

A.E.N ΜΑΚΕΔΟΝΙΑΣ

ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

ΕΠΙΒΛΕΠΩΝ ΚΑΘΗΓΗΤΗΣ: ΠΑΝΑΓΟΠΟΥΛΟΥ ΜΑΡΙΑ

ΘΕΜΑ: NAVIGATION AIDS AND SYSTEMS

ΤΟΥ ΣΠΟΥΔΑΣΤΗ: ΤΣΟΚΟΣ ΙΩΑΝΝΗΣ

A.Γ.Μ: 3491

Ημερομηνία ανάληψης της εργασίας:

Ημερομηνία παράδοσης της εργασίας:

<i>A/A</i>	<i>Όνοματεπώνυμο</i>	<i>Ειδικότης</i>	<i>Αξιολόγηση</i>	<i>Υπογραφή</i>
<i>1</i>				
<i>2</i>				
<i>3</i>				
ΤΕΛΙΚΗ ΑΞΙΟΛΟΓΗΣΗ				

Ο ΔΙΕΥΘΥΝΤΗΣ ΣΧΟΛΗΣ :

TABLE OF CONTENTS

1. INTRODUCTION	3
2. DEFINITIONS	5
3. AIDS TO NAVIGATION	6
3.1 TYPES OF AIDS TO NAVIGATION.....	6
3.2 EVOLUTION OF ATON.....	7
3.3 VIRTUAL AIDS TO NAVIGATION.....	8
3.4 IALA SYSTEM.....	10
3.5 RACONS.....	15
4. NAVIGATION SYSTEMS	17
4.1 COMPASS.....	17
4.2 LORAN C.....	21
4.3 GPS.....	22
4.4 AIS.....	26
4.5 RADAR.....	28
4.6 ECDIS.....	30
4.7 LRIT.....	33
4.8 VDR.....	34
5. RESOURCES AND BIBLIOGRAPHY	35

1. INTRODUCTION

Navigation is the art of getting from one place to another, safely and efficiently. Whenever you find a store in a mall or walk home from school, you are using the tools of the early navigators. But what if you found yourself in a place you didn't recognize such as out in the middle of the ocean?

The first record of boats large enough to carry goods for trade is around 3500 B.C. and this would mark the birth of the art of navigation. These first navigators stayed close to shore and navigated by sight of landmarks or land characteristics that they could see. Usually they travelled by day and sought a calm harbor or anchorage at night. But the need they had to explore more of the vast blue was what forced them to find ways that would help them navigate further. When they did venture out of sight of land, the navigators were able to determine their latitude (north/south direction) by observing the height of the sun during the day and the North Star at night.

Experienced mariners were said to plot their course by major constellations, though this was not an exact science. Vessels followed the east/west movement of the sun or the track of the stars. However, longitude could only be estimated, at best. This was because the measurement of longitude is made by comparing the time-of-day difference between the mariner's starting location and new location. Even some of the best clocks of the early eighteenth century could lose as much as 10 minutes per day, which translated into a computational error of 150 miles or more.

In 1764, British clockmaker John Harrison (1693–1776) invented the seagoing chronometer. This invention was the most important advance to marine navigation in the three millennia that open-ocean mariners had been going to sea.

In 1779, British naval officer and explorer Captain James Cook (1728–1779) used Harrison's chronometer to circumnavigate the globe. When he returned, his calculations of longitude based on the chronometer proved correct to within 8 miles. From information he gathered on his voyage, Cook completed many detailed charts of the world that completely changed the nature of navigation.



Picture 1 First type of compass

The navigators realized that they had to invent some tools that would help them orientate when they were in the middle of the ocean. One of the earliest man-made navigation tools was the mariner's compass, an early form of the magnetic compass (c.13th Century). Initially used only when the weather obscured the sun or the North

Merchant Marine Academy of Macedonia

Star, these first compasses were very crude. The navigator would rub an iron needle against a lodestone, stick it in a piece of straw and float it in a bowl of water. The needle would point in a northerly direction. Early mariners found the compass inconsistent – most likely because they did not understand that it pointed to the magnetic north pole, not true north (This is called variation). At the time, they could not explain these variations and could not put much trust in the readings when navigating an unknown area.

During the mid-thirteenth century, mariners began realizing that maps could be helpful and began keeping detailed records of their voyages. Thus, the first nautical charts were created. These first charts were not very accurate, but were considered valuable and often kept secret from other mariners. There was no latitude or longitude labeled on the charts, but between major ports there was a compass rose indicating the direction to travel.



Picture 2 Course plotting equipment

2. DEFINITIONS

Definition of the navigation aid:

According to the glossary of terms in the United States Coast Guard Light list, an Aid to Navigation (ATON) is any device external to a vessel or aircraft specifically intended to assist navigators in determining their position or safe course, or to warn them of dangers or obstructions to navigation.

On land, people get from place to place by using maps and by paying attention to street signs, stop signs, detours, and traffic lights. On the water, mariners navigate by using nautical charts and by paying attention to Aids to Navigation (ATON)-lights, buoys, daymarks, and fog signals. A nautical chart is a special map that shows what is under, in, on, and around water. Buoys are floating aids that are anchored to the seabed. Mariners interpret what they mean by their shape, color, and the characteristics of lights and sound signals. Beacons are fixed to the earth's surface (not floating) and can be anything from big lighthouses to a sign nailed to some pilings. Lighted beacons are simply called lights; unlighted beacons are called daybeacons and have shapes or colored signs to distinguish them from other beacons. Mariners can determine which beacon or buoy they are looking at by how they are marked and then comparing them to the chart. Buoys come in different shapes and colors and many are marked with numbers. Lighthouses are painted in different patterns and colors so they can be distinguished from one another. The characteristics for all ATON maintained by the Coast Guard are noted on charts and published in the USCG Light List.

Definition of the navigation system:

A navigation system is a (usually electronic) system that aids in navigation. Navigation systems may be entirely on board a vessel (on the ship's bridge), or they may be located elsewhere and communicate via radio or other signals with a vessel, or they may use a combination of these methods.

Navigation systems may be capable of:

- containing maps, which may be displayed in human readable format via text or in a graphical format
- determining a vessel's location via sensors, maps, or information from external sources
- providing suggested directions to a human in charge of a vessel via text or speech
- providing directions directly to an autonomous vehicle such as a robotic probe or guided missile
- providing information on nearby vessels, or other hazards or obstacles

- providing information on traffic conditions and suggesting alternative directions.

3. AIDS TO NAVIGATION (ATON)

3.1. TYPES OF AIDS TO NAVIGATION

The term "aids to navigation" encompasses a wide range of floating and fixed objects (fixed meaning attached to the bottom or shore), and consist primarily of:

- Buoys - floating objects that are anchored to the bottom. Their distinctive shapes and colors indicate their purpose and how to navigate around them.
- Beacons -Which are structures that are permanently fixed to the sea-bed or land. They range from structures such as light houses, to single-pile poles. Most beacons have lateral or non-lateral aids attached to them. Lighted beacons are called "lights", unlighted beacons are "daybeacons". Both Buoys and Beacons may have lights attached, and may have a sound making device such as a gong, bell or horn. Both Buoys and Beacons may be called "marks".

A marine aid to navigation (AtoN) may be defined as a signal deliberately placed to provide mariners with information. The signal may be:

- Visual
- Sound
- Electromagnetic (radio) IALA maritime buoyage system

A station may be defined as a point on the earth's surface defined by geographic coordinates. The following are the categories:

- Land (a fixed station accessible by land)
- Offshore (a fixed station only accessible by boat or helicopter)
- Floating (Light Vessels, Light Floats, Large Automatic Navigation Buoys, Buoys)

Several AtoN may be exhibited or transmitted from a single station and may comprise one or a number of the following AtoN:

- A Daymark and/or Topmark (including pole marker beacons, withies, perches)
- Warning Notices e.g. notice boards which may or may not be illuminated o
- Leading Mark (one of at least two separate daymark structures that provide a leading line)
- Main light

- Sector light (intensified or unintensified arc of visibility and/or color either as part of the main light or provided in addition to the main light, in which case the term subsidiary light is commonly used)
- Auxiliary light (a light of noticeable less intensity than the main light(s))
- Precision Direction Light (a light visible over a very narrow angle to indicate a direction to be followed)
- Leading Light (one of at least two lights, which are situated on at least two separate structures that provide a leading line)
- Emergency light (a light introduced upon the failure of lights, operated by a completely separate power supply, which may be of noticeable less intensity than the Main Light(s))
- Fog Signal
- Radar Target Enhancer
- Loran C (and other radio navigation systems)
- Differential GPS Signals
- Automatic Identification Systems (AIS)

3.2. EVOLUTION OF ATON

It is important that mariners don't confuse one navigational aid with another one. The way the light is produced in lighthouses and lightships changed over time with the development of new technologies. The first lighthouse ever built, the Pharos lighthouse in Egypt, built in the 3rd century BC, was lit with fire and was reflected out to sea with mirrors. Some of the earliest lights were made with multiple-wicked oil lamps with reflectors to concentrate it into a beam of light. In the 1820s, a French physicist, Augustin Fresnel, invented a special glass lens with rings, reflectors, and prisms that surrounded a single lamp.

These lenses proved to be so effective that many are still used today. Sound signals are also used to guide boats and ships in reduced visibility, such as fog. In colonial times, people fired cannons from shore to warn ships that they were getting close to land. Today, many buoys and beacons are equipped with bells, whistles, gongs, horns, and air sirens. Lightships were floating aids to navigation that were stationed in places where it was either too deep, too far from shore, or too dangerous to build a lighthouse. These vessels carried the same aids to navigation as lighthouses. The Coast Guard doesn't use lightships anymore. In 1983, the Nantucket Light ship, the last lightship in service as an ATON, was replaced with a Large Navigational Buoy (LNB). These "monster buoys" are up to 40 feet in diameter. Different types of towers are now built in some of the stations that used to be marked by lightships.



