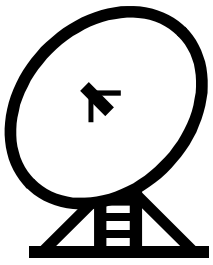


Navigating With GPS

Instructions for Navigating With GPS

Navigation is rather simple. Click on virtually any part of the screen and the slide will advance, but the best way is to click on the “Globe” in the lower right corner. To return to the previous slide, click on the “Satellite Dish” in the upper left corner. You can stop the Presentation at any time and return to Acrobat Reader™ by hitting the “Escape Key” on the upper left corner of your keyboard. Click on “START” to begin the Presentation. Click on the “Globe” on page 49 to return to the beginning of the Presentation.

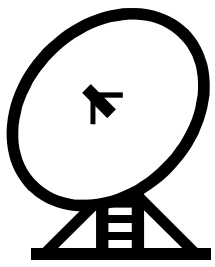




Navigating With GPS

Overheads to accompany a one-
lesson course on the *Global
Positioning System* (GPS)

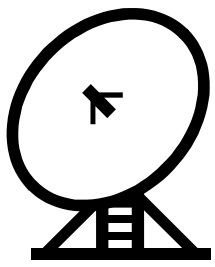




Outline of Presentation

- ◆ Background, course overview, and objectives
- ◆ Navigation review
- ◆ GPS system explained
- ◆ Basic receiver functions
- ◆ Selecting a receiver
- ◆ Waypoint navigation

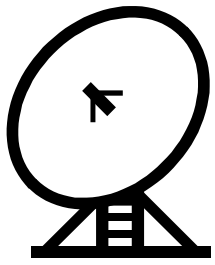




Outline of Presentation

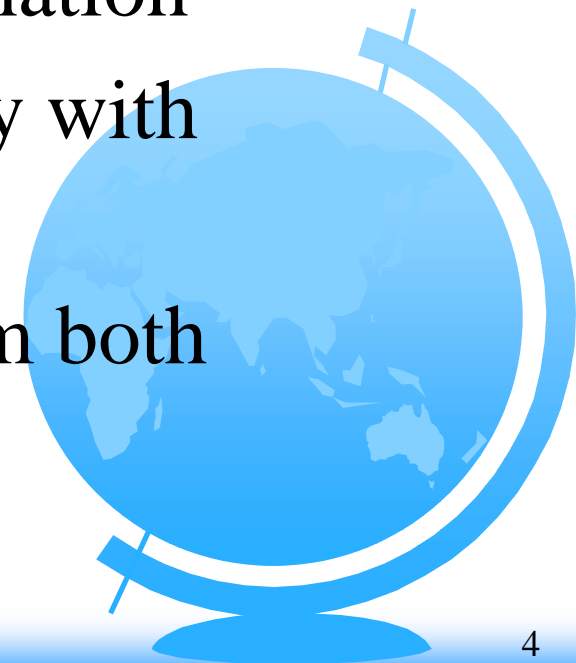
- ◆ Use of GPS underway
- ◆ More Tips
- ◆ How to learn more

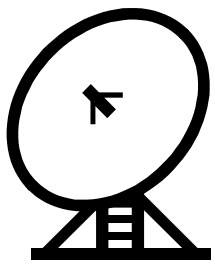




Background

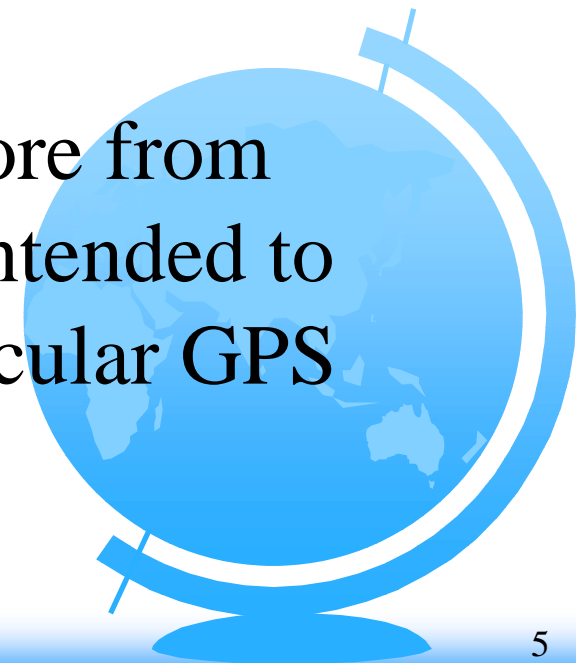
- ◆ Course developed by *United States Coast Guard Auxiliary* (USCGAUX) and *Canadian Power and Sail Squadrons* (CPS)
- ◆ One-lesson lecture, short examination
- ◆ Course assumes some familiarity with coastal navigation
- ◆ Advanced courses available from both USCGAUX and CPS

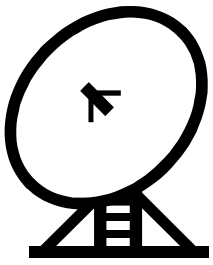




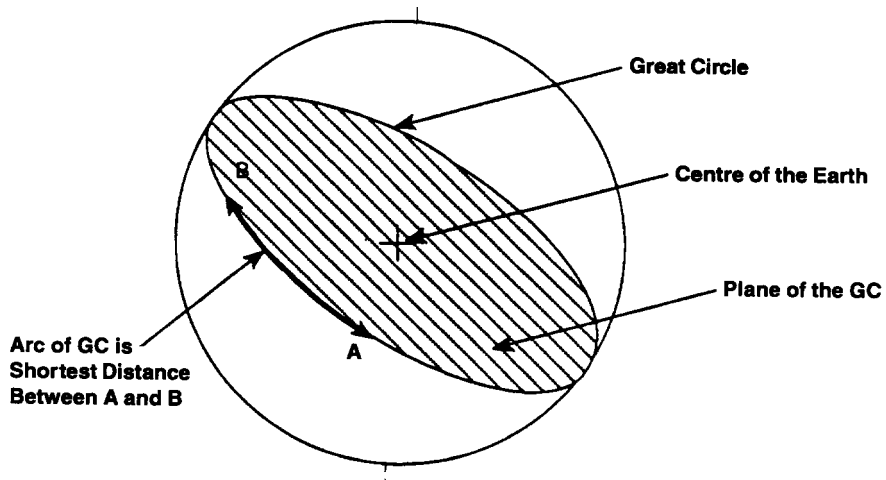
What you will learn

- ◆ Brief review of principles of navigation
- ◆ Overview of GPS
- ◆ Navigation techniques with GPS
- ◆ Characteristics of GPS receivers
- ◆ This course will help you get more from your owner's manual--it is not intended to teach you how to operate a particular GPS receiver



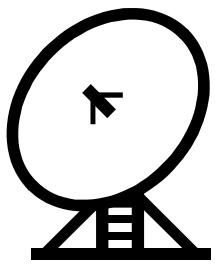


Navigation Review

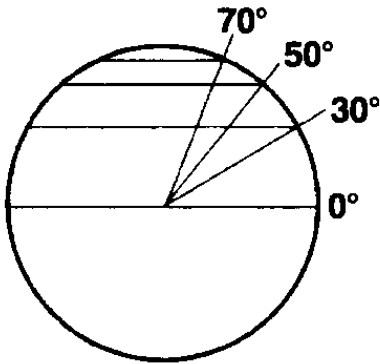


- ◆ Earth as sphere
- ◆ On plane, shortest distance between two points is straight line
- ◆ On sphere, shortest distance is great circle

