# Week 7

2023/24

1

# GPS and Plotters

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# The Hardware

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3

# What is GPS?

- GPS is a satellite-based radio-navigation system developed and operated by the U.S. Department of Defence.
- It permits land, sea and airborne users to determine their three-dimensional position, velocity and time 24 hours a day, in all weather, anywhere in the world.
- It reached full operational capacity on July 17, 1995.

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# The System Hardware.

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

- Space:
  - 24 satellites in six circular orbits.
  - at least 6 satellites always visible to users anywhere in the world.
  - satellites broadcast position and time data to users.
- Control
  - consists of a master control station, five monitor stations and three ground antennas located throughout the world.
  - these are used to monitor the satellite orbits, modified information about these is then broadcast to the satellites.
- User
  - consists of receivers, processors and antennas, which detect and process the information from the satellites to determine the user's position.

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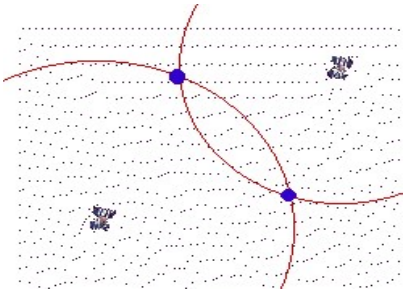
# How it works.

- GPS receivers calculate the range from the receiver to the satellite. To do this they need to know the time taken by the signal to transit from the satellite to the receiver and the speed at which the signal travels.
- Once the range is known, the receiver knows that it lies on the surface of a sphere with this radius from the satellite.



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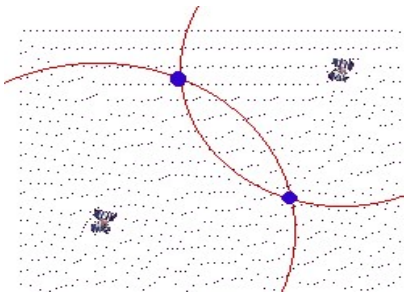
## How it works.

- 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.



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## 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.

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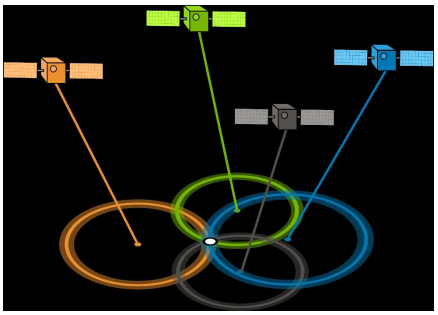
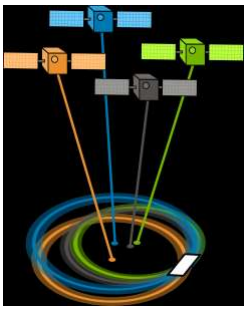
8

# HDOP
## Horizontal Dilution of Position



Wide satellite spacing – small area of cut



Small satellite spacing – large area of cut

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9

## 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. |

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10

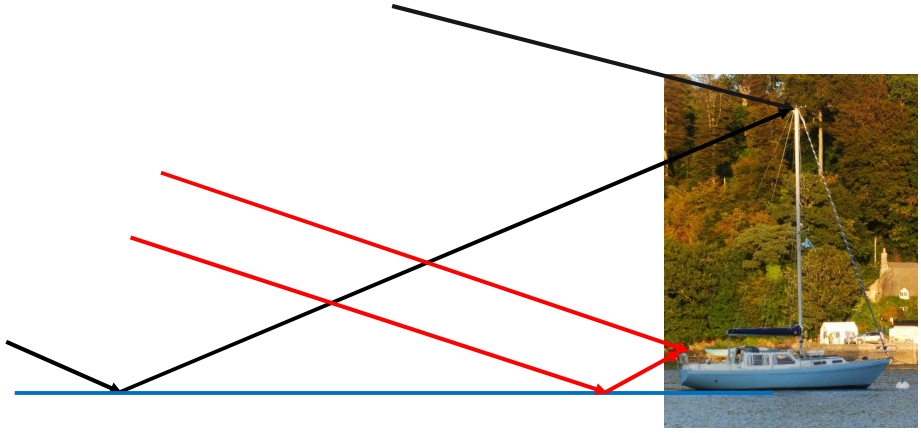
# Possible problems with GPS

- Power failure
- Transmissions from mobile phones
- Interruption of, or changes to, the satellite system
- Aerial failure or poor installation
  - Signal bounce