Picture 3.1 Pharos Lighthouse of Alexandria

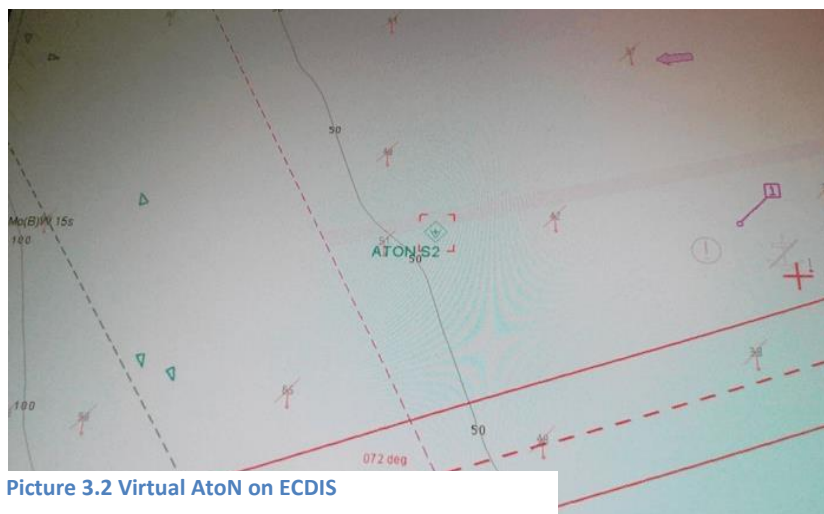
3.3. VIRTUAL AIDS TO NAVIGATION

A navigational aid or AtoN or navaid is any sort of marker that guides to mark safe waters and also help mariners in determining their position with respect to land or any navigational hazard or hidden danger. Traditionally aids to navigation have been physical aids such as lighthouses, buoys and beacons. The introduction of virtual aids to navigation has been one of the greatest achievements in recent navigation history. Though many are presently under development, they are used by a number of administrations around the world.

A virtual aid to navigation itself does not physically exist unlike buoys and beacons but comprises a signal broadcast to a location in a waterway. It can be described as a digital information transmitted from an Automatic Identification System (AIS) station located elsewhere for a specified location without being itself present in that specified location or simply stated, an electronic virtual marker of a hazard. The basic symbol of a virtual AIS aid to navigation looks like a diamond shape with cross hair at the centre on ECDIS or radar.

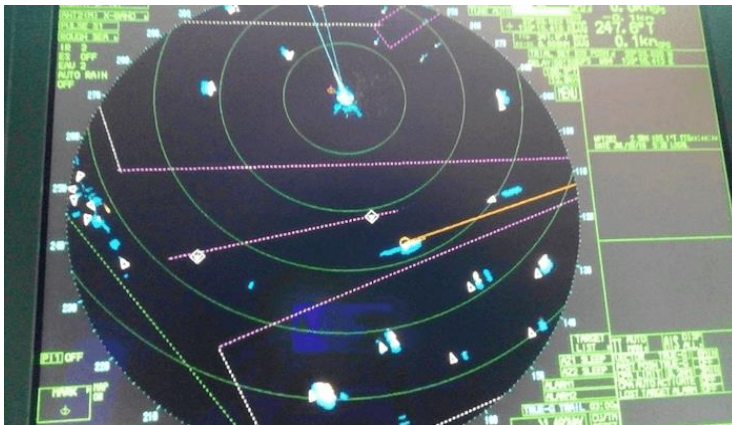
Virtual aids to navigation are potential in enhancing safety and their use brings us several advantages. Some of the reasons why it is considered important to ship navigation are pointed out below:

1. A virtual aid to navigation can be used in situations when it is not practically possible to equip or due to limitation of time a physical aid to navigation such as a buoy, beacon or a lighthouse cannot be set up. In this case virtual aid to navigation can be used whereby an AIS coast station can be configured to send information to mark its location and therefore help navigating officers to get the necessary information in real time.



Picture 3.2 Virtual AtoN on ECDIS

2. Virtual aids to navigation can be deployed rapidly to mark immediate wrecks. The implementation of virtual AtoN can be completed within a very short duration of time thereby aiding mariners to avoid unexpected hazards and dangers to navigation that can arise any time without any prior information by giving early warning. Hence, we can say that it prevents accidents through proactive notifications.
3. Another great benefit of using a virtual aid to navigation is that they are not prone to weather. Unlike traditional buoys or beacons that may not get detected, good or bad weather they will always be detected and displayed on Electronic Chart Display and Information System (ECDIS) or radar overlay and provide timely information to mariners.
4. They can be extremely helpful in areas where physical buoys are seasonally lifted or misplaced due to swell or ice or when a buoy is off station or damaged due to any natural disaster. It is difficult to install a physical buoy in areas prone to environmentally harsh conditions. Virtual aids to navigation can therefore help to overcome such difficulties.
5. Virtual aids to navigation are easy to install and do not require costly physical infrastructure unlike the physical aids to navigation. They also need less maintenance. This is yet another reason for its rapid growth and wide acceptance among authorities. They have the ability to move the marked locations as conditions change with ease and can also be removed when the wreck is no longer considered a danger to navigation.



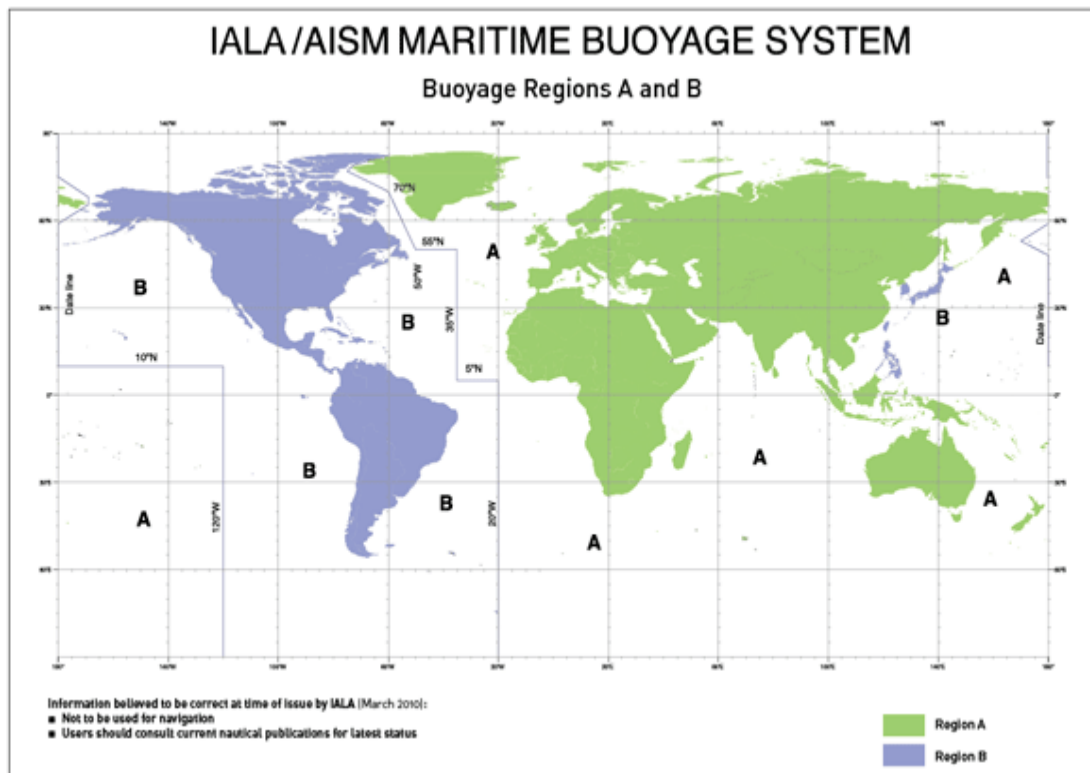
Picture 3.3 Virtual Aid on Radar display

6. Virtual aids to navigation can also be used to mark anchorages, restricted or dangerous areas as well as in environmentally sensitive and isolated coastline where there are no beacons or buoys. They can provide additional information about reporting points to officers. Besides, virtual aids to navigation provide good coverage in spite of rugged landscape or when approaching from internal waters. Ships can

identify dangerous underwater hazards well ahead before approaching and can know if they are on a collision course with any navigational hazard.

3.4. IALA SYSTEM

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA, previously known as International Association of Lighthouse Authorities) is a non-profit organization founded in 1957 to collect and provide nautical expertise and advice. IALA brings together representatives of the aids to navigation services of about 80 countries for technical coordination, information and sharing of improvements to aids to navigation throughout the world. The IALA system is divided between two regions, region A and region B which have differences on the color of the lateral marks.



Picture 3.4 IALA Regions

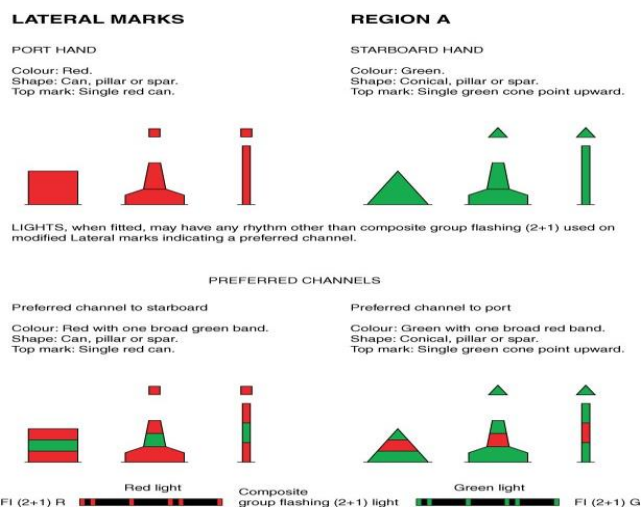
General principles of the system:

- The responsibility for safe navigation resides with the mariner, through the appropriate use of aids to navigation in conjunction with official nautical documents and prudent seamanship, including voyage planning as defined in IMO Resolutions.

