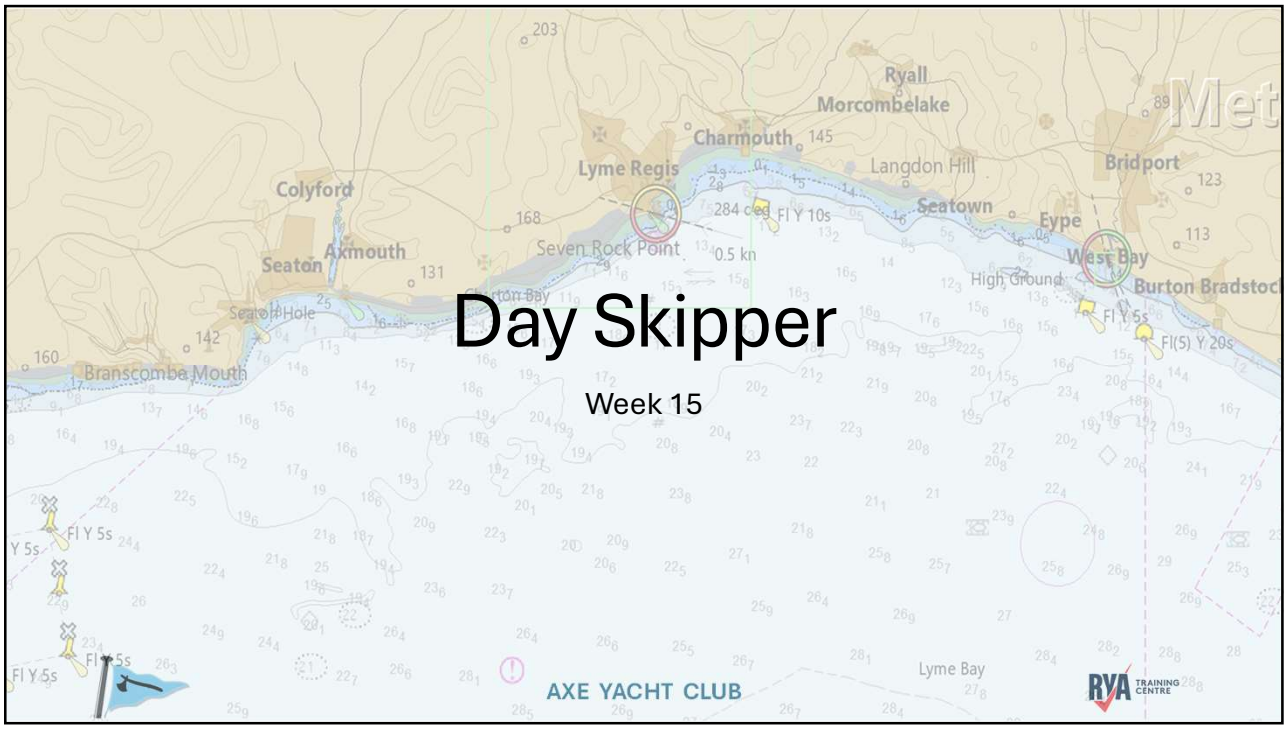
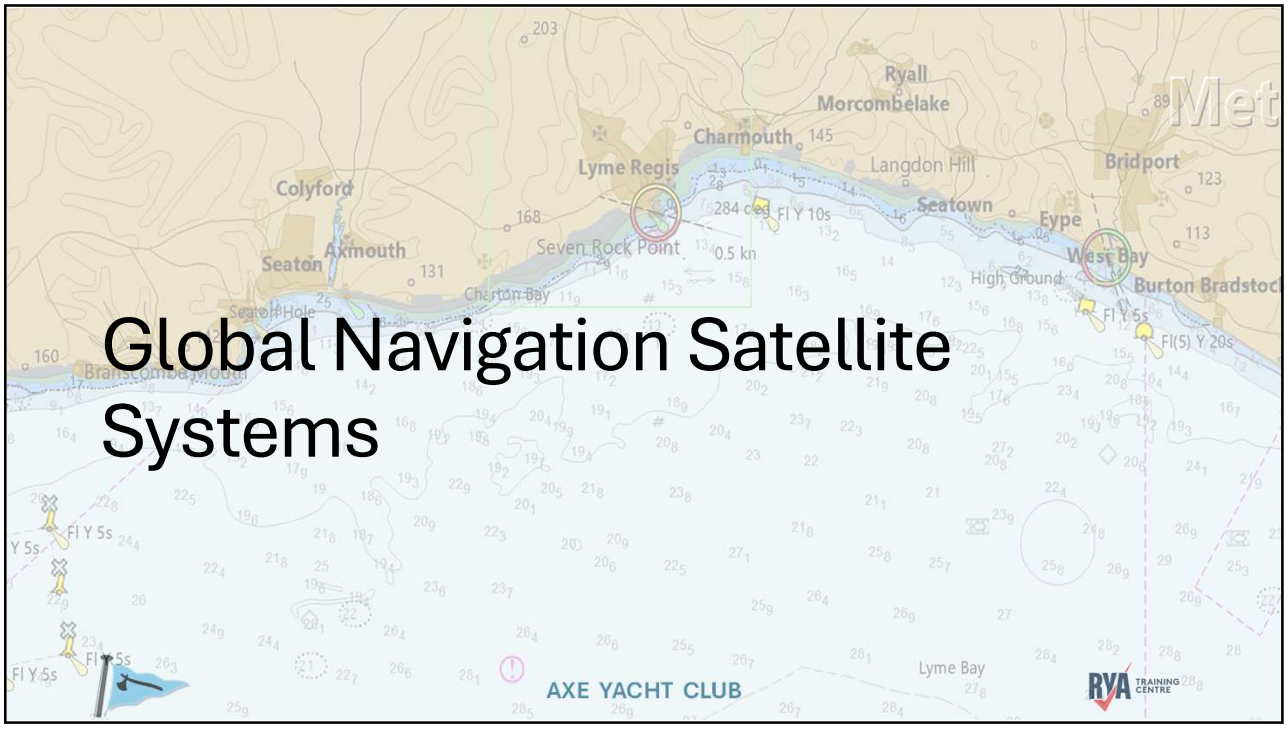

Day Skipper
Week 15
AXE YACHT CLUB
RYA TRAINING CENTRE

1


Global Navigation Satellite Systems
AXE YACHT CLUB
RYA TRAINING CENTRE

2

Satellite derived position lines

- GNSS
  - GPS most well known
  - Others
    - GLONASS
    - Galileo
    - Beidou



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3

The Hardware



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4

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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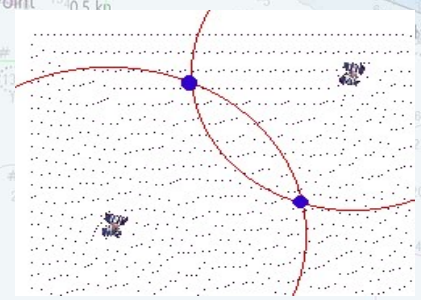
How it works.

