fishing zones data	INCOIS publishes real-time information online using web portal.	Need for additional remote observation buoys to be studied. Software to be developed for presenting information in S-100 framework
11	Establishment of MEH data centre and IT system at Cape Comorin	None	To be established completely
12	Communication network between all the components	None	To be setup completely
13	Installation of DGPS beacons for precise positioning within the MEH area	Indian Coast is covered by DGPS beacons.	One DGPS beacon to be installed to cover Sri Lankan coast
14	Establishment of proposed TSS within the region	None	TSS should be established with the approval of IMO
15	Fitment of ECDIS and latest communication equipment on-board ships	Fitment of ECDIS is progress as per the SOLAS implementation schedule	Encourage fitment of ECDIS on board national flag vessels.

7.5 Way forward for commissioning the proposed MEH project

The MEH system being proposed for the critical navigational stretch between the West Coast of India and the South Coast of Sri Lanka is a technology oriented futuristic project, towards achieving the goal of ‘sustainable maritime transportation system.’ Although the primary aim of the project is to ensure navigational safety and protection of the marine environment in this sensitive region, it intends to embrace the innovative e-Navigation solutions which are expected to begin roll-out in coming years. E-Navigation SIP endorsed by IMO has set a target for implementation of all the identified tasks in SIP by 2019 (IMO, 2014b).

In this context, it is proposed to implement this MEH project by 2020, in order to incorporate e-Navigation solutions within the system. To achieve this objective, it is vital to begin the process of public awareness and consultation among all the stakeholders at the earliest, beginning 2015. As a first step, India and Sri Lanka can jointly submit a two proposal to the IMO i.e. one for establishment of routing measures, as described in Chapter-6 and another for establishment of MEH in this region. IMO, being a specialized agency of the UN, has the mandate to support developing countries in their effort to implement such proactive measures. Furthermore, the establishment of MEH covering the entire shipping route, especially the oil route between the Gulf and Far East is already stated as a high level objective in the MEHSOMS project report of the World Bank (World Bank, 2006). Additionally, the background article on MEH published by IMO clearly indicates that the phase-3 of the regional MEH project covers the entire network with emphasis on oil and gas transportation routes (IMO, 2006).

Furthermore, the compelling need for the project, as explained before, is the protection of the environment because of the sensitivity of the region. Although there is no detailed study available about the economic value of coastal environment of this region, previous estimates indicates that around 2.1 \$billion per year is the direct economic value of coastal resources of India alone, which will definitely be much higher as on date (World Bank, 2010). The MEH project, if implemented, will be

able to reduce the economic losses and damages in case of any oil spill. Therefore, India and Sri Lanka, being members of the South Asia Co-operative Environment Programme (SACEP) together can submit the proposal for financial assistance for the MEH project, with the support of IMO. This is because of the fact that the sister organization 'Partnerships in Environmental Management for the seas of East Asia' (PEMSEA) has played a pivotal role in commencement of MEH project in SOMS, together with other agencies (PEMSEA, 2014).

Upon obtaining concurrence and approval of IMO for implementation of MEH, India can take the lead for implementation of the project, in agreement with Sri Lanka. Alternatively, the project can be handled directly under the supervision of IMO, similar to the pilot project in SOMS. In the meantime, both countries can take their own initiative for establishment of coastal VTS combined with SRS at Kolachel in India and Galle, Sri Lanka, since these VTS's are essential, irrespective of whether MEH is being implemented or not. DGLL has recently established a coastal VTS covering the complete stretch of Gulf of Kutch in India, using latest equipment and software, with full budgetary support from Government of India (DGLL, 2013). A similar approach may be adopted by the DGLL for setting up of VTS and SRS at Kolachel. Correspondingly, the necessary steps may be initiated by Sri Lanka for the installation of VTS and SRS at Galle, either by their own or through financial assistance by the international agencies.

The next important step towards the implementation of the MEH project is to prepare a detailed project report, including the financial implications of each component, short term and long term objectives, cost benefit analysis, technological capabilities and time frame for executing the project. The report should also explore the financing options for continued operation and maintenance of the MEH system, either through full government funding or utilization of amount being collected as *light house dues* from ships visiting the ports. However, in author's opinion, any attempt to collect user fees from ships transiting through this MEH, will not be successful and will dissuade the ship owners from participating in the project.

In such a scenario, this dissertation may be used as a starting point for the preparation of the project report. A detailed project report is essential for obtaining any financial support from the international agencies. If the project report is made ready by end of 2016 then within the succeeding three year period i.e., 2017-2020, the Marine Electronic Highway for this region can be implemented successfully with the co-operation and support of IMO and International agencies. Furthermore, during the period of implementation of the MEH IT system, the project can also function as a test bed for trial of e-Navigation solutions. In anticipation of the timely approval of the proposal by IMO, a tentative timeline for roll-out of the project is depicted in figure-39.

Marine Electronic Highway along West Coast of India and Sri Lanka - Tentative implementation schedule

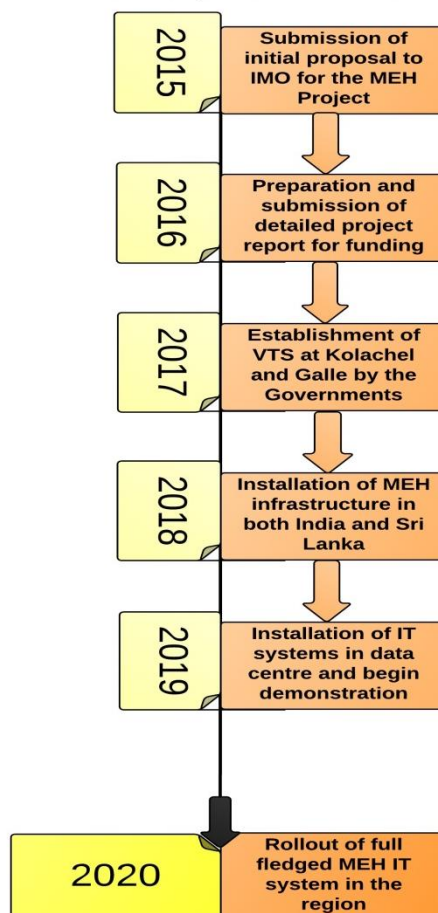


Figure 39: Tentative implementation schedule of the MEH project in the region. Source: Author

Chapter – 8 Summary and Conclusion

Ever since the adoption of the first International Convention on the Safety of Life at Sea in 1914, phenomenal changes have transpired in the field of navigational safety systems on-board and ashore, due to rapid advancements in technology in the past decades. The IMO, in cooperation with the member States, has also responded to the changing needs and circumstances by adopting pertinent regulations in SOLAS to improve navigational aids on-board ships as well as establishing shore-based navigational safety systems such as routeing schemes, Ship Reporting Systems (SRS) and Vessel Traffic Services (VTS) to enhance safety of navigation.

Despite these measures, collisions and groundings are occurring frequently, even in today's age, and these incidents are becoming more of a norm than an exception. Analysis of casualty statistics by the International Union of Marine Insurance has shown that during the period 2009-2013, collisions and groundings combined have contributed to a major share i.e. 46% of total number of casualties. However, it appears that not much attention is being paid to the causes of these incidents because the shipping industry is glued to the much published fact about the steady decline in the total loss of ships in recent years. It is rather surprising to note that even the performance indicators of the IMO take cognizance of only the total loss of ships and not targeting the many serious casualties with high potential of causing environmental disasters.

Hence, it is vital to investigate all the navigational accidents systematically to find out not only the root causes which lie on-board but the shortcomings in safety systems ashore as well. Moreover, in matters concerning navigational safety such as Maritime Traffic Management, a more proactive role of member States and IMO is

essential to prevent navigational accidents rather than reacting to such incidents, especially in view of the tremendous increase in maritime traffic causing congestion in the vital sea lanes of the world.

Therefore, this dissertation has made a proactive attempt to analyse the traffic density and traffic patterns in a highly congested critical navigational stretch of the Northern Indian Ocean, which lies between the South coast of Sri Lanka and the West coast of India, and proposed suitable traffic management solutions for this region, which need to be implemented to enhance the safety of shipping and protection of the marine environment. The proposed solutions include basic and reliable systems like the establishment of TSS, coastal VTS and SRS for this region, which have already been implemented in some parts of the world for many years. In addition, taking a cue from the Straits of Malacca and Singapore (SOMS), this dissertation has also proposed the establishment of technology driven, state of the art systems such as the Marine Electronic Highway (MEH) incorporating the e-Navigation solutions, so that maritime traffic management and environmental management are taken forward simultaneously.

Although, this dissertation has focussed on the Indo-Sri Lanka region, the broader aim is to contribute towards one of the identified objectives of IMO's concept in achieving the 'Sustainable Maritime Transportation System,' by enhancing the efficiency and reliability of 'maritime traffic support and advisory systems.' This is because the goals of IMO have explicitly mentioned the expansion of traffic information systems such as MEH beyond the Straits of Malacca and Singapore. Therefore, the feasibility study of the implementation of MEH system in this region have also been included as part of this dissertation.

It is often said that to resolve the problems existing today, we need to understand the past. Hence at the outset, the historical evolution of vessel traffic management systems, starting with 1857 from voluntary ship's routeing to the modern day systems of real-time traffic management and monitoring using the latest technologies, have been studied and detailed herein. Thereafter, the concepts of

MEH, the components of IMO led MEH pilot project in the SOMS, successes and shortcomings of the pilot project and its current status have been described and analysed in detail. Moreover, the futuristic concept of e-Navigation and its Strategy Implementation Plan endorsed by IMO have also been explained. Although, the MEH concept was initially proposed a decade ago, the unique part of this dissertation is that it has analysed the shortcomings of the pilot project and suggests the modified version of the MEH system for this region, incorporating the e-Navigation solutions being developed.