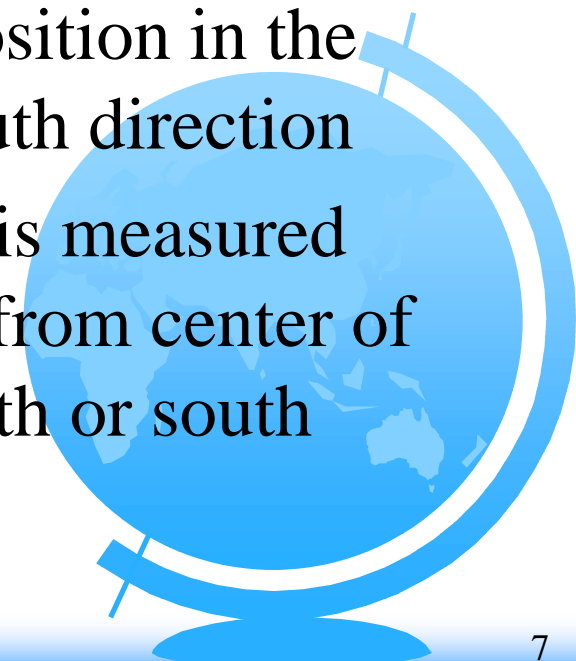


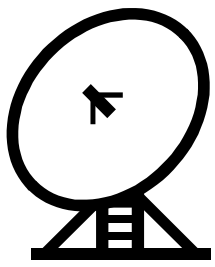


Navigation Review

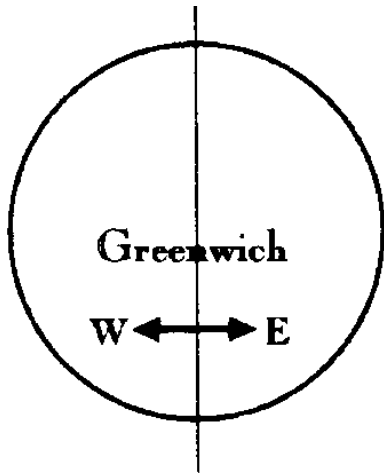


- ◆ Position on the earth is measured in terms of latitude and longitude
- ◆ Parallels of latitude define position in the north-south direction
- ◆ Latitude is measured as angle from center of earth north or south

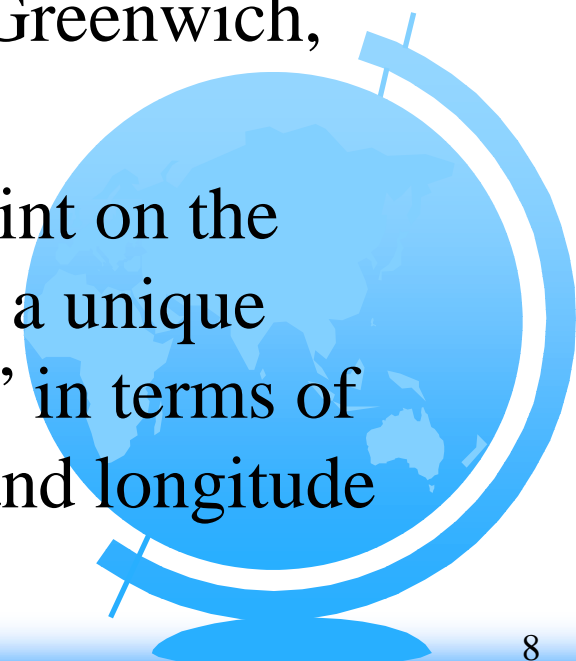


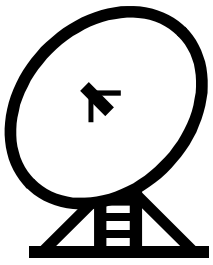


Navigation Review



- ◆ Longitude is defined as an angle, east or west of a reference meridian passing through Greenwich, England
- ◆ Every point on the earth has a unique “address” in terms of latitude and longitude

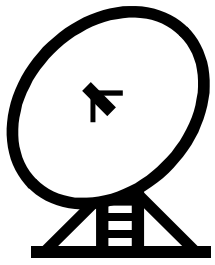




Navigation Review

- ◆ Horizontal datum is a chart coordinate reference system
- ◆ Although nautical charts are in the process of being standardized, not all are drawn to the same datum
- ◆ The datum is shown on each chart
- ◆ **GPS receivers must be adjusted to the same datum as used on the chart!**

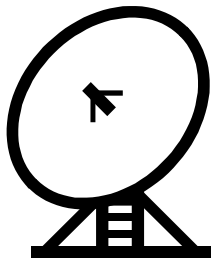




Navigation Review

- ◆ A *waypoint* (WPT or WP) is a designated location with geographic coordinates
- ◆ Waypoints are used extensively in electronic navigation
 - As boundaries between voyage segments
 - To mark turn points, destinations, navigational aids
 - To mark hazards to navigation

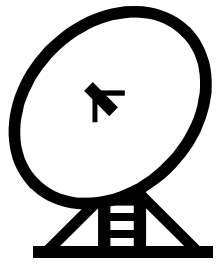




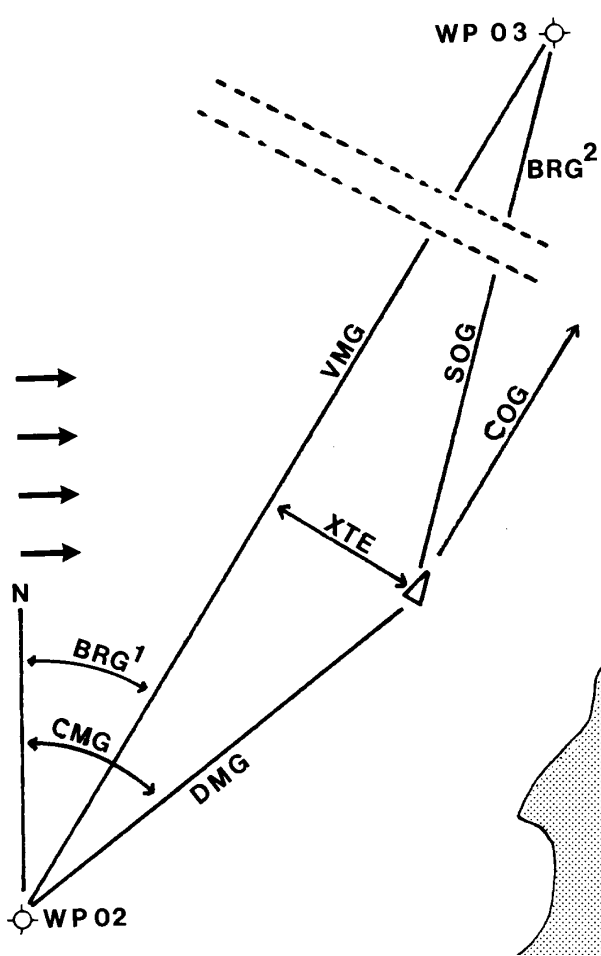
Navigation Review

- ◆ GPS receivers enable waypoints to be entered and stored in various ways (e.g., in lat/lo units, in terms of distance and bearing, etc.)
- ◆ A sequence of waypoints defines a planned route--many GPS receivers can store routes as well as waypoints

