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A study on prospects for the evolution of maritime traffic management systems taking into account e-Navigation

Kwang An
World Maritime University

WORLD MARITIME UNIVERSITY
Malmö, Sweden

A STUDY ON PROSPECTS FOR THE EVOLUTION OF MARITIME TRAFFIC MANAGEMENT SYSTEMS TAKING INTO ACCOUNT E-NAVIGATION

By

AN, KWANG
Republic of Korea

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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.

Signature:

Date: ....21 October 2011........

Supervised by: **Professor Dr. Raphael Baumler**
World Maritime University

Assessor: **LCDR Mark Sawyer**
Represents the U.S. Coast Guard assigned to WMU

Co-assessor: **Mr. Marco Svantesson**
Malmö VTS

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ABSTRACT

Title of Dissertation: **A Study on Prospects for the Evolution of Maritime Traffic Management Systems Taking Into Account e-Navigation**

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This dissertation is a study on prospects for the evolution of maritime traffic management systems taking into account e-Navigation. It aims to discuss the future direction for the GICOMS of the Republic of Korea as a precedent of e-Navigation. The study is done by investigating the traditional and newly adopted maritime traffic management systems. It is hoped that this study would be helpful to enhance the maritime safety, particularly fishing vessels and small ships in Korea.

Traditionally, vessel movements have been tracked from shore side for safety purposes. VTS, mandatory ship reporting systems and VMS are mainly used for tracking vessels. Since vessel movement information is a key for situational awareness and prompt initial actions against incidents, such systems have played an important role in reducing accidents at sea.

Since 2002, IMO has adopted various measures to enhance maritime security. AIS and LRIT provide a better environment for the identification and tracking of vessels globally. Currently, data exchange and system integration are important trends in the maritime systems. Furthermore, it is expected that full implementation of e-Navigation which is under development will bring great impacts to the whole shipping industry.

The GICOMS system is an integrated information system and data centre for information sharing. From the shore-based perspectives, the GICOMS has similar functionalities as shore-based e-Navigation. Despite of the successful implementation of the GICOMS project, some issues have remained.

Chapter 6 provides the future direction of the GICOMS system as a precedent of e-Navigation. Also it contains some recommendation to policy makers for the mandatory VMS for all ships. At the end, it is reiterated that fishing vessels and small ships should be managed in order to reduce marine accidents in coastal waters and to save human lives at sea.

KEY WORDS: Vessel Traffic Service (VTS), Vessel Monitoring System (VMS), Automatic Identification system (AIS), Long-range Identification and Tracking (LRIT) of Ships, Maritime traffic management, e-Navigation, General Information Centre on Maritime Safety and Security (GICOMS)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIS	Automatic Identification System
AMSA	Australian Maritime Safety Authority
AMVER	Automated Mutual Assistance Vessel Rescue System
ASP	Application Service Provider
AUSREP	The Australian Ship Reporting System
CCTV	Close-circuit Television
CSP	Communication Service Provider
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DSC	Digital Selective Calling
EC	European Committee
ECDIS	Electronic Chart and Display Information System
EEZ	Exclusive Economic Zone
EMSA	European Maritime Safety Agency
ENC	Electronic Navigational Chart
EPIRB	Emergency Position Indicating Radio Beacon
ETA	Estimated Time of Arrival
EU	European Union
FMC	Fisheries Management Centre
FSI	Sub-Committee on Flag State Implementation
GIS	Geographic Information System
GICOMS	General Information Centre on Maritime Safety and Security
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
GT	Gross Ton

HF	High Frequency
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISC	Information Sharing Centre
ITU	International Telecommunication Union
LRIT	Long Range Identification and Tracking
LRIT-IDE	International LRIT Data Exchange
MARPOL 73/38	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, as amended
MARPOL PROT 1997	Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978 relating thereto
MEH	Marine Electronic Highway
MF	Medium Frequency
MKD	Minimum Keyboard Display
MLTM	Ministry of Land, Transport and Maritime Affairs
MMSI	Maritime Mobile Service Identity
MOMAF	Ministry of Maritime Affairs and Fisheries
MRCC	Maritime Rescue Coordination Centre
MSC	Maritime Safety Committee
RCC	Rescue Coordination Centre
ReCAAP	Regional Cooperation Agreement on Anti-Piracy in Asia
RFMO	Regional Fisheries Management Organizations
SAR	Search And Rescue
SOLAS	International Convention for the Safety of Life at Sea

SOLAS 1974	International Convention for the Safety of Life at Sea, 1974, as amended
SP	Sailing Plan
SSAS	Ship Security Alert System
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
US	United States
USCG	United States Coast Guard
UTC	Coordinated Universal Time
VHF	Very High Frequency
VMS	Vessel Monitoring System
VTMIS	Vessel Traffic Management and Information Service
VTS	Vessel Traffic Service

1 INTRODUCTION

1.1 Background

Increasing the demand of maritime transportation has exerted many changes to the maritime industry, especially in terms of the size and speed of ships. Those changes raise the risk of marine accidents as much as the economic benefits. Marine accidents cause not only loss of lives and properties but also damage to the marine environment. As observed in many recent oil spill cases at sea, incidents have caused serious marine environmental problems in line with enormous economic losses. The impact of large-scaled marine pollution incidents is not limited to a specific area but also to adjacent countries.

Since ships are designed and built in compliance with the safety standards set in international regulations, ships do not bear higher possibility of capsizing or sinking itself. For ensuring the safety of ships, a large number of regulations and guidelines have been developed by the International Maritime Organization (IMO). Despite of these efforts to enhance the safety of ships, marine accidents have not been reduced. Recent marine accident statistics indicate[1] that around 80% of incidents are caused by operating errors, such as negligence of lookout, deficiency of preparation for and response to bad weather, violation of navigation rules and regulations, negligence of watchkeeping and neglecting safety working rules on board. Furthermore, in the

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[1] Marine accident statistics of the Korea Maritime Safety Tribunal (KMST) indicate that 82.3% of the marine accidents in the period of 2005-2010 are caused by the operating errors.

collision incidents, more than 95% of incidents are related to operating errors[2], particularly negligence of lookout and violation of navigation rules and regulations. This fact has same context with that most of marine accidents are mainly attributed to human errors (Kim & Kwak, 2011). The contribution of human errors to marine accidents is increasing (Baker & Seah, 2004, pp.14). It is also indicated[3] that 67% of the marine accidents are occurred in the coastal waters including port areas and their approaching channels. It is analyzed that the risk of accidents is relatively high particularly in port areas due to high traffic volumes, high portions of speed craft and ferries, close proximity of marine facilities within a small geographic area, active mid-steam operations for cargo movements, multiple water approaches to the port, and lots of single point moorings (Yip, 2006).

Traditionally, Vessel Traffic Service (VTS) has been used as a main tool for maritime traffic management. Typical VTS uses radar, VHF radio and closed-circuit television (CCTV) to monitor vessel movements. Once vessels report their position, course and speed to VTS centre by VHF-radio, VTS centre begins to track vessel movements by radar. VTS centre provides navigational safety information for vessels as well. Recent advances of technology change the concept of VTS. Considering the advances of information technology in maritime sector, it is expected that traditional concept of VTS would be developed as a general information system to enhance maritime safety and security and the protection of marine environment (An, Heo, Hong, Jeong, Kim, Lee, Park, & Yun, 2006).

After the September 11 attacks in 2001 in the United States, various measures have been taken to enhance maritime security. For example, IMO introduced the Automatic

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[2] Marine accident statistics (2005-2010) of Korea Maritime Safety Tribunal (KMST) indicate that 96.7 % of collision incidents are caused by operational errors.

[3] Marine accident statistics (2005-2010) of Korea Maritime Safety Tribunal (KMST) indicate that 10.7 % of marine accidents are occurred in ports and their approaching channels and the 56.3% of those are occurred in the coastal waters (territorial seas).

Identification System (AIS), Ship Security Alert System (SSAS) and Long-range Identification and Tracking (LRIT) of ships. They have been introduced with the intention to enhance: safety and security of life at sea; the safety and efficiency of navigation; and the protection of the marine environment (http://www.imo.org).

AIS exchanges data between ships and ship-to-shore. The purpose of AIS is to help identify vessels; assist in target tracking; simplify information exchange (e.g. reduce verbal mandatory ship reporting); and provide additional information to assist situational awareness. In particular, AIS has the ability to detect other ships in situations where the radar cannot detect targets due to functional limitation of radar. AIS is designed to improve the quality of the information available and AIS would become an important source of maritime traffic information for national and regional monitoring networks (IMO, 2001). However, due to poor performance and incorrect transmission of AIS data, mariners and VTS operators cannot wholly trust the system in their work. Poor performance and transmission of AIS information are vital issues on the use of AIS for anti-collision operation (Harati-Monkhtari, n.d.).

The Long-range Identification and Tracking (LRIT) of ships was introduced as an international system on 19 May 2006 by IMO. According to the SOLAS Convention, ships must report their position to their flag state at least four times a day by using existing satellite communications system. LRIT is also one of the sources of maritime traffic information for monitoring of vessel movements.

Recently, IMO has initiated the development of e-Navigation with the intention to reduce navigational accidents, errors and failures by developing standards for an accurate and cost effective system (Patraiko, n.d.). e-Navigation is a vision for the integration of existing and new navigation systems in a systematic manner. This would be expected to assist in improving both well-designed onboard systems for shipborne users and closer cooperation with vessel traffic management instruments and systems for shore users (Chakraborty, 2009). At the proposal of five countries[4], IMO developed the *"Strategy for the development and implementation of e-Navigation"* in co-operation with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and the International Hydrographic Organization (IHO) in 2008. IMO also adopted the "*Framework for the implementation process for the e-Navigation strategy"* in order to implement e-Navigation. According to this time frame, "*Gap analysis"* and *"Cost-benefit and risk analyses"* will be carried out by the relevant Sub-committees. On completion of the strategic implementation plan in 2012, all ocean going vessels and 169 IMO member States will be subject to e-Navigation.

e-Navigation is a very important issue because it is likely to be an unavoidable stream in maritime traffic management in the future. e-Navigation is not a new technology but a new concept to enhance the safety through the high quality of decision-making support systems, based on information management. According to the concept of e-Navigation, it is expected that maritime traffic management will be advanced by integration of existing systems, namely AIS, VMS, LRIT and SSAS on the basis of electronic geographic information system (GIS).

Generally, it is considered that that technological advances have contributed to improving the safety and efficiency of navigation. However, technological advances have not always brought advantages. For example, new functions of electronic navigational equipment on the bridge of ships would create some confusion to ship officers and jeopardize ships at risk. It is expected that full implementation of e-Navigation would bring great impacts to all stakeholders in the shipping industry.

In the Republic of Korea, the Government established the General Information Centre on Maritime Safety and Security (GICOMS) to enhance the national capability on maritime safety and security, and protection of the marine environment. The GICOMS

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[4] Japan, the Marshall Islands, Netherlands, Norway, Singapore, UK and USA submitted the proposal paper to develop an E-Navigation strategy (MSC 81/23/10).

is the national maritime crisis management system based on integrated maritime traffic information among governmental agencies. The GICOMS project includes the establishment of the global Vessel Monitoring System (VMS) for all Korean flagged vessels, LRIT, SSAS, the integration of local VTS centres, and information exchange system based on GIS. The foundation phase of the project was implemented during the period from 2003 to 2007. The operation centre of GICOMS is under operation in the Ministry of Land, Transport and Maritime Affairs (MLTM)[5] since 2005.

It is expected that the introduction of e-Navigation would change not only shipboard navigation systems but also maritime traffic management systems on shore. Under the above circumstances, it is very important to discuss the future direction of maritime traffic management systems taking into account the potential effects of e-Navigation. This dissertation deals with maritime traffic management systems, the basic concept of e-Navigation and the GICOMS project of the Republic of Korea. This dissertation provides a model case of how e-Navigation can be implemented on shore side based on the experience from the GICOMS project. Furthermore, this dissertation would be helpful for the people who are involved in policy making on maritime safety in maritime Administrations.

1.2 Objectives

The objectives of this dissertation are to analyse the trends of maritime traffic management systems taking into account e-Navigation and to provide policy makers with options based on the future direction of national marine traffic management in the Republic of Korea. Especially, it is hoped that this dissertation would contribute to enhancing the safety of fishing vessels and small ships in the Republic of Korea.

In order to achieve the objectives, this dissertation will:

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5 According to the reform of the governmental organization of the Republic of Korea, former the Ministry of Maritime Affairs and Fisheries (MOMAF) has changed into the Ministry of Land, Transport and Maritime Affairs (MLTM) in 2008.

- Examine and review the existing systems for marine traffic management;
- Analyze trends on maritime traffic management systems taking into account e-Navigation;
- Investigate the current progress of the development of e-Navigation in IMO and estimate consequences of e-Navigation;
- Review the case of GICOMS project of the Republic of Korea as a precedent of e-Navigation; and
- Discuss the prospects for evolution of maritime traffic management taking into account e-Navigation

1.3 Scope of the Study

This research work consists of 6 chapters. Chapter 1 gives the background, objectives, scope and methodology of the study.

Chapter 2 provides the general overviews, essential elements and services of the traditional systems for vessel traffic management. It describes the main functions of VTS, ship reporting system, emergency reporting system and VMS together with relevant cases. It also reviews legal provisions in relation to these systems on the basis of international conventions.

Chapter 3 investigates the systems that have been introduced recently by the international maritime community and discusses the recent trends on the integration of maritime traffic monitoring systems. It also gives a brief overview of the newly introduced systems for identification and tracking of ships, namely AIS and LRIT. The European cases of system integration for maritime traffic monitoring and surveillance are referred to in the discussion of recent trends.

Chapter 4 reviews the background of e-Navigation on the basis of the process of the development of e-Navigation by IMO. It also gives general overviews of the IMO Strategy of e-Navigation. Finally, it describes the expected consequences of e-Navigation.

Chapter 5 gives an overview of the GICOMS project implemented by the Government of the Republic of Korea. It also reviews the GICOMS system in detail on the basis of Plans and Project documents published by the relevant Ministry. In addition, it evaluates the process of project implementation and discusses the issues to be considered.

Finally, Chapter 6 includes the conclusion with discussion perspectives of GICOMS system.

1.4 Methodology and Sources of Information

This research work was conducted aiming to seek the future direction of maritime traffic management taking into account desirable functions and services of e-Navigation. To achieve the research objectives, the research methodology will be mixed with qualitative and quantitative analysis.

The qualitative analysis mainly focused on the examination of evolution and trends of maritime traffic management system, review of the GICOMS project of Korea and strategy of e-Navigation developed by IMO. The collection and review of relevant articles, reports, legislations and documents regarding maritime traffic management, the GICOMS project and e-Navigation were undertaken. To investigate the GICOMS project as a precedent of e-Navigation, project documents including system design and architecture will be referred to from the MLTM. IMO meeting documents will be reviewed to identify the potential effects of e-Navigation particularly on the meeting of the Maritime Safety Committee (MSC), the Sub-Committee on Safety of Navigation (NAV), the Sub-Committee on Radiocommunications and Search and

Rescue (COMSAR). The data for performance standards and guidance for the key navigational and traffic management systems, such as VTS, ship reporting system, VMS, AIS, LRIT and SSAS will be included. To add practical issues in this discussion, data collecting for conference proceedings, official meeting reports and public hearings for the last five years was carried out in co-operation with the MLTM.

On the other hand, the quantitative analysis will focus on the assessment of safety of small ships and fishing vessels in the costal waters of the Republic of Korea based on the statistic data for ship registry and marine accidents in Korea.

2 TRADITIONAL SYSTEMS FOR VESSEL TRAFFIC MANAGEMENT

2.1 Introduction

Ship position information is important because it is a key for situational awareness and prompt response to any occurrence. From a long time ago ship position information has been collected in many ways. Traditionally, there are three types of systems for vessel traffic management, namely Vessel Traffic Service (VTS), ship reporting system and Vessel Monitoring System (VMS). In addition, there are emergency reporting systems by using emergency distress devices[6] fitted on board vessels.

From the ship operator's perspective, they are different. For example, in VTS, vessels are detected by a VTS centre and the VTS operator is responsible for identifying and tracking vessels. However, in the ship reporting system and VMS, vessels must report their positions and movements. From the shore station's perspective, the systems have their own purposes. While VTS is to manage maritime traffic mainly in the port and harbour area, VMS is often used as a tool of Monitoring, Control and Surveillance (MSC) against illegal, unreported and unregulated (IUU) fishing.

This Chapter provides general overviews, essential elements and their services of the traditional systems for vessel traffic management ogether with relevant cases. It also reviews legal aspects of these systems for the discussion about the system integration in the following Chapters.

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[6] GMDSS and COSPAS-SARSAT

2.2 Vessel Traffic Service (VTS)

2.2.1 **General**

VTS is a shore-side system for maritime traffic management established by coastal states. VTS is designed to improve the safety and efficiency of navigation, safety of life at sea and the protection of the marine environment and the adjacent shore area, worksites and offshore installations from possible adverse effects of maritime traffic (IMO, 1997). The basic principles of VTS are stated in SOLAS Regulation V/12 together with the *Guidelines for Vessel Traffic Services* (IMO Resolution A.857(20)) adopted on 27 November 1997.

IMO defined 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."* There are two types of VTS, namely Port or Harbour VTS and a Coastal VTS. A Port VTS is mainly focused on the vessel traffic to and from a port or harbour, while a Coastal VTS is mainly designed to monitor vessel traffic passing through the coastal waters. In certain cases, a VTS can be a combination of both types. Generally a Port or Harbour VTS usually provides a navigational assistance service, while a Coastal VTS provides only an information service (IMO, 1997c).

According to port regulations, ships generally report to a VTS centre when they enter a certain area and the VTS centre will start tracking and monitoring the vessels. In the VTS area ships must keep watch on a specific VHF-radio channel for navigational or other warnings. The SOLAS Convention states that governments may establish VTS when, in their opinion, the volume of traffic or the degree of risk justifies such services.