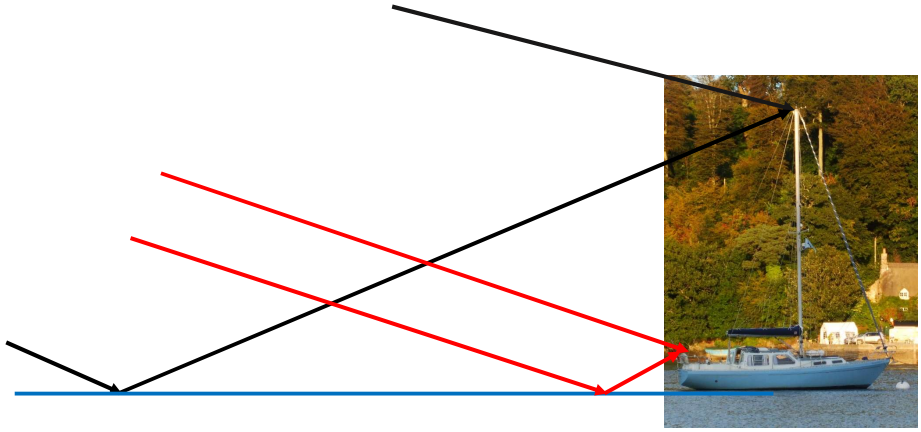
11

# Signal Bounce – different path lengths



12

# Signal Bounce – different path lengths



13

# Information from the GPS receiver

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



14

# Limitations of GPS

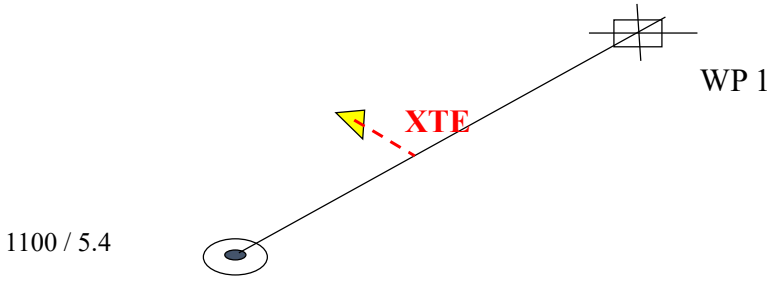




# Plotting Techniques with GPS

- Sailing / displacement power boat techniques:
  - Latitude and Longitude
  - Bearing and distance to a Waypoint
    - Use of centre point of compass rose
- Planing power boat techniques:
  - Distance to W.P. and X.T.E.
  - Web with distance and bearing to waypoint.

# Cross Track Error (XTE)

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17

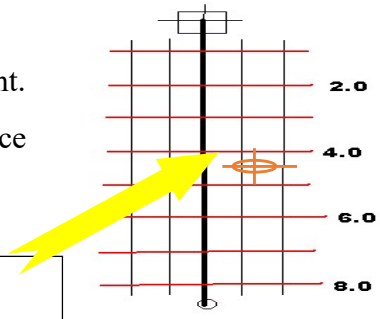
# Distance to Waypoint and Cross Track Error

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.

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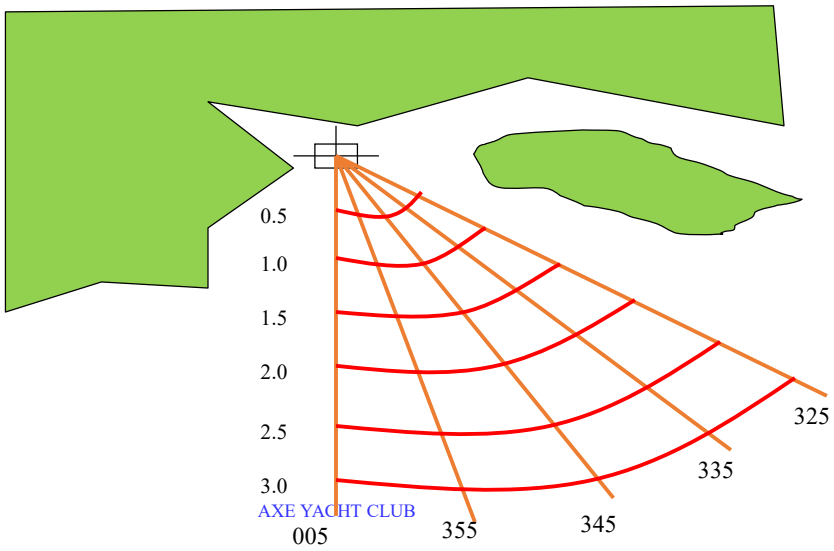
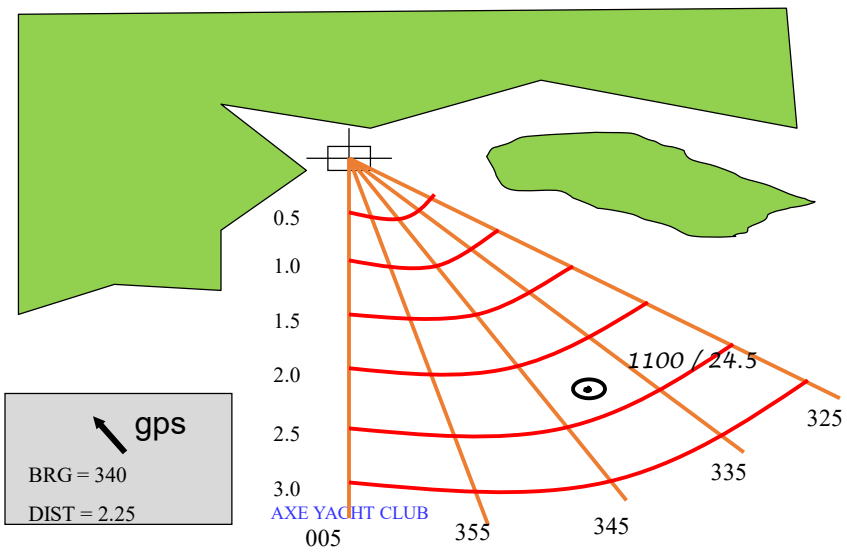
18

## Navigation Web




19

## Navigation Web 2




20