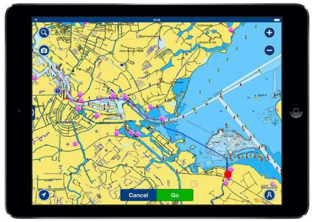
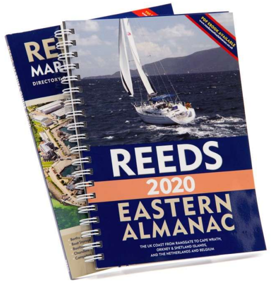
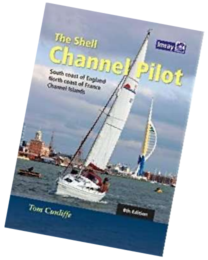
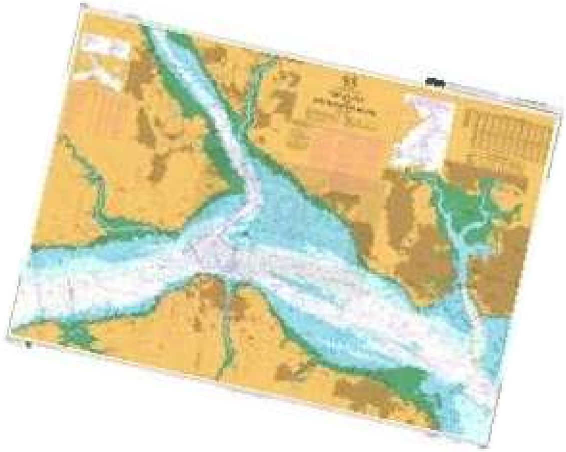








Electronic Aids to Navigation

Day Skipper Shorebased Training

29th October 2025

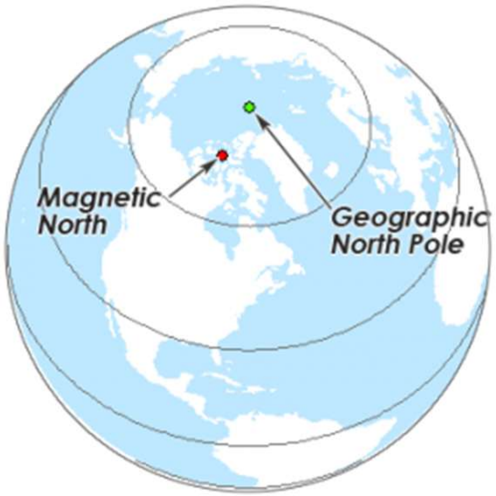
AXE YACHT CLUB

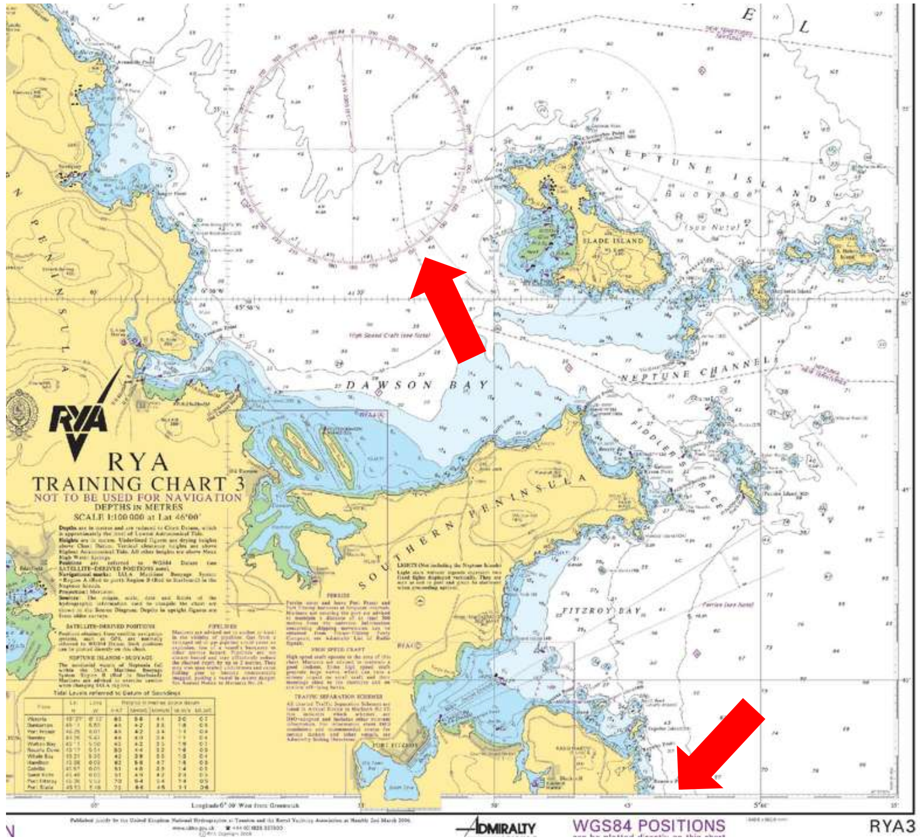
Electronic Aids to Navigation

- GNSS
- Chart Plotters
- Radar
- Automatic Identification System
- Multifunctional Display systems
- Other sources of information

Paper Charts

- References and alignments
  - WGS84
  - Compass Rose





Electronic Aids to Navigation

AXE YACHT CLUB

RYA TRAINING CENTRE

GNSS

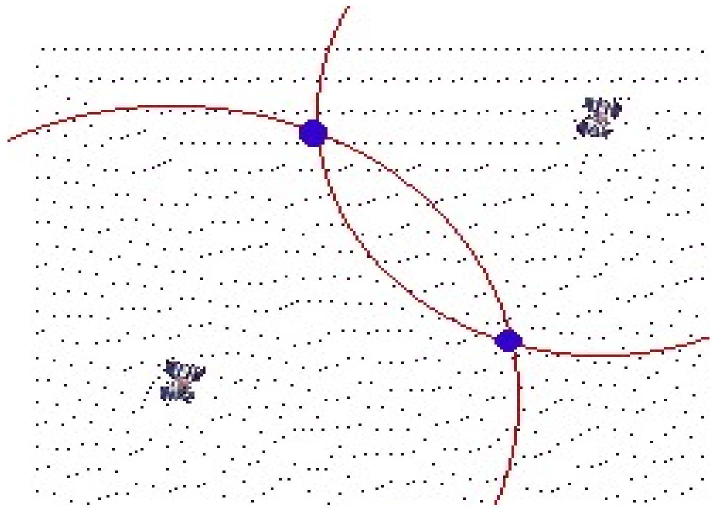
Global Navigation Satellite System

GNSS systems

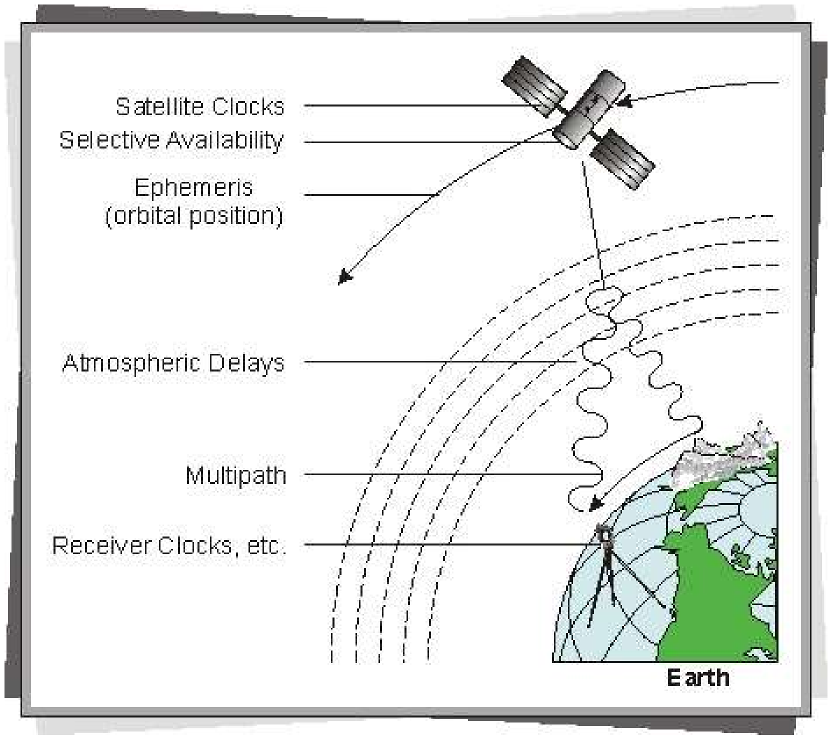
- Global Positioning System - USA
- BeiDou Navigation Satellite System (BDS) - Chinese
- GLONASS - Russian
- Indian Regional Navigation Satellite System (IRNSS) / Navigation Indian Constellation (NavIC) - Indian
- Quasi-Zenith Satellite System (QZSS) – Japanese
- Galileo - European
- *UK GPS??*

How it works.

