# Basic Radio wave  Principles

A radio wave is an electromagnetic (EM) wave with frequency characteristics that make it useful. The wave will travel long distances through space (in or out of the atmosphere) without losing too much strength. An antenna is used to convert electric current into a radio wave so it can travel through space to the receiving antenna, which converts it back into an electric current for use by a receiver.

**How Radio Waves Propagate**

All matter has a varying degree of conductivity or resistance to radio waves. The Earth itself acts as the greatest resistor to radio waves. Radiated energy that travels near the ground induces a voltage in the ground that subtracts energy from the wave, decreasing the strength of the wave as the distance from the antenna becomes greater. Trees, buildings, and mineral deposits affect the strength to varying degrees. Radiated energy in the upper atmosphere is likewise affected as the energy of radiation is absorbed by molecules of air, water, and dust. The characteristics of radio wave propagation vary according to the signal frequency and the design, use, and limitations of the equipment.

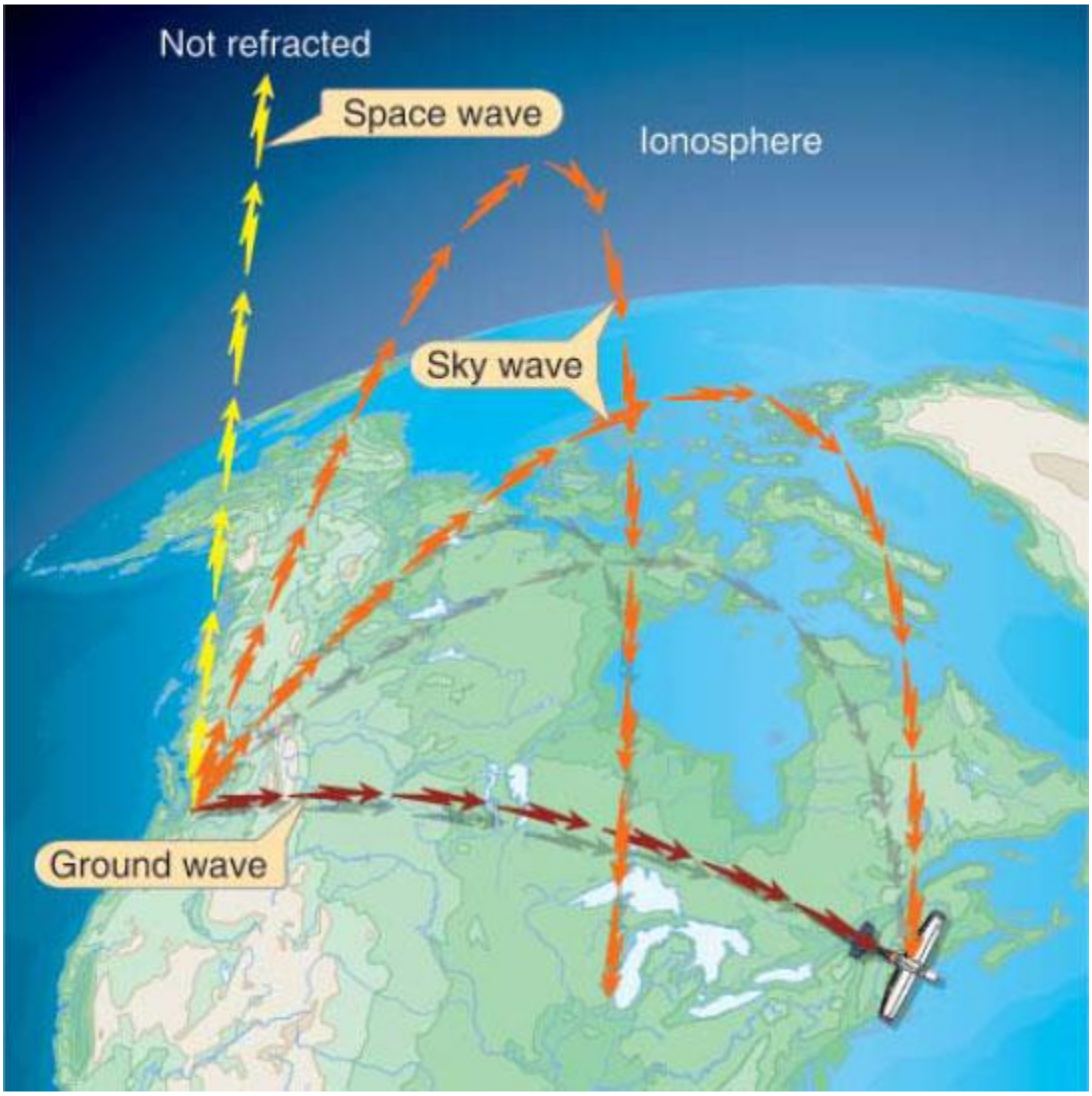
*Ground Wave*

A ground wave travels across the surface of the Earth. You can best imagine a ground wave's path as being in a tunnel or alley bounded by the surface of the Earth and by the ionosphere, which keeps the ground wave from going out into space. Generally, the lower the frequency, the farther the signal will travel.

Ground waves are usable for navigation purposes because they travel reliably and predictably along the same route day after day, and are not influenced by too many outside factors. The ground wave frequency range is generally from the lowest frequencies in the radio range (perhaps as low as 100 Hz) up to approximately 1,000 kHz (1 MHz). Although there is a ground wave component to frequencies above this, up to 30 MHz, the ground wave at these higher frequencies loses strength over very short distances.

*Sky Wave*

The sky wave, at frequencies of 1 to 30 MHz, is good for long distances because these frequencies are refracted or "bent" by the ionosphere, causing the signal to be sent back to Earth from high in the sky and received great distances away. [Figure 1] Used by high frequency (HF) radios in aircraft, messages can be sent across oceans using only 50 to 100 watts of power. Frequencies that produce a sky wave are not used for navigation because the pathway of the signal from transmitter to receiver is highly variable. The wave is "bounced" off of the ionosphere, which is always changing due to the varying amount of the sun's radiation reaching it (night/day and seasonal variations, sunspot activity, etc.). The sky wave is, therefore, unreliable for navigation purposes.




[Figure 1] *Ground, Space, and Sky Wave Propogation.*

For aeronautical communication purposes, the sky wave (HF) is about 80 to 90 percent reliable. HF is being gradually replaced by more reliable satellite communication.

*Space Wave*

When able to pass through the ionosphere, radio waves of 15 MHz and above (all the way up to many GHz), are considered space waves. Most navigation systems operate with signals propagating as space waves. Frequencies above 100 MHz have nearly no ground or sky wave components. They are space waves, but (except for global positioning system (GPS)) the navigation signal is used before it reaches the ionosphere so the effect of the ionosphere, which can cause some propagation errors, is minimal. GPS errors caused by passage through the ionosphere are significant and are corrected for by the GPS receiver system.

Space waves have another characteristic of concern to users. Space waves reflect off hard objects and may be blocked if the object is between the transmitter and the receiver. Site and terrain error, as well as propeller/rotor modulation error in very high omnidirectional range (VOR) systems is caused by this bounce. Instrument landing system (ILS) course distortion is also the result of this phenomenon, which led to the need for establishment of ILS critical areas.

Generally, space waves are "line of sight" receivable, but those of lower frequencies will "bend" somewhat over the horizon. The VOR signal at 108 to 118 MHz is a lower frequency than distance measuring equipment (DME) at 962 to 1213 MHz. Therefore, when an aircraft is f own "over the horizon" from a VOR/DME station, the DME will normally be the first to stop functioning.

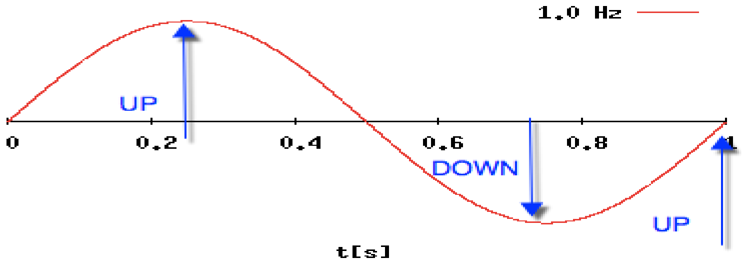
## FREQUENCY

RF Frequency is a electromagnetic wave using AC (Alternating Current). Just as the name implies, "frequency", its something that happens over and over and over again. There are different types of frequency; light, sound and in our case radio frequency (RF).

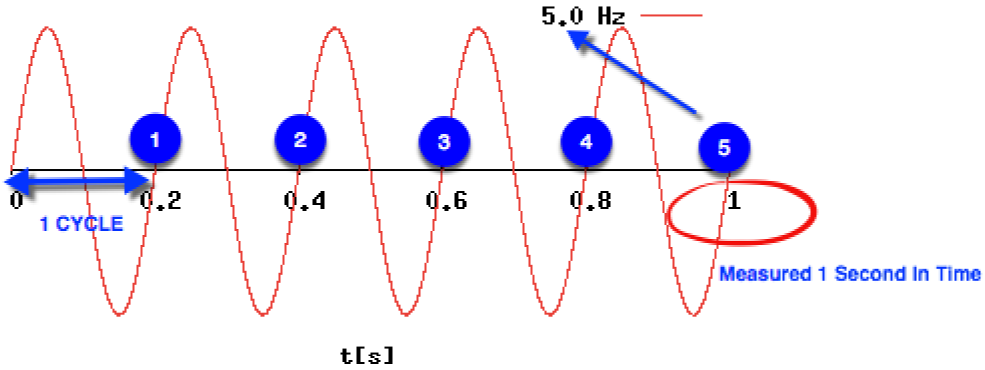
"*Frequency is the number of times a specified event occurs within a specified time interval. A standard measure of frequency is hertz (Hz)" –*

## CYCLE

"*An oscillation, or cycle, of this alternating current is defined as a single change from up to down to up, or as a change from positive, to negative to positive.*




One cycle, specified event, is measured 1 second in time which equals 1 Hz.

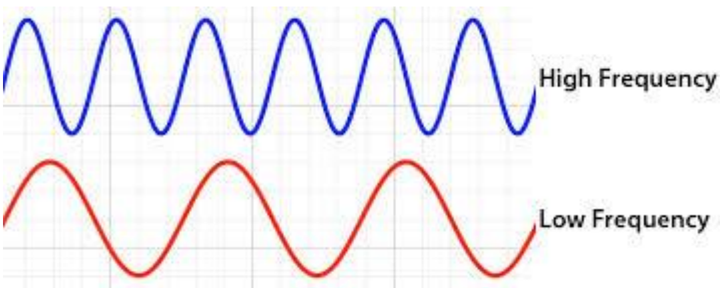



Five cycles, specified events, measured 1 second in time which equals 5 Hz.

We are dealing with simple math - 1 and 5 cycles per second. Imagine for a moment 2,400,000,000 / 5,000,000,000 billion cycles in 1 second. Thats a lot of cycles, eh ? That is the number of cycles 2.4 GHz and 5 GHz (WiFi) uses to transport data from one radio over the air to another radio.

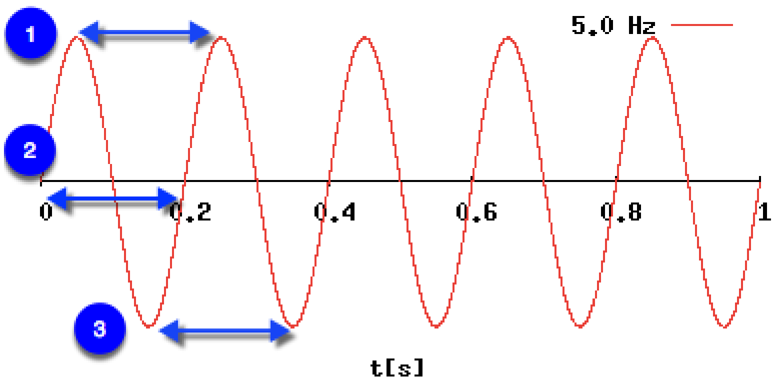
High frequency simple means there are more cycles per second.

Low and High frequency example




**WAVELENGTH**

*"Wavelength is the distance between similar points on two back-to-back waves."*



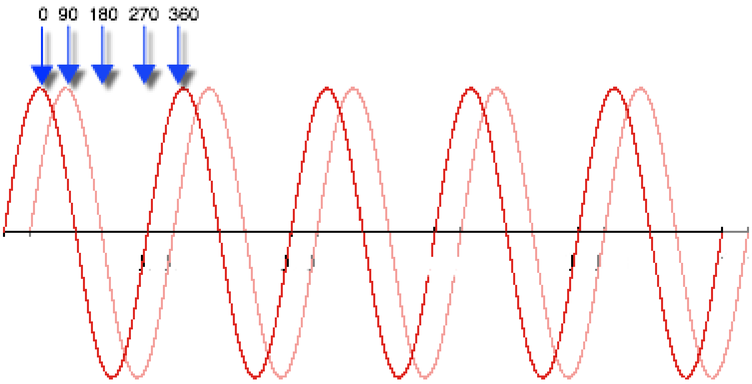
**PHASE**

Phase is the same frequency, same cycle, same wavelength, but are 2 or more wave forms not exactly aligned together.

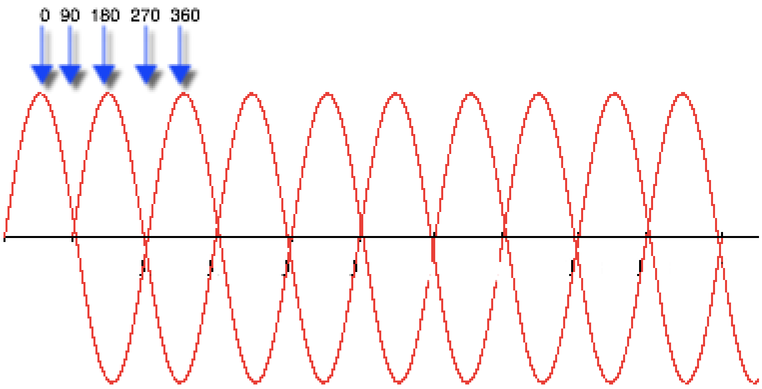
*"Phase is not a property of just one RF signal but instead involves the relationship between two or more signals that share the same frequency. The phase involves the relationship between the position of the amplitude crests and troughs of two waveforms.*

*Phase can be measured in distance, time, or degrees. If the peaks of two signals with the same frequency are in exact alignment at the same time, they are said to be in phase. Conversely, if the peaks of two signals with the same frequency are not in exact alignment at the same time, they are said to be out of phase." -*

Below is an example of 2 wave forms 90 degree out of phase.