- The IALA Aids to Navigation system has two components: The Maritime Buoyage System and other aids to navigation comprised of fixed and floating devices. This is primarily a physical system, however all of the marks may be complemented by electronic means.
- Within the Maritime Buoyage System there are six types of marks, which may be used alone or in combination. The mariner can distinguish between these marks by identifiable characteristics. Lateral marks differ between Buoyage Regions A and B, whereas the other five types of marks are common to both regions.

These marks are described below:

Lateral marks: Following the sense of a ‘conventional direction of buoyage’, lateral marks in Region A utilize red and green colors by day and night to denote the port and starboard sides of channels respectively. However, in Region B these colors are reversed with red to starboard and green to port. A modified lateral mark may be used at the point where a channel divides to distinguish the preferred channel, that is to say the primary route or channel that is so designated by the competent authority.



Picture 3.2 Lateral marks

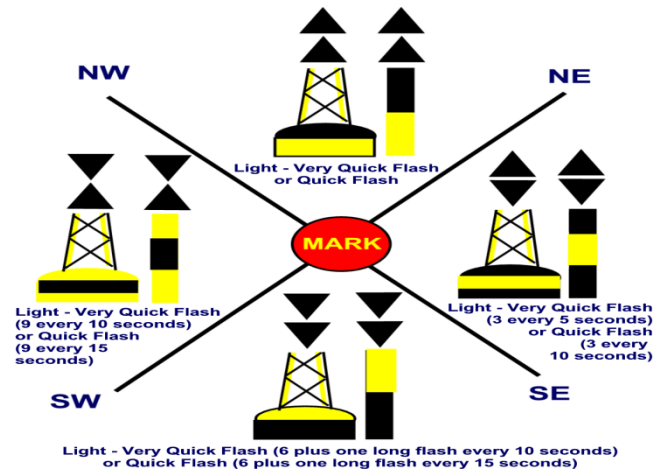
Cardinal marks: Cardinal marks

indicate that the deepest water in the area lies to the named side of the mark. This convention is necessary even though for example, a North mark may have navigable water not only to the North but also East and West of it. The mariner will know it is safe to the North, but shall consult the chart for further guidance. Cardinal marks do not have a distinctive shape but are normally pillar or spar. They are always painted in yellow and black horizontal bands and their distinctive double cone top-marks are always black. An aide-memoire to their coloring is provided by regarding the top-marks as pointers to the positions of the black band(s):

- North:
 Top-marks pointing upward: black band above yellow band.
- South:
 Top-marks pointing downward: black band below yellow band.

- East:
Top-marks pointing away from each other: black bands above and below a yellow band
- West:
Top-marks pointing towards each other: black band with yellow bands above and below

Cardinal marks also have a special system of flashing white lights. The rhythms are basically all “very quick” (VQ) or “quick” (Q) flashing but broken into varying lengths of the flashing phase. “Very quick flashing” is defined as a light flashing at a rate of either 120 or 100 flashes per minute, “quick flashing” is a light flashing at either 60 or 50 flashes per minute. The characters used for cardinal marks will be seen to be as follows:



Picture 3.3 Cardinal marks

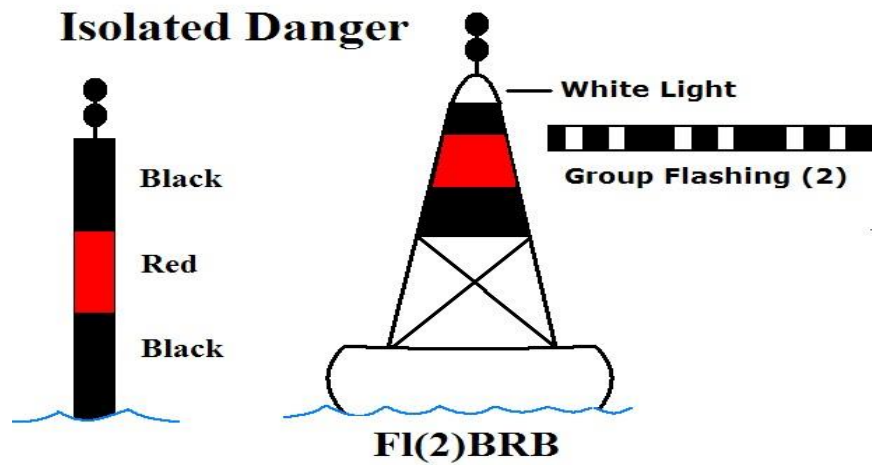
- North:
Continuous very quick flashing or quick flashing
- East:
Three “very quick” or “quick” flashes followed by darkness
- South:
Six “very quick” or “quick” flashes followed immediately by a long flash, then darkness.
- West:
Nine “very quick” or “quick” flashes followed by darkness.

The concept of three, six, nine is easily remembered when one associates it with a clock face. The long flash, defined as a light appearance of not less than 2 seconds, is merely a device to ensure that three or nine “very quick” or “quick” flashes cannot be mistaken for six. It will be observed that two other marks use white lights; Isolated Danger marks and Safe Water marks. Each has a distinctive light rhythm that cannot be confused with the very quick or quick flashing light of the Cardinal marks.

Isolated danger mark:

The Isolated Danger mark is placed on, or near to a danger that has navigable water all around it. Because the extent of the danger and the safe passing distance cannot be specified for all circumstances in which this mark may be used, the mariner shall

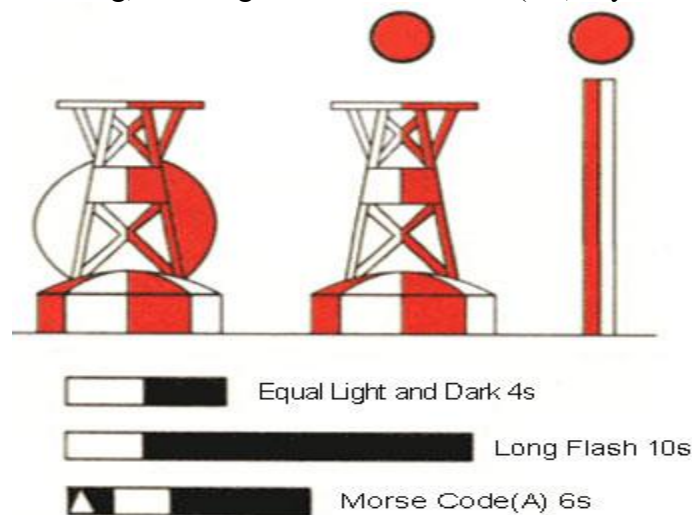
consult the chart and nautical publications for guidance. Distinctive double black spherical top-marks and Group flashing (2) white lights, serve to distinguish Isolated Danger marks from Cardinal marks.



Picture 3.7 Isolated Danger mark

Safe water mark:

The Safe Water mark has navigable water all around it, but does not mark a danger. Safe Water marks can be used, for example, as fairway, mid-channel or landfall marks. Safe Water marks have an appearance different from danger marking buoys. They are spherical, or alternatively pillar or spar with red and white vertical stripes and a single red spherical top-mark. Their lights, if any, are white using isophase, occulting, one long flash or Morse "A" (• -) rhythms.

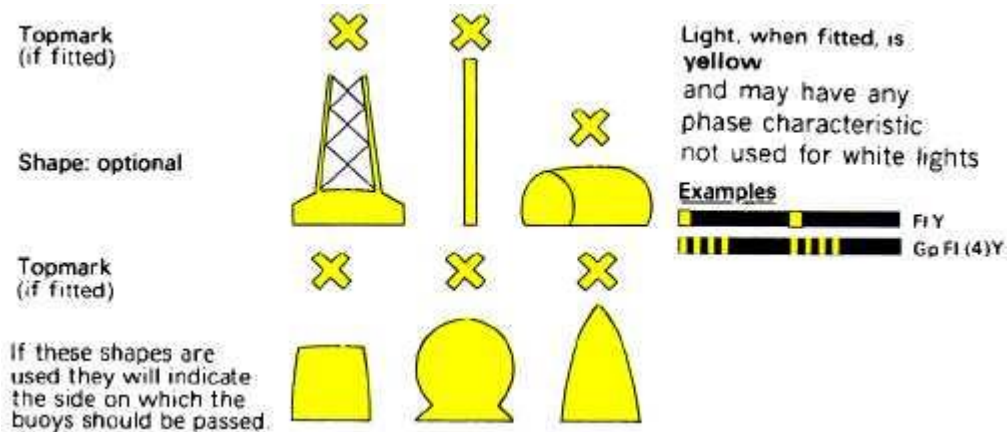


Picture 3.8 Safe water mark

Special marks:

Special marks are used to indicate a special area or feature whose nature may be apparent from reference to a chart or other nautical publication. They are not generally intended to mark channels or obstructions where the MBS provides suitable alternatives. Special marks are yellow. They may carry a yellow "X" top-mark, and

any light used is also yellow. To avoid the possibility of confusion between yellow and white in poor visibility, the yellow lights of Special marks do not have any of the rhythms used for white lights. Their shape will not conflict with that of navigational marks. This means, for example, that a special buoy located on the port hand side of a channel may be cylindrical but will not be conical. Special marks may be lettered or numbered, and may also include the use of a pictogram to indicate their purpose using the IHO symbology where appropriate.

