Content

Navigation Aids Questions

GPS

Kepler's Laws

1. A **satellite orbit**, with respect to the earth, is an **ellipse.**
2. **Vectors** drawn from the satellite orbit to the earth describe **equal areas** in **equal times.**
3. The square of the period of the orbit is equal in ratio to the cube of its mean altitude above the earth's surface

Explain how you may generally test/check operation, and performance of GPS equipment.

1: execute **self-test**

2: **Compare** GPS position with known geographical or a **land mark** position acquired by RADAR.

3: **DOP** value must be from **1**(excellent) to **3**.

4: **DGPS functionality** (HF applicable).

5: **GPS antenna** location

6: Good data interface with other navigational aids which require GPS data.

With the aid of simple sketch/s describe the principles of the global positioning system (GPS)?

the GPS system may be viewed simply as a continuous **series** of **radio signals broadcast** from orbiting **satellites to** a radio **receiver** on the surface of the earth.

These signals **contain information** on the position of the satellites, measurement data indicating the distance (range) to each satellite, and information describing the relative velocity of the satellites with respect to the receiver.

GPS position solution can be reduced to a familiar problem in trigonometry, known as a distance intersection. If we can measure the distance of three known points from an unknown point, the x, y, and z coordinates of the unknown point can be computed.

In order to understand how the GPS satellite system works, it is very helpful to understand the concept of trilateration.

Trilateration is a basic geometric principle that allows you to find one location if you know its distance from other, already known locations. The geometry behind this is very easy to understand in two dimensional space. This same concept works in three dimensional space as well, but you're dealing with spheres instead of circles. You also need four spheres instead of three circles to find your exact location. The heart of a GPS receiver is the ability to find the receiver's distance from four (or more) GPS satellites. Once it determines its distance from the four satellites, the receiver can calculate its exact location and altitude on Earth! If the receiver can only find three satellites, then it can use an imaginary sphere to represent the Earth and can give you location information but no altitude information.

For a GPS receiver to find your location, it has to determine two things:

- The location of **at least three satellites** above you

- The **distance** between **you** and each of those **satellites**.

1.what is the system configuration of GPS?

The GPS consists of three major segments: **Space**, **Control** and **User**.

a) space segment:

consists of 24 operational satellites in 6 orbital planes (four satellite in each plane), at a height of about 20200 km above the surface and separated from one another by 60 degrees of longitudinal and with a 12hours period. All SVs transmit a navigation message comprising orbital data, clock timing, characteristics, system time and a status message

b) Control segment:

Consist of five monitor stations, three ground antenna and a master control station (MCS) in the USA. The monitor stations track all satellites in view, accumulating ranging data. this information is processed at the MCS to determine satellite orbits and to update each satellites navigation message.

C) user segment:

Consists of antennas and receiver-processors that provide positioning, velocity and precise timing to the user. the antenna must be capable of receiving the signal from any of the satellites which are more than 5 degrees above the horizon. The marine user should be able to receive L_1 From at least 3 satellites and to generate the C/A code for each one.

Dilution of Precision (DOP):

Dilution of Precision (**DOP**) is a term used for expressing the **mathematical quality** of a **solution**. DOP can exist in **one dimension** only. Examples are; time DOP (**TDOP**); **horizontal** DOP; **vertical** DOP and **geometric** DOP, referring to SV geometry. But it is the **position** dilution of precision, PDOP, that is of most value to a navigator. The PDOP will approach unity when a solution is made with a satellite overhead and three other satellites evenly spaced at low elevation angles. The PDOP figure has a direct bearing on user range error (URE). For example, for a URE of 50 m and a PDOP of unity, the best fix accuracy is 50 m. If the PDOP is 2, the accuracy drops to 100 m.

2.explain the **accuracy** of **GPS** and factors affecting it? (position fix)

The GPS provides two levels of service known as:

1. Precise Positioning Service (PPS):
2. PPS fixes are based on range measurement and the acquiring and integrating of the C/A code and P code transmitted on both the L_1 and L_2 carrier frequencies. The method provides highly accurate positioning, timing and velocity figures for users. This service will be available on a continuous, worldwide basis to certain users authorized by p(y)code with accuracy of 22m horizontally and 27.5m vertically.

3. Standard Positioning Service (SPS):

SPS fixes are based on acquiring and integrating the C/A code data transmitted on the L_1 carrier frequency, measuring ranges and decoding the navigation message. SPS fix accuracy can be extensively improved by using Differential GPS. Data is received, at both a mobile and a ground station, from multiple SVs and, after the computation of correction figures at the fixed station, is retransmitted to the mobile receiver. It is a positioning and timing service which will be available to all GPS users on a CONTINOUS, WORLDWIDE basis with no direct charges, and a navigation data message with accuracy of 100m horizontally and 156m vertically.

How the receiver clock error is compensated in GPS system?

This Relativity error on GPS satellite and RECIEVER clocks error produced due to two causes:

1- GPS **satellites** move with **higher speed** rather than **receiver** on the earth surface, which can cause the atomic clocks on-board the satellites to register time about 7 microseconds/day **slower** than on earth.

2- **reduction** of **gravity on satellites** causes the clocks to run about 45 microseconds a day faster than they do on earth. The overall effect is a +38 microseconds/day increase in measured time which is then compensated for at the satellites. To compensate for all relativity errors, the SV clock oscillator frequency is slightly offset.

The following errors affect the accuracy of GPS position fixes:

Selective Availability (SA):

SA is the **intentional degradation of the SPS signals** by a time varying bias. SA is controlled by the DOD (Department of Defense) to **limit accuracy** for **non-US military** and government users. The potential accuracy of the C/A code of around 30 meters is reduced to 100 meters (two standard deviations). The SA bias on each satellite signal is different, and so the resulting position solution is a function of the combined SA bias from each SV used.

Satellite clock error satellite clock oscillator is necessary to re-adjust from the ground support network. Error introduced by SV clock error is unlikely to exceed 1m and regular up linking of clock data reduces it to a minimum. the latest SVs, carry better clock oscillators and will consequently provide higher accuracy fixes.

Ionospheric delay error

As the two transmitted carriers must pass through the ionosphere, a speed reduction caused by refraction of the radio wave occurs. fix error due to the ionosphere is unlikely to exceed 10m.

Tropospheric delay error

Extending from the earth's surface to an altitude of 70km, the troposphere also introduces a delay into the pseudo-range calculation. Unfortunately, the error is independent of frequency. GPS receivers hold a software solution in the form of a mathematical model to eliminate the effect of this delay. Error from this source is unlikely to exceed 1m. Both ionospheric and tropospheric errors are reduced if ranges are measured from SVs showing a high elevation from the receiver.

Multipath error

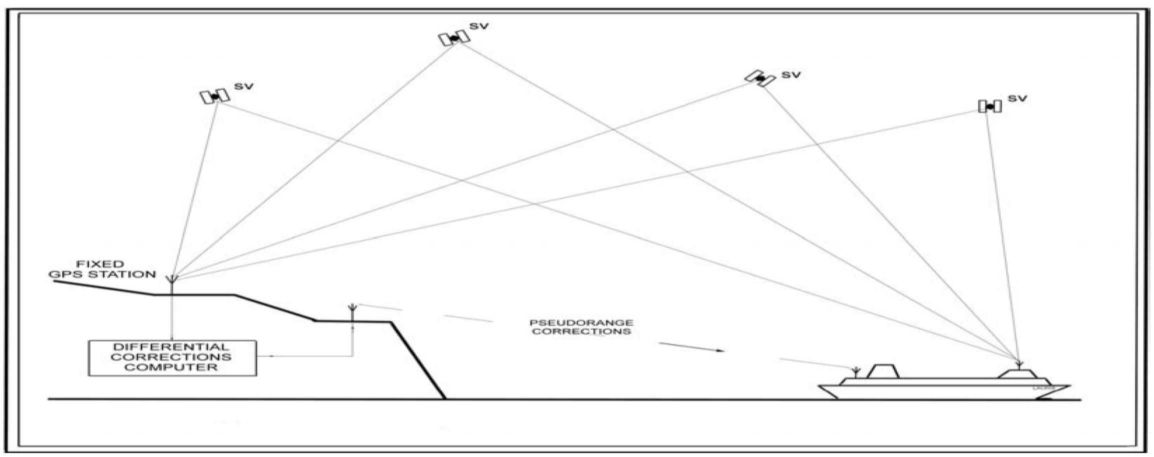
This results from the reception of the same SV signal from more than one source. A major contributor to this error is the reflected wave from an object close to the receiving antenna. Each receiver position is unique and therefore the error is not consistent. Final fix errors in the region of 1m can be produced by this effect. Careful positioning of the antenna will eliminate this error.

User Range Error (URE)

This is a parameter for the estimated error in range calculation due to unknown factors. These include multipath, unmodelled atmospheric effects, operator error and unpredictable orbital errors. The URE figure is sent from SVs to GPS receivers and may be displayed in metres.