- Information from two satellites gives two spheres which intersect to form a circle.
- Three satellites reduces this to two points. One of these will be far out in space and can thus be disregarded.
- A fourth satellite is needed to refine this information and give the accuracy which GPS is capable of.



Sources of GPS error

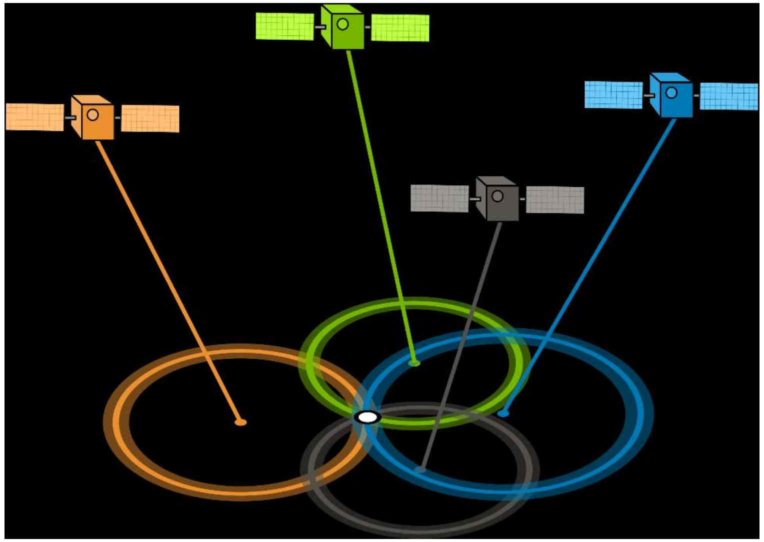


- Atmospheric Errors +/- 5m
- HDOP +/- 5m
- Ephemeris error +/- 2m
- Satellite Clock error +/- 2m
- Receiver error +/- 1m

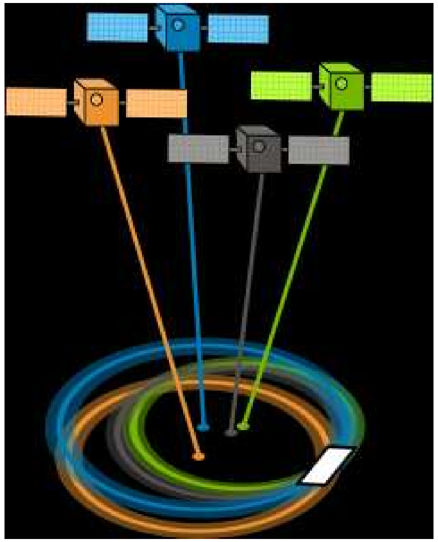
BUT

- Positional errors due to differences in the DATUM used to produce the chart and that used by the GPS receiver can result in larger errors occurring.

HDOP - Horizontal Dilution of Precision



Wide satellite spacing – small area of cut

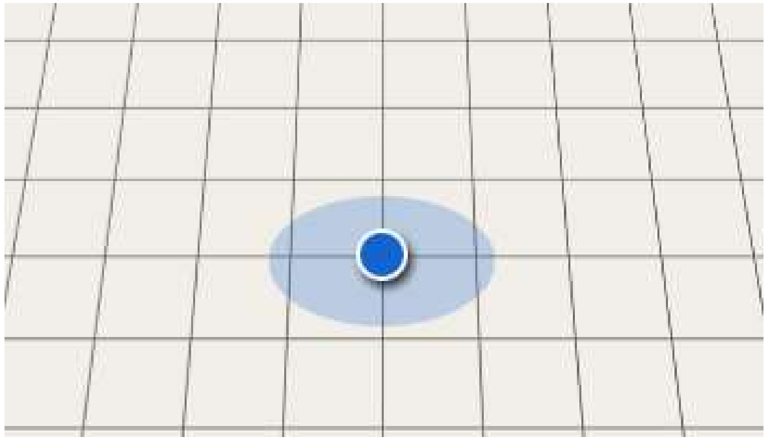


Small satellite spacing – large area of cut

HDOP Scale

DOP Value	Rating	Description
< 1	Ideal	Highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	Good	Represents a level that marks the minimum appropriate for making business decisions. Positional measurements could be used to make reliable in-route navigation suggestions to the user.
5-10	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
>20	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6-meter accurate device (50 DOP × 6 meters) and should be discarded.

Possible problems with GPS



- Power failure
- Aerial failure
- Transmissions from mobile phones
- Interruption of, or changes to, the satellite system
- Operator error – rubbish in = rubbish out!

Mounting the Hardware

- Mount the antennae where it can ‘see’ the satellites, but not aloft to avoid signal bounce.
- Watch for blind spots of the antennae

Information from the GPS receiver

- Lat / Long (and Elevation)
- COG and SOG
- Distance and bearing to waypoint
- ETA at waypoint
- Cross-track error
- MOB Function

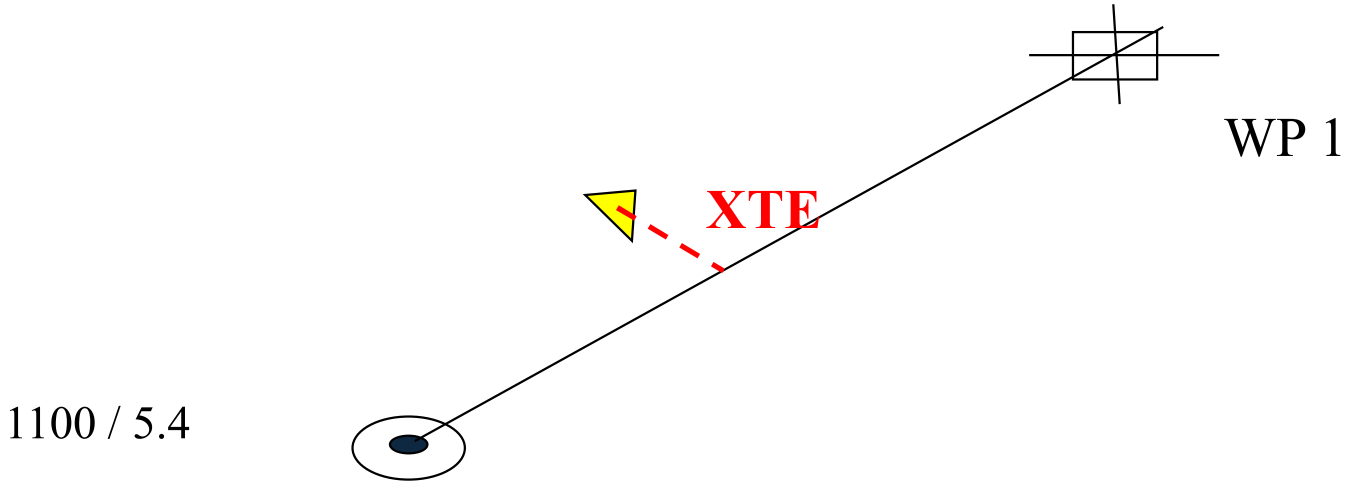
Plotting Techniques with GPS

- Sailing / displacement power boat techniques
  - Latitude and Longitude
  - Bearing and distance to a Waypoint

- Planing power boat techniques:
  - Distance to W.P. and X.T.E.
  - Web with distance and bearing to waypoint.