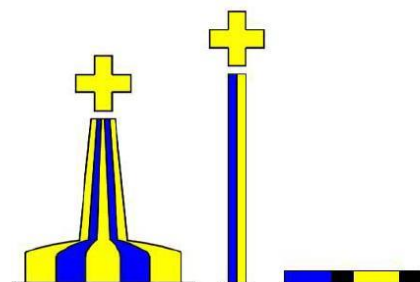


Picture 3.9 Special mark

Marking new dangers:

“New Dangers” are newly discovered hazards, natural or man-made, that may not yet be shown in nautical documents and publications, and until the information is sufficiently promulgated, should be indicated by:

- marking a new danger using appropriate marks such as; Lateral, Cardinal, Isolated Danger marks, or equally
- using the Emergency Wreck Marking Buoy (EWMB)



Picture 3. 4 Emergency wreck marking buoy (EWMB)

If the competent authority considers the risk to navigation to be especially high at least one of the marks should be duplicated. The Emergency Wreck

Marking Buoy has blue and yellow vertical stripes in equal number, with a vertical/perpendicular yellow cross top-mark, and display a blue and yellow alternating light. Marking of a new danger may include use of a Racon coded Morse “D” (- ●●) or other radio transmitting device such as automatic identification systems as an Aid to Navigation (AIS as an AtoN). Marking of a new danger may be discontinued when the appropriate competent Authority is satisfied that information

concerning the “New Danger” has been sufficiently promulgated or the danger has been resolved.

Other marks:

Other Marks include lighthouses, beacons, sector lights, leading lines, major floating aids, and auxiliary marks. These visual marks are intended to aid navigation as information to mariners, not necessarily regarding channel limits or obstructions.

- Lighthouses, beacons and other aids of lesser ranges are fixed aids to navigation that may display different colors and/or rhythms over designated arcs. Beacons may also be unlighted.
- Sector lights display different colors and/or rhythms over designated arcs. The color of the light provides directional information to the mariner.
- Leading lines / Ranges allow ships to be guided with precision along a portion of a straight route using the alignment of fixed lights (leading lights) or marks (leading marks), in some cases a single directional light may be used.
- Major floating aids include lightvessels, light floats and large navigational buoys intended to mark approaches from off shore.
- Auxiliary Marks are those other marks used to assist navigation or provide information. These include aids of non-lateral significance that are usually of defined channels and otherwise do not indicate the port and starboard sides of the route to be followed as well as those used to convey information for navigational safety.
- Port or Harbor Marks such as breakwater, quay/jetty lights, traffic signals, bridge marking and inland waterways aids to navigation.

3.5 RACONS

RACONS, also called radar responders, or radar transponder beacons, are receiver/transmitter transponder devices used as a navigation aid, identifying landmarks or buoys on a shipboard marine radar display. A racon responds to a received radar pulse by transmitting an identifiable mark back to the radar set. The displayed response has a length on the radar display corresponding to a few nautical miles, encoded as a Morse character beginning with a dash for identification. The inherent delay in the racon causes the displayed response to appear behind the echo from the structure on which the racon is mounted. Racons and their identifying marks are normally indicated on marine charts. Racons are used in the U.S. for the following purposes:

- to identify aids to navigation, both seaborne (e.g. buoys) and land-based (e.g. lighthouses)
- to identify landfall or positions on inconspicuous coastlines
- to indicate navigable spans under bridges

Merchant Marine Academy of Macedonia

- to identify offshore oil platforms and similar structures
- to identify and warn of environmentally-sensitive areas (such as coral reefs)

Outside the U.S., racons are also used:

- to mark new and uncharted hazards (these should use the Morse identifier ("D"))
- to identify center and turning points
- as leading line racons

Racons technical characteristics

All racons used by the USCG are frequency agile type, designed to measure the frequency of every incoming radar pulse, and transmit an approximately 25 microsecond Morse-encoded response less than 700 nanoseconds later back to the radar on that frequency. All racons operate over the frequency range 9300-9500 MHz marine radar band (X-band), and most additionally operate in the 2900-3100 MHz marine radar band (S-band). Racon range is approximately line-of-sight range, normally over 15 nautical miles, although actual range depends upon a number of factors, including mounting height, atmospheric conditions, and racon receiver sensitivity setting.

S-band racon antennas should be suitable for responding to radars using horizontal or vertical polarization. X-band racons should respond to radars using horizontal polarization. X-band antenna vertical divergence ranges from about 8 degrees for fixed installations, to 18 degrees for installation on buoys. S-band antenna vertical divergence is 22 degrees. Radiated power is 600 milliwatts. Receiver sensitivity is about -35 dbm.

Older racons, no longer used by the USCG but still used in other parts in the world, operate in a slow sweep mode. The transmitter on a slow sweep racon slowly sweeps every 1 to 2 minutes through the 9300-9500 MHz band, and when interrogated, responds back on the frequency the transmitter happens to be tuned to at the time. The response from most slow sweep racons is visible on a radar display for only about 5% of the time.

Ramarks are radar beacons which transmit independently, without having to be triggered by a ship radar. A ramark response on a radar display gives no indication of distance, but instead extends from the ship's position to the circumference of the display.

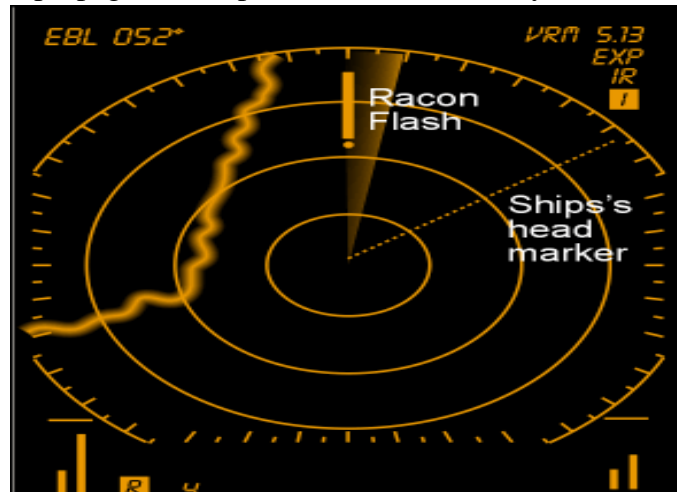
In order to conserve battery power, racons installed on buoys in the U.S. are programmed to operate 50% of the time. These racons are normally active for 20 seconds, and then off for the next 20 seconds. Racons installed on shore, where battery life is not a factor, are normally programmed to operate 75% of the time.

Merchant Marine Academy of Macedonia

Raconns are usually not programmed with a duty cycle greater than 75%, in order to ensure that the response never completely masks an important radar target.

The anti-clutter rain control on a radar could mask a racon return, and may need to be shut off. The anti-clutter sea control on certain radars could also degrade a racon response in some situations. Clutter rejection circuitry on some radar equipment may also suppress a racon response. The detection range of a racon may also be reduced if the radar receiver is off-tuned. Tweaking the radar tuning control should correct that problem.

Under conditions of abnormal radio propagation, a spurious racon flash may be received at ranges considerably in excess of a racon's quoted range, regardless of the range to which the ship's radar is set; such a spurious flash may appear in any random position along the correct bearing on the display. Therefore, reliance should only be placed on a racon flash if its appearance is consistent and if the ship is believed to be within the racon's quoted range.



Picture 3.11 Racon display on Radar screen

4. NAVIGATION SYSTEMS

4.1 COMPASS

A compass is an instrument used for navigation and orientation that shows direction relative to the geographic "cardinal directions", or "points". Usually, a diagram called a compass rose shows the directions north, south, east, and west on the compass face as abbreviated initials. When the compass is used, the rose can be aligned with the corresponding geographic directions, so, for example, the "N" mark on the rose really points to the north. Frequently, in addition to the rose or sometimes instead of it, angle markings in degrees are shown on the compass. North corresponds to zero degrees, and the angles increase clockwise, so east is 90 degrees, south is 180, and west is 270. These numbers allow the compass to show azimuths or bearings, which are commonly stated in this notation. The compass was invented more than 2000 years ago. The first compasses were made of lodestone, a naturally magnetized ore of iron, in Han dynasty China between 300 and 200 BC. The compass was later used for navigation by the Song Dynasty. Later compasses were made of iron needles, magnetized by striking them with a lodestone. Dry compasses begin appearing around

1300 in Medieval Europe and the Islamic world. This was replaced in the early 20th century by the liquid-filled magnetic compass. Prior to the introduction of the compass, geographical position and direction at sea were primarily determined by the sighting of landmarks, supplemented with the observation of the position of celestial bodies. On cloudy days, the Vikings may have used cordierite or some other birefringent crystal to determine the sun's direction and elevation from the polarization of daylight; their astronomical knowledge was sufficient to let them use this information to determine their proper heading. The invention of the compass enabled the determination of heading when the sky was overcast or foggy, and when landmarks were not in sight. This enabled mariners to navigate safely far from land, increasing sea trade, and contributing to the Age of Discovery.

Magnetic compass: The magnetic compass is the most familiar compass type. It functions as a pointer to "magnetic north", the local magnetic meridian, because the magnetized needle at its heart aligns itself with the horizontal component of the Earth's magnetic field. The magnetic field exerts a torque on the needle, pulling the North end or pole of the needle approximately toward the Earth's North magnetic pole, and pulling the other toward the Earth's South magnetic pole. The needle is mounted on a low-friction pivot point, in better compasses a jewel bearing, so it can turn easily. When the compass is held level, the needle turns until, after a few seconds to allow oscillations to die out, it settles into its equilibrium orientation.

In navigation, directions on maps are usually expressed with reference to geographical or true north, the direction toward the Geographical North Pole, the rotation axis of the Earth. Depending on where the compass is located on the surface of the Earth the angle between true north and magnetic north, called magnetic declination can vary widely with geographic location. The local magnetic declination is given on most maps, to allow the map to be oriented with a compass parallel to true north. The location of the Earth's magnetic poles slowly changes with time, which is referred to as geomagnetic secular variation. The effect of this means a map with the latest declination information should be used. Some magnetic compasses include means to manually compensate for the magnetic declination, so that the compass shows true directions.



