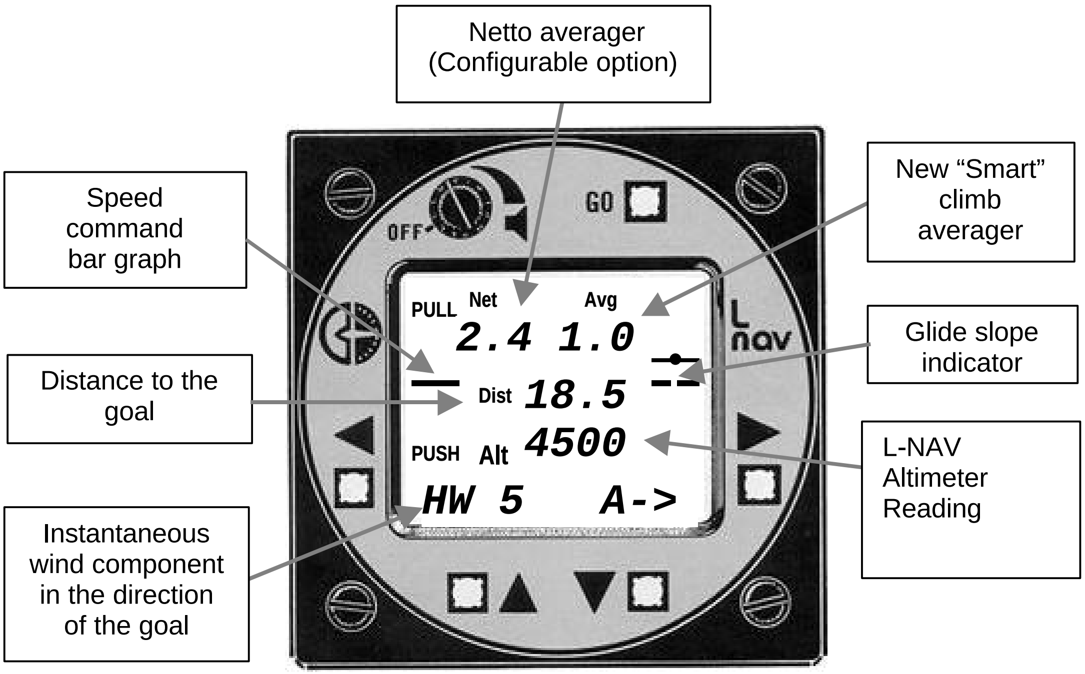
Cambridge Aero Instruments
L-NAV Glide Computer Version 5.8

March, 2000



Warranty

All Cambridge Aero Products are guaranteed against defects for TWO YEARS from date of original purchase, when used in gliders. The warranty is limited to faulty workmanship and/or materials. The unit must be returned to the factory or to an authorized repair station. This warranty is void if failure is due to accident, mis-handling, or if repairs are performed by unauthorized persons.

Cambridge Aero Instruments
1004 Dupont Road
P. O. Box 2246
Martinsville, VA 24113, USA

(01) 276.632.2033 276.632.2660 Fax
www.cambridge-aero.com

L-NAV Version 5.8 User's Guide

Firmware by Phil Schlosser and Chip Garner, text by Dave Ellis

L-NAV Version 5.8 User's Guide

1. Introduction

This User's Guide covers installation and operation of the Cambridge L-NAV. The document is complete but concise. Do not expect to understand the entire instrument by reading the User's Guide once. We suggest flying with the L-NAV for a while. Then return to the User's Guide with specific topics in mind. At Cambridge, we listen to our customers and fly with the instruments we build. Version 5 is the result of more than 18 years experience in design and construction of more than 2500 glide computers. We trust you will enjoy flying with it.

1.1 About the L-NAV

The L-NAV is designed to enhance gliding performance. It has sensors for altitude, rate-of-climb (variometer), airspeed, and vertical acceleration (with optional g-meter). Rate-of-climb is indicated on the attached variometer and by audio tones. The average climb rate is shown on the LCD screen. The instrument is configured with the glider polar (sink rate vs. airspeed). The pilot enters a MacCready setting, and the L-NAV calculates an optimum speed-to-fly. Speed commands are shown on a LCD bar graph and communicated by audio tone patterns.

The L-NAV is compatible with any GPS receiver having an NMEA-0183 output, but is optimized for use with the Cambridge GPS-NAV. Goal elevation as well as distance, bearing, glider track, and ground speed are sent from GPS-NAV to the L-NAV. Calculation of altitude required to reach any landing field includes the elevation of that field. Wind is measured as the difference between GPS-derived groundspeed and true airspeed. Using the stored polar curve and the MacCready setting, altitude required to reach the navigation point is displayed numerically and graphically on the LCD screen.

1.2 New and modified features with Version 5.8 firmware

Changes made since Version 5.7 are described.
We thank our loyal pilots and agents for their suggestions!

a. Achieved L/D over the ground (Slope) is now computed as GPS groundspeed divided by variometer reading. The value is reset upon switching from climb to cruise, and is averaged over the time available. After 30 seconds in cruise, averaging time is fixed at 30 seconds.

b. The temperature/altitude page now appears on start-up if there is no outside air temperature probe installed. This reminds the pilot to set the temperature for the day.

c. The Home 3 configuration shows component wind final glide altitude & instantaneous Headwind/Tailwind (HW/TW) on the Home screen. This page is now the same as L-NAV Versions 2 - 4. In Version 5.7, choosing Home 3 simply deleted the HW/TW page. Home 1 and Home 2 configurations show Altimeter reading on the instantaneous HW/TW page.

d. Utilizing the KISS principle, the non-functional “Quick” wind option has been deleted. .

e. Thermalling statistics are now based on total energy. This improves accuracy.

f. The default Averager configuration has been changed to “Smart”. Pilots used to the old, fixed interval averager will notice that accurate results appear sooner upon entering thermals.

g. Configuration options have been extended so variables shown at the upper left can be different in cruise and climb modes. See Section 4 for detailed description of choices.

h. Variometer scale change (x 1, x 0.5, or x 2) is now done on the rightmost page of the main flying screens. It is now easier to change this value in flight.

i. MacCready, bug polar and ballast setting are retained if power is cycled during flight. After a flight, MacCready ->0, Bug polar ->100% (Clean), and Ballast -> 0.

j. Climb statistics as well as logbook flight time are retained until the next takeoff.

k. We fixed a computational error that made the Averager read 2% high.

l. The display of instantaneous wind component (HW/TW) is now easier to interpret. It is rounded to the nearest knot, and the trend (+ or -) is shown following the value.

2. Basic L-NAV operation

2.1 The L-NAV User Interface -- what the keys do

L-NAV keys have consistent behavior for all functions:
- Change screens with the LEFT or RIGHT arrow key
- Change a value on a screen with the UP or DOWN key.
- Return to the Home Screen with the GO key.
- See elapsed time on the Home Screen by momentarily depressing the GO key.
- Reset elapsed time by holding the GO key down more than 4 seconds.
- Access Configure and Calibrate functions by holding down GO and LEFT or RIGHT key.

2.2 LCD Screens with no GPS connection

In this section, we assume the L-NAV is connected only to a 12-volt battery. At power-on the Firmware Version (5.8b) is shown followed by the altimeter screen. Battery voltage is also shown on this screen. Change the altimeter by adjusting the sea level barometric pressure (QNH) with the UP or DOWN arrow key. To see the Home Screen, press the GO key. If no Outside Air Temperature screen is present, another screen appears that lets you enter the ambient temperature. Press GO again to see the Home Screen.