Since the main focus of this dissertation is to propose suitable traffic management solutions for this region, the studies have shown that the statistics regarding the number of ships transiting through the region; traffic density and traffic patterns are essential to even suggest any remedial measures to solve the problem. Realising the absence of any credible statistics or past studies on this count, it was decided to embark on a mission of collecting traffic data, estimating the traffic statistics and recording the traffic pattern for this region. Although counting the number of ships transiting through a particular region is not a complex exercise in today's world, this interesting exercise was done, as part of this dissertation with the help of a live and historical data feed from the Indian LRIT National Data Centre (NDC), the Indian National AIS Chain, commercial Satellite AIS service providers 'Fleetmon' and 'exactEarth.'

This exercise has revealed that around 58,000 ship transits, including 25,000 tankers, are transiting through this critical navigational stretch every year, which is not very far behind the busier Strait of Malacca and Singapore with 78,000 ship transits every year. Despite the clear distinction between these two regions, i.e. one being an enclosed narrow International Strait and the other being a coastal region with sufficient sea room, the risks of navigational accidents are also very high in the Indo-Sri Lanka region, because of the unregulated and high density traffic pattern prevailing in this area. Therefore, traffic patterns and traffic density in this region have been thoroughly analysed utilizing the live data as well as historical data to

arrive at suitable traffic management solutions for the region. Through this analysis, three critical areas, with very high risk of collision encounters and groundings, have been identified.

Subsequently, to minimise the risks in these three critical areas, namely off Galle in Sri Lanka, off Kolachel and off Kollam in SW coast of India, this dissertation has proposed the establishment of TSS and coastal VTS combined with SRS for this region. Moreover, the draft layout of TSS for all the three identified areas has been designed as part of this dissertation, taking into consideration the IMO guidelines and criteria for the establishment of Ship's Routing measures. The direction and width of the traffic lanes and the width of separation zones of the TSS have been designed purely in line with the existing traffic patterns and to meet the existing and anticipated future traffic density of this region, simultaneously keeping in mind the concerns of the coastal States of India and Sri Lanka towards protection of the marine environment.

The success of any traffic management solution, such as routing measures, is heavily dependent upon the widespread acceptance by the stakeholders. Therefore, the proposed layouts of TSS along with a questionnaire have been sent to many mariners sailing in those regions to obtain their suggestions and feedback about the proposal with the help of shipping companies. This feedback exercise has revealed that an overwhelming majority, i.e. 98% of the mariners in spotlight survey, have welcomed this proposal and they also confirm that the proposed layout of TSS will adequately serve the purpose of reduction of navigational accidents in the region. Some of the mariners have also given very good suggestions for minor modifications in the TSS which have been incorporated in the proposal. Accordingly the revised layouts of the proposed Traffic Separation Schemes are given in this dissertation.

Nevertheless, prior to finalising the layout of TSS, detailed consultations by the States with the fishing industry and the awareness campaigns are necessary for the fishermen living along the coastline. It is a known fact that the SW coast of India has heavy fishing traffic along the main shipping routes in most parts of the year. Some

of the feedback received from the mariners has also expressed concern about the fishing traffic and suggested the regulation of fishing traffic in this region, so that the traffic lanes of TSS can be safely used for navigation. Since it is not possible to avoid fishing traffic, they need to be fitted with Radar reflectors and AIS for easy identification and fishermen are required to be trained about the traffic regulations as recommended in some of the casualty investigation reports.

This proposal to establish traffic management solutions for this region has also considered its vulnerability in view of increasing traffic. There have been many navigational accidents around the Indian sub-continent in the past, more specifically in the identified critical areas itself, which have resulted in a loss of lives and oil pollution. Therefore, the vulnerability of the region, along with the statistics of navigational accidents of the past five years, have also been collected and analysed as part of this dissertation. The details of some of the incidents have also been summarised, which clearly highlights the vulnerability due to navigational accidents. Moreover, the environmental sensitivity of the coastline and adjoining waters of India and Sri Lanka, as well as the potential impacts on the regional environment due to navigational accidents, have been described, to provide a better understanding of the hazards being confronted in this area. Considering the broad scenario, this dissertation has made a proactive attempt to go beyond proposing a mere TSS.

Lastly, this study has conceptualized the overarching Marine Electronic Highway system for this region which can integrate the elements of maritime safety systems as well as marine environmental protection and management systems. Although the basic framework is similar to the MEH project of Straits of Malacca and Singapore, the proposed architecture of the system designed for, is suitably modified to meet the local requirements and upgraded in many ways, since it proposes to incorporate the e-Navigation solutions within the MEH system. This dissertation has also identified the key deliverables and principal components of the proposed system. Moreover, it has conducted the gap analysis for the proposed MEH system vis-à-vis existing shore-based infrastructure in this area. Finally, it has also given a way forward, in

author's opinion, for implementation of the ambitious MEH system in this region, jointly by India and Sri Lanka, with a timeline to roll-out the system by 2020.

In conclusion, this dissertation has not only conducted the theoretical study of maritime traffic management but has also given a practical readymade proposal for the establishment of a Marine Electronic Highway and Routeing Scheme for a critical navigational stretch along the West coast of India and Sri Lanka, which is a lifeline for oil/gas trades between the Middle East and Far East. It has also produced credible statistics regarding the shipping traffic in this region. Moreover, consultations with the stakeholders regarding the proposed routeing measures have shown encouraging results.

Since the necessary ingredients are readily available, it is recommended that India and Sri Lanka together, will submit a proposal to IMO, utilizing the statistics, studies and feedback obtained as part of this dissertation, in order to establish routeing measures and a coastal VTS with SRS as a first step followed by the implementation of the MEH system, with the financial support from International agencies, if needed. Moreover, it is vital to note that this study has focussed only on the most critical and priority areas, because it is only a beginning in establishing an IMO approved traffic management system in this region. Therefore, it is also recommended to conduct a study and implement the suitable routeing measures for the remaining areas along the West coast of India sooner rather than later. For the future studies, it is also recommended to carry out the risk assessment of waterways using IWRAP (IALA Waterway Risk Assessment Programme) modelling software for estimating the frequency of collisions and groundings in this region with the help of complete set of AIS data.

Nevertheless, this dissertation will also help the IMO in taking forward its aim of extending the coverage of the MEH system to the entire oil/gas trading routes. It is the author's belief, in today's globalized world, that it is necessary for the industry to move in the direction of the Global Monitoring and Management of Shipping traffic, that may be termed either as 'Global VTS,' or 'Global MEH,' by adopting e-

Navigation solutions. Hence, it is high time for the shipping industry, member States and IMO to come out of the jurisdictional barriers of UNCLOS for the sake of improving safety, security, efficiency and environmental protection, and adopt the radical measures in shipping, analogous to the operational concept of Global Air Traffic Management (ICAO, 2005).

At the end, this dissertation hereby concludes with a small portion of exciting speech of Mr. Koji Sekimizu, IMO Secretary General, in 2012, about the Marine Electronic Highway system, which gave the inspiration for this work.

“Development of the maritime infrastructure and the move towards new and improved ways of achieving enhanced navigation and traffic control are among the pillars of sustainable maritime development. I firmly believe that the Marine Electronic Highway can be a great success – indeed, that it can provide a blueprint for similar schemes in other parts of the world; and that, collectively, they can have a massive beneficial effect on our global society which depends so much on the safe, secure, efficient and green carriage of trade, by sea” (Sekimizu K. , 2012).