Implementation of VTS has many benefits. It allows to identify vessels and to monitor vessel movements for providing navigational information and assistance. It can also assist in pollution prevention measures. Continuous reliable communications and provision of correct and relevant information are critical factors for the efficiency of VTS. The capability of detecting a developing dangerous situation and the ability to provide timely warning of such dangers are also very important factors for high quality VTS service. The particular objective of any VTS may depend on the particular circumstances in the VTS area and the volume and character of maritime traffic (IMO, 1997c).

2.2.2 **Development of VTS**

Traditionally, in port or harbour areas, masters of ships commanded a ship assisted by a pilot where necessary. Ships used some flags and sound signals as means of communication. However, the use of flags and sound signals was not efficient particular in foggy weather. Since late the 19th century, VHF-radio and radar have become more useful means of communication in port or harbour areas. The development of radar makes it possible to accurately monitor and track maritime traffic (An, Heo, Hong, Jeong, Kim, Lee, Park, & Yun, 2006).

VTS has about 60 years history. It is known that the world's first harbour surveillance radar was installed at the end of Victoria Pier, Douglas, Isle of Man on 27 February 1948. Five months later, a more sophisticated port radar system was installed at the Port of Liverpool, England. In 1951, a radar and VHF-radio equipment were installed in Long Beach, California, to facilitate port operations (http://www.maritime-vts.co.uk/).

Installation of radar and VHF-radio made it possible to observe vessel movements from the shore side under almost all weather conditions. Particularly, the combination of radar and VHF-radio began to provide an environment for real time information exchange between ships and shore. At the beginning, VTS was focused on the improvement of efficiency of port operations. After it has been recognized that VTS was useful to protect ships from collision and grounding accidents, VTS started to spread widely in the world (An, Heo, Hong, Jeong, Kim, Lee, Park, & Yun, 2006).

2.2.3 **SOLAS and VTS**

VTS is recognized internationally as a navigational safety measure through the SOLAS Convention. In particular, the SOLAS Regulation V/12 states that VTS contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment. Under the framework of SOLAS, IMO adopted Assembly resolution A.857(20) – *"Guidelines for Vessel Traffic Services provides guidelines for implementing and operating Vessel Traffic Services"*, including guidelines on recruitment, qualifications and training of VTS operators. Specifically, the resolution defines a Vessel Traffic Service as:

> *"A service 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".*

The guidelines also clearly state that decisions concerning effective navigation and manoeuvring of the vessel remain with the ship's master. Further, the guidelines highlight the importance of the pilot in VTS and reporting procedures for ships passing through an area where a VTS operates.

2.2.4 **VTS Services**

The benefits of VTS are that it allows identification and tracking of vessels, strategic planning of vessel movements and provision of navigational information and assistance. According to the *"Guidelines for Vessel Traffic Services of IMO"* (Res.A.857(20)), the VTS provides information service, navigational assistance service and traffic organization service. Details of such VTS services are as follows:

a. Information service

VTS provides the information service at fixed times and intervals or at the request of a vessel or by the VTS when deemed necessary. The broadcasting information will include the position, identity and intentions of other traffic; waterway conditions; weather; hazards; or any other factors that may influence the vessel's transit.

b. Navigational assistance service

The navigational assistance service is normally provided at the request of a vessel or by the VTS when deemed necessary. This service is very important in dangerous situation.

c. Traffic organization service

The VTS provides the traffic organization service to prevent congestion and dangerous situations in the VTS area. This service concerns the operational management of traffic and the forward planning of vessel movements. It is also particularly relevant in high traffic density. In addition, it may include establishing traffic clearance systems or VTS sailing plans, which are in relation to priority of movements, allocation of space, mandatory reporting, recommended routes, speed limits or other measures which are considered necessary by the VTS authority

2.2.5 VTS Elements

The requirements of each element are determined by the nature of the VTS area, the density and character of the traffic and the type of service that is to be provided. To perform the required tasks a VTS requires a shore centre, adequate operating staff, operational procedures and participating vessels. In addition, back-up facilities for a VTS system should be considered to sustain and maintain the desired level of reliability and availability (IMO, 1997c). The IMO guidelines describe the details of VTS elements as follows:

a. A shore VTS centre

A shore VTS centre should be equipped with a radar system to detect vessels, a radio communication system to communicate with vessels and patrol craft and aircraft. Recently, most VTS centres are equipped with Automatic Identification System (AIS) base stations which provides better picture of identification and tracking of vessels in the VTS area.

b. VTS operators

IMO provides the guidelines on recruitment, qualification and training of VTS operators. These guidelines provide guidance in determining how VTS authorities can recruit and train personnel in order to carry out their tasks in accordance with VTS standards. Authorities must be able to determine what competencies a VTS operator must possess to carry out assigned functions. Authorities should also establish concomitant training standards for VTS operators.

c. Operational procedures

Internal and external VTS operational procedures should be taken into account. Internal procedures include operating instruments, interactions among the staff and the internal routeing and distribution of data. External procedures cover interactions with users and related services. All operational procedures, routine or contingency, should be laid down in handbooks or manuals and be an integral part of regular training exercises.

d. Participating vessels

Vessels navigating in a VTS should make use of VTS services for the safety of navigation and port operations. Depending upon port regulations, participation in a VTS may be either voluntary or mandatory. Decisions concerning the actual navigation and the manoeuvring of the vessel remain with the master. However, communication with the VTS and other vessels should be maintained according to relevant rules and procedures. During their passage through the VTS area, vessels should maintain a continuous listening watch on the assigned frequency and report deviations from the agreed sailing plan. Masters of vessels should report any observed dangers to navigation or pollution to the VTS centre. Vessels should carry publications giving full particulars on governing rules and regulations regarding identification, reporting and conduct in the VTS area to be entered.

2.3 Ship Reporting Systems

2.3.1 General

There are many kinds of ship reporting regimes. Vessels report their position to port authorities, VTS centres and their company for various purposes. Ship position data can be also collected through the ship reporting systems. While VTS identify and track vessels automatically by VTS centre when a vessel enter the VTS area, vessels should send their position report to the designated authority at regular intervals under the ship reporting system. IMO has introduced ship reporting systems in the SOLAS Convention and SAR Convention with different intention.

2.3.2 Mandatory Ship Reporting Systems under SOLAS

SOLAS 1974 Convention[7] states that ship reporting systems contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment. This regulation does not address ship reporting systems established by governments for search and rescue purposes which are described in the SAR 1979 Convention.

Ship reporting systems can be established by a government after it has been accepted by IMO in compliance with all requirements of SOLAS. Ship reporting systems

[7] See the Regulation 11 in Chapter V (Safety of Navigation) of SOLAS 1974.

should be considered for adoption only for the purpose of enhancing maritime safety or the protection of the marine environment. A contracting government or contracting governments can propose the adoption of ship reporting system for a particular area to IMO. At the request of contracting government(s), IMO will assess the proposal in accordance with the guidelines and criteria adopted by the MSC of IMO by resolution MSC.43(64), as amended by resolution MSC.111(73) and MSC.189(79). The proposal should be in compliance with *"General principles for ship reporting systems and ship reporting requirements"*, adopted by IMO Resolution A.851(20). According to the *"Procedure for the adoption of ship reporting system*" adopted by IMO by resolution A.858(20), the function of adopting ship reporting systems shall be performed by the Maritime Safety Committee (MSC) on behalf of IMO.

In assessing proposals for the adoption of a ship reporting system, IMO should consider the technical and financial resources available for contracting governments. IMO has to ensure that adopted ship reporting systems are evaluated under the guidelines and criteria adopted by IMO. IMO has to also disseminate to member States the adoption of ship reporting systems (IMO, 2004).

The adopted ship reporting systems will be mandatory. The master of a ship must follow the requirements of adopted ship reporting systems and report to the appropriate authority information required in accordance with the provisions of each such system. The system should be operated by the shore-based authority designated by a contracting government. Such an authority may or may not be an authority in charge of a vessel traffic service. They may or may not be operated as part of VTS. The participation of ships should be subject to no cost.

2.3.3 Ship Reporting Systems for Search and Rescue

The International Convention on Maritime Search and Rescue, 1979 (SAR 1979) also states that ship reporting systems may be established to facilitate Search and Rescue (SAR) operations. According to the SAR 1979 Convention, ship reporting systems may be established either individually by governments or in co-operation with other governments. Governments considering the institution of a ship reporting system should take into account whether existing reporting systems or other sources of ship position data are available for the region. They should also seek to minimize unnecessary additional reports by ships, or the need for Rescue Co-ordination Centres (RCC) to check with multiple reporting systems to determine availability of ships to assist with SAR operations.

Reporting of ship location enables RCCs to take a positive SAR watch. If a regular position report or final report is not received from a ship, RCCs will check the ship for the safety. If these checks are unsuccessful, then they will initiate SAR operations. In this context, it is important that the ship master should comply with the defined procedures for reporting ship's position.

The SAR 1979 Convention requires that the ship reporting system, in the event of a distress incident, should provide up-to-date information for vessel movements in order to speed up SAR operations and get quick identification of vessels for assistance. Ship reporting systems should satisfy the operational requirements set in the SAR 1979 Convention. Governments should encourage all vessels to report their position in their SAR operation areas for safety purposes.

2.3.4 General Principles of Ship Reporting Systems

Ship reporting systems are used in order to collect, provide or exchange information through radio communications from ships. The information is used for many purposes including SAR, VTS, weather forecasting and prevention of marine pollution. However, many national ship reporting systems use different procedures and reporting formats. To unify the format and procedures of ship reporting systems, IMO developed *"General principles for ship reporting systems and ship reporting* *requirements"* by resolution A.851(20). According to these principles, ship reports should be simple by using the *Standard Marine Navigational Vocabulary*[8] and regular reports should be sufficiently flexible to avoid interference with essential navigational duties except for urgent reports regarding safety and pollution. Further, a shore-based authority who is responsible for system operation should be manned by properly trained persons. These principles are applicable for both mandatory ship reporting systems under the SOLAS and SAR Conventions.

2.3.5 Examples of Current Ship Reporting Systems

a. AMVER

AMVER (The Automated Mutual Assistance Vessel Rescue System) is a worldwide voluntary ship reporting system for SAR operated by the United States Coast Guard (USCG). The primary function of AMVER is to assist SAR authorities to arrange for assistance to persons in distress at sea. AMVER provides SAR authorities, on demand, information on the positions and characteristics of vessels near a reported distress location (USCG, 2005).

Any commercial vessel, regardless of flag, over 1,000 gross tons on voyages of 24 hours or greater is encouraged to participate in AMVER. International participation is voluntary regardless of the flag of vessel. However, according to U.S. Maritime Administration (MARAD) regulations, U.S. flag merchant vessels of 1,000 gross tons or more must report and regularly update their voyages and positions to AMVER. In addition, U.S. passenger ships transporting more than six passengers and operated more than 200 nautical miles from the nearest land, must participate in the AMVER.

[8] See "Standard Marine Navigational Vocabulary" - IMO Resolution A.380(X) and "Use of the Standard Marine Navigational Vocabulary" - IMO Resolution A.488(XII)

Prior to sailing, participating vessels send a sailing plan to the AMVER computer centre. Vessels then report their locations every 48 hours until arriving at their port of call. The AMVER system is able to predict the position of each ship at any point during its voyage. The position of each participating ship is displayed in an AMVER surface picture. In an emergency, any rescue coordination centre of any country can request ship data to determine the relative position of ships near the distress location.

To communicate with the AMVER system from ships, various communication networks can be used, such as electronic mail via the internet, HF radiotelex service of USCG Communication Stations, telex and telefax. It means that all GMDSS equipment is used for AMVER communication networks. However, CW (Morse Code) is not recommended. All distress messages must be sent to the nearest RCC, not AMVER (USCG, 2005).

b. AUSREP

AUSREP (The Australian Ship Reporting System) is an integral part of the Maritime Search and Rescue (SAR) system in Australia. AUSREP is operated by the Australian Maritime Safety Authority (AMSA) through the RCC Australia. The objective of the AUSREP system is to contribute to safety of life at sea by limiting the time between the loss of a ship and the initiation of SAR operations, in cases where no distress signal is sent out (AMSA, 2009).

A principal function of RCC Australia is the coordination of Maritime SAR activities within the Australian SAR area. On departure from an Australian port or on entering the AUSREP area from overseas, vessels have to send a Sailing Plan (SP) to RCC Australia and a computerized plot will be maintained of the ship's position.

According to the Commonwealth of Australia Navigation Act 1912, all Australian-registered ships in AUSREP area must report. Foreign ships must also report from their arrival at their first Australian port until their departure from their final

Australian port. However, they are encouraged to participate from their entry into and final departure from the AUSREP area (AMSA, 2009).

c. STRAITREP

STRAITREP is the mandatory ship reporting system in the Straits of Malacca and Singapore. STRAITREP has been adopted by IMO at the proposal of Indonesia, Malaysia and Singapore by resolution MSC.73(69). Objectives of the STRAITREP are described as follows (IMO, 1988):

- to enhance the safety of navigation;
- to protect the marine environment;
- to facilitate the movements of vessels; and
- to support SAR and oil pollution response operations.

STRAITREP took effect on 1 December 1998. Masters of vessels in the STRAITREP area must comply with its requirements according to SOLAS Regulation V/11. Vessels of 300 gross tons and above, vessels of 50 metres or more in length, vessels engaged in towing, vessels carrying hazardous cargo and all passenger vessels must participate in the reporting system. The operational area of STRAITREP covers the Straits of Malacca and Singapore. The area includes the routeing system in the Straits of Malacca and Singapore. The operational area is shown in the navigational charts. The ship must report to the three VTS authorities according to the prescribed reporting format. The report required from a ship contains only essential information. VTS operators will link the ship's position with the information supplied by the VTS facilities on receipt of a position message. The information on heading and speed will help the VTS operators identify a ship within a group.

STRAITREP provides information to ships about specific and critical situations that could cause conflicting traffic movements and other information concerning safety of navigation. Every ship must watch a VHF radio on the appropriate VHF channel depending on the sector where the ship is. The report must be made to the appropriate VTS authorities by the VHF radiotelephone. STRAITREP is based on VHF voice radio communication in English (IMO, 1988).

2.4 Emergency Reporting Systems

2.4.1 General

Global Maritime Distress and Safety System (GMDSS) is set of radio equipment, communication protocols and procedures to improve distress and safety communications. GMDSS is intended to provide means of automatic communications between ships and ship to shores in case of an emergency. Ship position information can be also collected through GMDSS equipment.

2.4.2 GMDSS

Using shipboard equipment, ships can send distress and emergency alerts to shore authorities as well as to other ships in the vicinity in case of an emergency. Ships can also receive such distress and emergency alert messages. In addition, ships can receive navigational safety and weather information through GMDSS equipment.

GMDSS is mandatory for SOLAS ships. Depending on the areas[9] where ships operate, ships are obliged to be fitted with the following GMDSS equipment:

- Radio at VHF and MF bands with DSC functionality;

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[9] According to SOLAS Convention, there are four "Sea Areas" defined in GMDSS:
- Area A1, within range of shore-based VHF DSC coast station (around 40 nautical miles);
- Area A2, within range of shore-based MF DSC coast station (excluding areas A1) (around 150 nautical miles);
- Area A3, within the coverage of an Inmarsat geostationary satellite (approximately 70°N to 70°S) (excluding sea areas A1 & A2); and
- Area A4, the remaining areas outside sea areas A1, A2 & A3 (polar regions).

- NAVTEX receivers for reception within 300 nautical miles of the coast;
- HF Narrow Band Direct Printing (NBDP) receivers;
- Satellite communications via Inmarsat (A, B or C terminals); and
- EPIRBs (Emergency Position Indicating Radio Beacons) which can issue a distress alert at 406 MHz that is received by the COSPAS-SARSAT satellite system anywhere in the world.

2.4.3 **COSPAS-SARSAT**

The COSPAS-SARSAT is an international satellite system intended to respond to distress signals from land, sea and air. The COSPAS-SARSAT programme was developed by Canada, France, the US and the former USSR. COSPAS is operated by Russia, and SARSAT (Search And Rescue Satellite-Aided Tracking) is operated by Canada, France and the US, but they work as one system. The shipboard radio beacon (EPIRB) transmits distress messages on 406 MHz. The message includes identification of the beacon and its country of registration. Beacons can be registered and their information held in a national database. COSPAS-SARSAT is part of GMDSS (EC, 2008).

2.5 Vessel Monitoring System (VMS)

2.5.1 **General**

Vessel Monitoring System (VMS)[10] collects position and operation data from ships automatically. The basic function of a VMS is to provide information on ship's

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[10] Recently, the term of VMS is defined by IMO in "Performance standards and functional requirements for the long-range identification and tracking (LRIT) of ships" by Resolution MSC.263(84) adopted on 16 May 2008 as "a system established by a Contracting Government or a group of Contracting Governments to monitor the movements of the ships entitled to fly its or their flag. A Vessel Monitoring System may also collect from the ships information specified by the Contracting Government(s) which has established it."

location and its movements at regular intervals. Generally, VMS is used in commercial fishing to monitor and regulate fishery resources by international, regional or national fishery authorities. However, VMS is used for monitoring the safety of merchant vessels as well in some countries, particularly in the Republic of Korea.

VMS is different from VTS and ship reporting systems. VMS is a programme of surveillance, in which equipment that is installed on vessels provides information about the vessels' position, movements and activities. It can thus provide information on whether a fishing vessel is in a permitted fishing area. However, it may also be used for the safety of navigation, SAR and maritime traffic management in the territorial waters or in the Exclusive Economic Zones (EEZ) of a country.

The 1982 United Nation Convention on the Law of the Sea (UNCLOS, 1982), the United Nations Environment Programme (UNEP) and the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) are emphasizing the importance of protection the marine resources and obligation of coastal States. The Food and Agriculture Organization (FAO) of the United Nations adopted the *"Code of Conduct for Responsible Fisheries"* in order to establish principles and standards applicable to the conservation, management and development of all fisheries on 31 October 1995. It provides a necessary framework for the implementation of effective fisheries monitoring, control, surveillance and law enforcement measures including VMS (FAO, 1995).