3.explain about DGPS (error, range)?

the accuracy of GPS fixes can be improved by using differential techniques. The principle is that GPS data from SVs are downloaded to both a mobile station and a fixed station at a precise location. A computer at the fixed site calculates the pseudo-range from GPS SVs and then compares it with the known ranges for that precise geographic location. It then computes a range error figure which is transmitted to mobile stations where it is used to correct the pseudo-range system errors. DGPS operates in the MF radio beacon band (285-325) kHz, and as a result the range over which they can be reliably received is limited to between 100 and 250km. But DGPS can assist in waters where freedom to manoeuvre is restricted.



Limitations in DGPS positioning accuracy:

The ionosphere is a dispersive medium, in which RF signals are refracted by an amount dependent on the given signal frequency and electron density, resulting in range error.

4.How to correcting GPS errors?

1.**real time correction:**

- The base **station calculates** and **broadcasts corrections** for each **satellite** as it receives the **data**.
- The **correction** is **received** by the GPS receiver via a **radio signal** and **applied** to the **position** it is calculating.
- As a result, the **position displayed** on the GPS receiver is a differentially **corrected position.**

2.**post processing correction:**

- Differentially correcting GPS data by post-processing uses a base GPS receiver that logs positions at a known location and a user GPS receiver that collects positions in the field.

The files from the base and user are transferred to the office processing software, which computes corrected positions for the users file.

5.explain about advantages and disadvantages of GPS?

- Advantages

-the system is **self-calibrating** (just turn on and use)

-can be **used any where**

-the technology is relatively small

-there is **currently** no charge to use **signal**.

- **Disadvantages**

-the technology is very **power hungry**

-the GPS **signal** is unable to pass through **solid structures**

-GPS **accuracy** is **related** to the **quality** of **signal reception**

Method of position fixing:

To obtain a position fix from GPS, a user **requires** an **antenna** which is capable of **receiving** the signal from any of the **satellites** which are more than **50 degrees above his horizon**. A **user** should be able to **receive L– 1** from at least **3 satellites** and to **generate the C/A code** for each one.

In theory by **comparing** the **PRN** code of the **received signal** with that of a similar one **generated** in the **Rx** it is possible to **determine** the **time** taken for the signal to reach the Rx. This **time**, **multiplied** by propagation **velocity** gives an indication of the range of the satellite.

The **intersection** of two such **ranges** should **provide** an observer on the surface of the earth with a **fix**, and, the intersection of three such ranges with a three dimensional fix.

6.How to compute of the fix (what is PSEDO RANGE)?

For the calculated range to be accurate, it is necessary for the **RX clock** to be perfectly **synchronized** with that in the **satellite**.an error of one micro could lead to substantial errors in position. the range which is obtained using an unknown clock error is there for called PSEDO RANGE. This further unknown can be looked up as a further dimensions and for the user on the surface a third psedo range is all that is required to determine the error in the RX clock. For the user in 3 dimensional spaces a fourth psedo range can provide the solution. Another requirement for the most accurated range is an understanding of the propagation velocity and path between the satellite and the RX at the time of transmission.

World Geodetic System 1984 (WGS 84)

WGS 84 is an **earth fixed global reference** frame, including an earth model. It is defined by a set of primary and secondary parameters:

- the **primary parameters** define the **shape of an earth ellipsoid,** its angular velocity, and the earth mass which is included in the ellipsoid reference
- the **secondary parameters** define a detailed **gravity model of the earth.**
- These **additional parameters** are needed because WGS 84 is used not only for defining coordinates in surveying, but, for example, also for **determining** the **orbits of GPS navigation satellites.**

The Russian Global Navigation Satellite System (GLONASS)

GLONASS is a **Russian** satellite navigation system similar to GPS.

GLONASS (Global Navigation Satellite System) is a satellite based **radio navigation system** which **enables** unlimited number of **users** to make **all-weather 3D positioning**, **velocity** measuring and **timing** anywhere in the world or near-Earth space.

The **GLONASS** system has **two** types of navigation **signal**: standard precision navigation signal (**SP**) and high precision navigation signal (**HP**). **SP** positioning and **timing** services are **available** to **all** GLONASS civil **users** on a continuous, worldwide basis and provide the capability to obtain horizontal positioning **accuracy within 5770 meters (99.7% probability)**, **vertical positioning accuracy within 70 meters (99.7% probability)**, **velocity** vector components measuring **accuracy** within **15 cm/s (99.7% probability)** and **timing accuracy within 1 µs (99.7% probability).** These characteristics may be significantly increased using differential mode of navigation and special methods of measurements (e.g. carrier phase etc.)

GALILEO **European Satellite Navigation System**

More and more often, it will become necessary to ascertain one's precise position in space and time in a reliable manner. In a few years' time this will be possible with the GALILEO satellite radio navigation system, an initiative launched by the European Union and the European Space Agency. This worldwide system will ensure complementarity with the current GPS system.

Satellite radio navigation is an advanced technology. It is based on the emission from satellites of signals indicating the time extremely precisely. This enables any individual to determine his or her position or the location of any moving or stationary object (e.g. a vehicle, a ship, or a herd of cattle, etc.) to within one meter thanks to a small cheap individual receiver. **GALILEO** is based on a constellation of **30 satellites** and ground stations providing information concerning the positioning of users in many sectors such as transport (vehicle location, route searching, speed control, guidance systems, etc.), social services (e.g. aid for the disabled or elderly), the justice system and customs services (location of suspects, border controls), public works (geographical information systems), search and rescue systems, or leisure (direction-finding at sea or in the mountains, etc.).

7.Describe the principle of an echo sounder.

In its simplest form, Acoustic **energy** is **transmitted perpendicularly** from the **transducer** to the **seabed**. **Some** of the **transmitted energy** is **reflected** and will be **received** by the **transducer** as an **echo**. **velocity** of **sound** waves in **seawater** is accepted to be **1500ms**$^{-1}$.

$$\text{Distance travelled} = \frac{\text{velocity} \times \text{time}}{2}$$

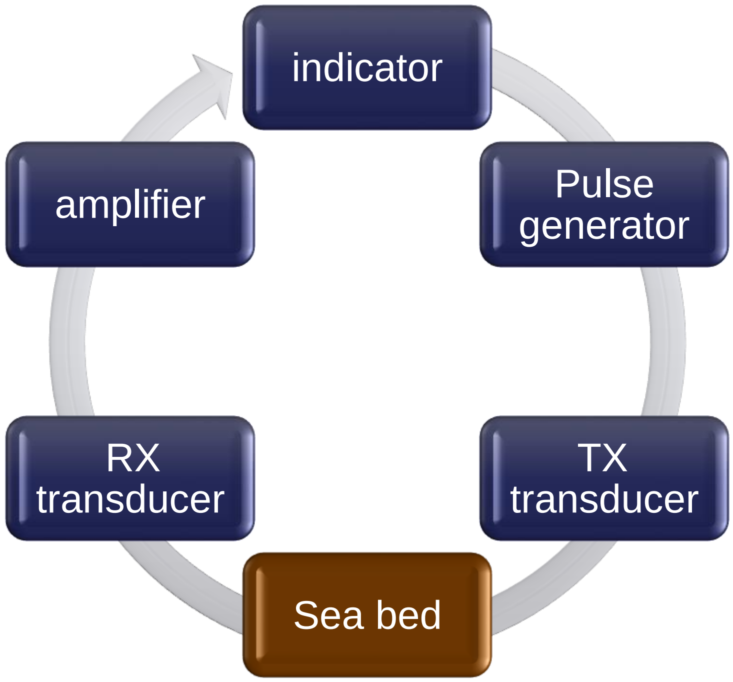
transducer, must be **capable** of **delivering** s**ufficient power** and the **receiver** must **possess adequate sensitivity** to **overcome** all of the **losses** in the **transmission** medium (seawater and seabed). Thus if the time taken for the return journey is 1s, the depth of water beneath the transducer is 750m.

Transmission of acoustic energy**:**

1- **Continuous wave**: The acoustic **energy** is **continuously transmitted** from one transducer. The returned echo signal is **received by a second transducer** and a **phase difference** between the two is used to **calculate the depth.** This system rarely used in merchant ships as is expensive and noise problem.

2- **Pulse system:** A **rapid short,** high intensity pulses are transmitted and **received** by a **single transducer.** The **depth** is **calculated** by measuring the **time delay** between the **transmission** and **reception**. The transmitter fires for a defined period of time and is then switched off. The pulse travels to the ocean floor and is reflected back to be received by the same transducer which is now switched to a receive mode.

8.explain main components of an echo sounder and their functions.



Pulse generator: this **generates** the **electrical oscillation** required for transmitting transducer.

Transducer: this is also **called oscillator**, they are installed at the **bottom of the ship** and performs the **following functions:**

- **Convert electrical** energy to **sound** energy
- **Sound energy** created, is beamed **vertically downwards** towards the **seabed**.
- **Receives** the **sound** waves **returning** to the ship **after reflection** from the sea bed.
- **Converts** the **reflected sound** waves into **electrical energy**.

Amplifier: this component will **amplify** the **weak electrical oscillations** that the receiving transducer has converted from sound vibrations.

Indicator: the depth indicator **measures the time elapsed between transmission** and **reception** of the reflected echo and expressed it in term of depth.

9.Explain the formation of types of false echoes and describe how to remove them?