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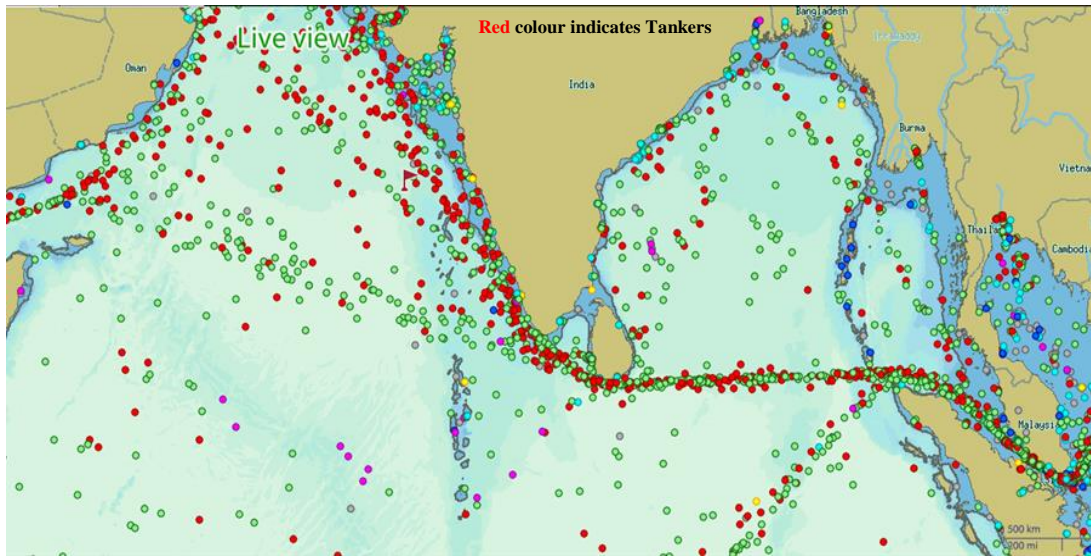
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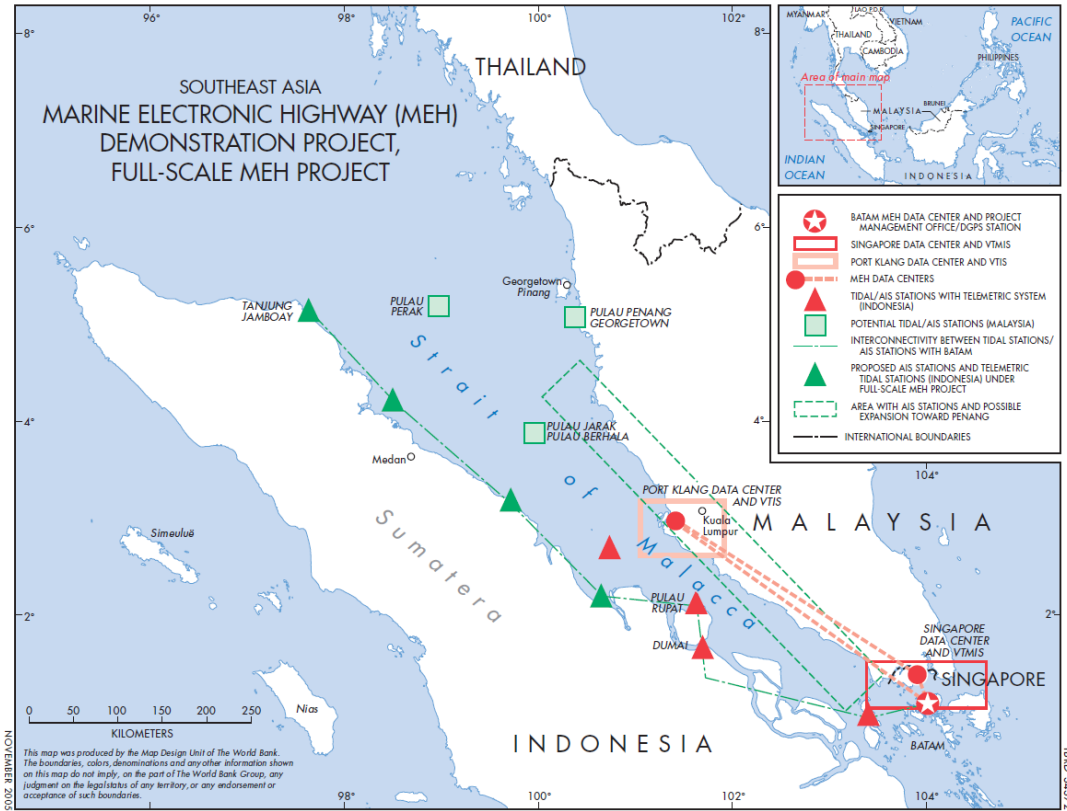
Appendices

Appendix-1: General flow of shipping traffic around Indian Sub-continent



Satellite AIS live display depicting the shipping traffic around Indian sub-continent. Dated: 23rd August 2014. Source: (FleetMon, 2014)

Appendix-2: Scope of Marine Electronic Highway in the Straits of Malacca and Singapore



Source: (World Bank, 2006)

Appendix-3 Statistics of vessel traffic through Straits of Malacca and Singapore and World Bank estimates of future traffic

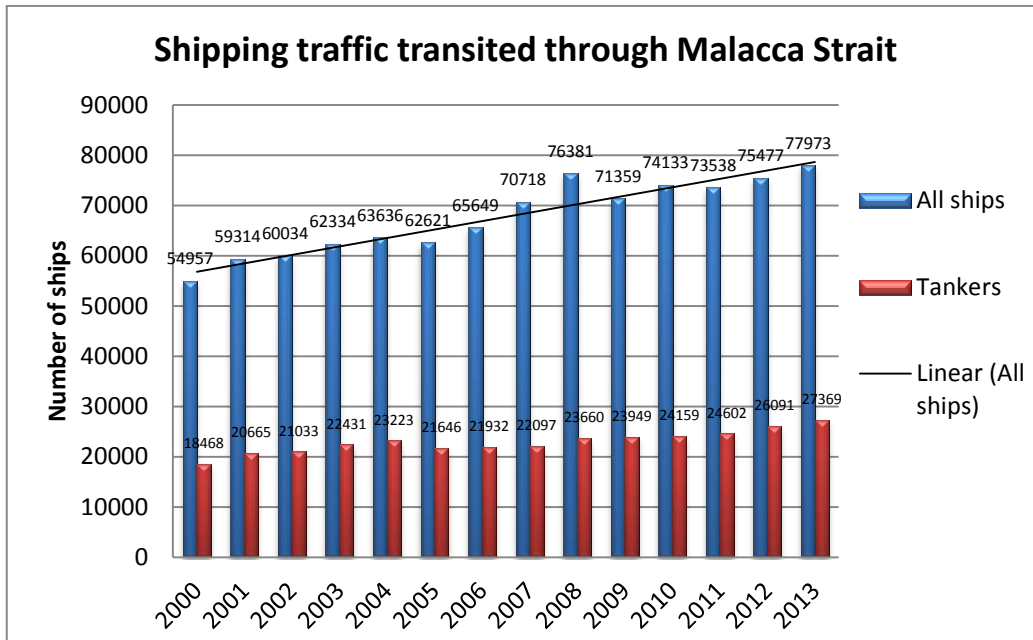


Figure-z: Chart showing the number of ships transited through the Malacca Strait every year since 2000. Data inputs obtained from STRAITREP and Nippon Foundation. Source: Author

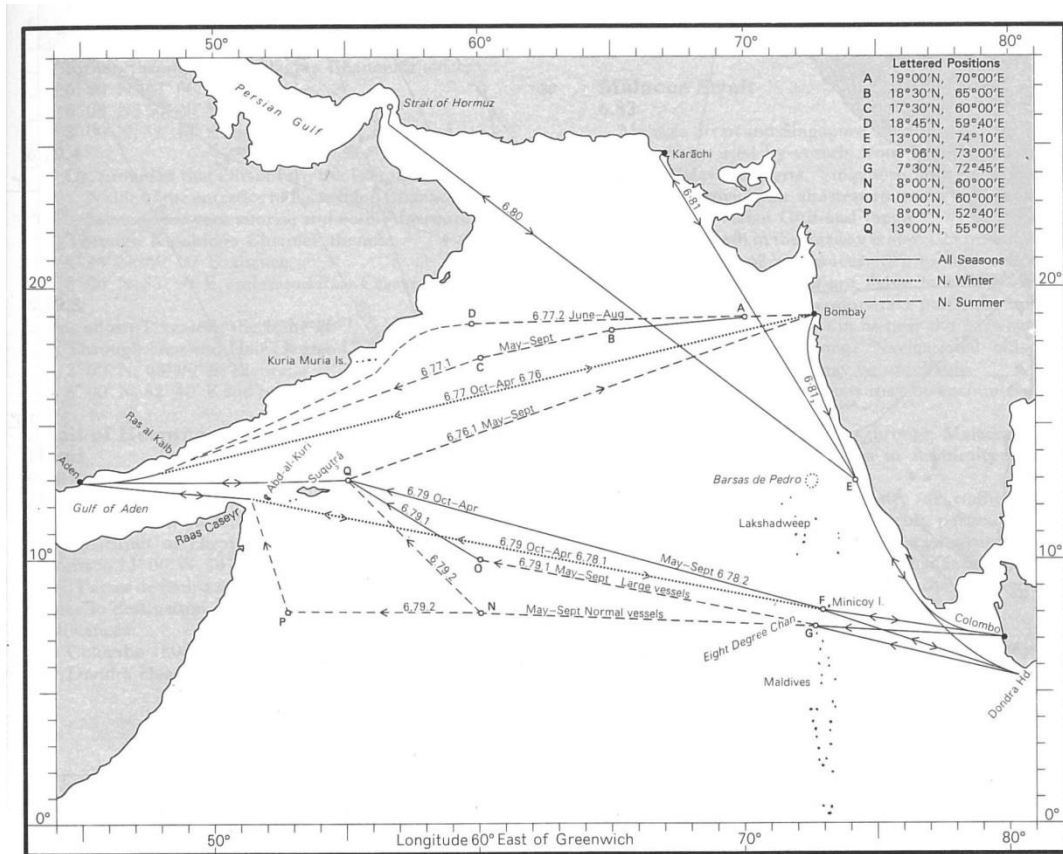
Estimates of future traffic through Straits of Malacca and Singapore as per World Bank are as follows:

Actual and Projected shipping movements in the Malacca Straits

Ship type	2002	2025
Non Very Large Crude	17,400	30,000
Ultra Large Crude Carriers	3,300	16,500
Container ships	23,000	34,200
Malacca Max	0	3,800
Other	18,600	41,000
Total	62,300	125,500