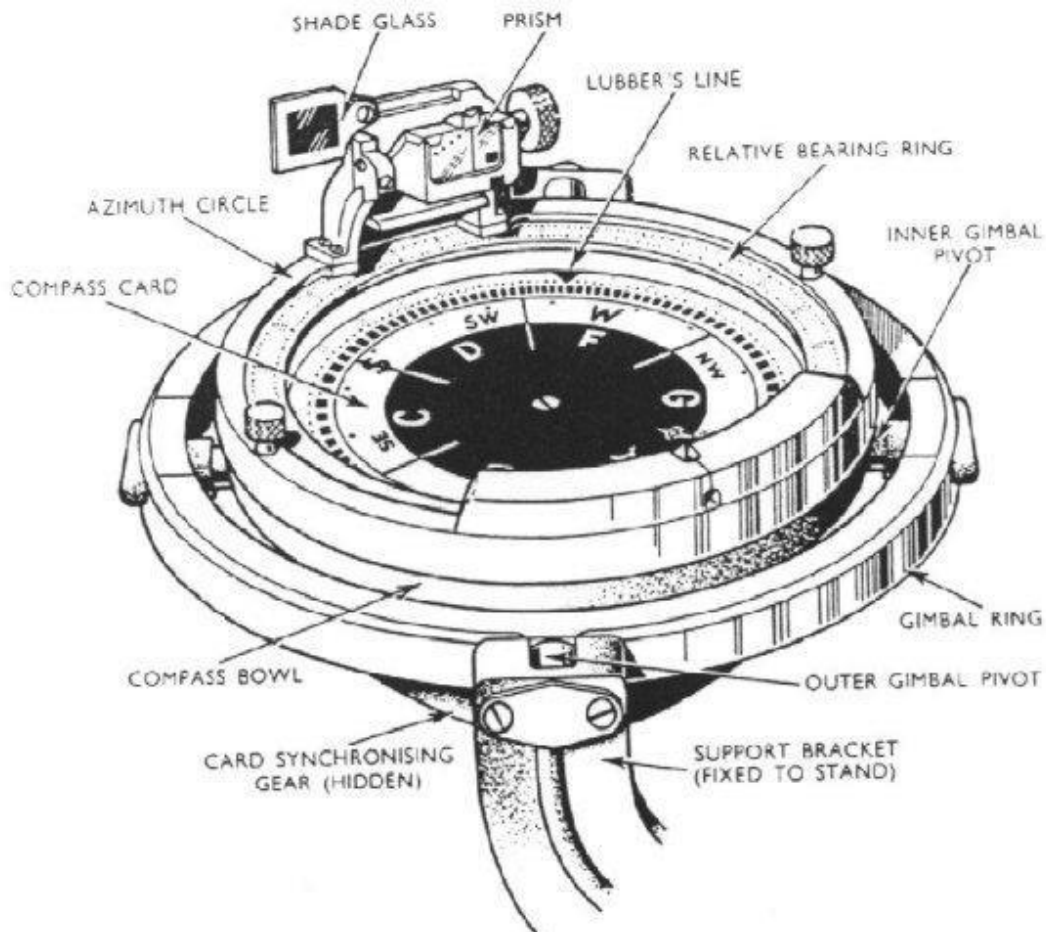
Picture 4.1 Magnetic compass

Gyro compass: A Gyro compass is a form of gyroscope, used widely on ships employing an electrically powered, fast-spinning gyroscope wheel and frictional forces among other factors utilizing the basic physical laws, influences of gravity and the Earth's rotation to find the true north.

Merchant Marine Academy of Macedonia

Construction: Gyro compass has become one indispensable instrument in almost all merchant ships or naval vessels for its ability to detect the direction of true north and not the magnetic north. It is comprised of the following units:

- Master Compass: Discovers and maintains the true north reading with the help of gyroscope.
- Repeater Compasses: Receive and indicate the true direction transmitted electrically from the Master Compass.
- Course Recorder: Makes a continuous record of the manoeuvring on a moving strip of paper.
- Control Panel: Governs the electrical operation of the system and ascertains the running condition by means of a suitable meter.
- Voltage Regulator: Maintains constant supply of the ship to the motor-generator.
- Alarm Unit: Indicates failure of the ship's supply.
- Amplifier Panel: Controls the follow-up system.
- Motor Generator: Converts the ship's DC supply to AC and energizes the Compass equipment.



Picture 4.2 Units of a Gyro compass

Gyro compasses are linked to the repeater compasses via one transmission system. The fast-spinning rotor attached weighs from 1.25 pounds to 55 pounds. It is driven thousands of revolutions per minute by another electric motor. However, the most essential part in a Gyro compass system is the spinning wheel, which is known as the Gyroscope.

Working: External magnetic fields which deflect normal compasses cannot affect Gyro compasses. When a ship alters its course the independently driven framework called 'Phantom' moves with it, but the rotor system continues to point northward. This lack of alignment enables it to send signal to the driving motor, which moves the phantom step in with the rotor system again in a path where the phantom may have crossed only a fraction of a degree or several degrees of the compass circle. As soon as they are aligned, electrical impulses are sent by the phantom to the repeater compasses for each degree it traverses.

The Gyroscope in the Gyrocompass is mounted in such a way so that it can move freely about three mutually perpendicular axes and is controlled as to enable its axis of spin settled parallel with the true meridian, influenced by the Earth's rotation and gravity. The Gyro compass system applications are based upon two fundamental characteristics, which are:

- Gyroscopic Inertia: The tendency of any revolving body to uphold its plane of rotation.
- Precession: A property that causes the gyroscope to move, when a couple is applied. But instead of moving in the direction of the couple, it moves at right angles to the axis of the applied couple and also the spinning wheel.

These two properties and the utilization of the Earth's two natural forces, rotation and gravity, enacts the Gyrocompass seek true north. Once settled on the true meridian the rotor indefinitely will remain there as long as the electrical supply of the ship remains constant and unaltered and unaffected by external forces.

Usage and Errors: Gyro compasses are pre-eminently used in most ships in order to detect true north, steer, and find positions and record courses. But due to the ship's course, speed and latitude, there could appear some steaming errors. It has been found that on Northerly courses the Gyro compass north is slightly deflected to the West of the true meridian whereas on Southerly courses it is deflected to the East.

Modern ships use a GPS system or other navigational aids feed data to the Gyrocompass for correcting the error. An orthogonal triad of fibre optic design and also ring laser gyroscopes which apply the principles of optical path difference to determine rate of rotation, instead of depending upon mechanical parts, may help eliminate the flaws and detect true north.

4.2 LORAN C

Loran-C was a hyperbolic radio navigation system which allowed a receiver to determine its position by listening to low frequency radio signals transmitted by fixed land-based radio beacons. Loran-C combined two different techniques to provide a signal that was both long-range and highly accurate, traits that had formerly been at odds. The downside was the expense of the equipment needed to interpret the signals, which meant that Loran-C was used primarily by militaries after it was first introduced in 1957.

By the 1970s the electronics needed to implement Loran-C had been dramatically reduced due to the introduction of solid state radio electronics, and especially the use of early microcontrollers to interpret the signal. Low-cost and easy-to-use Loran-C units became common from



Picture 4.3 Loran-C repeater

the late 1970s, especially in the early 1980s, leading to the earlier LORAN system being turned off in favor of installing more Loran-C stations around the world. Loran-C became one of the most common and widely used navigation systems for large areas of North America, Europe, Japan and the entire Atlantic and Pacific areas. The Soviet Union operated a nearly identical system, CHAYKA.

Although Loran-C was largely redundant by 2000, it has not universally disappeared as of 2014 due to a number of concerns. One is that the GPS system can be jammed through a variety of means; although the same is true of Loran-C, the transmitters are close-at-hand and can be adjusted if need be. More importantly, there are effects that might cause the GPS system to become unusable over wide areas, notably space weather events and potential EMP events. Loran, located entirely under the atmosphere, offers more resilience to these sorts of issues. There has been considerable debate about the relative merits of keeping the Loran-C system operational as a result of considerations like these.

In November 2009, the USCG announced that Loran-C is not needed by the U.S. for maritime navigation. This decision left the fate of LORAN and eLORAN in the U.S. to the Secretary of the Department of Homeland Security. Per a subsequent announcement, the U.S. Coast Guard, in accordance with the DHS Appropriations Act, terminated the transmission of all U.S. LORAN-C signals on 8 February 2010.

On 1 August 2010 the U.S. transmission of the Russian American signal was terminated, and on 3 August 2010 all Canadian signals were shut down by the USCG and the CCG.

The European Union had decided that the potential security advantages of Loran are worthy not only of keeping the system operational, but upgrading it and adding new stations. This is part of the wider Eurofix system which combines GPS, Galileo and nine Loran stations into a single integrated system.

However, in 2014, Norway and France both announced that all of their remaining transmitters, which make up a significant part of the Eurofix system, will be shut down on 31 December 2015. The two remaining transmitters in Europe (Anthorn, UK and Sylt, Germany) will no longer be able to sustain a positioning and navigation Loran service, with the result that the UK announced its trial eLoran service would be discontinued from the same date.

4.3 GPS

GPS is a satellite-based radionavigation system developed and operated by the U.S. Department of Defense (DOD). GPS permits land, sea, and airborne users to determine their three-dimensional position, velocity, and time 24 hours a day, in all weather, anywhere in the world with a precision and accuracy far better than other radionavigation systems available today or in the foreseeable future.

GPS consists of three segments: **space, control, and user**.

