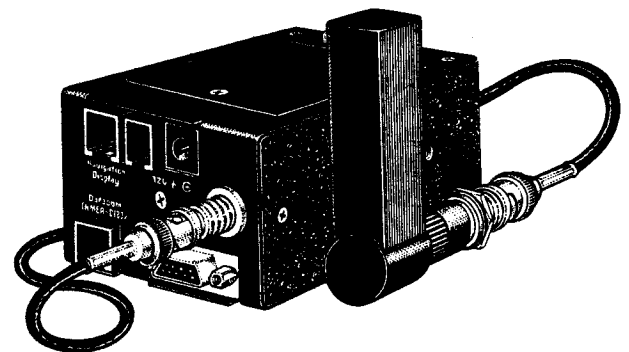
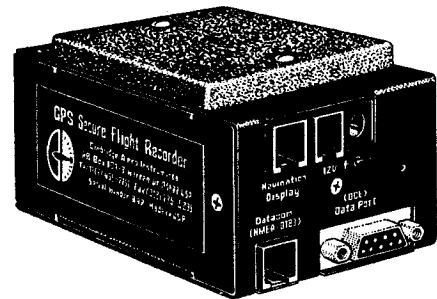


The Cambridge GPS Navigator and Secure Flight Recorder User's Guide

Models 10, 20, and 25

Recorder Version. 5

LCD Version. 5

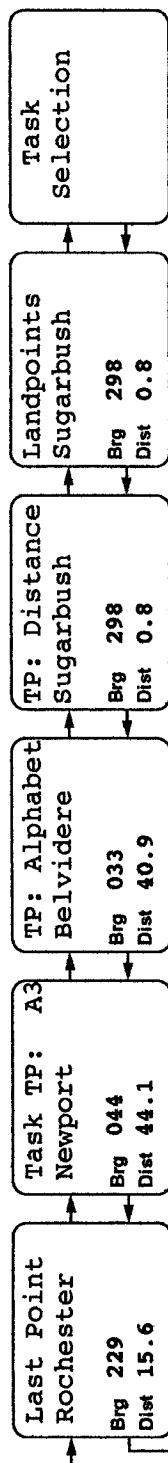


Cambridge Aero Instruments

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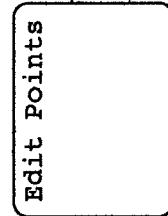
The most recent active navpoint.
 The next task turnpoint.
 Press UP or DOWN to review task turnpoints.

The list of turnpoints arranged by distance.

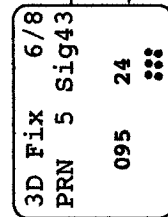
The list of turnpoints arranged alphabetically.

The list of landable, marked, and restricted points arranged by distance.

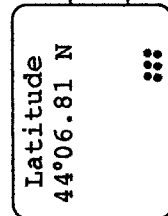
This is the entry point for selecting, editing, declaring, and starting tasks



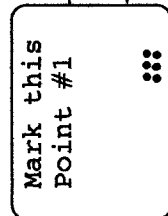
This is the entry point for editing and creating navpoints.



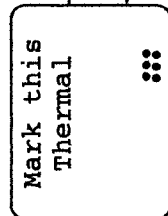
This is the GPS receiver status.
 Press DOWN to see data from other satellites.



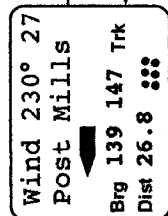
Press DOWN here to see Longitude, GPS Altitude, Pressure Altitude, Sound Level, Position Error, Date, and Time.



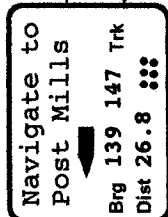
Press GO here to mark a point.
 Navigate to a marked point by pressing UP or DOWN to select it, then press GO.



Press GO here to mark a thermal.
 Navigate to the thermal by pressing UP or DOWN to select it, then press GO.



The Circling Wind screen shows wind at this altitude.
 Press UP or DOWN to see wind at different altitudes.



The Main Flying Screen shows the active waypoint.
 Pressing GO always returns to this screen.

Introduction

The GPS Navigator & Secure Flight Recorder (GPS-NAV) has three components: the Flight Recorder containing the GPS Receiver, the LCD Display, and software for an IBM compatible Personal Computer (PC). Connection to a Cambridge NAV computer is also provided. The Flight Recorder can be used with or without the LCD display. It records 9900 GPS fixes. Flight Logs are transferred to a personal computer using a serial data cable.

Gliding needs different navpoint data than most types of aviation. This is why GPS-NAV navigation data originates in a PC database program rather than the GPS-NAV itself. New Version 5 PC software tools make it easy to construct custom navpoint databases for the GPS-NAV from large National Databases. Thanks to John Leibacher and many other volunteers, an amazing source of turnpoint databases can be found at:

<http://acro.harvard.edu/SSA/JL/TP/HomePage.html>

Navpoints are sent to the Flight Recorder using the serial data cable. With navpoint data in the Flight Recorder, the GPS-NAV display provides navigation information. The unit can also mark its present location, and navpoints may be created, edited, and saved in the GPS-NAV database.

Bearing and distance to a waypoint, ground speed, and track are sent to an attached Cambridge S-NAV or L-NAV. GPS related functions of these NAV computers are described in their documentation.

Version 5 Firmware Additions and Improvements

This list covers only improvements made since Versions 4.1 and 4.6.

1. Automatic variable rate logging

Logging intervals can change automatically from 2 to 60 seconds. Logging changes to the minimum interval near the active navpoint. Two minutes of fast logging is also activated by pressing the ON key. This feature extends flight logging to 16 long flights. Maximum total flight time is now more than 120 hours.

2. Task entry from the PC

Up to 10 tasks (A - J) can be defined in the PC navpoint database editor. Tasks are transmitted to the GPS-NAV with the navpoints.

3. Fast scrolling of large Navpoint databases.

Any of the 250 navpoints in the database can be selected in less than 7 seconds. The secret is to tap the UP or DOWN arrow key quickly. This jumps past 9 navpoints.

4. Simplified Task editing

Task selection, editing, and declaration are now done in one group of screens. An active task can now be edited. Distance from the beginning of the task is shown for each intermediate turnpoint. A trial P.O.S.T. task can be started without declaring it.

5. Simplified Navpoint Editing.

Attribute and ID# are now shown in point editing screens.

6. Improved Circling Wind Algorithm

The circling detection algorithm is now more sensitive and reliable.

7. Error Detection and Correction for Navpoint database.

Some GPS-NAV instruments developed navpoint database errors when power was cycled rapidly. Critical navigation data is now stored in two locations. Error detection and correction algorithms ensure reliable navigation data.

8. Transmission of task data to L-NAV and S-NAV.

GPS-NAV Version 5.0 transmits the active task to an L-NAV or S-NAV. This makes it possible to compute altitude required to glide home around an intermediate turnpoint. GPS-NAV V4.8 does not have this feature.

The instrument and its associated PC software are approved by the IGC for FAI Glider and Motorglider Badge and Record flight documentation. As of October, 1996, tasks may be declared electronically using the GPS-NAV.

A Walking Tour

The quickest way to learn the Cambridge GPS-NAV is to walk around with it! Attach a 12 Volt battery (Model 20 & 25), connect the LCD display with the supplied test cable, and press the LCD display ON key. The LCD should show a sequence of messages. If it does not, make sure it is attached to the correct port (GPS Display) on the instrument. You should also note that the green GPS lamp is on continuously rather than blinking. This means there is not yet a GPS fix of your present position.

When a GPS receiver is moved to a new site more than 300 miles away from where it was last used, it can take up to 40 minutes to acquire the satellite orbital data required for its initial position fix. Also, GPS does not work indoors. Orient the antenna so it has a good view of the sky.

While waiting for the GPS receiver to wake up and smell the roses, take a look at the various LCD screens. Screens are arranged in Rows and Columns. Use the Primary Screen Map on page 2 as your guide. LEFT and RIGHT arrow keys move to the top row of a new column. UP and DOWN arrow keys move to new rows within a column, or change information within a screen.

Pressing the GO key several times always finds the Main Flying Screen. This is the screen you will use most of the time.