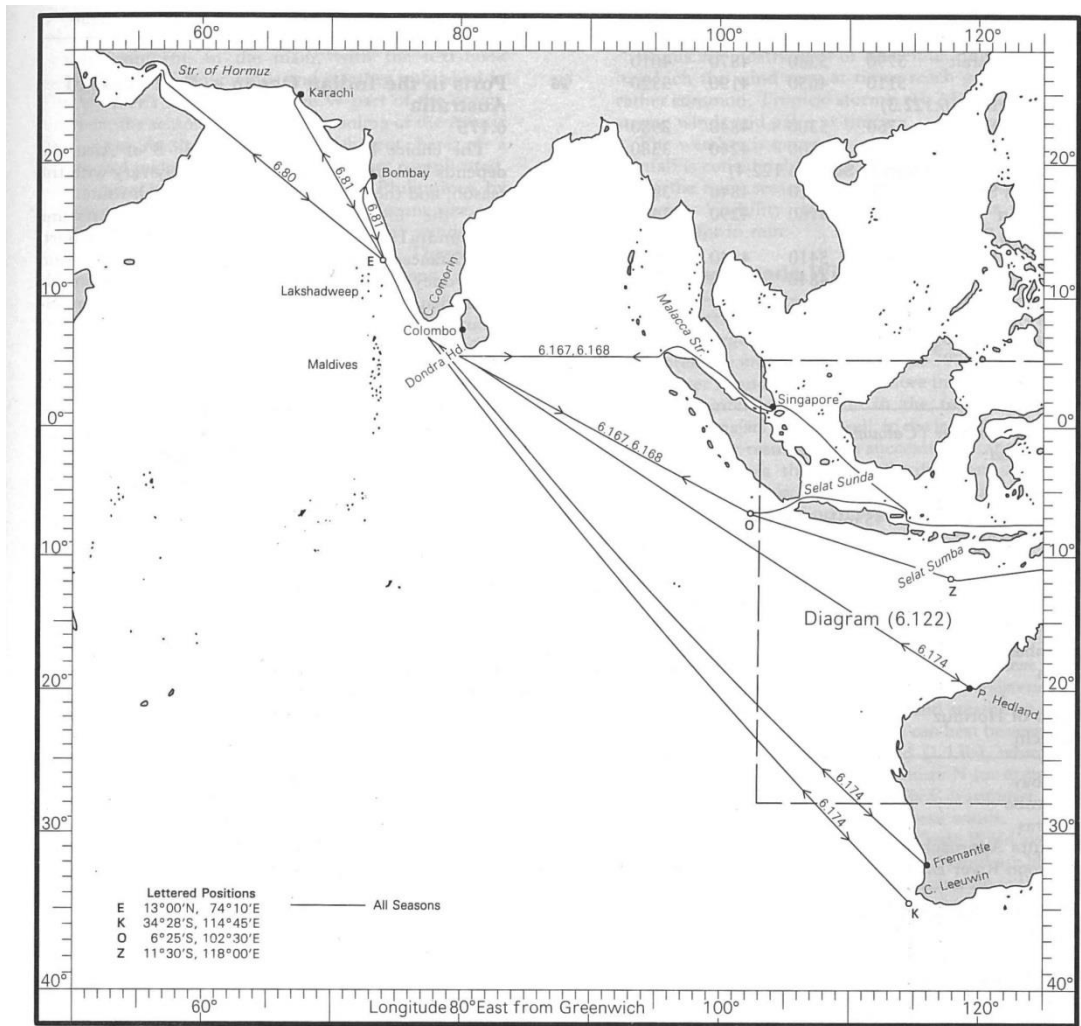
Source: World Bank estimates

Appendix-4: Recommended shipping routes between Middle East and Far East given in the Ocean Passages for the World



(6.76) ROUTES across Arabian Sea.

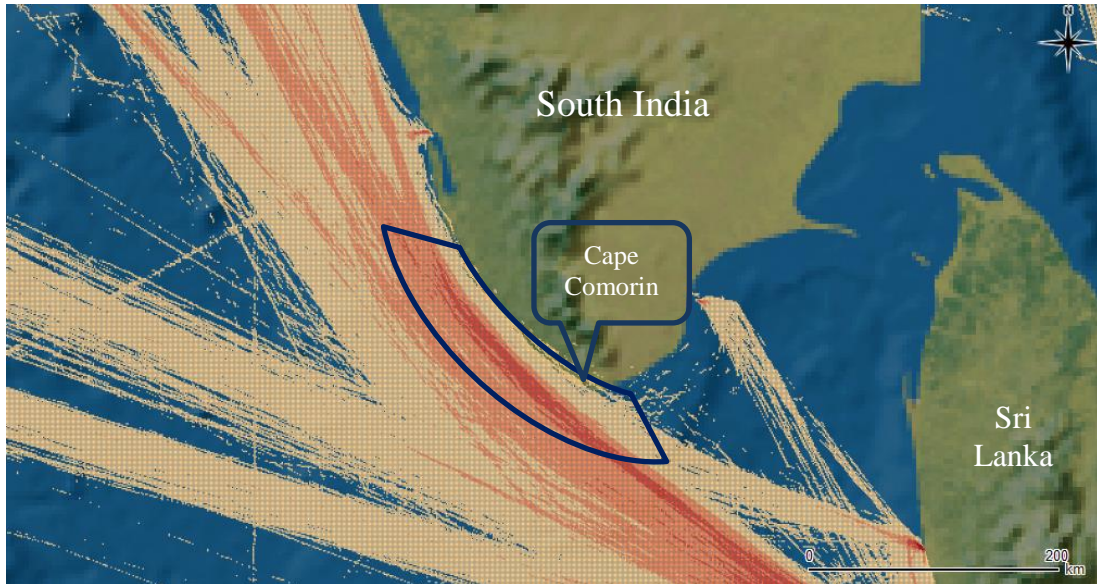
Routes across Arabian Sea recommended by Ocean Passages for the World. Source: (Hydrographer of the Navy, 1987)



(6.173) ROUTES—Eastern side of Arabian Sea ←→ Australia.

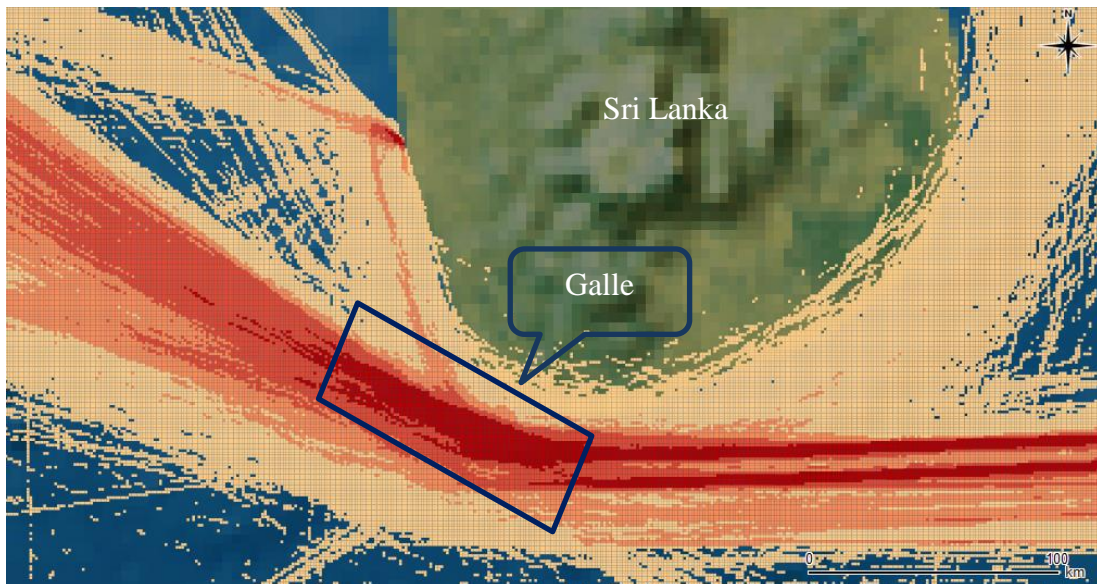
Routes in Indian Ocean recommended by Ocean Passages for the World. Source: (Hydrographer of the Navy, 1987)

Appendix 5: Traffic density map used for designing the layout of proposed TSS - obtained from commercial Satellite AIS service ‘exactEarth’ for August 2013



■ >100 ships
 ■ 51-100 ships
 ■ 26-50 ships
 ■ <25 ships per sq.km

Figure-x: Density map of SW coast of India, off Cape Comorin. Source: (exactEarth, 2014)



■ >100 ships
 ■ 51-100 ships
 ■ 26-50 ships
 ■ <25 ships per sq.km

Figure-Y: Density map of the South Coast of Sri Lanka. Source: (exactEarth, 2014)

Appendix-6: Questionnaire used for obtaining feedback from the mariners

Research work: Establishment of ship's routing measures in West coast of India and Sri Lanka

Name of student pursuing research: Capt. S.I. Abul Kalam Azad

Background information:

Mariners are mindful of the fact that, shipping route between Middle-east and Far-east, traditionally, follow along the West Coast of India and South Coast of Sri Lanka because of its geographical location. Whilst, it is strategically important for India that majority of trade flows through its EEZ, it also poses serious risk to Indian coast and its waters from any shipping casualties. In the past, incidents of grounding and collision around Indian waters led to loss of lives of fisherman and damages to environment. Research shows that within Arabian Sea and Bay of Bengal, density of shipping traffic is very high in areas between South Coast of Sri Lanka and West Coast of India, especially up to New Mangalore. Specifically, risk of accidents is severe off Kollam, Kolachel and Galle, due to convergence of vessels from different directions.