- 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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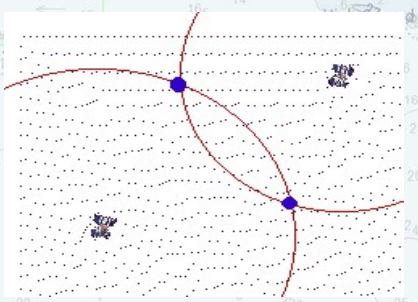
How it works.

- 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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8

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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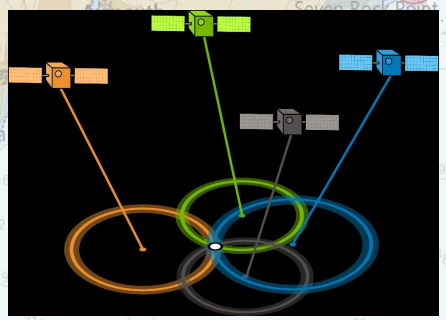
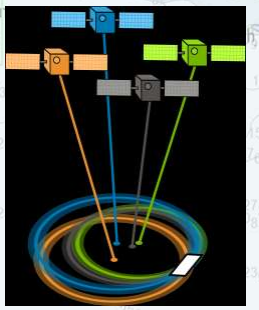
9

HDOP
Horizontal Dilution of Precision



Wide satellite spacing – small area of cut



Small satellite spacing – large area of cut

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HDOP Scale

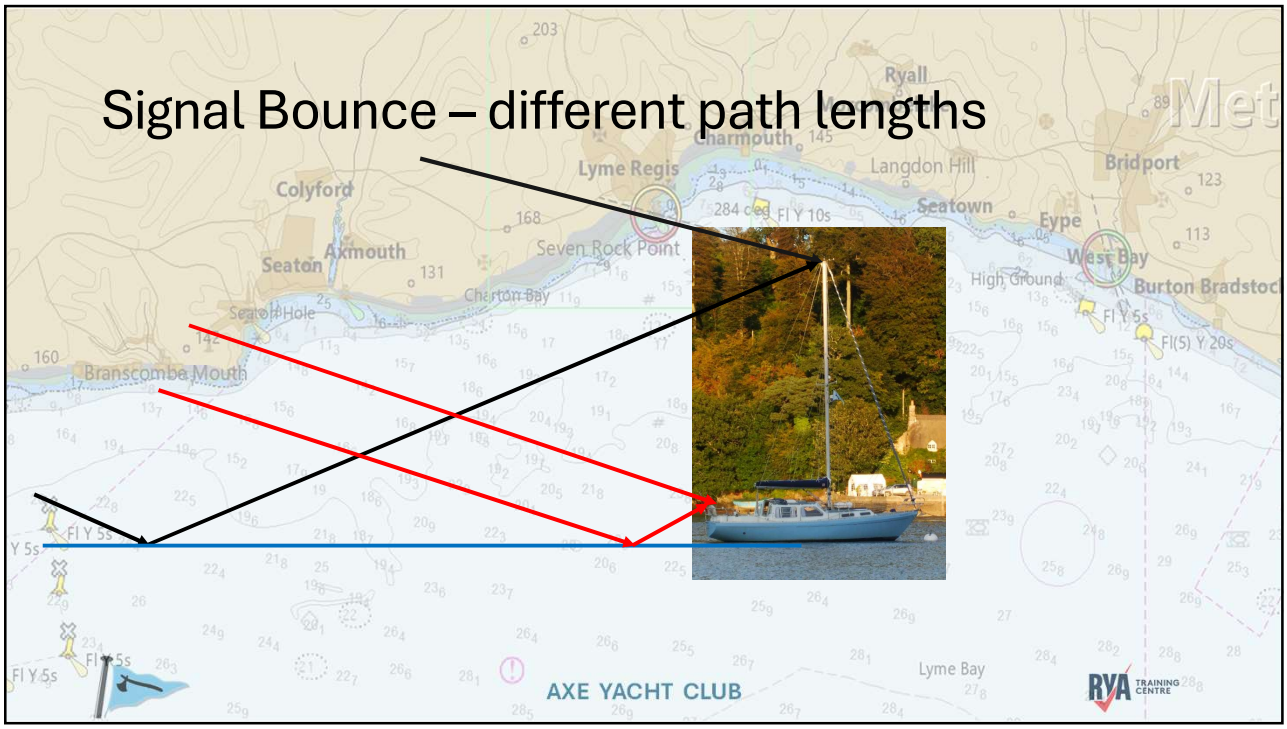
DOP Value	Rating	Description
< 1	Ideal	Highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	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.