There is great deal of literatures on the subject of monitoring, surveillance and control (MCS). According to FAO, MCS is the implementation of a plan or strategy for oceans and fisheries management. In the fisheries sector, MCS is the implementing tool to comply with obligations for all states to conserve the marine resources and their environment by the relevant international conventions (FAO, 1998).

2.5.2 Components of VMS

While VTS covers areas in harbours, ports and approaching channels on the basis of a radar system, a VMS covers the EEZ areas and high seas on the basis of long-range radio technologies. Each participating vessel must carry a transmitter or transceiver which is capable of fixing a position. An automated reporting system then controls the transmission of the position data and possibly other data through a communications system to a fisheries monitoring station. The transmitter or transceiver must have an integrated means of fixing a position and hence calculating speed and course. The Global Positioning System (GPS) is used generally because of its high level of accuracy and availability. Figure 1 shows how VMS does work. For communications networks between the vessels and the monitoring agency, satellite-based communications systems are generally used, such as Inmarsat, Argos, and Orbcomm.

In fisheries monitoring authority, a computerized monitoring station is needed to collect, store and analyze the data received from the earth station. A specialized GIS is used in the monitoring station particularly for historical and statistical analysis of both position and catch data. As a result, in the commercial fishing sector, any member state of participating regional fisheries management organizations (RFMOs) can observe its own vessels in all waters and the activities of vessels from other member states in its own waters. The received information will then be cross-checked against a range of other data.

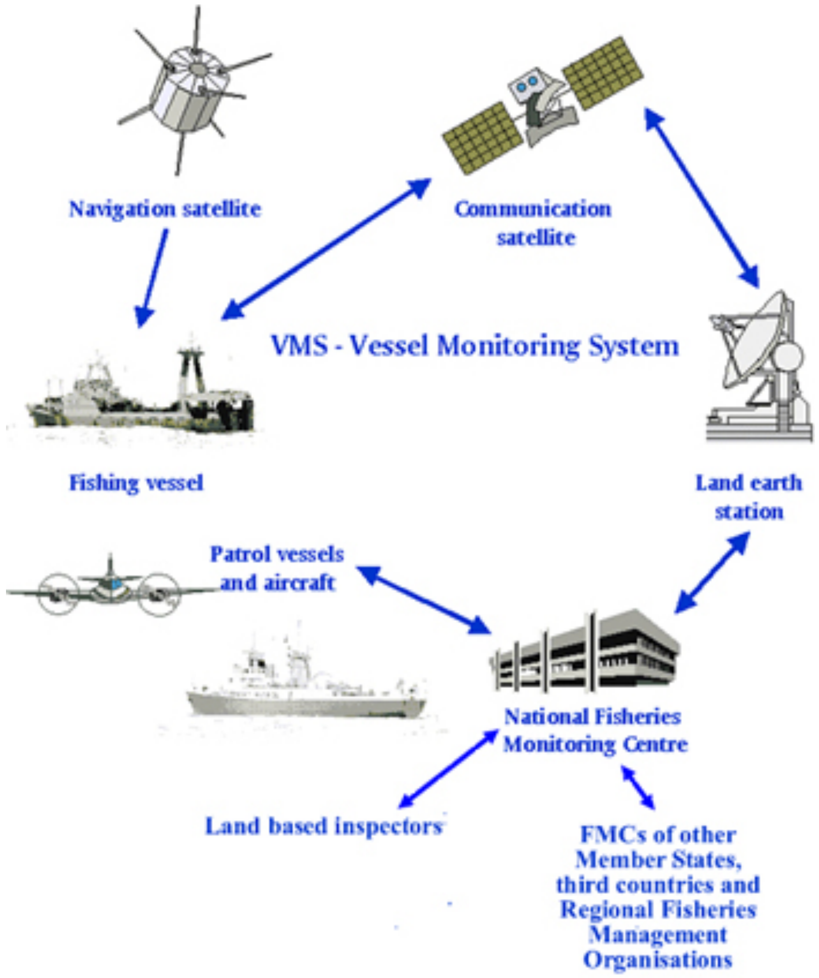

Figure 1 VMS (Source: European Commission Fisheries)

Due to the cost, most fisheries authorities and shipowners subscribe to VMS service providers. Then the VMS service company provides the users of VMS data by e-mail or other applications. Shipowners should pay for installation and maintenance for ship equipment and continuing satellite communication costs. VMS service providers also offer various optional services such as information services for navigation safety, weather and fisheries.

2.5.3 VMS Data

The fisheries VMS provides position information of vessels that are participating in the VMS at periodic time intervals. VMS data is very valuable and powerful information. Before the VMS was introduced, fisheries management agencies were depending on information provided by ship operators. Due to many reasons, the information provided by ship operators may not be reliable.

VMS also provide information of ship's speed and heading. Generally the ship's speed and heading can be computed on the basis of transmitted data from ships. However, ship's speed and heading can also be calculated at the monitoring station on the basis of consecutive position reports from ships. Ship's speed and heading information are very important for fisheries monitoring authorities because the fisheries monitoring authorities can conclude about the activities of a vessel from the vessel position and speed provided in a number of consecutive position reports.

VMS allows reports of catch data from the fishing vessel to monitoring authorities at the fishing grounds immediately after each fishing operation. Fisheries catch data cannot be transmitted automatically by VMS equipment onboard the vessel but must be input manually by the ship operator. As the data input is made manually, the catch data may not be accurate. However, since the vessel may be subject to a boarding inspection at sea or at the landing port, the ship operator should report as correct as possible. Regardless of its reliability, however, the reported catch data are used in many ways for the purpose of MCS.

Furthermore, the ship operator can enter and send the time of starting and ending of fishing operations to monitoring authorities through the VMS. The ship operator can also send other unformatted messages to shore fisheries monitoring authorities through VMS. This information includes notification of entering a port or fishing zone. Even though this information can be transmitted by other than VMS, the VMS is reliable, direct, and inexpensive means of communication between the ship and the shore side.

Apart from the position report, a VMS has the function to transmit other valuable information that is not entered manually by the vessel operator. Such information could be transmitted automatically from automatic sensors on board a ship. For example, seawater temperature or information about the operation of main equipment on board the vessel can be monitored from shore through VMS. Much of this information can be used for a specific purpose. However, data transmission from ships should not disturb ship operators. The issue of sensor data should be taken into account in the longer term as use of this technology develops (FAO, 1998).

2.5.4 **Application of VMS**

The essential functions of VMS are tracking vessel locations, identifying fishing activities and providing a means of communication between ship and shore. VMS is a powerful MCS tool against illegal, unreported and unregulated (IUU) fishing in both national and international contexts. The effects of VMS can be realized in the context of exchange of the VMS data between coastal and flag states. It is estimated that more than 80 countries are using VMS to monitor fishing vessel activities. However, many developing countries have problems in implementing a VMS due to economic and technical difficulties. FAO has contributed to the system by providing technical and operational guidelines on implementation of VMS to support national fisheries administrations in the management and development of fisheries resources (FAO, 2007).

The case of the European Union is a good example of widespread cooperation on VMS. The European Commission (EC) established legislation to mandate a satellite-based VMS for European fishing vessels in 1997 (EC, 1997). Since 1 January 2000 all fishing vessels exceeding 24 metres in overall length have been required to transmit their position every two hours (EC, 1997). The regulation was amended to include all vessels exceeding 18 metres in 2004 and 15 metres from 2005 (EC, 2003). From 2006 vessels are obliged to transmit their speed and course according to the Commission Regulation (EC) No. 2244/2003 of 18 December 2003 laying down detailed provisions regarding satellite-based VMS (EC 2003).

Currently, most of the major flag or coastal states are using VMS. A number of Regional Fisheries Management Organizations (RFMOs) also are requiring VMS. The 2005 Rome Declaration on IUU fishing by Fisheries Ministers calls for further expansion of VMS on the high seas. Although VMS is intended principally for fisheries management, VMS data can be used for other purpose. For example, VMS data can be helpful in SAR operations, especially when the SAR authority participates in GMDSS.

2.6 Conclusion of Traditional Maritime Traffic Management Systems

Ship position information is crucial for identification and tracking of vessels. Without ship position information, it would not be possible to conduct traffic management and SAR operations efficiently. VTS is a primary shore-based maritime traffic management system. In addition to VTS, vessels can be tracked in many different ways, such as ship reporting systems, GMDSS and VMS. While vessels are tracked by VTS in the coastal waters and port area, VMS provides global tracking of vessels by using the satellite communications. Although these systems are different each other, as discussed in this Chapter, they are mainly used for enhancing the safety of ship and protection of the marine environment.

3 TRENDS ON MARITIME TRAFFIC MANAGEMENT SYSTEMS

3.1 Introduction

To enhance maritime security the international community introduced various measures and technologies in response to the threats to ships and port facilities in the wake of the September 11 attack in the United States in 2001. In December 2002, IMO adopted a series of measures to strengthen maritime security and to combat maritime terrorism. In the SOLAS Convention, the new chapter XI-2 (Special measures to enhance maritime security) was adopted to implement the International Ship and Port Facility Security Code (ISPS Code) and Chapter V (Safety of Navigation) was amended to introduce new equipment and systems on board vessels. According to the amendment of SOLAS, the carriage of the Automatic Identification System (AIS) and Ship Security Alert System (SSAS) has been mandated on board vessels.

In line with the measures for the enhancement of maritime security, IMO also adopted the Long-Range Identification and Tracking (LRIT) for global identification and tracking of vessels in 2006. The United States made a proposal to IMO for the introduction of LRIT in 2002 to enhance maritime security. However, LRIT was adopted, at the end, in SOLAS Chapter V for safety and marine environment protection purposes. In the LRIT system, ships are obliged to automatically transmit the LRIT information to their flag States.

In addition, IMO mandated to install the Electronic Chart Display and Information System (ECDIS) on board vessels for navigation safety. Ships engaged on international voyages must be fitted with ECDIS after 2012 through the time schedule as set in SOLAS Regulation.

The introduction of new technologies, such as AIS, LRIT, SSAS and ECDIS, are very important and it is estimated that such new systems will give great impacts on maritime traffic monitoring in the world. In this context, this Chapter investigates the systems that have been introduced recently by the international maritime community and discusses the recent trends on the integration of maritime traffic management systems. It also gives a brief overview of the newly introduced systems for identification and tracking of ships, namely AIS, LRIT and SSAS. The European cases of system integration for maritime traffic monitoring and surveillance are referred to in the discussion of recent trends.

3.2 Automatic Identification and Tracking of Ships in Short-range

3.2.1 AIS in Short-range

AIS technology has been developed as a navigation tool for collision avoidance. The benefit of AIS for mariners is its capabilities for increasing navigational awareness and help in collision avoidance. AIS is one of the means of data exchange between ships, and shore to shore.

AIS is a VTS tool as well. Nowadays AIS became an important source of information about the maritime traffic in the coastal waters including port areas. Due to its functions for automatic identification and tracking of vessels, AIS is playing a significant role in maritime traffic management in ports, harbours and approaching channels (in a shot-range).

3.2.2 **Overview of AIS**

a. Objectives and Description of AIS

IMO introduced AIS with the intention of enhancing safety of navigation and protection of the marine environment. The carriage of AIS on board vessel was mandated by the amendments to SOLAS Chapter V (Safety of Navigation) by IMO Resolution MSC.99(73) on 5 December 2000. AIS technology was created as a tool for collision avoidance and means of automatic data exchange between ships and ships and shore. IMO states that the purpose of AIS is to identify vessels; assist in target tracking; reduce verbal mandatory ship reporting; and provide additional information to avoid collision accident (IMO, 2001).

AIS is a broadcast communication system based on the marine very high frequency (VHF) mobile band. SOLAS Regulation V/19 requires that AIS must provide and receive information automatically with shore stations, other ships and aircraft. AIS is capable of sending ship information related to ship identification, navigation status and voyage to other ships and to shore as shown in Figure 2. Thus, ships fitted with AIS can be tracked and monitored by other ships and shore surveillance station. Further, data exchange between ships and shore-based facilities is possible via AIS.

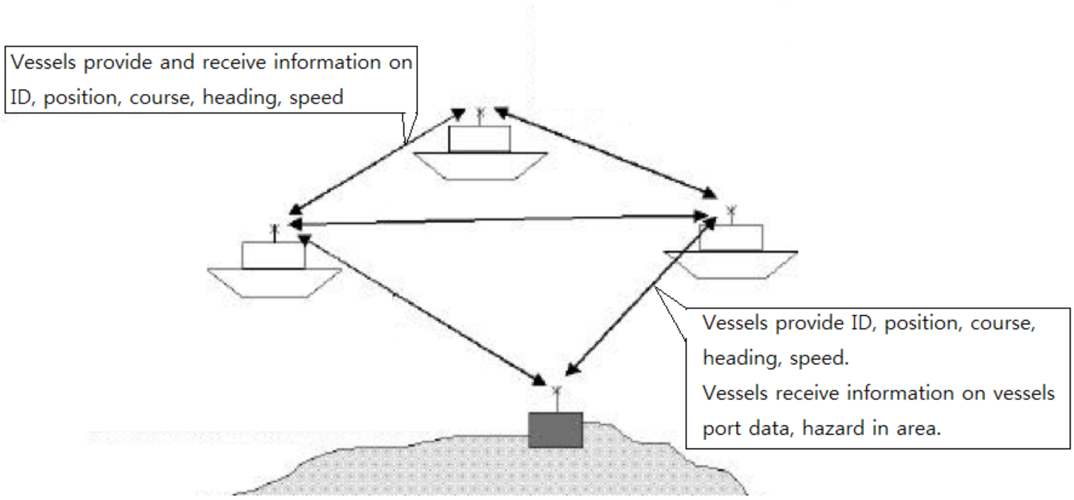

Figure 2 AIS System Overview (Source: IMO)

Since AIS is a supplement to existing communication systems, AIS information can be useful not only for ship operators but also for a shore surveillance station. Thus, it is generally recognized that AIS is an important tool for increasing situational awareness of maritime traffic and for vessel traffic management without additional burden on users (IALA, 2001).

b. Recommendations, standards and guidelines for AIS

To provide technical and operational standards and guidelines for AIS, various international organizations are involved, such as IMO, International Telecommunications Union (ITU) and International Electrotechnical Commission (IEC). Particularly, IALA developed guidelines on AIS operational issues and technical issues.

c. Carriage requirements

According to SOLAS Regulation V/19, AIS had to be fitted on all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size through a phased time schedule from 2002 to 2008.

However, all ships are not fitted with AIS. For example, warships, naval auxiliaries and government ships are not required to be fitted with AIS. In addition, leisure craft, fishing vessels and small vessels are exempt from the carriage of AIS. Moreover, ships fitted with AIS might have the equipment switched off or defective. For this reason, IMO cautions AIS users to bear in mind that information provided by AIS may not provide a complete and accurate picture (IMO, 2001).

3.2.3 AIS Information Sent by Ships

AIS information includes the ship's identity, type, position, course, speed, navigational status and other safety-related information. According to IMO performance standards, there are three types of AIS information transmitted by a ship as follows (see Figure 3):

a. Fixed or static information - entered on installation;

b. Dynamic information - automatically updated depending on the navigational status; and

c. Voyage-related information - manually entered and updated during the voyage.

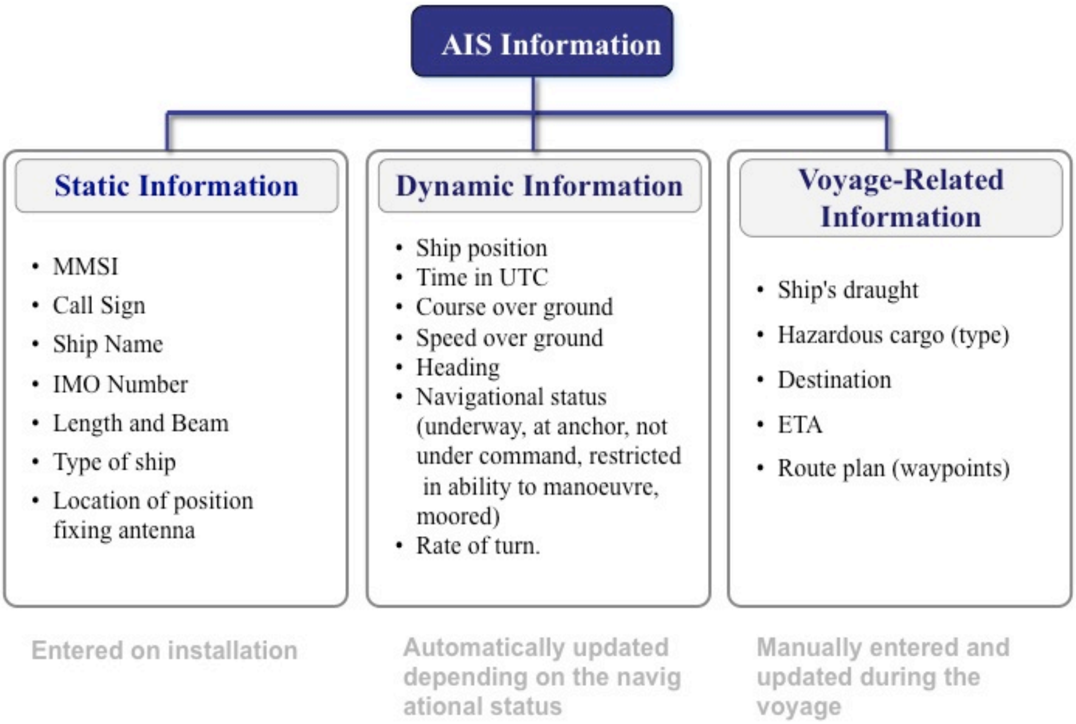

Figure 3 AIS Information (Source: Author sourced from IMO)

The static information includes MMSI (Maritime Mobile Service Identity), call sign and name, IMO Number, length and beam, type of ship and location of position-fixing antenna on the ship. The dynamic information includes ship's position, time in UTC, course over ground, speed over ground, heading, navigational status (underway, at anchor, not under command, restricted in ability to manoeuvre, moored, etc) and rate of turn. Some information is provided from other devices through sensor network. For example, the heading information is entered from gyro compass and position fix data is entered from GPS. Voyage-related information includes ship's draught, hazardous cargo (type), destination and ETA and route plan (waypoints).