Statistics show that on every day around 150 ships, i.e. 55,000 ships in one year, are transiting in these high density traffic areas, out of which around 40% are tankers including many VLCCs. Realizing the potential consequences of any navigational accidents around Indian Coast, albeit late, this research is proposing to establish TSS in two focal areas of heavy traffic in West Coast of India and one TSS off Galle, Sri Lanka. Therefore it is imperative that feedback from master mariners and navigating officers sailing in these regions should be obtained on the proposed TSS to verify its practical utility and for obtaining any suggestions, changes and constructive criticism about the proposal.

Furthermore, kindly note that all the suggestions and feedback will be given due consideration to amend or improve the scope of proposal. Therefore you are kindly requested to give your feedback on the proposed TSS. All the information given will be kept confidential for research purpose only.

Instructions for filling the Questionnaire:

- Questionnaire can be filled using pen and scanned or typed in computer and sent as soft copy
- Wherever there are multiple options, you may select the most appropriate by either tick mark or circle

Questionnaire:



1. Name of the person:
2. Age group (in years of age): a) less than 30 b) 30 to 39 c) 40 to 49 d) Above 50 ✓
3. Qualification: a) Master b) First Mate c) OOW d) Navy/CG officer ✓
4. Name of the company/ organization:
5. Experience in sailing around Indian and Sri Lankan Coast: ✓
 - a. Very good experience and very familiar with this region
 - b. Average experience in this region
 - c. Less experience in these region
 - d. Never sailed in these region
6. Do you feel the proposed TSS for this area will be useful in enhancing safety of navigation
 - a. Indicate in a scale of 1 to 5. 1 indicates least useful 3 indicates moderately useful 5 indicates very useful



Comments/Suggestions if any:

7. Kindly provide more comments on the proposed **TSS off Quilon**: (Refer chart for information)
 - a. Do you agree that direction of traffic lane matches with the general traffic pattern in this region (indicate in a scale of 1 to 5. 1 indicates you do not agree with the direction. 3 indicates moderate agreement and 5 indicates you fully agree with the proposed direction)



Suggestions regarding the direction of traffic lane, if any:

- b. Do you agree with the width of the traffic lane and separation zone (around 3'), considering the average traffic in this region. (Indicate in a scale of 1 to 5. 1 indicates least agreement with the . 3 indicates moderate agreement and 5 indicates you fully agree with the proposed width of the lane)



Suggestions regarding the width of traffic lane and separation zone, if any:

- c. Do you consider the need for Coastal VTS in this region anticipating future traffic

(Indicate in a scale of 1 to 5. 1 indicates no need for VTS, 3 indicates VTS will be helpful, 5 indicates VTS must be established in this region)



- d. Provide your suggestions regarding the type of shore based services required in this region. Select the two most appropriate choices.

- i. Real time Meteorological services
- ii. Emergency response services in addition to SAR ✓
- iii. Shore based vessel monitoring services
- iv. Traffic management services
- v. Latest aids to navigation

8. Your comments on proposed **TSS off Kolachel** (Refer chart for info: – Open the PDF file)

- a. Do you agree that direction of traffic lane matches with the general traffic pattern in this region (indicate in a scale of 1 to 5. 1 indicates you do not agree with the direction. 3 indicates moderate agreement and 5 indicates you fully agree with the proposed direction)



Suggestions regarding the direction of traffic lane, if any:

- b. Do you agree with the width of the traffic lane and separation zone (around 3'), considering the average traffic in this region. (Indicate in a scale of 1 to 5. 1 indicates least agreement with the . 3 indicates moderate agreement and 5 indicates you fully agree with the proposed width of the lane)



Suggestions regarding the width of traffic lane and separation zone, if any:

- c. Do you consider the need for Coastal VTS in this region anticipating future traffic

(Indicate in a scale of 1 to 5. 1 indicates no need for VTS, 3 indicates VTS will be helpful, 5 indicates VTS must be established in this region)



d. Provide your suggestions regarding the type of shore based services required in this region. Select the two most appropriate choices.

- i. Real time Meteorological services
- ii. Emergency response services in addition to SAR
- iii. Shore based vessel monitoring services
- iv. Traffic management services
- v. Latest aids to navigation



9. Your comments on proposed **TSS off Galle** (Refer chart for information – open the PDF file)

a. Do you agree that direction of traffic lane matches with the general traffic pattern in this region (indicate in a scale of 1 to 5. 1 indicates you do not agree with the direction. 3 indicates moderate agreement and 5 indicates you fully agree with the proposed direction)



Suggestions regarding the direction of traffic lane, if any:

b. Do you agree with the width of the traffic lane and separation zone (around 3'), considering the average traffic in this region. (Indicate in a scale of 1 to 5. 1 indicates least agreement with the . 3 indicates moderate agreement and 5 indicates you fully agree with the proposed width of the lane)




Suggestions regarding the width of traffic lane and separation zone, if any:

c. Do you consider the need for Coastal VTS in this region anticipating future traffic

(Indicate in a scale of 1 to 5. 1 indicates no need for VTS, 3 indicates VTS will be helpful, 5 indicates VTS must be established in this region)



- d. Provide your suggestions regarding the type of shore based services required in this region. Select the two most appropriate choices.
 - i. Real time Meteorological services
 - ii. Emergency response services in addition to SAR 
 - iii. Shore based vessel monitoring services
 - iv. Traffic management services
 - v. Latest aids to navigation

10. Any other valuable comments you wish to make about the proposed routing measures:

Appendix-7: Comments received from the stakeholders about the proposal

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
1	14/08/2014	30-39	Master	Synergy Maritime Pvt. Ltd	Very good exp.	Very useful	Of the above three routeing measures, TSS off Galle harbour is the most important and will definitely improve the safety of navigation due to converging traffic in that region. An in-shore traffic zone may be established near the TSS off Kollam with restrictions for merchant vessels as we are seeing many vessels with Indian seafarers passing very close to Kollam for reasons known causing considerable risk to safety of navigation and damage to environment.
2	16/08/2014	Above 50	Master	Mercator Limited Mumbai	Very good exp.	Very useful	Some reporting procedures should be in place by which the Indian administration can monitor the vessel crossing India as a security back up.
3	16/08/2014	30-39	Coast Guard officer	Indian Coast Guard	Very good exp.	Definitely useful	TSS off Kolachel: The tracks should be have a sector separation of 45 to 60 degree so that to enable significant appreciation of vessel's intentions. TSS off Galle: The routeing measures should also involve Sri Lankan authorities also on a common platform.
4	16/08/2014	30-39	Master	Edin Maritime Limited	Average exp.	Definitely useful	When sailing more than 12nm from Indian coast line, insurance shall be an issue, whereas less than 12 nm is hazardous to both fishing traffic and transit vessels. Any TSS must be accompanied by a caution note. Any TSS development should also take into account security concerns pertaining to that geographical area. Width of TSS should also take into account fishing traffic expected that area in fishing season.
5	16/08/2014	Above 50	Marine Engineer	Mercantile Marine Department Mumbai	Very good exp.	Definitely useful	I am not sure about the required width of traffic zone and also not sure whether the direction of traffic zones matches with that of the general traffic pattern. Suggest to refer the authentic documents.
6	17/08/2014	30-39	Master	Anglo Eastern Ship Management	Very good exp.	Very useful	TSS must be considered. TSS off Quilon: for North and south part with a PRECAUTIONARY AREAS in between to allow traffic flow to and from the port or inland waters. It will certainly help in improving the safe navigation in the region
7	17/08/2014	40-49	Master	Univan Ship Management	Average exp.	Very useful	Kolachel TSS: Three lanes are converging to form One Lane. It is not a comfortable precautionary area. Maybe it is better to provide two TSS. One TSS for coastal transit and the outer TSS for vessels other coastal traffic

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
8	18/08/2014	30-39	Master	Mercantile Marine Department Mumbai	Average exp.	Very useful	TSS off Kolachel: Would suggest 2 T.S.S Lanes then 3 to avoid confusion/more traffic congestions at precautionary. area. TSS off Galle: Considering the traffic density, would prefer more than 3.5nm (though inshore traffic zone may be further reduced as required). final comment: Would prefer the entire region to be VTMS controlled to enhance further maritime safety.
9	18/08/2014	40-49	Master	Tamil Nadu Maritime Board	Very good exp.	Very useful	TSS off Kolachel: But, only two lanes on the southern side may be enough. One may be common for vessels calling Tuticorin and west coast of Sri Lanka and other may be for south coast of Sri Lanka. But, of course the chart may be checked and a rough study with radar observation from Colombo may be done for 3 months to understand the traffic flow. TSS off Galle: The Cautionary area on the northern side should be bigger in size. It may be aligned with the existing Dondra Head TSS
10	19/08/2014	Above 50	Naval officer	DG Shipping, Mumbai	Average exp.	Very useful	Most prone to accident like collision, hit and run with fishing vessels. Experienced strong on shore currents. Propose distance of 15 nm adequate (inner periphery of TSS). The fishing vessels will have to be instructed to keep clear of TSS
11	19/08/2014	Above 50	Master	Five Star Shipping/Maha Roos	Very good exp.	Moderately useful	None
12	19/08/2014	30-39	Master	Five Star Shipping/Maha Aarti	Average exp.	(for quilon only)	TSS off Quilon can be avoided
13	19/08/2014	30-39	Master	Five Star Shipping/Maha Anosha	Average exp.	Very useful	Width of TSS may be increased to 5 nm. Ref to below msg Pls be advised that due to High Risk Area in Arabian sea, all ships owner/master prefer to keep their ships near to the coast of India and which results in heavy shipping traffic on west coast of India. Traffic Separation scheme will be a great help in view of safety of navigation.As there are lots of fishing traffic near the west coast of India, it is recommended that if these schemes can also to be inform/educate them and request to keep away from TSS area.Fishing vessel may be considered as a pirate boats when they approach towards the vessel to save their nets and due to same ships are taking evasive action. Also ships which are having armed guards on board they might use same. It is advisable to mark these areas as prohibited for fishing on the chart.Due to above reasons vessel's using TSS may have difficulty to follow their respective lane.Establishment of VTS to monitor TSS traffic will be a great help in shipping traffic and also to monitor fishing vessels.For easy monitoring of fishing vsl by VTS or other vsl, it is advisable to make necessary use AIS by all fishing vsl in coast of India(For eg. in east china sea, yellow sea and south china sea all fishing vsl are fitted with AIS)

