

### Learn GPS

#### Basic Concepts in Coastal and Inland Navigation

By far the most popular electronic navigation system is the Global Positioning System, or GPS. The low cost and superb performance of a handheld GPS receiver make it a near-essential tool to have on a boat.

GPS uses multiple satellites as artificial stars to provide precise position fixes. To be effective, a GPS receiver must have a clear view of the sky above the boat and be able to simultaneously receive signals from four or more satellites.

The resultant three- dimensional fix provides precise north-south and east-west coordinates (typically expressed as a latitude and longitude), a nominal altitude (meaningless to the boater, though not to a pilot or mountain climber), and a precise time. GPS references your fix to a horizontal datum; you must be sure the datum selected corresponds to that used on your nautical chart.

By means of its built-in navigation computer, a GPS receiver can provide other useful information in addition to your position. By comparing your current position with one from a few seconds earlier, the GPS receiver can determine your boat's direction and speed. And by comparing your position with the coordinates of a selected waypoint, the GPS receiver can provide the bearing and distance to that waypoint, plot a course to it, provide a continuous indication of how close you are to that course line, and calculate a time of arrival from your present speed.

Some GPS receivers are hardwired to the boat's power supply. If yours is not, be sure to stow extra batteries or a cigarette lighter—type adapter aboard. As with any electronic device, a GPS receiver is quite reliable but not infallible. If you use it as your primary position sensor, it's a good idea to carry a backup GPS just in case. If all else fails, you will need to get out your plotting tools and limber up your chart-and-compass piloting skills. And remember, a GPS position is just an abstraction until you plot it on a chart.

Your GPS receiver has no inherent knowledge of the shorelines, ledges, or other hazards arrayed around your boat (unless you've programmed a few avoidance waypoints into its memory, as will be described. There's just no substitute for a chart's-eye view of your surroundings.

### **Piloting:**

Being near shore, you generally can use landmarks and navigation aids in piloting. Offshore navigators do not have that support structure, but they are seldom exposed to the potential underwater hazards that the coastal or inland boater will encounter. Even in relatively familiar waters near shore, the recreational boater is faced with a challenging environment that requires solid skills and a good understanding of piloting in order to boat safely.

Piloting helps to answer some basic questions, such as:

**“Where am I?” and “How do I get where I want to go?”**

Unlike mariners in past ages, today's boaters are armed with valuable tools like GPS that answer the first question with great ease and precision. In order to answer the second question, you need to use charts to plot your current position and the intended path to your destination. Often, the straight-line path from here to there is not available, either because land blocks the way, or because underwater hazards preclude a safe passage.

This course will explain the basic principles of navigation, including lines of motion (your course), lines of position (bearings), and fixes. It covers not only use of the GPS but also traditional methods that you also need to know.

This course will present you with two levels of techniques you can use to navigate safely. First, you will learn the time-tested of piloting. These typically involve the use of various instruments and tools. Second under the category of **“Seaman's Eye.”** you be presented with some quick

tips and techniques that will teach you how to estimate your boat's position without formal instruments or tools.

### **Seaman's Eye:**

As an extension of the more formal process of piloting, you need to develop a sense of your environment. This helps to cross-check your navigation and alerts to conditions that may warrant some further action. "Seaman's Eye" is a set of skills developed over time by experienced mariners.

This course will highlight a number of these skills to help you. It is essential that you not rely upon them for your navigation, but use them as supplements to the more detailed process of piloting.

### **Using Basic Piloting Skills to get the most from your GPS.**

Charts are your road maps for the water, but they lack clearly defined highways. You will need to plot your paths on the water using information that you get from the charts.

Your chart is an accurately scaled depiction of the land and water area it covers. The chart scale, printed on the chart, represents a ratio (e.g., 1:n). For example, a 1:40,000 scale indicates that one unit of measure on the paper chart is equal to 40,000 of the same units in the real world. Thus one inch on the chart covers the same distance as 40,000 inches (0.6 nautical miles) on the Earth.

A chart with a small value of n is called a large scale chart because one divided by a smaller n is a larger number. Generally a large scale chart covers a smaller area, but in greater detail.

Each chart provides a distance scale, usually in nautical miles and statute miles and sometimes in kilometers. In addition, you can use the latitude scale on a coastal chart for measuring distance in nautical miles. This will be explained below. Mariners typically use nautical miles for distance. Each nautical mile (nm) is exactly equal to one minute of latitude and is approximately 6076 feet. For comparison, a statute mile (often used on lakes and rivers) is exactly 5280 feet.

Instead of roads, you will draw course lines. Each of these course lines will have a direction and a distance.

You will need to measure course direction in order to steer your boat. You will want to know the distance in order to estimate travel time.

Your position is indicated by a set of coordinates. Boaters generally use latitude and longitude as the frame of reference. Using these coordinates is similar to using the intersection of two streets to define a specific location. This is your frame of reference, and it is especially important if you are using a GPS to help you navigate. Your GPS provides a very precise position as a point in three-dimensional space, but it has no inherent knowledge of what is there. The GPS uses a model of the Earth to relate this point in space to a set of coordinates which include latitude, longitude and altitude. The GPS latitude and longitude values identify your location on the chart. (Altitude is not normally a factor in marine navigation.) Once you have the coordinates, you can find where you are and what is around you by plotting these coordinates on your chart.