From top to bottom, the numbers on the default Home 1 Screen are:

A 30 second moving average of the climb rate (top right)
A 30 second average of vertical airmass motion, "Netto" (top left)
The distance to the goal
The L-NAV Altimeter reading
GPS receiver status. With no GPS data present, this shows **`[GPS (Off) ]`**.

A bar graph at the left side of the screen shows if you are flying at the optimum speed to reach your goal (Speed-to-Fly). The graphic display at the right side of the screen indicates whether you are above or below the glide slope needed to reach the goal.

Pressing the RIGHT arrow key 3 times shows the **`[Distance ]`** entry screen. Use the UP key to enter a distance of about 10 miles. Use the LEFT key to enter the Mc/Wind screen.

Note the cursor under the W symbol. This means the wind setting can be changed with UP and DOWN keys.

This screen shows the Altitude Required to reach your goal. Note that a headwind (HW) increases Altitude Required. **Be careful not to confuse Altimeter reading on the Home 1 screen with Altitude Required on the HW/TW Glide Screen!**

Press the LEFT key again to move the cursor under the MacCready setting. Higher MacCready mean you will be directed to fly at higher average speed. Glider polars bend downward more as speed increases, so a faster glide needs more altitude to reach the goal.

Pressing the GO key always returns the L-NAV to the Home screen. Pressing the GO key in the Home screen shows elapsed time since takeoff.

Without a GPS receiver, the L-NAV counts down the distance by dead reckoning. The count rate is the sum of total airspeed and wind strength in the direction of flight. This works like an automobile speedometer and odometer (in reverse!). Distance counting can be stopped manually by actuation of an external "hold" switch, or automatically when the optional g-meter detects the increase in wing loading that results from circling flight.

2.3 Variometer and Audio Functions

Both visual and audio variometers are of the "Relative" type. Below the glider's best L/D speed, the vario indication and sound will be the same as an ordinary Total Energy Variometer. While cruising at high speed, the Relative Vario and associated audio tones indicate lift you would have if you slowed to best L/D speed. This helps you evaluate lift even when cruising fast. The R "Relative" flag at the top of the screen is turned on above the glider's best L/D speed. The best L/D speed increases at higher wind loading. The Relative variometer is better than a "Netto" variometer because the pilot does not have to subtract out the glider's sink rate to see the actual climb rate in a thermal. Note that the Average on the LCD screen shows the glider's actual rather than Relative sink or climb rate.

Cambridge has traditionally used an interrupted tone as a speed-up alert and a continuous tone as a slow-down alert. When in “climb” mode, Cambridge products have been silent in sink. European glide computers have often used a continuous tone as a speed-up alert, and an interrupted tone as a slow-down alert. In “climb” mode, these instruments give a continuous tone in sink.

Warning and alarm functions have also been added to the audio channel. In [Audio 2] mode, the climb tone pattern changes subtly as lift falls below the current MacCready setting. With the optional g-meter, the L-NAV provides a pilot-configurable “slow-alarm” pattern that relates to airspeed, the glider polar, and the instantaneous wing loading.

Landing gear alarms can be fitted to gliders, often after the first gear-up landing! The alarm sounds if spoilers are extended with the landing gear retracted. Failure to latch spoilers in the closed position for takeoff is another alarm condition. Spoilers can deploy as the glider hits a bump on takeoff, causing problems with the tow. Traditional landing gear alarms cannot detect this condition, but the L-NAV does. Customer installed switches on spoiler and landing gear actuators are combined with airspeed to make intelligent alarm sounds.

There are a large number of different audio functions. This can be confusing to the pilot. The L-NAV defaults to simple audio tones. Configuration switches add audio functions that the pilot finds useful. The following text assumes that all optional functions are switched on. Lowest priority tone patterns are listed first.

A. **[No Sink T] [Sink Tone]** and Speed-to-fly alert patterns

This Configuration switch (see Section 4) does two things. In climb mode it activates the continuous sink tone, and in cruise mode it selects the speed-to-fly tone pattern.

In the default **[Sink Tone]** configuration, the sound goes from interrupted to continuous as vario readings go from positive to negative in climb mode. In cruise mode, the audio is silent if you are cruising near the optimum speed. A continuous tone means you should speed up. A short tone (25% on, 75% off) means you should slow down.

In the optional **[No Sink T]** configuration, the variometer tone disappears when the vario goes negative in climb mode. In cruise mode, double-beeps means you should speed up. A continuous tone means you should slow down.

B. The Climb Tone

The climb tone starts whenever the Relative vario reading goes from negative to positive. The pitch rises and the interrupt rate increases as lift improves. The default **[Audio 1]** configuration setting turns the climb tone on 75% of the time. The optional [**Audio 2]** pattern is 50% on, 50% off for lift less than the MacCready setting, and 75% on, 25% off for lift > MacCready.

C. The "Slow Alarm" tone pattern

This feature helps the pilot maintain correct airspeed while circling. Higher wing loading from ballast or increased g-forces during circling raises stall speed. The optional L-NAV g-meter quickly senses the increased wing loading. If airspeed, corrected for g-loading and ballast, is too low, the vario audio pitch stays the same, but you will hear a dit-dit-dah tone pattern. The slow-alarm airspeed threshold is set on the Configuration screen labeled **[Slow Alarm]**. This speed is for an un-ballasted glider in 1.0 g conditions. If you are carrying water ballast or circling, you will hear the sound at the correct (increased) airspeed.

D. Spoiler and Landing Gear Alarms

These alarms depend on switches connected to spoiler and landing gear actuators. See Section 6 for information on switch wiring.

The L-NAV measures airspeed. Airspeed above 25 knots (46 kph) means “flying”. If the glider is on the ground with un-locked spoilers, the “police siren” alarm sounds, and the screen shows **[Spoilers?]** Pressing the GO key cancels the alarm so spoilers can be deployed for the takeoff roll. If the glider goes from non-flying to flying state with the spoilers unlocked, the **[Spoilers?]** alarm sounds again. Closing the spoilers cancels the alarm.

If the glider is flying with the landing gear up and the spoilers are unlocked, the alarm sound is heard and the screen says **[L Gear Up?]**. Lowering the landing gear or pressing the GO key cancels the alarm.

2.4 Optimum MacCready setting for cross-country flight.

According to the theory popularized by MacCready, this number should be set to the average climb rate expected in the next thermal. The average over the whole thermal must take into account the process of entering and centering the lift. This is often much less than the peak averager reading observed during the best part of the climb.

Experienced pilots rarely set MacCready above 4 knots, even in very strong conditions. Lower MacCready settings offer the pilot greater cruising range, and hence the opportunity to pass up a weak thermal in favor of a more distant strong thermal. In strong conditions, a low MacCready setting may allow cross-country flight without circling.

Even in weak conditions with a modern glider, it rarely pays to set MacCready below 2 knots unless the expected lift is known to be < 2 knots or you are low. Occasionally, a glide at best L/D (MacCready = 0) is needed to safely reach the next area of lift.

Historically, a "speed ring" attached to the variometer face indicated speed-to-fly based on glider polar, vario reading and MacCready setting. The result was optimized flight between thermals. Speed-to-fly did not consider wind.