- **The Space Segment** consists of a minimum of 24 operational satellites in six circular orbits 20,200 km (10,900 NM) above the earth at an inclination angle of 55 degrees with an 11 hour 58 minute period. Although it is not a stated requirement, typically the satellites are spaced in primary orbital slots so that at any time a minimum of 6 satellites will be in view to users anywhere in the world.
- **The Control Segment** consists of a master control station in Colorado Springs, with five monitor stations and three ground antennas located throughout the world. The monitor stations track all GPS satellites in view and collect ranging information from the satellite broadcasts. The monitor stations send the information they collect from each of the satellites back to the master control station, which computes extremely precise satellite orbits. The information is then formatted into updated navigation messages for each satellite. The updated information is transmitted to each satellite via the ground antennas, which also transmit and receive satellite control and monitoring signals.
- **The User Segment** consists of the receivers, processors, and antennas that allow land, sea, or airborne operators to receive the GPS satellite broadcasts and compute their precise position, velocity and time.

The GPS concept of operation is based upon satellite ranging. Users figure their position on the earth by measuring their distance from the group of satellites in space, that act as precise reference points.

Each GPS satellite transmits an accurate position and time signal. The user's receiver measures the time delay for the signal to reach the receiver, which is the direct measure of the apparent range to the satellite. Measurements collected simultaneously from four satellites are processed to solve for the three dimensions of position, velocity and time.

Space Segment: The GPS space segment consists of a constellation of satellites transmitting radio signals to users. The United States is committed to maintaining the availability of at least 24 operational GPS satellites, 95% of the time.

GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day. The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures users can view at least four satellites from virtually any point on the planet.

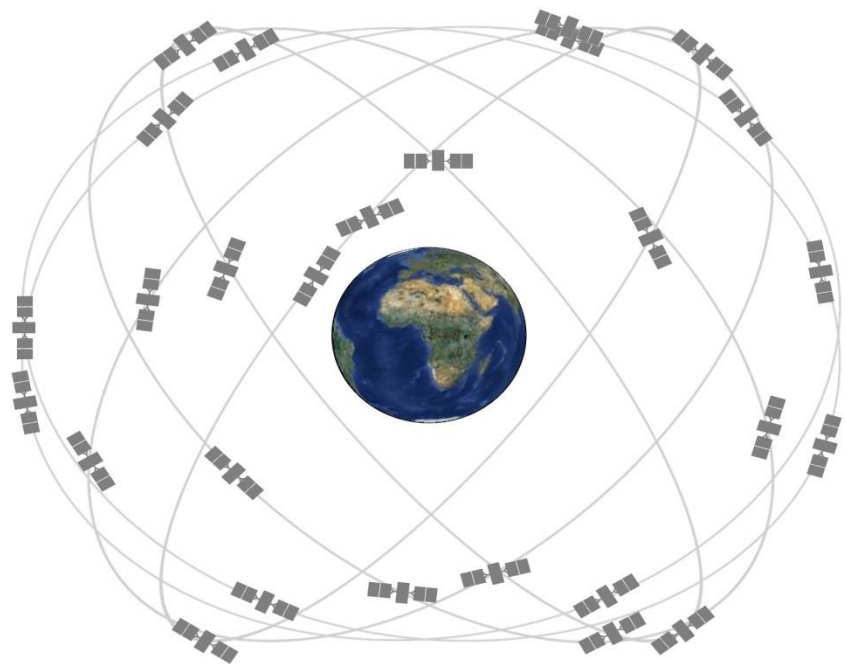
The Air Force normally flies more than 24 GPS satellites to maintain coverage whenever the baseline satellites are serviced or decommissioned. The extra satellites may increase GPS performance but are not considered part of the core constellation.

In June 2011, the Air Force successfully completed a GPS constellation expansion known as the

"Expandable 24"

configuration. Three of

the 24 slots were expanded, and six satellites were repositioned, so that three of the extra satellites became part of the constellation baseline. As a result, GPS now effectively operates as a 27-slot constellation with improved coverage in most parts of the world.



Picture 4.4 Expandable 24-slot satellite constellation

Merchant Marine Academy of Macedonia

GPS Augmentation Systems: A GPS augmentation is any system that aids GPS by providing accuracy, integrity, availability, or any other improvement to positioning, navigation, and timing that is not inherently part of GPS itself.

A wide range of different augmentation systems have been developed by both the public and private sectors. To meet specific requirements, the U.S. government has fielded a number of publicly available GPS augmentation systems.

Nationwide Differential GPS System (NDGPS)

NDGPS is a ground-based augmentation system that provides increased accuracy and integrity of GPS information to users on U.S. waterways. Since March 15th, 1999, the U.S. Coast Guard Navigation Center has operated the Nationwide Differential GPS (DGPS) Service, currently consisting of one control center and 46 remote broadcast sites. The DGPS service broadcasts correction signals on marine radiobeacon frequencies to improve the accuracy and integrity to GPS-derived positions.



Picture 4.5 DGPS reference station antenna

Users can expect better than 10-meter accuracy throughout all established coverage areas. Typically, the positional error of a DGPS position is 1 to 3 meters. In addition, this maritime service provides 10-meter (2 dRMS) navigation accuracy and integrity alarms for GPS and DGPS out-of-tolerance conditions within ten seconds of detection.

Wide Area Augmentation System (WAAS)

WAAS, a satellite-based augmentation system operated by the Federal Aviation Administration (FAA), supports aircraft navigation across North America. Although designed primarily for aviation users, WAAS is widely available in receivers used by other positioning, navigation, and timing communities. FAA is committed to providing WAAS service at the performance levels specified in the GPS WAAS Performance Standard. FAA is improving WAAS to take advantage of the future GPS safety-of-life signal to provide even better performance. Other similar space-based augmentation systems include Japan's Multi-functional Transport Satellite (MTSAT)-based Satellite Augmentation System (MSAS) and Quasi-Zenith Satellite System (QZSS), the European Geostationary Navigation Overlay Service (EGNOS), and India's GPS And Geo-Augmented Navigation (GAGAN) system.

Continuously Operating Reference Stations (CORS)

The U.S. CORS network, managed by the National Oceanic and Atmospheric Administration, archives and distributes GPS data for precise positioning tied to the National Spatial Reference System. Over 200 private, public, and academic organizations contribute data from over 1,800 GPS tracking stations to CORS. The web-based Online Positioning User Service (OPUS) offers free post-processing of GPS data sets to the centimeter level using CORS information. CORS is also being modernized to support real-time users.

Global Differential GPS (GDGPS)

GDGPS is a high accuracy GPS augmentation system, developed by the NASA Jet Propulsion Laboratory (JPL) to support the real-time positioning, timing, and determination requirements of NASA science missions. Future NASA plans include using the Tracking and Data Relay Satellite System (TDRSS) to disseminate via satellite a real-time differential correction message. This system is referred to as the TDRSS Augmentation Service Satellites (TASS).

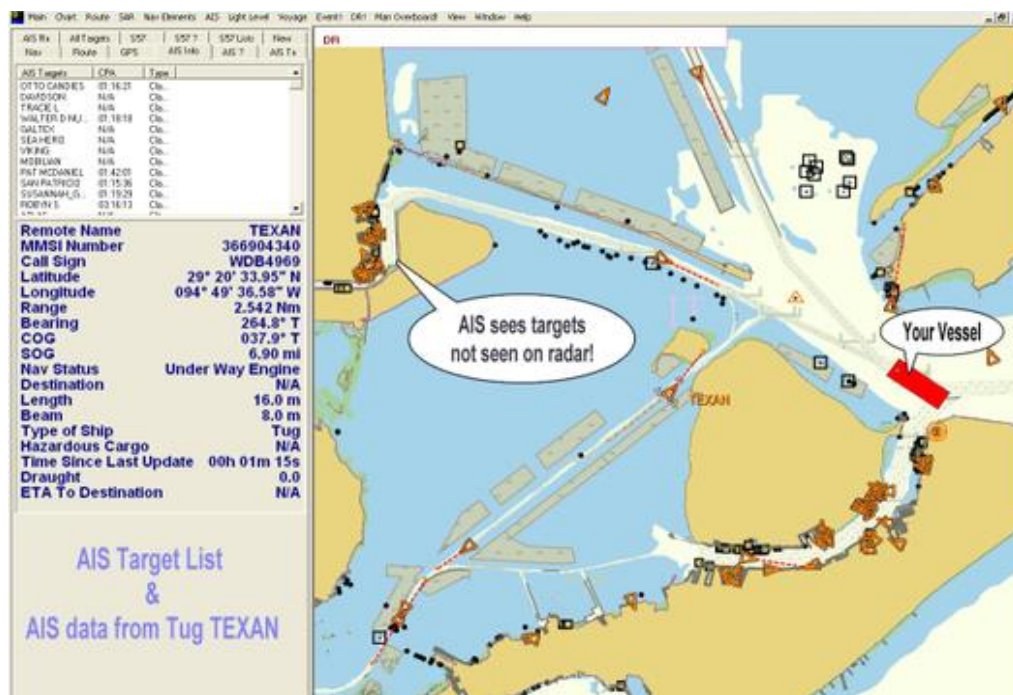
International GNSS Service (IGS)

IGS is a network of over 350 GPS monitoring stations from 200 contributing organizations in 80 countries. Its mission is to provide the highest quality data and products as the standard for global navigation satellite systems (GNSS) in support of Earth science research, multidisciplinary applications, and education, as well as to facilitate other applications benefiting society. Approximately 100 IGS stations transmit their tracking data within one hour of collection.

GPS Modernization: The GPS modernization program is an ongoing, multibillion-dollar effort to upgrade the GPS space and control segments with new features to improve GPS performance. In addition to the new features, GPS modernization is introducing modern technologies throughout the space and control segments that will enhance overall performance. For example, legacy computers and communications systems are being replaced with a network-centric architecture, allowing more frequent and precise satellite commands that will improve accuracy for everyone.