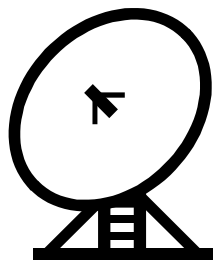




Navigation Review--Terms

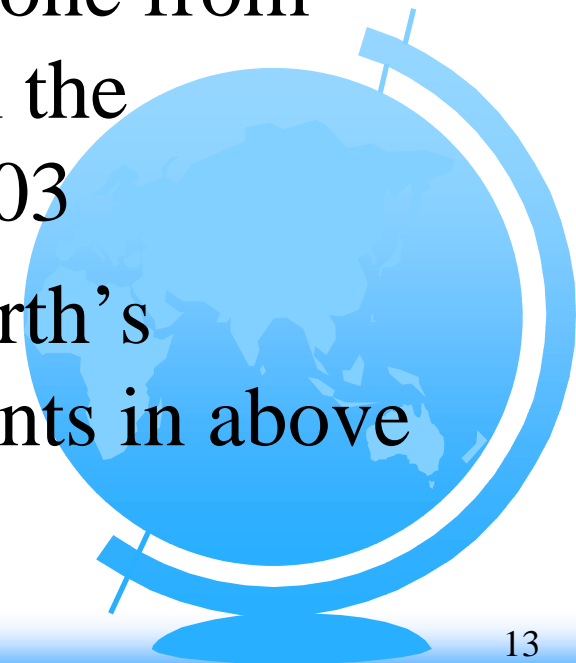


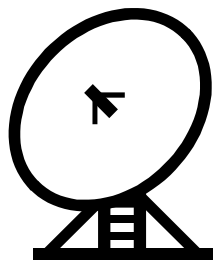
- ◆ **Heading**; direction in which vessel's bow is pointed
- ◆ **Course Made Good (CMG)**; direction traveled from one fix to another
- ◆ **Distance made good (DMG)**; same in distance terms



Navigation Review--Terms

- ◆ **Bearing** (BRG); horizontal direction from one point to another measured relative to true or magnetic north
- ◆ Two bearings are shown above, one from WP 02 to WP 03, the other from the vessel's present position to WP 03
- ◆ **Track**; intended path over the earth's surface--shown between waypoints in above illustration

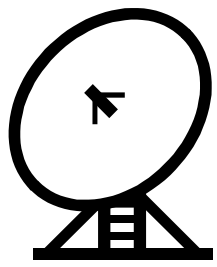




Navigation Review--Terms

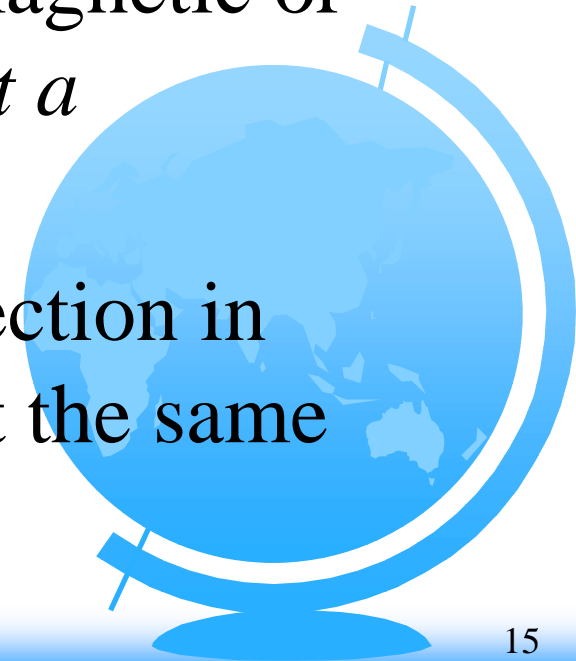
- ◆ **Course**; horizontal direction in which a boat is to be steered
- ◆ **Velocity made good (VMG)**; average speed over the ground along the track between waypoints
- ◆ **Speed Over Ground (SOG)**; speed with reference to ground

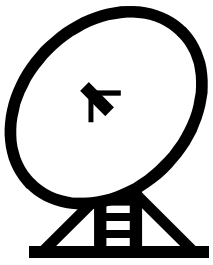




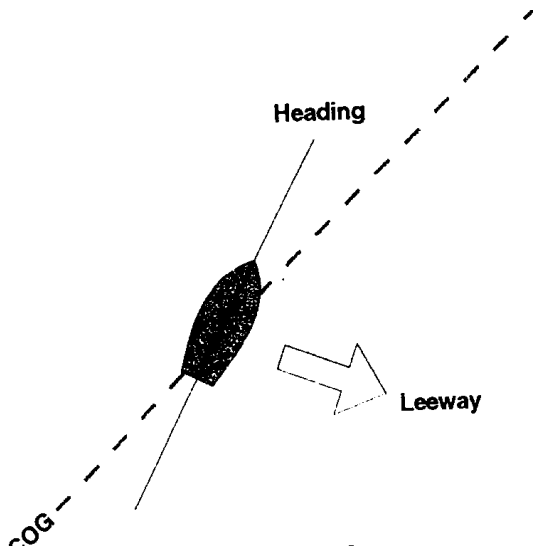
Navigation Review--Terms

- ◆ **Cross track error** (XTE); boat's distance from intended track
- ◆ GPS receivers can be adjusted to express bearings or courses relative to magnetic or true north--*a GPS receiver is not a compass!*
- ◆ **Course over ground** (COG); direction in which vessel is moving--it is not the same as heading



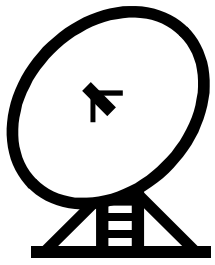


COG and Heading



- ◆ Heading refers to the direction in which the bow is pointed
- ◆ COG refers to the direction of movement of the vessel
- ◆ Leeway is the difference

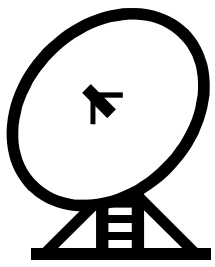




In Brief

- ◆ GPS is a satellite navigation system developed by the US *Dept. of Defense* (DOD)
- ◆ GPS provides continuous, all-weather, three-dimensional, positioning information
- ◆ GPS is used by aviators, mariners, surveyors, truck and auto operators, and hikers

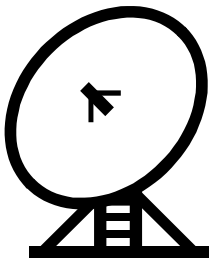




In Brief

- ◆ Positional accuracy varies from 15 - 100 meters--*differential GPS* (DGPS) is yet more accurate, but requires additional equipment
- ◆ Inexpensive full function GPS receivers provide fix data and other navigation features (e.g., bearing and distance to waypoints, track and ground speed, cross-track error)

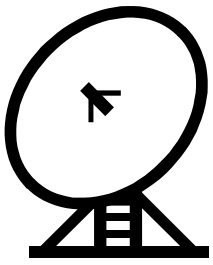




Overview of GPS

- ◆ GPS system includes 18 operational satellites plus 3 (or more) spares in orbit at altitudes of approximately 20,200 km (at least 5 are normally visible above the horizon at any time)
- ◆ Ground stations to monitor and control these satellites
- ◆ GPS receivers employed by users