- 2nd trace echo
- Velocity of sound
- Incorrect stylus speed in echo graph
- Shallow water effect
- Cross noise
- Multiple echo
- Double echoes
- Aeriation
- Pythagoras Error
- Error arising due to list and trim

2nd trace echo:

False reading may be obtained from a correctly adjusted echo sounder when the returning echo is not received until after the stylus has completed one or more revolution and the next pulse has been transmitted. If an echo sounder has its scale divided so that one revolution of the stylus corresponds to a depth of 600m, an indicated depth of 50m, could be a sounding of 50650 or even 1250m.

Multiple echoes:

This usually occur over a rocky bottom especially in shallow waters. They are caused by part of the **pulse** being **reflected** a **number of times between** the **ship's bottom** and the **sea bed.** only first echo is to be considered

Double echoes:

This type of echo is a **double reflection** of the **transmitted pulse.** It occurs **when** the energy is **reflected** from the **sea bed** and then **reflected back** from the **surface of the water** before being received by the transducer. A **double echo** is always **weaker** than the **true echo,** and can be expected to fade quickly with a reduction in the sensitivity of the equipment.

Shallow water effect:

This error is likely in shallow waters where the **receiving** and **transmitting transducers**, if any, are **widely separated**. The **echo sounder measures** the **slant range** whereas the true depth is the vertical distance. As this effect can give greater depth than the true depth this can be dangerous.

Aeration:

Air bubbles trapped under the hull tend to **shield** the **sound pulse** giving a weak echo or none at all. This occurs when the ship goes astern.

The main causes of aeration are:

- turbulence caused by having the **rudder hard over**;
- having a light ship which is **pitching heavily**;
- having **sternway** on the vessel;
- having **broken water** over shoals;
- entering an area where prevalent bad weather has left pockets of air bubbles over comparatively long periods.

Possible cures for the above include stopping or reducing the vessel's speed, and abrupt movement of the rudder either way to sweep away formed bubbles.

Cross noise:

This is caused by part of the sound **wave** going **directly** from **transmitter** to the **receiver** through the bottom plates and **through** the **aeration** of the **water**. Due to the unequal length of those pulses and difference propagation, velocity, each pulse will be received and recorded as a series of pulses. As a result, several lines appear near the zero mark the effect of cross noise occurs, the actual echo may be totally or partially masked in shallow depth.

Possible errors of echo-sounding equipment:

1 **Differences** of the **velocity** of **propagation**. Owing to the differences of salinity and temperature encountered in various parts of the world, adjustment tables are available, published by the Admiralty.

2 **Transmission line error**. This is caused by the misalignment of the reference 'zero' on the scale. Reference 'zero' sets the timer of the recorder unit, and if it is not set at 'zero' then a false time and recording will be obtained.

3 **Pythagorean error.** This error is encountered with separated transducers rather than with the combined transmit/receive unit. The error is caused by the measuring of the 'slant distance' as opposed to the vertical distance under the keel.

10. Explain two different types of transducers?

Electrostrictive transducers:

Certain materials, such as Rochelle salt and quartz, exhibit pressure electric effects when they are subjected to mechanical stress. The ceramic material contains random electric domains which when subjected to mechanical stress will line up to produce a potential difference, across the two plate ends of the material section. Alternatively, if a voltage is applied across the plate ends of the ceramic crystal section its length will be varied. when the crystals are set vibrating mechanically, an alternating voltage is generated between the two faces. This property is reciprocal, when a voltage is applied between the two faces, the crystal contract or expands a little, according to which face is positive and negative. The crystal is sandwiched between two steel plates, when an alternating voltage is applied between steel plate of the transducer, the crystal and plates vibrate together. These vibrations are enhanced by resonance. The lower of the two steel plates is in contact with the water and so produce the vibration in the water. This type only fitted on large merchant vessels when the power transmitted is low and the frequency is high. The whole unit is pre stressed by inserting a stainless steel bolt through the center of the active unit.

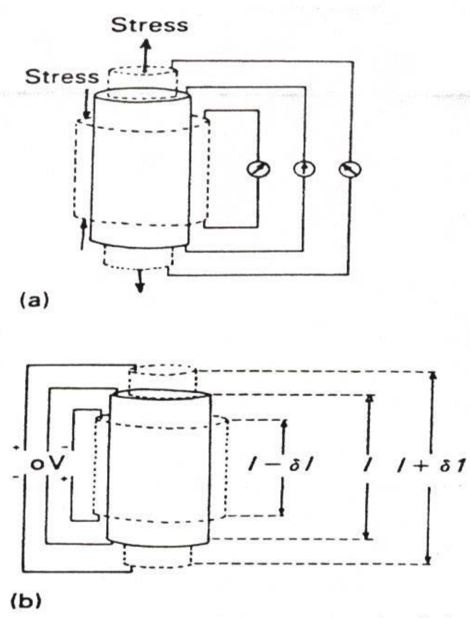


Figure 2.5 (a) An output is produced when a piezoelectric ceramic cylinder is subjected to stress. (b) A change of length occurs if a voltage is applied across the ends of a piezoelectric ceramic cylinder.

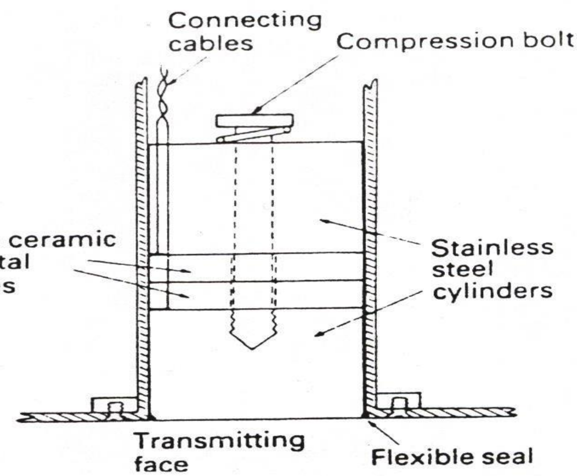


Figure 2.6 Construction details of a ceramic electrostrictive transducer.

Magnetostrictive transducers:

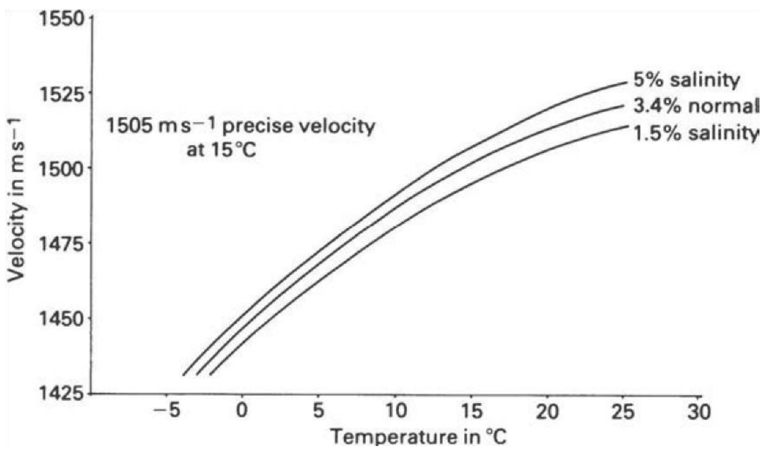
a bar of ferromagnetic material around which is wound a coil. If the bar is held rigid and a large current is passed through the coil, the resulting magnetic field produced will cause the bar to change in length. This slight change may be an increase or a decrease depending upon the material used for construction. For maximum change of length for a given input signal, annealed nickel has been found to be the optimum material and consequently this is used extensively in the construction of marine transducers. As the A.C through the coil increases to a maximum in one direction, the annealed nickel bar will reach its maximum construction length *(l+l*). With the A.C at zero the bar returns to normal (*l*). The current now increases in the opposite direction and the bar once again constricts (*l–l*). The phenomenon that causes the bar to change in length under the influence of a magnetic field is called ‘magnetostriction. and in common with most mechanical laws possesses the reciprocal quality. When acoustic vibrations cause the bar to constrict, at its natural resonant frequency, an alternating magnetic field is produced around the coil. A minute alternating current is caused to flow in the coil and a small e.m.f. is generated. This is then amplified and processed by the receiver as the returned echo. They are extensively used with depth sounding apparatus because at the low frequencies used they can be constructed to an acceptable size and will handle the large power requirement of a deep sounding system.

11.physical factors which affect the velocity of sound in water.

The speed of acoustic waves in seawater varies with temperature, pressure and salinity.

Temperature

Water temperature also affects absorption. As temperature decreases, attenuation decreases. The effect of temperature change is small and in most cases can be ignored, although modern sonar equipment is usually fitted with a temperature sensor to provide corrective data to the processor. As salinity increases, sonar wave velocity increases producing a shallower depth indication, although in practice errors due to salinity changes would not be greater than 0.5%. The error can be ignored except when the vessel transfers from seawater to fresh water.