11

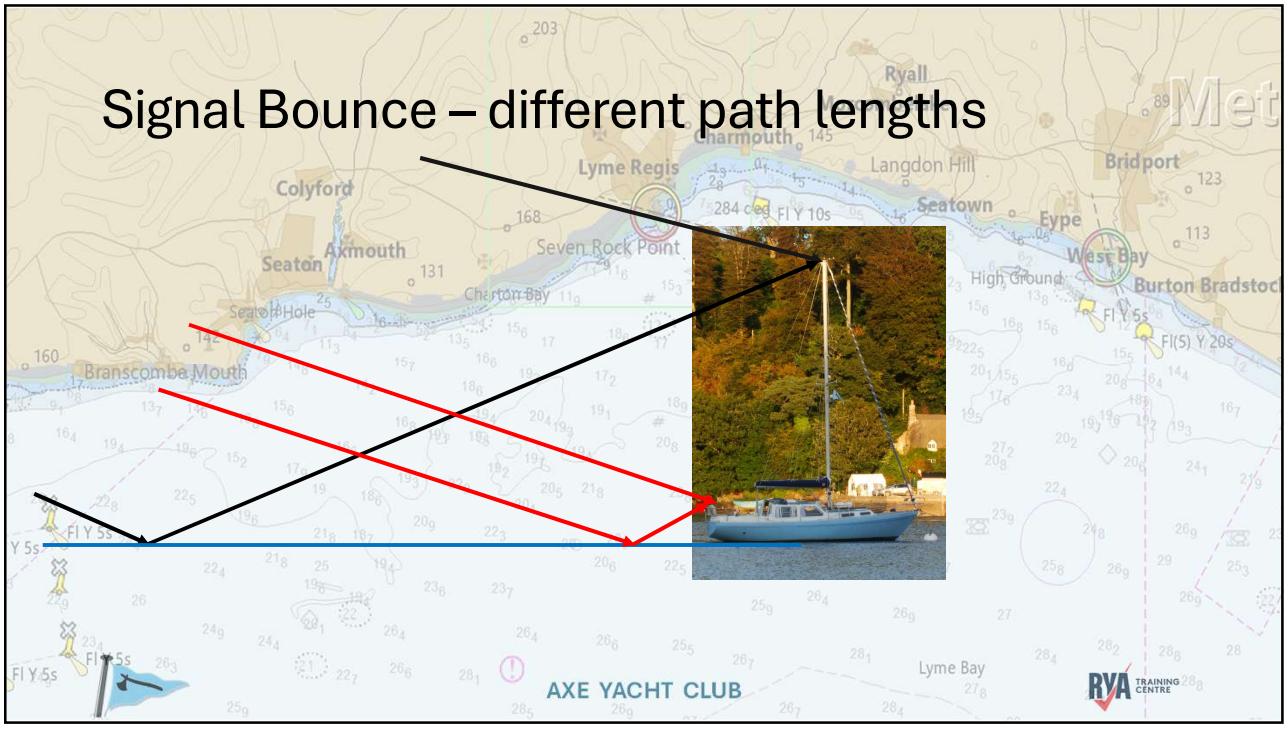
Possible problems with GPS

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

12


Signal Bounce – different path lengths
Lyme Regis
Colyford
Seaton
Axmouth
Seven Rock Point
Charton Bay
Seaton Hole
Branscomba Mouth
Langdon Hill
Seatown
Eype
West Bay
Bridport
High Ground
Burton Bradstock
Ryall
Charmouth
AXE YACHT CLUB
Lyme Bay
RYA TRAINING CENTRE

13


Signal Bounce – different path lengths
Lyme Regis
Colyford
Seaton
Axmouth
Seven Rock Point
Charton Bay
Seaton Hole
Branscomba Mouth
Langdon Hill
Seatown
Eype
West Bay
Bridport
High Ground
Burton Bradstock
Ryall
Charmouth
AXE YACHT CLUB
Lyme Bay
RYA TRAINING CENTRE