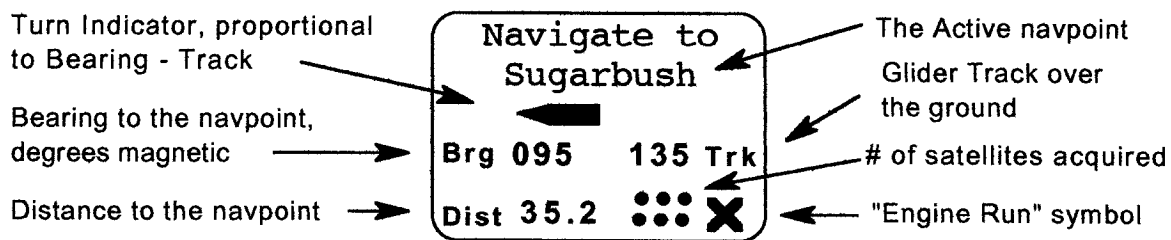


Figure 1. The Main Flying Screen

If you are technically inclined or just bored waiting for satellite acquisition, you may wish to review GPS status, 5 screens to the left of the **Navigate to** screen. There are at least 24 GPS satellites orbiting 11,000 miles above the earth. One orbit takes about 12 hours, so satellites are constantly rising and setting like the sun. The GPS receiver knows the approximate orbits of all satellites from data sent in each signal. Thus, when it is turned on, the receiver knows approximately where to look for satellites. GPS status screens show data from each satellite in the constellation. Use the UP and DOWN keys to see data from all visible satellites.

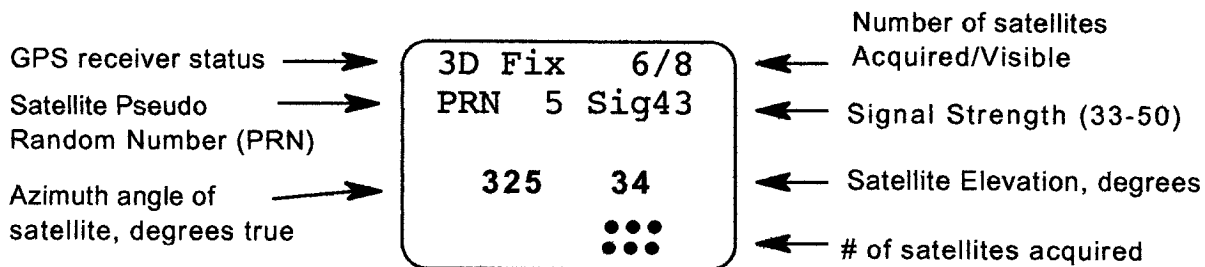


Figure 2. A GPS Status Screen

As a satellite gets close to the horizon, its signal is more likely to be obstructed by buildings, trees, and the glider itself. Signal strengths should be above 36 for high satellite elevations. If they are not, check the antenna and its mounting. Compare signal strengths using different antenna locations.

Once a GPS "fix" has been obtained, you can see detailed information in the set of screens just to the right of GPS Status. Latitude including hemisphere (North or South) is shown first. Use the DOWN key to see Longitude, GPS Altitude, Pressure Altitude based on standard atmosphere (1013 mBar, 29.92" Hg), Sound Level, Estimated Position Error (EPE), Date, and time (UTC). Time and date come from the satellites and cannot be edited.

Pressure Altitude comes from a calibrated altimeter sensor within the GPS recorder. It has better short term stability than GPS Altitude, and is used for the barograph trace. Sound level is measured with a calibrated microphone and recorded as part of the Flight Log. The recorded sound level shows when a motorglider engine is running.

The Cambridge GPS-NAV is optimized for use in a glider moving towards a waypoint. Those conditions must be simulated to fully understand the "Navigate to" screen. This is where the walking comes in. To keep things simple, you will mark your present position as a thermal, walk some distance away, and navigate back to this position. Here is the sequence:

1. Return to the "Navigate to" screen by pressing GO.
2. Move one screen left to the "Mark Thermal" screen.
3. Press GO to Mark your present position as a Thermal.

The next step is to actually navigate to this marked "Thermal".

4. Move to the Mark Thermal screen again.
5. Press the UP or DOWN key. You will see:
**Select
Last Thermal**
6. Press GO again. "Thermal" becomes the active navpoint.
**Navigate to
Thermal**
7. Walk away to a distance of at least 500 feet. Turn around and let the GPS-NAV guide you back to your "Thermal".

You must walk faster than 2 Kts (3km/hr) to see the Track number and the Turn Indicator. You will quickly learn to interpret the graphic arrow as well as the track and bearing numbers.

You can measure your velocity by pressing the UP key. The Brg. number changes to velocity, V, and the first line changes from "Navigate to" into the date and time (UTC) the thermal was marked. As always, press GO to return to the Main Flying Screen.

This completes the walking tour. The basic concept of screens and use of GO and arrow keys have been described. Screens are consistent in design, labelling is clear, and keys always work the same way. This means GPS-NAV functions can be mastered by simply trying them. Most users can quit reading here, install the GPS-NAV, and go flying without further delay.

But, if it is raining, feel free to read on!

Bearing, Heading, Track, and the Turn Indicator

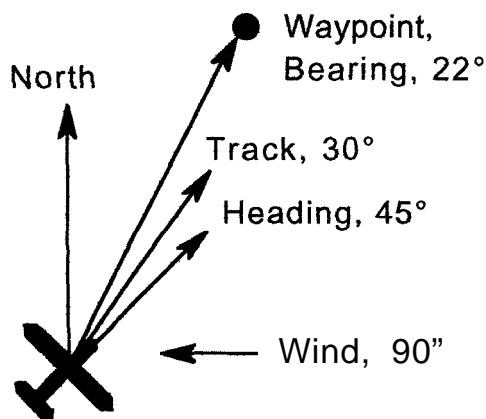


Figure 3. Definition of GPS Navigation Terms

Angles are defined relative to Magnetic North. Bearing is defined as the angle of the line between the glider's position and the waypoint. Imagine the shadow of the glider tracing a line on the ground. The angle of this imaginary line is the glider's Track. Heading is where the nose of the glider is pointed. A compass shows Heading. Crosswinds make Track and Heading different.

The GPS receiver computes its position every 2 seconds. Even though position is only known for sure to within the Estimated Position Error (typically about 100 meters), positions determined 2 seconds apart are very accurate relative to one another. This means the GPS receiver can measure the glider's direction of flight (the Track) and its true ground speed, V , with high accuracy. This is done by calculating the angle (relative to magnetic north) between two fixes for Track and dividing the distance between two fixes by time for V .

GPS navigation is simple. It is no longer necessary to worry about glider Heading as indicated by the compass. Without GPS, the pilot has to guess the crosswind and then crab into it to fly the desired Track. With GPS, Track itself is measured accurately, so there is no need to estimate crab angles, etc. When Track and Bearing are the same, the glider is heading directly to the waypoint.

The GPS-NAV shows both Bearing and Track in the "Navigate to" screen. **Bearing - Track = Track Error.** Positive Track Error means the glider must turn right to fly towards the navpoint. Glider pilots have little time for arithmetic while racing. So, the GPS-NAV has a graphic Track Error Indicator. When the Indicator is centered, the glider is flying directly to the active navpoint. This is true even with crosswinds. A glance at the graphic Indicator shows which way and how much to turn. This is much simpler than remembering a compass Bearing, setting up a compass Heading, and guessing the required Track.

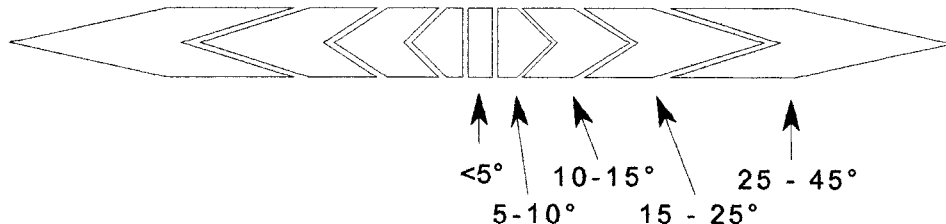


Figure 4. The GPS-NAV Track Error Indicator

When Track Error is less than 5° , only the center vertical bar shows. For Track Error greater than 45° , the center vertical bar goes away, followed by the inner segments. GPS Track lags behind the actual glider track during circling. For this reason, the graphic Track Error Indicator is switched off during circling flight.