AIS information also includes short safety-related messages. They are fixed or free format text messages addressed either to a specified destination (MMSI) or all ships in the area. Free format short text messages would be manually entered, addressed either a specific addressee or broadcast to all ships and shore stations. Their content should be relevant to the safety of navigation and should be kept as short as possible. The system allows up to 158 characters per message.

While static and voyage-related data are sent every 6 minutes or on request, dynamic information has to be updated automatically depending on speed and course alteration from 2 seconds to 3 minutes.

3.2.4 **AIS as a Navigation Tool**

In IMO Resolution 74(69) *"Recommendation on performance standards for an Universal Shipborne Automatic Identification System (AIS)"* adopted on 12 May 1998 and IMO Resolution A.917(22) as amended by A.956(23) *"Guidelines for the Onboard Operational use of Shipborne Automatic Identification Systems (AIS)"*, various benefits of AIS as a navigation tool are described.

According to IMO, the most benefit of AIS for mariners is its capabilities for increasing navigational situation awareness and help in collision avoidance in the ship-to-ship mode. Through AIS information, mariners on AIS fitted vessels can identify other vessels' identification and movement automatically. Mariners can use accurate information by cross check between AIS and radar. This is a very important and convenient feature for mariners. Before using AIS, mariners had to confirm the radar target by using a VHF radiotelephone. As a means of collision avoidance, mariners exchange information about ship's identification and their intention for collision avoidance in voice communications by using VHF radio. However, the voice communications between the ships may jeopardize vessels in collision danger especially in a dense traffic situation due to wrong identification of vessel.

Compared to radar system, AIS has additional benefits, because AIS has no blind areas created by islands, rocky fiords or high structures in the port. In addition, AIS signals are not affected by false target acquisition between two ships. AIS transmission is also more robust in heavy rain and snow weather conditions. However, the accuracy of AIS information completely depends on used positioning system (GPS, DGPS, etc) and the accuracy of data entered manually by mariners.

If AIS integrate with other devices such as ECDIS, automatic radar plotting aid (ARPA), the effectiveness of AIS can be increased significantly. When AIS is used with the display unit based on graphical information, ship operators can obtain the Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA) calculated from the information transmitted by the target vessels.

AIS transponders also have message exchanging functions with other ships and shore VTS centres. This message includes safety related messages, text messages in relation ship to ship or ship to shore, and binary massages like DGPS corrections data from shore VTS centres. Through message functions, the ship with AIS transponders can exchange various safety related messages, such as navigation warning and weather information from shore. Ships can obtain accurate position fix through AIS binary messages. The mariners can also make use of aid to navigation information, virtual navigational aids and radar target broadcasting through AIS data exchange functions.

3.2.5 **AIS as a VTS Tool**

According to IALA *"Guidelines on AIS as a VTS tool"* adopted in December 2001, when AIS information is used in the ship-to-shore mode, littoral states obtain information about vessels and their cargo as a VTS tool for traffic management. AIS can also assist in the identification of targets, by name or call sign and by ship type and navigational status. IALA guidelines describe the possible functions and benefits of AIS as a VTS tool as follows:

a. Automatic Vessel Identification

Automatic identification of ship's identity (name, MMSI and call sign) can facilitate quick and correct radio communication. This benefit is of great value for both mariners and VTS authorities. The process of achieving ship's identity and correlating this information with an unassigned radar target is time consuming and wholly depending on the co-operation of participating vessels.

b. Improved Vessel Tracking

VTS authorities can receive AIS data through AIS base stations. VTS operators may detect vessel targets outside the conventional radar range. Since AIS uses dedicated VHF channels, AIS is able to detect ships within the VHF/FM range. A typical AIS range is 20 to 30 nautical miles depending on the antenna height and other conditions. With the help of repeater stations, the coverage for both ship and VTS stations can be improved. Wider geographical coverage of VTS detection range may be achieved by the installation of additional base or repeater stations at much lower cost than radar. When AIS is associated with the Differential Global Navigation Satellite System (DGNSS) correction signals, AIS can achieve greater positional accuracy than radar[11]. AIS tracking can prevent many adverse effects which may occur in radar systems due to shadow areas, target swapping and heavy rain or snow.

c. Capable of being programmed by shore

According to the recommendation on performance standards of AIS, AIS should be capable of operating in various modes: an autonomous and continuous mode for all areas; an assigned mode for specific areas; and polling or controlled mode. In an assigned mode, a shore traffic monitoring authority can set the data transmission

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[11] According to the IALA AIS guidelines as a VTS tool, while radar which as a function of frequency, pulse repetition rate, and beam width will only achieve positional accuracy in the range 30 to 50 metres, AIS aims to achieve positional accuracy better than 10 metres when associated with DGNSS correction signals.

interval and/or time slots remotely. AIS information should be transmitted continuously and automatically without any intervention of ship operators. An AIS shore station can require updated information from a specific ship or all ships within a defined sea area by 'polling'. However, the shore station can only increase the ships reporting rate, not decrease it.

d. Electronic transfer of sailing plan information and safety messages

Where AIS is integrated with a VTS system, the exchange of sailing plan information is possible between vessels and the VTS centre. Also, transmission of short safety messages makes the electronic broadcasting from a VTS centre of local navigation warnings, and similar safety related messages possible. It is anticipated that VTS centres may have broadcast local chart corrections information to ECDIS fitted ships through AIS.

e. Pseudo AIS information

VTS centres may send information about non-AIS vessels which are tracked only by VTS radar via the AIS to vessels fitted with AIS. Pseudo AIS target broadcast by VTS centre should be identified by ship AIS transponders. When using this information, the mariners should be careful because accuracy of these targets may not be as complete as actual targets and the information content may not be as extensive.

f. AIS on SAR operations

AIS may be used in search and rescue operations, especially in combined helicopter and surface searches. AIS allows the direct presentation of the position of the vessel in distress on other displays such as radar or ECDIS, which facilitates the task of SAR craft. For ships in distress not equipped with AIS, the On Scene Co-ordinator (OSC) could create a pseudo.

g. AIS networks

Networking between VTS centres is emphasized increasingly on a regional basis. Such regional AIS network make the rapid transfer of vessel details between different VTS centres possible.

3.2.6 Limitations Associated with Use of AIS

Despite the many benefits of AIS, there are limitations of AIS as a navigation tool. A ship without AIS transponders cannot be identified and detected. The capabilities of AIS as a navigational tool can be maximized with enhancement to the mandatory carriage of AIS equipment for all ships. Moreover, if the AIS is not integrated with GIS like ECDIS, it is difficult to utilize AIS information efficiently. The display unit of AIS information, minimum keyboard display (MKD) on the shipboard equipment, which is the basic display unit by IMO requirement, has very limited possibilities because it is difficult to read the text message on MKD and situational awareness requires cooperation with external chart system. Practically, the use of MKD might add workload to mariners.

Similarly, there are several limitations in VTS operations. Since all vessels may not be equipped with AIS, VTS operators should not overly depend on AIS as means for vessel identification. Further, VTS operators should remember that AIS data might include errors. According to the research carried out by *Lloyd's Register Educational Trust Research Unit Seafarers International Research Centre*, there are many errors in the transmitted AIS. The effectiveness of such systems depends upon the competence of those who operate them. To ensure the effectiveness of AIS, the ship operator should be trained and educated properly (Bailey, Ellis & Sampson, 2008). In addition, proper supervision of data accuracy by competent maritime authorities would enhance its efficiency in all navigation operations (Harati-Mokhtari, n.d.).

3.3 Global Identification and Tracking of Ships

3.3.1 Global Identification and Tracking of Ships

While AIS provides identification and tracking of ships in a short range, LRIT is designed to provide the global identification and tracking of ships. Since LRIT uses satellite communications, vessels can be tracked regardless of their location in the LRIT system. Although LRIT was introduced to enhance the maritime security, LRIT is expected to be an essential system on maritime safety and marine environment protection.

3.3.2 Long-Range Identification and Tracking (LRIT) of Ships

LRIT was introduced to enhance maritime safety and security, and marine environment protection. According to SOLAS Regulation V/19-1, ships must automatically transmit LRIT information to ship's Administration at least four times a day. The Administration should be able to receive LRIT information about ships flying its flag regardless of ships location (see Figure 4).

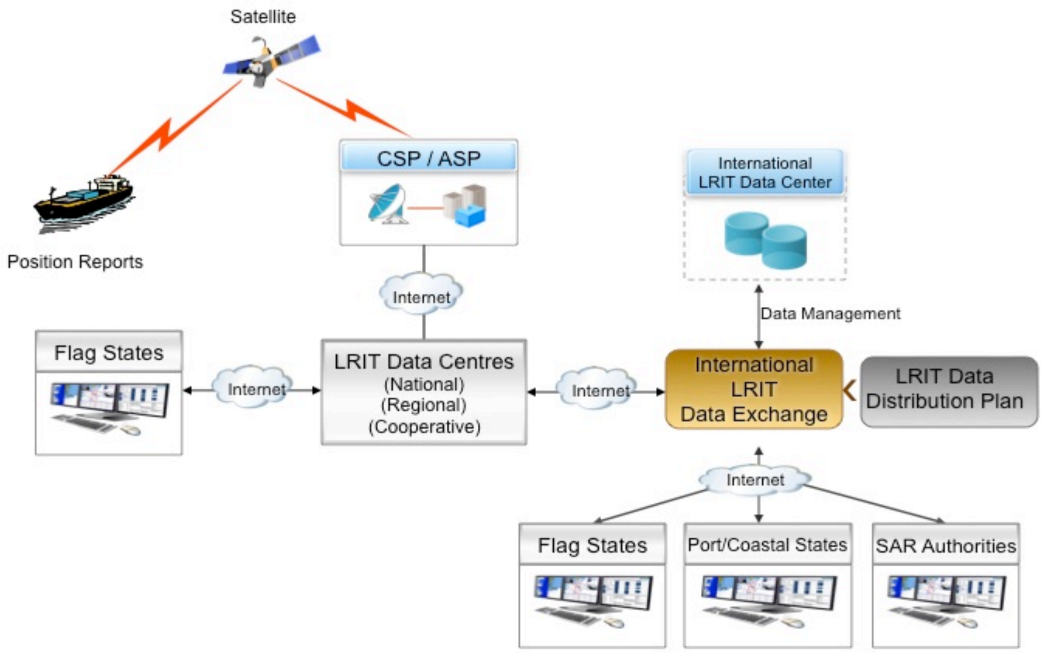

Figure 4 LRIT (Source: Author)

In addition, a contracting government may receive LRIT information about ships intended to enter within its waters regardless of ship's location. Moreover, a contracting government may receive LRIT information about any ships navigating within a distance not exceeding 1,000 nautical miles of its coast. LRIT information should include the identity of the ship, the position of the ship (latitude and longitude) and the date and time of the position provided. Figure 5 shows an illustration of the LRIT system architecture.

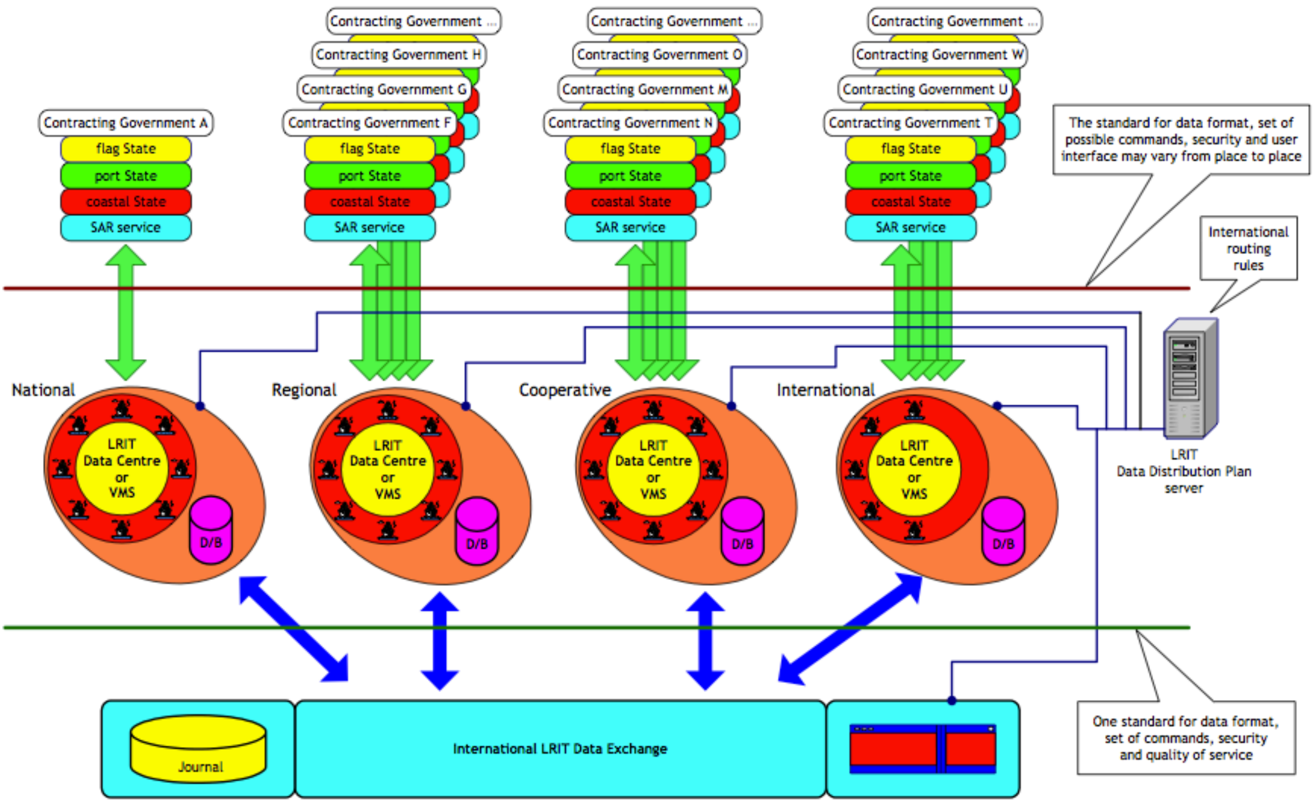

Figure 5 LRIT System Architecture (Source: IMO)

LRIT information can be provided to contracting governments and search and rescue authorities, upon request, through a system of national, regional and cooperative LRIT Data Centres using the International LRIT Data Exchange. Each Administration should provide to their LRIT Data Centre a list of the ships entitled to fly its flag together with other salient details and then the list should be updated. Ships should only transmit the LRIT information to the LRIT Data Centre selected by their Administration (IMO, 2008a).

The SOLAS Regulation provides the principles for the cost incurred in LRIT data exchange. Contracting governments should bear all costs associated with any LRIT information and they should not impose any charges on ships in relation to the LRIT information they may seek to receive. Basically ships entitled to fly its flag should not incur any charges for transmitting LRIT information. The search and rescue services of contracting governments may receive LRIT information free of any charges in relation to the search and rescue of persons in distress at sea (IMO, 2008a).

3.3.3 Components of the LRIT System

According to *Performance standards and functional requirements for the LRIT* adopted by the resolution MSC.263(84) adopted on 16 May 2008, the LRIT system consists of the shipborne LRIT information transmitting equipment, the Application Service Provider (ASP), the Communication Service Provider (CSP), the LRIT Data Centre, including any related VMS, the LRIT Data Distribution Plan and the International LRIT Data Exchange (IMO, 2008a). The details are described as follows:

a. Shipborne equipment

Generally, GMDSS equipment may be used as LRIT shipborne equipment. LRIT shipborne equipment should transmit the LRIT information using a satellite communication system which provides coverage in all areas where the ship operates. The shipborne equipment should be set to automatically transmit the ship's LRIT information at 6-hour intervals to the LRIT Data Centre identified by the Administration. The equipment should be capable of transmitting the Global Navigation Satellite System (GNSS) position (latitude and longitude) of the ship, without human interaction. The interval of data transmitting can be configured remotely. In addition, the shipborne equipment should transmit LRIT information following receipt of polling commands.

b. Application Service Provider (ASP)

The ASP provides a communication protocol interface between the Communication Service Providers (CSP) and the LRIT Data Centre. ASP provides services to: a national LRIT Data Centre; a regional or a cooperative LRIT Data Centre; and an international LRIT Data Centre.

c. Communications Service Provider (CSP)

The CSP links the various parts of the LRIT system using communications protocols in order to transfer the LRIT information. A CSP may also play a role as an ASP.

d. LRIT Data Centre

The LRIT Data Centre collects LRIT information from ships instructed by their Administrations and provides information to LRIT users upon request. There are three types of LRIT Data Centres: a national LRIT Data Centre; a regional or a cooperative LRIT Data Centre; and an international LRIT Data Centre.

A national LRIT data centre is established by a contracting government. A regional or a cooperative LRIT Data Centre is established by a group of contracting governments. Upon request, national, regional and cooperative LRIT Data Centres may provide services to contracting governments other than those establishing the centre. An international LRIT Data Centre recognized should be established by IMO. Contracting governments not participating in a national, regional or cooperative LRIT Data Centre, or contracting governments may participate in the establishment of an international LRIT Data Centre. Ships, other than those which are required to transmit LRIT information to either a national, regional or cooperative LRIT Data Centre, should transmit the required LRIT information to the international LRIT Data Centre.

e. International LRIT Data Exchange

The international LRIT Data Exchange (LRIT-IDE) routes LRIT information between LRIT Data Centres using the information provided in the LRIT Data Distribution Plan. LRIT-IDE should be connected to all LRIT Data Centres and the LRIT Data Distribution Plan server. European Maritime Safety Agency (EMSA) was appointed as the LRIT-IDE operator by IMO, and EMSA commenced its duty as the LRIT-IDE operator from 18 October 2011 (EMSA, 2011).

f. LRIT Data Distribution Plan

The LRIT Data Distribution Plan is established and maintained by IMO. The LRIT Data Distribution Plan should include a list indicating the unique LRIT identities of contracting governments, SAR services entitled to receive LRIT information, LRIT Data Centres, the international LRIT Data Exchange, ASPs, the LRIT Data Distribution Plan server and the LRIT Coordinator.