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
14	19/08/2014		Master	Essar Shipping Limited./Arun	Very good exp.	Definitely useful	None
15	21/08/2014	40-49	Master	Swiber Offshore, Singapore	Very good exp.	Definitely useful	Alongwith safety of navigation we are able to enhance security of Indian coast. highlight inshore traffic zone. Kolachel TSS: We should reduce one traffic lane by removing the option of middle lane. To exit from the lane since it is joining cautionary area so no issue. My suggestion will be to remove TSS lane. Mark Inshore Traffic Zone. with these 3 TSS in place there is no doubt will improve safety of navigation. The local fisher man has to be warned not to venture the TSS. __TSS is good idea you can encourage your colleague to take it up for their region as I can see you are more worried about safety of Navigation around Indian / Sri Lankan Coast. In year 1993/1994 we had a collision between SCI cargo vessel Ravidas with other Indian Ratnakar vessel. I had signed off from Ravidas before this incident and incident could have been avoided with TSS in place
16	21/08/2014	<30	OOW	Essar Shipping Limited.	Average exp.	Very useful	At this moment I am transiting TSS off Dondra head & proceeding to Hazira Port via Kolachel & Quilon. I think the length of the TSS off Dondra Head is not sufficient enough considering no's of V/L transiting through this area. I can see most of the V/L are moving along the same lane that u r proposed even if it is not there. No's of V/L transit to coastal passages & en-route to Singapore through TSS off Dondra Head ; I think making a TSS that u propose will make huge difference in the safety of Navigation & as well as with controlling the ship's movement.
17	21/08/2014	<30	OOW	Essar Shipping Limited.	Very good exp.	Very useful	As when there will be traffic lane ,vessel will have less clearing alteration area for fishing traffic. Fishing vessel should not be allowed to enter in the Traffic lane as this is highly dense traffic area. Width should be more wide for more vessels entering for India & Gulf Area. Also for clearing Fishing Vessels. Weather Fax System should be establish in the fully Indian region (East & West India) as there is no Weather service for India. 1. Traffic lane for going to South of India (Tuticorin).2. Traffic lane for going to Sri Lanka and East of India.3. Traffic lane for going to Mauritius & South Africa area from 78°NWidth should be more wide for more vessels entering for India ,Gulf Area, and going to South Africa and Sri Lanka. Width should be more wide for more vessels entering for India ,Gulf Area, Singapore and also now days vessels are also coming to Galle for Arms Guards which create many crossing situations. There should be the Preferred Recommended Route for the vessels entering to India , Gulf Area while coming from Galle towards India and vice versa. As all the ships follow different courses which create different situations specially near Galle.

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
18	21/08/2014	30-39	First Mate	Essar Shipping Limited	Average exp.	Definitely useful	None
19	21/08/2014	40-49	Master	Essar Shipping Limited	Average exp.	Very useful	THE PROPOSED TSS WILL DEFINITELY ASSIST IN SAFE PASSAGE FOR MERCHANT VESSELS ESPECIALLY DURING NON-MONSOON PERIOD WHEN THE DENSITY OF FISHING TRAFFIC IS MORE AND FISHING VESSELS ARE SCATTERED OVER A VERY WIDE AREA CAUSING DIFFICULTIES IN SAFE PASSAGE
20	24/08/2014	40-49	Master	Valles Steamship canada ltd./ Seanostrum	Average exp.	Very useful	Completely agree that there is need of TSS in this area to streamline traffic. Consider what route traffic will follow during SW monsoon to avoid beam swell. Ships may consider other route. Strongly suggest that width of TSS to be increased. More VLCC are 62 mtr beam. Oil majors and company's required minimum CPA from traffic, which may be difficult to achieve. If we require traffic to follow these TSS, specially VLCC, Suezmax and Aframax, distance from land to be increased minimum 10nm. A width of TSS to be increased now on tankers there are lot of pressure of ship's vetting by OCIMF and company's which will not allow to follow these TSS, unless safety criteria are met, to avoid any observation during SIRE vetting. Vessels may avoid TSS (Example of such TSS is GHATA TSS in Med Sea). I understand that now traffic passing close to Indian Coast due to piracy attack. But once piracy problem is solved and weather is bad tankers would not like to come near coast.
21	27/08/2014	Above 50	Master	ICC Shipping Association	Very good exp.	Very useful	Southern part of India & Srilanka has seen quantum jump in traffic and size of ships and increased coastal activities. Due to piracy infested Arabian Sea, lot of traffic is now going past coast of India which will be assisted by proposed TSS. Width of traffic separation scheme should be arrived at after public consultation in the proposed area including those from the fishing community. It is recommended that adoption of TSS should be fully compliant with IMO Guidelines in this regard before sending it to IMO appropriate sub committee. It might help to generate draft paper for the sub committee to consider. Indian Administration may be invited to comment on said draft paper. Informatively, earlier TSS in and around India such as off Bombay and Kandla have not been adopted for lack of public consultation.
22	27/08/2014	30-39	Master	SCI	Average exp.	Very useful	None

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
23	27/08/2014	<30	First Mate	SCI	Average exp.	Very useful	None
24	27/08/2014	<30	OOW	SCI	Average exp.	Very useful	None
25	27/08/2014	<30	OOW	SCI	Average exp.	Very useful	None
26	28/08/2014	Above 50	Master	Five Stars Shipping/Grace One	Average exp.	Very useful	None
27	28/08/2014	Above 50	Master	Five Stars Shipping/Maha Jacqueline	Very good exp.	Very useful	None
28	28/08/2014	30-39	Master	Epic Ship management pte ltd Singapore	Very good exp.	Very useful	Two areas , one contained between E bound lane , WNW bound lane & meridian 077o 33' E and other contained between NW bound lane , SE bound lane outer limits & line joining the extreme outward points of both lines can be developed as OPL / transshipment area by Indian Govt port of Trivendrum/Kolachel for multi purpose as bunkering / Lightering / crew change / stores & provision supply / embarkation & disembarkation of armed guards for GOA. There is always a traffic bound to / from Colombo at this area specially high speeding container ships on a crossing situation/converging situation with traffic coming from NW , approaching off Galle and traffic coming out from Galle TSS and bound to NW to India/GOA. Therefore establishment of N/S lane from precautionary area to Off Colombo is needed. As shown in attached chart. . Its advisable to make a north/south bound lane for traffic to/from Colombo joining in precautionary area and extension of NW/SE lane to TSS off Kolachel after th precautionary area.
29	28/08/2014	30-39	Master	SCI/Swarna Pushp	Very good exp.	Very useful	TSS off Kolachel: Would like to suggest that that the general traffic pattern for the South bound Traffic should be in one single TSS of South Easterly Direction. General comments: Would like to suggest that at the TSS off Galle vessel's have been drifting at this area for Picking up Arms guards, Provisions, Spares, Paints and Crew change are taking place. After setting up of TSS off Galle , it will affect the movement of other Vessel's which not stopping at Galle. Hope these suggestions will be valuable to your project.