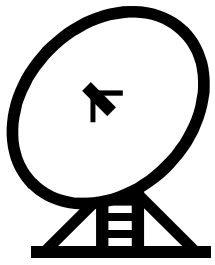




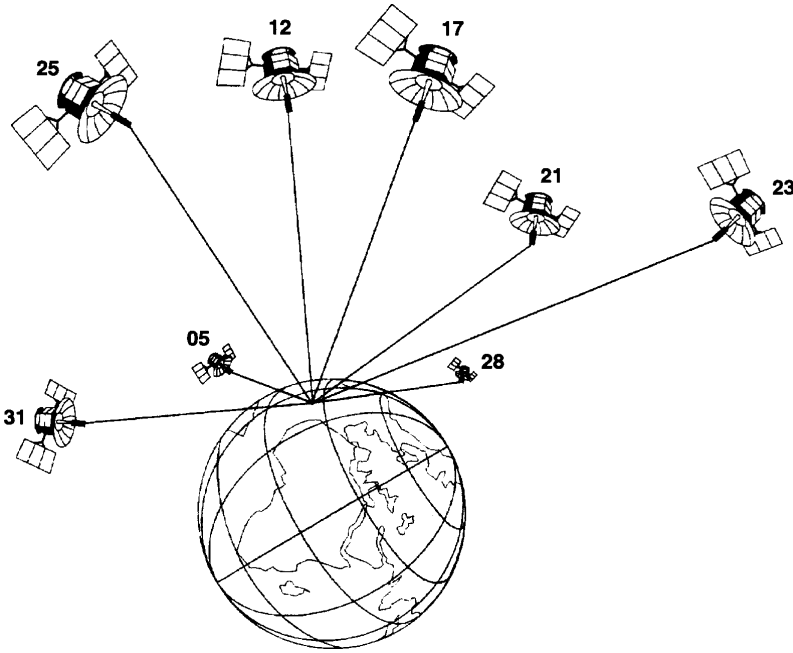
Overview of GPS

- ◆ Receivers acquire and process data from satellites to estimate the user's position
 - Some use all available data for optimal positioning--others select and use most suitable combination
 - Because satellites positions vary continually, the receiver switches satellites in use
 - Receivers make additional calculations

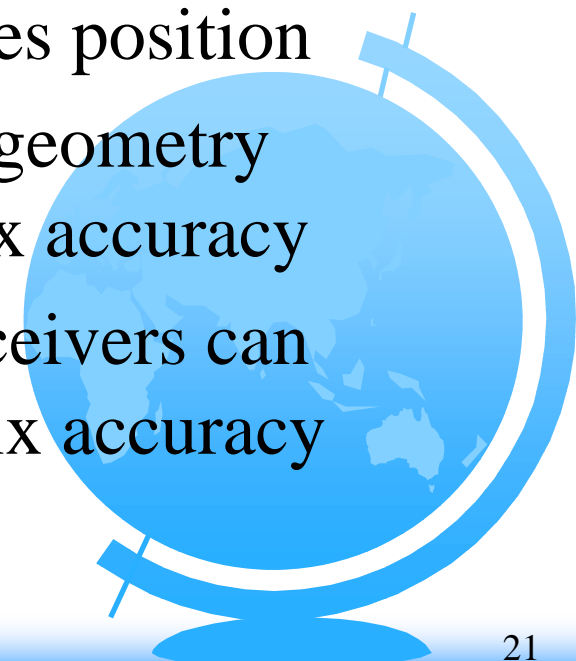


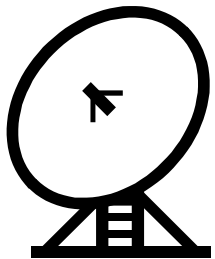


Position Determination

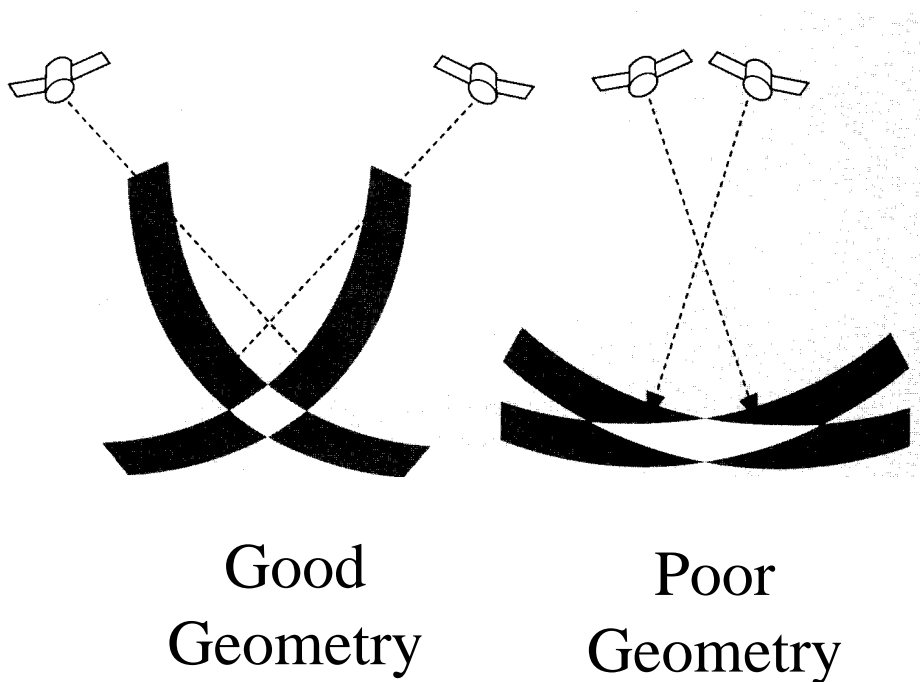


- ◆ Receivers can estimate “pseudo range” from satellite data
- ◆ Intersection of LOPs determines position
- ◆ Satellite geometry affects fix accuracy
- ◆ Many receivers can display fix accuracy



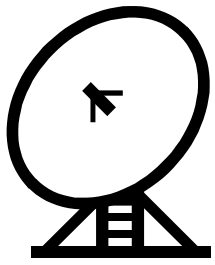


Dilution of Precision

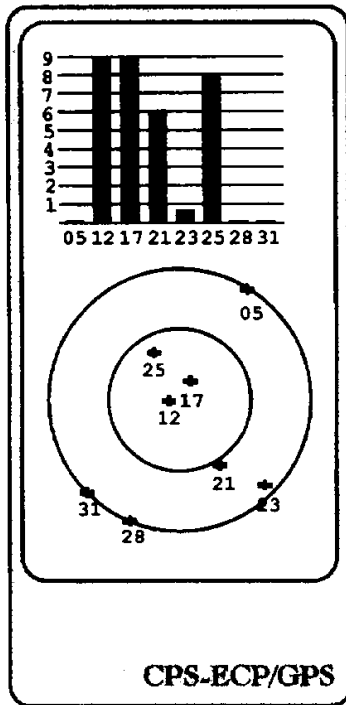


- ◆ **Dilution of Precision** (DOP) is a measure of satellite fix geometry quality
- ◆ Figure at far left has lower (better) DOP
- ◆ Receivers measure and display DOP