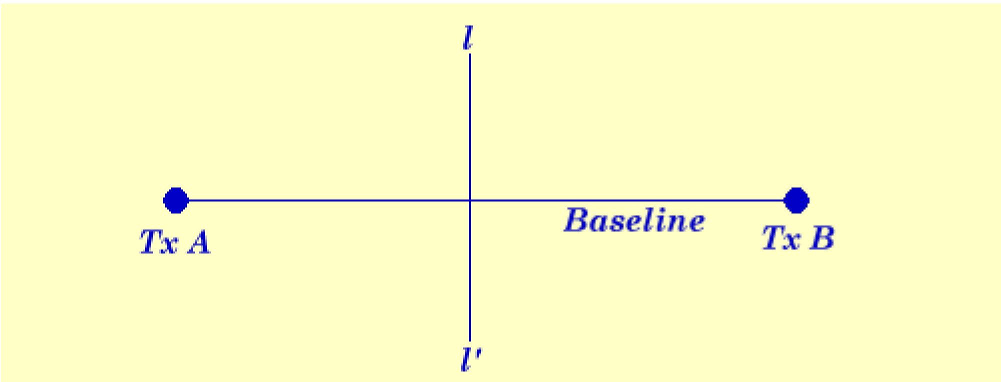

Below is an example of 2 wave forms 180 degree out of phase.



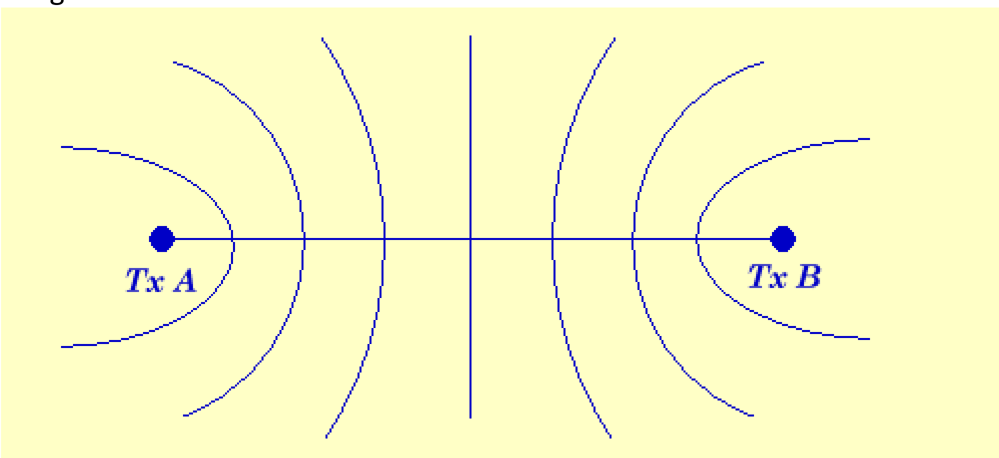
**Hyperbolic System operating principle**

Is A short range positioning system use for marine purposes, capable of providing a fix with an accuracy of about 1.5m at 30 miles from the shore stations. hyperbolic system using a chain of three transmitters, one as master and two as slaves.

The principle on which all hyperbolic navigation and positioning systems operate is essentially the same. If two transmitters radiating a radio wave in the same frequency are located at the ends of a baseline, as shown in the diagram below, then a receiver in the center of the baseline will receive the wave in the same phase because the time-of-flight of the wave to the receiver from both transmitters is the same. So if the receiver is receiving the two waves in same phase, then it must be located either at the center of the baseline or somewhere along the perpendicular line l - l'.

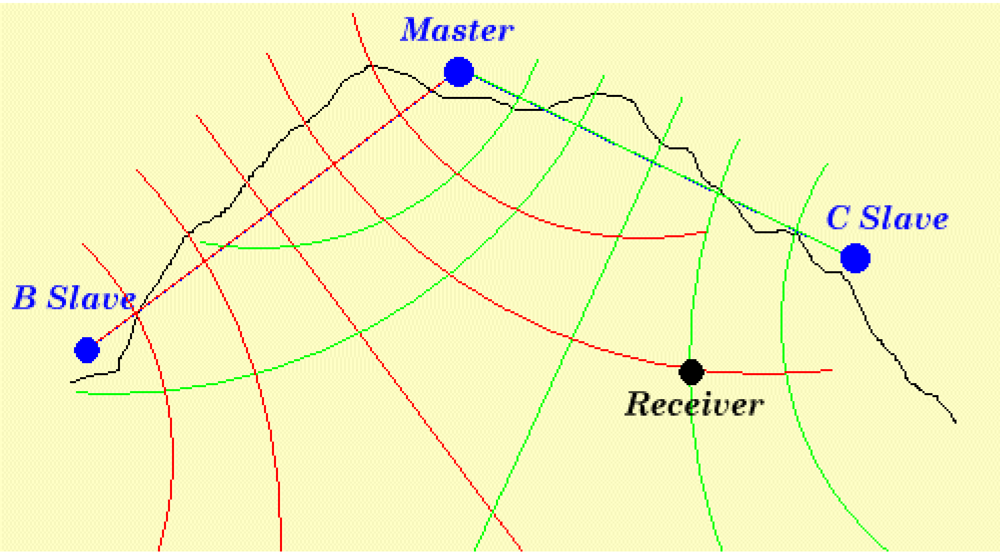



Unlike the simple case outlined above, these points of equal phase will produce a family of curves instead of a straight line. These curves are referred to as hyperbolae. each hyperbolae connect the points which have same phase. set of hyperbolae generated by the master and one slave are referred to as a pattern. If we are receiving signals with a particular phase then we know that we are somewhere along one of these curves.



In order to give a navigational 'fix' to find out exactly where on the curve we are, we need another pair of transmitters and to carry out the phase measurement process on the pattern produced by these transmitters. The hyperbolae from this second pair will overlap hyperbolae from first pair of transmitters, If we can establish our location along a hyperbola from each pattern, then we have found our position. In practice, one of the transmitters can be same for both pairs, this station named master station; those at the ends of the two baselines are the B and C slaves. The diagram below shows a section of coastline with the 3 sites and their overlapping pattern of hyperbolae.

Master station and B slave will make sets of hyperbolae which called pattern. With phase measurement between master station and B slave we can found jwe are in which curve(hyperbolae). Master station and C slave also make sets hyperbolae. with phase measurement between master station and C slave we can found that we are in which curve in relation with these two station. The first curve and second curve cut each other in one position which is our position.




**Loran-C**

Loran-C is an electronic system of land-based transmitters broadcasting low-frequency pulsed signals capable of reception aboard a ship, or aircraft, and being used by the receiver to determine position in time difference or longitude/latitude.

**System principles**

The loran transmitter stations send out a stream of pulses at a specified rate known as the pulse repetition frequency (PRF) or the pulse repetition rate (PRR). The pulse repetition period is the

reciprocal of the PRF. Assume the PRF is 25, i.e. 25 pulses are transmitted every second, then the period of the pulse is 1/25 s or 40 000 µs.

the velocity of radio waves in free space is known, then the distance travelled by a pulse may be measured by use of the time taken to travel that distance, i.e. if a pulse took 1000

µs to travel a certain distance then the distance is given by:

$d = v \times t$

where $d$ = distance in meters

$v$ = velocity of radio waves, and

$t$ = time in seconds taken for pulse to travel

*so* $d$ = 300 km.

The velocity of light is 300000 km per second but this value is for free space it's a little different in the earth.

Consider two transmitters A and B simultaneously transmitting the same pulse stream (Figure 4.1).

If we assume that the distance between the transmitters is 972 n.miles or 1800 km (since 1 n.miles =1.85 km, approximately), then the time taken to cover the distance between the transmitters can be found from equation to be: $t = d/v$

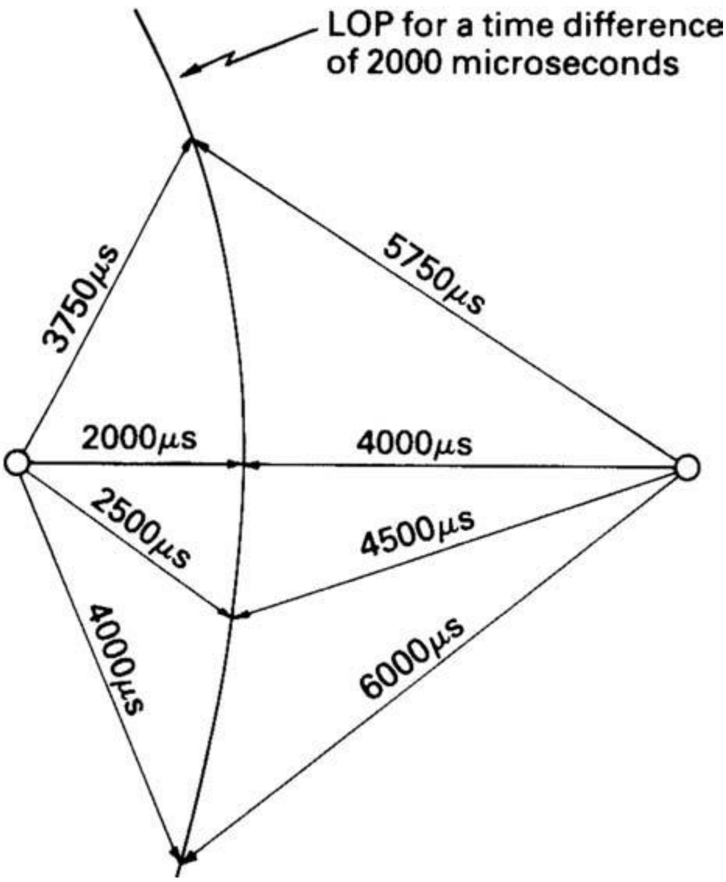
A receiver situated along center of the baseline joining the two transmitters would receive both pulse streams at the same where no time difference of receiving of both plus is present.

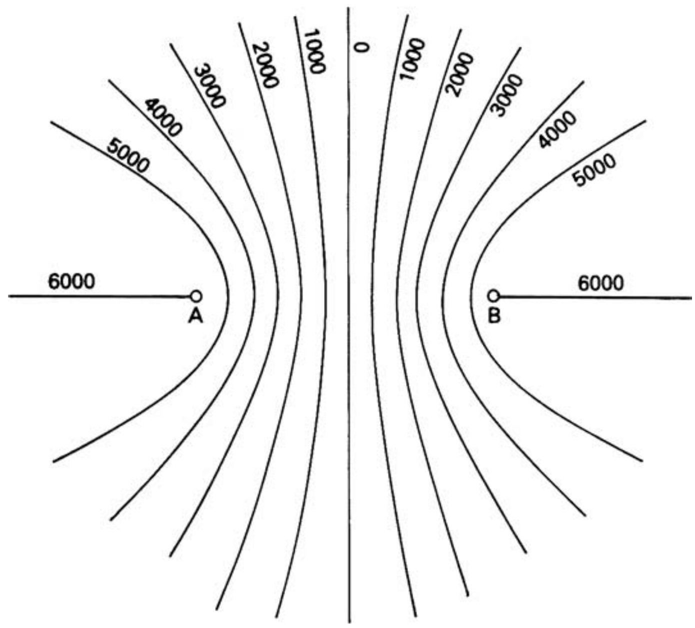
If the receiver was positioned 600 km from station A and 1200 km from station B then the pulse stream from station A would arrive after 2000 µs, while that from station B would arrive after 4000 µs. This means that there is a difference in arrival time of 2000 µs.

There would be other receiver positions in the region between the transmitters, not necessarily on the baseline, where the difference in arrival time was 2000 µs. It follows that by connecting all possible points where there is a difference in arrival time of 2000 µs, a line of position (LOP) may be plotted.

Figure 4.2 shows a plot of all possible positions where the time difference in pulse reception is 2000 µs.

The LOP shown in Figure 4.2 is a plot of a hyperbola with the transmitter stations For this reason loran, and other similar systems, are known as hyperbolic systems. It follows that other hyperbolae may be plotted for other time differences and this has been done in Figure 4.3 for time differences in steps of 1000 µs.



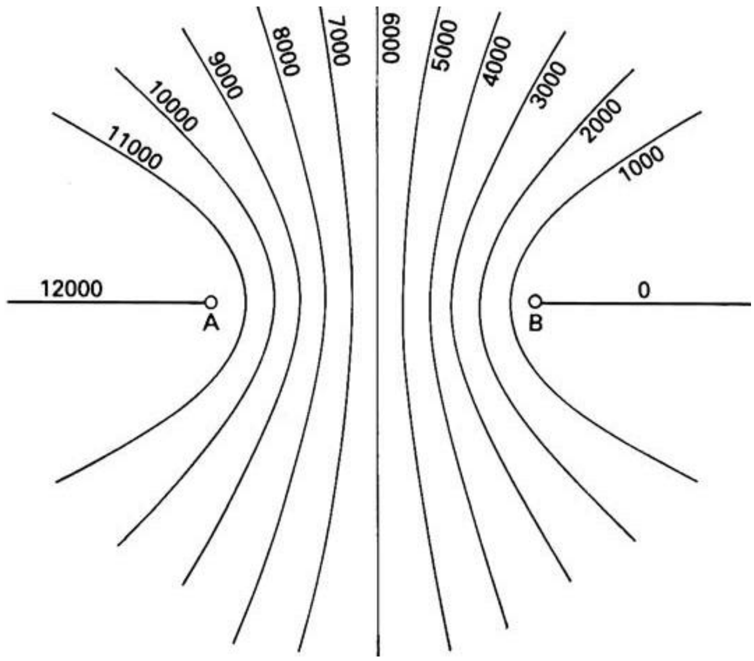



Note: total time taken from A to B is 6000 µs i.e lop 1000=3500-2500

Note that from this diagram the time difference LOPs are symmetrically disposed about the center line, i.e. there are two 2000-µs LOPs.(one on each side of center line)

Hence if the only information at the receiver is the time

difference value then an ambiguity can occur. The ambiguity may be avoided if second station, say station B, to be triggered by the pulse received from station A. The hyperbolic LOPs for this arrangement are no different from the original arrangement but the values of time difference are different for each LOP, as shown in Figure 4.4



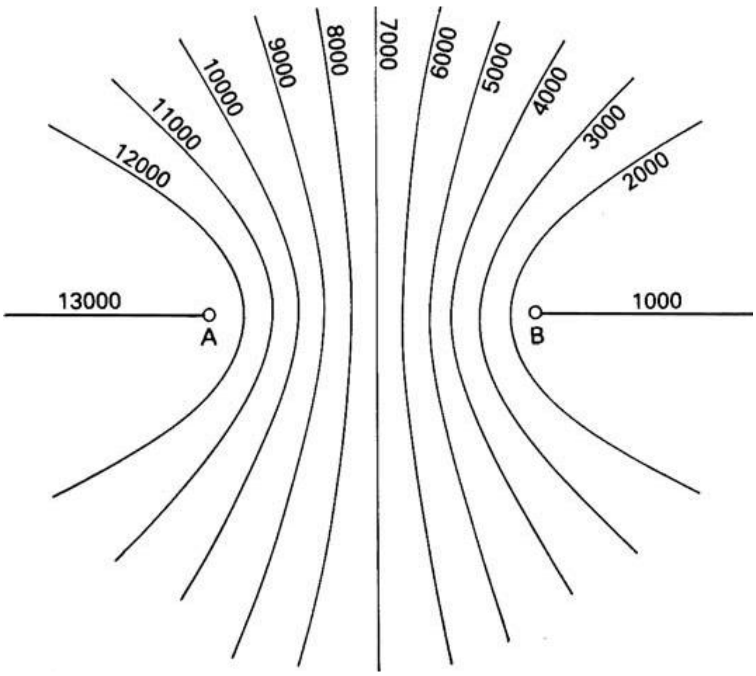

Note: if RCVER be in center when receive signal from station A he shall wait for 3000 µs until signal reach to station B then station B trigger and 3000 µs will take until signal from station B reach to center so total time difference will be 6000 µs

Station B is not allowed to transmit until triggered by a pulse from Station A.