4.4 AIS

The AIS is a shipboard broadcast system that acts like a transponder, operating in the VHF maritime band, that is capable of handling well over 4,500 reports per minute and updates as often as every two seconds. It uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this high broadcast rate and ensure reliable ship-to-ship operation. Picture a shipboard radar or an electronic chart display that includes a symbol for every significant ship within radio range, each as desired with a velocity vector (indicating speed and heading). Each ship "symbol" can reflect the actual size of the ship, with position to GPS or differential GPS accuracy. By "clicking" on a ship symbol, you can learn the ship name, course and speed, classification, call sign, registration number, MMSI, and other information. Maneuvering information, closest point of approach (CPA), time to closest point of approach (TCPA) and other navigation information, more accurate and more timely than information available from an automatic radar plotting aid, can also be available. Display information previously available only to modern Vessel Traffic Service operations centers can now be available to every AIS user. With this information, you can call any ship over VHF radiotelephone by name, rather than by "ship off my port bow" or some other imprecise means. Or you can dial it up directly using GMDSS equipment. Or you can send to the ship, or receive from it, short safety-related email messages.



Picture 4.6 AIS screen display

AIS is intended, primarily, to allow ships to view marine traffic in their area and to be seen by that traffic. This requires a dedicated VHF AIS transceiver that allows local traffic to be viewed on an AIS enabled chartplotter or computer monitor while transmitting information about the ship itself to other AIS receivers. Port authorities or other shore-based facilities may be equipped with receivers only, so that they can view the local traffic without the need to transmit their own location.

If a suitable chartplotter is not available, local area AIS transceiver signals may be viewed via a computer using one of several computer applications such as ShipPlotter and Gnuais. These demodulate the signal from a modified marine VHF radiotelephone tuned to the AIS frequencies and convert into a digital format that the computer can read and display on a monitor; this data may then be shared via a local or wide area network via TCP or UDP protocols but will still be limited to the collective range of the radio receivers used in the network. Because computer AIS monitoring applications and normal VHF radio transceivers do not possess AIS transceivers, they may be used by shore-based facilities that have no need to transmit or as an inexpensive alternative to a dedicated AIS device for smaller vessels to view local traffic but, of course, the user will remain unseen by other traffic on the network.

A secondary, unplanned and emerging use for AIS data is to make it viewable publicly, on the internet, without the need for an AIS receiver. Global AIS transceiver data collected from both satellite and internet-connected shore-based stations are aggregated and made available on the internet through a number of service providers. Data aggregated this way can be viewed on any internet-capable device to provide near global, real-time position data from anywhere in the world. Typical data includes vessel name, details, location, speed and heading on a map, is searchable, has potentially unlimited, global range and the history is archived. Most of this data is free of charge but satellite data and special services such as searching the archives are usually supplied at a cost. The data is a read-only view and the users will not be seen on the AIS network itself. Shore-based AIS receivers contributing to the internet are mostly run by a large number of volunteers. AIS mobile apps are also readily available for use with Android, Windows and iOS devices. Ship owners and cargo dispatchers use these services to find and track vessels and their cargoes while marine enthusiasts may add to their photograph collections.

AIS Messages: There are 27 different types of top level messages defined in ITU 1371-4 that can be sent by AIS transceivers.

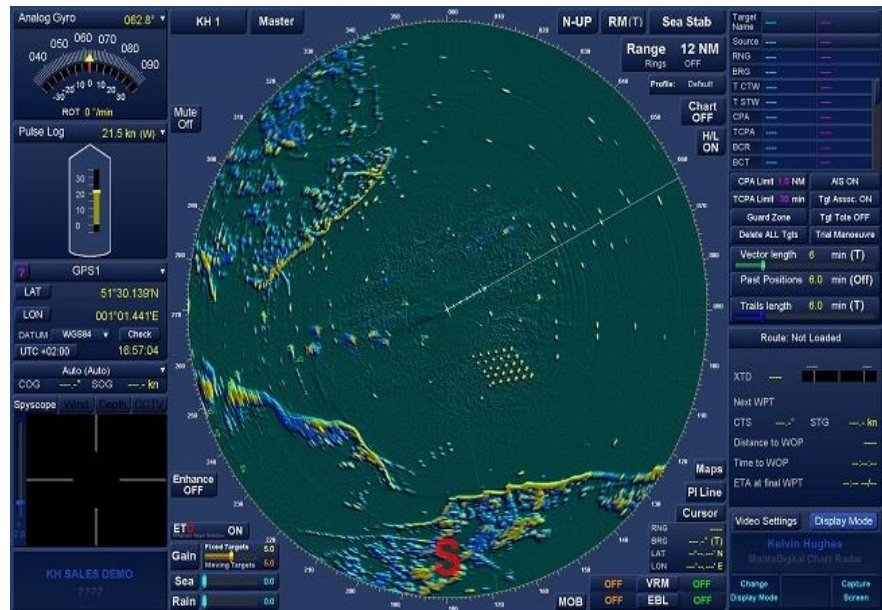
AIS messages 6, 8, 25, and 26 provide "Application Specific Messages" (ASM), that allow "competent authorities" to define additional AIS message subtypes. There are both "addressed" (ABM) and "broadcast" (BBM) variants of the message. Addressed messages, while containing a destination MMSI, are not private and may be decoded by any receiver.

One of the first uses of ASMs was the Saint Lawrence Seaway use of AIS binary messages (message type 8) to provide information about water levels, lock orders, and weather. The Panama Canal uses AIS type 8 messages to provide information about rain along the canal and wind in the locks. In 2010, the International Maritime Organization issued Circular 289 that defines the next iteration of ASMs for type 6 and 8 messages. Alexander, Schwehr and Zetterberg proposed that the community of competent authorities work together to maintain a regional register of these messages and their locations of use. The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA-AISM) now established a process for collection of regional application-specific messages.

4.5 RADAR

Radar was developed secretly for military use by several nations in the period before and during World War II. The term RADAR was coined in 1940 by the United States Navy as an acronym for **R**adio **D**etection **A**nd **R**anging. A radar system consists of a transmitter producing electromagnetic waves in the radio or microwaves domain, a transmitting antenna, a receiving antenna (often the same antenna is used for transmitting and receiving) and a receiver and processor to determine properties of the object(s). Radio waves (pulsed or continuous) from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed.

Radar is a vital component for safety at sea and near the shore.



Picture 4.7 Marine radar screen

Captains need to be able to maneuver their ships within feet in the worst of conditions and to be able to navigate "blind". This means inside a dark room with no visibility they need to safely navigate their way through waters in the worst of weather. Radars are rarely used alone in a marine setting. In commercial ships, they are integrated into a full system of marine instruments including chartplotters, sonar, two-way radio communication devices, and emergency locators (SART).

The integration of these devices is very important as it becomes quite distracting to look at several different screens. Therefore, displays can often overlay charting, radar, sonar into a single system. This gives the captain unprecedented instrumentation to maneuver the ship. With digital backbones, these devices have advanced greatly in the last years. For example, the newer ones have 3D displays that allow you to see above, below and all around the ship, including overlays of satellite imaging.

In port or in harbour, shore-based vessel traffic service radar systems are used to monitor and regulate ship movements in busy waters. The ship radar has a screen that displays all the objects that are present in the immediate range of the radar. Since all the objects are clearly visible on the screen, navigating and monitoring the position of the ship becomes really feasible.

Operation of the Marine Radar

The operation of the marine radars can be explained as follows:

- There is an antenna on the top of the radar that continuously rotates and flashes
- The flashes actually are frequency beams that are transmitted from the radar to find out whether there any objects present in the path of the ship
- The frequency and the time taken by the flashes to return (reflections) to the radar receiver of the ship helps to find out whether the route of the boat can be continued with or not
- On the display screen, the reflections can be seen so that identifying the actual distance of the objects can be even more easy

There are two basic marine radar frequencies commonly known as "X" and "S" band. "X" band, because of its higher frequency, 10 GHz provides a higher resolution and a crisper image while "S" band, at 3 GHz is less affected by rain and fog. In most situations larger vessels are fitted with both "X" and "S" band radars while smaller vessels will only have an "X" band. Vessels in excess of 300 gross tons are required to have two operational marine radars and one of those radars must be an ARPA.

What Radar can do

Radar mainly functions as an anti-collision aid. It also provides information about the whereabouts of neighboring vessels, coastal outlines, etc.

- **Navigate in darkness and fog**

In fog or darkness, you may lose situational awareness around your own ship because of poor or no visibility. With Radar acting as your eyes, however, you have the ability to monitor other ships' movement under these conditions.

- **Collision avoidance**

The guard alarm feature of every Radar alerts you when targets enter a particular area, or own ship is nearing a danger area. The alarm area can be forward of own ship or a 360-degree circle around the vessel. When Radar targets such as other ships, landmasses or buoys enter the zone, an audible alarm sounds to alert the operator.

- **Assess target movement**

The Echo Trail feature simulates target movement in afterglow. It is useful for assessing the movement of all targets relative to own ship. Some Radars have the capability to show the true movement of targets, providing increased navigational safety.