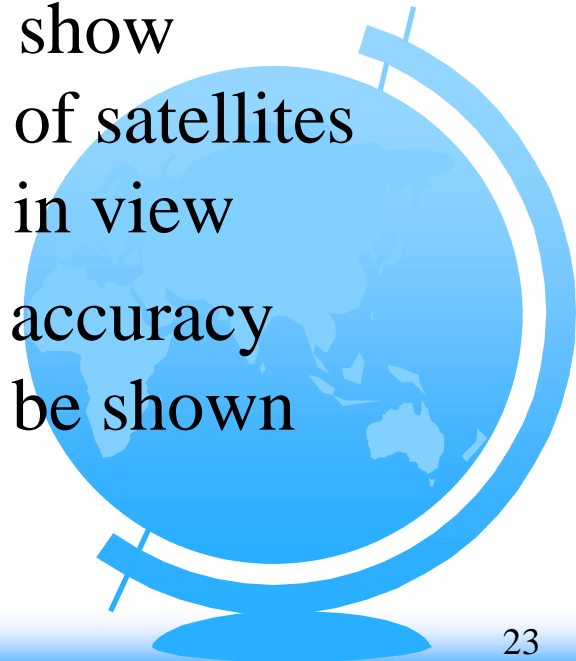


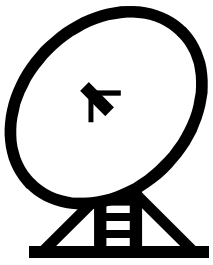


Signal Quality and Accuracy



- ◆ Height of bars in display shows signal quality from each satellite
- ◆ Numbers show positions of satellites currently in view
- ◆ Probable accuracy may also be shown

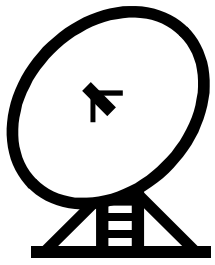




Overview of GPS

- ◆ Two “systems”
 - *Precise Positioning System* (PPS) for military users only
 - *Standard Positioning System* (SPS) for civilian users, limited by scrambling technique termed *selective availability* (SA) which degrades accuracy and can be turned on or off
- ◆ DGPS (operated by USCG) enables local corrections for SA and other errors

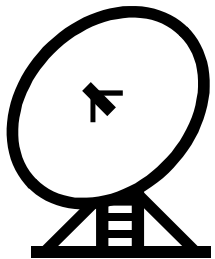




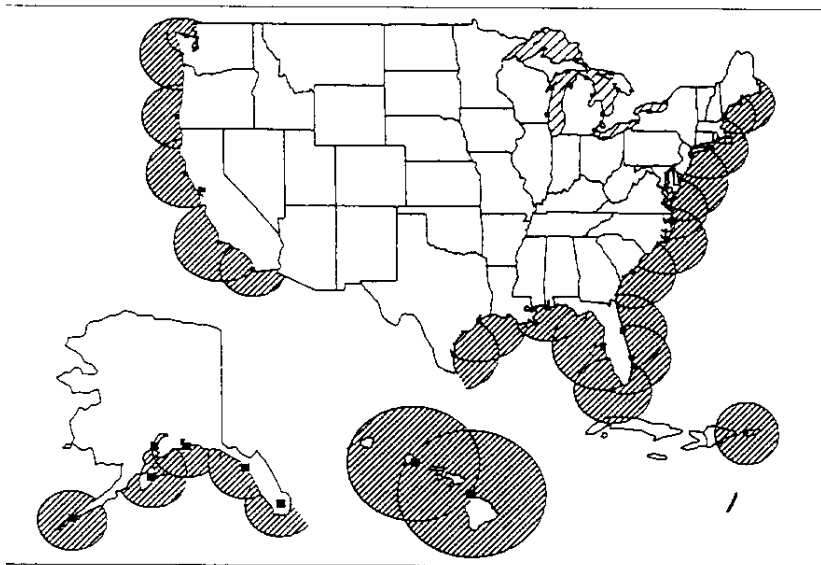
Specifications

- ◆ Accuracy--SPS; 100 meters 95% of time, PPS; 22 meters 95% of time, DGPS; < 10 meters
- ◆ Availability--99.85% of time
- ◆ Coverage--world wide



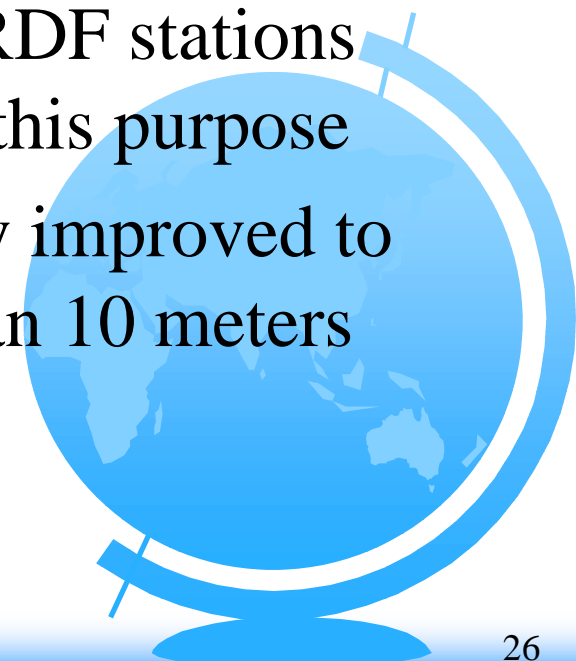


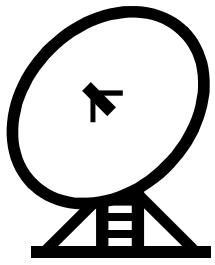
DGPS



Note: Stations on Great Lakes not shown on this illustration

- ◆ Series of shore-based stations broadcast corrections to GPS signal
- ◆ Former RDF stations used for this purpose
- ◆ Accuracy improved to better than 10 meters

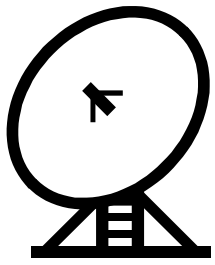




Basic Receiver Functions

- ◆ Determine user position continuously
- ◆ Display local time or *Greenwich Mean Time* (GMT)--now coordinated universal time
- ◆ Show track and ground speed on present heading
- ◆ Accept waypoint definition/description and show track and distance to any selected waypoint

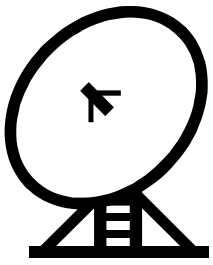




Basic Receiver Functions

- ◆ Show distance off the selected track and the *cross-track error* (XTE)
- ◆ Show *time to go* (TTG) and *estimated time of arrival* (ETA) at next waypoint
- ◆ Provide details of GPS system status, and
- ◆ Show satellite positions and signal quality
- ◆ Sophisticated receivers have other functions including graphic displays