14

Information from the GPS receiver

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

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15

Screen Information



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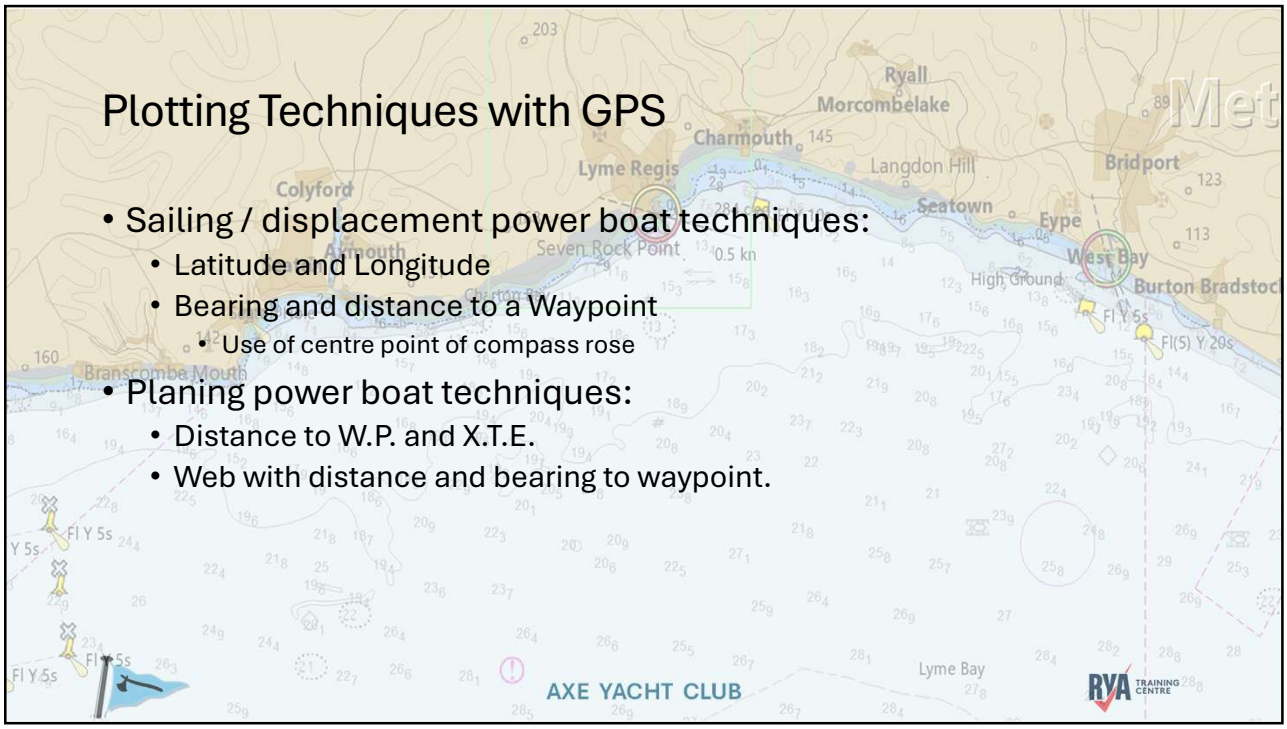
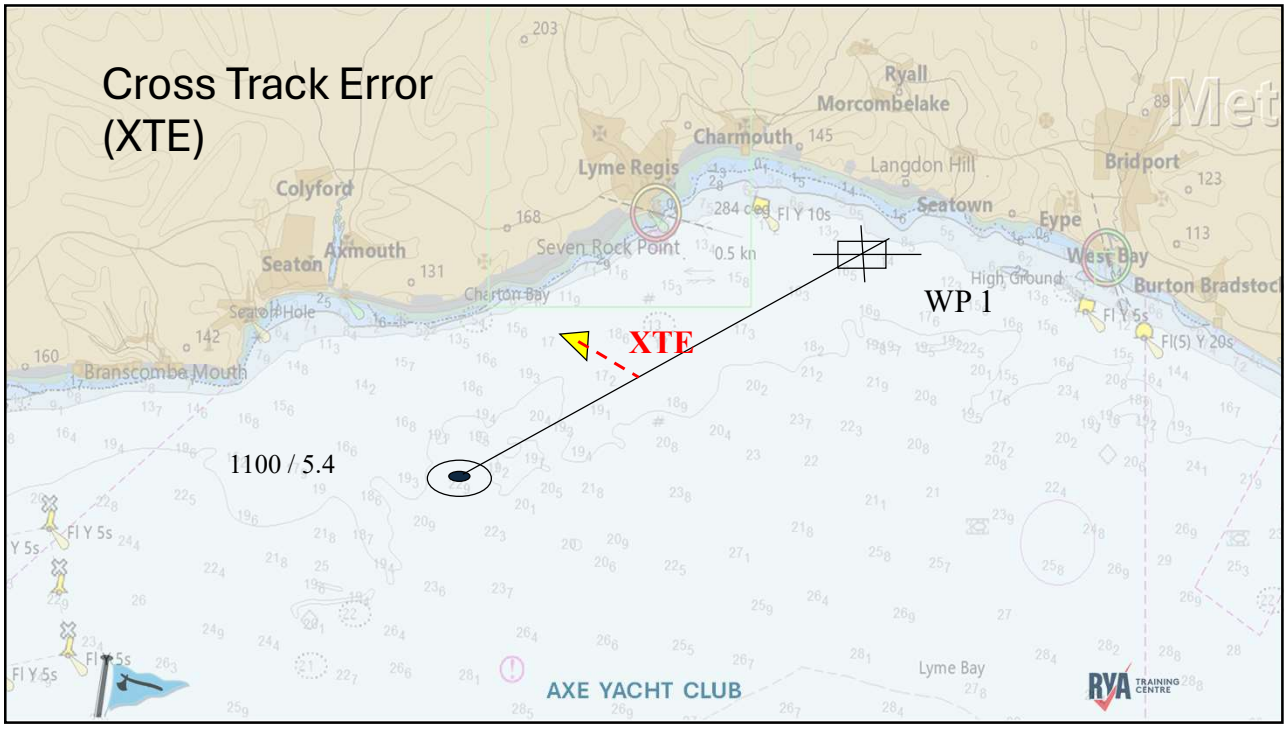
16


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.
AXE YACHT CLUB
Lyme Bay
Ryall
Morcombelake
Charmouth
Lyme Regis
Langdon Hill
Bridport
Colyford
Seatown
Eype
West Bay
Seven Rock Point
0.5 kn
High Ground
Burton Bradstock
Branscombe Mouth
Fl Y 5s
Fl(5) Y 20s

17

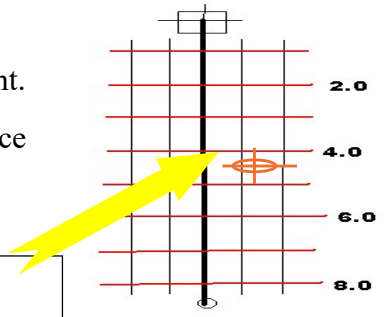

Cross Track Error
(XTE)
WP 1
XTE
1100 / 5.4
AXE YACHT CLUB
Lyme Bay
Ryall
Morcombelake
Charmouth
Lyme Regis
Langdon Hill
Bridport
Colyford
Seatown
Eype
West Bay
Seaton
Axmouth
Seven Rock Point
0.5 kn
High Ground
Burton Bradstock
Branscombe Mouth
Fl Y 5s
Fl(5) Y 20s

18

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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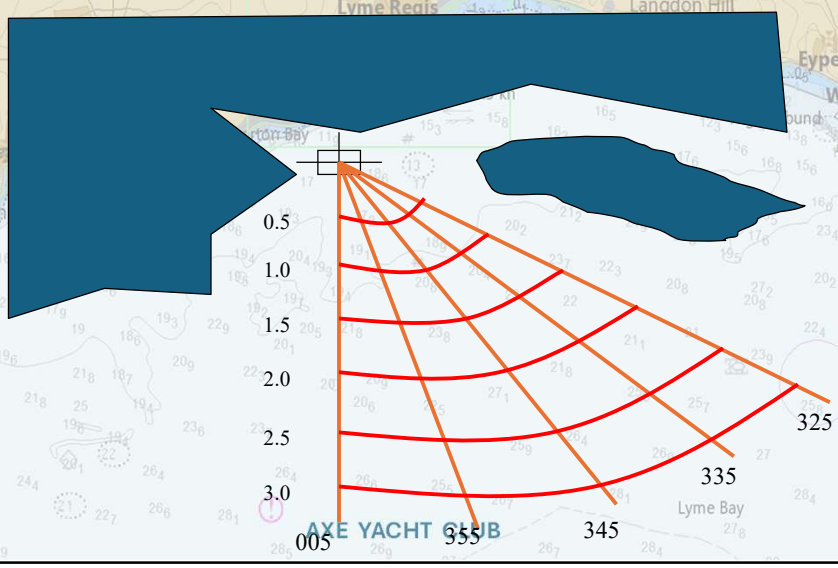
Navigation Web