You will get a chance to do that in this session.

### **Plotting Tools**

In order to work with your chart, you will use some basic plotting tools. The lines that you draw must be accurate, because any error can be reflected by a substantial difference in location when you are on the water.

In this session, I will use the USPS Rectangular Course Plotter, a clear plastic device

approximately 4 inches wide by 15 inches long. It is imprinted with a series of lines parallel with the long edges and two half-circle segments similar to protractor scales for measuring directions. You will use this plotter to draw course lines and measure course directions, or to lay out a course in a specified direction.

### [Plotter view](#)

### [Another view](#)

Other plotting tools are available, including parallel rules, rolling parallel rules, and protractors with movable arms.

A protractor plotting tool is often included among the materials for basic plotting courses. These tools are inexpensive and reliable. If you're in cramped quarters or on a small charting table, protractors can be less cumbersome than parallel rules. Plus, because a protractor scale is printed directly on the plotting tool, you won't need to access the compass rose for angles. This added flexibility is especially helpful when lack of space forces you to do your plotting on a folded chart. Murphy's law being what it is, the compass rose is always folded underneath and therefore inaccessible. There is also a two-piece protractor with a swinging arm. For now, let's focus on the one-piece rectangular plotting tool.

This simple, rectangular, see-through-plastic template was designed by the United States Power Squadrons. Two protractor scales and parallel lines are printed on the template with one for use with latitude lines and the other (printed in reverse order) for use with longitude lines.

Course and bearing directions can be determined by using the scales on a protractor plotting

tool. You need to align the bullseye with a grid line while you have the plotter aligned with the course line. You can align the top of the plotter or any of the printed parallel lines with the course line. Finally you read the course direction from the appropriate protractor scale. Which scale to use? Use common sense. This simplistic compass rose (upper right) provides you with a sense of direction. Any course or bearing toward the top right of the chart will be between  $0^\circ$  and  $90^\circ$ . By the same token, any course or bearing toward the bottom right will be between  $90^\circ$  and  $180^\circ$ . Toward the lower left will be between  $180^\circ$  and  $270^\circ$ . Finally toward the upper left will be between  $270^\circ$  and  $360^\circ$  (0).

To plot a course, align the course's starting point (whether a navigation buoy or simply a waypoint on the plotter edge, orient the plotter's bull's-eye on a latitude or longitude line as appropriate, and read a direction in degrees true from one of the protractor's scales. This device takes some practice in order to avoid reading or using the wrong scale, and it requires those pesky conversions between true and magnetic bearings and courses, which you can avoid by using parallel rules. Nevertheless, these plotting tools are the least expensive and among the easiest to use once you are comfortable with the conversion between true and magnetic, as we have discussed in TVMDC.

### Tool Kit

You should put together an onboard kit of tools to support your navigation tasks. In addition to plotting tools and dividers, consider including a drawing compass, a calculator, a notebook for keeping waypoint information and calculations, a collection of fine tipped pencils and water proof sleeves for charts.

As you gain experience, you will find that some tools work well at home or on a chart table and others are easier to use on the boat, where space and flat surfaces are limited. On the water you will lay out the directions of sighted bearings and plot them to help identify your location. The USPS Course Plotter represents a good compromise for use in both locations.

Dividers are the second major plotting tool. They are used principally to measure distances or plot coordinates. Several types of dividers are described in the reference text. The simplest form consists of two arms ending in points and joined at the other end with a friction pivot. Once set, good dividers will not change their setting without some moderate effort; this allows you to accurately transfer a measurement from one place on the chart to another. You will mainly be

using the latitude and longitude scales and possibly the distance scale as references for your dividers.

Accuracy is important. On a 1:80,000 scale chart, your pencil line width on the chart can represent over a hundred feet on the water. Generally, you will be asked to strive for course lines drawn with a sharp, medium-soft pencil to an accuracy of 1° of angle and one-tenth of a nautical mile in distance.

### **Using GPS as your Primary Position Sensor**

Much of traditional navigation is based on techniques to locate your current position. With GPS, that information is available continuously and with great precision, freeing you to concentrate on your other navigational duties. However, you need to understand and appreciate what GPS does and its limitations.

Remember that all GPS does for you is provide a 3-dimensional point in space that corresponds with your current location. Your GPS receiver compares this point in space with a mathematical grid that represents the surface of the Earth. Using the grid, the point is converted into a latitude and a longitude (coordinates) on the Earth, plus an altitude. For marine navigation, you are not interested in altitude, which generally is less accurate than your horizontal position.

#### **[Example 1](#)**

#### **[Example 2](#)**

### Example 3

It is essential to bear in mind that GPS has no inherent knowledge of what is located at that spot or in its immediate vicinity. Your charts provide that critical information. You need to plot the coordinates reported by the GPS on the chart to gain a sense of the local terrain and features.

Your GPS receiver contains a miniature navigation computer that takes the position information and provides a great deal more information that is useful to your navigation. Specifically, GPS can compute your motion; and it can compare your current location with one that you have stored in the GPS as a way- point.

GPS computes your actual course over the Earth's surface (or Track) by comparing your current location with your position just seconds ago. By doing this, the GPS can also compute which direction you moved and how fast you moved that way. These are reported as Course Over Ground (COG) or Track, and Speed Over Ground (SOG) or Speed.

To be Continued...