It is important to remember that this indicator shows Track rather than glider Heading. This is especially useful during high wind conditions such as flight in wave lift. When flying directly into a high wind, the glider may be almost stationary over the ground. Think how the shadow of the glider moves over the ground. A small change in Heading makes a big change in Track. Trust the Indicator!

Navpoint Screens.

The Cambridge GPS-NAV is optimized for competitive and recreational gliding. Quick navpoint review is a unique feature of the instrument. Most screens to the right of the "Navigate to" screen are devoted to navpoint review. Once the desired navpoint has been found, it is always activated by pressing GO.

It is helpful to experiment with the GPS-NAV as you read this section, First, load enough navpoints to get the idea. See the section labelled Waypoint Editing for details. Better yet, load a navpoint database from the PC software library. Finding and activating navpoints is the same for all screens.

Note: Refer to the Primary Screen Map on Page 2 to see how navpoints are organized into columns of screens.

1. Choose the optimum navpoint selection screen for your needs using the LEFT or RIGHT arrow keys.
2. Use the UP or DOWN arrow keys to find a navpoint.
3. To make this the active navpoint, press GO.
4. To keep the existing active navpoint, return to the Main Flying Screen using the LEFT or RIGHT arrow key.

The "Last Point" screen

The GPS-NAV lets the pilot switch easily between two waypoints of interest. Here is how it works with navpoints named PARIS and MOSCOW:

The pilot is navigating to PARIS but is interested in MOSCOW.

MOSCOW is selected from any **waypoint** list and GO is pressed. Now MOSCOW is active and is shown in the "Navigate to" screen.

PARIS is now stored in the "Last Point" screen just to the right of the "Navigate to" screen. The pilot can re-activate PARIS from there by pressing GO.

When PARIS is re-activated, MOSCOW replaces PARIS as the "Last Point". It is quick and easy to re-select MOSCOW if desired. But it may take a long time to fly there!

More about Navpoints

The GPS-NAV can store up to 250 navpoints. Here is the data for each navpoint, using Sugarbush, home of Cambridge, as a sample navpoint:

Name: Sugarbush
Latitude: 44°07.05 N
Longitude: 072°49.61 W
Elevation: 1470 ft.
ID #: 27
Text: Runway 4/22

Attributes: A - Airport F - Finish Point H - Home Point
 L - **Landable** Point M - Markpoint R - Restricted Point
 S - Start Point T - Turnpoint W - **Waypoint**

A point can have multiple attributes. Attributes are displayed in **edit point** screens. Only T & L can be assigned on the GPS-NAV Point editing screens. By default a Markpoint (M) changes to W during editing if no other choices are made.

Attributes control the organization of navpoints into LCD screen lists. Points with T, S, F, or R attributes are listed in `TP: Alphabet` and `TP: Distance` screens. Points with A, L, M, and W attributes are listed in the `Landpoints` screen in order of distance from the present location. This means the pilot can mark a potential landing field while flying over it. Later, it can be selected quickly.

Attributes also control other behavior. For example, when the GPS-NAV is first turned on, the `Navigate to` screen shows the Home Point (H). If there is no Home Point, the GPS-NAV displays the navpoint with the lowest ID #.

Editing a Markpoint changes the attribute from M to W. Thanks to Dickie Feakes, W points can now be shown together with Task points on the PC display. Marked mountain passes and cols are now easy to visualize. Remember that the total number of points including Markpoints cannot exceed 250.

Only points with Turnpoint (T), Start (S), and Finish (F) attributes are included in the list from which tasks are constructed. Even though you can navigate to a Thermal, it is not kept in the database and has no ID #.

Markpoints and Thermals show up on navpoint selection lists. But they are also easy to find in the screens where they have been marked. For example, suppose 3 points have been marked. The Markpoint screen shows the next point (**#4**) which could be marked.

`Mark
Point #4`

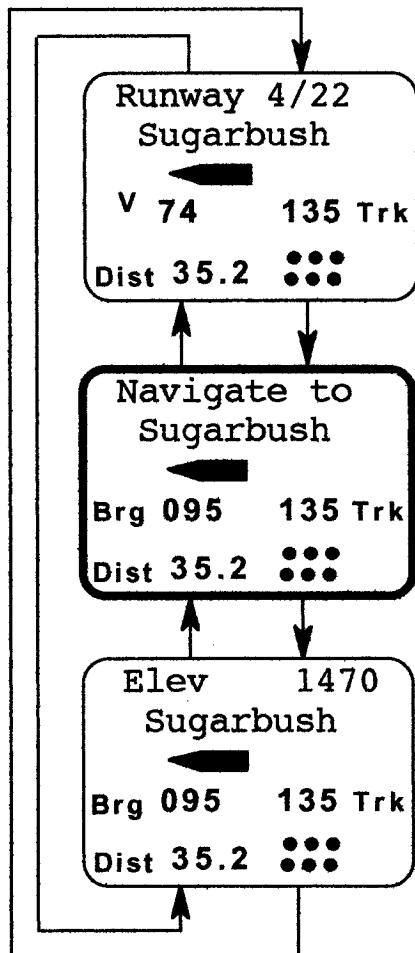
if the UP key is pressed, the screen changes to:

`Select
Markpoint #3`

All the previously marked points may be found this way. In this case, pressing GO makes Markpoint **#3** the active point.

Supplementary "Navigate to" screens

In the Main Flying Screen, more information about the active waypoint can be seen by pressing the UP or DOWN arrow key.



Bearing to a goal is replaced by velocity, V, over the ground. On a Task, Track is replaced by Cross Track Error (XTE). Comments such as "Runway 4/22" come from the waypoint database created and stored in the the PC.

This is the Main Flying Screen. It is the starting point for these screens. Use the UP and DOWN keys to see the other screens.

This is the "Elevation" screen. The Elevation number (1470) comes from the waypoint database created and stored in the the PC.

Figure 5. Screens for the Active Navpoint

Ground Speed Display and Wind Estimation

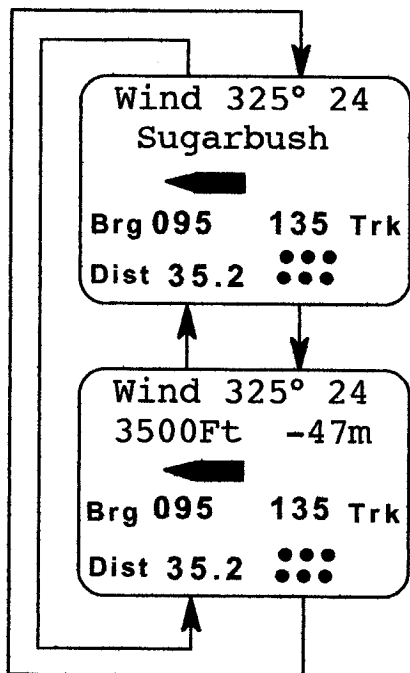
The glider's ground speed (displayed with the label V) replaces Bearing on the screen where the comment text is displayed. The wind component in the direction of flight can be estimated from the difference between indicated airspeed (from the mechanical ASI) and the ground speed. This is only accurate at low altitude because of the difference between indicated and true airspeed. If a Cambridge NAV vario/glide computer is connected to the GPS-NAV, true airspeed (TAS) is computed and subtracted from ground speed. The difference is an accurate measure of the wind component in the direction of flight. This is displayed on the NAV and used in its final glide computations.

The ground speed display is especially useful in wave flying. If the glider is pointed directly into the wind, ground speed may be near zero. If ground speed decreases when airspeed is increased, the glider is actually moving backwards over the ground. The Track display will also show this.

Wind Measurement from Drift while Circling

GPS-NAV Version 4 introduced a new concept in measurement of Wind. If a glider circles without reference to the ground, it will drift with the wind. The GPS-NAV automatically computes both wind speed and direction during circling maneuvers.

Each wind measurement takes about 2 minutes. Circling must continue un-interrupted during this time. Accuracy improves with continued circling. Note that wind direction may be inaccurate when wind strength is very low. Wind is shown on the display screen just to the left of the Main Flying Screen.



This screen shows direction and strength of the wind measurement closest to the current altitude.

This screen shows complete wind information. The second line shows the altitude (3500) at which the measurement was made. The second number on this line shows the time (47 minutes) since the measurement was made.

Figure 6. Wind Measurement Screens

Wind varies with altitude and time. The GPS-NAV stores and organizes wind information at 300 metre altitude increments. The UP or DOWN arrow keys are used to scroll through all available wind measurements.