Loran-C uses a chain of typically three to five transmitters broadcasting at 100 kHz with a specially shaped pulse of 250 µs duration repeated at a particular rate.

One transmitter of a Loran-C chain is designated the master (M) while the others are secondary stations known as whisky (W), x-ray (X), Yankee (Y) and Zulu (Z). The chain is formed of master–secondary pairs, i.e. M–W, M–X, M–Y and M–Z.

The master station always transmits its signal first and this signal is used to trigger emissions from the secondary stations. An additional time delay is added at the secondary station. The total elapsed time between master transmission and secondary transmission is known as the emission delay.




Not only must Station B wait for a pulse from Station A but there is also a coding delay (1000 µs in this example) which alters the time difference value of each LOP.

The emission delay ensures no ambiguity in reception within the coverage area for a chain. The unique time difference between reception of the master pulse and reception of a relevant secondary gives a specific line-of-position (LOP) for that pair. A unique LOP for a second master–secondary pair gives a point of intersection which determines the position of the receiver.

The master transmits a set of pulses.

The pulses are received at the ship and at W, X, Y and Z.

When the ship receives the first master pulse, it starts a timing clock.

When the secondary stations receive the first master pulse, they wait for a short time known as a coding delay and then each transmits a similar 8 pulses.

The ship receives the pulses from W, X, Y and Z and times the interval between receiving the master pulse and receiving each of the four secondary pulses. So it can find the position of ship.

Uses the third cycle of the received pulse because;

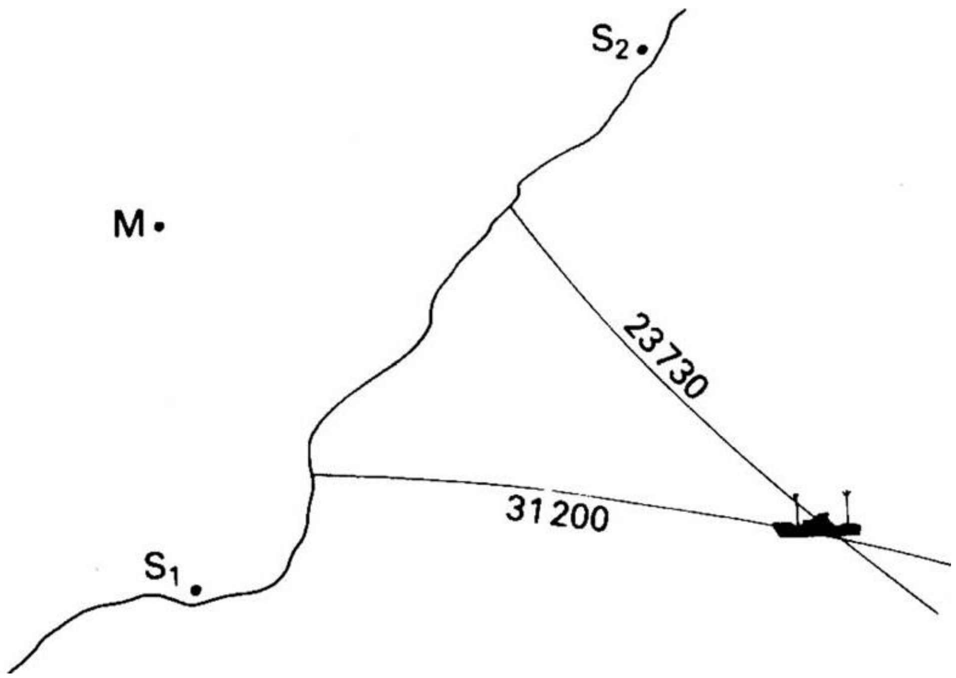
1.The start of the received pulse may be too weak to be heard

2.The master and secondary signals may not be received at the same strength.

3.It is possible to accurately identify the time when the third cycle ends and time this point.

4.This part of the pulse arrives at the ship before there can be any sky wave interference.

- The accuracy of the Loran system depends upon:
  - The accuracy of measuring the timing delays (0.1 μ sec).
  - The angle between the Loran lines of position (LOP).
  - The position of the ship in the Loran coverage area, that is whether the position is near the base line or the base line extension.

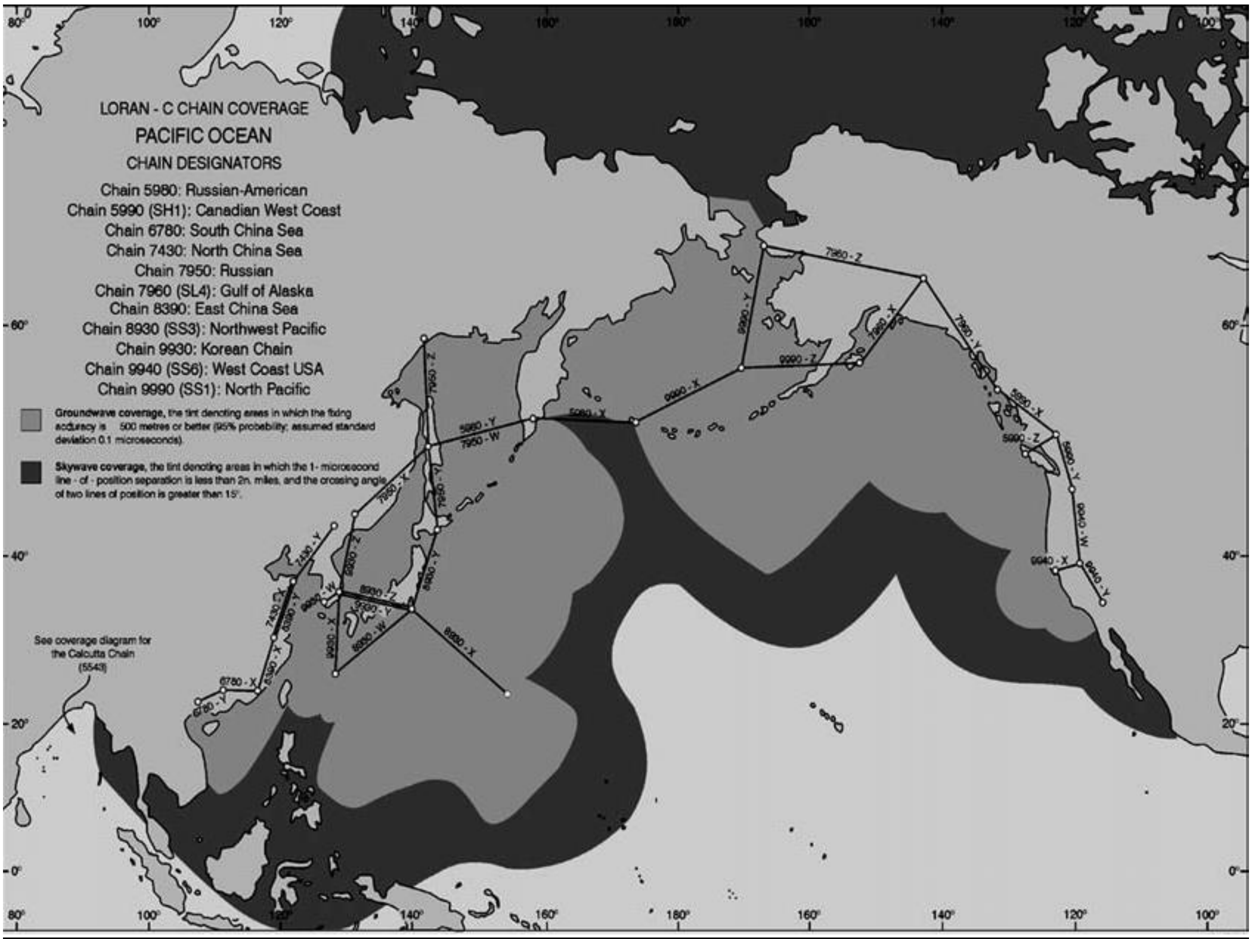



Normal operation of Loran-C assumes reception by ground waves. A ground wave signal will always arrive before a sky wave signal with a time difference of not less than 30 μs anywhere

in the Loran-C coverage area, hence if only the first 30 μs of a pulse is used it will be a ground wave. Sky waves can be used at greater distances (>1000 nautical miles) where ground wave

reception is unreliable but sky wave correction factors will need to be applied.

A Loran-C receiver should be able to acquire the signal automatically, identify the master and secondary pulses of a given chain pair and track the signal. The receiver should also possess filters, used to eliminate unwanted interference, and alarms which can be used to inform the operator about signal status and receiver conditions.




## Loran (E)

Enhanced Loran, or e Loran, is independent of GPS but fully compatible in its positioning and timing information, and its failure modes are very different.
Loran e exist today in the United States, Europe, and Far East, and in fact throughout much of the northern hemisphere.
It is an internationally recognized positioning and timing service, the latest evolution of the low frequency long-range navigation (Loran-C) radio navigation system.

**Why (E) Loran?**

GPS may disruption, and it doesn't work everywhere - entering a tunnel or parking garage or even traveling down a narrow city street: the navigation system generally alerts to "loss of satellite reception."

All transmitters are timed directly to UTC, so that a user may use all e Loran signals in view and may combine them with GNSS signals for position and time solutions.
Each transmitter includes a messaging channel; this is a signalling channel that allows the eLoran signal to also carry information to improve the user's solution.
Very much like GPS this messaging channel provides transmitter identification, time of transmission, differential corrections.

each user's e-Loran receiver will be operable in all regions where an e-Loran service is provided.

This Enhanced Loran *(eLoran)* Definition Document has been published by the International Loran Association to provide a high-level definition of eLoran for policy makers, service providers, and users. It was developed in November 2006 at the United States Coast Guard Navigation Center by an international team of authors.

Enhanced Loran is an internationally-standardized positioning, navigation, and timing (PNT) service for use by many modes of transport and in other applications.

The principal difference between *eLoran* and traditional Loran-C is the addition of a data channel on the transmitted signal. This conveys application-specific corrections, warnings, and signal integrity information to the user’s receiver. It is this data channel that allows eLoran to meet the requirements of landing aircraft using non-precision instrument approaches and bringing ships safely into harbor in low-visibility conditions. *eLoran* is also capable of providing the exceedingly precise time and frequency references needed by the telecommunications systems that carry voice and internet communications.

The core eLoran system consist of modernized control centers, transmitting stations and monitoring sites

**Transmitting Stations**

All *eLoran* transmitters have uninterruptible power supplies (UPS) that ensure that any failure of the incoming power will neither interrupt nor affect the transmitted signal. The time and frequency control systems of the

transmitter are designed for *eLoran.* they use

Coordinated Universal Time (UTC) by a method wholly independent of GNSS.

### Control Centers

*eLoran* transmitting stations run unattended. Sufficient personnel are at the control centers and on call to respond rapidly to failures and to maintain the published very high levels of availability and continuity.

### Monitor Sites/Reference Stations

Monitor sites, located in the *eLoran* coverage area and used at these sites monitor the *eLoran* signals and provide real-time information to the control centers regarding signals in space. Users are notified immediately if

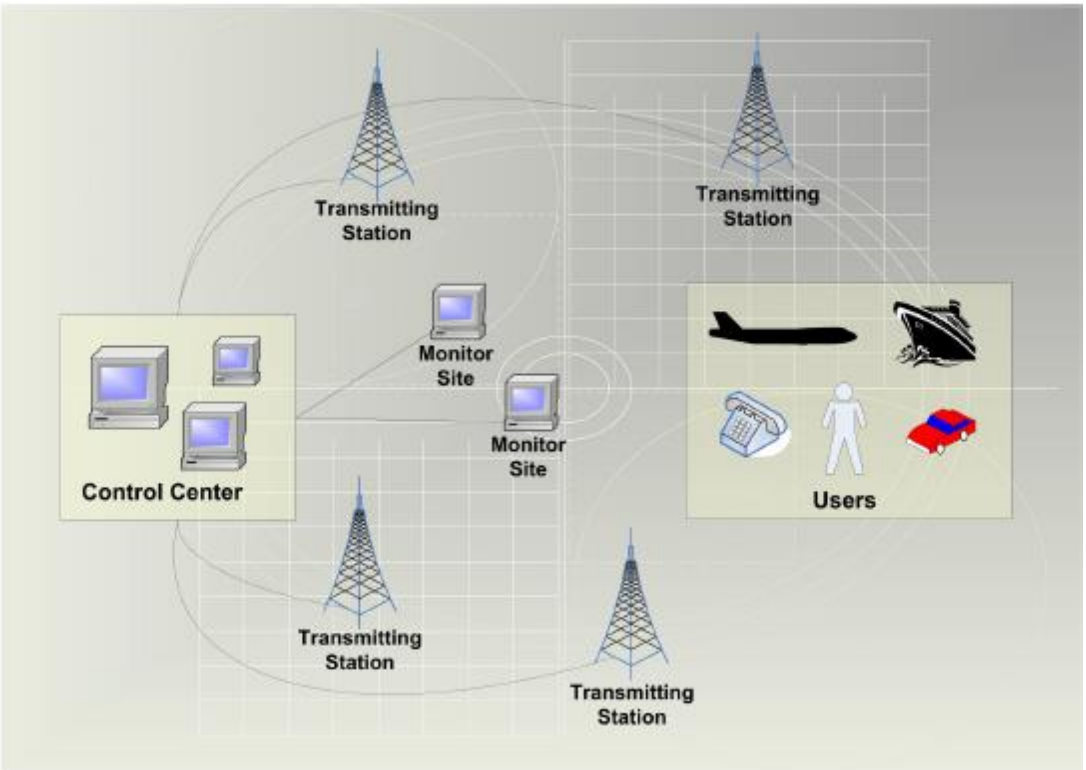
Any problem is detected. Some of the monitor sites will be used as reference stations. also have at least one highly accurate clock for synchronization to UTC to provide time and frequency corrections for timing users.

### Users' Equipment

*eLoran* users' receivers operate in an *all-in-view* mode. That is, they acquire and track the signals of many Loran stations (the same way GNSS receivers acquire and track multiple satellites) and employ them to make the most accurate and reliable position and timing measurements. Another benefit of using the all-in-view mode is that it ensures that the *eLoran*

receiver is always tracking the correct cycle of each individual signal.

An *eLoran* receiver is capable of receiving and decoding the data channel messages .