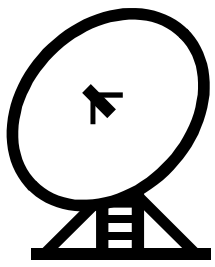




SOG and ETA

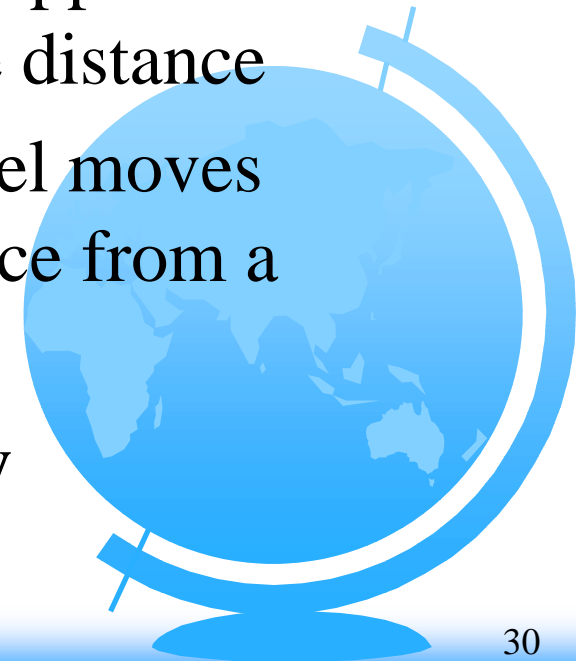
- ◆ SOG is based upon the vessel's speed over the ground over an adjustable averaging period--this may not be highly accurate--particularly if the speed is not constant (wind, current effects, etc.)
- ◆ ETA or TTG are based on the distance to the waypoint and the current SOG--these will vary as the vessel's speed varies

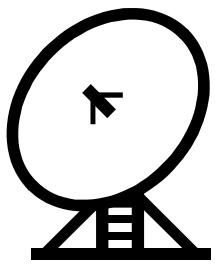




Basic Receiver Functions

- ◆ Most GPS receivers enable alarms to be set
 - **XTE alarm** indicates when boat departs from track by more than adjustable amount
 - **Waypoint arrival alarm** informs skipper that waypoint is within user-adjustable distance
 - **Anchor watch alarm** warns if vessel moves more than a user-adjustable distance from a waypoint
- ◆ Alarms should be used sparingly

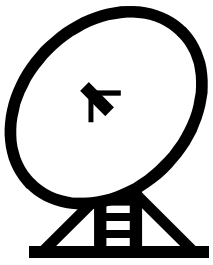




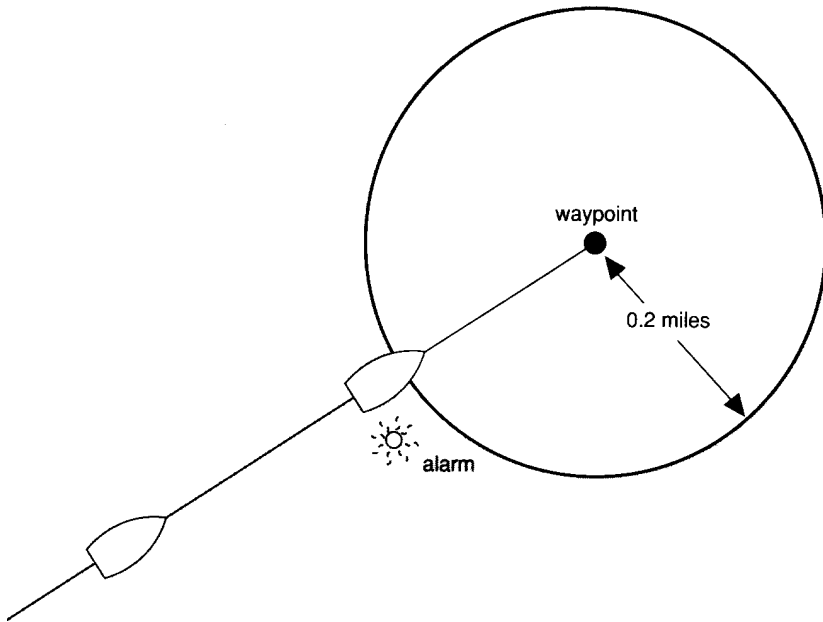
GPS Sensors

- ◆ A GPS sensor is a receiver without any controls or display screens
- ◆ Sensors provide output used by other electronic components, such as radar
- ◆ Sensors can be coupled with DGPS units
- ◆ A sensor serves as a back-up receiver, but lacks many key features



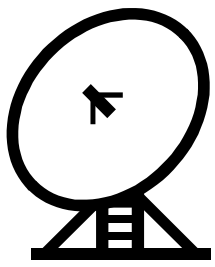


Alarm Illustrated



- ◆ An arrival alarm sounds whenever the boat penetrates an adjustable ring around the destination waypoint
- ◆ If the waypoint is an ATON the boat should be slowed on hearing the alarm

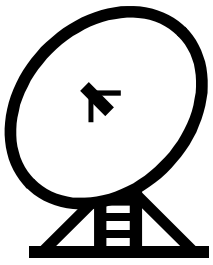




Receiver Features

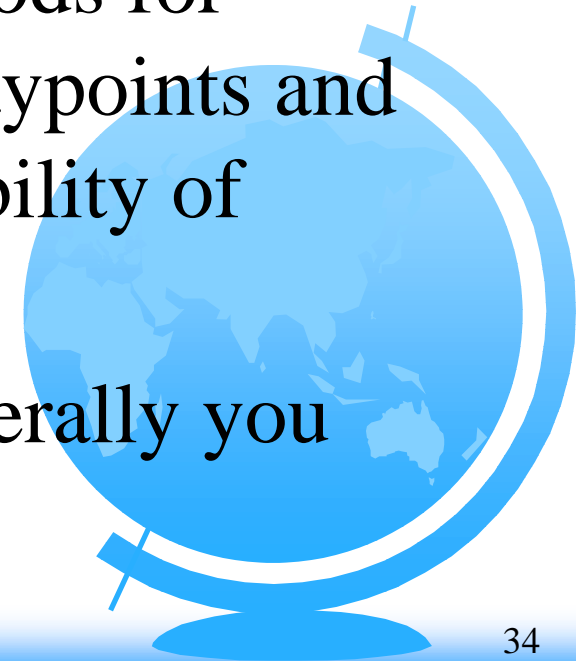
- ◆ Most receivers have several “pages” or display options, such as
 - Latitude/longitude of present position, waypoint in use, bearing and distance
 - “Road” views graphically depicting position, XTE, and waypoint location
 - “Left/right” needles
 - System status
- ◆ Some receivers warn of malfunctions

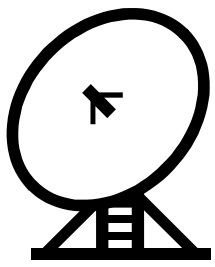




Selecting a Receiver

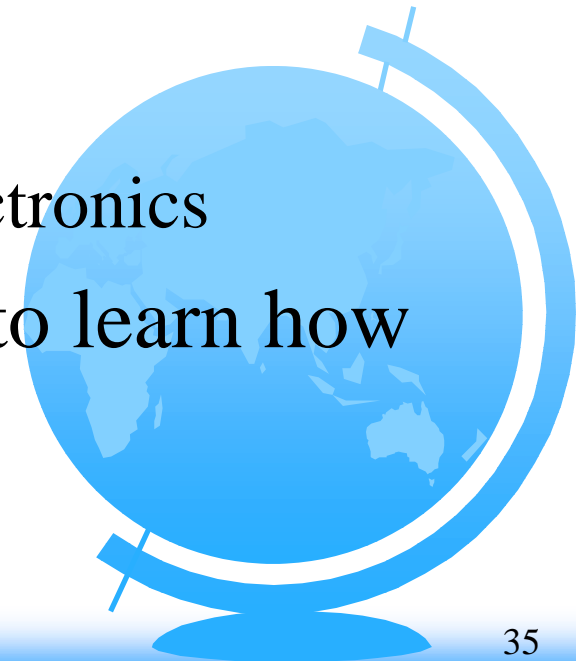
- ◆ Both portable and fixed-mount receivers made--portables function as useful backup units
- ◆ Technical features include methods for signal processing, number of waypoints and routes that can be stored, availability of database, etc.
- ◆ Cost may be a criterion, but generally you get what you pay for