Creating and Editing Navpoints

The best way to get the navpoint database so essential to GPS navigation is to transfer it from the PC using software supplied by Cambridge. Please refer to the PC software User's Guide for more information.

The GPS-NAV also has limited, built-in navpoint editing. This means markpoints can be named and new points can be added without using a PC. With Versions 4.8 and 5, navpoint deletion can only be done in the PC. This keeps Mr. Murphy and his law from zapping critical data at the wrong time.

Navpoint editing uses two additional groups of screens. When Edit Points is displayed, pressing GO branches to the first group. As usual, the LEFT and RIGHT arrow keys are used to select the desired screen. The choices are: edit an existing point, create a new point, or simply Exit to the "Navigate to" Screen.

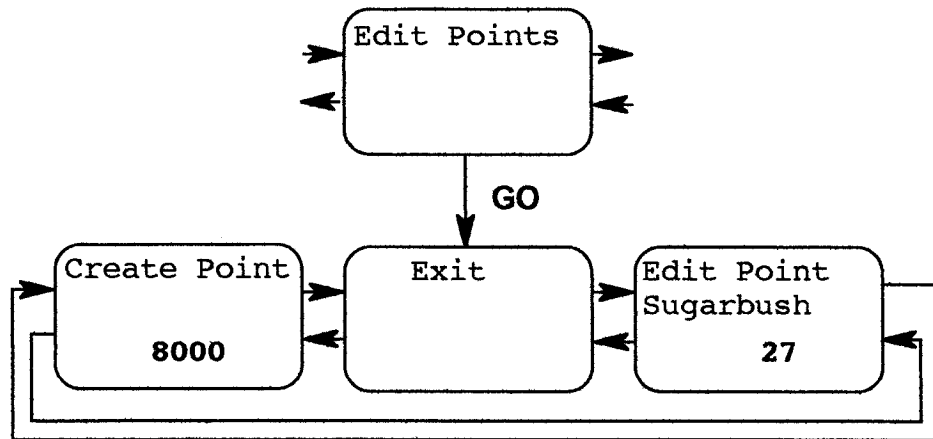


Figure 7. Point Editing Screens

In the Exit screen, pressing GO returns to the "Navigate to" screen. In Edit Point, the UP and DOWN keys find the point of interest (arranged by ID #).

In Edit Point and Create Point screens, pressing GO branches to a second sequence of 7 detail screens for editing the selected point.

Edit Name	Edit Lat	Edit Long	Edit Elev
Edit ID#	Landpoint?	Turnpoint?	

The starting point is Name. The default name for a freshly created point is NEW. At the start of editing there is an underline cursor beneath the first letter of the name. The UP and DOWN arrow keys scroll through all possible letters for this location. The LEFT and RIGHT arrow keys move the cursor left and right in the Name, Latitude, and Longitude screens.

For a newly created point, the GPS-NAV assigns the last known GPS receiver position to simplify Latitude, Longitude, and Elevation entry. New points are arbitrarily assigned ID numbers starting with 8000. Markpoints are assigned ID numbers starting with 9000. This makes it easy to find these classes of points when they are arranged by ID number.

The GPS-NAV assigns an internal, hidden index number for each point. Thus, two points may have the same Name, ID #, and position without the GPS-NAV being confused. However, transferring waypoints to the PC database does require unique ID #s, so it is best to assign a different number to each waypoint.

These screens also allow Landpoint (L) and Turnpoint (T) attributes to be assigned for each waypoint. Landpoint means the point is suitable for landing. The Landpoint attribute makes the point show up in the list of Landpoints arranged by distance. Turnpoint means the point can be selected for a task and will show up on the PC screen. If no attributes are assigned, the point is simply called a **Waypoint** (W).

Pressing the GO key from the detailed point editing screens stores the new or edited point in the GPS-NAV database.

Selecting and Editing Tasks

A sequence of Turnpoints is called a task. The GPS-NAV can store up to 10 tasks with up to 9 turnpoints per task. Stepping through a sequence of task points is quicker than searching through the navpoint database each time you arrive at a turnpoint.

GPS-NAV Version 5 simplifies task functions. Selecting, choosing, editing and declaring tasks are all done at the far right end of the Primary Screen Map. The entry point is the **Task Selection** Screen.

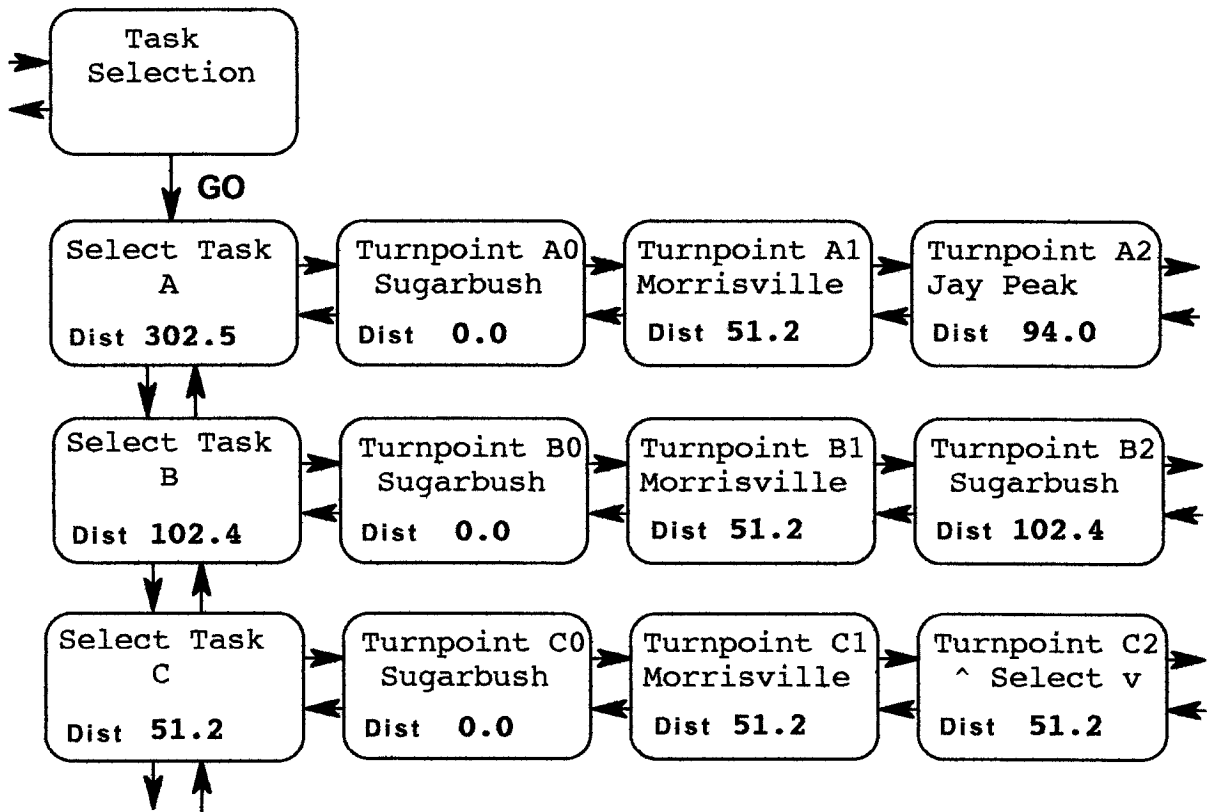


Figure 8. Task Selection and Editing

Pressing the right arrow key again and again eventually gets to the Task Selection screen. Pressing GO selects Task A. The DOWN arrow key selects Task B and so on to Task J. Total distance for each Task is shown on these screens.

Task creation and editing is simple compared with older versions of the GPS-NAV. As an example, start with no tasks in the GPS-NAV. On the **Edit Task** screen, press the RIGHT arrow key. You will see the message:

Turnpoint A0
^ **Select** v

This is a gentle hint to select a turnpoint using the UP and DOWN arrow keys. If you take the hint, you will see turnpoints arranged on a circular scroll in alphabetic order. The ^ **Select** v message occupies the slot between Z and A. Note that the start point is the zero'th point of the A task. The task distance to this point is always zero. Find the start point you want. There is no need to press the GO key. You have just selected the start point of your task.