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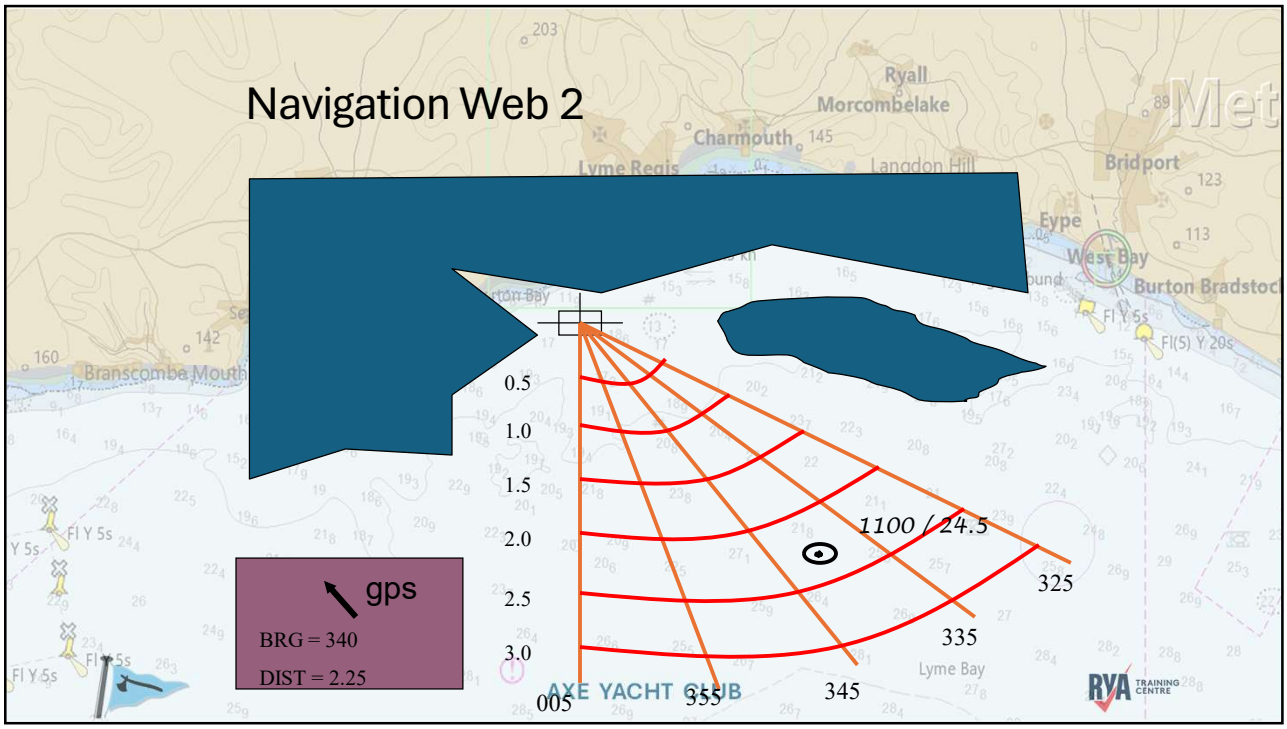
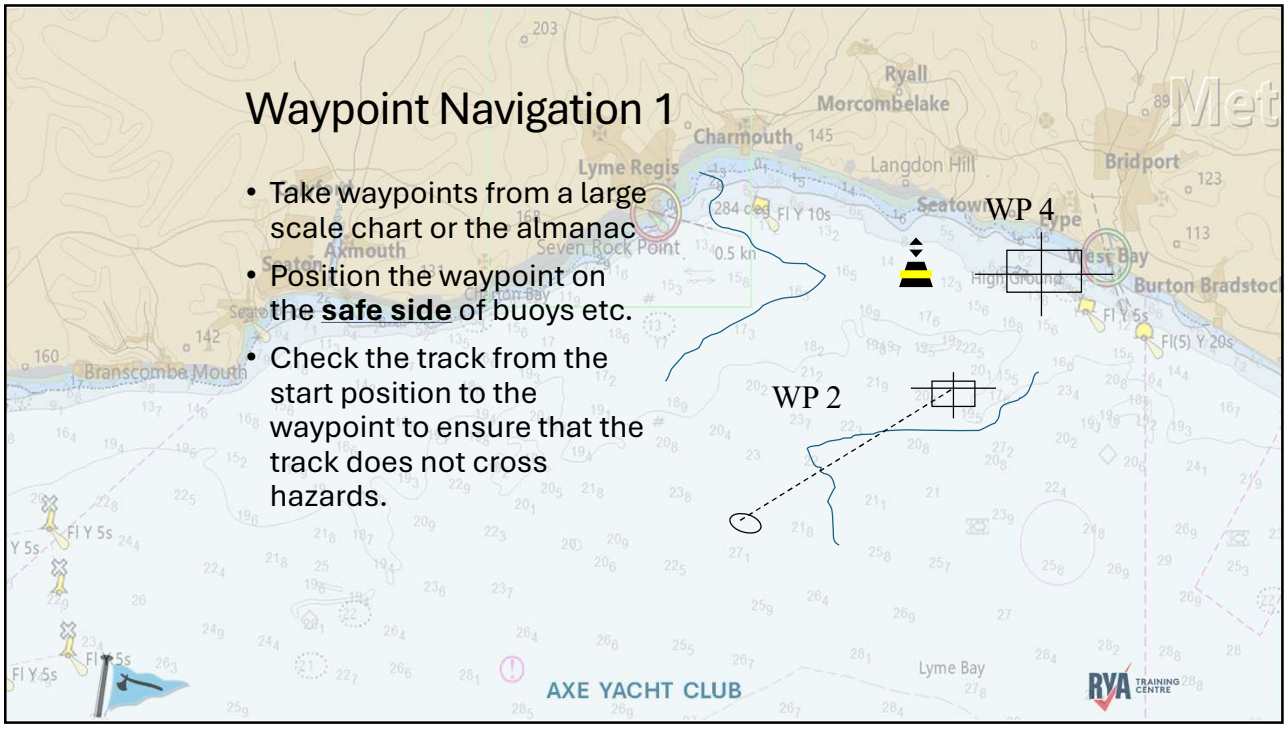
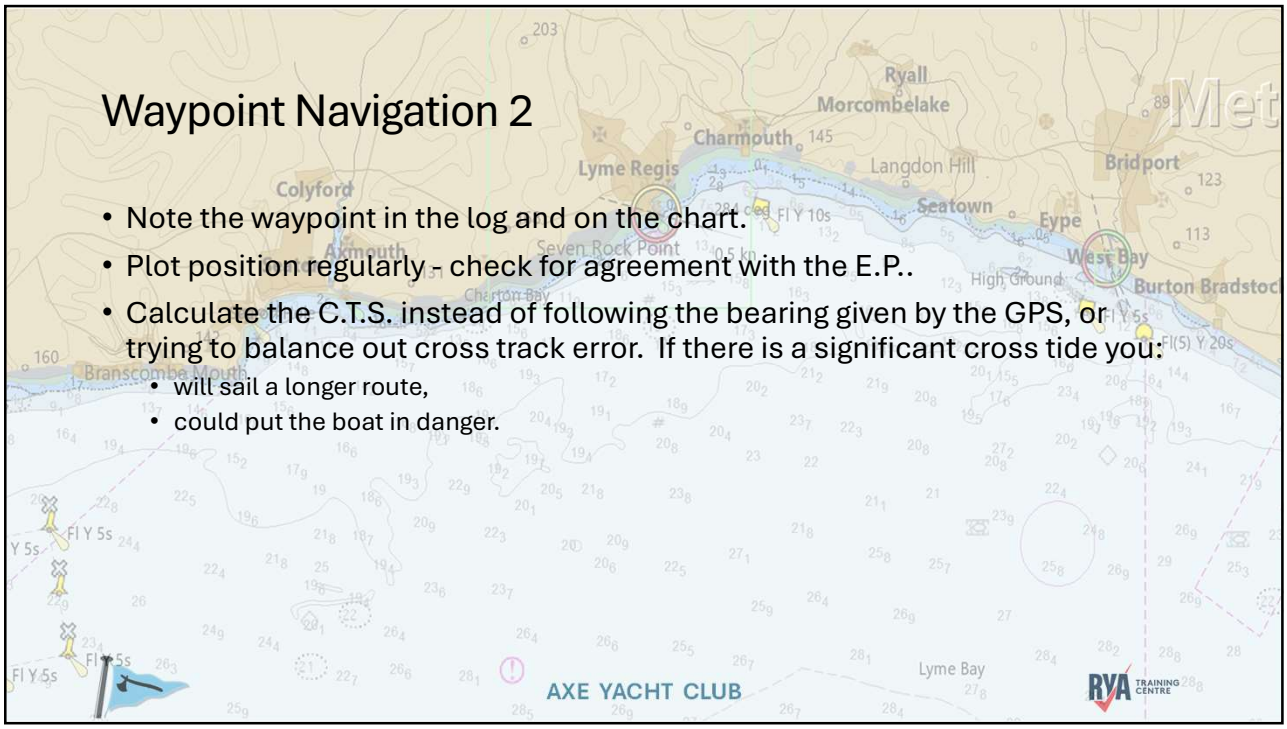
20