*Loran systems use groundwave propagation hence its limitation is that its signal may diffract around obstacles.*

The radius of coverage areas depends on transmitted power and type of ground which signal flies over it, but 1000km is typical.

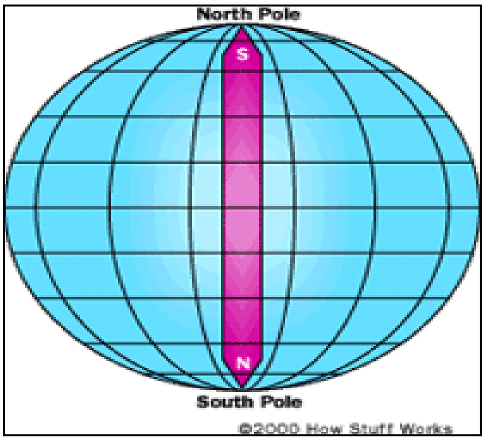
+meach user's e-Loran receiver will be operable in all regions where an e-Loran service is provided

## MAGNETIC COMPASS

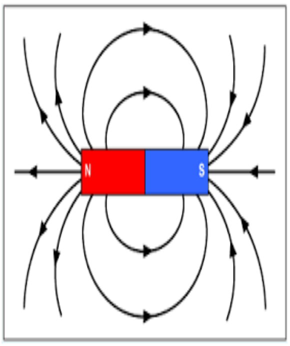
### Magnet :

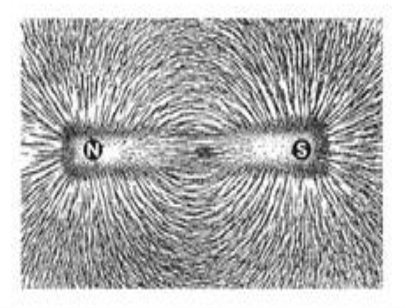
Magnetic lines of force of a bar magnet can be shown by iron filings on paper. A magnet is an object that has a magnetic field.

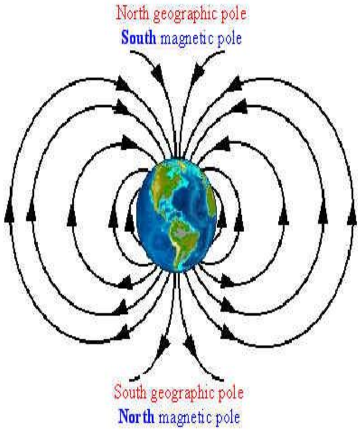
A so-called *permanent* magnet is made of a ferromagnetic material. Such materials consist of atoms or molecules that have a magnetic field (resulting from the spin angular momentum of electrons within them), but objects composed of these materials have magnetic fields only to the extent that these microscopic magnetic fields are positioned to reinforce rather than cancel each other.
An electromagnet has a field produced by a current, typically through a loop or a coil of many turns; its field becomes insignificant when the current ceases.
Various materials (soft iron is a frequent example), when exposed to a magnetic field, direct and concentrate it, and consequently share many of the properties of permanent and electro- magnets. Their behavior is often described as induced magnetism. Combinations of electromagnets with such materials, for the sake of this behavior, are often designed as a form of enhanced electromagnet.
A magnet is a magnetic dipole. That is not really a statement about "having two poles", but about the mathematical properties of its magnetic field, which are reflected in the "magnetic field lines" or "lines of force". The poles are not a pair of things on or inside the magnet, but rather, for the purposes of this article, the two areas on the surface that look as they do in the image. (That look is a consequence of the highest surface intensity of the magnetic field strength occurring there.)
A standard naming system for the poles of magnets is important. A magnet can be regarded as having two magnetic poles; one "north" and one "south"



A freely suspended magnet will eventually orient itself north-to-south, because of its attraction to the north and south magnetic poles of the earth. The end that points towards the Earth's geographical North Pole is called the magnetic north pole; correspondingly, the other end that ends up pointing south is the magnetic South Pole. Note that since the north pole of the magnet is attracted to the south pole of another magnet, the Earth's *geographic north* is actually a *magnetic south*.




Using this approach as a definition of terminology for magnetic poles and fields would require a clarification about the terms not being interchanged when the earth's magnetic field undergoes its next reversal. Without addressing the details, a formal definition in terms of direction of current in an electromagnet and a "right-hand rule" defines north and south for magnetic fields.

The mistaken idea of a magnetic pole is that cutting a magnet in half should separate the two poles. separation of parts of such a magnet produces smaller magnets with weaker dipole fields, each with ends that we label north and south. we will never see a north pole without a south one, because in all the magnets that have been found or created they are complementary directions rather than two separable things.

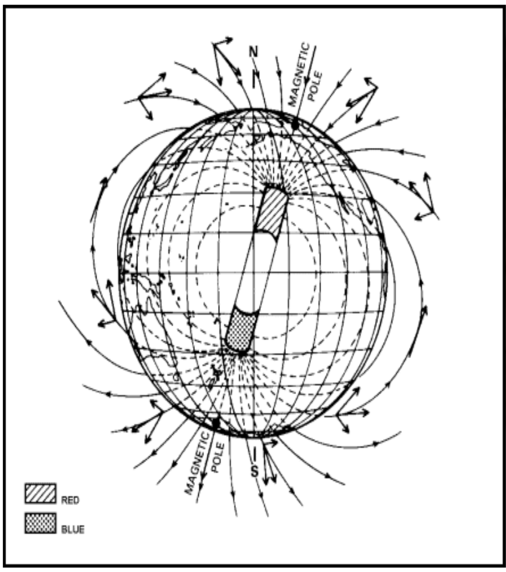
The Earth's magnetic field has a north and south pole. We can use the magnetic field of the Earth to help navigate by using a magnetic compass.

Compasses can also be used to figure out which side of a magnet is the north or south pole of that magnet.

Earth's magnetic field :

The earth, like all other magnets, has a magnetic north pole and magnetic south pole. The axis of the dipole is offset from the axis of the Earth's rotation by approximately 11 degrees. The magnetic north pole is located at an approximate latitude and longitude of 74° N and 101° W. The magnetic south pole

is located at an approximate latitude and longitude of 68° S and 144° E. These magnetic poles are distinguished from the true North Pole, latitude of 90° N and the true South Pole, latitude of 90° S.
---The magnetic lines of force that connect the magnetic poles are called "magnetic meridians." These meridians are not great circles. Because of the irregular distribution of magnetic material in the earth, the meridians are irregular, and the planes of the magnetic meridians do not pass through the center of the earth. Approximately midway between the magnetic poles is a line called the "magnetic equator." The magnetic equator is an irregular arc, varying in latitude from 15° S in South America to 20° S in Africa.
--- Colors have been assigned to avoid confusion when speaking of the action of poles. The earth's north magnetic pole is designated as "blue" and the south magnetic pole is designated as "red." A law of magnetism states that "unlike poles" attract each other while "like poles" repel. Therefore, the north-seeking pole of a magnet is attracted to the earth's north magnetic pole and is "red" while the south-seeking pole is attracted by the earth's south magnetic pole and is "blue."




Geographic South Pole :

The Geographic South Pole is the point where the earth's axis of rotation intersects the surface. This is the point usually meant when an unspecified "south pole" is mentioned.
At present, Antarctica is located over the South Pole, although this has not been the case for all of Earth's history because of continental drift.

Magnetic South Pole:

The Magnetic South Pole is the point nearest the Geographic north Pole where the field lines of Earth's magnetic field point directly into the ground.

The earth's magnetism undergoes changes. These changes consist of the following:

Diurnal Changes: These are daily changes which are caused by the movement of the magnetic poles in an orbit having a diameter of about 50 miles.

Annual Changes: These simply represent the yearly permanent changes in the earth's magnetic field.

Secular Changes: These are changes which occur over a period of years.

Some useful definitions

Angle of dip : The angle between the direction of inclination of line of force and the earth's horizontal surface is called dip .Somewhere near the earth geographic equator , each line of force becomes parallel to the earth and the dip becomes zero .

Magnetic equator : An imaginary line on the earth surface joining all places where the dip is zero is called magnetic equator .

Geomagnetic latitude(magnetic latitude) is a parameter analogous to geographic latitude, except that bearing is with respect to the magnetic poles, as opposed to the geographic poles. An angular distance north or south of the magnetic equator , The angle is equal to the magnetic dip or the magnetic inclination

Magnetic materials : These are substances which are capable of being magnetized. They are mainly ferrous materials.

What is the difference between Hard-iron and Soft-iron?

Hard-iron distortions are caused by permanent magnets and magnetized steel or iron object within close proximity to the sensors. This type of distortion will remain constant and in fixed location relative to the sensors for all heading orientations.

Soft-iron distortions are the result of interactions between a magnetic field such as the earth's magnetic field and any magnetically "soft" material within close proximity to the sensors. In technical terms, soft materials have a high permeability. The permeability of a given material is a measure of how well it serves as
a path for magnetic lines of force

.Induced magnetism : Magnetism which is present only when the material is under the influence of an external field .

Permanent magnetism : Magnetism which remains for long period without any appreciable reduction , unless the substances is subjected to a demagnetizing force , is called permanent magnetism .

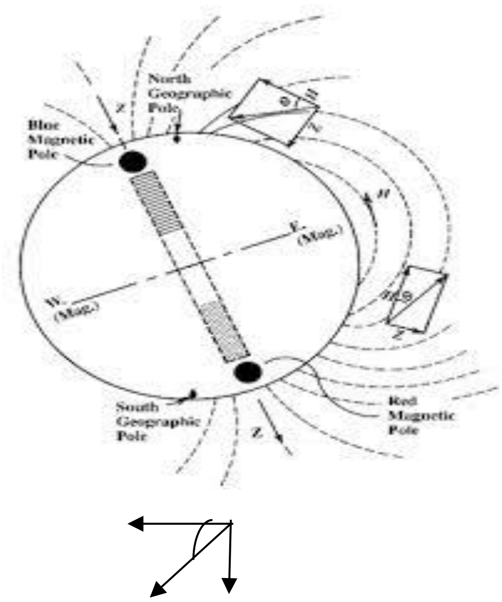
Residual magnetism : That part which remains after magnetizing is removed .

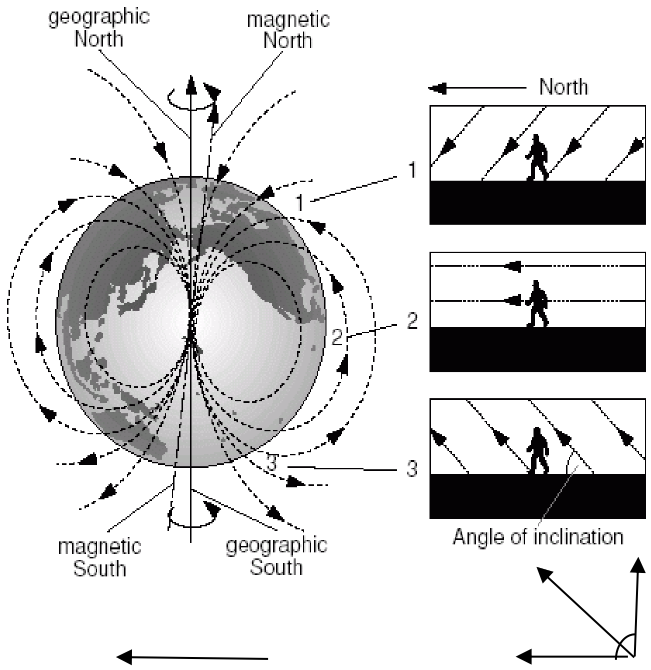
Intensity of magnetization : The strength of magnetization that is much greater in a bar than in the surrounding .

Magnetic Susceptibility : Is a ratio between the intensity of the magnet station and the intensity of magnetizing force causing magnetization .

Magnetic permeability :is the measure of the ability of a material to support the formation of a magnetic field within itself. Hence, it is the degree of magnetization that a material obtains in response to an applied magnetic field.

The earth magnetic field split in to horizontal and vertical components. The horizontal component of the earth magnetic field is a directive force at the compass needle which cause it to lie in the magnetic meridian and show the poles. The vertical component just tilts the needle head toward down or up. In the magnetic equator only horizontal component presents and in the Poles where the lines of Earth's magnetic field point directly into or out of the ground only vertical component presents, there is no horizontal directive component to guide the compass needle toward poles, so magnetic compass does not work in the magnetic poles and it isn't effective in the area near the magnetic poles.




Magnetic compass :

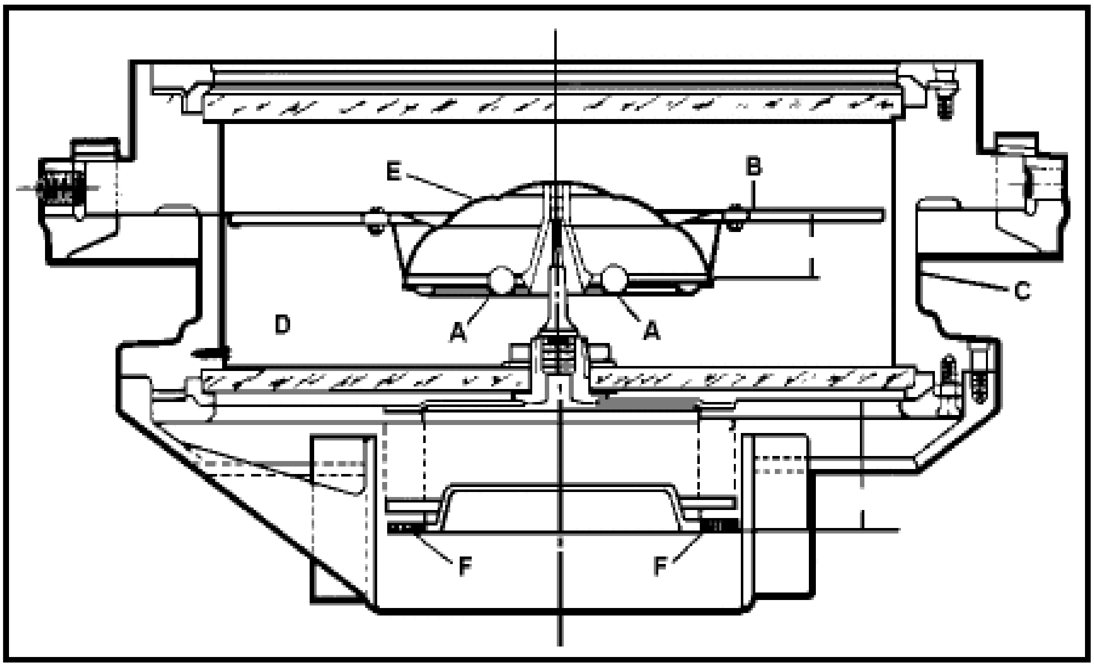
A compass (or mariner's compass) is navigational instrument for finding directions. It consists of a magnetized pointer free to align itself accurately with Earth's magnetic field. A compass provides a known reference direction which is of great assistance in navigation. The cardinal points are north, south, east and west. A compass can be used in conjunction with a clock and a sextant to provide a very accurate navigation capability. This device greatly improved maritime trade by making travel safer and more efficient.