The GPS Plotter is an aid to Navigation, not the answer to Navigation

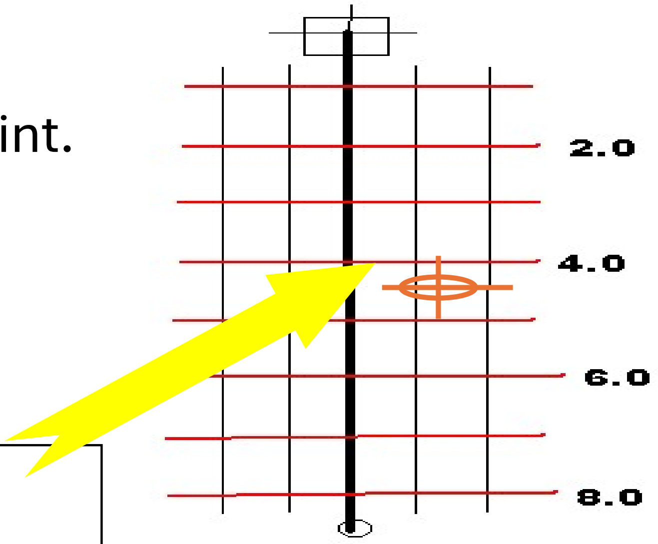
Cross Track Error (XTE)



Distance to Waypoint and Cross Track Error

Grid drawn on chart from starting position to way point.

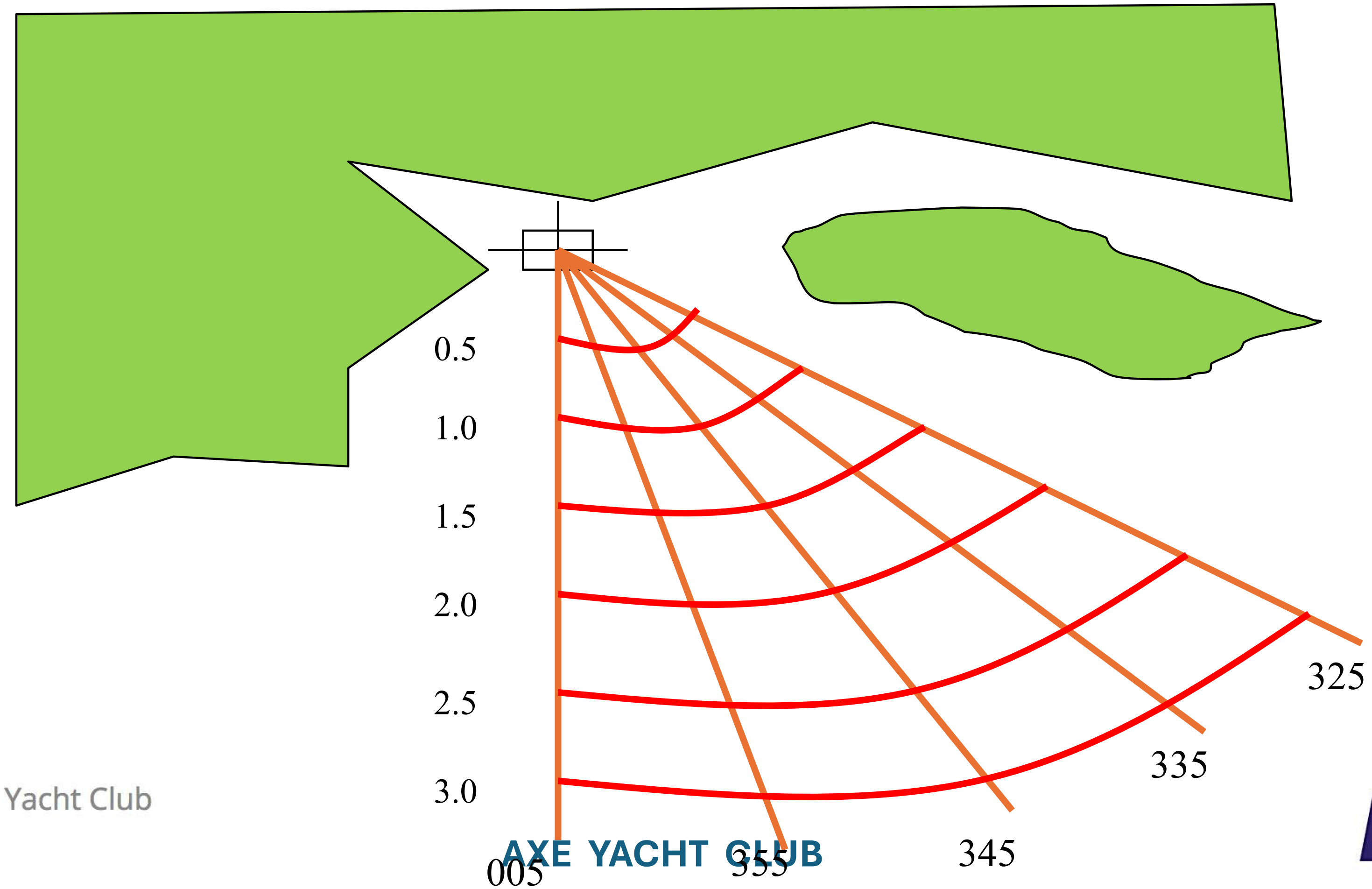
Position is plotted by distance to run and CTE.



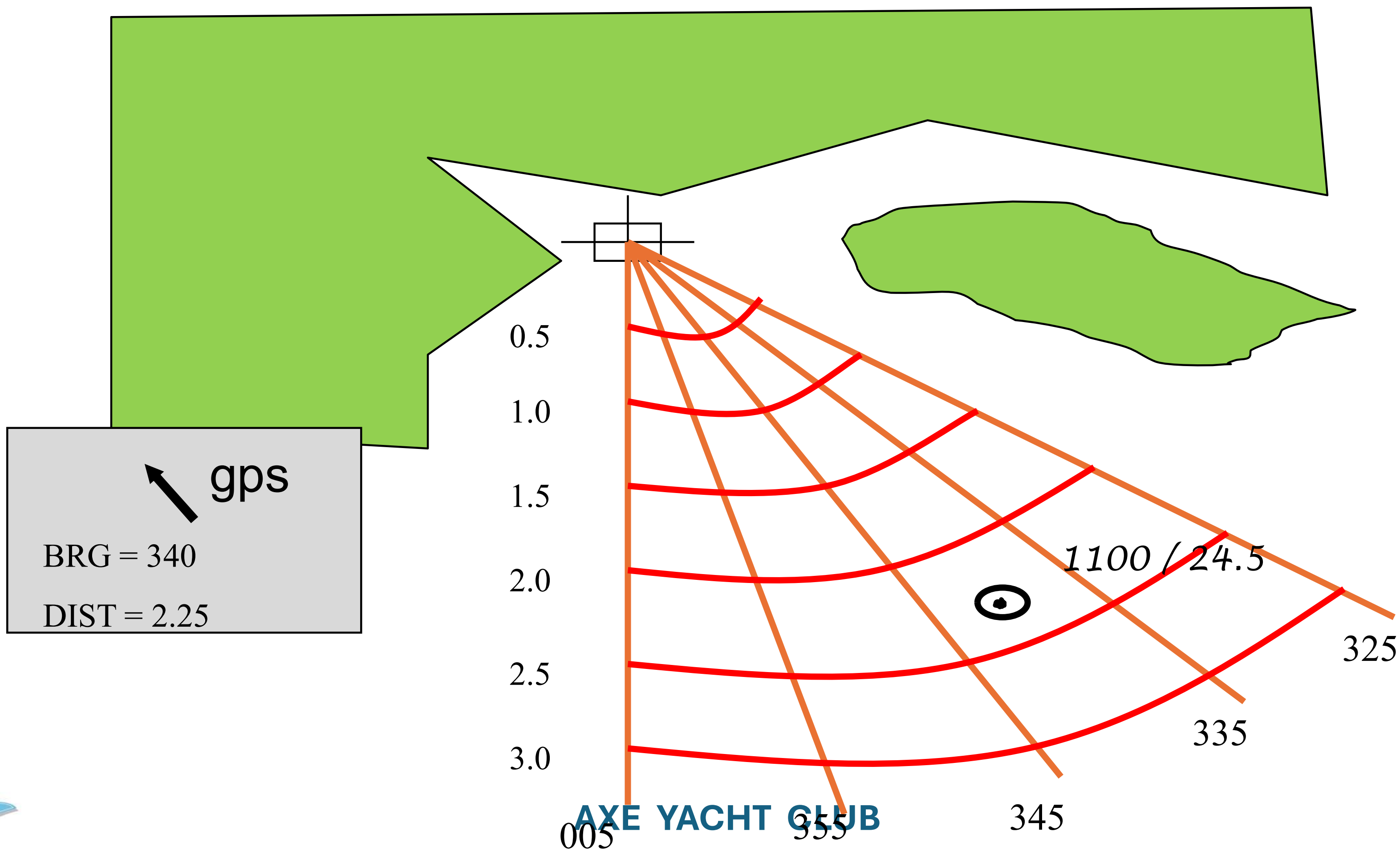
E.g. DST = 4.5’

CTE = 0.75’to st’b’d.