Press the RIGHT arrow key again. Now you can choose **A1**, the first turnpoint of the A task. The distance from **A0** to **A1** is shown at the bottom of this screen.

Press the RIGHT arrow key again for the next turnpoint. Get the idea? The distance shown is always from the start point to the selected point.

To clear out a task, go to the zero'th point and scroll to the ^ **Select** v message. If you just keep on scrollin', the task is saved. But the task is cleared if you exit this screen with this message shown.

Declaring and Starting the Selected Task

The GO key is used to exit Task Selection screens. On the way towards the exit you must make two choices. The first choice is about Declaring the task. A declared task has date and time attached to it. The Declared task is attached to the Flight Log file in the PC. This permits Official Observers to see if you declared your intentions before takeoff. You may want to edit a task without declaring or starting it. The GPS-NAV design is clever enough to give you just the right choices.

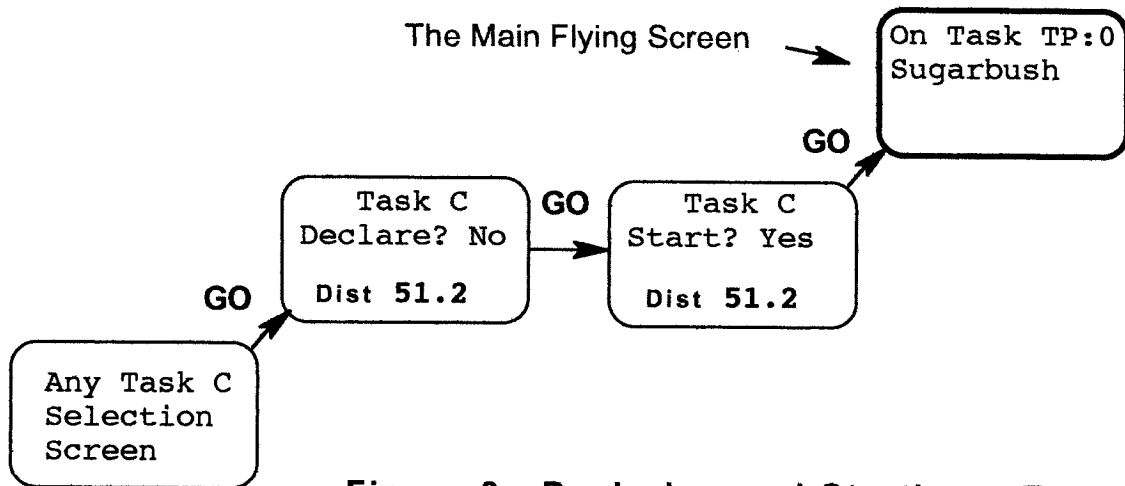


Figure 9. Declaring and Starting a Task

The first choice is about declaring the selected task. The default setting is No. Change the choice with the UP or DOWN key and press the GO key again. If Yes is chosen, the following message appears for 2 seconds:

**Task C
is Declared**

The second choice is to start the selected task. Again, the default setting is No. If Yes is chosen, the message **Navigate to** on the Main Flying Screen changes to **On Task TP:0**. The Task Turnpoint number (0 in this case) advances as new task turnpoints are selected

New task turnpoints are selected from the Task Management screen, two screens to the right of the Main Flying Screen. It shows the next turnpoint by name and number. As with any other navpoint selection screen, pressing GO makes it the active navpoint.

The current Task can be reviewed by scrolling UP or DOWN in the Task Management Screen. The choice to stop a task is also available here.

Tasks are flexible. For example, it is OK to select non-task navpoints such as Thermals or Landpoints. In this case the Task Management screen will show **Resume Task**. Pressing the GO key re-activates the task. Of course, a task is also resumed whenever the next task turnpoint is activated using the normal navpoint selection lists.

Messages and Sounds near Active Navpoints

The GPS-NAV provides extra help near the active waypoint. As the glider approaches the waypoint, the recorder gives two short beeps, and the display shows **Close to:** in place of **Navigate to.** When the glider gets nearer the turnpoint, the recorder gives one long beep and the display changes to **Arrival!**. The GPS-NAV is silent as the glider leaves the turnpoint, but the pilot may beep or cheer as the spirit moves. The radius at which each message appears is configurable. See the PC software User's Guide for details.

If the GPS-NAV LCD **Navigate to:** screen is not visible, the letter **M** for Message will appear on the screen. Pressing GO returns to the main navigation screen where the message **Close to:** or **Arrival!** is visible.

Messages and Sounds in Restricted Areas

The GPS-NAV warns the pilot as a restricted area is entered. In the PC Navpoint database, a point with an R attribute is assigned a radius, a bottom, and a top altitude. The restricted area is a cylinder with these dimensions surrounding the R point. Restricted points are listed on the Landpoints screen in order of distance from the current position.

When the glider enters this area, the GPS-NAV gives 4 short beeps, and the display shows **Restricted !** in place of **Navigate to.** While the glider is inside the circle, the **Restricted !** message overrides all other messages on the Main Flying Screen. Inside restricted space the audio warning is repeated every 10 minutes.

The GPS-NAV warning happens at the exact boundary of the restricted area. Careful pilots will choose restricted area dimensions slightly larger than the actual airspace boundaries.

Recording Flights

The GPS-NAV is designed so the Flight Recorder may be used by itself without the LCD Navigation display. The GPS lamp on the Flight Recorder flashes whenever the receiver is able to find its position.

Once position is known, flight logging is automatic. It begins when either horizontal or vertical motion starts. Position, GPS Altitude, Pressure Altitude, Estimated Position Error, and GPS-derived date and time are written periodically into the Flight Log. The GPS-NAV keeps a buffer of fixes at all times. When motion starts, two minutes of pre-flight fixes are logged. This provides a stable barograph baseline for altitude measurement. Logging continues for two minutes after motion stops. GPS-NAV Flight Logs are erased only when new pilot and navpoint data are transferred to it from the PC. This means pilots can transfer Flight Logs as often as they please to several different PC's.

Under new FAI Sporting Code rules, Flight Logs made by the GPS-NAV can verify FAI badge and record claims. They can also be used in glider competition to validate flight paths around turnpoints. Pressure altitude as well as GPS altitude and position are recorded. Motorglider engine noise is also continuously recorded. Therefore, Flight Logs from the GPS-NAV can replace photographs and barograph traces for both glider and motorglider flight validation. Flight Logs also provide useful information for all stages of glider pilot training.

Version 5 firmware adds two new features to GPS-NAV flight recording:

1. The GPS-NAV **Arrival!** message and its associated acoustic warning are now synchronized with logging. This means you can leave a turnpoint as soon as you see the message or hear the long beep.
2. The pilot can select short and long logging intervals in the PC software. The range is 2 to 60 seconds. The long interval is used far from the active navpoint. As the glider approaches the arrival radius of the active navpoint, the logging interval is reduced automatically to the short value. 15 fixes at the short logging interval begin whenever the ON key is pressed

Flight Log Security

The design of the Cambridge GPS Navigator and Secure Flight Recorder guarantees integrity of Flight Logs. Several mechanisms are used. The first is to append a digital "Signature" to each Flight Log. If the Flight Log is modified in any way, its "Signature" changes in a way that is virtually impossible to decipher.

The Cambridge GPS-NAV system permits Flight Logs to be shipped by diskette or even by modem or Internet from one site to another without risk of tampering or alteration. This means it is practically impossible to cheat by supplying contest officials or badge and record issuing authorities with altered, bogus flight logs.

GPS-NAV Recorder Sealing

The system described in the previous section prevents alteration of a Flight Log from the moment it is transferred to the PC from the Flight Recorder. However, without further measures, it is easy to cause a GPS Flight Recorder to contain a bogus, altered Flight Log. This could be done by taking the following steps:

1. The pilot flies the task but misses one turnpoint.
2. The Flight Log is sent to the PC.
3. The Flight Log is modified within the PC to show the pilot actually going around the turnpoint.
4. The data file is converted to the standard, NMEA-0183 format used for data transmission between the GPS receiver "engine" and the GPS-NAV Recorder memory.
5. The modified Flight Log is sent to the GPS-NAV Recorder memory using the wires from the GPS receiver "engine".
6. The modified Flight Log is sent back to the PC. The GPS-NAV "signs" the modified Flight Log as it is uploaded to the PC.