Speed-to-fly between thermals is not the same as optimum speed-to-fly to a point fixed on the ground. When wind is taken into account, the optimum speed-to-fly increases for upwind flight. Imagine a 50-knot headwind with flight at a best L/D speed of 50 knots. With MacCready = 0, the interthermal speed-to-fly will be 50 knots, but the glider will never reach the turnpoint. The L-NAV takes the component wind (HW / TW) into account. In a strong headwind, raising the MacCready setting from zero will reduce Altitude Required. Some non-zero MacCready setting will minimize Altitude Required to a goal point.

2.5 Total Energy Final Glide

A high performance glider climbs more than 600 feet as it slows down from V_{NE}, the "never-exceed-speed", to V_M, the speed of best glide ratio. During the last part of a high-speed final glide, it is helpful to know how much altitude can be recovered by slowing down to V_M. When total (potential + kinetic) rather than just potential energy is taken into account, the difference between actual and required altitude becomes independent of airspeed.

By default the L-NAV displays Altitude Required **`[Alt. Req.]`** to reach the goal. The instrument can also be configured to display the difference between Altitude Required and the glider's current altitude **`[Alt. Diff.]`**. Another Configure setting allows the pilot to add the altitude available from speed to the altimeter reading. The Total Energy Height setting **`[TE Height]`** adds the altitude that can be gained or lost in going from the current airspeed to V_M, the speed of best glide ratio. Actual altitude recovery is less than the theoretical value. An open class glider recovers more altitude than a standard class glider. The L-NAV compensates for this with a drag factor related to the configured L/D of the glider. (80% for a 40/1 glider; 90% for a 55/1 glider)

When the L-NAV is configured to show Total Energy Altitude, the graphic glide slope indicator shows the difference between Required and Total Energy Altitude. This is a GLIDE SLOPE indicator. The altitude difference corresponding to each bar depends on distance. At 15 miles out, each bar equals 200 feet. A 45/1 glider needs ~2000 feet at 0 MacCready to go 15 nautical miles. Thus, each bar represents about 10% of the altitude required to go the distance. If you are gliding at 45/1, one bar above the reference line means you can glide at 41/1 and still reach the goal.

If lift is encountered enroute, you will find yourself above the glidepath. This means you can fly faster and still reach your goal. Increase the MacCready setting until the Glide path display is centered. Speed-to-Fly will increase at the higher setting. The glider's total energy does not go down as you increase speed, so the Glide Slope display will stay centered unless you encounter lift or sink.

If you expect the average airmass motion to be slightly positive during the final glide, you may be able to start the glide 1or 2 bars low and still reach the goal. An average vertical airmass motion of +0.1 knots changes the effective best-glide angle of a 45/1 glider to 49/1.

3. L-NAV operation with Cambridge GPS-NAV

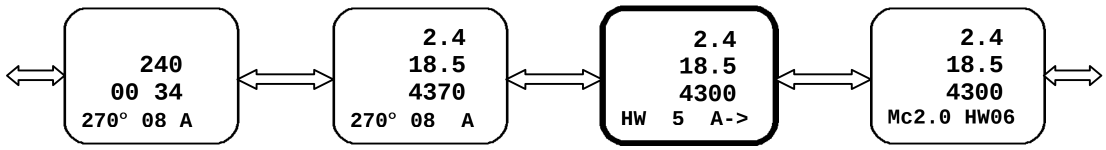
This section assumes the L-NAV is connected to a Cambridge GPS-NAV. Screen maps show the default L-NAV polar with a goal distance = 18.5 nautical miles, track of 240 degrees, wind = 08 knots at 270 degrees, headwind component of 4.6 knots, MacCready setting of 2.0 knots, and 34 seconds elapsed since the last vector wind measurement. The displayed average climb rate is 2.4 knots. The Home and Vector Wind glide screens shows GPS status, and Vector Wind screens show zeros if no GPS data is available.

If you are using a non-Cambridge GPS receiver, you must enter Goal Altitude. In addition, the final glide around a turnpoint feature is not available.

With any GPS receiver connected to the L-NAV, Climb/Cruise switching is based on the rate at which GPS-derived Ground Track changes. When track changes more than 3 degrees per second for 12 seconds, and the total turn is greater than 110 degrees, the glider is assumed to be circling. Otherwise, it is assumed to be cruising.

3.1 The Primary Screens

The first map shows the primary screens you will use most during flight. Pressing the GO key several times ALWAYS brings the instrument back to the Home Screen.



Vector Wind Measurement	**Home 2 Screen with Vector Wind**	**Home 1/3 Screen with fast HW/TW**	**HW / TW Final Glide Screen**
See: Glider Track, Time since last Vector Wind measurement, Wind Direction, Wind Strength, Measure Mode Select Mode: Auto **A,** Manual **M,** or Quik **O**	See: Average Climb, Total Goal Distance, Total Altitude Reqd., Wind Direction, Wind Strength, Measure Mode Adjust: Strength or Direction of wind in **M** mode.	See: Average Climb, Goal Distance, **Altimeter (Home 1)** **Alt. Req. (Home 3)** Instantaneous component wind Select Mode: Auto **A** or Manual **M** wind entry in HW/TW Final Glide	See: Average Climb, Goal Distance, Altitude Required, MacCready Setting Final Glide Wind Adjust: MacCready Value, Wind component in Manual **M** mode

These screens provide information about the airmass around the glider, and show the altitude required to reach a distant goal point. Distance to the goal comes from the GPS receiver. The predicted Glide Altitude is based on the assumption of zero vertical airmass motion between thermals. The pilot decides on the MacCready value. Required Glide Altitude is then computed from the glider polar and the wind.

Note: HOME 1 shows Altimeter reading. Home 3 shows HW/TW Altitude Required

The L-NAV has two independent glide calculators. One is based on the wind component in the direction of flight. The other uses vector wind. The L-NAV automatically computes both winds. Each wind can also be entered manually .

3.2 Glide Calculations based on Wind Component (HW / TW)

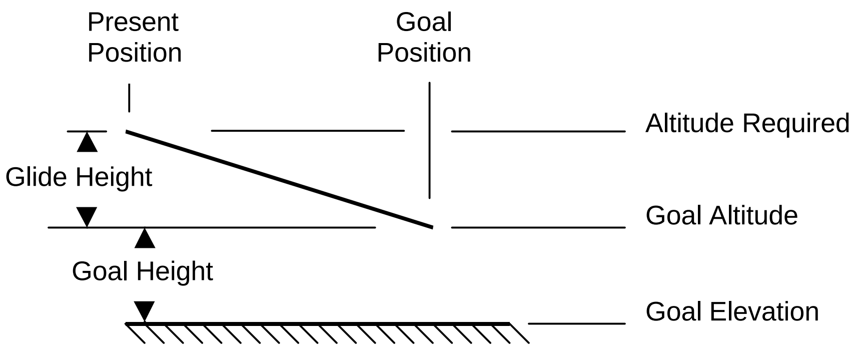
The Home screen and HW/TW Final Glide Screen show and use component (HW TW) computed from True Airspeed and GPS groundspeed. HW / TW on the Home screen is updated every 2 seconds. In Automatic mode, **A**, HW / TW averaged for 30 seconds is used in the glide altitude calculation. Track Error is the difference between bearing to the goal and the glider's track. When Track Error is greater than 20°, the **HW** or **TW** label changes to **hw** or **tw**, and the average component wind is not updated. This helps prevent crosswinds from affecting the glide altitude. When new wind data is being used, the arrow symbol (->) appears at the right side of the Home screen. In Manual mode, **M**, the pilot enters the estimated wind.