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
30	28/08/2014	40-49	Master	Essar Shipping/Shravan	Average exp.	Very useful	TSS off quilon: DUE TO LESS TRAFFIC DENSITY IN THIS AREA, SUGGEST ITS NOT NECESSARY FOR THE TSS. NO NEED FOR VTS. General Comments: VTMS IS NOT NECESSARY IN THIS AREA AS TRAFFIC DENSITY IS NOT MUCH MORE. IN MY OPINION, ONLY TSS IS NECESSRY NEAR GALLE AND KOLACHEL.
31	28/08/2014	<30	First Mate	SCI/Swarna Pushp	Very good exp.	Definitely useful	Tss off Quilon: TRAFFIC LANE IS GOOD BUT WITH REGARD TO FISHING TRAFFIC IN THIS AREA, I DONOT FIND IT SO USEFUL. TSS off Kolachel: I DONOT FEEL THE NEED OF THREE TRAFFIC LANE AFTER PRECAUTIONARY AREA FOR VESSEL PROCEEDING SOUTH.
32	28/08/2014	<30	OOW	SCI/Swarna Pushp	Very good exp.	Definitely useful	TSS off quilon: TRAFFIC LANE IS GOOD BUT WITH REGARD TO FISHING TRAFFIC IN THIS AREA, I DONOT FIND IT SO USEFUL. TSS off Kolachel: I DONOT FEEL THE NEED OF THREE TRAFFIC LANE AFTER PRECAUTIONARY AREA FOR VESSEL PROCEEDING SOUTH. TSS AT GALLE SOUTHERN COAST OF SRILANKA IS VERY USEFUL FOR MERCHANT SHIPS BUT VESSEL COASTING AROUND INDIA GOING TO EAST COAST ENCOUNTERS HEAVY INCOMING TRAFFIC FROM EAST ASIA SUCH AS SINGAPORE , CHINA ETC. SO THERE IS NEED TO EXTEND THIS TRAFFIC LANE SO THAT VESSEL CAN PROCEED SAFELY TO EAST COAST OF INDIA. VTS SHOULD BE SETUP TO PROVIDE USEFUL TRAFFIC INFORMATION TO VESSELS TRANSITTING
33	28/08/2014	<30	OOW	SCI/Swarna Pushp	Very good exp.	Definitely useful	Tss off quilon: TRAFFIC LANE IS GOOD BUT WITH REGARD TO FISHING TRAFFIC IN THIS AREA, I DONOT FIND IT SO USEFUL. TSS off Kolachel: : I DONOT FEEL THE NEED OF THREE TRAFFIC LANE AFTER PRECAUTIONARY AREA FOR VESSEL PROCEEDING IN SOUTHERLY DIRECTION.
34	01/09/2014	40-49	Coast Guard officer	Indian Coast Guard	Very good exp.	Moderately useful	I agree that the TSS will be useful in streamlining the traffic. However, the proposed model may be wetted by the realistic traffic data (LRIT, Satellite derived traffic data, AIS inputs)
35	05/09/2014	Above 50	Master	SCI	Very good exp.	Very useful	Due to the more number of fishing boats are engaging in fishing, chances are there they will not mind your TSS. They will put their nets in the middle of TSS also. Fishing traffic will be more especially small Kettumarams in that area. As I am staying coastal area of Kerala KASARAGOD, I am suggesting the following: 01) A strict training to be given to the fisherman community regarding safety at sea. 02) Importance of LSA/FFA items to be explained to them. 03) Teach them strictly what is a TSS and to avoid fishing in TSS areas. 04) Kerala coast is always have fishing traffics due to availability of seasonal fish. 05) Before teaching fishermen the fisheries Dept staff should trained and teach regarding safety at sea and the importance of TSS and their fitness to teach convince fisherman. 06) Most of districts in kerala we can see Port offices. But after 11'o'clock you cannot see any staff in those offices including Port officer. It is also their right to teach the poor fisherman communities every year when they are surveying their fishing boats . 07) No all fishing boats ever surveyed by these office regarding the safety of fishing boats etc. Most of the fisherman are not much educated.

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
36	05/09/2014	Above 50	Master	SCI	Very good exp.	Definitely useful	<p>The proposed TSS may be used only by those ships which are familiar and are bound for Indian ports. Where as VLCC and large container ships will avoid the TSS area to keep well clear of fishing traffic and as a safe guard against the inadvertent confusion with piracy issues which may pose by genuine fishing traffic during fair weather conditions. General direction is favourable for medium size vessels and coastal vessels however large vessel would like to avoid this area due to heavy fishing traffic in the areas. We observed in the first week of August at the peak of monsoon season this area was full with fishing crafts and deep drafted vessels transiting may not be safe. Also there should be mechanism to promulgate this TSS areas to be kept safe for transiting ocean going vessels to avoid impedance by fishing crafts. TSS off Kolachel: As per the general observations VLCC and large container ships will avoid the TSS area to keep well clear of fishing traffic and also unnecessary intrusion in the coastal areas on another country. We observe many ships keeping about 20 NM away from the suggested TSS area in this region. Most of them were laden VLCCs and container vessels. Also in case of any mishaps with laden tankers a distance of 20 nm as per the suggested TSS may not be good for environment considering the availability of antipollution resources around the Indian coasts at present scenario and the direction of ocean currents in the area specially during the SW monsoon season. Galle TSS: This TSS will serve to be a a very good continuity to the existing TSS off Dondra head and will achieve the streamlining of traffic which will be bound for west coast of India and Arabian sea. Fair weather season concerns shall be taken into consideration with respect to fishing traffic while making these TSS mandatory as heavy fishing traffic on the Kerala coast specially for large vessels drawing drafts more than 15 mtrs and above and for the large freeboard area vessels may cause concern to many mariners. At times large vessels find it very difficult to maneuver through these areas as many of the fishing crafts are in bunches and do not leave a safe passage for ocean going vessels. Also there may be need for marking of inshore traffic zones off these TSS areas as the coastal traffic may not like to transit this far.</p>
37	05/09/2014	<30	OOW	SCI/ Desh Bakht	Average exp.	Very useful	<p>Width of 4 miles would be better as too many vessels are passing at one time; larger width would avoid any dangers while vessels overtaking one another along with fishing traffic as well. TSS off Galle: Suggesting for a round TSS at the Eastern alteration Point where the three branch TSS meets the Main TSS. These TSS if implemented would be very helpful in planning a safe and secure passage. Monitoring by VTS is a must to make sure the vessels following the TSS Correctly. Fishing vessels should be instructed about the new TSS area by VTS and port authorities & should be instructed to keep clear of the TSS. This plan would enhance port security as well. Due the lack of TSS in these areas vessels are passing through port limits without authority. Proposing a TSS along with VTS would be helpful in all respects.</p>

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
38	05/09/2014	40-49	Master	SCI /Swarna Kamal	Very good exp.	Moderately useful	Definitely a TSS will improve safety of navigation. Kollam VTS: General traffic flow in this area is as per the proposed TSS. Shipping traffics are not the main concern with respect to no of traffic encountered in these area ,but the fishing boats are, eg. enormous unlit skiff with out- board engine .So when we are adopting the proposed TSS ,fishing traffic to be kept away from the TSS as far as possible ,otherwise it may lead to futile. Kolachel TSS: Definitely it will facilitate a disciplined general flow along the coast. 3'Separation width is sufficient. Among other two proposed TSS this proposed extension of existing TSS is more relevant with respect to number of traffic, also would like to suggest a precautionary marks within the TSS ,(Marked on the attached chart).Because in recent past lots of off shore activities happening south of point DE GALLE, like crew change ,pick up stores, Armed guards boarding /disembarking etc. These involves Xing of TSS very frequent. In all the three proposed places main concern are not only the density of the traffic but the menace of fishing traffic, which usually found less in other part of the world where TSS exist or proposed, so the real challenge is how do we educate and convince fishermen community to avoid at least the proposed TSS area, It could be dealt with well demarcation of the area by DAY/NIGHT BUOYS, Proper training to the fishermen by respective fisheries department,.etc.
39	05/09/2014	30-39	Master	SCI/ Swarna Ganga	Very good exp.	Definitely useful	It will definitely improve the navigation system. However one of the major concern is fishing vessels in the area which are bind by no rules and no definite pattern . Quilon TSS: 1. At the proposed location we have found that fishing vessel with their long nets are fishing in large group. The above routing measures will definitely enhance maritime safety in the area however one of the major hazards that is concentration of fishing vessels is to be addressed .For eg. Even off dondra TSS is established many vessels are not following it due to high concentration of fishing vessels in area. In restricted visibility the situation become more tense with unable to sight the fishing nets . The fishing vessels in the area should be equipped with AIS and proper uniform signaling means should be established for location of nets .
40	05/09/2014	40-49	Master	SCI/ Swarna Jayanthi	Average exp.	Definitely useful	None

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
41	06/09/2014	30-39	Master	SCI/ Vishva Vijeta	Very good exp.	Very useful	Due to heavy congestion of traffic, fishing boats, trawlers, it is utmost important to have TSS in this region, especially because of HRA traffic. TSS off Quilon: Separation lane width of 3' is useful. However it should be clearly distinguished for fishing traffic. As in this region, fishing boats/trawlers are hampering safe navigation. TSS off Kolachel: width of separation zone/traffic lane of 3' is appropriate, however it would be better to extend the traffic lane in both NW and SE direction. TSS off Galle: width of 3' is appropriate, as we are in regular route from Tuticorin to paradip / haldia. we face lots of fishing traffic using the TSS. So have to divert to North/South traffic lane. The TSS in this region is of great help for the safety of the vessel, crew and its environment. We are in regular run from Tuticorin/ Paradip. Till we join TSS south of Sri Lanka, we face many crossing/head on vessels and implementing TSS in this region will reduce this type of close quarters situation. This is very helpful for all maritime fraternity. My all best wishes are with you.
42	06/09/2014	<30	OOW	SCI	Less exp.	Very useful	None
43	06/09/2014	<30	First Mate	SCI	Very good exp.	Very useful	It is very useful because lots of fishing traffic is encounter in this region and also head on situation for all vessel. TSS off Quilon: This TSS should extend upto Kochi. More width of TSS zone should be there, so a vessel can get a enough of sea room to take action against fishing traffic and head on situation. TSS off Kolachel: The TSS should be more towards main land because lots of foreign register vessel which are not bound to India, comes closer to coast for mobile network. Width should be slightly increased to take appropriate action to avoid collision. TSS off Galle: one more lane to be added in TSS for vessel heading towards south africa. More width should be increased so that vessel heading towards cape of good hope, west coast of India and towards somalia and st. of hormuz via lakshadweep sea. final comments: one more TSS should be implemented near Goa and Mangalore area because vessel coming from Somalia, St. of Hormuz and West Coast of India gets crossing and head on situation. The fishing boat owners association also needs to be informed that small boats should not impede the safe navigation of all vessel in TSS region.
44	06/09/2014	30-39	Master	SCI/ Swarna	Very good exp.	Definitely useful	None