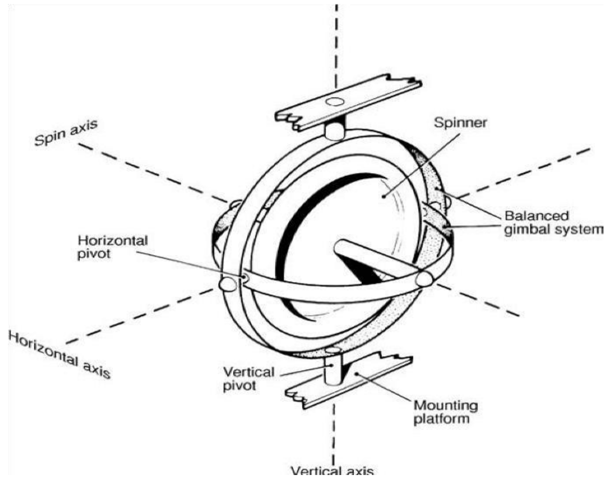
Gyro compass

The compass provides a **directional reference** to **true north** and is **unaffected** by the **earth's magnetism** and that of the **ship**.

12. Gyroscopic principles:

a marine gyrocompass assembly is a modern gyroscope consisting of a perfectly balanced wheel arranged to spin symmetrically at high speed about an axis. The rotor, spins about its own axis and, by suspending the mass in a precisely designed gimbals assembly, the unit is free to move in two planes each at right angles to the plane of spin. There are therefore three axes in which the gyroscope is free to move as illustrated in Figure.

- the spin axis
- the horizontal axis
- the vertical axis.



If such a gyroscope is supported with its spin axis approximately North-South and horizontal, its spin axis will remain fixed in space due to gyroscopic inertia. To an observer and due to the earth's rotation, the spin axis will appear to tilt, or tilt and drift, as if following the path traced out by a heavenly body. By applying the force due to gravity the spin axis can be made to precess towards the true meridian and by suitable damping settle in (or close to) the meridian. The gyroscope has now become a compass whose spin axis continuously seeks and settles in, or close to, the true meridian.

Free gyroscope:

If the gyroscope is not constrained in any way so that there are no forces acting upon the rotor so as to alter the direction in which the spin axis points, then the gyro is called a free gyroscope.

13.first property of the GYRO: Gyro inertia

This is the property of a free gyroscope which causes it to **maintain the position of its spin axis in space.** Regardless of how the supporting base is turned or twisted. The **amount** of **gyroscopic** inertia depends on the **angular velocity**, **mass**, and **radius of the wheel or rotor**. The rigidity in space of a gyroscope is a consequence of Newton's first law of motion, which states that a body tends to continue in its state of rest or uniform motion unless subject to outside forces. An example of this tendency is a rifle bullet that, because it spins on itself in flight, exhibits gyroscopic inertia, tending to maintain a straighter line of flight than it would if not rotating

14.secondary property of the GYRO: precession

If a force is applied to one end of the spin axis so as to produce a torque, the spin axis will not move in the direction of the applied force but at right angles to both applies force and spin axis, and in a direction determined by the direction of rotation of the spinner. This resultant motion is called precession.

Torque: Torque is defined as the moment of a couple or system of couples producing pure rotation. For a rotating body, torque is equal to the product of the moment of inertia and the angular acceleration.

15. The north-seeking gyro:

The gyro spin axis can maintain the spin axis parallel to the earth's spin axis by the use of a pendulum acting under the influence of earth gravity. The pendulum causes a force to act upon the gyro assembly causing it to precess. Precession, the second fundamental property of a gyroscope, enables the instrument to become north seeking. As the pendulum swings towards the centre of gravity, a downward force is applied to the wheel axle, which causes horizontal precession to occur. This gravitational force acting downward on the spinner axle causes the compass to precess horizontally and maintain the axle pointing towards true north. Bottom- and top-heavy controls are methods used for settling a north-seeking gyroscope.

16.Starting a gyrocompass:

start-up a gyrocompass needs time to settle on the meridian. The time taken depends upon the make, model and the geographic location of the compass, but in general it is between one and several hours. The duration also depends upon whether the gyro wheel is already rotating or not. If the compass has been switched off, it will take much longer to bring the compass into use. Inputting the ship's heading to reduce the initial error factor can reduce the time period. During this procedure the gyro wheel is checked for movement. If it is stationary, the system ops for a cold start, if it is rotating a hot start is programmed. When starting from cold, gyrocompasses require time to settle on the meridian.

Drift:

Drift is east-west (**side way**) movement of spin about vertical axis.

Tilt:

Tilt is north-south (**up and down**) movement of spin about horizontal axis.

17.when a magnetic compass should be adjusted?

1. **First installed**
2. Become **unreliable**
3. Observed **error** consistently exceeds the allowed limit of **5º** on one or more headings.
4. After **dry docking**, after structural alterations have been made to the ship
5. **Electrical or magnetic equipment** close to the compass is **installed** or **removed**.
6. **After 1 year** from when the compass was last **adjusted** if the required record of compass deviations has not been properly maintained
7. When deemed **necessary** by **master**.

Damping:

In order to make a **gyro settle**, and **point** to a **fixed direction** on **earth** and not space, it is necessary to impose a further precession which will damp out the gravity controlled elliptical path, traced only by spin axis i.e. Damping makes the gyro north settling. This is achieved by creating a force about the vertical axis to cause precession about the horizontal axis.

In gyro system, by offsetting the mercury ballistic controlling force slightly to the east of the vertical, the necessary force can be achieved.

18. What is gyro compass error?

 Static errors:

1.alignment error:

- ✓ an **error** existing between the indicated **heading** and the **vessel's lubber line**
- ✓ an **error** existing between the **indicated lubber line** and the **fore and aft line of the vessel.** Both of these errors can be accurately eliminated by critically aligning the compass with the ship's lubber line at installation

*2.*Transmission error:

An **error** existing between the indicated **heading** on the **master compass** and the heading produced by any remote **repeater** is a transmission error. Transmission errors are kept to a minimum by the use of multispeed pulse transmission.

3.variable error:

Variable compass errors can effectively be classified into two groups.

Dynamic errors that are caused by the angular **motion of the vessel** during heavy weather and maneuvering.

Speed/latitude errors that are caused by movement of the vessel across the earth's surface. The

magnitude of each error can be reduced to some extent

Dynamic errors:

1. Rolling error:

When a vessel rolls, the compass is swung like a pendulum causing a twisting motion that tends to move the plane of the sensitive element towards the plane of the swing. If the ship is steaming due north or south, no redistribution of mercury occurs due to roll and there will be no error but with a ship steaming due east or west, maximum lateral acceleration occurs in the north/south direction causing precession of the compass. However, rolls to port and starboard are equal, producing equivalent easterly and westerly precession. The resulting mean-error is therefore zero. If the ship is on an intercardinal course the force exerted by the mercury (or pendulum) must be resolved into north/south and east/west components.

For a vessel on an intercardinal course, rolling produces an anticlockwise torque.

Electrically-controlled compasses are roll-damped by the use of a viscous fluid damping the gravity pendulum. since roll error is caused by lateral acceleration, mounting the gyrocompass low in the vessel and as close as possible to the centre of roll will reduce this error still further.

2. Maneuvering (ballistic) error:

This error occurs whenever the ship is subject to rapid changes of speed or heading. Because of its pendulous nature, the compass gravity control moves away from the centre of gravity whenever the vessel changes speed or alters course. Torque's produced about the horizontal and vertical axis by maneuvering cause the gyro mechanism to precess in both azimuth and tilt. If the ship is steaming due north and rapidly reducing speed, mercury will continue to flow into the north pot, or the gravity pendulum continues to swing, making the gyro spin axis north heavy and thus causing a precession in azimuth.

3. Latitude (damping) error:

Latitude error is a constant error, the magnitude of which is directly proportional to the earth's rotation at any given latitude. It is, therefore, present even when the ship is stationary.

Correction for latitude error requires that a torque be applied to precess the gyro at an angular rate, varying with latitude, to cancel the error. This will be an external correction that can be either mechanical or electronic. For mechanical correction, a weight on the gyro case provides the necessary torque. The weight, or 'mechanical latitude rider', is adjustable thus enabling corrections to be made for varying latitudes. Another method of mechanical correction is to move the lubber line by an amount equal to the error

4. Speed and course error*:*

If a vessel makes good a northerly or southerly course, the north end of the gyro spin axis will apparently tilt up or down since the curvature of the earth causes the ship to effectively tilt bows up or down with respect to space, Speed/course gyrocompass error magnitude must also be affected by latitude and will produce an angle of tilt in the settled gyro. Hence latitude/course /speed error is sometimes referred to as LCS error

MAGNETIC COMPASS

Component of a magnetic compasses:

Magnets (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**. Some newer compasses have a circular magnet made of a metallic alloy.

Compass Card (B): This is an aluminum disc, graduated in degrees from 0° to 360°. It also shows cardinal and intercardinal points. North is usually indicated by the fleur de lis figure in addition to the cardinal point. Being attached to the magnets, the compass card provides a means of reading direction.

Compass bowel (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 Archimedes 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.

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. The compass rests on the binnacle. An important concept is that regardless of the movement of the ship, the compass card remains fixed (unless some magnetic material is introduced to cause additional deviation from the magnetic meridian). The ship, the compass bowl, and the lubber line move around the compass card. To the observer witnessing this relative motion, it appears that the compass card moves.