A *compass* can be any magnetic device using a needle to indicate the direction of the magnetic north of a planet's magnetosphere. Any instrument with a magnetized bar or needle turning freely upon a pivot and pointing in a northerly and southerly direction can be considered a compass

Compass Designation :

The magnetic compass onboard ship may be classified or named according to its location or use. The magnetic compass located in a position favorable for taking bearings and used in navigation is called the standard compass. The magnetic compass at the steering station (used normally for steering or as a standby when the steering gyro repeater fails) is called the steering compass. Direction from either of these instruments must be labeled as "per standard compass" or "per steering compass" for identification. The ship magnetic compass is usually housed on the ‘monkey island’ above the navigating bridge and reflected into the bridge by means of a periscope like device, so a helmsman can easily read the compass when he is steering the ship.

Component of a magnetic  compasses:



agnets ( A ) : These are four (two in older compasses) cylindrical bundles of magnetic steel wire or bar magnets which are attached to the compass card to supply directive force.

Compass Card ( B ) : This is an aluminum disc, graduated in degrees from 0° to 360° . It also shows cardinal and inter cardinal points. Being attached to the magnets, the compass card provides a means of reading direction.

Compass bowl ( C ) : This is a bowl-shaped container of nonmagnetic material (brass) which serves to contain the magnetic elements, a reference mark, and the fluid. Part of the bottom may be transparent (glass) to permit light to shine upward against the compass card.

Fluid ( D ) : This is liquid surrounding the magnetic element. According to principle of buoyancy, a reduction of weight results in a reduction of friction, making possible closer alignment of the compass needle with the magnetic meridian. Any friction present will tend to prevent complete alignment with the magnetic meridian. Today's compasses contain a highly refined petroleum distillate similar to Varsol, which increases stability and efficiency and neither freezes nor becomes viscous at low temperatures.

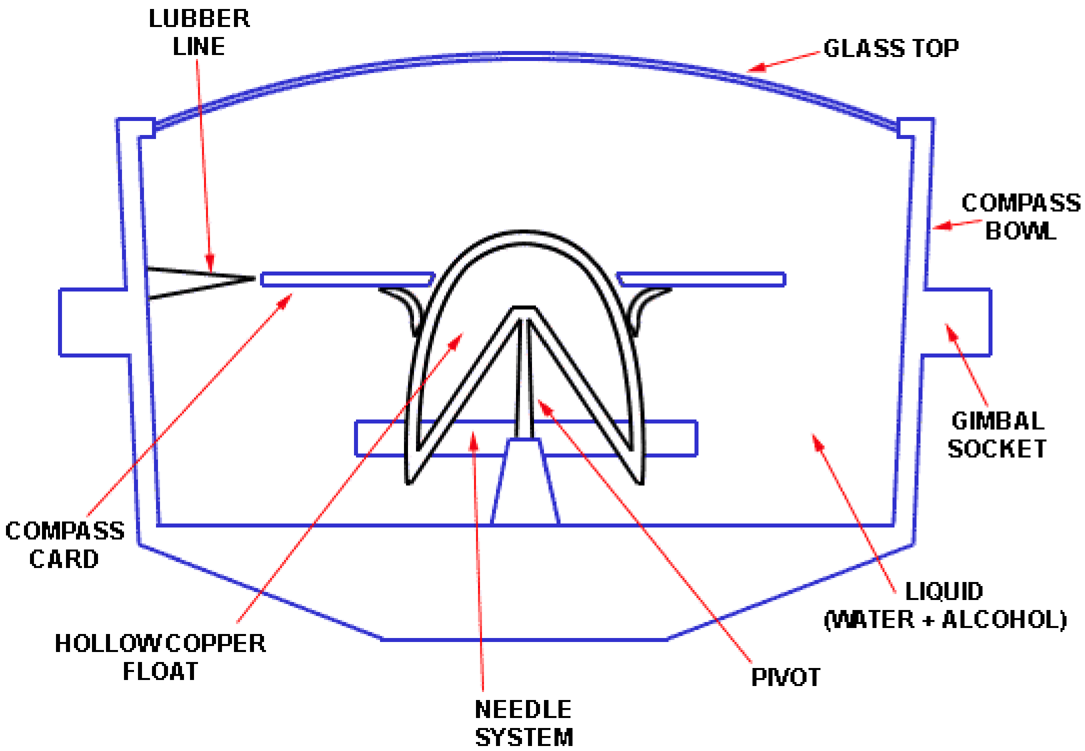
Float ( E ) : This is an aluminum, air-filled chamber in the center of the compass card. This further reduces weight and friction at the pivot point.

Expansion bellows ( F ): This is an arrangement in the bottom of the compass bowl. This operates to keep the compass bowl completely filled with liquid, allowing for temperature changes. A filling screw facilitates addition of liquid, which may become necessary notwithstanding the expansion bellows.

NOTE: sometimes an air bubble formed in the compass bowl, this bubbles shall remove by adding fluid to the bowl as per compass maker instruction.

Lubber line : This is a reference mark on the inside of the compass bowl. It is aligned with the ship's fore and aft axis or keel line of the ship. The lubber line is a reference for the reading of direction from the compass card. The reading of the compass card on the lubber line at any time is the "ship's heading."

Gimbals : This is a metal ring on two pivots in which the compass bowl is placed. The compass is also on two pivots which permits it to tilt freely in any direction and remain almost horizontal in spite of the ship's motion. An important concept is that regardless of the movement of the ship, the compass card remains fixed




<u>LIMITATIONS OF THE MAGNETIC COMPASS :</u>

The following characteristics of the magnetic compass limit its direction-finding ability:

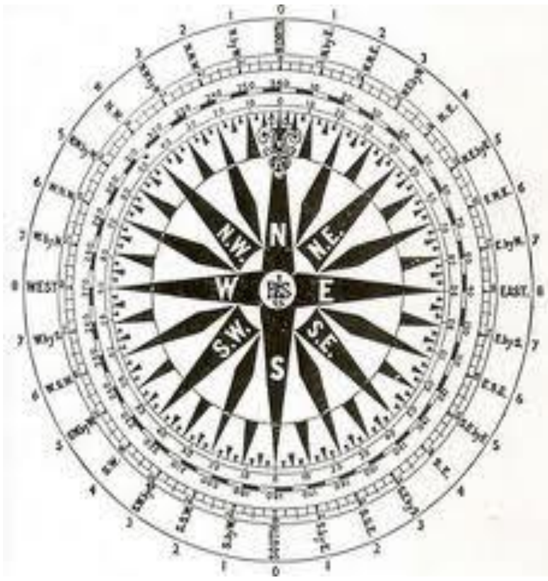
- Sensitive to any magnetic disturbance. So it's important to keep electromagnetic equipment such as walkie talkie away from magnetic compass
- Useless at the magnetic poles and is sluggish and unreliable in areas near the poles.
- Deviation (explained later) changes as a ship's magnetic properties change. The magnetic properties also change with changes in the ship's structure or magnetic cargo.
- Deviation changes with heading. The ship as well as the earth may be considered as a magnet. The effect of the ship's magnetism upon the compass changes with the heading.
- Does not point to true north.

<u>Points of the compass :Boxing the compass</u>

The mariner's compass card is divided into thirty-two equally spaced points. Four of these - east, west, north, and south - are the cardinal points, and the names of the others are derived from these.

| REPEAT THE COMPASS. | |
|---|---|
| N. Stands for North. | S. by W., South by West. |

| | |
|---|---|
| N. by E., North by East. | S. S. W., South South-West. |
| N. N. E., North North-East. | S.W. by S., South-West by South. |
| N. E. by N., North-East by North, | S. W., South-West. |
| N . E., Nort-East. | S. W, by W., South-West by West. |
| N. E. by E., North-East by East. | W. S. W., West South-West. |
| E. N. E., East North-East. | W. by S., West by South. |
| E. by N., East by North. | W., West. |
| E., East. | W. by N. West by North. |
| E. by S., East by South. | W. N. W., West North-West. |
| E. S. E., East South-East. | N.W. by W., North-West by West |
| S. E. by E., South-East by East. | N. W., North-West. |
| S. E., South-East. | N.W. by N., North-West by North. |
| S. E. by S., South-East by South. | N. N. W., North North-West. |
| S. S. E., South South-East. | N, by W., North by West. |
| S. by E. South by East. | N., North. |




Do iron ships pose particular problems for magnetic compasses?

Yes. The magnetic field of the iron body of the ship itself affects the reading on the compass. When iron and steel ships became common, many scientists studied the problem. One of the earliest was the Astronomer Royal, Sir G.B. Airy, who in 1838 used the iron steamer Rainbow for his experiments. Airy thought of a method of neutralizing a ship's magnetism by placing magnets and pieces of unmagnified iron near the compass. The compass needle effected by earth magnetic field, permanent and induced magnetic fields from ship's iron. The needle will stay in direction with resultant of all magnetic field available.

How was the problem of magnetic variation solved?

Variations do not worry navigators now because of the introduction of the gyroscopic compass. It was invented in 1908. This uses a spinning gyroscope which keeps the compass pointing not to the magnetic north, but to Earth's true North. A rapidly spinning gyroscope is at the heart of the gyrocompass. Once the gyroscope is set spinning, it remains pointing in the same direction, regardless of the ship's heaving motion.Today, a ship anywhere in the world can check its exact position by means of a signal from a satellite in orbit. However, all navigators still have a compass on board as well.

## Compass Error

Direction relative to the Geographic North Pole is regarded as TRUE direction. Anything that affects our compass reading, that is, anything that alters it from the direction of true north, is called compass error. We need to understand what forces will do this so that we can correct these errors and derive our actual heading.

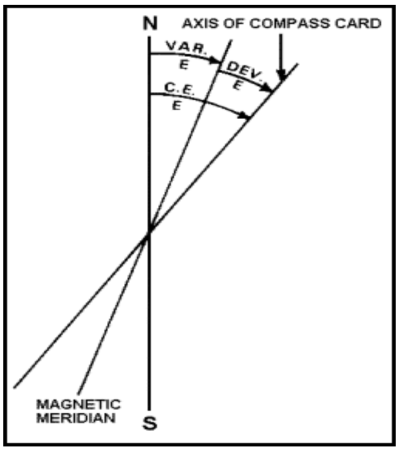
## Variation :

As previously mentioned, the magnetic poles correspond roughly with the actual geographical poles. Close, but no cigar. The north magnetic pole is located at approximately 78.9°N latitude and 103.8°W , over 600 miles from the geological north pole. And while your compass doesn't point exactly towards the north magnetic pole, it does point to a location near it.

The problem that's created here is that a compass will point to a direction other than true north, the difference between the two depending where on Earth the compass is.

This error is called *Variation*, and it's the angular difference between true north and magnetic north.

Look at the fig.



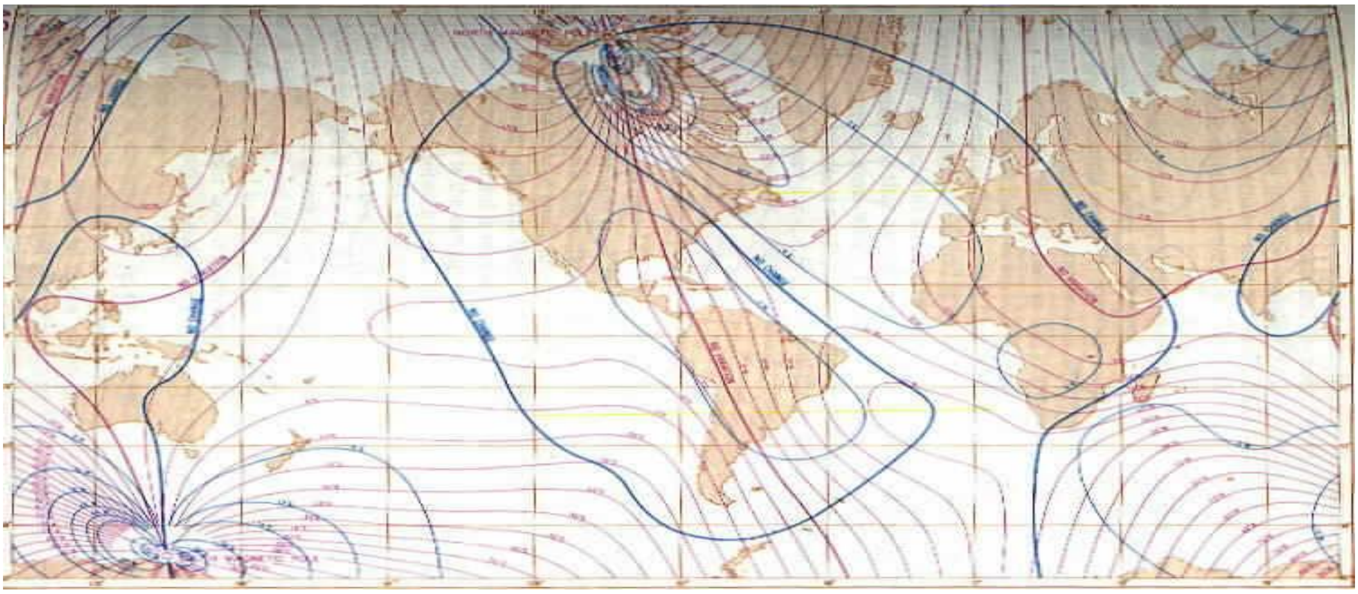



fig.M1

Magnetic Variation

Variation is determined by measuring the angular difference between true north and magnetic north. So, if we are located on Long Island, NY, magnetic north (the direction that our compass points to barring any other errors) is about 14° *west* of the true, geographic north, so our variation is 14°W. Now let's go to the Aleutian Islands of Alaska. Here magnetic north is about 15° *east* of true north, and our variation is 15°E.