3.3.4 **Ship Security Alert System (SSAS)**

In addition to the existing emergency and distress system (GMDSS), the SOLAS Regulation XI-2/5 requires ships to be fitted with a Ship Security Alert System (SSAS) in order to address the maritime threat from piracy and terrorism. In emergency cases, the SSAS will transmit a security alert to ship's administration.

The security alert includes identification and location of the ship, and indicates that the security of the ship is under threat or it has been compromised. The system will not raise any alarm on-board the ship. It should be capable of being activated from the navigation bridge and in at least one other location. The procedures for the security alert should be agreed with the ship's administration as part of the ship's security plan. Procedures and format of the ship's security alert are not standardized internationally. Commercial SSAS service providers offer solutions employing e.g. INMARSAT-C or Iridium.

3.4 Data Exchange and System Integration

Under the integrated maritime policy, the recent trends are pursuing the enhanced interoperability and integration between existing monitoring and tracking systems, across the different maritime sectors. Such an integration of the existing or future maritime surveillance systems is considered as an essential tool towards the improvement of services provided by authorities at sea.

VMS has been regarded as relatively far advanced in operational data sharing between countries, but restricted in any sharing outside the fisheries sector. Recently, national and regional AIS data exchange is developing fast. Due to the many benefits of data exchange and system integration, all countries have plans to start or further develop the integration.

3.4.1 Cooperation on Data Exchange

a. VMS data exchanges

In the fisheries sector, it was agreed that there was a need for international and regional cooperation in VMS and in monitoring, surveillance and control (MCS) in view of the high levels of IUU fishing across jurisdictions. As a result, various kinds of VMS data exchange networks are in operation between fisheries authorities and Regional Fisheries Management Organizations (RFMOs)[12] to share data on IUU vessels at the international level (FAO, 2007).

[12] According to FAO Fisheries Report 185, expert consultation of the use of VMS and satellite for fisheries MCS, the following Regional Fisheries Management Organizations have implemented or are considering implementing VMS measures within their areas of competency for their member States:

- North East Atlantic Fisheries Commission (NEAFC);
- Northwest Atlantic Fisheries Organization (NAFO);
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR);
- International Commission for the Conservation of Atlantic Tuna (ICCAT);
- Commission of the Conservation for Southern Blue Fin Tuna (CCSBT); and
- Indian Ocean Tuna Commission (IOTC)

VMS data of a fishing vessel that is in the waters of another country are sent to coastal states. VMS data are also forwarded to RFMOs by flag states whose vessels are operating in the waters controlled by the RFMO. Under the VMS data exchange system, the member states can access to VMS data on specific request, and that received data are to be treated as confidential. In practice, VMS data are generally not exchanged with other national agencies such as maritime authority, customs and police. However, there is a possibility of data access from such national agencies for public purposes in specific cases (EC, 2008).

b. Regional AIS networks

With a view to benefit from AIS information, many maritime authorities have recognized the value of exchanging the AIS data with a centralized national network. In this context, most countries have national AIS network systems. Furthermore, adjacent countries are collaborating to exchange a national AIS network in several regions. There are many examples of regional AIS networks such as HELCOM for the Baltic Sea and the North Sea Safety at Sea Working Group for the North Sea. There has been a similar initiative in the Mediterranean Sea amongst 10 countries[13]. At the end, many military initiatives for AIS networks have been built, such as MSSIS (Maritime Safety & Security Information System) operated by NATO, the Regional Virtual Maritime Traffic Centre (V-RMTC) hosted by the Italian Navy, and the Black Sea Harmony network managed by the Turkish Defense.

c. LRIT data exchange

Pursuant to the SOLAS Regulation on LRIT, multi-lateral or regional agreements for sharing LRIT information between SOLAS contracting governments have been established. Such agreements are mainly for maritime security and search and rescue purposes. Contracting governments can receive information about ships navigating

[13] A common AIS Mediterranean network whereby 10 Member States: Portugal, Spain, France, Slovenia, Italy, Malta, Greece, Cyprus, Bulgaria and Romania

within a distance not exceeding 1,000 nautical miles off their coast through the LRIT Data Exchange.

In the European Union (EU), the EU LRIT Data Centre plays a role as regional LRIT Data Centre for the member states of the Committee. The existing SafeSeaNet system communication platform is used to facilitate the sharing of LRIT information between Member States. Through the regional LRIT Data Centre, member States can make use of LRIT data for maritime security, SAR, maritime safety and protection of the marine environment. For the functionality of LRIT, all LRIT data could be exchanged via LRIT Data Exchange between national, regional/cooperative and international LRIT Data Centres.

3.4.2 System Integration

a. VMS and LRIT

LRIT is a similar system to VMS. As examined in the previous Chapter, VMS has been introduced by FAO as a tool for MSC for fisheries industry and also by IMO in the interests of marine safety and search and rescue. Under the LRIT and VMS systems, ships are required to report their positions to their flag states at regular intervals and, if such a report is not received, an alert will be provided to the operator.

According to the *LRIT Performance standards*[14], national, regional and cooperative LRIT Data Centres may also serve as a national, regional or cooperative VMS and may require, as VMS, the transmission from ships of additional information, or of information at different intervals, or of information from ships which are not required to transmit LRIT information. VMS may also perform other functions in addition to

[14] Revised performance standards and functional requirements for the long-range identification and tracking of ships (IMO Res. MSC.263(84)) adopted in May 16 2008.

the basic functions for LRIT. There is good example in the Republic of Korea. In Korea, a National VMS is playing a role as a National LRIT Data Centre[15].

If LRIT requirements are extended to fishing vessels for maritime security purposes, fishing vessels fitted with VMS equipment could easily meet the requirements of LRIT. In this case, fisheries authorities can easily pass the VMS data to the LRIT centre in the flag state, the coastal state, or the regional centre, upon request. FAO indicates that this sharing of VMS information is already being discussed by flag states to coastal states where fisheries agreements make this a requirement of access to fishery resources (FAO, 2006).

b. AIS and VMS

While AIS is a system for identification and tracking of ships in short-range, LRIT is a global system for identification and tracking of ships. AIS and LRIT/VMS are not inter-operable or compatible because each uses different communications systems and reporting rates. Furthermore LRIT and VMS are not designed for collision avoidance or situational awareness. Therefore, LRIT and VMS are not an acceptable substitute for AIS. However, AIS is acceptable for LRIT. It is clearly described in SOLAS Regulation V/19-1 that ships fitted with an AIS, and operated exclusively within sea area A1, will not be required to carry the LRIT equipment. Since the LRIT message information is a subset of the AIS message information, integration of functionalities of AIS and LRIT could be efficient. On the receiving side, the LRIT exemption for ships operating only in sea area A1 creates the impression that any required LRIT information of those ships is supposed to be extracted from the received AIS data (EC, 2008). Currently, satellite AIS is under development by the US. It is anticipated that the development of satellite AIS will overcome the shortcoming of present AIS by extending its coverage from short-range to global.

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[15] See the 5.4.4 of Chapter 5

3.4.3 **Vessel Traffic Monitoring and Information System (VTMIS) in EU**

The European case shows a good example for the integration of an interoperable surveillance system. The EU adopted the policy[16] on establishing a Community Vessel Traffic Monitoring and Information System (VTMIS) in 2002 with a view to enhancing the safety and efficiency of maritime traffic, improving the response of authorities to incidents, accidents or potentially dangerous situations at sea, including search and rescue operations, and contributing to a better prevention and detection of pollution by ships. VTMIS is an interoperable surveillance system to bring together existing monitoring and tracking systems used for maritime safety and security, protection of the marine environment, fisheries control, control of external borders and other law enforcement activities.

Such an integration of the existing maritime monitoring and surveillance systems is considered as an essential tool towards the improvement of services provided by authorities at sea in all the areas. To establish the VTMIS, member states are required to set up infrastructures for ship reporting systems, ships' routeing systems and VTS. Member states should also be provided the appropriate equipment and shore-based installations for receiving and utilizing the AIS information (EC, 2002).

In addition to the above, member states should establish and operate the maritime information management exchange system, national SafeSeaNet, at national or local levels. SafeSeaNet is a specialized system to facilitate the exchange of information in an electronic format between member states and to provide the Commission with the relevant information. It is composed of a network of national SafeSeaNet systems in member states and a SafeSeaNet central system acting as a nodal point. The

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[16] DIRECTIVE 2002/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 June 2002, establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC

SafeSeaNet network links all national SafeSeaNet systems and include the SafeSeaNet central system (see Figure 6). The system allows information to be transmitted 24 hours a day. Upon request, through SafeSeaNet, member states should be able to send information on the ship and the dangerous or polluting goods on board to other state (EC, 2002).

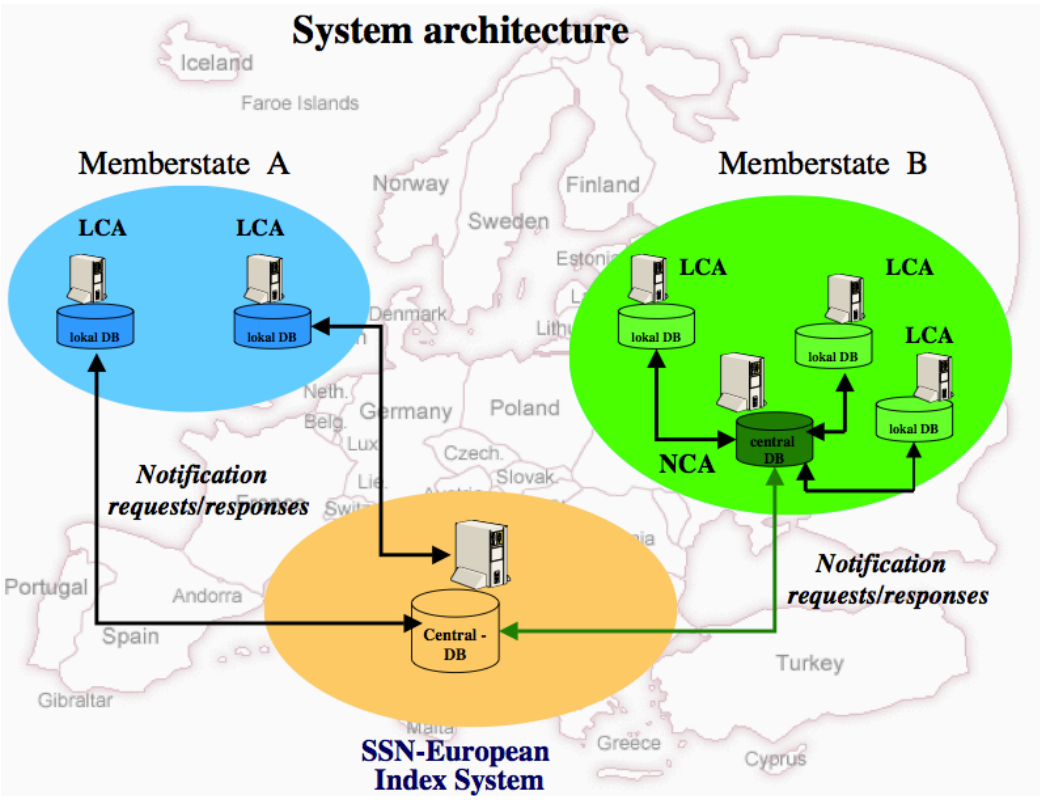

Figure 6 SafeSeaNet (Source: German Federal Waterways Administration)

3.5 Small Ships Monitoring

In the Republic of Korea, 90.8% of registered ships are fishing vessels[17] and 94.9% are small ships of less than 100 gross ton[18]. According to the marine accidents

[17]The total number of registered ships is 85,556. Among them, fishing vessels are 77,713 (90.8%) and non-fishing vessels are 7,843 (9.2%).

statistics, 72.2%[19] of marine accidents are caused by small-sized ships of less than 100 G/T. Generally, small ships are vulnerable to safety compared to big ships. Since most small ships are operating in coastal waters, they are not obliged to carry safety and emergency equipment on board ships. To reduce marine accident, the maritime policy should be focused on the small ship. In this context, it is very important to discuss small ships monitoring as a future trends.

Chapter V is the section that specifically includes fishing vessels in the SOLAS Convention. Nevertheless, SOLAS Regulation V/19 does not require the mandatory carriage requirement of AIS for fishing vessels, small ships, pleasure craft and inland waterway vessels. However, under SOLAS Regulation V/1.4, the Administration may determine to extend the provisions of the regulation for: ships below 150 gross tonnage engaged on any voyage; ships below 500 gross tonnage not engaged on international voyages; and fishing vessels. This means that a national administration can choose to implement the regulations on AIS for its own fishing vessels, if it so wishes. It is expected that many maritime administrations and ship operators may realize the potential benefits of AIS to enhance the safety of navigation.

ITU classifies AIS into class A and Class B in the AIS Technical Standards (ITU-R M.1371-1[20]). According to the ITU Recommendation, while the Class A AIS is intended for SOLAS ships, the Class B AIS provides facilities for non-SOLAS ships. The Class B AIS device, for example, transmits information at less frequent intervals than the Class A AIS. The Class B AIS also does not transmit the vessel's IMO number, ETA or destination, navigational status and text safety messages.

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[18] 4,229 ships out of 7,843 non-fishing vessels are less than 100 gross ton. 76,948 ships out of fishing vessels are less than 100 gross ton.

[19] 2,984 incidents (72.2%) out of 4,136 incidents are caused by ships of less than 100 G/T.

[20] Recommendation ITU-R M.1371-1, Technical characteristics for a universal shipborne automatic identification system using time division multiple access in the VHF maritime mobile band

Administrations have the responsibility of determining the applicability of the Class A or Class B AIS device to vessel categories.

Most fishing vessels currently do not carry AIS, except for those on ships of 300 gross tonnage and upwards engaged on international voyages. However, in Europe, carriage of AIS is mandatory for fishing vessels. According to the EU regulation[21], fishing vessel with an overall length of more than 15 metres and flying the flag of a EU member state and registered in the Community, or operating in the internal waters or territorial sea of a member state, or landing its catch in the port of a member state should be fitted with an AIS (Class A). Fishing vessels equipped with AIS must maintain it in operation at all times (EC, 2009). The decision to introduce an obligation to carry AIS for fishing vessels was a response to the large number of collision accidents involving fishing vessels. In short, AIS is a valuable and useful tool for tracking of small ships including fishing vessels, pleasure craft and inland waterway vessels.

Recognizing the importance of the small ship monitoring, the Korean Government established the legislation to mandate the carriage of vessel monitoring equipment on board in 2006. According to the *Article 30 (Ship Position Transmitter) of Ship Safety Act*, ships must be equipped with a device which automatically transmits the position of the ship (ship position transmitter) in order to secure the ship's safety of navigation and to enable a quick response to marine accidents. The ship position transmitter should function properly when the ship is in operation. Where radio communication equipment has a function of a ship position transmitter, the ship should be deemed as being equipped with a ship position transmitter. Practically, all kinds of radio

[21] DIRECTIVE 2009/17/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009, amending Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system

communications devices[22] are reflected in the law. In the event of determining that frequent appearances of piracy attacks may pose a threat to the safety of a ship, the master of the ship may turn off the ship position transmitter. In such a case, the master should record the fact in the ship's logbook.

Pursuant to the Article 30 of the Ship Safety Act, in 2006, MTLM determined the ships to be fitted with ship position transmitter as follows:

- Passenger ships[23] of 2 G/T and above
- Ships other than passenger ships of 300 G/T and above, engaged in international voyages
- Ships other than passenger ships of 500 G/T and above, engaged in domestic voyages
- Tug boats, oil tankers and ships carrying dangerous goods in bulk, of 50 G/T and above

It is noted that fishing vessels and small ships are excluded in mandatory VMS scheme due to the objections of the fisheries industries in Korea. The guidelines for installation of Class A and Class B AIS and other radio equipment are established under *the Ship Safety Act.*

3.6 Conclusion of Trends on Maritime Traffic Management Systems

The author does not intend to complete the summary of existing surveillance systems or VTMIS, but rather draw attention to current and further trends on system integration. With a view to the technological advances in maritime traffic monitoring systems, it is expected that VTS would be extended into VTMIS. As defined in the

[22] In GICOMS System, VMS equipment includes AIS, VHF DSC, commercial mobile phone for sea area 1, MF/HF radio and satellite for sea area 2, and satellite for sea area 3.

[23] The Ship Safety Act (Article 2) defines that "passenger ship" is a ship which can transport more than 13 passengers.

EU Directive, VTMIS is an integration of various systems such as VTS, AIS, VMS, LRIT and data exchange system. Through the data exchange system, VTS Centres, maritime authorities, fisheries monitoring authorities and MRCC may utilize the ship movement information regardless of location in the world. It is likely that implementation of LRIT would accelerate the system integration because existing VMSs have regarded as LRIT Data Centre in accordance with the SOLAS Regulation.

In addition to data exchange and system integration, the small ships monitoring will be focused in the world. To reduce the number of marine accident, the small ships monitoring is crucial.

4 DEVELOPMENT OF E-NAVIGATION

4.1 Introduction

It is expected that the introduction of e-Navigation will bring great impacts on maritime traffic monitoring and surveillance. As outlined in the previous Chapter, recent trends in maritime systems are the integration of existing and future systems and the form of global network for information exchange. It is estimated that e-Navigation will lead the information exchange through system integration. In this context, this Chapter reviews the background of e-Navigation on the basis of the process of the development of e-Navigation by IMO. It also gives general overviews of the IMO strategy of e-Navigation. Finally, it describes the expected consequences of e-Navigation.