LIMITATIONS OF THE MAGNETIC COMPASS:

- **Sensitive** to any **magnetic disturbance**.
- **useless** at the **magnetic poles** and is sluggish and **unreliable** in areas **near the poles**.
- **Deviation 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**.

Retentive error:

A vessel on steady course for a considerable period acquires a certain amount of sub-permanent magnetism, with a red pole to the north ward and the blue pole on the south ward of the compass due to vibration, pounding, etc. though the vessel alters course, there for these poles are retained for a few hours during which period they gradually decay. On the new heading the sub-permanent magnetism gradually decays and there for the retentive errors gradually decreases and cause it to exit after few hours

GAUSSIN ERRORS:

When a vessel alters course rapidly, the different part of the ships structure cuts the earth's magnetic field E.M.F at varying rate. This set up on E.M.F and there for electric current in the ship's hull, this current set up magnetic field on its own, which according to the lens law will act in a direction opposite to that of the ships swing which caused it. There is also a short lay in the shift of the induced poles of the ships soft iron structure because of hysteresis.

Compass Error

Anything that affects our compass reading, that is, anything that alters it from the direction of true north, is called compass error.

Magnetic Variation:

The **angle** between the **true meridian** & **magnetic meridian** at a place is the magnetic variation at that place, it is name **easterly** or positive when the **north seeking** end of the **needle** lies **to the east** of the true meridian & **westerly** or negative when the **north seeking** end lies to the **west** of the true meridian. Magnetic variation is the angle between magnetic north and true north and is caused by the different locations of the Geographic North Pole and the Magnetic North Pole.

Deviation:

force that acts upon your compass to create error is *deviation*. **Deviation** is the **influence** of the immediate **environment** upon **your compass**. Deviation is measured by the **angular difference between** the **magnetic heading** and the **compass heading.**

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

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.

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

Receptivity: A ferromagnetic substance that retains much its magnetism in the absence of an external field is said to have high receptivity.

Coactivity: The strength of reverse field requires to reduce the magnetism of a magnet to zero is called coactivity.

Soft iron sphere: A pair of soft iron sphere is normally placed athwart ship. These acquire induced magnesium from earth's field & cause effect on the compass to compensate the effect of induced magnetism. The heeling magnet is the only corrector that corrects for both permanent and induced effects, and consequently must be readjusted occasionally with radical changes in the latitude of the ship.

Flinders bar: This is a vertical soft iron bar placed on the fore & aft side of the compass, on normal ships it is generally on the fore side, this also compensate for induced magnetism of the ship.

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.

FLUXGATE COMPASS:

A flux gate element is effectively a **magnetometer** that is used to **detect** both the **magnitude** and the **direction** of a **magnetic field**.

The basic flux gate consists of **two** thin **wires** of mumetal or permalloy, each contained **in** a **glass** tube **around** which is wound a **coil**. Two such assemblies are used. They are mounted side by side and **parallel** to each other.
The two coils are connected in series so that their magnetic fields are in opposition when a low frequency. secondary coil, wound around the whole assembly, provides a mutually induced e.m.f. as the output voltage.

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.

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.

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.

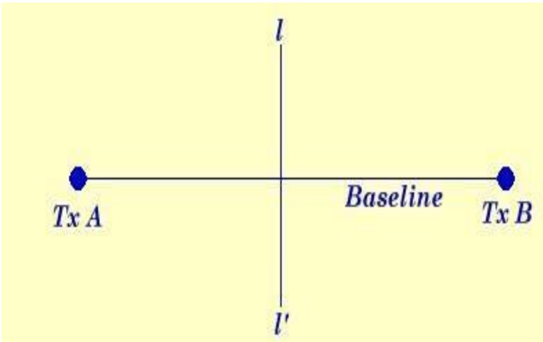
Loran c

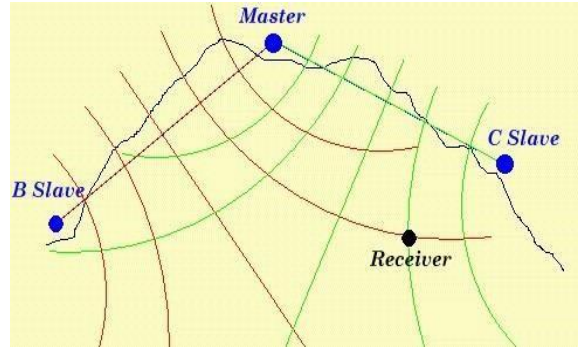
Loran-C is an electronic system of land-based transmitters broadcasting low-frequency pulsed signals capable of reception aboard a ship, or aircraft, and being used by the receiver to determine position in time difference or longitude/latitude

Principle

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 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. these points of equal phase will produce a family of curves instead of a straight line. These curves are referred to as hyperbolae. each hyperbola connects 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 accuracy of the Loran system depends upon:

1. The accuracy of measuring the timing delays (0.1 sec).
2. The angle between the Loran lines of position (LOP).
3. 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.

e-loran:

E LORAN is internationally-standardized positioning, navigation, and timing service for use by many modes of transport and in other applications. It is the latest in the long-standing and proven series of low frequency, loran systems, one that takes full advantage of 21st century technology.

E LORAN is an independent, dissimilar, complement to global navigation satellite system. It allows GNSS users to retain the safety, security, and economic benefits of GNSS, even when their satellite services are disrupted.

E LORAN meets a set of worldwide standards and operates wholly independently of GPS, GLONASS, GALILEO, or any future GNSS. Each user E LORAN receiver will be operable in all regions where an E LORAN service is provided. E LORAN receivers shall work automatically, with minimal user input.

The principal difference between E LORAN and LORAN C is the addition of a data channel on the transmitted signal. This convoys application-specific corrections, warnings, and signal integrity information to the user receiver. It is this data channel that allows E LORAN to meet the very demanding requirements of landing aircraft using non-precision instrument approaches and bringing ships safely into harbor in low visibility conditions.

E LORAN is also capable of providing the exceedingly precise time and frequency references needed by the telecommunications systems.

Why e-loran?

- GPS doesn't work everywhere
- Some interruptions of cell-phone operations or losses of other services for no apparent reason have been the result of GNSS interference

LRIT

It is a system used for the **global identification** and **tracking of ships**.

It requires vessels to **automatically transmit this information to their flag administration:**

Ship's identity

Ship's position

Date and time of the position.

The LRIT regulation will apply to the following ship types engaged on international voyages:

@ All passenger ships including high-speed craft,

@ Cargo ships, including high-speed craft of 300 gross tonnage and above, and

@ Mobile offshore drilling units.

The system Components:

ship borne satellite communications equipment: communications

service providers (CSPs):

Provides the communications services which **transfer** LRIT **data securely** from **ship** to the **ASP** on shore. The means of **communication** will often be via **satellite**, but the IRIT system itself **independent** of 'the **means of communication**, and any method can be used

Application service providers (ASPs):

Receives the LRIT **reports** transmitted **by the ship via** the **CSP**, **adds** certain **additional information** to each them, and **forwards** the reports to the corresponding **Data Centre.**

The **added information** to includes:

IMO ship identification **number** and **MMSI** for the ship;

Name of the **ship**

Unique identification code

Number of **time stamps** used for tracking and audits process

AIS

AIS is a **shipboard broadcast transponder** system in which ships continually **transmit** their **Id position**, **course**, **speed** and other data to all other nearby ships and shore side, authorities, **on a common VHF radio channel**. other information, such as the vessel name and vhf call sign, is programmed when Installing the equipment and is also transmitted regularly. The signals are received by AIS transponders fitted on other ships or on land based systems, such as VTS systems. the received information can be displayed on a screen or chart plotter, showing the other vessels' positions in much the same manner as a radar display.

OBJECTIVE:

In a ship-to-ship mode for collision avoidance Due to the limitations of VHF radio communications, and because not all vessels are equipped with AIS and using as a lookout to determining risk of collision.

As a means for coastal states to obtain information about a ship and its cargo

AIS Unit Components:

1 GPS

2 VHF TX/Rx

3 controller

4 power unit.

The IMO has specified three standard message types:

Static message: This contains the ship's IMO number, call sign and name, together with dimensions of ship's length and beam, type of ship and the location of the position-fixing antenna aboard the vessel.

Dynamic message: This contains the ship's position with indicated accuracy and integrity status, time of report, course over the ground, speed over the ground, heading, rate of turn, navigational status and optionally angles of heel, pitch and roll.

Voyage-related messages: These contain ship's draught, types of hazardous cargo carried, destination and ETA (at Master's discretion) and optionally the route plan in way-point format.

IMO Resolution MSC.74(69). Annex 3, Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS):

1 **All ships** of **300** gross tonnage and upwards (engaged on **international voyages**), **cargo ships of 500** gross tonnages and upwards (**not** engaged on **international voyages**), and **passenger ships**, **irrespective of size**, shall be fitted with AIS, as follows:

1.1 ships constructed on or **after 1 July 2002;**

1.2 ships engaged on **international voyages** constructed **before 1 July 2002**;

1.2.1 in the case of **passenger ships** irrespective of size and **tankers** of all sizes, **not later than 1 July 2003**

1.2.2 in the case of ships, other than passenger ships and tankers, of 50000 gross tonnages and upwards, not later than 1 July 2004

1.2.3 in the case of ships, other than passenger ships and tankers, of 10000 gross tonnages and upwards but less than 50000 gross tonnages, not later than 1 July 2005

1.2.4 in the case of ships, other than passenger ships and tankers, of 3000 gross tonnages and upwards but less than 10000 gross tonnages, not later than 1 July 2006

1.2.5 in the case of ships, other than passenger ships and tankers, of 300 gross tonnage and upwards but less than 3000 gross tonnages, not later than 1 July 2007; and

1.3 ships not engaged on international voyages constructed before 1 July 2002, not later than 1 July 2008.