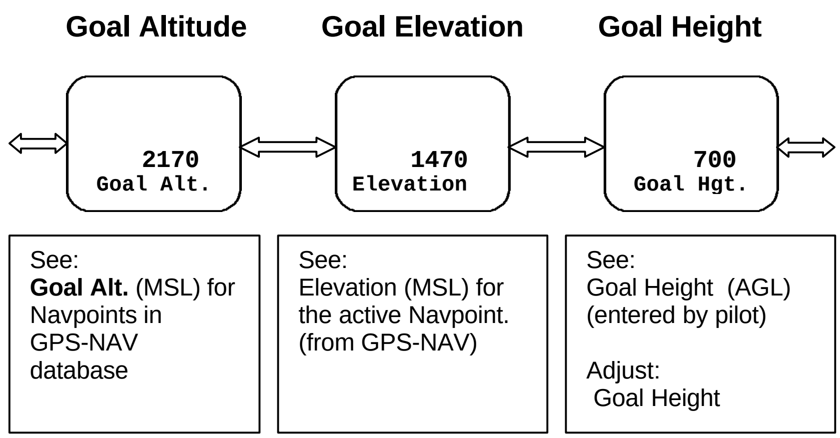
Glide Altitude shown on the Home screen is the same as that shown on the HW/TW glide screen. For this altitude to be accurate, the glider must be pointing towards the goal.

3.3 Altitude Required for Glide to a GPS-NAV Goal Point

With navigation data from the GPS-NAV, Altitude Required is the sum of:

1. The Glide Height needed to fly from the glider's present position to the goal
2. The Height over the ground that the pilot desires at the goal (Goal Height)
3. The Goal Elevation from the GPS-NAV Navigation Point Database





The screens in this illustration are found to the right of the Primary screens shown earlier. The illustration is for a GPS-NAV Goal point with an elevation of 1470 ft. and a pilot-entered Goal height of 700 feet.

3.4 Measurement of Wind Strength and Direction (Vector Wind)

Glider Ground Track, Ground Speed, and True Airspeed measured in two flight directions gives enough data for computation of wind strength and direction (the Vector Wind). A track angle difference of 50 to 100° between points is needed for best accuracy. Suitable points are selected automatically by the L-NAV. There are two different modes for measuring and using Vector Wind. The modes are Manual (**M**)**,** and Automatic (**A**). Modes are selected with the UP and DOWN keys on the Vector Wind Measurement screen. New Vector Wind measurements happen whenever the appropriate maneuvers are made.

The L-NAV continuously analyses the flight. First, the current point is checked for flight path stability. The **GO** flag appears for suitable measurement points. For each selected point, the instrument steps backward in time for up to 3 minutes and looks for another suitable point. A new wind measurement is made when the older GPS Track differs from the current Track between 50° and 110°. In Automatic **A** and Manual **M**, up to 30 individual measurements are averaged to produce the displayed Wind Vector. The average age of wind measurement data is shown in the format **`[mm ss]`** just above the wind value. Automatic mode provides an accurate wind vector in most conditions.

In Automatic (**A**) mode, the new wind measurement is sent to the Vector Wind Final Glide screen for use in calculation of required altitude. Manual (**M**) mode allows the pilot to modify wind direction and strength values on the Vector Wind Final Glide screen.

The most recent Vector Wind measurement is shown at the bottom of the screen. The time elapsed since the midpoint of the first and second measured data points is displayed above the Vector Wind measurement. This number increases as the measurement gets older. Glider Track is also displayed on this screen as an aid during the required turn maneuver.

3.5 Glide Calculations based on Vector Wind

The screen to the left of the Home screen uses the Vector Wind to compute Required Altitude. The wind is computed automatically or manually by selecting **A** or **M** on the Vector Wind measurement page to the left. The choice of **A** or **M** made here applies only to Vector Wind. Because both wind strength and direction are known, it is possible to compute the Total Altitude required to glide around the last turnpoint to the Finish point.

Note: The glide calculation on the Vector Wind page is independent of the glide calculation on the Home and HW/TW page, and will yield a different glide altitude if the winds are different.

3.6 Vector Wind Final Glide around the last turnpoint

This new feature works only when the L-NAV is coupled to a Cambridge GPS-NAV Version 5.1 or later. Distance and bearing for the last leg of an active GPS-NAV task are sent from the GPS-NAV to the L-NAV. Operation is fully automatic. When the GPS-NAV is navigating to the last turnpoint of a task, the Total Altitude required shown on the Vector Wind Final Glide screen is the sum of:

1. The Glide Altitude needed to fly from the glider's present position to the last turnpoint.
2. The Altitude required to fly from the last task turnpoint to the finish point.

The same Vector Wind and MacCready values are assumed for flight to the last turnpoint and for flight from the last turnpoint to the finish point.

The Home and Component (HW / TW) Wind final glide pages always show altitude required for glide to the next turnpoint using the wind component in the direction of flight rather than the vector wind.

Important Note:

Make sure the Finish Point is the last GPS-NAV Task Point. It is easy to add an extra point to a task without realizing it. The GPS-NAV transmits information only about the LAST leg of a task.

3.7 Vector Wind Glide to a landing field.

The Vector Wind Glide screen computes the wind component in the direction of flight to any landing field in the GPS-NAV database. Unlike the Component Wind glide calculator, you can see the altitude required without pointing the glider towards that landing field. When combined with the GPS-NAV Goal Elevation feature, the L-NAV Vector Wind Glide screen shows safety margins for glides to different landing fields while you are flying to a task turnpoint.

Note: For this feature to work properly, the GPS-NAV database elevation for the point must be accurate. Remember that GPS-NAV Markpoints are recorded with flight altitude rather than actual Markpoint elevation.

3.8 Differences in Altitude Required between Vector and HW /TW Glide Screens

The component (HW / TW) wind is measured continuously. The measurements are averaged for 30 seconds and used in computation of the HW /TW Required Altitude.

Automatic Vector Wind does not typically update on final glide because flight direction is constant. Therefore, the derived wind in the flight direction may not match the current HW / TW value. This will cause differences between Vector Wind and HW / TW glide altitudes. If you are using the Vector Wind glide altitude, you can detect changes in wind magnitude or direction by comparing the two glide altitudes.

3.9 So many winds, so much confusion!

The L-NAV computes three different winds. Each one is useful in particular circumstances.

Instantaneous HW/TW on the Home 1 screen is updated every 2 seconds. TW will increase as you head towards a ridge that is generating lift. Air flowing into a thermal at low altitude will also show increasing TW or decreasing HW.

Averaged HW/TW is used in computing Altitude required on the Home Screen and on the HW/TW Final Glide screen. Averaged HW/TW updates continuously as you fly in a straight line. Therefore, it most accurately reflects the current wind "on the nose".

Vector Wind is computed automatically when the glider does circling maneuvers. It is the best way to look for wind direction changes that may indicate a shear line or convergence zone. Vector Wind Final Glide gives Altitude Required to a landing field without the need to point the glider towards that field.

3.10 Calculation of True Airspeed

The basis of L-NAV wind measurement is the relationship of GPS groundspeed and track to true airspeed (TAS) measured by the L-NAV. GPS groundspeed and track are remarkably stable and accurate. Most problems come from TAS errors. Small percentage errors in TAS generate large percentage errors in wind. This is because wind is the small difference between two large numbers. At 50 knots TAS in a 5-knot wind, a 1-knot (2%) error gives a 1-knot (20%!) wind strength error.