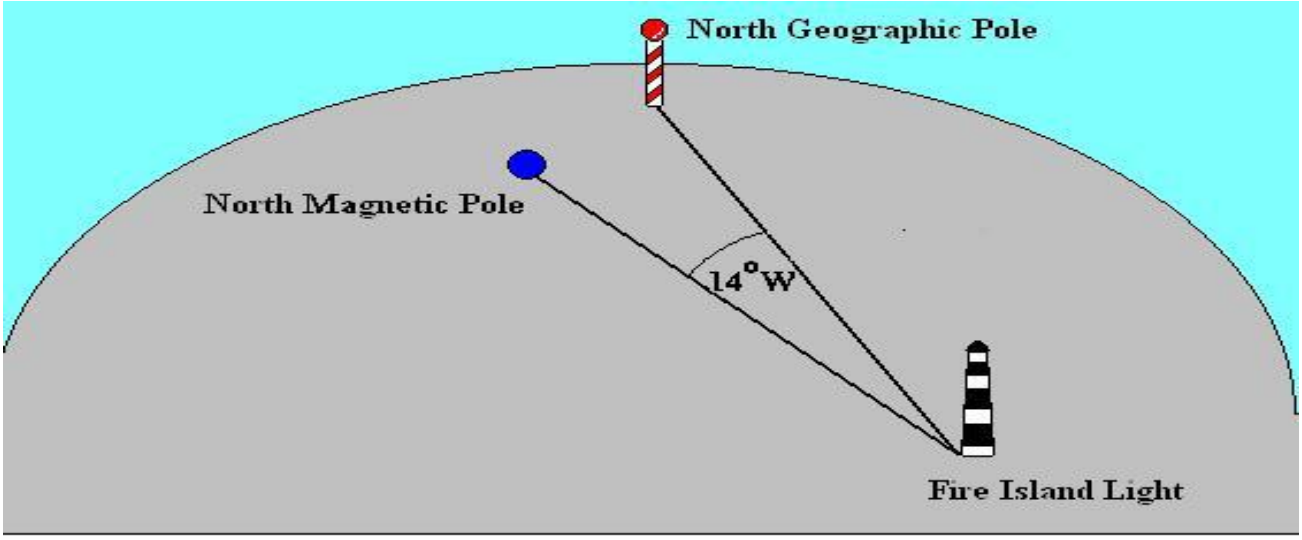



fig. M2 Magnetic Variation

Let's look at an example of variation. As shown in fig. M2 above, if we look at our compass as we sail next to the Fire Island Light, we know that the local variation is 14° West. That means that all of our compass readings (barring additional errors) are going to be 14° west of the true direction. Say our compass says we are heading on a course of 090° psc (per ship's compass). We are actually heading 076° *true*. If the compass reads 015°, we're on a course of 001°.

Some things to remember:

- Another name for variation is *declination*.
- An area's local variation can be found within the Compass Rose of your nautical chart. It changes a very slight amount every year due to the slow migration of the Earth's magnetic poles so check the year that your chart was printed and note the annual increase or decrease in variation.
- Some places have no variation. Other areas have extreme magnetic disturbances, to the point where conventional magnetic compasses are useless. These areas will be marked on charts of the area.

- Variation affects devices that rely on the Earth's magnetic field to work. Gyroscopic compasses, radio direction finders, and global positioning instruments are not effected by variation.

Deviation :

Another force that acts upon your compass to create error is *deviation*. Deviation is the influence of the immediate environment upon your compass. Being a magnet, your compass will be attracted to (or repelled by) iron bearing metal and other magnets (including magnetic fields created by flowing electricity). Unlike variation, deviation is not constant, it's different in every ship, and it's even different within the same ship, depending on which heading she's sailing. Deviation is measured by the angular difference between the magnetic heading and the compass heading.

The magnetic properties of a ship cause deviation in the magnetic compass. Ship magnetism is of two types:

- Permanent: Magnetism in steel or hard iron that acts as a permanent magnet.
- Induced: Magnetism of soft iron, which is only temporary and is constantly changing depending upon ship's heading and latitude.

The navigator should know what the deviation is on his vessel. most quality compasses can be adjusted to eliminate most, if not all deviation error. What deviation remains can be found and documented on a *Deviation Card*.

This card or graph will list the deviation for various compass courses and is referred to by the navigator when compass courses need to be corrected.

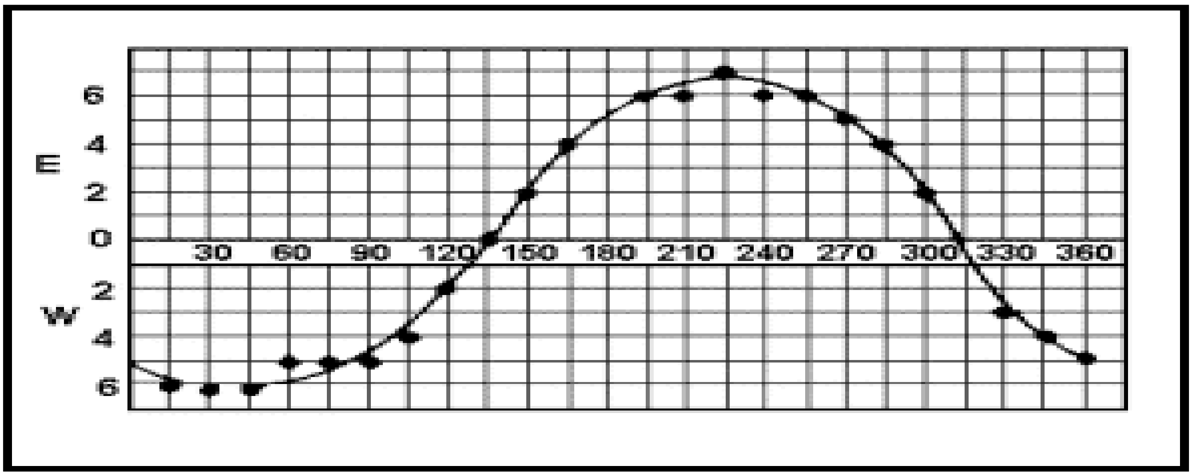
METHODS OF DETERMINING DEVIATION

The most convenient method of determining deviation, and the one most commonly used, is to check the compass on each 15 heading against a properly functioning gyrocompass. Because the ship must be on a magnetic heading when determining deviation, gyro error and local variation must be applied to each gyro heading to obtain magnetic heading. With comparing magnetic heading and compass heading deviation will found for each heading. As much as possible the deviation will be removed by placing permanent magnetic & soft iron near to magnetic compass. The residual deviation will be given in the form of a table or in the form of a graph called the deviation curve.

Some more facts about deviation:

- A common mistake we make as cops is to place the portable radio next to the compass. This is guaranteed to add a huge error to our compass readings.

Sample of deviation card :




Applying compass error:

There many ways to remember how to apply compass error , here we have mentioned one : Error East –Compass Least / Error West – Compass Best.

Our true course is 045° and we know our variation to be 14°W, while our deviation card gives our deviation on this course to be 4°E. First we plug in the numbers:

| TRUE | VARIATION | MAGNETIC | DEVIATION | COMPASS |
|---|---|---|---|---|
| 045° | 14°W | | 4°E | |

Since we're working from left to right, that is we know our true course and need to find our compass course to steer, we will add west errors and subtract east errors.

| TRUE | VARIATION | MAGNETIC | DEVIATION | COMPASS |
|---|---|---|---|---|
| 045° | 14°W | 059° | 4°E | 055° |

Which gives us a compass course of 055°.

Let's try another one. Here our compass reads 232°, our local variation is 8°E, and our deviation for this course is 6°W. What is our True Course?

| TRUE | VARIATION | MAGNETIC | DEVIATION | COMPASS |
|---|---|---|---|---|
| | 8°E | | 6°W | 232° |

This time we are working from right to left, so instead of adding west errors, we subtract them (and add east errors) which gives us ....

| TRUE | VARIATION | MAGNETIC | DEVIATION | COMPASS |
|---|---|---|---|---|
| 234° | 8°E | 226° | 6°W | 232° |

<u>Swinging ship :</u>

when a ship is completed ,she is swung and the deviation is found for all headings .As much as possible the deviation will be removed by contracting the ship's polarity with permanent magnets .The vessel will be swung once more and the deviation will be found for all headings .The residual deviation will be given in the form of a table or in the form of a graph called the deviation curve .

This will be done every two years or after any dry dock . It should be noted that different cargoes will have different effects on the ship's polarity and this will affect the deviation

➢ At dry dock the swing normally will be carried by a compass adjuster .A complete adjustment and swing should be carried out in the following cases:

1- A new ship after her sea trial and prior to her maiden voyage .

2- When there is a large structural changes to the hull .

3- When the ship has been in collision or stranded and subsequently repaired .

4- When the ship has been stricken by lightning .

5- After being laid up for a long time .

6- After a major fire on board .

➢ A swing should be carried out and deviations tabulated in the following cases :

1- Once a year .

2- After any dry dock .

3- After carriage of cargoes of magnetic nature .

4- After using of electromagnetic cranes .

5- After changing any correctors on board .

6- When considerable change in magnetic latitude or when 50 nm from magnetic equator .

7- When operating in an area remote from the last place of swing .

<u>When we need to check the compass:(taking compass error)</u>

1- After carriage of cargo possessing magnetic properties.
2- After loading or discharging in which electromagnetic crane is used.
3- At least once a watch.
4- Several minutes after any alteration of course.

The deviation so obtained should be recorded in the compass error book.

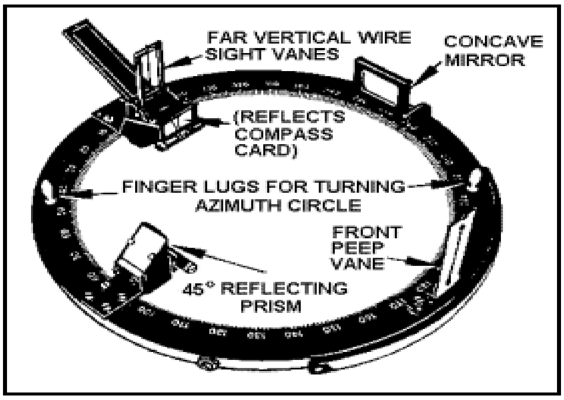
Care and maintenance of magnetic compass:

1- Keep the binnacle door locked.
2- Keep a record of position of all magnets, spheres, length of filnder bars.
3- Keep the hood on the binnacle to avoid spray and sun lights.
4- Keep free from bubbles, if necessary top up.
5- Check the pivot system move freely.
6- Check no dev. Change when binnacle light on / off.
7- Check the heeling error bucket , chain free to move.
8- Check safe distance from the electro magnetic materials.
9- No portable radio to be placed near to compass.
10- Check the deviation book for any changing pattern from previous voyage.
11- If the V/L strike by lighting check the card , magnets and deviation.
12- Check azimuth mirror regularly.

Azimuth Circle

This is a nonmagnetic metal ring. The inner lip is marked in degrees from 0° to 360° counterclockwise for measuring relative bearings. The azimuth circle is fitted with two sighting vanes. The forward or far vane has a vertical wire and the after or near vane has a peep sight. Two finger lugs are used to position the instrument while aligning the vanes. A hinged reflector vane mounted at the base and beyond the forward vane is used for reflecting stars and planets when observing azimuths. Beneath the forward vane are mounted a reflecting mirror and the extended vertical wire.

This lets the mate read the bearing or azimuth from the reflected portion of the compass card. For taking azimuths of the sun, an additional reflecting mirror and housing are mounted on the ring, each midway between the forward and after vanes. The sun's rays are reflected by the mirror to the housing, where a vertical slit admits a line of light. This admitted light passes through a 45 reflecting prism and is projected on the compass card from which the azimuth is directly read. In observing both bearings and azimuths, two attached spirit levels are used to level the instrument.



## Fluxgate Compass

The basic fluxgate compass is a simple electromagnetic device that employs two or more small coils of wire around a core of highly permeable magnetic material, to directly sense the direction of the horizontal component of the earth's magnetic field. It can be single core or dual core.

A fluxgate compass is a very important and unique tool in marine navigation as it does not operate automatically like other magnetic compasses. Technically a fluxgate compass is an electromagnetic compass which solves the purpose of a conventional compass.

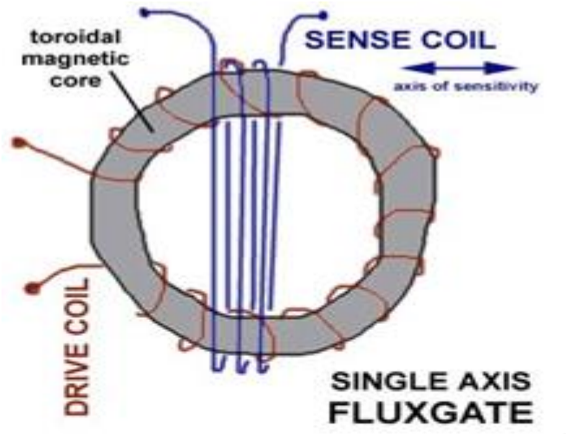
The fluxgate compass is used in ships mainly for the purpose of steering. Since the compass is an electronic one, the scope of errors is greatly reduced.

The difference between a magnetic compass and an electronic compass is that in the former variety there is a pointer that constantly moves indicating the direction. However, in an electronic compass there are no pointers that specify the direction. Electric currents that pass through coils of wire that are kept inside the compass indicate the geographic direction through signals that are displayed digitally. (Solid state type)

Construction & Advantages

There are two coils of wire that are located perpendicular to each other around a permeable magnetic material. When electric current is passed through the coils the core material works an electromagnet and senses the direction of the horizontal component of the earth’s magnetic field. This completely eradicates the problem caused due to the interference of the magnetic north is completely avoided. Another advantage of installing this type of compass in the ship is that these types of compasses are unaffected by their placement on the ship. They can be placed anywhere and the directions pointed by the compass can be relied on completely. Fluxgate compass can prove very useful during rough seas as they are unaffected by position and unusual movements.

However, the disadvantage of having an electronic compass is that if there is a complete lack of electricity on the ship then the device will not function making the shipmen rely again on the magnetic compass.




Working principle

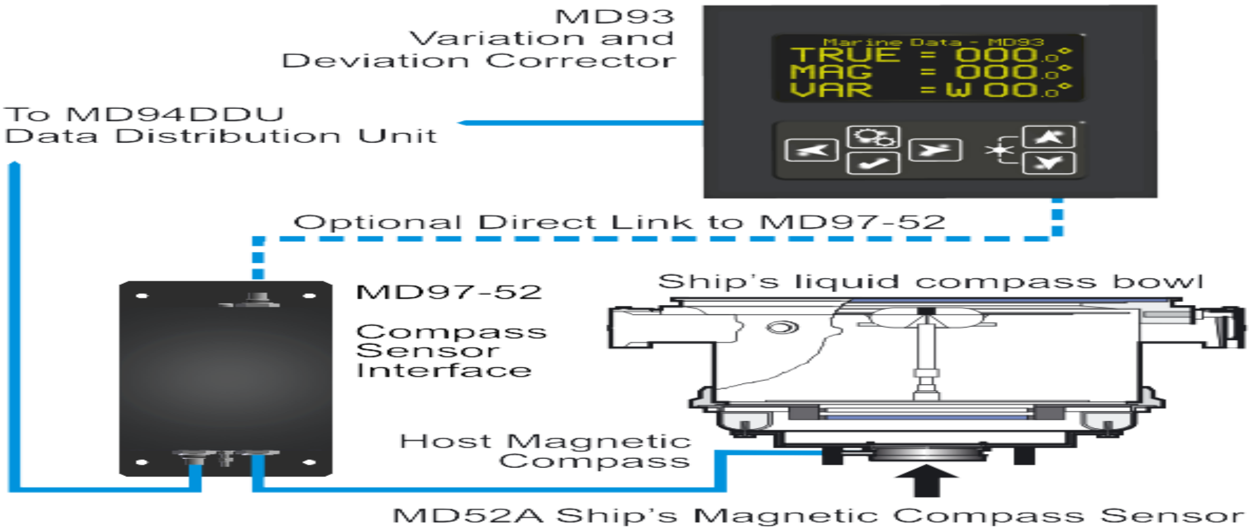
the fluxgate compass consists of a coil wound around a permeable core which again, is surrounded by a second coil. This core is magnetically saturated by an alternating cycle in opposing directions called excitation. This will result into a plus and minus saturation of the core. When no external magnetic field present, the flux in one half cancels out the flux in the other coil. When an external magnetic field is briefly applied, a net flux imbalance will occur between the two coils which means the two coils do not cancel out each other anymore.