4.2 Background of e-Navigation

In December 2005, Japan, the Marshall Islands, the Netherlands, Norway, Singapore, the UK and the USA submitted a proposal[24] to IMO on the development of an e-Navigation strategy. It was proposed to add a new work programme on the NAV (Safety of Navigation) and COMSAR (Radio Communications and Search and Rescue) Sub-committees. The proposal was aimed to develop a strategic vision for the utilization of existing and new navigational tools, in particular electronic tools, in a holistic and systematic manner. The proposal paper stated that e-Navigation would

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[24] It is proposed to add a new item on e-Navigation to the work programme of NAV and COMSAR Sub-Committee (MSC 81/23/10) on 19 December 2005.

help reduce navigational accidents, errors and failures by developing standards for an accurate and cost effective system that would make a major contribution to IMO's agenda of safe, secure and efficient shipping on clean oceans (IMO, 2005). The MSC discussed the proposal and decided to include, in the work programmes of the NAV and COMSAR Sub-Committees, a high priority item on *"Development of an e-Navigation strategy"*, with a target completion date of 2008. The MSC also agreed that the two Sub-Committees should consider the issues with the aim of developing a strategic vision to develop the necessary policy direction for further progress of this important work (IMO, 2006).

Many groups and organizations had cooperated on the development of an e-Navigation strategy. Particularly the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has been charged by IMO with developing the e-Navigation standards. IALA e-Navigation Committee was established in 2006 by international delegates, representing practitioners and technical experts to contribute to the concept of e-Navigation through IMO.

Following the considerable discussion, the MSC of IMO at its eighty-fifth session, in December 2008, approved *"Strategy for the development and implementation of e-Navigation"*, as set out in MSC 85/26, annex 20 and approved the Framework for the implementation process for the e-Navigation strategy along with *"Time frame for implementation of the proposed e-Navigation strategy"*, as set out in MSC 85/26, annex 21. MSC 85 also agreed to include a high-priority item on development of an e-Navigation strategy implementation plan in the work programme of NAV, COMSAR and STW (Standards of Training and Watchkeeping) Sub-committees. According to the MSC 85's decision, the COMSAR, NAV and STW Sub-Committees have jointly participated in the development of an implementation plan of the proposed e-Navigation strategy.

MSC recognized that it is needed to capture evolving user needs and to develop an architecture and to carry out a gap analysis, a cost- benefit analysis and a risk analysis.

Upon formulating the implementation plan, e-Navigation will begin to be implemented in 2012. It is agreed that the NAV would be responsible for overall coordination: navigational aspects (equipment, ship reporting and vessel traffic management); the COMSAR would be responsible for communication and SAR aspects (equipment, procedures); and the STW would consider from the training aspects.

The strategy for the development and implementation of e-Navigation states that e-Navigation would intend to help reduce navigational accidents, errors and failures and make a major contribution to IMO's agenda. It is expected that the introduction of e-Navigation would bring great effects on maritime traffic management and surveillance systems.

4.3 Overview of IMO Strategy of e-Navigation

4.3.1 Definition and the Concept of e-Navigation

e-Navigation is currently defined by IMO as follows:

> *"e-Navigation is the harmonized collection, integration, exchange and presentation 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"*

IALA interprets that the 'e' stands for 'enhanced' or 'electronic', but this is not necessarily limited. According to the IMO strategy, e-Navigation is conceptually based on the harmonization of navigation systems on board and supporting services ashore. e-Navigation is also based on global communications, electronic navigation charts and electronic positioning systems. Its pillars are communications, navigation and situational awareness on a foundation of the human/machine interface.

It is understood that there will be three significant outcomes from e-Navigation that are currently discussed. These are represented by ship based systems, shore based systems and a communication infrastructure. Onboard navigation systems will be developed by the integration of own ship sensors, supporting information, a standard user interface, and a comprehensive system for managing guard zones and alerts. The e-Navigation architecture is shown in Figure 7. The maritime traffic management will be enhanced through better provision, coordination, and exchange of comprehensive data. Information exchange onboard ship, between ships, between ship and shore and between shore agencies will be promoted (IALA, 2009a).

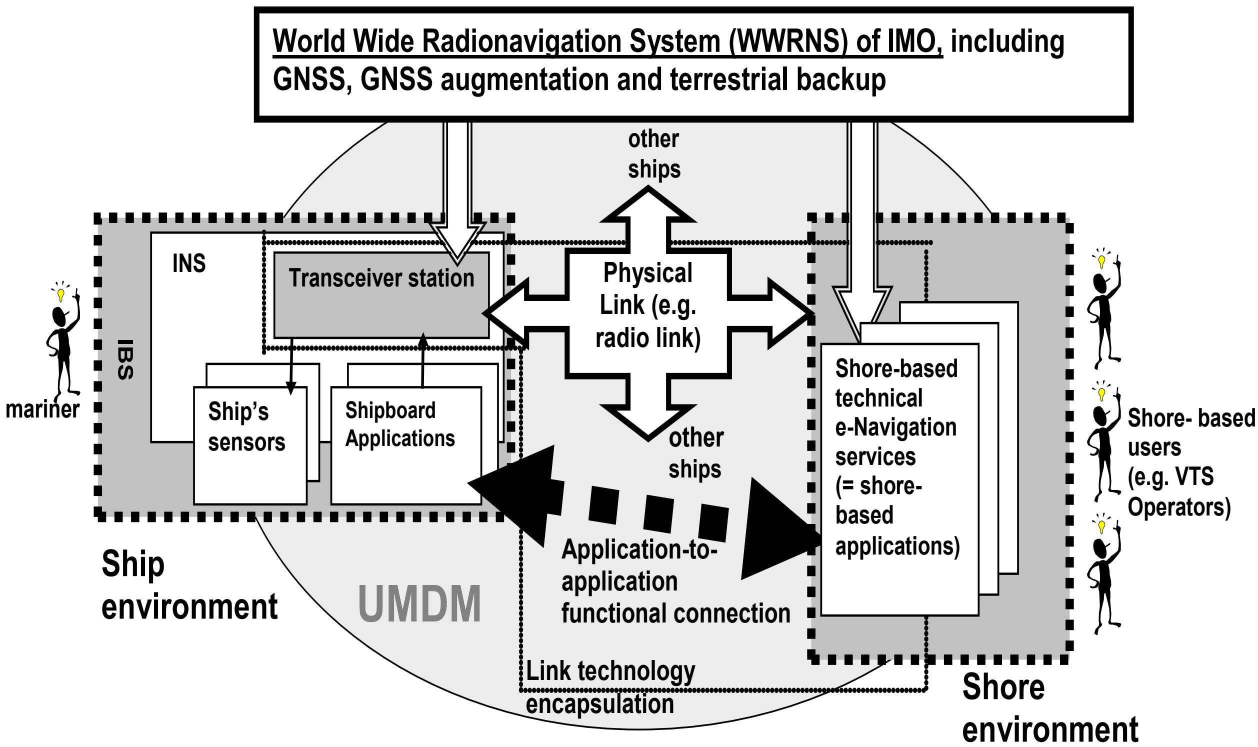

Figure 7 e-Navigation Architecture (Source: IALA)

4.3.2 **Objectives and Benefits of e-Navigation**

According to the IMO strategy, the core objectives[25] of an integrated e-Navigation are to facilitate basic functions which are undertaken regarding ship operations by using electronic data capture, communication, processing and presentation. The overall goal is to reduce errors by making maritime navigation and communications become more reliable and user-friendly. In addition, there are aims to provide standards for integration and sharing of information between ships, between ship and shore and between shore authorities and other parties in order to maximize navigational safety benefits and minimize risks of confusion or misinterpretation.

The primary value of e-Navigation is to connect the ship's bridge and VTS that would achieve safer navigation through shared information. For full implementation of such a system it would be mandatory for vessels by the SOLAS Convention (Chakraborty, 2009). IMO indicates the main benefits of e-Navigation in many aspects: improved safety; better protection of the environment; augmented security; higher efficiency and

[25] According to the strategy for the development and implementation of e-Navigation (MSC 85/26, annex 20), the core objectives of the e-Navigation concept are to:

1 facilitate safe and secure navigation of vessels having regard to hydrographic, meteorological and navigational information and risks;

2 facilitate vessel traffic observation and management from shore/coastal facilities, where appropriate;

3 facilitate communications, including data exchange, among ship to ship, ship to shore, shore to ship, shore to shore and other users;

4 provide opportunities for improving the efficiency of transport and logistics;

5 support the effective operation of contingency response, and search and rescue services;

6 demonstrate defined levels of accuracy, integrity and continuity appropriate to a safety-critical system;

7 integrate and present information on board and ashore through a human-machine interface which maximizes navigational safety benefits and minimizes any risks of confusion or misinterpretation on the part of the user;

8 integrate and present information onboard and ashore to manage the workload of the users, while also motivating and engaging the user and supporting decision-making;

9 incorporate training and familiarization requirements for the users throughout the development and implementation process;

10 facilitate global coverage, consistent standards and arrangements, and mutual compatibility and interoperability of equipment, systems, symbology and operational procedures, so as to avoid potential conflicts between users; and

11 support scalability, to facilitate use by all potential maritime users.

reduced costs; and improved human resource management are detailed below (IMO, 2009a).

a. Improving safety

The standards in safe navigation will be promoted by improved decision support enabling the users to select relevant unambiguous information pertinent to the prevailing circumstances. It will be helpful to reduce human error through provision of automatic indicators, warnings and fail-safe methods. The better integration of ship and shore-based systems will lead to better utilization of all human resources.

b. Better protection of the environment and augmented security

Improving navigation safety will reduce the risk of collisions and groundings and the associated oil pollution. Reducing emissions by using optimum routes and speeds will contribute to protection of the marine environment. Silent operation mode for shore-based stakeholders for domain surveillance and monitoring will augment the security.

c. Higher efficiency and reduced costs

A fast track change management process in relation to technical standards for equipment will augment the global standardization and type approval of equipment. Automated and standardized reporting procedures will reduce administrative overhead. Improved bridge efficiency will allow watch keepers to maximize time for a proper lookout.

d. Improved human resource management

Enhancing the experience and status of the bridge team will improve human resource management.

4.3.3 **Key Elements of e-Navigation**

IMO defined seven key structural components of the e-Navigation policy as the basis of developing e-Navigation (Pillich, 2011). They are mostly applicable onboard ships and are follows:

- Integrated display of information using Electronic Chart Display Information Systems (ECDIS);
- Electronic Positioning Fixing Systems (EPFS);
- Electronic information on vessel route, course, maneuvering etc.;
- Transmission of positional and navigational information using AIS;
- Electronic Navigation Charts (ENCs);
- Information reporting, prioritization and alert capability; and
- Transmission of distress alerts and maritime safety information.

As outlined in the concept of e-Navigation, mutually interacting parts of the e-Navigation architecture can be identified as follows:

- Shipboard systems of information/data processing devices;
- Application-to-application data exchange via physical links ship to shore and shore to ship; and
- Shore-based e-Navigation system architecture that integrates a variety of shore-based technologies and data processing devices.

e-Navigation would provide an infrastructure designed to enable authorized seamless information transfer onboard ships, between ships, between ships and shore and between shore authorities and other parties with many attendant benefits. It is supposed that architectures of a shipboard system and a shore-based system would be as shown in Figure 8 and Figure 9.

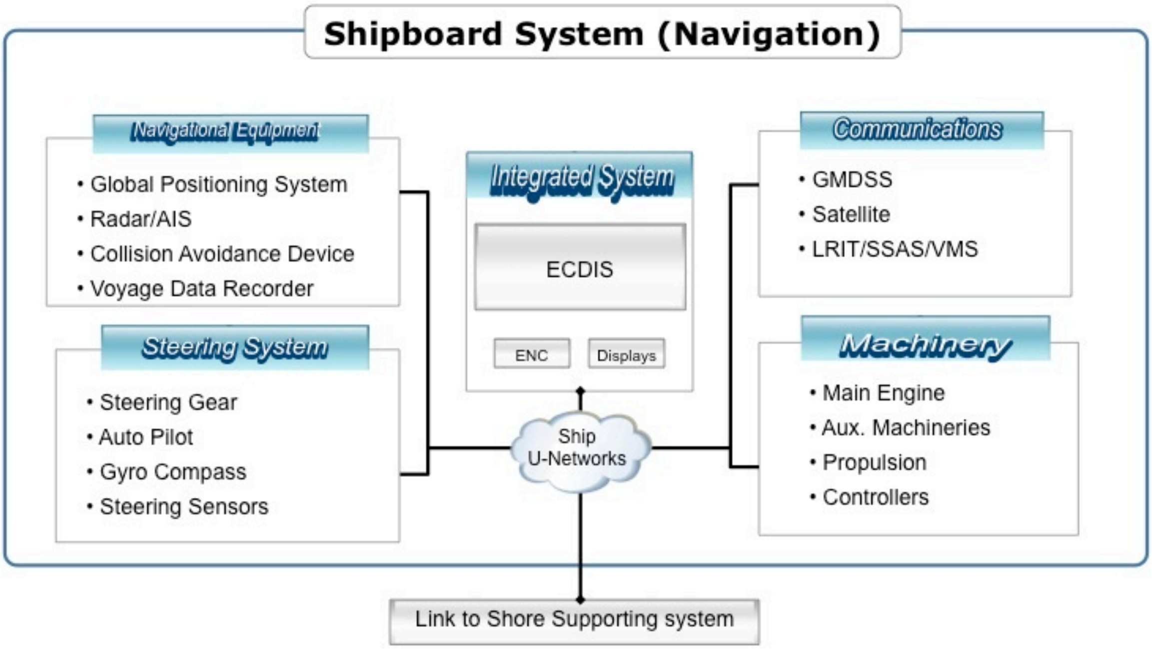

Figure 8 Shipboard System (Source: Author sourced from IMO)

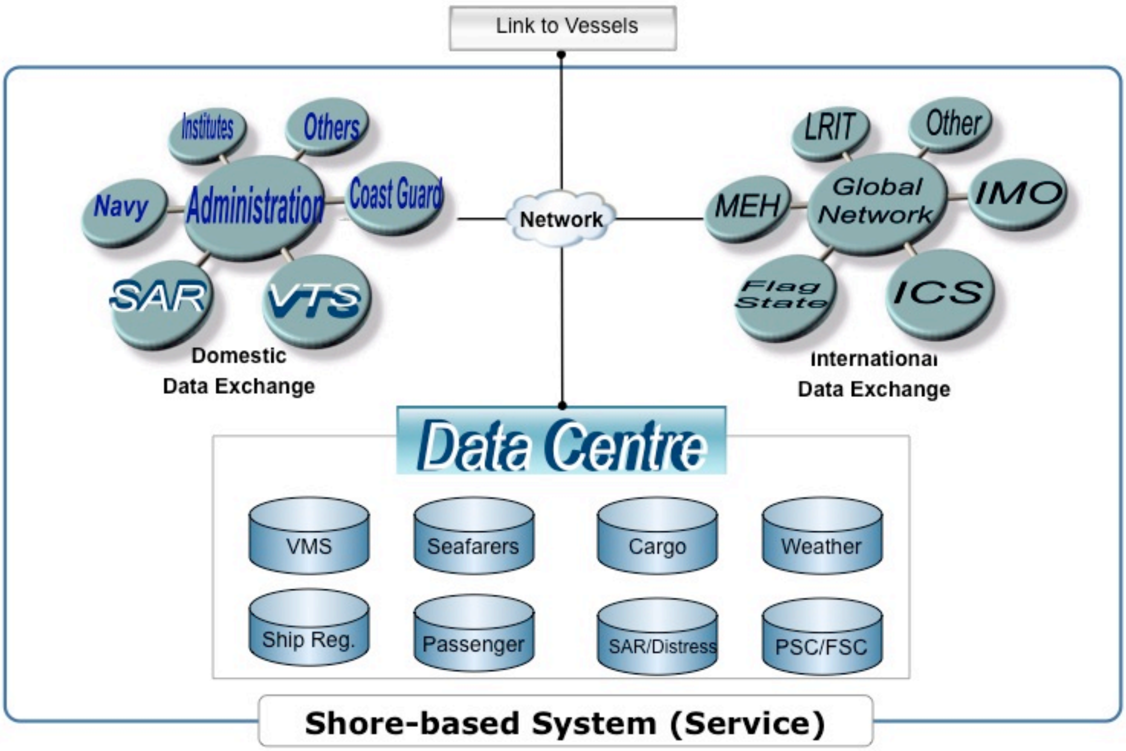

Figure 9 Shore-based System (Source: Author sourced from IMO)

4.4 Expected Consequences of e-Navigation

E-Navigation is a broad and long-term concept involving many stakeholders and having the potential to impact on the entire maritime community. Amongst those likely to be affected are seafarers, ship owners, pilots, equipment manufactures, VTS organizations, coastal states, port states and flag states. Further, the development of e-Navigation will have a significant impact on all parts of training and the ship's operating procedures.

It is generally noted that the overall maritime trends are likely to lead to the following consequences for e-Navigation (Pillich, 2011):

- The need for more efficient and harmonized data transfer between ships, and between ships and shore will be increased.
- The need for improved communication facilities between shore and ship to exchange information will be increased.
- It will be possible in detection, identification, and precise tracking of vessels regardless of ship's location on the global basis through the integration of LRIT, VMS and satellite-based AIS.
- There may be a new need to manage fishing vessels, recreational craft and small ships by shore-side authorities for the safety of navigation and maritime security.
- There will be an increased need to assure and certify the competency of mariners and shore-side users so as to make best use of e-Navigation facilities.
- Comprehensive and effective risk assessment will increasingly become the basis for the safe management of navigation, including means of VTS.

4.5 Conclusion of the Development of e-Navigation

It is generally accepted the role of shore organizations, particularly VTS, in contributing to prevent marine accidents. In VTS and other shore-based organizations, there are significant developments taking place in relation to the collection, management and display of information. The proposal paper to develop e-Navigation was submitted to IMO in December 2005 as a strategic vision for the utilization of existing and new navigational tools. This concept has been generally approved and the implementation stage of e-Navigation is now beginning.

e-Navigation will bring great impacts to whole shipping industry. Amongst those likely to be affected are seafarers, ship owners, pilots, equipment manufactures, VTS organizations, coastal states, port states and flag states. The overall maritime trends are likely to lead to the various consequences for e-Navigation. One of them is that it will be possible in detection, identification, and tracking of vessels on the global basis through the integration of LRIT, VMS and satellite-based AIS.