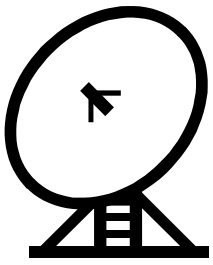




Selecting a Receiver

- ◆ Key criteria for most users:
 - Size and legibility of display
 - Ease of use (including waypoints)
 - Ease of data entry
 - Quality of owner's manual
 - Ability to interface with other electronics
- ◆ Read owner's manual carefully to learn how to mount antenna on fixed units

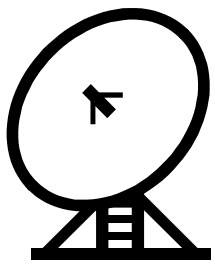




Waypoint Navigation

- ◆ Waypoints are often used to define route segments; here are some tips
 - Insert waypoints at all turn points on track
 - Establish some voyage waypoints close to (but not at) aids to navigation
 - Take advantage of maximum number of characters in defining waypoints
 - Write down list of waypoints in log for reference

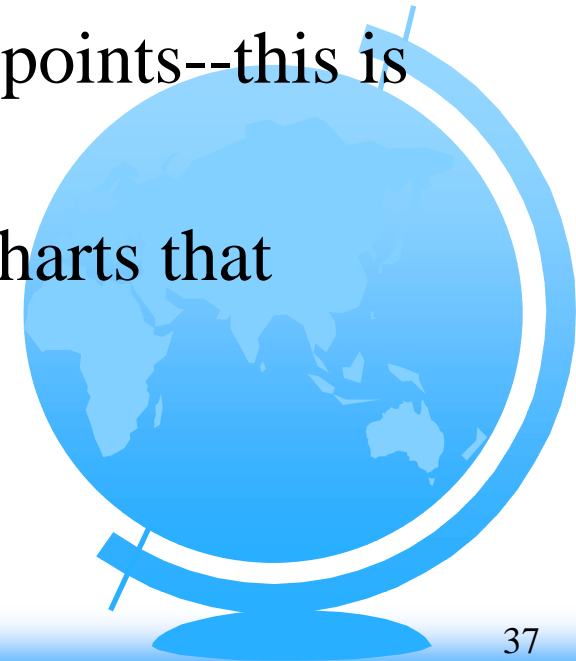


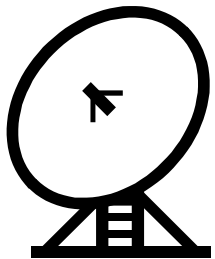


Waypoint Navigation

◆ More tips:

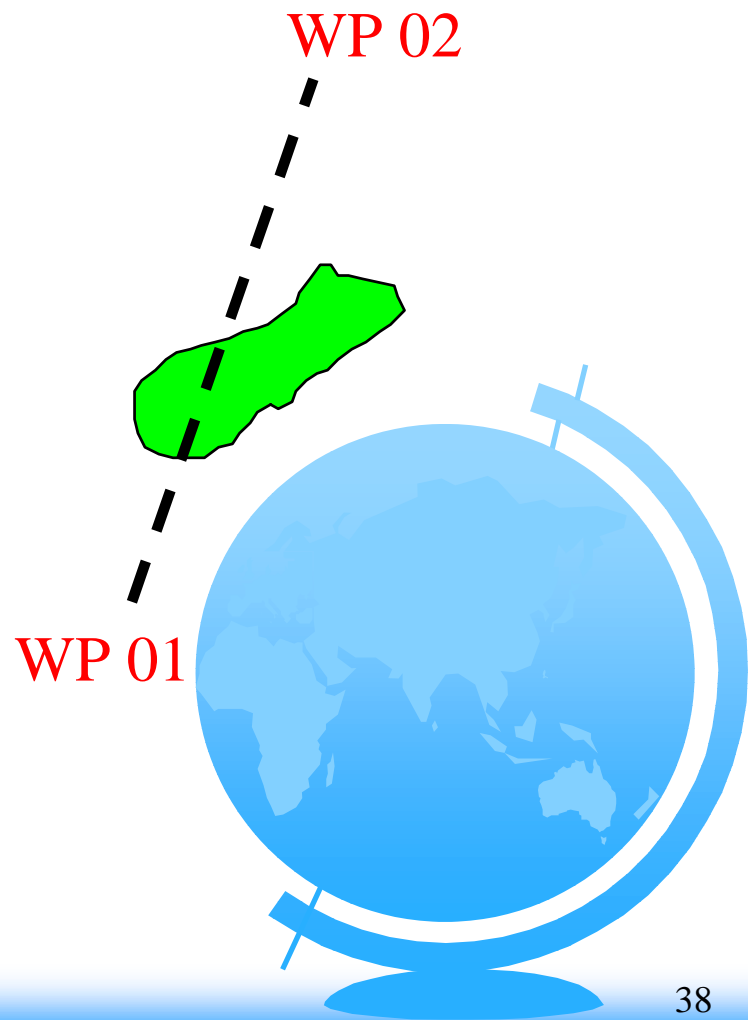
- Where possible, select waypoints with rounded-off coordinates to minimize transcription errors
- Plot all waypoints on a chart and measure the distance and bearing between waypoints--this is a handy check when underway
- Verify by plotting on large scale charts that voyage legs are in safe water

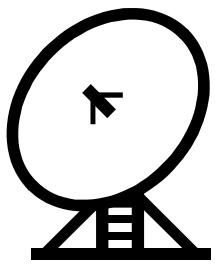




Intelligent use of GPS

- ◆ It is important to check your chart before entering wpts
- ◆ This course crosses an island--and the GPS receiver will help you navigate there!
- ◆ Always use a large-scale chart

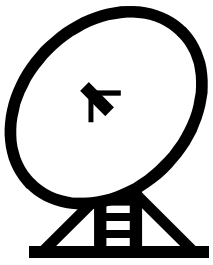




More Waypoint Tips

- ◆ Waypoints do not have to be located in the water--e.g., locate a waypoint at a lighthouse to enable you to know where--and when--to look for it
- ◆ Waypoints can be used to mark hazards to navigation--areas to avoid--as well as areas to visit

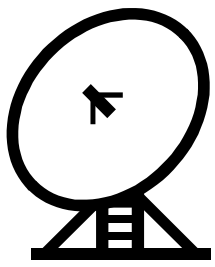




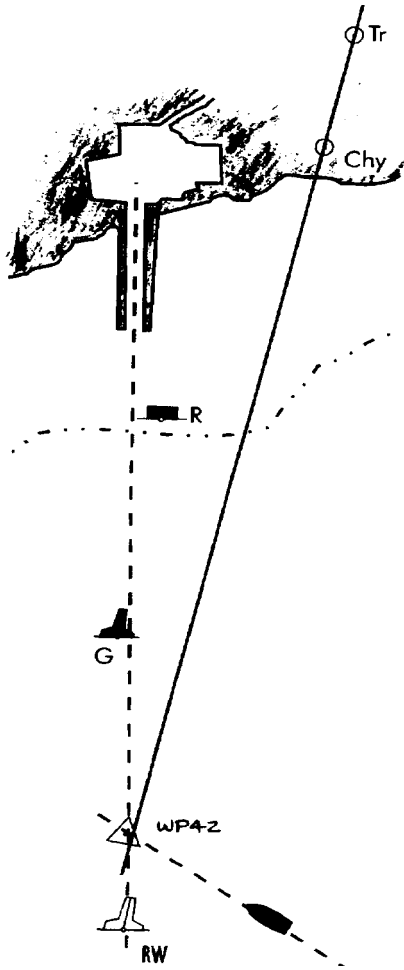
Intelligent use of GPS

- ◆ Where possible, select waypoints that can be verified by other means (e.g., visual fixes, soundings, radar, etc.)--do not rely on any one means of navigation
- ◆ Do not place waypoints at exact location of other **Aids to Navigation** (e.g., buoys)--these can present collision hazard with ATON or other boats in low visibility