Navigation Web 2
0.5
1.0
1.5
2.0
2.5
3.0
gps
BRG = 340
DIST = 2.25
1100 / 24.5
325
335
345
355
005
AXE YACHT CLUB
Lyme Bay
Ryall
Morcombelake
Charmouth
Lyme Regis
Langdon Hill
Bridport
Eype
West Bay
Burton Bradstock
Branscombe Mouth

21


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.
WP 4
WP 2
AXE YACHT CLUB
Lyme Bay
Ryall
Morcombelake
Charmouth
Lyme Regis
Langdon Hill
Bridport
Eype
West Bay
Burton Bradstock
Branscombe Mouth

22


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.
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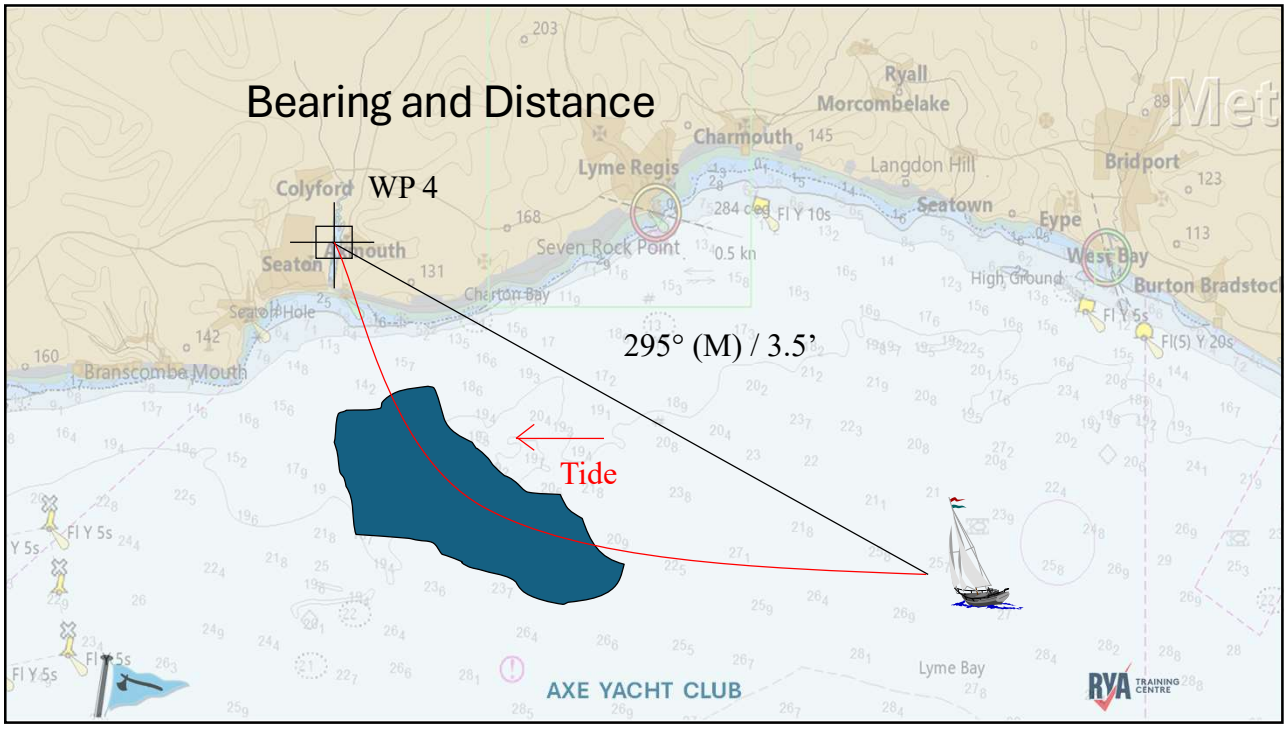
Lyme Bay
RYA TRAINING CENTRE