Navigation Web

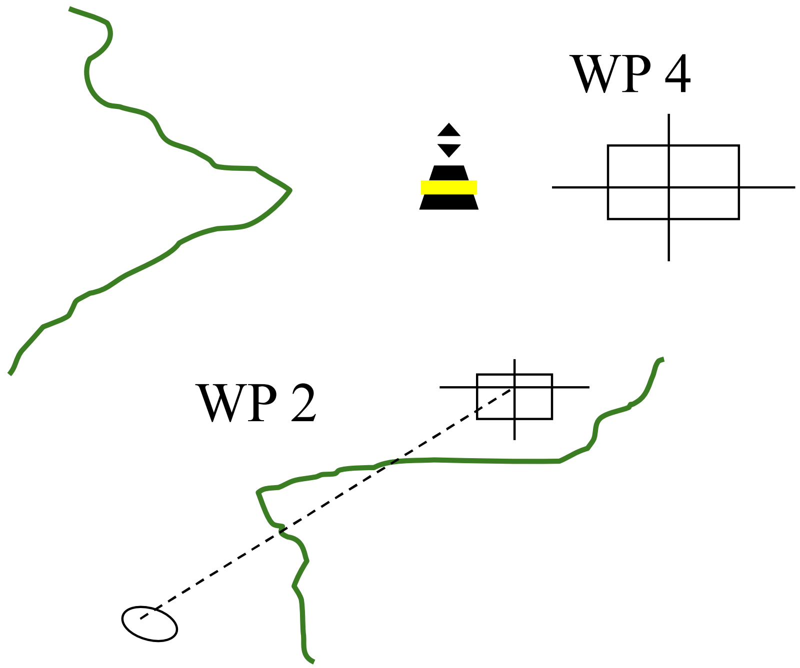


Navigation Web 2

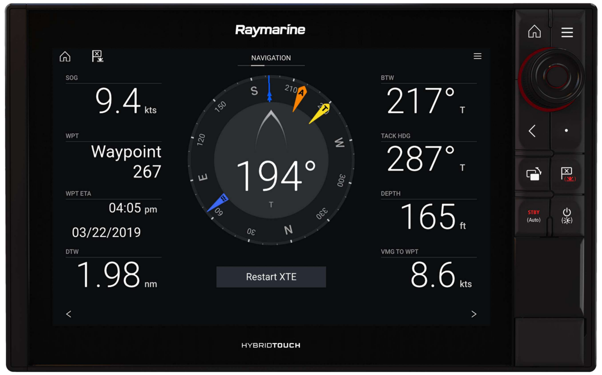


Waypoint Navigation 1

- Take waypoints from a large scale chart or the almanac
- Position the waypoint on the **safe side** of buoys etc.
- Check the track from the start position to the waypoint to ensure that the track does not cross hazards.
- Mark bearing and distance between waypoints on the chart.



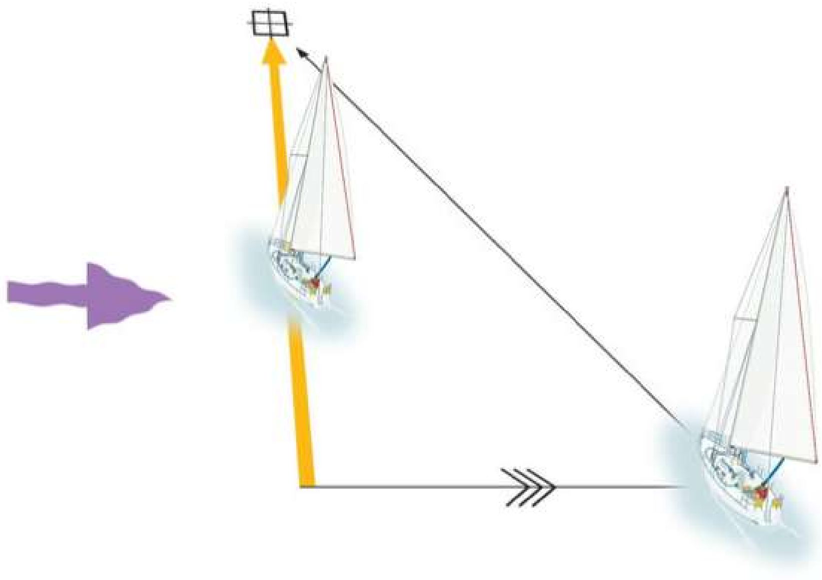
Waypoint Navigation 2



- Note the waypoint in the log and on the chart.
- Plot position regularly - check for agreement with the E.P..
- Calculate the C.T.S. instead of following the bearing given by the GPS, or trying to balance out cross track error. If there is a significant cross tide you:
  - will sail a longer route,
  - could put the boat in danger.

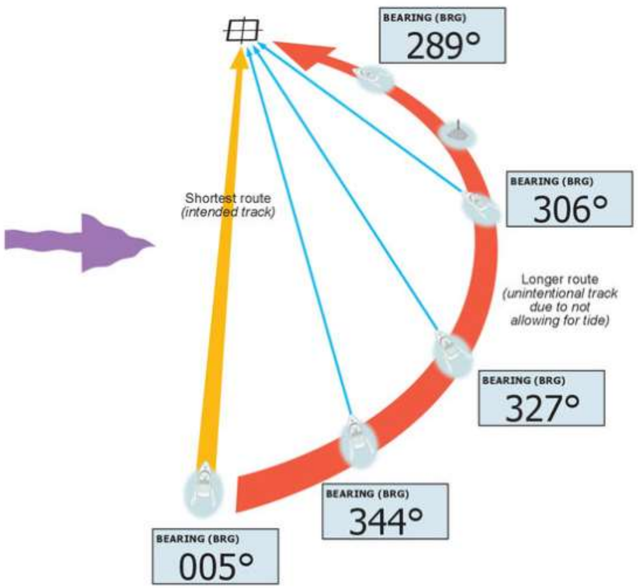
So why don't we just use the GPS?