5 GENERAL INFORMATION CENTRE ON MARITIME SAFETY AND SECURITY (GICOMS)

5.1 Introduction

To improve the national capacity on maritime safety and security, the Korean Government has established the “General Information Centre on Maritime Safety and Security (GICOMS)”. The GICOMS is an information system which provides a general picture for all Korean ships regardless of their location in the world and for all foreign ships in Korean coastal waters on the basis of Geographic Information System (GIS), what is called “Global Vessel Monitoring System (VMS)[26]”. Moreover, the GICOMS is a national project to establish an information center to share information between related governmental agencies.

Since a large portion of marine accidents is involved in fishing vessels and small ships[27], the Korean Government recognized the necessity of intensive safety management for such ships in a systematic way. It is generally indicated that fishing vessels and small ships are vulnerable to accidents due to poor safety equipment. Recent marine accident statistics indicate that around 70% of marine accidents belong to fishing vessels and small ships in Korea. The maritime traffic management for such ships became an urgent issue in Korea.

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[26] The term of “Global Vessel Monitoring System (VMS)” is used as a integrated vessel monitoring system which includes all available systems, such as VTS, VHF DSC, MF/HF DSC, AIS, Mobile Phone and satellite in the concept of GICOMS system

[27] The Ship Safety Act (Article 2) defines that “small ship” is ship whose length is less than 12 meters.

In addition, the Korean Government recognized the benefits of data exchange and system integration. The GICOMS is a model case for data exchange and system integration in reflection with current trends in maritime sector. Furthermore, the GICOMS could be regarded as a precedent in the shore-based system of e-Navigation.

In this context, this Chapter gives an overview of the GICOMS system on the basis of plans and project papers published in the Ministry of Land, Transport and Maritime Affairs (MLTM)[28]. In addition, it investigates the process and current status on the implementation of GICOMS on the basis of official reports of public hearing and conference held by MOMAF during a consultation process. Finally, it evaluates the process of project implementation and discusses the issues to be considered from the perspective of future development of maritime traffic management in Korea.

5.2 Safety of Fishing Vessels and Small Ships

According to the accident statistics from Korea Maritime Safety Tribunal (KMST) for the period from 2005 to 2010, 72.2%[29] of marine accidents involved small-sized ships of less than 100 G/T and 67%[30] of marine accidents occurred in the coastal waters. Moreover, most marine accidents affect fishing vessels. According to the statistics[31], 70.4 % of accidents are caused by fishing vessels. Especially around half of the fishing vessel involved in accidents belong to small-sized fishing vessels of less than 20 G/T[32].

The more serious fact is that 65% of total life losses are caused in fishing vessel. 437 peoples died in fishing vessels accidents in the period of 5 years (2005-2010). In addition, about 134 peoples die annually in marine accidents in Korea (KMST, 2011).

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[28] The Ministry of Maritime Affairs and Fisheries (MOMAF) was changed into the Ministry of Land, Transport and Maritime Affairs (MLTM) in February, 2007.
[29] 2,984 incidents (72.2%) out of 4,136 incidents are caused by ships of less than 100 G/T.
[30] 2,118 incidents (67%) out of 4,136 incidents are caused in the coastal sea areas.
[31] 2,911 incidents (70.4%) out of 4,136 incidents are caused by fishing vessels.
[32] 1,320 (45.4%) incidents out of 2,911 incidents are caused by small sized fishing vessels of less than 20 G/T.

The above fact indicates that fishing vessels and small ships are more vulnerable to marine accidents compared to SOLAS Convention ships. It is also indicated that the poor emergency communications and distress alert system of small fishing vessels are affecting to higher accident portion of fishing vessels.

Table 1 shows the requirements of radio communication equipment. It indicates that there is no means of communications and distress alert especially for fishing vessels of less than 5 G/T.

Table 1 The Requirements of Radio Communication Equipment (Ship Safety Act)

Ship			Radio communication equipment	Remark
Non-Fishing Vessel	Ocean area		VHF(DSC), MF/HF(DSC), NAVTEX, Inmarsat, EPIRB, Radar Transponder(2), Portable VHF(3), SSAS, AIS	GMDSS
	Far coastal area		VHF(DSC), MF/HF(DSC), NAVTEX, Inmarsat, EPIRB, Radar Transponder(2), Portable VHF(3), SSAS, AIS	GMDSS
	Coastal Area	Above 300G/T	VHF(DSC), MF/HF(DSC), NAVTEX, EPIRB, AIS	
		Below 300G/T	VHF(DSC), EPIRB, AIS(partly)	
	Near coastal area		VHF(DSC)	
Fishing Vessel	Ocean area		VHF(DSC), MF/HF(DSC), NAVTEX, EPIRB Radar Transponder, PortableVHF, AIS	
	Coastal area	Above 24m	VHF(DSC), MF, EPIRB	
		Below 24m	VHF(DSC), MF	
	Near Coastal area	Above 5G/T	VHF(DSC)	
		Below 5G/T	**No Requirements**	

(Source: Author sourced from the Ship Safety Act)

Adequate means of emergency communications and distress alert are crucial for efficient search and rescue (SAR) operations. To reduce the number of accident, the means of emergency communications and distress alert are necessary for small fishing vessels.

5.3 Overview of the GICOMS

To face with a dramatic situation, the Korean Government has decided to act by launching the GICOMS system. The GICOMS is a national project to set up a marine crisis management system and an integrated maritime information system (MOMAF, 2002c). The GICOMS was established in order to enhance maritime safety and security and the efficiency of maritime traffic. Moreover, the GICOMS was designed to improve a national capability of response to incidents or dangerous situations at sea, including search and rescue (SAR) operations. One of the main targets of the GICOMS project is to enhance the safety of fishing vessels and small ships.

5.3.1 Background of the GICOMS

The rise of maritime transportation is mathematically increasing a risk of marine accidents. In addition, piracy and armed robbery against ships have increased along with the possibility of terrorist attacks on ships carrying hazardous cargo. Moreover, the importance of maritime security was recognized after the September 11 terrorist attack in the USA. To this end, there was a need to enhance the implementation of the monitoring and information system for maritime traffic by using the advanced information technologies.

To improve the capability of maritime monitoring and surveillance, it is crucial to extend the coverage of the monitoring area globally. The GICOMS collects ship's position information through the integration of existing systems, such as AIS network, VTS and satellite-based VMS. Ship's position information are gathered and managed in Global VMS. Global VMS is key element of the GICOMS system.

In addition, the GICOMS Data Centre has been set up at a national level. The purpose of this Data Centre is to facilitate the exchange and sharing of information among the governmental agencies in relation to human, ships and cargos.

In May 2001, the Ministry of Maritime Affairs and Fisheries (MOMAF) initiated an analysis of the working environments and established a five-year information strategy plan to establish the GICOMS system. The fundamental stage of the GICOMS project was carried out for 5 years from 2003 to 2007. Further, the expending stage of the GICOMS project has been carried out from 2008.

In the first-year of the fundamental stage, a national AIS network, a satellite-based VMS for international voyage merchant ships and a pilot system for the integrated information centre were established successfully. On the basis of the successful first-year's outcomes, the GICOMS project had been implemented phase by phase.

5.3.2 Objectives of the GICOMS

The GICOMS project aims to set up a national marine crisis management system on the basis of data exchange and system integration (see Figure 10). It also aims to improve the national capability of responding to marine accidents, incidents and potentially dangerous situations at sea. Furthermore, it is ultimately aimed to enhance maritime safety and security and protection of the marine environment (MOMAF, 2002a). It is hoped that the GICOMS system will play a significant role to enhance the safety of fishing vessels and small ships in the Republic of Korea.

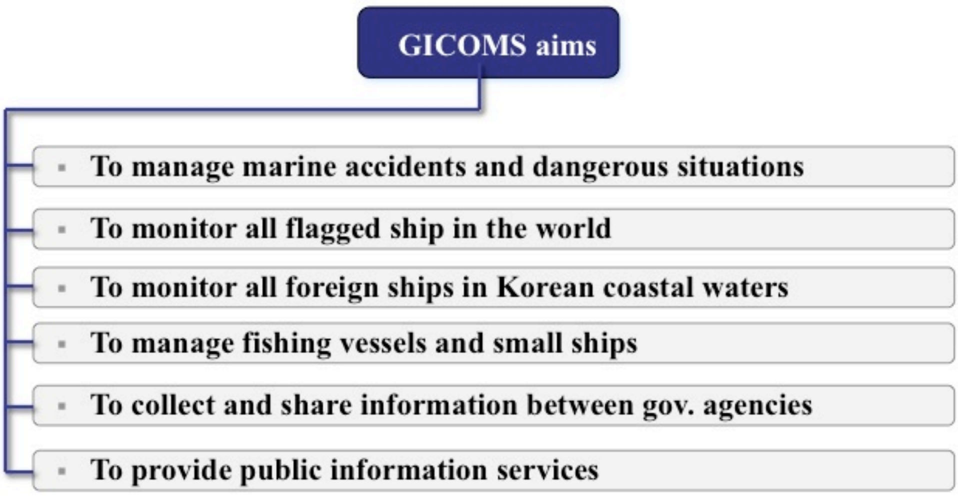

Figure 10 Objectives of GICOMS (Source: MLTM)

5.3.3 Legal Framework

MLTM is the responsible organization for establishment and implementation of the GICOMS. To facilitate the implementation of this project, MLTM established the guidelines and operational procedures. According to the procedures, the GICOMS Operation Centre was established in MLTM headquarter, in Seoul, in 2004. The GICOMS Operation Centre is in operation for 24 hours a day 365 days a year with exclusive 5 operating staff.

Since the global VMS is the essential part of GICOMS, the Korean Government amended the Ship Safety Act in January 2006 in order to include fishing vessels and small ships in the scope of global VMS. As described in Chapter 3, the carriage of ship position transmitter was mandated for all Korean ships by the Ship Safety Act. To implement the mandatory VMS to fishing vessels and small ships, MLTM established *"Implementation Plan of VMS"* in July 2006. The plan indicates that the purpose of mandatory VMS is to reduce the marine accidents by fishing vessels and small ships particularly in the coastal sea area (MOMAF, 2006a).

Currently, the Korean Government exempted fishing vessels from mandatory VMS scheme for a certain period in consideration of the opinion from fishing industry. According to the Ship Safety Law, the scope of the mandatory VMS should be determined by the Minister of Land, Transport and Maritime Affairs.

5.4 Components of GICOMS

GICOMS consists of four parts as shown in Figure 11: Global VMS; Marine Accident Management system; GICOMS Data Centre; and International Cooperation (MOMAF, 2002b). Each component of the GICOMS is detailed below.

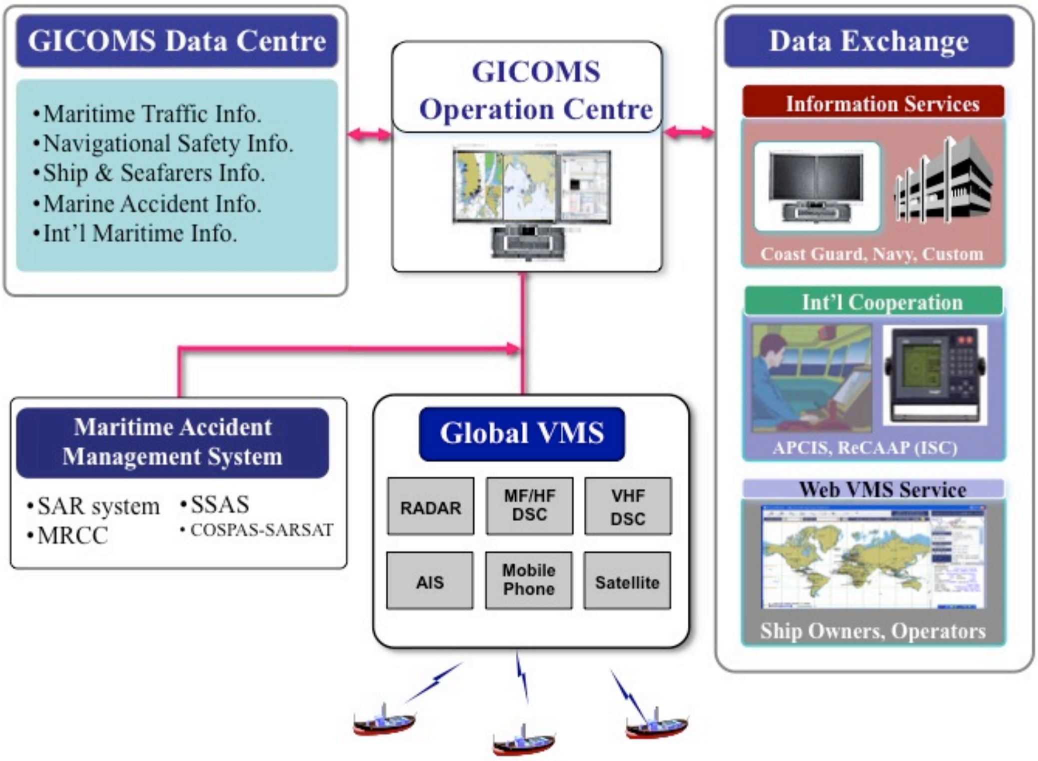

Figure 11 System Architecture of GICOMS (Source: MLTM)

5.4.1 Global VMS

Global VMS is the core part of the GICOMS system. Ship position information is a key data for situational awareness and initial response action to marine accidents. Global VMS is a ship position information system on the basis of ENC. It tracks all vessels in the coastal waters regardless of their flag and Korean flagged vessels in the EEZ and oceans.

Depending on the sea areas as defined in SOLAS Regulation IV/2[33], various communications are used to track vessels as shown in Table 2.

Table 2 Radio Communication Device for VMS

Sea Area	Radio Device	Remarks
A1	AIS, VHF DSC and Mobile phone	Within 30~50 n.m
A2	MF/HF Radio, Satellite	Within 150 n.m.
A3	Satellite	

(Source : MLTM)

Global VMS consists of port VTSs, national AIS network and satellite-based VMS as described in the following. Since vessels are operating in different areas, different systems are used to monitor all vessels depending on their operation areas. Global VMS gathers all information from the different systems.

a. Harbour VTSs

Harbour VTSs are traditional systems, which use radars and VHF. A total of fourteen VTS centres are in operation in Korean main ports. In the scope of the GICOMS project, the 14 VTS Centres were integrated into data centre and connected to the GICOMS Operation Centre. All radar target data can be monitored from GICOMS Operation Centre on real time basis. Moreover, a particular ship can be contacted via VHF radiotelephone or VHF DSC[34] from the GICOMS Operation Centre.

[33] According to SOLAS Regulation IV/2,
Sea area A1 means an area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available.
Sea area A2 means an area, excluding sea area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available.
Sea area A3 means an area, excluding sea areas A1 and A2, within the coverage of an INMARSAT geostationary satellite in which continuous alerting is available.
Sea area A4 means an area outside sea areas A1,A2, and A3.
[34] Digital Selective Calling

b. AIS Network

Pursuant to the SOLAS Convention, a National AIS network was established. It covers the whole Korean coastal area with the coverage of 50 nautical miles at least. All VTS centres have the AIS operation system to make use of AIS data as a VTS tool.

c. Satellite-based VMS

A satellite-based VMS covers all Korean ocean going vessels. Ships must report their position at regular intervals via a GMDSS satellite transmitter outside Korean coastal waters. Satellite-based VMS also performs the functions of the Ship Security Alert System (SSAS). Any satellite communications can be used at the shipowner's choice in VMS and SSAS system.

5.4.2 **Marine Accident Management System**

The marine accident management system is a supporting tool for the decision-making process against marine accidents or incidents related to maritime safety and security and marine environment. It creates an accident report automatically on the basis of received information via the government information network when an accident occurs at sea. The system spreads the accident report to the relevant agencies via all possible methods as soon as possible. It searches and extracts automatically and systematically from the GICOMS Data Centre all relevant information about the vessels involved in the accident such as shipowners, crews, cargo, last and next port of call and ship inspection.

Before this system, collecting information and making an accident report were carried out manually. It was time consuming work. Further, marine accident information was distributed and managed via the telephone, fax and e-mail. Converting into the standardized computerization system would contribute to the efficiency of accident analysis and the reliability of situational management. So far, this system is applicable for only Korean flagged ships (MOMAF, 2002b).

5.4.3 **GICOMS Data Centre**

The GICOMS Data Centre collects and exchanges information to speed up counter measures to marine accidents. It integrates a large number of individual databases or information systems in the country as shown in Table 3.

Table 3 The List of Individual Systems Consisting of GICOMS Data Centre

Category	Individual Information System
Marine Traffic Information	• VTS information (MOMAF) • AIS Network (MOMAF) • Satellite-based VMS (MOMAF) • LRIT Data Centre (MOMAF) • Fisheries information system (MOMAF) • Fisheries guidance ship information (MOMAF) • Passenger ship operation management system (Korea Coast Guard)
Navigational Safety Information	• Navigation safety information system (KMST) • Salvage management system (MOMAF) • NAVTEX (Coast guard) • Weather information system (Meteorological Administration) • Marine weather forecast system (MOMAF) • Tide and current signal system (local marine administration)
Ship & Seafarers Information	• Ship registration information system (MOMAF) • Ship inspection information system (ROs) • Port State Control information system (MOMAF) • Flag State Control information system (MOMAF) • Seafarers information system (MOAMF) • Port traffic and management system (MOMAF)
Marine Accident information	• SAR system and COSPAS-SARSAT (Coast Guard) • Marine rescue coordination system (Coast guard) • Marine accident information system (KMST) • Red-tide alert system (National Fisheries Research & Development Institute)
International Maritime Affairs Information	• International maritime affair information system (MOMAF) • APCIS (Tokyo-MOU) • ReCAAP ISC information network

(Source : MLTM, Design Plan for GICOMS)

A diversity of information about marine traffic information, navigational safety information, ship information and marine accident information are collected in the GICOMS Data Centre from the many different agencies in various formats. It processes the received data and stores them into a central database.

The purpose is to collect as much data as possible from all available sources in order to be able to cope with all situations as fast and efficient as possible. Where an accident occurs, all relevant information about the vessels can be searched from the GICOMS Data Centre on the basis of ship position information. These searched information can be utilized by related agencies, such as SAR authorities.