23


Bearing and Distance
WP 4
295° (M) / 3.5'
Tide
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Lyme Bay
RYA TRAINING CENTRE

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Course to Steer

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The Situation

On Friday 24 May you are approaching Colville from the North, making for the waypoint that you have called “Colville N” (45° 58.8’N / 006° 10.7’W)

At 1145 the GPS gives the bearing and distance to the waypoint as 173T / 6.3nm. Your boat speed through the water on a southerly course is 6 knots.

What course will the helm have to steer if you are to arrive at the waypoint?

To answer this question, we have to work out the **Course To Steer (CTS).**



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CTS - what we need to know

- The starting point
- The destination
- The distance between the two and the time that we expect it to take us to cover this distance:

Time = distance ÷ speed

- The set and drift of the tidal stream during the period that we are planning the CTS for

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CTS – the process

a. Decide whether to draw a one hour triangle, or a half hour triangle based on the expected time duration.

b. On the chart draw a line from the start point through the destination waypoint and **beyond**. This will be the **Course over the Ground** (COG).

c. Lay off the tidal set and drift for the appropriate period from the start position.

d. Set your dividers to the distance that you expect to cover in the same period (from your speed through the water).

e. With one point of the dividers on the end of the tide vector, arc off and mark the point at which the arc crosses the line in (b).

f. Join the end of the tide vector to this point – **this is your course to steer**.

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Back to the problem……

From the chart – distance =6.3 nm

Anticipated speed = 6 knots

Time = 6.3 ÷ 6 = 1.05 hours

We will draw a one hour triangle.



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Back to the problem….

Tidal Stream from 1145 to 1245 using <> H

Friday May 24
HW Victoria HW 0816UT / 0916 DST 5.5m LW 0.6m
Range 4.9m => Springs

1145 to 1245 = HW+3
<> H HW+3 Sp = 293T / 2.0 kn



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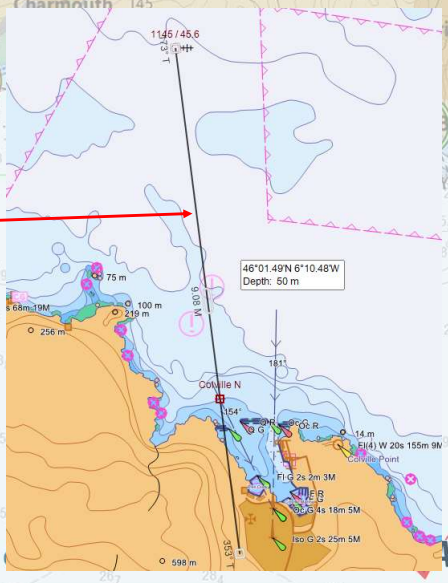
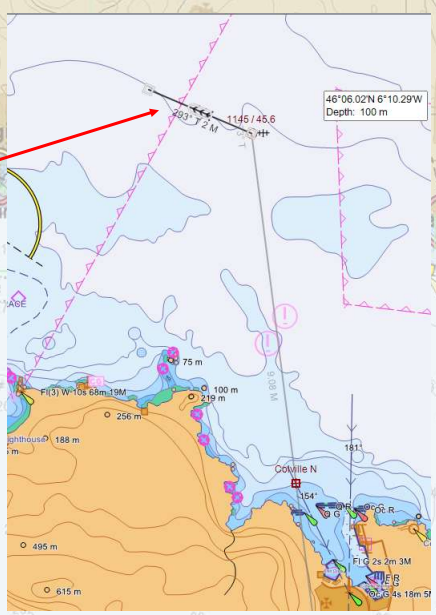
Back to the problem – on the chart

Draw a line from the start point through the waypoint and beyond.