In addition it Indicated Airspeed measurement errors from a variety of sources, an erroneous air temperature estimate will produce an error in conversion of IAS to TAS.

The inherent accuracy and precision of GPS groundspeed enables TAS errors to be reduced through in-flight calibration. Sources of IAS error are removed by procedures described in the Calibrate section of this User's Guide.

3.11 Miscellaneous L-NAV Screens

Screens a. - f. are to the left of the Primary Screens. Find them by browsing.

a. The Temperature/Altitude Screen

True Air Speed (TAS), and therefore wind calculations, depend on air temperature as well as altitude. The temperature should be correct to within about 9° Fahrenheit (5° Celsius) to avoid wind errors. The simplest way to obtain temperature is with a low cost electronic outside air temperature probe. These can be purchased from electronics shops such as Radio Shack.

When the optional L-NAV Outside Temperature (OAT) probe is installed, there is no need to enter the current temperature or altitude. In this case, indicated (IAS) to true (TAS) airspeed correction is fully automatic. The screen labeled Temperature shows the Outside Air Temperature, and you can be confident of highest quality IAS/TAS correction.

If the option is not installed or the probe is not connected, the pilot can enter this information manually on the Temperature/Altitude screen. This screen is provided for entering the outside air temperature at a given altitude. When the cursor is under the temperature, it can be set. When the **alt** annunciate blinks, the altitude for that temperature can be entered. Once a Temperature/Altitude data point has been entered, the L-NAV altimeter reading and an adiabatic lapse rate of 3.5° Celsius/1000 feet is used to predict outside air temperature.

b. The %Clean Screen

Sometimes gliders are attacked by zillions of bugs. Both bugs and gliders lose in this battle. Bugs splattered on the wing degrade the polar and increase altitude needed to reach a goal.

Bugs, like people, come in all sizes and shapes. Airfoils differ in rain and bug splat sensitivity. While flying, one cannot count bugs/meter, so there is no way to precisely enter this factor. Bugs bugging you? Wing messy? Try 80% clean and smile if you make it home.

c. The % Ballast screen

The glider polar changes when water ballast is added. The % Ballast screen lets you modify the polar curve according to the percentage of maximum ballast being carried. This screen appears only if the polar has been configured with the maximum amount of water the glider can carry. If the maximum is 160 liters, 50% ballast means the glider is carrying 80 liters of water.

d. The Altimeter-setting screen.

This screen shows the current altitude and lets you modify the altitude by changing the sea level barometric pressure (QNH).

When configured for Metric Altitude (Meters), the L-NAV shows two Altimeter screens. One shows Altitude in Meters, the other in Feet. This is useful in avoiding restricted airspace.

e. The G-Meter screen

This screen appears only if the optional G-Meter has been installed. Instantaneous g is shown at the bottom of the screen. Upper left digits capture the peak negative acceleration, while upper right digits capture peak positive acceleration. UP and DOWN keys reset these numbers, so the instrument can be used to record peak accelerations during aerobatic flight. NOTE: the maximum reading is +/- 5.0 g.

f. The Voltage/Temperature screen

This screen shows battery voltage at the upper right. Cambridge thinks through little details, so battery voltage is also shown in the same location on the Power-on Altimeter screen.

g. The Thermal Statistics Screens.

These three screens are at the right of the primary screens. Circling in thermals is detected by the change in GPS Track. The screen labeled **`[Thermal]`** shows the achieved average climb rate (Upper Left), the normal averager (Upper Right), and the total height gain in this thermal.

The screen labeled **`[Total]`** shows the achieved climb rate, the percentage of time spent circling, and the total altitude gained while circling since the last reset. Totals are reset when you take off, and when elapsed time is reset to zero.

The screen labeled **`[Reset? NO]`** resets thermal statistics when you use the UP or DOWN key to select YES, and press the GO key.

h. The Variometer Scale change screen.

This screen is at the far right hand side of the primary screens. Selecting **`[Scale: x.5`**] doubles variometer sensitivity, while selecting **`[Scale: x2 ]`** halves vario sensitivity. Non-standard vario scales are indicated at the top right hand side of the screen. The scale returns to **`[Scale: x1 ]`** at the beginning of a flight.

4. Configuring the L-NAV

The L-NAV is shipped with factory default settings for many functions. Because the product is used around the world by both racing and recreational pilots, pilots can change the default settings to customize the instrument for their glider, their preferred units of measurement, and their personal tastes. To keep the primary flying screens simple and easy to understand, the necessary switches and settings are grouped together in Configure screens.

4.1 Configure and Calibrate Screens - Simplified Access Method

In previous L-NAV firmware versions, access to Configure screens was by holding GO as the power was turned on. With this new firmware, some functions have moved from the Flying to the Configure screens, so we now provide an easier way to access these screens:

Hold the GO key and LEFT or RIGHT arrow key down. Release the GO key first. You will see the word **[Configure]** on the screen. Press the GO key again to review and modify settings. Settings are stored when you return to the Main Screen by pressing GO.

Note: The factory default setting is listed first.

a. [Short Wing] [Long wing] (Choose one of two configured polars)
b. [Fast Vario] [Std. Vario] [Slow Vario]
c. [Show Netto] [Show Slope] [Show Tk Er] [Sh Thermal] [Show McC.] [Sh Max McC] [Sh MMc/Net] [Sh MMc/Slp] [Sh MMc/TEr] [Sh Thm/Net] [Sh Thm/Slp] [Sh Thm/TEr] (Parameters(s) at the upper left of the Home Screen)
d. [Alt. Req.] [Alt. Diff.]
e. [No TE Hgt.] [TE Height]
f. [Slow Alarm] (Adjust threshold airspeed)
g. [Push Tone] (# of bars below line for speed-up tone, 1-sensitive, 5-off)
h. [Pull Tone] (# of bars above line for slow-down tone, 1-sensitive, 5-off)
i. [Sink Tone] [No Sink T] (sets audio vario behavior in both climb & Cruise)
j. [Audio 1] [Audio 2] (Audio 2 gives different pattern for lift < McCready)
k. [Average S] [Average 30] [Average 20] (select averager time interval)
l. [Home 1] [Home 2] [Home 3] (select the Home screen)
m. [Km,m,m/s] [Nmi,ft,kts] [Smi,ft,kts] [Km,ft,kts]
n. [Millibars] [Inches Hg.] (Units of measure for barometric pressure)
o. [Celsius] [Fahrenheit] (Units of measure for temperature)
p. [Good NMEA] [Bad NMEA]

[GO: Polar] (See Section 4.3, The Polar entry screens)

4.2 Configuration Settings

a. [Short wing] [Long wing]

This screen exists only if two polar curves have been configured. The most common reason for 2 polars is use of wing tip extensions, so the two polars are labeled Short & Long.

b. [Fast Vario] [Std. Vario] [Slow Vario]

This controls vario response time. Fast is a time constant of about 1 second. Standard is about 1.3 seconds, and slow is about 2 seconds. Most pilots prefer the Fast setting.

c. [Show Netto] [Show Slope] [Show Tk Er] [Sh Thermal] [Sh McC.] [Sh Max McC] [Sh MMc/Slp] [Sh MMc/TEr] [Sh Thm/Net] [Sh Thm/Slp] [Sh Thm/TEr]