At this stage current pulses are induced in the second coil which result in a signal that is dependent on polarity and the external magnetic field. This particular signal can be used for finding of the magnetic heading.

The most common use for the fluxgate compass is for steering, giving direct feedback to the pilot or the captain through a display. In the case of using autopilot the fluxgate compass can be used as immediate feedback for the autopilot equipment. A digital signal is sent to the equipment which provides the input for the right steering adjustments. The digital output can also be used for other navigational equipment like radar and chart plotters.

A transmitting magnetic compass (TMC) is used to take the magnetic heading and convert it into a digital signal. By feeding DEV & VAR can show the true heading. This can be used for a variety of reasons including:

- Replacing the periscope
- A back up heading to the auto pilot
- An independent off course alarm
- Showing the magnetic heading in more than one place


MD93
Variation and
Deviation Corrector
Marine Data - MD93
TRUE = 000.0°
MAG = 000.0°
VAR = W 00.0°
To MD94DDU
Data Distribution Unit
Optional Direct Link to MD97-52
MD97-52
Compass
Sensor
Interface
Ship's liquid compass bowl
Host Magnetic
Compass
MD52A Ship's Magnetic Compass Sensor

# AIS (Automatic Identification System)

AIS is a transponder system for ships, intending to increase the safety at sea. It operates in the VHF band. The two frequencies used are 161.975 Mhz (send) and 162.025 MHz (RCVD).

Every 2 - 10 seconds, transmits the following data:

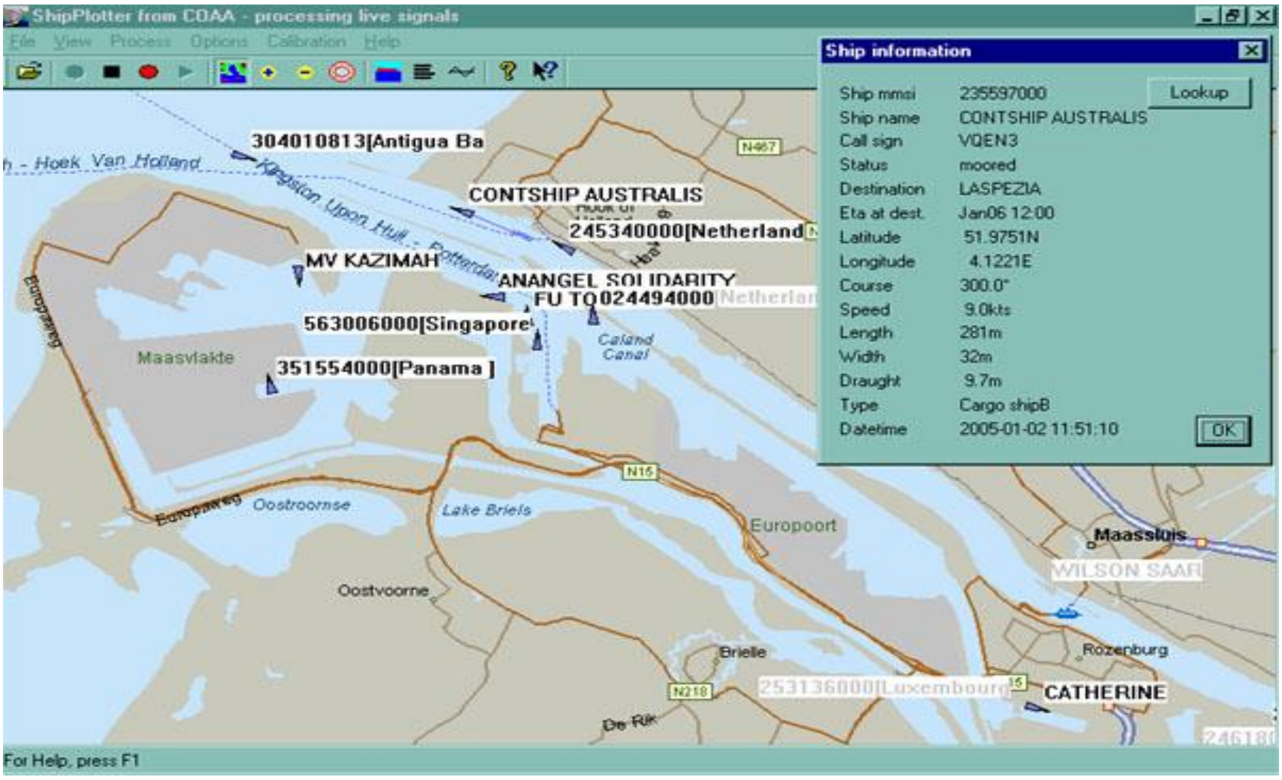
- MMSI number
- Navigation status, e.g. 'at anchor' or 'under way'
- Ground speed
- Rate of turn
- Position
- Heading and Course over Ground

Furthermore, every six minutes the following information is transmitted:

- MMSI number
- IMO number
- Call sign
- Ship's name
- Type of ship or cargo
- Dimensions of the ship
- Draught, 0.1 to 25.5 m
- Destination & ETA


Below we have included a screen copy of Ship Plotter, a map of the Rotterdam port area. All ships with AIS in the vicinity are visible. The software draws a trail behind the ship if it is moving.

The system also greatly increases safety at night and AIS signals are received in poor conditions such as heavy rain and squally conditions where a radar may have some limitation.




The system coverage range is similar to other VHF applications, essentially depending on the height of the antenna & its connections, Its propagation is slightly better than that of radar, due to the longer wavelength, so it's possible to "see" around bends and behind islands if the land masses are not too high. A typical value to be expected at sea is nominally 20 nautical miles. With the help of repeater stations, the coverage for both ship and VTS stations can be improved considerably.

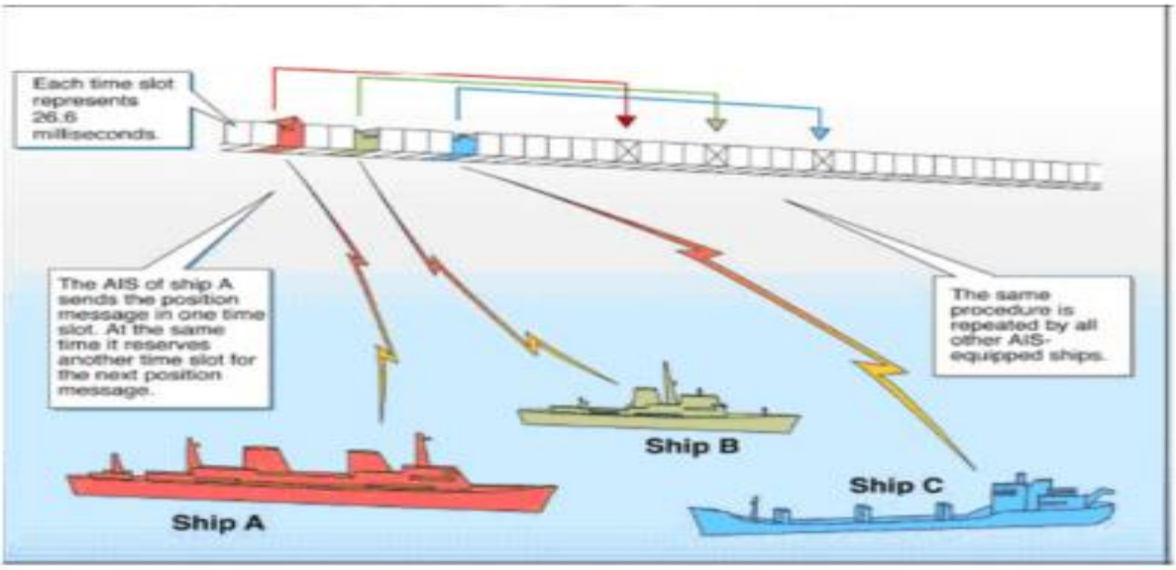
## **How Does It Work?**

Each AIS system consists of one VHF transmitter, two VHF receivers, one VHF DSC receiver, and a standard marine electronic communications link (IEC 61162/NMEA 0183) to shipboard display and sensor systems. Position and timing information is normally derived from an integral or external global navigation satellite system (e.g. GPS) receiver, including a medium frequency differential GNSS receiver for precise position in coastal and inland waters. Other information broadcast by the AIS, if available, is electronically obtained from shipboard equipment through standard marine data connections.

each station transmits and receives over two radio channels to avoid interference problems, and to allow channels to be shifted without communications loss from other ships.

Each station determines its own transmission schedule (slot), A position report from one AIS station fits into one of 2250 time slots established every 60 seconds. AIS stations continuously synchronize themselves to each other, to avoid overlap of slot transmissions. Slot selection by an AIS station is randomized within a defined interval. when new stations, including those stations which suddenly come within radio range close to other vessels, choose her slot & will always be received by those vessels.
In the event of system overload, only targets further away will be subject to drop-out, in order to give preference to nearer targets that are a primary concern to ship operators. In practice, the capacity of

the system is nearly unlimited, allowing for a great number of ships to be accommodated at the same time.



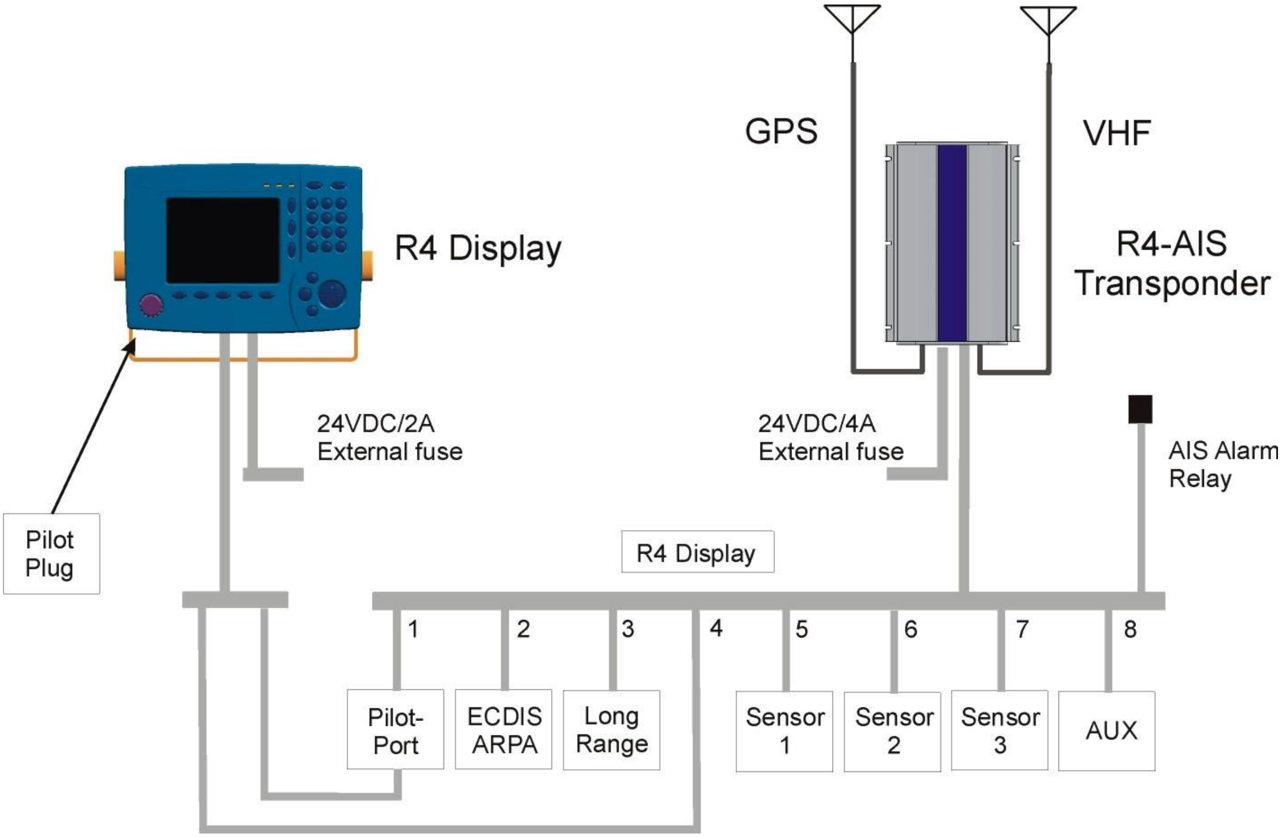




**Figure 1: R4-AIS Transponder System overview**

**Types of AIS**

ITU Recommendation M.1371-1 describes the following types of AIS:

**Class A**

Shipborne mobile equipment intended for vessels meeting the requirements of IMO AIS carriage requirement, and is described above.

**Class B**

The Class B is nearly identical to the Class A, except the Class B:

- Has a reporting rate less than a Class A (e.g. every 30 sec. when under 14 knots, as opposed to every 10 sec. for Class A)
- Does not transmit the vessel's IMO number or call sign
- Does not transmit ETA or destination
- Does not transmit navigational status
- Is only required to receive, not transmit, text safety messages
- Is only required to receive, not transmit
- Does not transmit rate of turn information
- Does not transmit maximum present static draught

the availability of class B transponders is increasing amongst smaller commercial boats, fishing and work boats and recreational boaters.

*Search and Rescue Aircraft*

Aircraft mobile equipment, normally reporting every ten seconds.

*Aids to Navigation*

Shore-based station providing location of an aid to navigation. Normally reports every three minutes. This may eventually replace the racon.

*AIS base station.*

Shore-based station providing text messages, time synchronization, meteorological or hydrological information, navigation information, or position of other vessels. Normally reports every ten seconds.

**Regulations for carriage of AIS**

Regulation 19 of SOLAS Chapter V - Carriage requirements for shipborne navigational systems and equipment - sets out navigational equipment to be carried on board ships, according to ship type. In 2000, IMO adopted a new requirement (as part of a revised new chapter V) for all ships to carry automatic identification systems (AISs) capable of providing information about the ship to other ships and to coastal authorities automatically.

The regulation requires AIS to be fitted aboard 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. The requirement became effective for all ships by 31 December 2004.

Ships fitted with AIS shall maintain AIS in operation at all times except where international agreements, rules or standards provide for the protection of navigational information.

A flag State may exempt ships from carrying AISs when ships will be taken permanently out of service within two years after the implementation date. Performance standards for AIS were adopted in 1998.