- Can we plot a series of Way Points & have the Plotter give us directions?
- No! - Our course over the ground may be very different to our heading

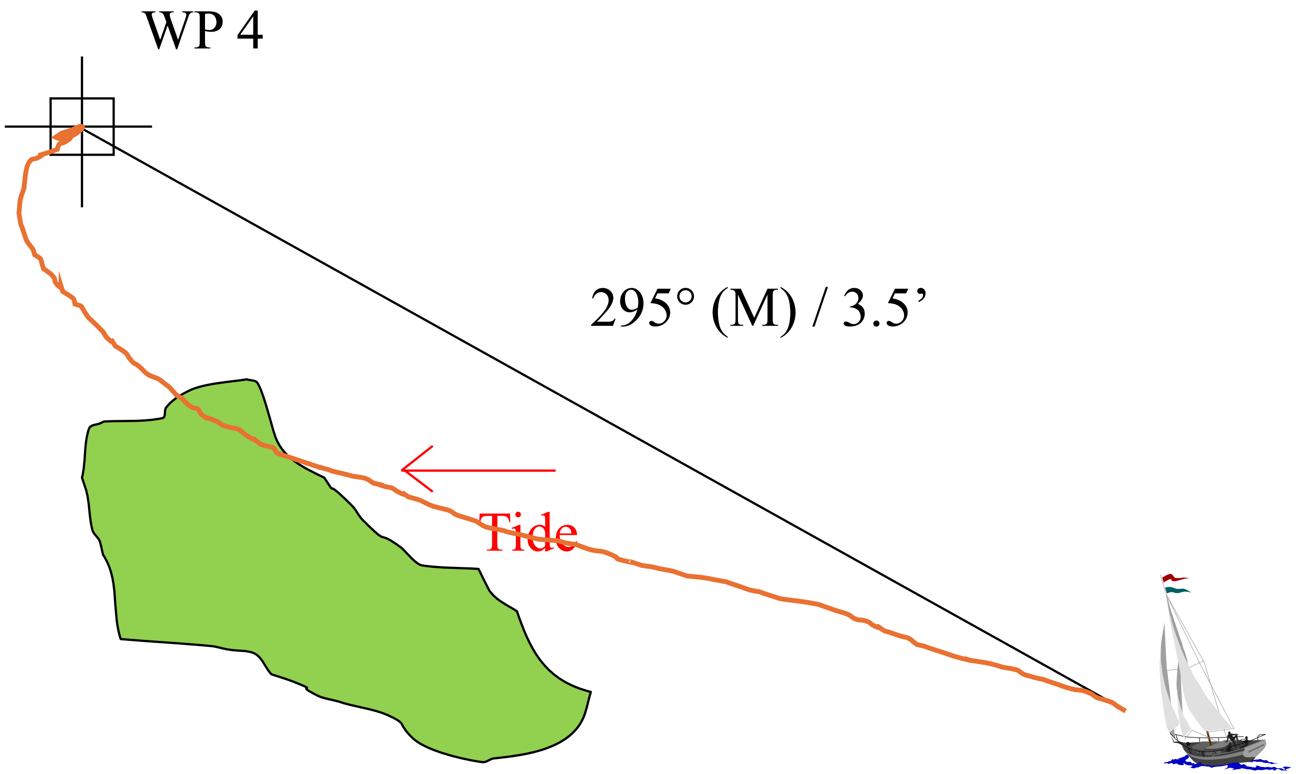


The GPS doesn't allow for tidal stream

- It seems easy just to steer the direction to the waypoint that the GPS gives but if there is a significant cross-tide, you will sail a longer route and could put the boat in danger.



Bearing and Distance



GNSS

Global Navigation Satellite System

An aid to good Navigation

Electronic Chartplotters

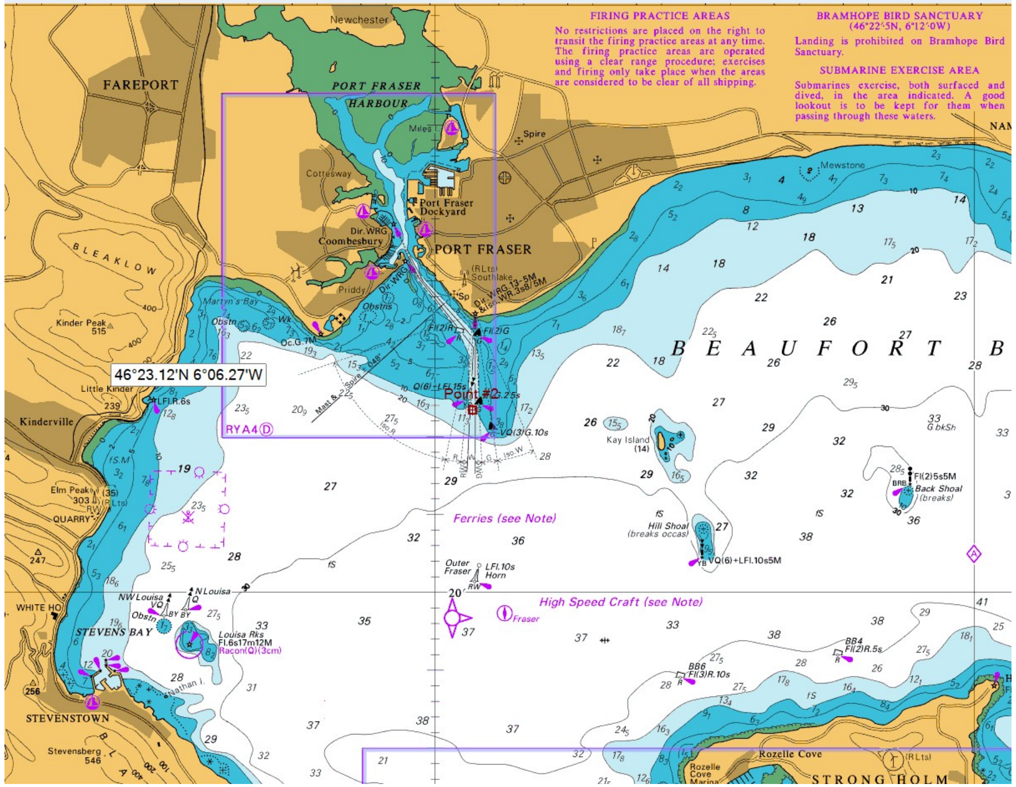
Chart Plotter Features

- Electronic Charts
  - May be specific to Plotter Manufacturer
  - Normally Vector charts
- Update by download or SD card
- Different Cards for different areas.
- Provides:
  - Waypoint store
  - Routes
  - Distance Measurement
  - Same outputs as stand-alone GPS.