This selects the information shown at the top left of the Home screen.
[Show Netto] shows average of the net airmass motion. The annunciator is **Net.**
[Show Slope] shows average of achieved glide slope. The annunciator is **≥**
[Show Tk Er] shows GPS Track - GPS Bearing. --- use with a hand-held GPS receiver.
[Sh Thermal] shows average climb rate from the beginning of the present thermal.
[Sh McC.] repeats the MacCready setting shown on the HW / TW Final Glide screen.
[Sh Max McC] shows the maximum MacCready setting possible for the Final Glide.
The number shown is the maximum MacCready value at which the glide can be achieved.
The number is valid for either the Vector or HW/TW Final Glide screen
It changes from --- to 0.0 when the glide becomes possible at best L/D.
Final glide is optimized when the Max Mc Value = current Averager reading.
[Sh MMc/Net] shows Max MacCready in climb and Netto in cruise
[Sh MMc/Slp] shows Max MacCready in climb and Slope in cruise
[Sh MMc/TEr] shows Max MacCready in climb and Track Error in cruise
[Sh Thm/Net] shows the whole-thermal average in climb & Netto in cruise
[Sh Thm/Slp] shows the whole-thermal average in climb and Slope in cruise
[Sh Thm/TEr] shows the whole-thermal average in climb and Track Error in cruise

d. [Alt. Req.] [Alt. Diff.]

This selects the variable shown in the altitude field just above the alphanumeric label field for the Home Screen, the Vector Wind Glide screen, and HW / TW Glide screen.
Alt. Req. is the Altitude Required to reach the goal point. The annunciator is **Alt ---- Req** .
Alt. Diff. is Pressure Altitude - Altitude Required. The annunciator is **Alt -----** .

e. [No TE Hgt.] [TE Height]

This switch determines whether the Alt. Diff. number in e. above includes the altitude that can be gained by slowing down to best-glide speed. TE Height means yes. The switch selection also affects the glide slope bars at the right side of the LCD. Using TE Height makes the Altitude Difference number and glide bars accurate, stable, and independent of airspeed.

f. [Slow Alarm]

If a g-meter has been installed, the airspeed set in this screen is the threshold speed below which you will get the slow alarm tone in straight flight with no water ballast. A reasonable setting is approximately 10% above the glider's stall speed. **New in Version 5: Threshold airspeed is displayed in Knots for English units and Km/Hr for metric units.**

g. [Push Tone] (# of bars below line for speed-up tone, 1-sensitive, 5-off)
h. [Pull Tone] (# of bars above line for slow-down tone, 1-sensitive, 5-off)

These settings determine the speed error at which you will get an audio alert tone. The speed error for the first graphic speed bar is about 3 kts (5 kph). Each additional speed bar appears with a speed error increase of 7 knots (12 kph).

i. [Sink Tone] [No Sink T]

This switch controls sink tone in “climb” mode and Speed-to-fly alerts in “Cruise” mode.

j. [Audio 1] [Audio 2]

This switch selects the audio tone pattern for climb less than the MacCready setting.
Audio 1 gives 75%-on pattern for all lift rates.
Audio 2 gives 50%-on pattern for lift < Mc, and 75% on pattern for lift > Mc.

k. [Average S] [Average 30] [Average 20]

[Average S] At cruise/climb transition, window size starts at 1 sec. and grows to 30 sec.
[Average 30] is a 30-second moving window averager
[Average 20] is a 20-second moving window averager

l. [Home 1] [Home 2] [Home 3] (select the Home screen)

The default, Home 1, shows Altimeter reading and instantaneous component wind.

With Home 2, pressing GO shows the Vector Wind final glide screen.
This screen also shows GPS status information when no fix has been obtained.

With Home 3, pressing GO shows instantaneous HW/TW and component wind final glide altitude. This is the same as the home screen on L-NAV Version 4 and earlier.

m. [Km,m,m/s] [Nmi,ft,kts] [Smi,ft,kts] [Km,ft,kts]

This switch selects the basic units for distance, altitude, and vertical or horizontal speed.
In Nautical miles (Nmi) or Statute miles (Smi), horizontal speed is measured in Knots.

n. [Millibars] [Inches Hg.] (Units of measure for barometric pressure)

o. [Celsius] [Fahrenheit] (Units of measure for temperature)

p. [Good NMEA] [Bad NMEA]

NMEA data sentences transmitted by GPS receivers include an error detection checksum. If the sentence transmission or reception is bad, the checksum will show this, and the L-NAV can ignore the sentence.

Earlier versions of the L-NAV did not look for NMEA sentence checksum errors. Version 5 does look for checksum errors. This gives more reliable navigation and wind information. Some GPS receivers send NMEA data with bad checksums. If navigation data has intermittent problems, try selecting Bad NMEA.

4.3 The Polar entry screens

The **[GO: Polar]** screen is the starting point for entering or modifying the instrument's stored graph of sink vs. airspeed (the Polar curve). For now assume only one polar curve is needed. Press the RIGHT arrow key to see the Max L/D, the best glide ratio of the glider. Modify the number to suit the glider. The next screen shows V_M in km/hr. This is the speed of best glide angle for the glider. The next screen shows the speed, V_2 at which the glider sinks 2 meters per second. The next two screens show the dry weight (glider + pilot + parachute) and the maximum water ballast capacity (in Liters) for the glider.

Two separate polars can be entered. Typically, this is used for 15/18 meter span gliders. If you select **[2 Spans]** on the first polar entry screen, the first Configure screen lets you select the correct polar for the glider's configuration.

The default numbers are for an ASW-20. The stored polar curve is for the dry state. If the water ballast level in a polar entry screen is non-zero, a new screen appears to the left of the primary screens. The polar curve can be adjusted for the current ballast level expressed as a percentage of the maximum configured ballast capacity. Here are the relevant Metric/English conversion factors:

1000 ft = 305 meters; 1 kt = 1.85 Km/hr; 1 gallon = 3.78 liters = 3.78 Kg; 1 Kg = 2.2 lbs.

5. L-NAV Calibrate Screens

To access Calibrate screens, hold the GO key and ANY other key down together. Release the GO key first. You will see the word **[Configure]** on the screen. Press the LEFT arrow key to see the word **[Calibrate].** Press the GO key again to review and modify the settings. Store the settings and return to the Main Screen by pressing GO again.

a. [Speeds]
b. [ASI Zero]
c. [SLOW HW/TW]
d. [FAST HW/TW]
e. [Variometer]
f. [% TE Probe]
g. [Altimeter]
h. [Alt Zero]
i. [Alt Gain]
j. [G-Meter]
k. [Int. Temp.]
l. [*LCD Test*]
m. [Meter Test]
n. [Battery]

5.1 Airspeed Calibration

Quality wind data depends on accurate airspeed measurement. Screens a. - d. are for in-flight airspeed calibration. The first screen shows all speeds used in computing wind. Use this screen to verify that you have correctly connected the L-NAV to the glider Pitot and Statics.

a. Speeds	**b. ASI Zero**	**c. Slow HW / TW**	**d. Fast HW / TW**

`76.4`
`74.2`
`86.4`
`Speeds`
	`00`
	`1011`
	`03`
	`ASI Zero`
		`2.4`
		`270`
		`Slow T10.0`
			`-1.2`
			`270`
			`Fast H11.5`

See: TAS (Top Right) IAS (middle) GPS GS (bottom) (Note: The Home screen will show TW = 10 kts with the speeds shown)	See: Sensor offset (top) ASI Sensor A/D Indicated Air speed Adjust: Sensor offset (Note: adjust Sensor to read 1012 at zero airspeed.)	See: Slow ASI Offset Glider Track Wind component Speed-to-fly bars Adjust: Slow ASI offset so maximum H and T Wind are equal at best L/D speed.	See: Fast ASI offset Glider Track Wind component Adjust: Fast ASI offset so maximum HW is independent of airspeed

Notes:

Factory ASI sensor calibration is done with two trimpots on the sensor board. The Analog/Digital (A/D) converter reading is set to 1012 at zero airspeed. With Slow and Fast ASI offsets set to zero, the sensor gain is factory calibrated at 80 knots.