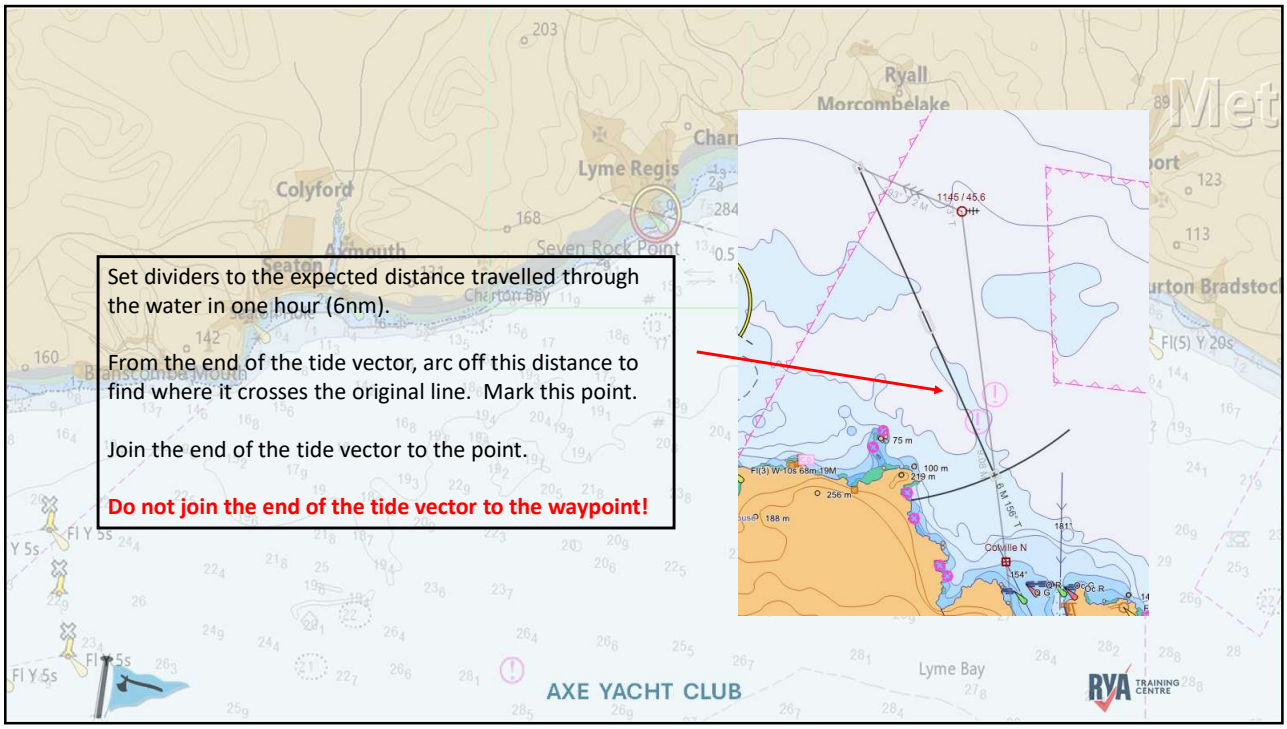


31

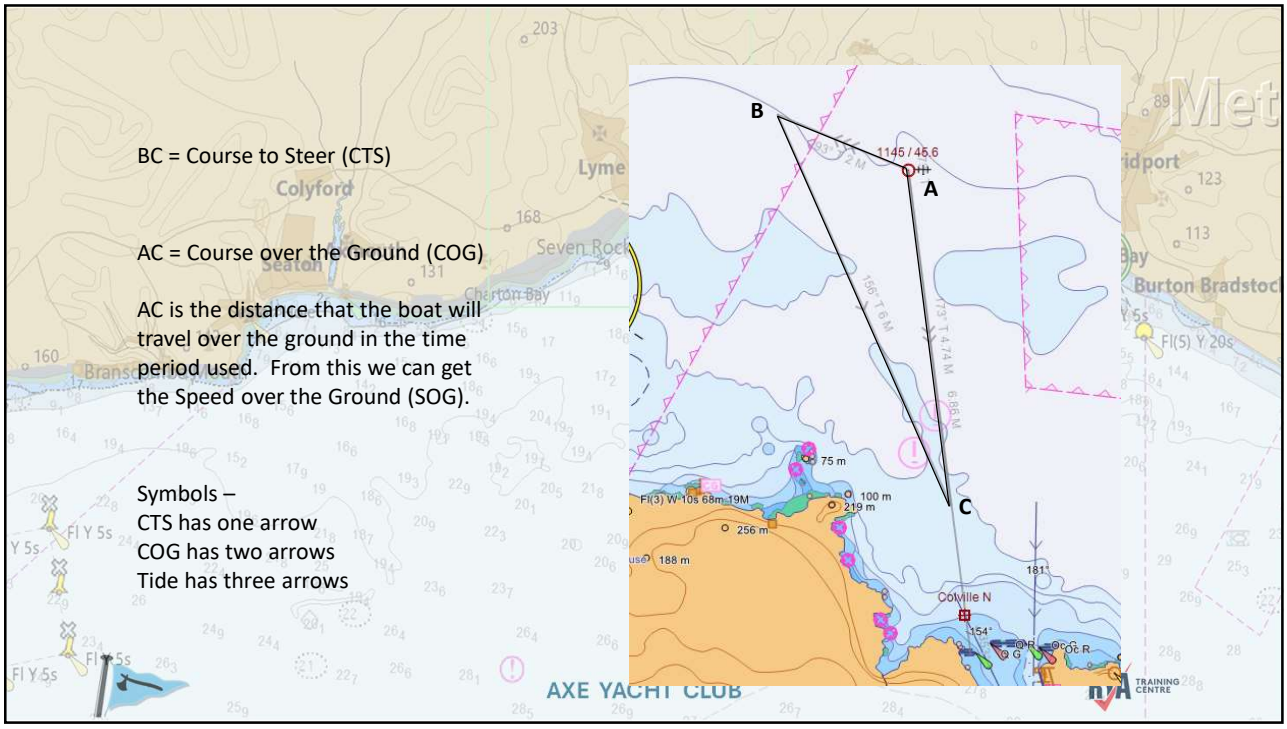
Lay off the tide from the start position



32


Set dividers to the expected distance travelled through the water in one hour (6nm).
From the end of the tide vector, arc off this distance to find where it crosses the original line. Mark this point.
Join the end of the tide vector to the point.
Do not join the end of the tide vector to the waypoint!
1145 / 45.6
75 m
100 m
219 m
256 m
188 m
Colville N
AXE YACHT CLUB
Lyme Bay
Lyme Regis
Colyford
Seven Rock Point
Charton Bay
Ryall
Morcombelake
Burton Bradstock
RYA TRAINING CENTRE

33


BC = Course to Steer (CTS)
AC = Course over the Ground (COG)
AC is the distance that the boat will travel over the ground in the time period used. From this we can get the Speed over the Ground (SOG).
Symbols –
CTS has one arrow
COG has two arrows
Tide has three arrows
B
A
C
1145 / 45.6
75 m
100 m
219 m
256 m
188 m
Colville N
AXE YACHT CLUB
Burton Bradstock
RYA TRAINING CENTRE

34

The Problem - solutions

- From the diagram CTS = 156T
- Predicted SOG is 4.8 knots
- Time to the waypoint is Distance ÷ Speed = 6.3 ÷ 4.8 = 1.3 hours (1 hour 18 minutes)

- The course passed to the helm needs to be converted to a magnetic bearing and then an allowance made for leeway.

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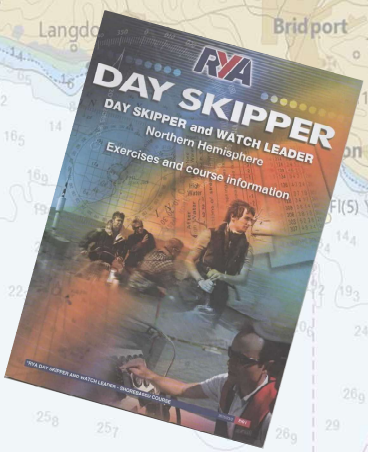
Homework

Exercise –

Using Global Navigation Satellite Systems – p14

Questions 1 - 4



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