- From around £300 plus charts

Raster Charts

- Scans of paper charts
- Familiar presentation and comparison to Paper Charts



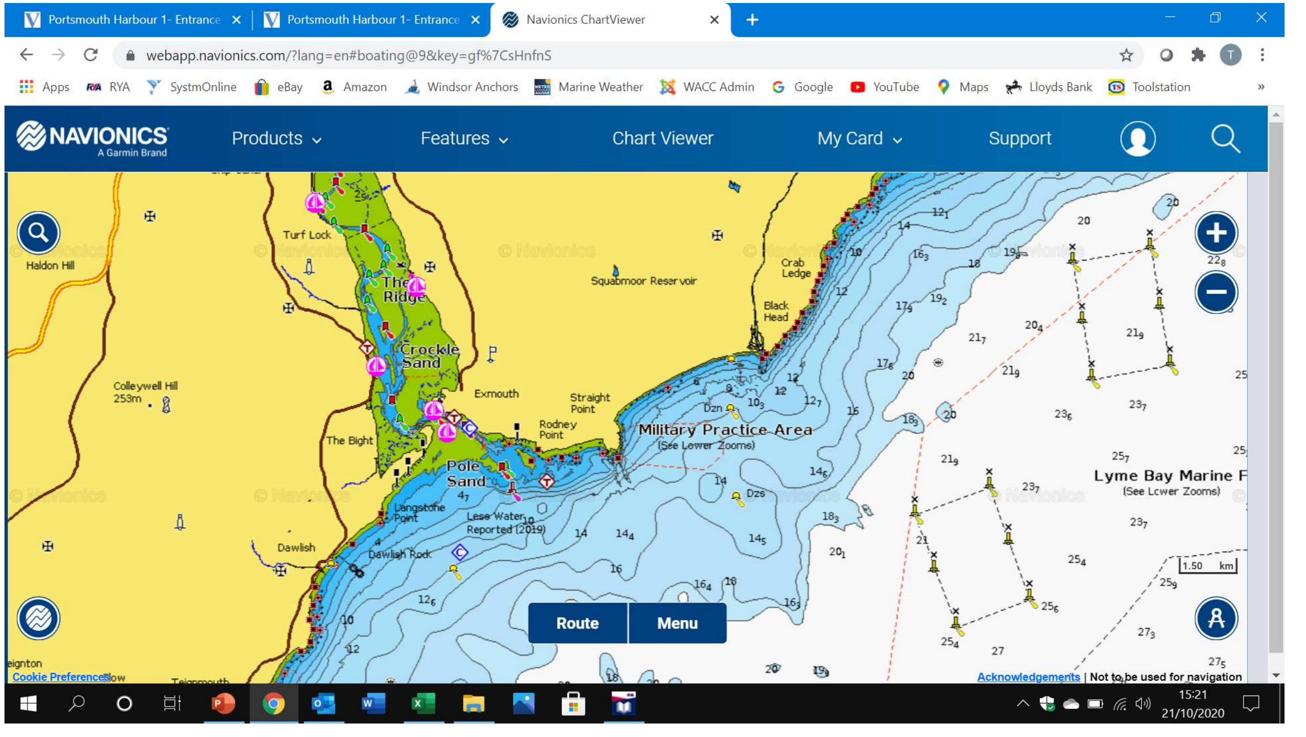
Vector Charts

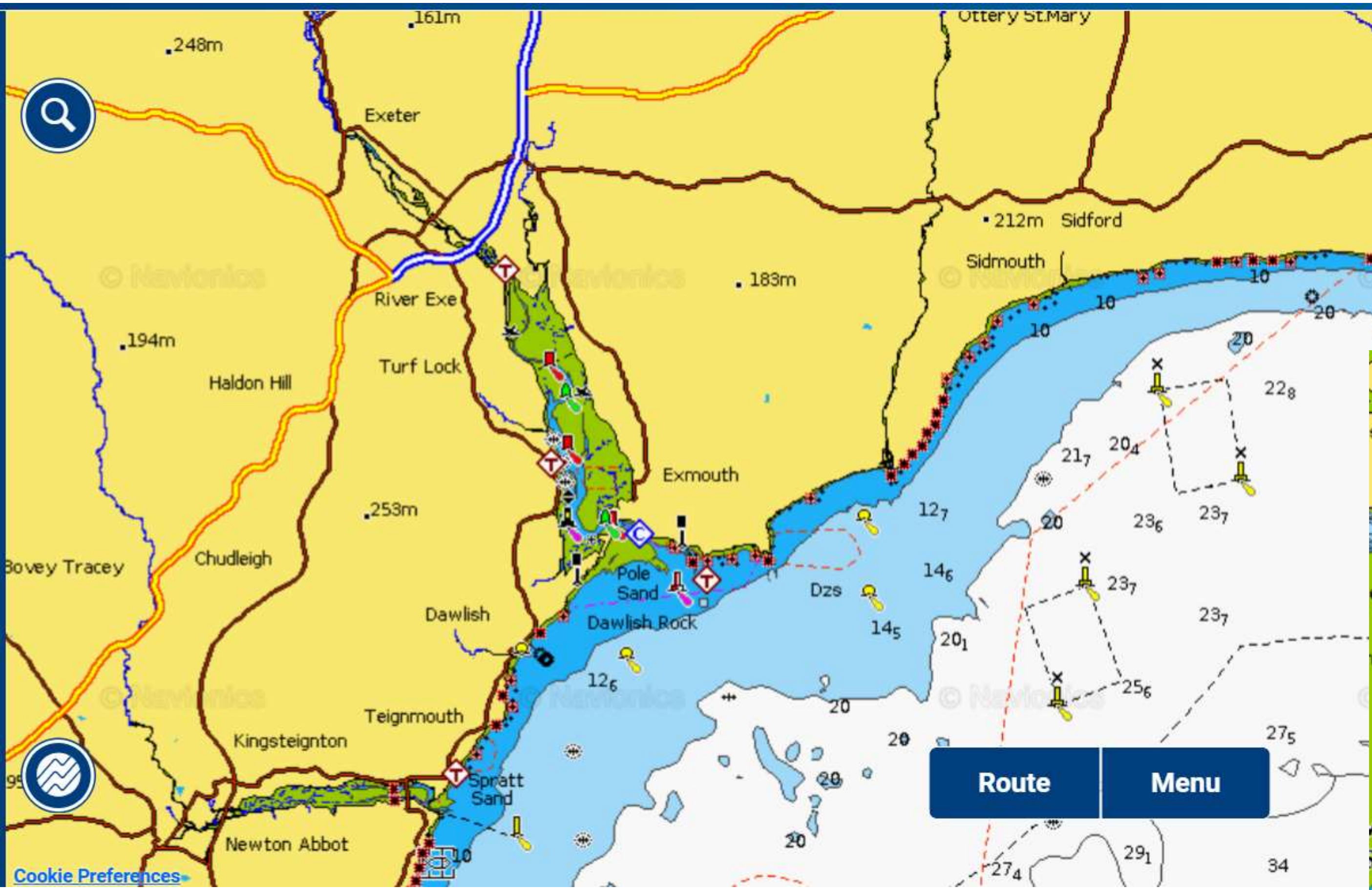
- Interactive electronic charts
- Reveal more detail as the view is zoomed - care needed as obstacles could be obscured/hidden
- Navionics is a brand leader

Electronic Charts

Navionics is a leading brand

See: www.navionics.com





Remember... Vector charts can often hide detail on larger scale charts and careful use of zoom functions is required to reveal all features/hazards

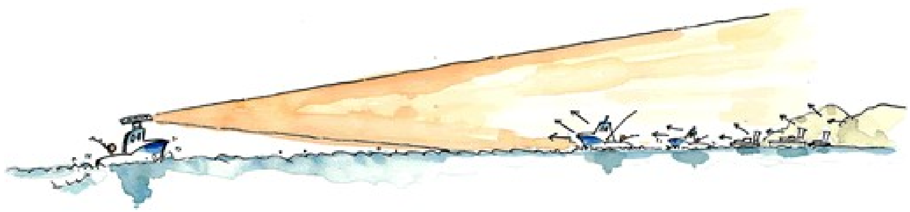
Using the Chart Plotter

- Treat as an aid to navigation.
- Maintain a record (log) to enable a position to be worked up on a paper chart.
- Vessel's position on the plotter is derived from a single source – take every opportunity to confirm this by an alternative means.

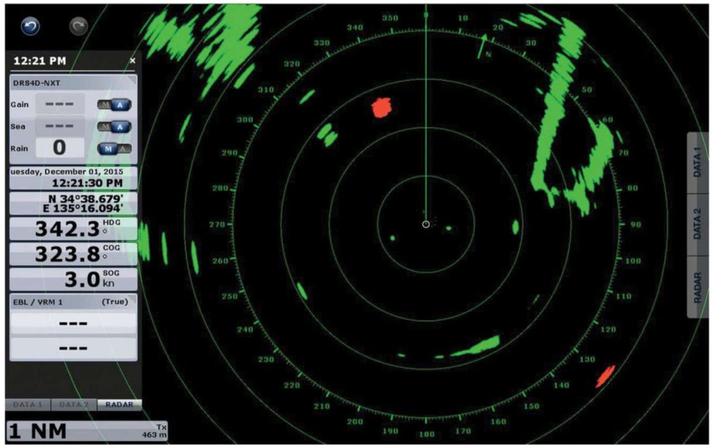
Radar

Radio detection and ranging

Radar - Principle



- The radar set produces radio waves which travel at the speed of light. These are transmitted by a rotating aerial.
- The radio waves are reflected from objects and the reflected wave is detected by the aerial.
- The time difference between sending and receiving can be converted to the range of the detected object.
- Information is displayed showing distance and relative bearing.



Radar - Navigation

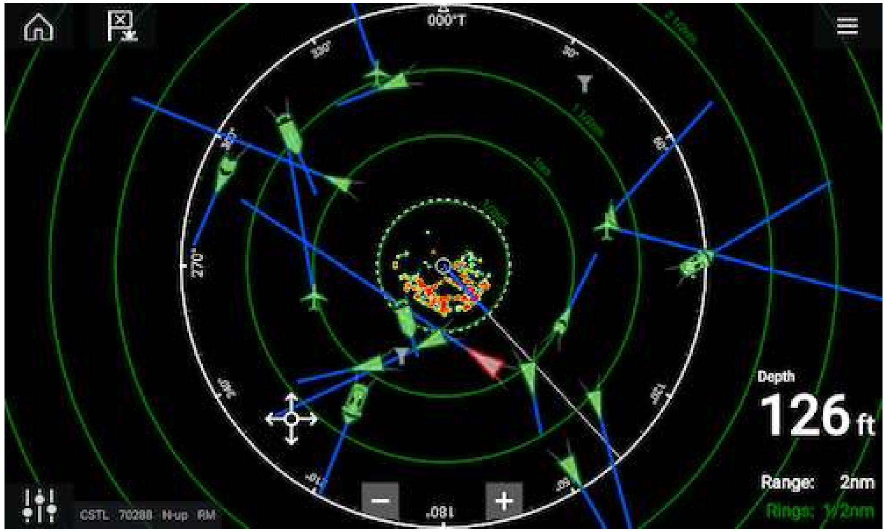
- Fixing position
- Locating objects in the dark or poor visibility
    - Definition of objects / features
- Pilotage by parallel indexing

BUT!