- Determine own ship's position

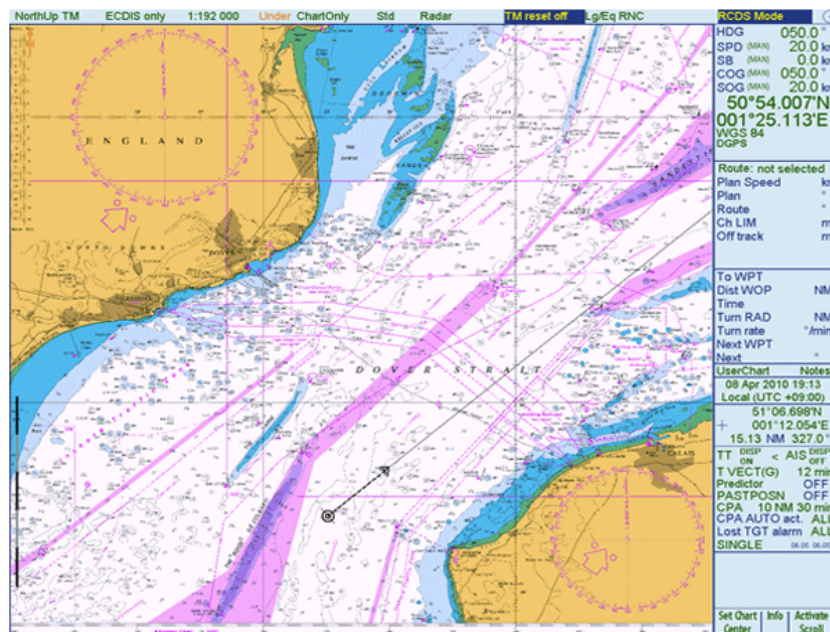
Since Radar sees further than the naked eye, the echoes from islands and landmasses can be used to determine own ships' position. When running near land, you can use peninsulas and other targets whose echoes show distinct contours on the display to determine own ships' position. Distant, tall mountains or bridges may be similarly used provided they are above the horizon.

4.6 ECDIS

According to the IMO ECDIS Performance Standards (IMO Resolution A.817 (19)), ECDIS is defined as follows:

Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention, by displaying selected information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information if required.

The Electronic Chart Display and Information System (ECDIS) is a development in the navigational chart system used in naval vessels and ships. With the use of the electronic chart system, it has become easier for a ship's navigating crew to pinpoint locations and



Picture 4.8 ECDIS screen display

attain directions. The ECDIS utilizes the feature of the Global Positioning System (GPS) to successfully pinpoint the navigational points. It also has to be noted that the ECDIS adheres to the stipulations set by the International Maritime Organisation, and thus it adds to the trustworthiness of the electronic chart system. ECDIS is basically a navigational information system, interfaced with other navigational equipments such as the GPS, Gyro, RADAR, ARPA, Echo

Sounder etc. ECDIS also incorporates and displays information contained in other nautical publications such as Tide Tables and Sailing Directions and incorporates additional maritime information such as radar information, weather, ice conditions and automatic vessel identification.

Advantages of ECDIS over paper charts

- All information is processed and displayed in real time
- It eases the process of passage planning
- One can get all necessary navigational information at a glance
- Alarms and indications are in place to indicate and highlight dangers
- Chart correction is made easier in ECDIS as compared to paper charts
- Charts can be tailored as per the requirement of the voyage
- Other navigational equipments such as the AIS, ARPA etc can be overlaid and integrated
- Charts can be oriented as per requirement
- With the facility to zoom in and out, features can be examined as per necessity
- One can obtain a more accurate ETA
- Charts can be interrogated for detailed information
- All in all, it enhances the safety of navigation

Types of ECDIS charts

1. Raster Chart (RNC): RNCs are direct copy or a scan of the paper charts. It looks identical to a paper chart as all the information shown is directly printed. The chart only grows larger or smaller as per the zooming and when rotated, everything rotates.
2. Vector Chart (ENC): ENCs are computer generated charts. The details on an ENC can be turned on and off depending on the requirement of the user. Objects on the ENC can be clicked for more details on the same. Depths can also be monitored to obtain a warning with regard to grounding. When zooming, the features grow large or small but the text remains the same. The ENC chart can be divided in four different layers, the Display Base (where no information can be deleted), the Standard Display, the Full Display and finally the Custom Display.

Chart Updating

Updates to the ECDIS charts may reach the ship in various ways, depending upon the capabilities of the service provider and the onboard communication facilities.

- On data distribution media (DVD)
- As an email attachment (SATCOM)
- As a broadcast message via SATCOM plus additional communication hardware
- As an internet download

Alarms and/or Indication in ECDIS

Alarms

- Exceeding cross track limits
- Crossing selected safety contour
- Deviation from the route
- Critical Point Approach
- Different datum from the positioning system

Alarms or Indication

- Largest scale for alarm (present chart too small a scale)
- Area with special conditions
- Malfunction of ECDIS

Indication

- Chart over scale (zoomed too close)
- Larger scale ENC available
- Different reference units
- Route crosses safety contour
- Route crosses specific area activated for alarms
- System test failure

Limitations of ECDIS

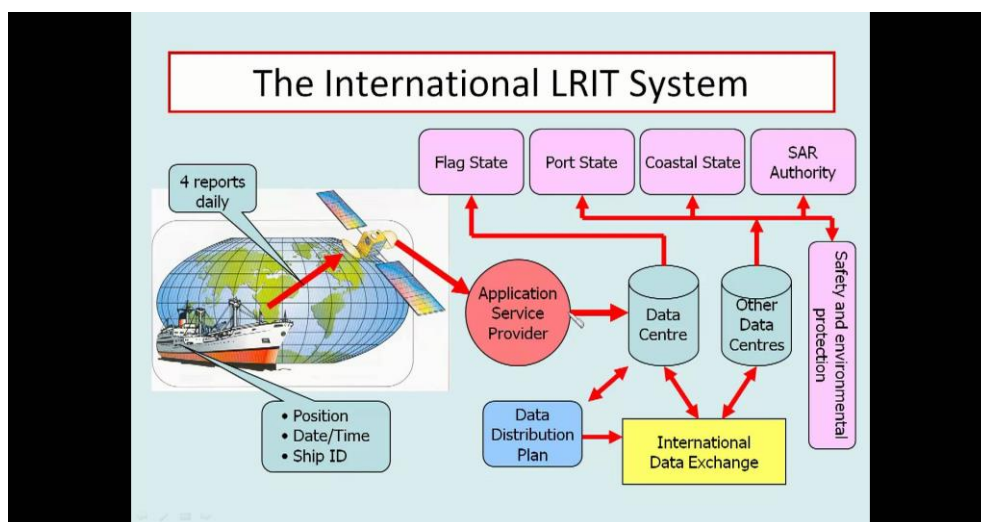
- The accuracy of the information received via AIS is only as good as the accuracy of the AIS information transmitted. The same is applicable for all other equipments interfaced with the ECDIS.
- Position of ships received on ECDIS display might not be referenced to WGS 84 datum
- Over reliance on ECDIS for navigational safety should be avoided until it is confirmed that all the data transmitted, received and displayed are accurate
- Users must be aware that any erroneous information is detrimental to the safety of own as well as other vessels
- Some sensors might lack the integrity with regard to accuracy and those that have not been tested
- Not all ships are fitted with ECDIS and hence one cannot be sure of technical ability with regard to positioning as well as navigation; the kind that ECDIS provides

4.7 LRIT

The Long Range Identification and Tracking (LRIT) system is a designated International Maritime Organization (IMO) system designed to collect and disseminate vessel position information received from IMO member States ships that are subject to the International Convention for the Safety of Life at Sea (SOLAS). LRIT provides an enhanced level of Maritime Domain Awareness that is the first of its kind. LRIT is a satellite-based, real-time reporting mechanism that allows unique visibility to position reports of vessels that would otherwise be invisible.

The most important advantage of having this system is that the information required to be shared is restricted only to those parties which are required to have it. This reduces unnecessary problems and increases the transparency and viability of the system on the whole. The main requirements to the system's application are the following:

- The transmitting device and gadget to send the information data
- Specific providers for this type of communication service. One such service provider is the Absolute Maritime Tracking Services, Inc. (AMTS) established by the Panama Flag Registry. This service provider is the sole service provider to those ships falling under the Panamanian registration
- Centers of data for the system
- Service providers for the overall application of the system
- A thorough distribution plan for the data collected from the system
- International data exchange for the LRIT application also forms an important part of the overall system requirements.



Picture 4.9 LRIT system configuration

4.8 VDR

A VDR or voyage data recorder is an instrument safely installed on a ship to continuously record vital information related to the operation of a vessel. It contains a voice recording system for a period of at least last 12 hours. This recording is recovered and made used for investigation in events of accidents. A ship's VDR, unlike an airplane's black box, can store a variety of data for a period of 12 hours. After the 12 hours the existing data is overwritten by new data.

The VDR must at least record the following data:

- Date and time
- Ship's position
- Speed and heading
- Bridge audio
- Communication audio (radio)
- Radar data
- Post display data
- Echo sounder
- Main alarms
- Rudder order and response
- Hull opening (doors) status
- Watertight and fire door status
- Speed and acceleration
- Hull stresses
- Wind speed and direction

5.RESOURCES & BIBLIOGRAPHY:

<https://www.wikipedia.com>

<https://www.boatsafe.com>

<https://www.waterencyclopedia.com>

<https://www.marineinsight.com>

<https://www.riceelectronics.com>

Rosenbach Company. The Sea: Books and Manuscripts on the Art of Navigation, Geography, Naval History, Shipbuilding, Voyages, Shipwrecks, and Mathematics, Including Atlases and Maps. Storrs-Mansfield, CT: Maurizio Martino Publishers, 2003.

Sobel, Dava. Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time. New York: Penguin USA, 1996.

Thurman, Harold V. Introductory Oceanography, 7th ed. New York: Macmillan Publishing Company, 1994.

Toghill, Jeff E. Celestial Navigation. New York: W. W. Norton & Co., 1988.

Maritime Buoyage System and other Aids to Navigation booklet. International Association of Marine Aids to Navigation and Lighthouse Authorities,
<https://www.iala-aism.org>

Jefferson Laboratory, Exploring the Nature of matter website, www.jlab.or

The navigation center of the U.S. Department of Homeland Security and Coast Guard website, <https://www.navcen.uscg.gov>

The IALA organization website, <https://www.iala-aism.org>

Official U.S. Government information about the Global Positioning System and related topics website, <https://www.gps.gov>

Operator's guide to Marine Radar, <https://www.furunousa.com>