The ASI zero screen allows the pilot to make the sensor accurate at zero airspeed without opening the instrument. Use the UP or DOWN key to get an A/D reading of 1012 counts when the glider is stationary. Store the offset value in non-volatile memory by pressing the GO key. If the offset is more than 40 counts, consider sending the unit to Cambridge over the winter.

The Slow and Fast ASI offset screens are used in flight to compensate for airspeed errors present in the entire glider pitot-static system. Calibration is much easier in quiet air. Therefore we suggest calibration flights be done in the morning before thermal activity begins. Calibration is also easier in light winds.

The vector wind is accurate even with significant errors in True Airspeed (TAS). This is because an airspeed error averages out when wind measurements are made at many different headings. Therefore, an accurate vector wind can be used to correct the airspeed measurement. Here are the procedures:

1. On the flying screens, enter your current altitude and outside air temperature readings. This is important because it affects the conversion of Indicated to True airspeed. (This procedure is not required if the optional Auxiliary PC board and temperature probe are installed.)

2. Fly several smooth slow circles at the glider's best L/D speed. Note the vector wind speed and direction.

3. Go to the **[Slow HW/TW] Calibration** screen. The objective is to adjust the L-NAV, if required, so that the indicated maximum tailwind matches the maximum headwind at the best L/D speed. (This must be so in the actual atmosphere.)

a. Fly directly downwind at the glider's best L/D using the graphic speed commands. Note the indicated Tailwind. With the UP or DOWN key, adjust the correction factor until the indicated TW matches the Vector wind strength.

b. Fly directly upwind to verify that maximum HW = maximum TW. Re-adjust the Slow correction factor until agreement is reached.

3. Go to the **[Fast HW/TW]** screen. The objective is to adjust the L-NAV to minimize dependence of wind calculation errors on speed. (In real life, the wind does not depend on the glider's speed.) Use the following procedures to determine airspeed influences:

a. Fly upwind at best L/D and note the HW value.

b. Gradually increase speed to your typical fast cruise airspeed. Stabilize speed and note the new HW value.

c. Adjust the Fast Offset number so HW is the same at fast and slow speeds.

d. Repeat the maneuver to verify matching HW at fast and slow speeds.

The glider's airspeed measurement system has now been calibrated by reference to precision groundspeed data from the GPS receiver.

5.2 Other Calibrate Screens

e. [Variometer]

This screen shows the Variometer A/D reading. With no lift or sink, the reading should be 511. If is not, you may add or subtract an offset with the UP or DOWN arrow keys. If the offset is more than 40 counts, consider sending your unit to Cambridge over the winter.

f. [% TE Probe]

This screen allows you to make in-flight calibration of the total energy probe. To a large extent, you can correct for non-ideal probe installations. The number on the screen is the "percentage of ideal suction the probe is actually providing". If your total energy system is under-compensated (vario needle swings UP in a gentle pull-up), DECREASE the number on the screen.

g. [Altimeter]

This screen is solely for diagnostic purposes. The L-NAV has a dual-range altimeter. At about 10,000 ft, the altimeter changes range. This screen shows the Altimeter A/D reading, the Lo range - Hi range offset (should be about 900 counts, and the Altitude reading should not change.

h. [Alt. Zero]
i. [Alt. Gain]

These screens are used to calibrate the L-NAV altimeter. For the L-NAV, connect the altimeter fitting nearest the PC board to a reference altimeter and adjustable pressure/vacuum source. Use the Alt. Zero screen at zero altitude. Use the Alt. Gain screen at 3000 meters (9000 ft). Zero and Gain settings interact. You will need to go back and forth between high and low altitude to achieve calibration. Altimeter gain and zero settings are stored in the L-NAV non-volatile memory chip. They are also written on a small tag inside the instrument cover.

j. [G-Meter]

The G-Meter is optional. If there is no G-Meter present, the Analog/Digital (A/D) converter reading should be 511. The G-Meter reading with the L-NAV on a horizontal surface should be 611. The instrument senses only the vertical component of g-force. When the instrument is rotated 90 degrees, this component goes to zero, and the A/D reading should be 511. (1 g = 100 counts) The reading can be corrected using the UP or DOWN key to enter an offset.

k. [Int. Temp]

A/D reading and temperature for the internal sensor are shown here. No adjustment is possible.

l. [*LCD Test*]

This screen shows all the LCD segments. The UP key operates the speed command graph. The DOWN key operates the glide slope graph.

m. [Meter Test]

With this screen, you can check audio sounds and variometer indicator calibration. Mid-scale for the indicator and tone is at 127. Zero and 255 are at full scale for the meter. Pitch of the tone is the same as for the variometer under actual flight conditions.

n. [Battery]

A/D converter reading associated with battery voltage is shown on this screen. No calibration adjustment is possible.

5.3 Returning the Instrument to Factory Default settings

Configuration and Calibration settings are stored in non-volatile memory. This means they are retained even if the instrument's backup battery is dead. When power is applied to the instrument, the configuration is transferred to volatile RAM for quick access.

The factory default configuration is stored in the main program EPROM. These settings are transferred to non-volatile memory at the factory. Except for altimeter calibration settings, you can return the instrument to factory default settings as follows:

Hold down GO and any other key. The word **[Configure]** will appear.
Press the LEFT arrow key twice. The word **[Defaults]** will appear.
Press GO. You will see the Main Screen.
Re-enter your choices for Configure and Calibrate settings.

6. L-NAV Installation

6.1 Pneumatic tubing

Using PVC or silicone tubing of 3/16" inside diameter, connect the 4 pneumatic inputs to the instrument. Use the same sources of Pitot and Static pressure as those for the glider's mechanical airspeed indicator. Use tubing "tee" fittings as appropriate. Use another "tee" fitting to connect the glider's Total Energy (TE) probe to both the L-NAV TE input and the mechanical variometer. The supplied 0.45-Liter variometer flask is connected to the L-NAV Flask fitting.

6.2 Power and external speaker connections

Connect the red {+} and black {-} wires to the glider battery. No separate fuse is needed if the battery itself is fused at less than 5 amps. L-NAV current drain is about 160 ma.

L-NAV REV. 4 main PC boards (from 1993+) can drive an external speaker. Connect an 8-ohm speaker to the yellow and green wires of the power cable. The internal 8-ohm speaker can be removed and used for this purpose. Alternatively, both internal and external speaker may be used together.

6.3 Hold switch cable connections

The yellow wire is the common ground wire for all functions of this cable. Yellow and green wires go to the optional "hold" switch. The switch can be mounted on the instrument panel or the stick. When the hold switch is closed, the L-NAV goes into "climb" mode. Speed-to-fly tones and the speed-to-fly bar graph are turned off. When the instrument is in dead-reckoning mode (no GPS distance information available), the "hold" switch turns off distance counting.