The Cambridge GPS-NAV prevents this kind of Flight Log alteration by permanently sealing the Recorder box and, therefore, the critical connection between GPS receiver “engine” and Flight Recorder memory. Removing the Model 10 GPS-NAV top cover breaks this seal. Removing the Model 20 or 25 GPS-NAV main cover also breaks this seal. The **Waypoint** database and Flight Log are lost. Replacing the cover does not replace the seal. The permanent factory electronic seal can be replaced only by returning the GPS-NAV to Cambridge Aero Instruments.

The status of the GPS-NAV Recorder seal is shown at power-on. See the following section for details of the power-on message sequence. When a GPS-NAV cover has been removed, the message:

GPS Recorder Sealed	is replaced by:	GPS Recorder Not Sealed
--------------------------------------	-----------------	--

The GPS-NAV will still function. However, Flight Logs will not be secure and will fail the electronic Validation test. This means that an Official Observer will be required to verify independently that the flight recording has not been altered.

Power-on Messages

A series of messages is shown when the GPS-NAV is first turned on. They show revision levels of Recorder and LCD display firmware, Pilot’s name, glider identifier, Recorder serial number, Recorder seal status, and battery status. Some messages are also shown whenever the ON key is pressed. Pressing GO stops the display of messages.

Recorder serial number and factory security code are assigned by the manufacturer. They cannot be altered. The pilot’s name and glider identifier are supplied by the pilot using the PC. See the PC Software User’s Guide for details.

GPS-NAV Model 10 Battery Status and Battery Charging

The Model 10 GPS-NAV has a self-contained 12 volt, 2.0 Amp/Hour Gel-Cell Lead Acid battery. The Model 10 GPS-NAV draws about 220mA. A fully charged battery reads above 12.7 volts. Normally, this will power the Recorder for more than 8 hours. An old battery or cold weather will reduce this time. When the battery drops below 11 volts, it is discharged. The GPS-NAV shuts itself off when the battery drops below 9.5 volts.

The glider main battery can be connected to the Model 10 GPS-NAV. Power is drawn from the battery with the higher voltage. This improves reliability if the GPS-NAV battery fails. When the external, glider battery has a higher voltage than the internal battery, External Battery voltage is also displayed in the message sequence. The Recorder will work with external power even when the internal battery fuse has failed.

The GPS-NAV is supplied with a 12 Volt 300mA battery charger. With the GPS-NAV turned off, about 12 hours are required to completely re-charge a discharged battery. Since overcharging will shorten battery life, the charger should not be connected for longer periods. A typical discharged battery will charge at more than 300 mA, while a charged battery takes less than 150 mA. Charging current is shown in the power-on message sequence when the charger is connected. If the Battery charge lamp fails to blink or the charge current shown on the LCD display is zero, check charger wiring and the battery fuse under the bottom cover.

The backup battery preserves the Flight Log even when power to the Recorder is turned off. The output of a new backup battery is about 3 volts, and it should last about 5 years. When its output falls below 2.0 volts, the backup battery should be replaced.

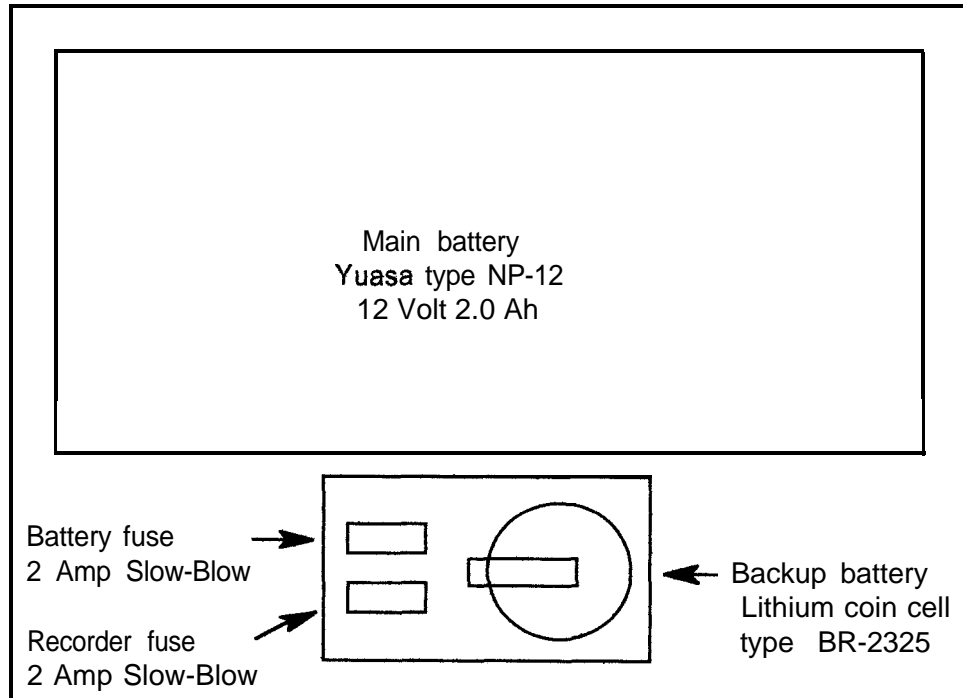


Figure 8. GPS-NAV Model 10 Battery and Fuse Locations

Note: Disconnect Main Battery before changing fuses !!

Note: The Recorder seal is broken and Flight Logs are lost if the backup battery is removed with the Recorder turned off. Turn Recorder ON during Backup Battery replacement.

GPS-NAV Model 20 & 25 Backup Battery and External Supply

The Model 20 & 25 GPS NAV rely on the Glider's battery for electrical power during operation. A lithium back-up battery is used to preserve flight recordings when power is removed. It also preserves the permanent electronic seal which prevents tampering. When the output of the lithium battery drops below 2.0 volts, it should be replaced.

The lithium battery is located under the flat plate antenna on the GPS-NAV Model 20. On the GPS-NAV Model 25, the battery is under the side cover plate.

Note: Before replacing the lithium battery, be sure to turn the GPS-NAV on. This will prevent the permanent electronic seal from being broken.

Note: It is important to keep power supplied to the Model 20 & 25 GPS-NAV during Flight. For gliders with 2 batteries, switching between batteries must be done quickly to avoid removal of power to the GPS-NAV. We recommend two separate battery switches. This way, battery #2 can be connected before Battery #1 is disconnected.

The Model 20 & 25 GPS-NAV's are supplied with a wall mounted power supply. (12 Volts DC @ 300 mA) This unit runs the GPS-NAV during transfer of data to or from the PC. Note that the outer contact on the power supply connector is Positive. See the Specifications section for details and wire color codes for other connections to the GPS-NAV.

Troubleshooting

The following problem/answer (P./A.) list may help locate the source of difficulties in installation and use of the GPS-NAV:

- P. The GPS-NAV Model 10 Recorder will not turn on using its own power switch.
- A. Its battery is completely discharged or an internal fuse is blown.
- P. The GPS-NAV Model 10 runs with an external battery but not with its internal battery.
- A. The battery fuse is blown. This can happen if a high capacity charger has been used, if the charging leads have been shorted together, or if the charger is of the wrong polarity. We strongly recommend use of the charger supplied by Cambridge.
- P. The GPS-NAV Model 10 turns itself off soon after being turned on.
- A. Its internal battery is almost completely discharged. The GPS-NAV shuts down at 9.5 V.
- P. The GPS-NAV Recorder cannot be turned on from the display unit.
- A. The display cable must go to the "GPS Display" port on the Recorder. The cable may have been connected to the "NMEA-0183" port. No damage results from this. The cable may also be defective. See the Installation Guide for the correct way to put connectors on the flat cable. Check for proper operation using the test cable.
- P. The display lights up, but shows "Navigate to: No Points!".
- A. Either there are no waypoints in the Recorder database, or the cable between display and Recorder is defective. To check for a bad cable, see if the UTC clock is running. The clock is shown in the "Latitude" screen list. The internal GPS "engine" keeps time even when there are no visible satellites. If the clock is running, the GPS "engine" and Recorder are functioning, and the Recorder/Display cable is OK.