- Remember lack of resolution through beam width.

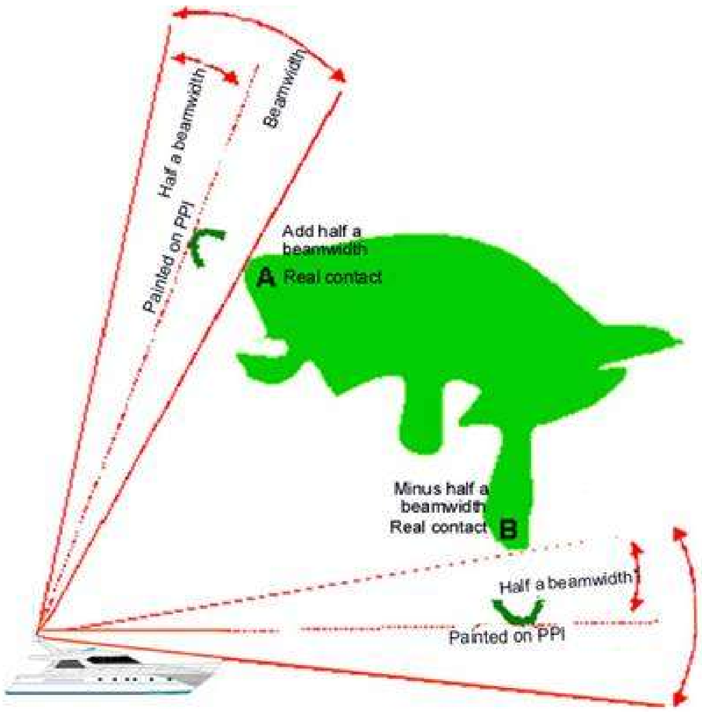
Radar functions

- The Gain Control adjusts the power of the system and is used to reduce scatter and noise
- Range control adjusts the ‘zoom’ of the display
- VRM – Variable range marker feature that allows the user to set a range on the screen to aid interpreting the display.
- EBL – An electronic Bearing Line is a drawn angle from the vessel.
- Parallel Indexing is a system on more complex systems that allows automatic tracking along a coastline, say.



Beam Width

- Marine radar is classified under the **x-band (10 GHz) or S-band (3GHz) frequencies**.
- X-band gives a sharper image and better resolution & the S-band is used in rain or fog for identification and tracking.
- The smaller sized rotating antenna on leisure vessels reduces the angular accuracy of the reflected target

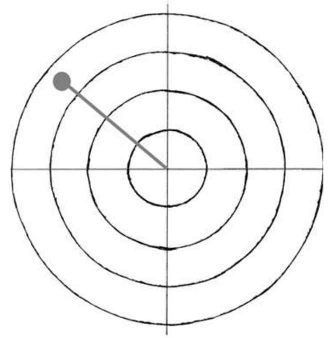


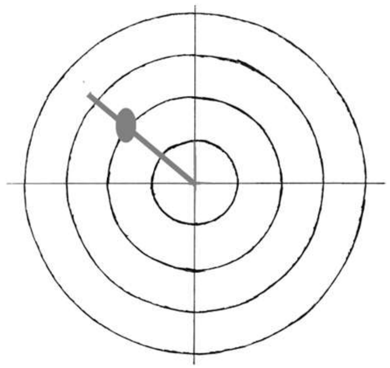
*PPI = Plan Position Indicator (The radar display)

Radar – Collision Avoidance

- Constant bearing and reducing range = danger of collision.
- MARPA

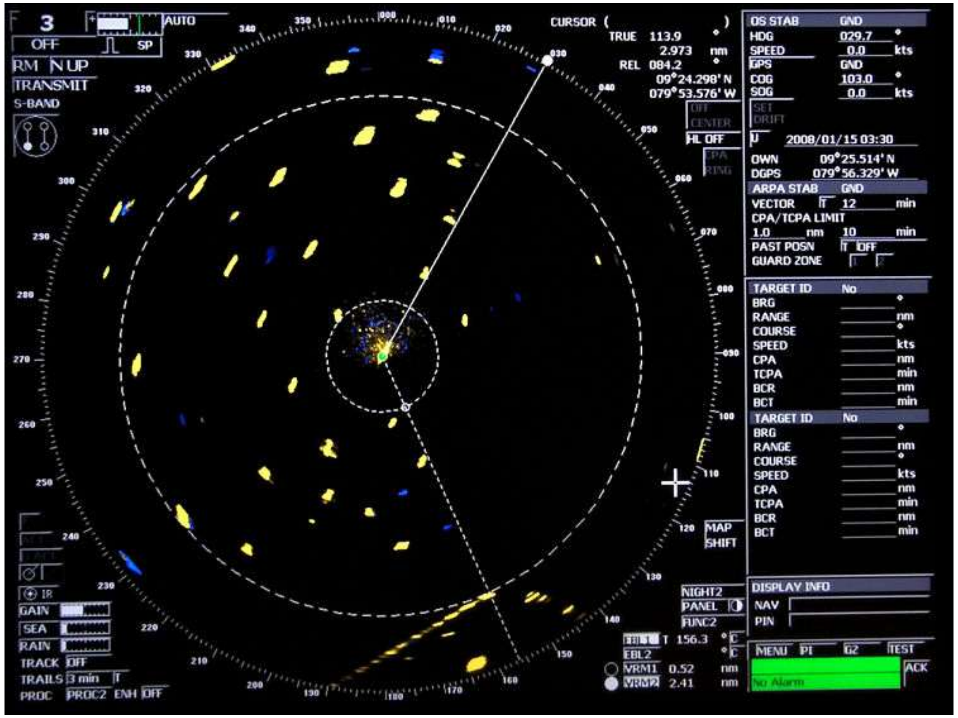
  Mini-automatic radar plotting aid (or MARPA) is a maritime radar feature for target tracking and collision avoidance. Targets must be manually selected, but are then tracked automatically, including range, bearing, target speed, target direction (course), CPA (closest point of approach), and TCPA (time of closest point of approach), safe or dangerous indication, and proximity alarm. MARPA is a more basic form of ARPA (automatic radar plotting aid). *Source – Wikipedia





Interpretation of the screen

- Head up / North up
- Relative motion



AIS

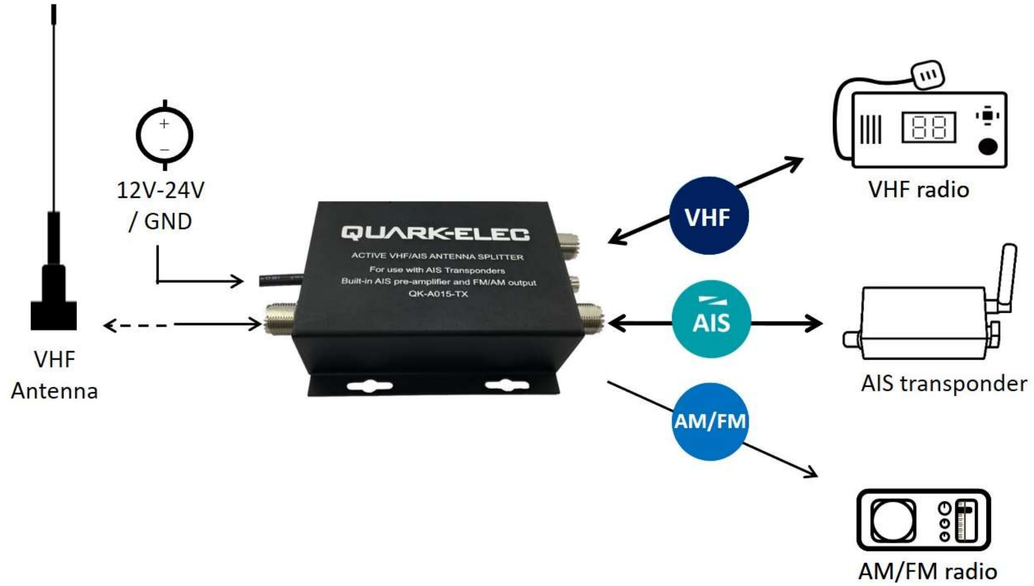
Automatic Identification System

Hardware

- Transmitter / Receiver operating at one end of the marine VHF frequency band.
- Transmitters
  - Type A – more powerful, signals prioritized by receivers.
  - Type B – less power, less information.
- Receivers
  - Information displayed on Radar or Chartplotter.
  - Can have a receiver without having a transmitter.