The regulation requires that AIS shall:

- provide information - including the ship's identity, type, position, course, speed, navigational status and other safety-related information - automatically to appropriately equipped shore stations, other ships and aircraft;
- receive automatically such information from similarly fitted ships; · monitor and track ships;
- exchange data with shore-based facilities.

The AIS Pilot Plug, on each vessel over 1,600 gross tons, on international voyage, shall be available for pilot use, easily accessible from the primary conning position of the vessel, and near 120 volt, AC power, 3-prong receptacle

**BENEFITS OF AIS**

Automatic Vessel Identification AIS brings to the mariner many benefits. Principal amongst these is sending & receiving vessel identity (MMSI, call sign etc), thereby facilitating rapid radio communication where necessary. This benefit is of equal, if not even greater value to VTS authorities.

a) Wider geographical coverage.
AIS data will be received by other AIS units, or by base or repeater stations. Thus where a VTS organization is fitted with such equipment, it will be capable of receiving both identity and precise location of a vessel at the maximum reception range of the VHF radio communications frequency.

b) Greater positional accuracy.
AIS aims to achieve positional accuracy better than 10 meters when associated with DGNSS correction signals. This compares favorably with radar which positional accuracy in the range 30 to 50 meters. provide the position of floating aids (primarily buoys). possibly to replace radar transponder beacons (RACONS);

c) Absence of “radar shadow” areas.
In coastal and harbor waters radar tracking of vessels can be masked, or otherwise affected by the proximity of land and buildings. Whilst AIS tracks will avoid the great majority of such effects.

d) Traffic image accuracy

Vessel tracking can similarly be interrupted when two vessels pass close to one another, with the result that the radar tracking of one contact is confused by the proximity of the other. Importantly, this can result in the identity of one track transferring or “swapping” to the other. Self-evidently, such a situation introduces a potentially dangerous inaccuracy in the vessel traffic image, unless noticed and rectified quickly by VTS center.

e) Real time maneuvering data.

Radar based VTS systems will typically provide details of a vessel’s course and speed over the ground. In contrast, AIS will provide all recipients with certain elements of real time maneuvering data such as Ships Heading and Rate of Turn.

f) Weather effects on tracking performance.

Navigational radar performance is often adversely affected by precipitation as a function of the radio frequency on which it operates. In heavy rain or snow, effective radar tracking is sometimes unachievable. As a consequence, a VTS center is much more likely to maintain an accurate traffic image in adverse weather where that tracking is based on AIS data.

g) Provision of more precise navigational advice.

It follows that where a VTS center is able to receive AIS information from vessels within or adjacent to its area, the quality, accuracy and reliability of vessel tracking will be improve. As a consequence, that VTS center will be able to provide more precise navigational advice. Moreover, the availability of certain real time maneuvering data within the VTS center will enable VTS operators to appreciate more rapidly, and in greater detail, actual vessel movement.

h) Electronic transfer of sailing plan information

Where AIS is integrated into a VTS system, it becomes possible for vessels and the VTS center to exchange passage information such as intended way points.

i) Electronic transfer of safety messages.

The facility available within AIS for the transmission of short safety messages makes possible the electronic broadcasting from a VTS center of local navigation warnings, and similar safety related messages.

VTS center may have the capability to broadcast via AIS local chart corrections to ECDIS fitted ships. Vessels are normally required to report to the VTS authority that any dangerous goods are being carried.

j)Impact on VHF communications

one of major benefit of AIS is the consequential reduction of VHF voice messages. This in turn reduces the reliance placed on vessels understanding such messages from a VTS center and vice versa.

k)Archiving data

The automatic availability within a VTS center of AIS data for each vessel facilitates the rapid and comprehensive recording, replay and archiving of data

l)Improved SAR management

Many marine and VTS authorities are equipping SAR capable units, including aircraft and helicopters, with AIS. The AIS voyage related message permits a vessel to transmit the number of persons onboard. Whilst this is not mandatory for vessels at sea, it can be made a formal requirement in a VTS area. The provision of such details, and the ready identification and location of SAR units greatly facilitates the management and evaluation of any SAR response.

m)binary messages

for transmission of Specific Messages as a means for certain types of limited communications between ship & shore station. For example:

- ships to report information to other ships and shore stations;
- shore stations to report navigation information, conditions and warnings

n) AIS for Meteorological information

The information to be broadcast will depend on the operational requirement and the availability of measuring and processing equipment. Examples include:
· Wind speed, average and gust values
· Wind direction
· Water level
· Water temperature
· Air temperature
· Current speed and direction at different depths
· Tide information
Such data permits the presentation of real time information at receiving stations, including onboard ships within VHF range.

**LIMITATIONS ASSOCIATED WITH USE OF AIS**

Although AIS has the potential to greatly enhance VTS operations, the system does have several limitations:
· VTS operators may become overly dependent on AIS and, therefore, may treat the system as a sole or primary means for vessel identification; as a result, they may fail to identify contacts, because all vessels may not be equipped with AIS;
· AIS has the same limitations as VHF-FM;
· When a AIS unit reaches its saturation point (maximum number of transmission receipts), accepting those closest to the unit and eliminating those furthest away, a feature particularly useful to ships, however, this feature could prove detrimental to VTS operations that must service a large area this can, however be overcome by better coverage through the addition of more base stations and/or repeaters.
· Whilst AIS tracks will avoid the great majority of radar shadow effects, the very close proximity of buildings and bridges, can degrade the AIS positional information.

**Bridge Arrangement**

1) Minimum Keyboard and Display

The functionality of the. Minimum Keyboard and Display (MKD). shall be available to the mariner at the position from which the ship is normally operated. internal MKD (integrated or remote) or through the equivalent functionality on a separate display system.

2)Pilot plug

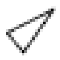
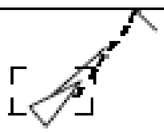
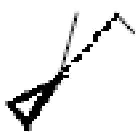
A pilot input/output port is part of an AIS Class A station. A plug connected to this port should be installed on the bridge near the pilots operating position so that a pilot can connect a Personal Pilot Unit (PPU).

3)Display system

If there is navigational equipment capable of processing and displaying AIS information such as ECDIS, ARPA.

4) alarm output

The AIS requires that an alarm output (relay) be connected to an audible alarm device or the ships alarm system.

| AIS target | Symbol | Description of symbol |
|---|---|---|
| AIS target (sleeping) |  | An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available. The symbol of the sleeping target may be smaller than that of the activated target. |
| Activated AIS target |  | An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available.<br>The COG/SOG vector should be displayed as dashed line starting at the centroid of the triangle<br>The heading should be displayed as solid line of fixed length starting at the apex of the triangle<br>A flag on the heading indicates a turn and its direction in order to detect a target manoeuvre without delay<br>A path predictor may also be provided |
| Selected target |  | A square indicated by its corners should be drawn around the target symbol. |
| Dangerous target |  | A bold line clearly distinguishable from the standard lines should be used to draw the symbol. The size of the symbol may be increased. The target should be displayed with: vector, heading and rate of turn indication. The symbol should flash until acknowledged.<br>The triangle should be red on colour displays. |
| Lost target |  | A prominent solid line across the symbol, perpendicular to the last orientation of the symbol should be used. The symbol should flash until acknowledged. The target should be displayed without vector, heading and rate of turn indication. |

**Information shown by AIS divided in to 2 types:**

**Dynamic data input**

1. External Sensors
2. Position
3. Heading
4. Rate of Turn
5. Speed and Course If a bottom track (BT)-log for speed over the ground (SOG) is available, it may be connected.
6. Navigational Status: A simplified means should be provided for the operator to input the ships navigational status e.g. underway using engine, at anchor, not under command, restricted in ability to maneuver.

**Static Information**

The AIS standards require that certain static, voyage-related, information be entered manually, normally by means of the MKD,

• Maritime Mobile Service Identity (MMSI) number
• IMO vessel number
• Radio call sign
• Name of ship
• Type of ship
• Dimension of the ship.

voyage related data**:**

•ships draft
•destination
•eta
•type of cargo
•number of crew onboard

**Long-Range function**

The AIS. long-range function needs a compatible long-range communication system
(e.g. Inmarsat-C or MF/HF radio as part of GMDSS).
If this is available, a connection between that communication system and the Class A mobile unit can be made. This connection is needed to activate the LR function of AIS.

**AIS & COLREG:**

As per COLREGS requirement that the Officer Of the Watch (OOW) should use "all available means", it is a clear indication that IMO intended the AIS to be used to avoid collision.
However, a word of caution should be included: the guidelines also warn that the mariner should not rely on AIS alone, and should not use the AIS as an excuse to slacken his lookout or responsibility. This statement agrees fully with COLREGS requirements for good seamanship and proper look-out. Possibly the reader should also be aware that, in interpreting AIS data by ECDIS systems, the good practice is to use the target positions only and not trust the SOG (Speed Over Ground) and COG (Course Over Ground) computed and sent by the target's AIS transmitter. Those parameters are calculated separately using ARPA systems.

**Use of AIS in oil terminals**

The AIS operates on a VHF frequency and transmits and receives information automatically, and the output power ranges between 2 and 12.5 watts.
When alongside a terminal or port area where hydrocarbon gases may be present, either the AIS should be switched off or the aerial isolated.
When alongside a terminal or port areas where no hydrocarbon gases are likely to be present, and if the unit has the facility, the AIS should be switched to low power.

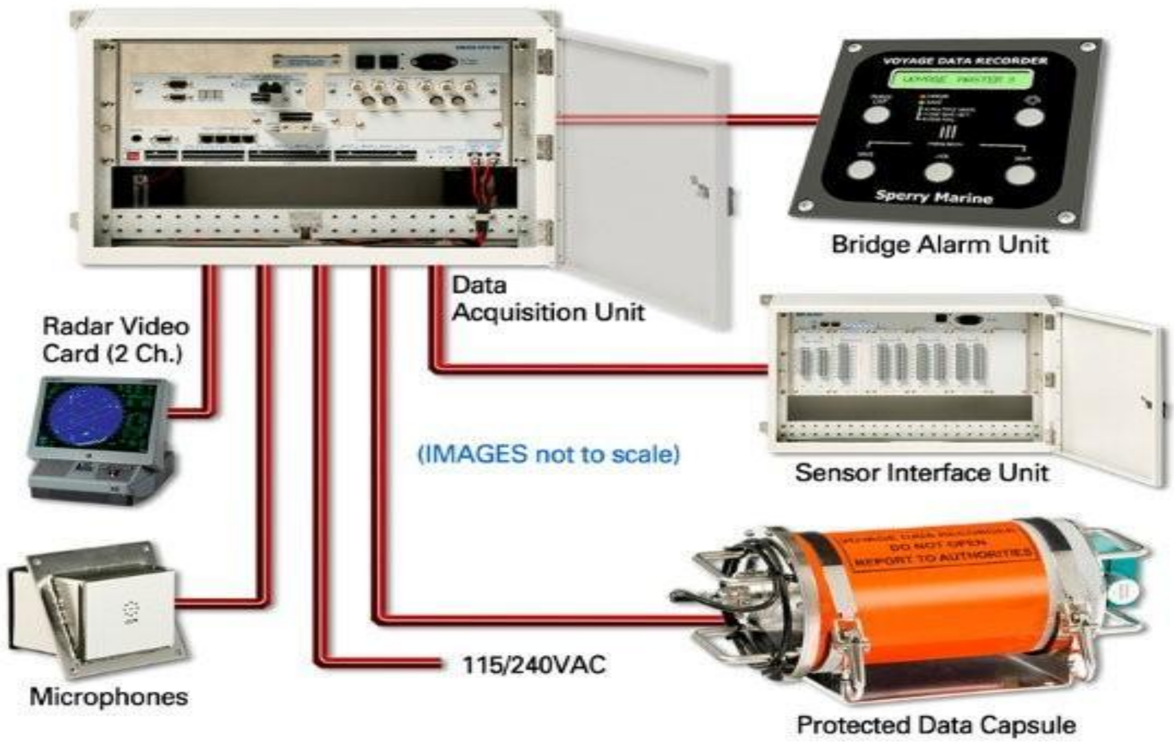
# VOYAGE DATE RECORDER ( VDR)

**What is VDR (VOYAGE DATA RECORDER)?**

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. This recording is recovered and made use of for investigation in events of accidents.

A ship's VDR is far superior to a black box of an aero plane as it store variety of data.

A VDR is capable of withstanding heavy weather, collisions, fires and pressure conditions even when a ship is at a depth of several meters in water.



**How VDR Works?**

The purpose of a Voyage Data Recorder is to store information in a secure and retrievable form, relating to the position, movement, physical status, command and control of a ship over the period and following an incident. Information contained in a VDR should be made available to both the authorities and the ship-owner. This information will be required during any subsequent safety investigation to identify the cause(s) of the incident

There are various sensors placed on bridge of the ship and on prominent location from which the required data is continuously collected.

There is also a record button provided in the bridge unit so that after pushing button (say during starting of any incident like collision or grounding), the recorder will start recording new set of information from that period of time.

The collected data by VDR is digitalized, compressed, and is stored in a protective storage units which is mounted in a safe place. This temper proof storage unit can be a retrievable fixed & floating unit connected with EPIRB for early location in the event of accident. In floating type, a hydrostatic release unit is fitted which will be active when ship skunked and detached from vessel & float in sea level.

**The VDR at least must record the following:**

- Date and time (SVDR)
- Ship’s position (SVDR)
- Speed and heading (SVDR)
- Bridge audio (SVDR)
- Communication audio (radio) (SVDR)
- Radar data (SVDR)
- ECDIS data (SVDR)
- 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

**Regulatory requirements for carrying VDR**

The requirement for carrying VDR under IMO came into force on 1st July 2002 for all the passenger ships constructed after 1st July 2002 and vessel other than passenger ship above 3000 GT as per SOLAS Chapter V.

On December 2004, an amendment was adopted for above regulation for carrying simplified voyage data recorder or S-VDR and it entered into force on 1st July 2006.

A S-VDR is a simple data recorder which stores less but vital data as compared to a standard VDR; however, the storage criteria is same.

**In May 2012 the Maritime Safety Committee of IMO (International Maritime Organization) adopted a revised recommendation on performance standards for voyage data recorders (VDRs), to be enforced by 1 July 2014.**

New requirements defined in MSC.333(90):

- Data shall be recorded in a fixed capsule, a float-free capsule and internally in the VDR
- Data shall be recorded for minimum 48 hours in both capsules and 30 days internally in the VDR
- Bridge audio shall be recorded using at least two tracks for indoor microphones. Outdoor microphones (where applicable) shall be recorded on an additional separate track. The current standard is not very specific regarding this. The new standard also specifies that audible alarms and noise on the vessel shall not prevent the VDR from recording audio properly
- Images, chart(s) used and settings from the ECDIS shall be recorded. Images from both radars on the vessel shall be recorded
- Data from the AIS shall be recorded.
- Data from an inclinometer shall be recoded if installed.