Sr. No.	Date of receipt of comment	Q.2 Age Group	Q.3 Qualification	Q.4 Name of the Company	Q.5 Sailing exp. around Indian Coast	Q.6 Do you feel the proposed TSS will be useful	Q.10 comments and suggestions
45	06/09/2014	<30	First Mate	SCI/ Swarna	Very good exp.	Very useful	None
46	06/09/2014	<30	OOW	SCI/ Desh Bakht	Average exp.	Very useful	<p>TSS off quilon: One of the thickly populated fishing traffic area. More information and training to the fisherman is required. A more width than 3' would be better as too many vessels are passing at one time; larger width would avoid any dangers while vessels overtaking one another along with fishing traffic as well. TSS off Kolachel: Very safe TSS. A little larger width would avoid any dangers while vessels overtaking one another along with fishing traffic as well. TSS off Galle: Suggesting for a round TSS at the Eastern alteration point where the three branch TSS meets the Main TSS. Width of 4 miles would be better as too many vessels are passing at one time; larger width would avoid any dangers while vessels overtaking one another along with fishing traffic as well. These TSS if implemented would be very helpful in planning a safe and secure passage. Monitoring by VTS is a must to make sure the vessels following the TSS</p> <p>Correctly. Fishing vessels should be instructed about the new TSS area by VTS and port authorities & should be instructed to keep clear of the TSS. This plan would enhance port security as well. Due the lack of TSS in these areas vessels are passing through port limits without authority. Proposing a TSS along with VTS would be helpful in all respects.</p>
47	07/09/2014	<30	First Mate	SCI/ Vishva Diksha	Very good exp.	Very useful	<p>TSS off quilon: Plz note that it is a high fishing traffic density area. Either the tss to be moved to 25 miles from land or fishing zones to be built around the tss to avoid the colossal number of boats entering the tss . TSS off Kolachel: the width of tss for Colombo needs to be increased (at least 2 miles width) as Colombo caters for large amount of container movement with large and fast containers moving to and fro from colombo. TSS off Galle: the tss to be such that the limits coincides with the tss presently in use off galle. Or the limits of tss off galle to be increased to match with the tss to be made anew. due consideration to be made for high traffic density(fishing) off Indian coast to be kept in mind.</p>

Appendix-8: Geographical co-ordinates of the proposed layout of the Traffic Separation schemes

I. Off Kollam TSS, Kerala coast, India

- a) A separation zone in the Southern part of the TSS is bounded by a line connecting the following geographical positions:
- | | |
|------------------------------|-----------------------------|
| 1) 08° 31.6' N 076° 32.5' E | 4) 08° 45.5' N 076° 17.5' E |
| 2) 08° 41.2' N 076° 22.6' E | 5) 08° 40.0' N 076° 20.1' E |
| 3) 08° 46.75' N 076° 20.0' E | 6) 08° 29.5' N 076° 30.5' E |
- b) A separation zone in the Northern part of the TSS is bounded by a line connecting the following geographical positions:
- | | |
|-----------------------------|------------------------------|
| 7) 08° 50.2' N 076° 18.3' E | 9) 08° 54.6' N 076° 13.0' E |
| 8) 08° 55.8' N 076° 15.7' E | 10) 08° 49.0' N 076° 15.8' E |
- c) A traffic lane of around 3nm wide, for North-west bound traffic is established between the separation zones in paragraphs (a) and (b) above and a line connecting the following geographical positions:
- | | |
|------------------------------|------------------------------|
| 11) 08° 33.8' N 076° 34.5' E | 13) 08° 57.0' N 076° 18.3' E |
| 12) 08° 43.0' N 076° 25.0' E | |
- d) A traffic lane of around 4nm wide, for South-east bound traffic is established between the separation zones in paragraphs (a) and (b) above and a line connecting the following geographical positions:
- | | |
|------------------------------|------------------------------|
| 14) 08° 26.8' N 076° 28.2' E | 16) 08° 53.1' N 076° 09.5' E |
| 15) 08° 38.0' N 076° 17.0' E | |
- e) A precautionary area is established connecting the following geographical positions:
- | | |
|------------------------------|------------------------------|
| 17) 08° 48.0' N 076° 22.8' E | 19) 08° 47.3' N 076° 12.3' E |
| 18) 08° 43.8' N 076° 14.2' E | 20) 08° 51.5' N 076° 21.0' E |

II. Off Kolachel TSS, Tamil Nadu coast, India

- a) A separation zone in the Eastern part of the TSS is bounded by a line connecting the following geographical positions:
- 1) 07° 50.6' N 077° 33.1' E 3) 07° 52.25' N 077° 16.9' E
2) 07° 53.6' N 077° 17.1' E 4) 07° 48.3' N 077° 32.7' E
- b) A traffic lane of around 3nm wide, for the westbound traffic is established between the separation zone in paragraph (a) and a line connecting the following geographical positions:
- 5) 07° 54.5' N 077° 33.6' E 6) 07° 55.75' N 077° 17.6' E
- c) A traffic lane of around 3nm wide, for the eastbound traffic is established between the separation zone in paragraph (a) and a line connecting the following geographical positions:
- 7) 07° 44.0' N 077° 32.1' E 8) 07° 50.4' N 077° 16.3' E
- d) A separation zone in the South-eastern part of the TSS is bounded by a line connecting the following geographical positions:
- 9) 07° 36.1' N 077° 27.5' E 11) 07° 47.1' N 077° 13.3' E
10) 07° 48.1' N 077° 14.5' E 12) 07° 34.25' N 077° 26.2' E
- e) A traffic lane of around 3nm wide, for the north-west bound traffic is established between the separation zone in paragraph (d) and a line connecting the following geographical positions:
- 13) 07° 38.8' N 077° 30' E 14) 07° 50.2' N 077° 16.1' E
- f) A traffic lane of around 3.5nm wide, for the south-east bound traffic is established between the separation zone in paragraph (d) and a line connecting the following geographical positions:
- 15) 07° 31.5' N 077° 23.3' E 16) 07° 44.2' N 077° 11.2' E
- g) A separation zone in the North-western part of the TSS is bounded by a line connecting the following geographical positions:
- 17) 07° 55.4' N 077° 10.25' E 20) 07° 54.8' N 077° 06.8' E
18) 08° 03.9' N 077° 01.3' E 21) 07° 54.7' N 077° 09.5' E

- 19) 08° 01.8' N 076° 59.5' E
- h) A traffic lane of around 3nm wide, for North-west bound traffic is established between the separation zones in paragraph (g) and a line connecting the following geographical positions:
- 22) 07° 57.3' N 077° 12.4' E 23) 08° 06.0' N 077° 03.3' E
- i) A traffic lane of around 4nm wide, for South-east bound traffic is established between the separation zones in paragraph (g) and a line connecting the following geographical positions:
- 24) 07° 50.25' N 077° 05.5' E 25) 07° 58.8' N 076° 56.5' E
- j) A precautionary area is established connecting the following geographical positions:
- 26) 07° 55.75' N 077° 17.6' E 30) 07° 50.25' N 077° 05.5' E
 27) 07° 50.4' N 077° 16.3' E 31) 07° 54.8' N 077° 06.8' E
 28) 07° 50.2' N 077° 16.1' E 32) 07° 54.7' N 077° 09.5' E
 29) 07° 44.2' N 077° 11.2' E 33) 07° 57.3' N 077° 12.4' E

III. Off Galle TSS, Sri Lanka, India

- a) A separation zone in the eastern part of the TSS is bounded by a line connecting the following geographical positions:
- 1) 05° 41.0' N 080° 30.0' E 3) 05° 38.0' N 080° 16.0' E
 2) 05° 41.0' N 080° 16.0' E 4) 05° 38.0' N 080° 30.0' E
- b) A traffic lane of 4nm wide, for west bound traffic is established between the separation zone in paragraph (a) and a line connecting the following geographical positions:
- 5) 05° 45.0' N 080° 30.0' E 6) 05° 45.0' N 080° 16.0' E
- c) A traffic lane of 5nm wide, for east bound traffic is established between the separation zone in paragraph (a) and a line connecting the following geographical positions:
- 7) 05° 33.0' N 080° 30.0' E 8) 05° 33.0' N 080° 16.0' E

- d) A separation zone in the western part of the TSS is bounded by a line connecting the following geographical positions:
- 9) 05° 41.0' N 080° 08.8' E 11) 05° 48.0' N 079° 52.1' E
 10) 05° 50.5' N 079° 53.55' E 12) 05° 38.0' N 080° 07.8' E
- e) A traffic lane of around 4nm wide, for North-west bound traffic is established between the separation zone in paragraph (d) and a line connecting the following geographical positions:
- 13) 05° 45.0' N 080° 10.2' E 14) 05° 56.5' N 079° 57.0' E
- f) A traffic lane of around 5nm wide, for South-east bound traffic is established between the separation zone in paragraph (d) and a line connecting the following geographical positions:
- 15) 05° 33.0' N 080° 06.2' E 16) 05° 42.2' N 079° 48.9' E
- g) A precautionary area in the mid-part of the TSS is established connecting the following geographical positions:
- 17) 05° 45.0' N 080° 16.0' E 19) 05° 33.0' N 080° 06.2' E
 18) 05° 33.0' N 080° 16.0' E 20) 05° 45.0' N 080° 10.2' E
- h) A precautionary area in the western edge of the TSS is established connecting the following geographical positions:
- 21) 05° 56.5' N 079° 57.0' E 23) 05° 45.7' N 079° 42.7' E
 22) 06° 00.2' N 079° 50.7' E 24) 05° 42.2' N 079° 48.9' E

Appendix-9: Mind mapping exercise done for preparation of MEH architecture