Automatic Identification System (AIS)

- An extension to the VHF radio service
- Provides information about the vessel to all ships in radio range
- Used by ships and vessels traffic services (VTS)
- Compulsory for commercial vessels



Leisure Vessels

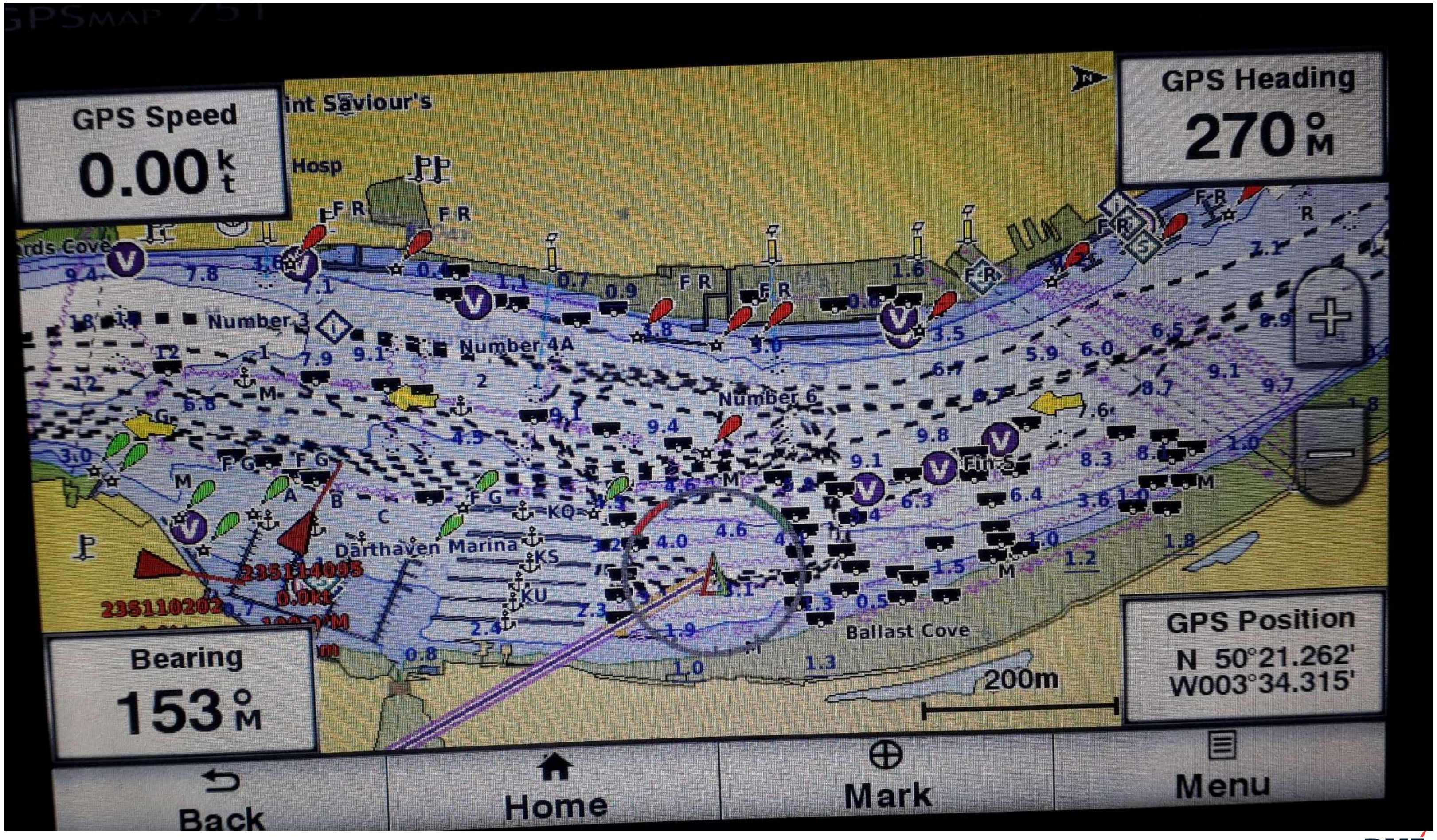
- Simple AIS receivers
- AIS Transponders send and receive data

- Simple AIS ‘Radar’ displays
- Lately Combined:
  - Multi-functional displays
  - VHF/AIS SRC Radio sets

AIS data allows

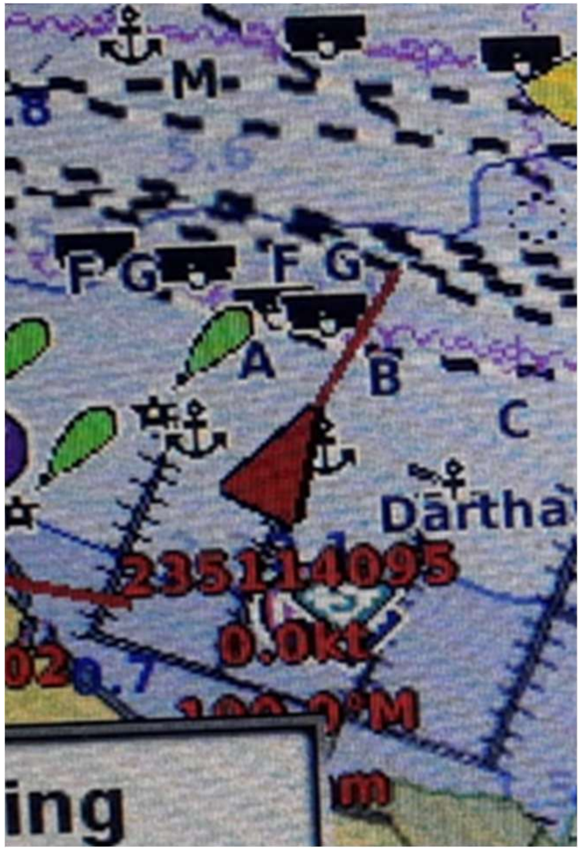
- Identification of target; Vessel name, MMSI, port of registration, destination, departure & arrival dates, etc.
- Course & speed information
- Closest point of approach
- Closest time of approach
- Web services relay data

AIS for collision avoidance



AIS for collision avoidance

- Information for target contact:
  - MMSI number
  - Speed
  - Course
  - CPA
  - Time to CPA
- Alarm / indication of danger on screen



However,…….

- AIS must be carried by all vessels >300grt on international voyages, all vessels >500grt and all passenger vessels.
- It must also be carried by all British registered fishing vessels.
- It can be carried by any vessel
- **IT DOES NOT MEAN THAT THEY WILL HAVE IT SWITCHED ON!!!!**

AIS MOB Personal Locator Beacon (PLB)

- Sounds alarm on receiver
- Symbol displayed on screen with distance and bearing
- **Shows actual position**

Web derived AIS – Real Time?

Multi Function Displays

Pros and Cons

Advantages

- One screen to look at / SPoG
- Ability to overlay radar onto chart (compass link required)
- Only one display to buy
- Often can be linked to a tablet / phone to provide “mobile” repeater

Possible Disadvantages

- All eggs in one basket!
- Screen needs to be very large if displaying several sources of information
- Familiarity with the system

Electronic Aids to Navigation

- GNSS
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- Radar
- Automatic Identification System
- Multifunctional Display systems