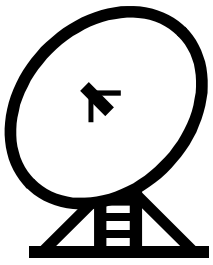




Low Visibility Harbor Approaches



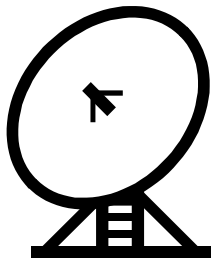
- ◆ Set waypoint close to sea buoy, others sequenced on approach course
- ◆ Verify position using both buoys and other means
- ◆ Do not enter shallow water without visual contact with buoys!



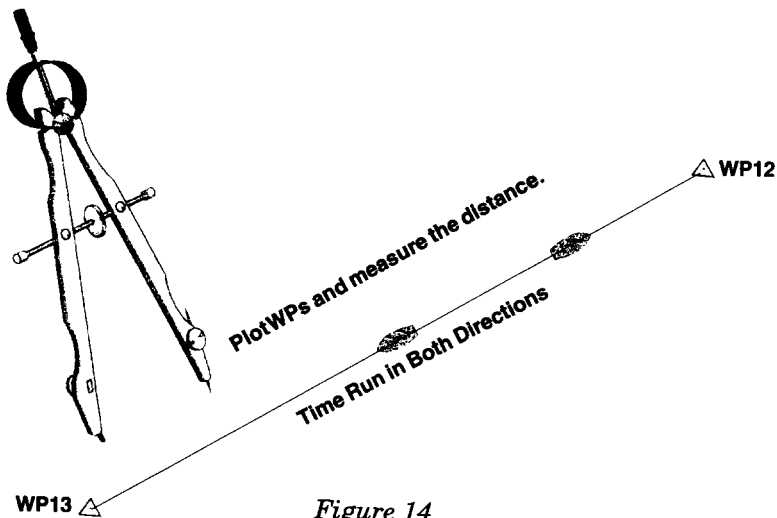
Plotting GPS Positions

- ◆ Plotting GPS positions on nautical charts based on latitude and longitude is tedious and subject to errors
- ◆ It is easier to plot distance and bearing from a waypoint
- ◆ Write down positions every few minutes so that you will have a last known position in the event of receiver failure



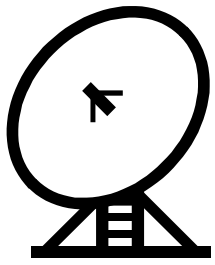


Speed Curves

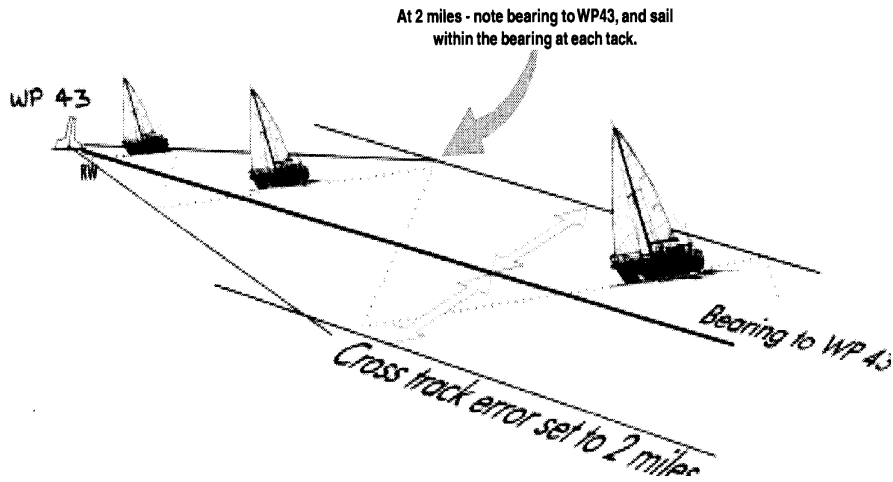


- ◆ Speed curves are calculated from timed transits over a measured range
- ◆ These are useful checks on engine and hull condition



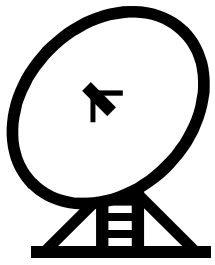


Use of GPS by Sailors



- ◆ XTE can be used to establish bounds for sailboat tacks
- ◆ Angles can be optimized to maximize VMG indication on GPS receiver

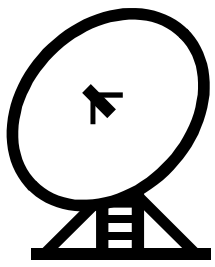




Use of GPS Underway

- ◆ At each waypoint, check receiver indication of bearing and distance against those measured on chart--this is a both a receiver check and detects errors in entering waypoints
- ◆ Periodically verify GPS position using other methods
- ◆ Periodically check for malfunctions!

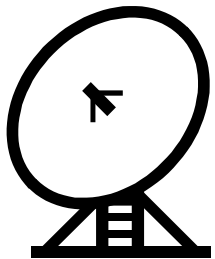




Other Tips

- ◆ Practice use of GPS during ideal conditions to ensure familiarity with controls and procedures
- ◆ Read the owner's manual carefully and master the essential features of your GPS-- there may not be time to do this in an emergency
- ◆ Periodically (especially after winter recess) re-read owner's manual

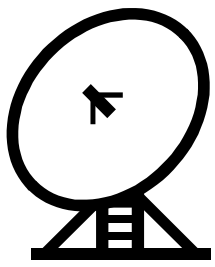




Other Tips

- ◆ Take along hand-held GPS units as backups to ship-mounted units--bring extra batteries
- ◆ Even if you have GPS and linked electronic charts, bring along conventional paper charts
- ◆ Remember that the greatest hazard to navigation is a bored navigator!

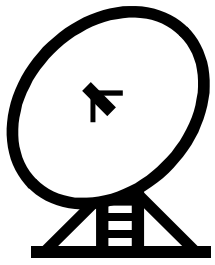




For More Information

- ◆ Several texts and videotapes available on GPS and specific make/model of GPS
- ◆ USCG Navigation Center (NAVCEN) web site <http://www.navcen.uscg.gov> provides:
 - General information
 - Coverage diagrams for DGPS
 - System outage information
- ◆ There are several other GPS-related web sites





USCGAUX Courses

- ◆ The USCGAUX and CPS offer a variety of basic and advanced courses, see your instructor for details
- ◆ If you found this course interesting, you might want to take either *Basic Coastal Navigation* (BCN) or *Advanced Coastal Navigation* (ACN)