2 The Administration may exempt ships from the application of the requirements of this paragraph when such ships will be taken permanently out of service within two years after the implementation date specified in paragraph 1. 3 AIS shall:

3.1 provide automatically to appropriately equipped shore stations, other ships and aircraft information, including the ship's identity, type, position, course, speed, navigational status and other safety-related information;

3.2 receive automatically such information from similarly fitted ships;

3.3 monitor and track ships; and

3.4 exchange data with shore-based facilities, the requirements of this paragraph shall not be applied to cases where international agreements, rules or standards provide for the protection of navigational information. AIS shall be operated taking into account the guidelines adopted by the Organization.

VDR

PURPOSE

The primary purpose of a voyage data recorder (VDR) or a simplified voyage data recorder (S-VDR) is to **maintain a store of information**, in a **secure** and **retrievable form**, concerning the **position**, **movement**, **physical status**, command and control of a vessel over the period leading up to and following an incident. This information will be required during any subsequent safety investigation to identify the cause(s) of the incident.

VDR information	SVDR information
Date and Time (GPS)	Date and Time (GPS)
Ship's Position (GPS)	Ship's Position (GPS)
Speed (Speed Log)	Speed (Speed Log or GPS)
Heading (Gyro Compass)	Heading (Gyro Compass)
Bridge Audio & VHF Communications	Bridge Audio & VHF Communications
Radar Display Image	Radar Display Image and/or AIS (can substitute AIS for Radar Display with class waiver)
Water Depth (Echo sounder)	Any other Serial (NMEA) format
Wind Speed and Wind Direction	
Main alarms (as required by class), Steering Alarms, Engine Alarms, -Fire Detection Alarms	
Rudder Order and Response	
Heading Keeping Information	
Engine Order and Response	
Ship Control and Indication Statuses	
Hull Openings, Watertight and Fire Door Status (if fitted)	
Accelerations and Hull Stresses (if fitted)	

State the requirements of Data Capsule fixed or float-free Type in a **VDR**:

- **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.

Fixed recording medium:

1- Be capable of being accessed following on incident but **secure against** a **physical** or **electronically** manipulated change or deletion of record data
2- **Maintain** the recorded **data** for a period of at **least 2 years** following termination of recording
3- **Maximize** the probability of **survival against fire**, **shock**, penetration and **deep-sea-pressure** and recovery of the final recorded data after any incident
4- Be of a **highly visible color** and marked with **retro reflective materials**
5- Be fitted with an appropriate device to aid location under water

Float free recording medium

1- Be fitted with means to **facilitate grappling and recovery**
2- **Maintain** the **recorded** date for a period of **at least 6 months** following termination of recording
3- **Minimize risk of damage** during recovery operations
4- Be capable of transmitting an initial locating signal and further locating homing signal for at least 48 hours over period of not less than seven days.

carriage requirement of VDR as per SOLAS chapter V

1. passenger ships constructed on or after 1 July 2002
2. ro-ro passenger ships constructed before 1 July 2002 not later than first survey on or after 1 July 2002re
3. passenger ships other than ro-ro passenger ships constructed before 1 July 2002 not later than 1 January 2004
4. ships, other than passenger ships, of 3000 GT and upwards constructed on or after 1 July 2002

carriage requirement of S-VDR as per SOLAS chapter V

to assist in casualty investigations, cargo ships, when engaged on international voyages, shall be fitted with a VDR which may be a simplified voyage data recorder as follows:

in the case of cargo ships of 20000 GT and upwards constructed before 1 July 2002, at the first scheduled dry-docking after 1 July 2006 but not later than 1 July 2009

in the case of cargo ships of 3000 GT and upwards but less than 20000 GT constructed before 1 July 2002, at the first scheduled dry-docking after 1 July 2007 but not later than 1 July 2010.

Speed log:

There are different types of speed log:

1- Patent rotor log.
2- Impeller log.
3- Electromagnetic log.
4- Acoustic correlation log.
5- Doppler log.

Patent rotor log:

This consist of a rotator manufactured in phosphor bronze, which is towed astern of the vessel. The towline used to be man-made fiber line of an 8 m diameter mm size. The number of rotations is recorded by a clock mechanism secured to the after rail of the vessel. The reading can be seen from bridge by use of repeaters.

Component of patent rotator speed log:

1- Clock: the clock, which is attached to the vessel, converts the turns of rotator into distance, like the distance recorder in a car.

2- Governor: this wheel is to provide steadiness to the inner spindle of the log clock as it revolves due to action of the rotator.

3- Rotator: the rotator is made of either brass or phosphor bronze to resist the corrosive action of salt water. rotator is a hollow tube having curved vanes

IMPELLER LOG:

The impeller log may be considered an electric log, since its operations is all electrical, except for the mechanical rotation of the impeller. The principle of operation is based on turning an impeller by a flow of water, the speed of rotation being proportional to the rate of flow past the impeller (t**urbine principle)** a pick-up coil transmits the generated pulses via an amplifier to an electromagnetic counter the signal is then displayed by a speed indicator and distance recorder. **the two most popular being one with a ring magnet attached to the spindle and one with the magnet incorporated in the blades of the impeller,** performance of the log is in general considered to be very good, but obvious problems arise in dirty water areas with a muddy bottom and heavily polluted canals.

PRESSURE TUBE LOG:

this is a **simple** instrument which works on **pitot tube principle**. It **consists** of pressure chamber at **bottom** of the ship There are two tube which connect the chamber to the sea. **One** of them is **static** tube and **other** is **dynamic** tube which lets the water out of the chamber There is a diaphragm connected to a mechanical linkage inside the chamber.

If there is no relative fluid movement then the static pressure in each tube will be the same hence the pressures on each side of diaphragm will be equal Relative fluid movement an additional dynamic pressure will be created in s/d tube and hence on bottom side of diaphragm causing an upward movement of the linkage rod.

SOURCES OF ERROR:

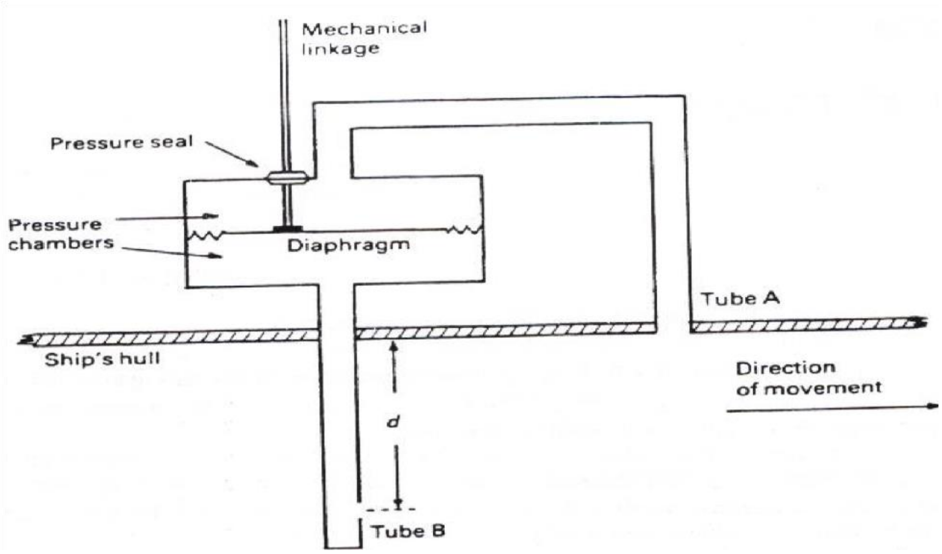
1- Calibration must be carefully done when installed. Allows for shape of vessel and flow of water into dynamic tube.

2-Pressure / speed relationship means not very accurate at very low or high speeds.

3-Obstruction in tubes e.g. marine growth can cause problem.

4-Error in time input will cause incorrect distance reading.

5-Only forward speed can be measured



ELECTRO-MAGNETIC LOG

This instrument uses the **principle** of **the generator** i.e. if a conductor is moved across a magnetic field the conductor will have a small electro-motive force (E.M. F) induced into it The magnitude of the E.M.F is proportional to the rate at which the conductor will cuts the magnetic lines of force.

Equally if the conductor remains stationary and the magnetic field moves. the E.M. F is similarly induced in the case of the E.M.LOG, the water is the conductor and a probe produced the magnetic field from a COIL. The E.M.LOG consists of a probe with two sensors, an indicator / transmitter and a remote control switch.