- P. The GPS Recorder always shows zero satellites. That is, no satellite annunciators are visible in the "Navigate to" screen, and the Status screens show O/n on the top line.
- A. If the GPS receiver is OK, this means no signals are being received from the antenna. There are several possible reasons for this:
1. The 1575 MHz GPS signal does not pass through buildings, so GPS doesn't work indoors.
 2. The coaxial antenna cable may be defective. Check reception with the antenna attached directly to the Recorder. Twist-on BNC connectors are not as reliable as crimp-on types. Check continuity of the coaxial cable center conductor with an ohmmeter.
 3. The antenna may be defective. This is a rare occurrence.
- P. The GPS lamp on the Recorder never flashes. One or two satellites are visible. Satellite Status screens show signal strengths below 40.
- A. The antenna is in a poor location. Antenna location is critical to performance. GPS signals have no problem going through the fiberglass used in a glider fuselage skin. Plexiglass canopies are also transparent to GPS signals. However, thick fiberglass such as a spar will cause problems. A carbon fiber fuselage will block the GPS signal. Also, a metal frame, panel or even **pushrods** may cause problems.
- P. The Recorder always takes a long time to acquire satellites.
- A. If the Recorder is turned on before the antenna is attached, or in a location where the sky is obscured, it may go into "search the sky" mode. This takes up to 40 minutes. Turn power off and on again when signals are available. This will shorten acquisition time.
- P. The Recorder switches between **2D** and **3D** navigation. Flight recordings show high EPE. Track (Trk) and ground speed (V) numbers are erratic.
- A. The antenna is not working properly. The receiver will normally acquire between 6 and 8 satellites during flight. It should usually see more than 5 satellites. If this is not so, check the antenna mounting location.

- P. The graphic Track Error Indicator and the visual location of an active **waypoint** do not agree. The Indicator seems to guide me in the wrong direction.
- A. This is normal! You are seeing the effect of wind. The glider's heading will crab into the wind. This points the nose of the glider away from the goal. In a strong headwind, the Indicator will be very sensitive because it relates to Track and not Heading.
- P. GPS Recorder distances are slightly different from those calculated by the PC software.
- A. This is normal. The PC software uses the Great Circle method. The GPS Recorder uses rectilinear coordinates . This gives fast updates and is optimum for in-flight navigation. These numbers should not be used for calculation of badge and record distances.
- P. Distances shown by the GPS Recorder are very different from map distances.
- A. The maximum distance which can be displayed on the GPS Navigator is 1400 NM or 2700 Km. The Recorder and the map may use different units for distance. The Recorder is configured by the PC software for one of 4 different units systems.

They are:

- Nautical Miles, feet, knots
- Kilometers, meters, **kilometers/hr**
- Kilometers, feet, knots
- Statute miles, feet, knots

Specifications

Size:	Model 10 with mounting bracket	6.2" (158 mm) long, 6.2" (158 mm) wide 3.1" (79 mm) height
	Model 20 with GPS Antenna	4.7" (120 mm) long, 2.7" (68 mm) wide 2.3" (84 mm) high
	Model 25 with BNC Connector	5.5" (140 mm) long, 2.7" (68 mm) wide 1.9" (74 mm) high
	LCD Display and control unit	2.6" (66 mm) height and width 0.47" (12 mm) in front of instrument panel 0.80" (20 mm) behind instrument panel Fits standard 57 mm panel opening.
Weight:	Model 10	3.6 lbs (1.64 Kg)
	Model 20 or 25	0.8 lbs (0.36 Kg)
	LCD Display and control unit	0.35 lbs (0.15 Kg)
Power:	Model 10	Internal 12 volt or external 12-14 volt battery Current drain 220 mA with 1 LCD display
	Model 20 or 25	External 12-14 Volts or power supply Current drain 160 mA with 1 LCD display
	LCD display	Second seat LCD adds 10 mA to current drain
Fuses:	Model 10	Recorder: 2 Amp Slow-Blow
		Battery: 2 Amp Slow-Blow
Voltage: Indicator	Model 10	1 flash, 10 second repeat $v < 10.75$
		2 flashes, 10 second repeat $10.75 < V < 11.25$
		3 flashes $11.25 < V < 11.75$
		4 flashes $11.75 < v < 12.25$
		5 flashes $12.25 < V < 12.75$
		6 flashes $12.75 < V < 13.25$

Charger/Power Supply	12 volt DC, 300 mA, Center pin negative
Charge: Model 10	0 flashes $0 < I < 50 \text{ mA}$
LED	1 flash $50 < I < 150 \text{ mA}$
	2 flashes $150 < I < 250 \text{ mA}$
	3 flashes $250 < I < 350 \text{ mA}$
	Note: Charge current flash is longer than voltage flash
Logging Interval:	4 seconds minimum up to 32 seconds; PC configurable
Maximum Flight time:	11 hours at 4 seconds logging interval
Altimeter:	Temperature compensated, piezoresistive sensor Range 36,000 feet. Resolution 30 (10 meters) feet at sea level.
Means of Propulsion (moP) (Engine Run) detector	Calibrated microphone

Installation Guide

Gliders were designed without regard to GPS receivers. This makes installation difficult but not impossible. The Model 10 Recorder is intended to fit where a Barograph would go. Models 20 and 25 are about the same size as a 35 mm camera, and use the same mounting screws. Don't try to install the GPS-NAV when the weather forecast is for a 300 KM soaring day. You will get very frustrated!

The GPS-NAV display mounts in a standard 57 mm (2 1/4") diameter instrument panel hole. The 4 long 3 mm threaded mounting nuts hold the display in place. Use a piece of standard plastic instrument tubing to hold the nut when the threaded stud on the display is hard to reach. The nuts can also be used to mount the display in front of the panel. This will make the display easier to reach in some gliders.

If there is no room in the instrument panel, the special bracket supplied by Cambridge mounts the display to the canopy rail or other parts of the glider cockpit. There are many ways to bend this bracket depending on the specific glider and the desired GPS-NAV display location. Tilting the display up about 10° will let more light fall on the LCD and improve its contrast. We strongly suggest making a heavy paper model of the bracket as a guide before bending the actual aluminum part. The bracket can be attached to glider fuselage with several 3 mm (#4) self-tapping screws.

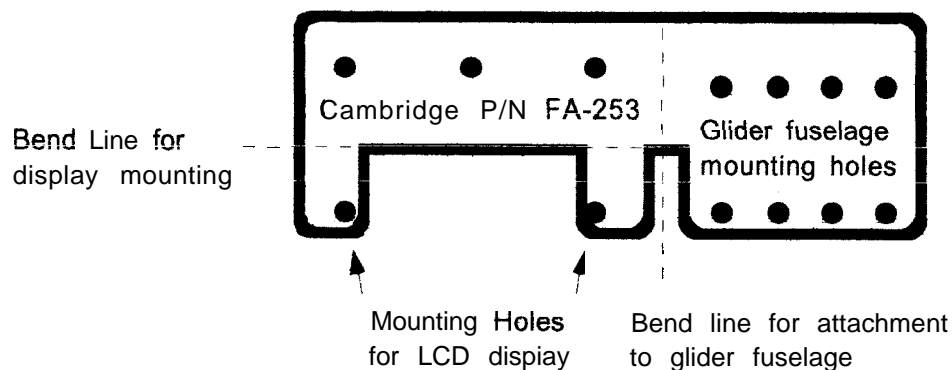


Figure 9. GPS-NAV Display Mounting Bracket

The GPS-NAV Model 10 mounting system consists of the **black** painted Mounting Bracket (P/N FA-245) and the Backup Plate (P/N FA-246). Attach so the glider fuselage part is sandwiched between bracket and Backup Plate. We have personally done more than 100 different installations, so contact us for advice and psychological counseling.

The GPS-NAV Model 20 has a built-in flat plate antenna covered by a black plastic radome. The antenna must have an unobstructed view of the sky. there are three favored locations for the model 20:

1. On or under the instrument panel top cover. Mount the GPS-NAV as close as possible to the canopy. It is OK to put the unit under the cover as long as it is not constructed of carbon fiber or metal.
2. In the same location as your obsolete 35 mm turnpoint camera .
3. Behind your head near the top of the fuselage. This works when the top of the fuselage is not made of carbon fiber. GPS signals will not pass through people, so position the antenna above your head.

The GPS-NAV Model 25 is for desperate pilots with impossible gliders. It combines the small size of the Model 20 with the separable antenna of the Model IO.

Note that the antenna mounting bracket supplied with the Model 10 and 25 has mounting **holes** which match microphone bracket mounting holes in many gliders. The Cambridge difference is in the little details!

Bend this end if you use
the hole on the case edge.