GICOMS Data Centre provides the users with an information service in many ways. The exclusive data link and specialized applications are used for the governmental agencies. For better information sharing, special information consoles are installed in specific agencies, such as Coast Guard and Local Maritime Authorities. In addition, the GICOMS Data Centre provides shipowners with VMS service on the basis of ENC via internet free of charge. The registered shipowners can search their own ship at any place wherever an internet service is available (see Figure 12).

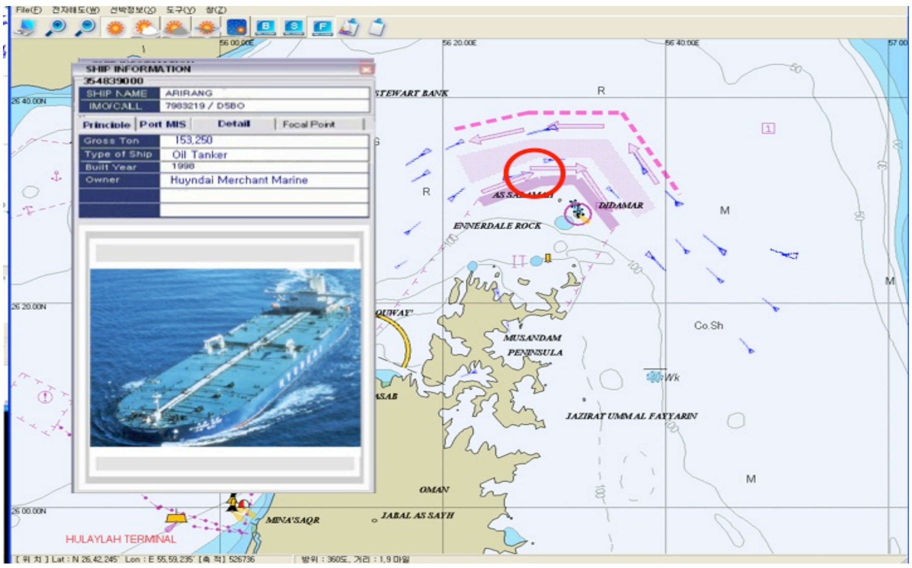

Figure 12 The Web Page of Web-VMS (Source: MLTM)

5.4.4 International Cooperation

The GICOMS system provides international cooperation with the Information Sharing Centre (ISC) of the Regional Cooperation Agreement on Anti-Piracy in Asia (ReCAAP). ISC was installed as an information interface terminal for international cooperation within member States networking and operating 24 hours. The GICOMS Operation Centre is playing a function as a focal point required by ReCAAP and maintaining communications networks with ISC. The GICOMS system also plays a role as a National LRIT Data Centre to exchange LRIT information (MOMAF, 2002b).

To participate in an international cooperation, the Korean Government has contributed[35] in the Marine Electronic Highway (MEH) project in the Straits of Malacca and Singapore since 2003. The MEH project has aimed to set up a prototype for the integration of the maritime safety component with the environmental protection and management technologies (Sekimizu, Sainlos & Paw, 2001). Pillich indicates that the MEH project is regarded as the first practical step towards e-Navigation conducted by IMO (Pillich, n.d.). There is potential possibility in mutual cooperation between the GICOMS and e-Navigation.

5.5 Perspective of GICOMS

5.5.1 Implementation of VMS for Fishing Vessels and Small Ships

As noted that the mandatory VMS could contribute to reducing the accident rate for small ships and fishing vessels, MLTM drafted a public notice on the mandatory VMS for fishing vessels. MLTM has a strong intention to include fishing vessels and small ships in the scope of Global VMS within the GICOMS system for safety and security purposes.

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[35]The Korean Government has participated in financial contribution to the MEH project from 2003. According to the MLTM, about 1 million USD was donated in the MEH project from the Korean Government.

As a consultation process, MLTM held public hearings 4 times in September 2006 at different local places to collect public opinions about the mandatory VMS for fishing vessels. According to the official reports of the public hearings, there are some negative opinions in implementing VMS for fishing vessels. Even though most of the people agreed basically on the mandatory VMS for fishing vessels for safety and security purposes, the fisheries industry was concerned that the VMS data could be used by law enforcement authorities. As a result, fishing vessels are excluded from the mandatory VMS at the moment. The fisheries industry requires the following (MOMAF, 2006b):

- To delay the implementation of mandatory VMS as long as possible;
- To make sure that the VMS data should not be used by law enforcement authorities; and
- To support the cost for installation of VMS device by the Government.

It is expected that the mandatory VMS for Korean fishing vessels would take a little longer. However, considering the positive effects of mandatory VMS, every ship should be tracked and monitored to protect human lives and properties at sea. It should be reminded the fact that 70.4 % of accidents are caused by fishing vessels and 437 peoples died by fishing vessels' accidents for 5 years.

In this context, the fishing industry should be accompanied and supported by the government in order to accept and integrate Global VMS installation. The target number of small ships and fishing vessels for VMS are shown in Table 4 together with the recommended VMS devices. Furthermore, the total cost for installation of VMS devices for a total of 31,119 ships (small ships 2,496, fishing vessels 28,623) is estimated[36] to around 24,984,900 USD based on Table 4.

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[36] The detail of total amount 24,984,900 USD are calculated as follows:
- · Fixed Devices : 10,672 ships × 1,000 USD = 10,672,000 USD
  · Potable Devices : 20,447 ships × 700 USD = 14,312,900 USD

According to the Ship Safety Act, the Minister of MLTM may decide the scope of the applicable ships for vessel monitoring system. The positive and active approach to the fisheries industry is necessary to achieve the ultimate goal of the GICOMS project.

Table 4 Number of Ships for VMS and Recommended VMS Devices

<table>
<tr><th colspan="2">Type</th><th>Number of Ships</th><th>Communications Devices</th><th>VMS Devices</th></tr>
<tr><td rowspan="2">Non-Fishing Vessels</td><td>Coastal Area (ships≥5G/T)</td><td>2,332</td><td>VHF</td><td>Classs-B AIS
VHF DSC,
SSB(modem)</td></tr>
<tr><td>Coastal Area (ships<5G/T)</td><td>164</td><td></td><td>Portable Device</td></tr>
<tr><td rowspan="2">Fishing Vessels</td><td>Coastal Area (ships≥5G/T)</td><td>8,340</td><td>VHF</td><td>Classs-B AIS
VHF DSC,
SSB(modem)</td></tr>
<tr><td>Coastal Area (ships<5G/T)</td><td>20,283</td><td></td><td>Portable Device</td></tr>
</table>

(Source: MLTM)

5.5.2 Perspective of GICOMS taking into account e-Navigation

As outlined in the Chapter 4, the core of shore-based e-Navigation is the integration of individual information systems and seamless information exchange in a unified and simple way.

Under the concept of e-Navigation, seamless information transfer between potential e-Navigation users will be provided. The integration of individual information systems and information sharing are the core part in the GICOMS project as well. The GICOMS project has been developed and implemented from the beginning of discussion of e-Navigation in IMO. In this context, the GICOMS project is regarded as an important precedent case in e-Navigation.

To concrete implementation of the GICOMS, it is crucial that the safety and security for fishing vessels and small ships should be managed. As discussed in this Chapter, the maritime traffic monitoring and surveillance for fishing vessels and small ships could contribute in reducing the marine accidents especially in the coastal waters. To this end, a legal framework for implementation of GICOMS should be improved. Moreover, the GICOMS system should be evaluated and upgraded continuously in line with the progress of the development of e-Navigation by IMO. All requirements for the e-Navigation adopted within the framework of IMO should be reflected in the GICOMS system and vice versa.

In addition to this, the user's opinion should be collected and reflected regularly during the process of system development.

5.6 Conclusion of the Development of the GICOMS

The GICOMS is considered as a successful model case for system integration and data exchange in maritime sector. The GICOMS has contributed in enhancing overall maritime safety, security and protection of marine environment in Korea. However, the monitoring for fishing vessels and small ships are remaining issue.

The GICOMS system is an integrated information system reflecting recent trends in maritime sector. In terms of data exchange and system integration, the GICOMS system could be regarded as a precedent of e-Navigation.

The GICOMS system should be evaluated and upgraded to reflect the progress of the development of e-Navigation by IMO. To concrete implementation of the GICOMS, the GICOMS system should be developed in line with e-Navigation through the international cooperation.

It is anticipated that the GICOMS will be a national marine crisis management system on the basis of Global VMS covering fishing vessels and small ship in near future.

6 CONCLUSION

This dissertation intended to review the existing systems for maritime traffic management and analyzed the trends of such systems taking into account e-Navigation. It also attempted to investigate the current status of development of e-Navigation and estimate consequences of e-Navigation. Furthermore, it reviewed the case of GICOMS project of the Republic of Korea as a precedent of e-Navigation. Ultimately, this dissertation aimed to study the prospects for evolution of maritime traffic management taking into account e-Navigation. It is hoped that this research works would be helpful to policy makers for providing policy options on the future direction of national marine traffic management in the Republic of Korea.

At the outset, the author examined the traditional systems for maritime traffic management, namely VTS, Mandatory Ship Reporting System and VMS. Vessel movement information is a key for maritime traffic managements and surveillance. Also, without ship's position information, it would not be possible to conduct search and rescue operations efficiently. It is true that VTS has played a significant role in reducing marine accidents in the area of ports and their approaching channels.

VTS is primarily a shore-based maritime traffic management system. The benefits of VTS are that it allows identification and monitoring of vessels, strategic planning of vessel movements and provision of navigational information and assistance. VTS renders information services at fixed times or at the request of a vessel. It also renders the navigational assistance services and the traffic organization services to prevent congestion and dangerous situations in the VTS area. Shore VTS centres should be equipped with radar systems to detect vessels, radio communications systems to communicate with vessels, and operating staff. Vessels navigating in a VTS should make use of VTS services for the safety of navigation and port operation.

There are two types of ship reporting systems under the international conventions. The mandatory ship reporting system under the SOLAS Convention for the purpose of maritime safety or the marine environment should be accepted by IMO. The master of a ship must report to the appropriate authority. The system should be operated by the shore-based authority designated by a Contracting Government. The participation of ships should be subject to no cost. STRAITREP is an example of the mandatory ship reporting system operated by VTS authorities in the Straits of Malacca and Singapore.

On the contrary, the ship reporting system under the SAR Convention is not required to be accepted by IMO but generally operated generally by MRCC for SAR operations. Reporting of a ship location makes RCCs take a positive SAR watch. If a regular position report or final report is not received from a ship, RCCs will check for the safety of the ship. If these checks are unsuccessful, then they will initiate SAR operations. In this context, it is important that the masters of ships should comply with the defined procedures for reporting ship's position. AMVER and AUSREP are good examples of ship reporting systems for SAR operated coast guard as an MRCC.

VMS collects position and operation data from ships automatically. Generally it is used in commercial fishing to monitor and regulate fishery resources by fishery authorities. It is noted that VMS is an essential tool as an approved monitoring, control and surveillance system. FAO encourages states to implement effective fisheries monitoring, control, surveillance and law enforcement measures including VMS. As a result, most fishery authorities are operating VMS as a MCS tool against IUU fishing in both national and international contexts.

The author has analyzed the trends of maritime traffic management particularly on the basis of the systems for the identification and tracking of ships in both short-range and long-range. As a result, the integration of systems and information sharing seem to be the trends in the maritime systems during the last decade. Especially, maritime security has been an issue together with maritime safety. As measures to strengthen maritime security and to combat maritime terrorism, the carriage of the AIS and SSAS was mandated on board vessels in 2004. Also, IMO adopted LRIT for global identification and tracking of vessels in 2006. Moreover, IMO mandates to install ECDIS on board vessels from 2012. It is clear that such new technologies have brought great influences on maritime traffic monitoring and surveillance in the world.

AIS has changed the working environment not only on board ships but also in shore stations. AIS allows to automatically identify and track ships in a short range. The most benefit of AIS for mariners is its capabilities to increase navigational situation awareness and help in collision avoidance in the ship-to-ship mode. Moreover, AIS has become a key element in VTS. AIS can assist in identifying targets, by name or call sign and by ship type and navigational status. In addition to the automatic identification of vessels, AIS has many possible functions and benefits as VTS tools, such as improved tracking area outside of the radar coverage and electronic transfer of safety messages. AIS can also be used in search and rescue operations. AIS will become a key part in an overall international maritime information system, supporting voyage planning and monitoring. This will help Administrations to monitor all the vessels in their areas of concern and to track dangerous cargo.

Although AIS has many benefits, AIS users should keep in mind that there are some limitations. Since all vessels may not be equipped with AIS, AIS users should not be overly dependent on AIS as means for vessel identification. Moreover, AIS users should remember that AIS data might include errors. The unreliability of AIS data is a critical issue. Since the effectiveness of such systems depends upon the competence of those who operate them, the ship operator should be trained and educated properly. In addition, proper supervision of data accuracy by competent maritime authorities would enhance its efficiency in all navigation operations.

While AIS is designed for coastal areas, LRIT is designed to provide the global identification and tracking of ships. Ships should automatically transmit LRIT information, which can be provided to contracting governments and search and rescue authorities, upon request, through a system of national, regional and cooperative LRIT Data Centres using the International LRIT Data Exchange.

As outlined before, it is clear that the data exchange and system integration are current trends in maritime traffic management systems. Various VMS data exchange networks are in operation between fisheries authorities to share data on IUU vessels at the international level. Many regional AIS networks are used in the world to make use of the benefit of AIS information. LRIT information is also shared via LRIT Data Exchange between Contracting Governments globally.

With a view to the technological advances in maritime traffic monitoring systems, it is expected that VTS would be extended into vessel traffic management and information systems (VTMIS). As shown in the EU Directive, VTMIS is integration of various systems such as VTS, AIS, VMS, LRIT and data exchange system. Through the data exchange system, VTS centres, maritime authorities, fisheries monitoring authorities and maritime rescue coordination centres may utilize the ship movement information regardless of location in the world. It is likely that implementation of LRIT would accelerate the system integration because existing VMSs are regarded as LRIT Data Centre in accordance with the SOLAS Regulation.

Furthermore, the technological advances allow to facilitate identification and tracking of fishing vessels and small ships in coastal areas. Especially, class B AIS was developed for non-SOLAS ships. It is likely that AIS will play a key role in monitor small ships including fishing vessels, pleasure craft and inland waterway vessels in the near future.

The author, then, examined the development of e-Navigation based on the current status and trends in maritime traffic management systems. It is indicated that e-Navigation has the potential to enhance maritime safety and security, protection of the environment; the efficiency of operations and the human resource management. It is expected that e-Navigation would play a role to overcome the shortcomings accompanied by new technologies and systems in the maritime sector. Full implementation of e-Navigation would bring great impacts on the whole shipping industry. Also, e-Navigation is a broad and long-term concept involving many stakeholders and has the potential to impact on the entire maritime community. Amongst those likely to be affected are seafarers, ship owners, pilots, equipment manufactures, VTS organizations, coastal states, port states and flag states.

The overall maritime trends are likely to lead to various consequences for e-Navigation. One of them is that it will be possible in detection, identification, and precise tracking of vessels regardless of ship's location on a global basis through the integration of LRIT, VMS and satellite-based AIS.

Finally, the author has reviewed the GICOMS project as a precedent in e-Navigation. Under the concept of the GICOMS, all possible existing maritime systems have been integrated at a national level and GICOMS Data Centre was established for information exchange among the related government agencies. GICOMS has been evaluated as a successful project to enhance maritime safety, security and marine environment protection. However, from the implementation point of view, the GICOMS system does not play a role in the safety of fishing vessels and small ships, because the legal framework was not set up to apply the mandatory vessel monitoring scheme for them.

As described in Chapter 5, fishing vessels and small ships are more vulnerable to marine accidents compared to SOLAS ships. Statistics indicate that most marine accidents are occurred by small-sized ships and fishing vessels in coastal waters. Moreover, in fishing vessels less than 5 G/T, there are no means for emergency communication and distress alerts. To reiterate the argument, fishing vessels and small ships should be managed in a systematic way in order to reduce marine accidents in coastal waters and to save human lives at sea. In this context, the author emphasizes the importance of the implementation of the mandatory VMS for fishing vessels and small ships to reduce marine accidents in coastal areas.

To apply the mandatory VMS to fishing vessels and small ships, the author is of the opinion the following issues should be considered.

Firstly, with a view to the poor economic condition of the fisheries industry, the installation of VMS equipment on fishing vessels and small ships should be supported by the government. As reviewed in Chapter 5, the target number of small ships and fishing vessels for VMS are 31,119 ships (small ships 2,496, fishing vessels 28,623). The estimated installation cost should be covered by the financial assistance from the government. The effort to establish new funds for supporting installation costs would be desirable in cooperation between the government and the marine insurance industry, because the insurance industry will be a primary beneficiary in the reduction of marine accidents.

Secondly, the position information for fishing grounds should be protected. Apart from the possibility of illegal fishing, position data for successful fishing grounds is highly valuable information commercially. For this reason, the fishing industry objects to provide VMS information. Therefore, this matter should be reflected in the development of VMS devices and shore facilities. In addition, it should be assured that the position information of fishing vessels should not be used for law enforcement purposes by marine police agencies, but it should be used solely for safety and security purposes.

Lastly, the operation coasts of VMS would be subjected to the government. In satellite-based VMS, the communication costs should be paid by shipowners. However, in the system for safety purposes, the operation costs should be covered by the government.

In conclusion, the legal framework for implementation of GICOMS should be improved. Even thought the system integration and information sharing facilitation have been established successfully, the system is not fully implemented yet due to lack of participation from fishing vessels and small ships. To realize and achieve the ultimate goal of the GICOMS and e-Navigation, all ships in all waters should participate in such systems. In addition, the GICOMS system should be evaluated and upgraded continuously in line with the progress of the development of e-Navigation by IMO. All requirements for e-Navigation adopted within the framework of IMO should be applied to the GICOMS system. In the process of this application, the user's opinion should be collected and reflected regularly.

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