The sensor CAN be a rod which projects out through the underwater portion of the ship's hull. Its outer surface is insulating except for two copper nickel electrodes, one on each side. The rod projects such that these electrodes are clear of the turbulent water around the ship's hull**.**

System configuration:

Typically, the E.M.LOG system consist of:

1- Main electronic unit. (MEU)This houses the system electronics, power supply and output facilities for displays and interfacing to the ship's navigation system, if any.

2- User interface panel; (UIP) provides speed and distance displayed and calibration facilities.

3- Under water sensors: This can be any types, e.g. fixed probe, fin probe, flush probe or retractable rod meter

4- speed and distance Repeaters; they can be in either digital or analogue format.

Comparing Doppler and pressure tube log:

1.**doppler** can measure the **athwart ship speed** as well as **FWD** speed but pressure **tube** shows only **FWD** speed

2.**doppler** works on principle of **frequency** but pressure **tube** works on the principle of **pitot** tube

3.**doppler** measures **W/T** and **G/T** speed but the pressure **tube** measures **W/T** speed

4.pressure **tube** log consist of **mechanical part** which need regular **maintenance** but, Doppler log is not such that.

DOPPLER

The Doppler speed log is based on measurement of the Doppler effect that is, if a moving ship transmits an acoustic signal, the frequency of a received return signal after reflection is different from the frequency of the original transmitted signal. The shift in frequency is proportional to the speed of movement of the transmitter. The Doppler log uses the sea bottom as the reflector, but clearly the ship is not moving towards the sea bottom.

Vertical movement of the ship, the effects of pitching and changing trim can all largely be accounted for by having not just a single beam pointing forward but by also having a second beam pointing astern at the same angle.

PRINCIPLE

- Transducer emits continuous a high frequency sound pulse in the forward direction at an angle of 60° to the keel.
- Higher the sound frequency, smaller the transducer, narrower the beam and higher the accuracy.
- The beam bounces back from the sea bottom.
- The frequency of the bottom echo will be higher when the ship is moving ahead or lower if she is moving astern.
- The Doppler equation is solved to obtain ship's speed. • When signal is bounced off the sea bed, (called Bottom Track), the speed displayed the "Speed over the ground (SOG)"

Advantages

- Most accurate
- Can measure ahead, astern & athwart ship movements
- Can be used for ocean navigation as well as berthing and maneuvering in close waters.
- Can measure very low speeds
- This log is most prevalent in today's marine world.

Limitation

There are many factors that affecting Doppler Log performance, they are:

- The performance (accuracy) may be reduced or even lost under following conditions:
- Rough weather (may be sea state 6 or severer)
- Improper location of sensor, e.g., too close to the propeller, thrusters, drain tubes, echo, sounder transducer
- Depth under the keel if less than 3 m.
- Aeration in the proximity of propellers while coming along side.

Environmental factors affecting the accuracy of speed logs:

- **water clarity**. in exceptional cases the purity of the seawater may lead to insufficient scattering of the acoustic energy and prevent an adequate signal return. it is not likely to be a significant factor because most seawater holds the suspended particles and micro-organisms that adequately scatter an acoustic beam.

aeration. aerated water bubbles beneath the transducer face may reflect acoustic energy of sufficient strength to be interpreted as sea bottom returns producing inaccurate depth indications and reduced speed accuracy. proper sitting of the transducer. away from bow thrusters. for instance, will reduce this error factor.

vessel trim and list. a change in the vessel's trim from the calibrated normal will affect fore/aft speed indication and an excessive list will affect athwart ship speed. a Janus configuration transducer reduces this error.

ocean current profile. this effect is prevalent in areas with strong tides or ocean currents. in the water track mode. a speed log measures velocity relative to multiple thermos layers several feet down in the water. if these layers are moving in opposite directions to the surface water. an error may be introduced**.**

ACOUSTI CORRELATION LOG:

This type of speed log derives the vessel speed by the use of, acoustic correlation, method. This is the way of combining the properties of sonic wave in sea water with the correlation technique. Speed measurement is achieved by bottom tracking to a maximum depth of 200m, the system automatically switches to water tracking and will record the vessel's speed with respect to a water mass approximately 12m below the keel. The transducer transmits pulses of energy at the frequency of 150 KHZ from its two active Piezo-ceramic elements which are arranged in the fore and aft line of the vessel. Each Element transmits in a wide signal perpendicular to the sea bed, as with an echo sounder, the transducer elements are switched to the receive mode after transmission has taken place. The sea bed or water mass, reflected signal possess a time delay(T) dependent upon the counter of the sea bed. Thus the received echo is uniquely a function of the fix position of each sensor element and the ship's speed.

GROUND SPEED AND WATER SPEED:

In depths greater than 200m the return echo is too weak to be useful and the log will no longer give ground speed.

The water layers at 10 – 30 meters below the keel also cause an echo and Doppler effect, this is used to give speed relative to the water. It is known as water track as distinct from bottom track and speed log automatically Shift to this mode when ground contact is lost. An indicator light displays which mode the log is.

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Auto pilot

Auto pilot is an automatic steering device whose purpose is:

1. To maintain automatically a constant heading. (course keeping)
2. To change course when necessary. (course changing)
3. To replace the dull and fatiguing job of a helmsman.

Principle:

The Autopilot works on the principle of the closed loop system. The actual heading of the ship obtained from the gyro or magnetic compass is continuously compared with the desired value of the, demanded, course to be steered.

If there is any difference between these two an error signal proportional to the magnitude and sign of the off course error is produced. This error signal is amplified, differentiated and integrated and then fed to a rudder actuating circuit which makes the rudder move in the required direction. The movement of the rudder produces the rudder feedback signal which reduce the off course error, closes the control loop and finally stops the action.

Components:

1- Heading sensor:

This is used to obtain a course error signal. A gyro repeater motor can be used to obtain this or in the case of a magnetic compass, a flux gate sensor

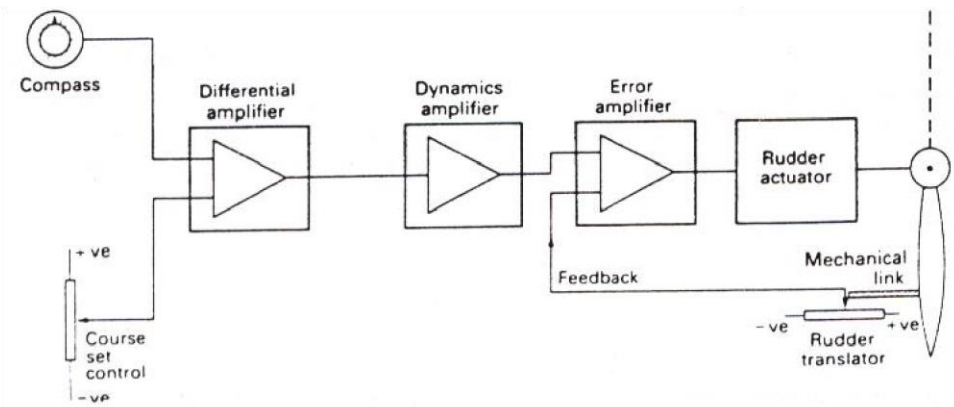
2- Rudder position transmitter: (rudder feedback) This supplies continuous rudder angle information to the controller unit which is necessary to ensure that rudder is driven to ordered position

3-Actuator

A power device which on command from the controller unit develops mechanical or hydraulic power, generally by an electric motor and applies it to the steering gear which moves the rudder.

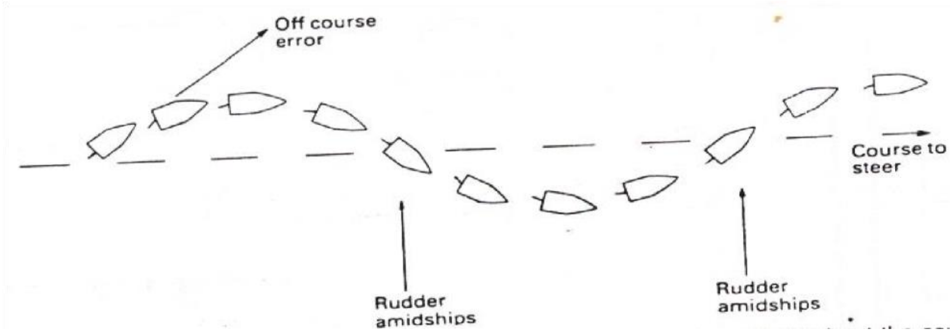
1- Controller unit:

Analyses course error, rate of change of course error and rudder angle feedback information and decide the magnitude / direction of steering corrections



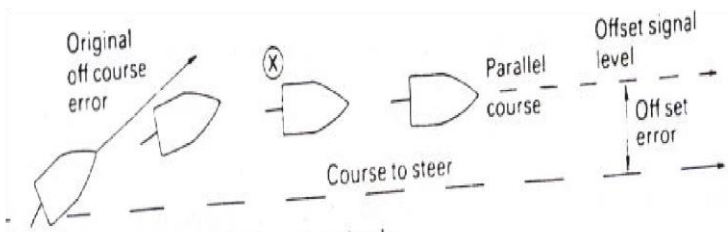
Proportional controller action:

Orders a rudder angle that is proportional to the course error, e.g. 1º rudder ordered for 1º course error. If used by itself, the vessel will oscillate about the desired course, the oscillation will not be damped out.