Bend this end if you use
the hole on the case bottom

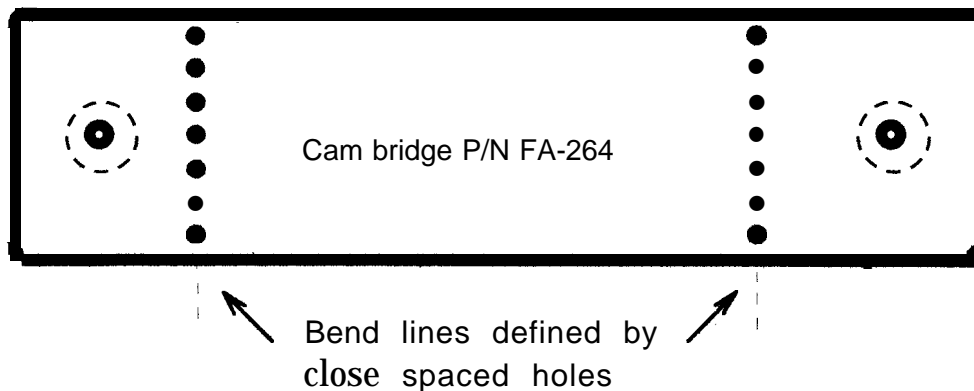
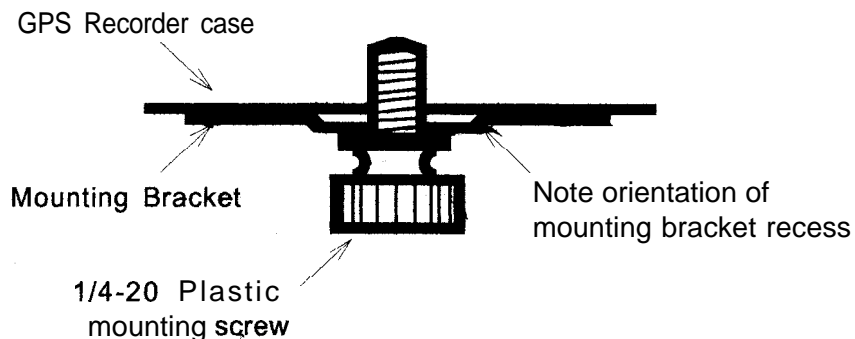


Figure 10. GPS-NAV Model 20/25 Mounting Bracket



**Figure 11. Detail view showing anti-rotation
recess in Model 20/25 Mounting Bracket**

The Model 20/25 mounting bracket lets the pilot mount these GPS Recorders in an astonishing variety of ways. The bracket can be bent (only once !) by hand using the pre-drilled line of holes. Note that the two ends are not the same. Use the narrow end with the Model 25 on the side of the cockpit. The Model 20 uses the wide end in most situations.

Power Cable Wiring

There are 2 GPS-NAV cables for which the pilot needs to know the wiring. These are the power cable and the NMEA-0183 connection to an S or L-NAV or other piece of equipment using real-time GPS data. It is vital that the cable connectors be attached with the correct orientation. Please refer to the diagrams shown below.

Power to the Model 10 is supplied through the red (+) and black (-)wires in the 4-wire cable. Note: Use Ferrite RFI Bead on the power cable.

Model 20/25 power control is more complex. Un-switched power (using the Red wire) means the GPS-NAV is turned on as soon as power is applied. The GPS-NAV display ON switch is not used. You must use this connection if the GPS-NAV is to be used without its LCD display and without connection to a Cambridge L-NAV.

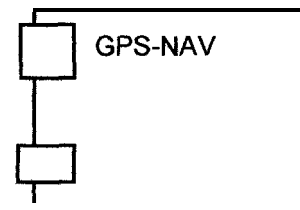
Switched power (using the Green wire) means the Model 20/25 GPS-NAV responds to the ON switch. Power may also be slaved to a Cambridge L-NAV. When the L-NAV is turned on, the GPS-NAV turns on automatically. When the L-NAV is turned off, the GPS-NAV waits 30 seconds and then turns itself off.

Wire color	Yellow	Green	Red	Black
Port Name	Pin 1	Pin 2	Pin 3	Pin 4
12-14 Volt Model 10	-----	-----	Switched +12 Volt	Power Ground
12-14 Volt Model 20125	Power Ground	Switched +12 Volt	Un-switched +12 Volt	Power Ground

Power Cable
Orientation

Black wire this side

"Barrel" connector, 12 VDC
Un-switched, Outside Positive



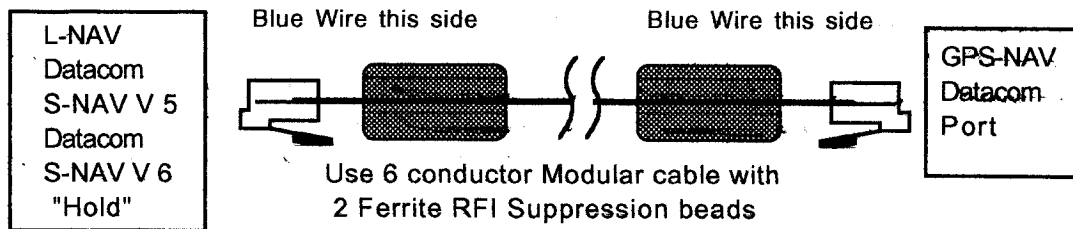
Datacom Cable Wiring

The 6-wire Datacom cable carries NMEA-0183 data from the GPS-NAV to other devices. These signals are used by a Cambridge L-NAV or S-NAV. They can also be used to provide input to other devices.

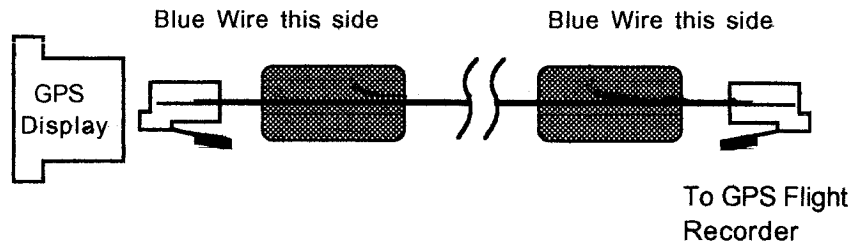
The GPS-NAV outputs NMEA sentences \$GPRMB and \$GPRMC. It also outputs a proprietary sentence which gives the elevation and attributes of the active waypoint. Further details of this sentence may be obtained from Cambridge.

Pin 1, the power control switch input, enables a remote device to turn the GPS-NAV on and off. When this input is +5 Volts, the GPS-NAV will turn on. When this input goes low, the GPS-NAV will turn off in 32 seconds.

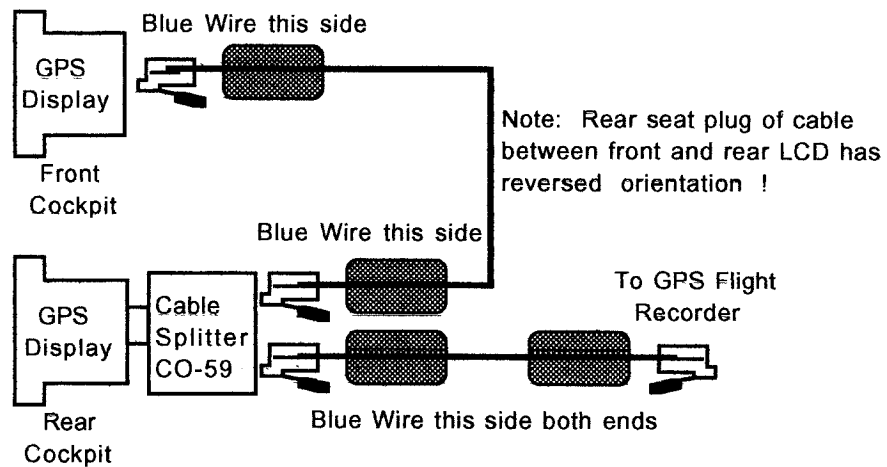
Wire color	Blue	Yellow	Green	Red	Black	White
Part Name	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6
Datacom	Power Control Switch Input	Serial data Input to Recorder	-----	NMEA-0183 Output from Recorder	-----	Logic Ground



Display Cable Wiring



Display wiring for single seat gliders



Display wiring for 2 seat gliders