4-Derivative controller action

The rate of change of course error is measured and counter rudder ordered that is proportional to this rate of change of error. Derivative control by itself will only check the swing of the vessel after it has moved off course and will not bring the vessel back to its desired course. It is always used in conjunction with proportional control and any rudder ordered is in addition to that needed for proportional control.



The effect of applying derivative control only.

Integral control action:

Continuously compares the course being steered with the set course and if a long term error exists i.e. the vessel being set more off course more to one side than the other a permanent rudder angle bias is ordered.

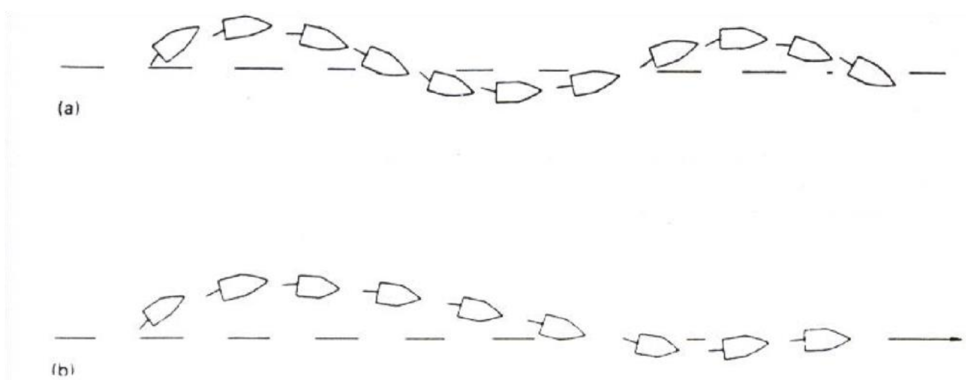


Figure 9.5 (a) If 'counter rudder' and 'rudder' controls are set too high, severe oscillations are produced before the equipment settles.(b) If 'counter rudder' and 'rudder' controls are set too low, there will be little overshoot and a sluggish return to the course.

Manual operator controls

Permanent helm: This control is intended for use when the vessel is being driven unilaterally off-course by a crosswind. Its function is to apply sufficient permanent rudder angle to offset the drift caused by the wind, thus holding the vessel on the required heading. Permanent helm is also applied automatically when the steering system is in the automatic mode of operation. Automatic application of permanent helm makes no use of the permanent helm control. The degree of rudder offset required for course holding is now electronically computed and applied automatically.

Rudder angle or rudder limit: This control sets the maximum rudder angle which the autopilot may apply. This limit overrides the angle commanded by the automatic control circuitry.

Weather or sensitivity: This sets the amount by which the vessel is allowed to be off course before correction is applied, it will be uses during rough weather, so less helm command will be used. In calm weather it will be set to zero. The heaver the weather, the higher the setting allowing the ship to recover naturally when under the influence of repetitive yaw. Hence the steering gear will not be subjected to continuous port / starboard commands causing un-necessary working of the gear and added the drag due to rudder action.

Rudder: This control alters the ratio between the instantaneous course error and the amount of the helm. It determines the absolute degree of rudder command for every degree of heading error e.g. if this control set to 2 the rudder may move two degrees for every degree of heading error. the higher the setting, the tighter will be the control of the heading, but may result in overshooting. if too low, the movement of the ship will be sluggish.

Counter rudder: This control determines the degree of opposite helm to be applied when required. Counter rudder is applied when there is a change of sign of the rate of change of heading data. The amount to be applied can be varied according the condition of the vessel The greater the moment of inertia of the ship, the greater should be the counter rudder setting.

Non-follow-up mode (NFU) The rudder is manually controlled by means of two position port/starboard lever switches. These switches energize the directional valves on the hydraulic power unit directly, thus removing the rudder feedback control. In this mode the normal autopilot control with repeat back is by-passed and the rudder is said to be under 'open loop' control. There is no feedback from the rudder to close the loop. The helmsman closes the loop by observing the rudder angle indicator and operating the NFU control as appropriate.

Follow-up mode (FU) In this mode the FU tiller control voltage is applied to the error amplifier (Figure 9.9) along with the rudder feedback voltage. Rudder action is now under the influence of a single closed loop control.

ADAPTIVE STEERING MODULE (ASM)

In order that good course keeping is maintained at all times the watch officer will have to make frequent adjustments to the manual controls, e.g. rudder, weather, counter rudder etc. this is not always possible when the officers workload is high and when course, speed, wind and sea conditions are continuously changing .An ASM is simply an autopilot using PID control techniques linked to a microcomputer Contained in the computer is date relating to the heavier of a “model ship“ .Course keeping performance is continuously fed to the computer where it is compared against that of the model ship and rudder commands for the actual ship are predicted .The computer ensure that corrective rudder is only used when course keeping is affected by environmental conditions and not by the natural yaw of the vessel .An ASM will continuously adjust the rudder commanded to meet the prevailing conditions and there is no need for the watch officer to make manual adjustment.

The benefits of an ASM are:

(i) Removes the need for operator adjustments.

(ii) Ships natural yaw not smoothed out which reduces the need for excessive rudder angles of movements resulting in less rudder drag and wear on the steering gear.

(iii) Improves fuel consumption.

(iv) Achieves good course changing stability which is important in coastal waters.

ADVANTAGE OF AUTO PILOT:

1.there is no need for a helms man to be continuously on wheel

2.the vessel keeps her course with little deviation and greater speed, so saving fuel, minimizing steering wear, tear

How the autopilot should be tested prior to ships departure?

According to the solas within 12 hours before departure, the ships steering gear shall be checked and tested as follows:

The rudder should be put hard over from 35 on one side to 35 on the other side to ensure it is operating freely.

The rudder angle indicator in relation to the actual position of the rudder should be checked

When putting the rudder from 35 on either side to 35 on other side, it should not take more than 28 seconds.

All steering units should be run and tested

Test the main and secondary communications between bridge and steering flat Test the steering gear power failure audible and visual alarm.

Engage the steering system into autopilot mode, then change the autopilot set point by about 15, since the main engine is stopped and the ship is stationary, the ships head will not change and thus off course alarm must be activated audibly and visually Run and test steering system by:

Follow up and non-follow up operation from bridge

Operation from bridge wing consoles

Operation of emergency steering from steering flat

Check the operation of the auto/manual change over switch

Check that the Gyro repeater used in autopilot is aligned with the master Gyro

While steering on auto pilot what will you do in the following conditions: a) Calm sea

b) Rough sea

c) High traffic density

d) Immediate collision avoidance

yaw: ---------

rudder limit: ----------------

With the aid of a block diagram, describe the basic principal operation of a steering control system. ---------

Purpose of "off course alarm"

What are the advantages of D-GPS over GPS.--------------

With the aid of simple block diagram, describe principle elements of a typical marine echo sounder.-----------------------------

How you ensure that Gyro compass is working properly on board.---------------------------

Procedure to align gyro repeater with master gyro. -----------

Explain celestial and terrestrial methods of finding gyro error and how this error can be used to correct courses and bearings.---------------------

Hard iron ------------

Magnetic pole :-------------------

Deviation card :-----------------------

Air bubble and how to remove it.

Explain how you may generally test/check operation, and performance of speed log equipment…………….

What is enhanced loran (E-LORAN) and states the principal difference between E-LORAN and traditional LORAN-C?

E-LORAN is an internationally standardized positioning,navigation,and timing service for use by many modes of transport and in other applications. It is the latest in the long-standing and proven series of low-frequency, long-range navigation (LORAN) system, one that takes full advantage of 21st century technology.

E-loran is an independent, dissimilar, complement to global navigation satellite system (GNSS). it allows GNSS users to retain the safety, security, and economic benefits of GNSS, even when their satellite services are disrupted.

E-LORAN meets a set of worldwide standards and operates wholly independently of GPS, GLONASS, GALILEO, or any future GNSS. Each users e-loran receiver will be operable in all regions where an e-loran service is provided. E-loran receivers shall work automatically, with minimal user input.

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 users receiver. It is this data channel that allows e-loran to meet the very demanding requirements of landing aircraft using non-precision instrument approaches and bringing ships safety into harbor in low-visibility conditions.e-loran is also capable of providing the exceedingly precise time and frequency references needed by the telecommunication systems.

Doppler

The main function of Doppler speed log is to measure speed and distance of the vessel in respect of speed, most Doppler log can measure speed through the water and speed over the ground. The unique feature of some of the Doppler log is to provide athwart-ship speed over ground, which was never possible by any other logs. To measure the athwart-ship speed over ground.which was never possible by any other logs. To measure the athwart-ship speed. Additional transducers are employed. These are called dual axis speed logs. Generally, Doppler log can receive echoes from seabed only up to depths of 200 m or so however, beyond these depths. A weaker echo is available from a layer between 10 to 30m below the keel. The speed of the vessel can be determined as earlier but in this case, it will be with respect to this layer and not with respect to ground. This is called speed over water . in this case the effect of current has to be allowed for to get the speed made good but the reflections from a layer deep down eliminate the effect of disturbances caused by the vessel itself and the effect