The L-NAV has connections for two microswitches that control spoiler and landing gear alarms. The black and yellow wires in the “hold” cable go to a switch actuated by the spoilers. The switch is closed if the spoilers are not in the locked position. This switch activates the **`[spoilers?]`** alarm. The red and yellow wire go to a switch actuated by the landing gear. The switch is closed when the landing gear is up. This switch and the spoiler switch activate the **`[L Gear Up?]`** alarm.

Please note that the landing gear alarm does not work unless the glider is flying (Airspeed above 25 knots). Enter an offset in the **`[ASI zero]`** Calibrate screen to artificially raise airspeed for ground testing purposes. Don’t forget to reset the airspeed zero!

6.4 Variometer, Remote Keypad, and Repeater connections

Connect the vario readout to the L-NAV meter port. If you are using either a remote keypad or a rear seat repeater in a 2-seat glider, the optional L-NAV auxiliary PC board must be installed. Connect a remote keypad or special stick with keypad to the port labeled Remote. The rear seat repeater connects to the port labeled "Repeater" with a 6 wire modular cable. The rear seat vario readout plugs into the 4 wire modular socket on the L-NAV repeater.

6.5 Optional Outside Air Temperature Probe Installation

The temperature probe MUST be mounted so that it senses outside air temperature. A ventilation duct is usually the best place, but only if fresh air is always moving through it. Note that the temperature probe tip must not be in contact with the wall of the ventilation duct. Another mounting spot on some gliders is the tow hook opening at the front of the fuselage.

6.6 GPS receiver connection

The national Marine Electronics Association (NMEA) publishes several data interface standards. Originally set up for connecting LORAN receivers to moving map displays and marine autopilots, the standard has been upgraded to include GPS and aviation related functions. The L-NAV requires the GPS receiver to transmit the $GPRMB and $GPRMC sentences as defined in NMEA-0183 Version 2.1. Most currently available hand-held GPS receivers will transmit these sentences.

Important Note:

To work with the Cambridge L-NAV, the GPS receiver must be configured to transmit NMEA-0183 Version 2.0 sentences at 4800 baud.

The L-NAV is supplied with a six wire modular cable labeled "Datacom/GPS". As you face the rear of the L-NAV, pin 1 of the Datacom connector is on your <u>right</u> side. Only two of these wires are used for the NMEA sentences from the GPS receiver. These are:

The A-line (signal +) = pin 4, Red wire   Logic Ground (signal -) = pin 6, White wire

Note: Face the rear of the L-NAV. Make sure the White wire is on the LEFT side of the 6 pin modular connector when it is plugged into the L-NAV. If the BLUE wire is on the left side of the connector use the following wire colors:

The A-line (signal +) = pin 4, Green wire   Logic Ground (signal -) = pin 6, Blue wire

The GPS receiver has a matching pair of wires in its interface cable. Color codes will NOT match those in the Cambridge L-NAV GPS cable. Here is a list of interface wire colors for some common GPS receivers:

GARMIN GPS-100	A-Line = Yellow	Ground = Black
GARMIN GPS 55, 45, 89, 90, GPS 12, GPS III	A-Line = Brown	Ground = Black
Lowrance Airmap & Explorer	A-Line = White	Ground = Shield

The Trimble Flight-Mate and Apollo Portable use a female 9-pin D connector, which may be plugged directly into a PC. For this connector: A-Line = Pin 2   Ground = Pin 5.

Connect the L-NAV A-line (pin 4) to the GPS receiver A-Line
Connect the L-NAV Ground wire (pin 6) to the GPS receiver Ground wire

The Cambridge GPS-NAV is designed to work with the Cambridge L-NAV. This means connection is made between the two products with a 6 wire modular cable. No wire splicing is needed. See section 7.7 for instructions in making up custom cable lengths.

7. Maintenance and Hardware Calibration

7.1 Removing the Instrument Top Cover

The L-NAV is designed for easy service and upgrade. Don't worry about taking it apart. Here is how to open the instrument case: Remove the screw near the front of the top cover. Loosen 4 screws around the sides of the case bottom and 2 screws at the top of the rear panel. Gently pull the top cover straight up. When putting the cover back on take care that the silicone rubber tubing does not get pinched between the PC board and the case.

Check www.cambridge-aero.com for up-to-date maintenance information.

7.2 Adding the Optional G-Meter

As you face the front of the L-NAV, the G-meter goes towards the left rear of the instrument. It fits in the plastic guide, and connects via 6 pins to the main PC board. Before inserting the G-Meter, a small black jumper must be removed from the rearmost 2 pins. When the instrument is re-started the instrument recognizes the presence of the G-meter and its current reading will be shown on a screen at the far left of the flying screens.

The G-Meter is factory calibrated with an A/D reading 611 counts at 1.0 g and 511 counts at 0 g. Check this in the Calibrate screens and adjust the G-meter A/D offset as required. You can do this because the entire earth is a 1-g calibration field. Don't forget to exit the Calibrate screen by pushing the GO key to store the new offset value.

7.3 Adjusting L-NAV Display Contrast

If the L-NAV is mounted in an unusual instrument panel location, it may be easier to read if the LCD contrast is changed. Facing the front of the instrument, the LCD contrast control is near the left front of the main PC board. Clockwise rotation darkens the screen.

7.4 Adjusting Vario and Airspeed Zero and Gain

These adjustments should not be required in normal use. The information is provided for reference purposes. Gain adjustment requires a calibrated reference instrument. Vario and airspeed sensors each have three adjustments. The airspeed sensor is nearest the front of the instrument. For each sensor the adjustment trimpot locations are as follows:

Trimpot location	Trimpot function
Nearest the front (dab of red paint)	Sensor temperature compensation (DO NOT ADJUST!!)
Middle of group	Sensor zero adjustment
Nearest the rear	Sensor gain adjustment

Before adjusting trimpots, set firmware offsets to zero in the appropriate Calibrate screen. Correct sensor readings at zero airspeed and zero sink are listed in Section 5 of this User's Guide. When adjusting airspeed gain, Slow and Fast offset numbers must also be set to zero. Cambridge calibrates airspeed sensor gain at 80 knots and vario gain at + 5 knots.

7.5 Replacing the Memory Backup Battery

The 3 volt lithium coin cell battery (type BR-2325) preserves flight information. It should last more than 5 years. You will get a screen message when the output drops to 2.2 volts. There is no emergency. Replace the battery at the end of your flying season.

7.6 Rear Panel Connector Wire Color Codes

As you face the rear of the L-NAV, connector pin 1 is on your right.

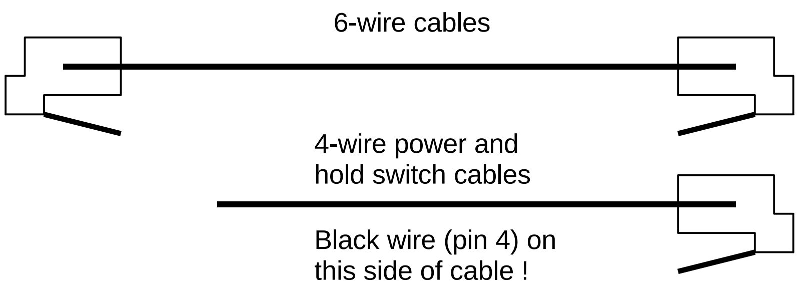
4-wire color	Yellow	Green	Red	Black	-------	-------
6-wire color	Blue	Yellow	Green	Red	Black	White
Port Name	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6
12 Volts	Speaker +	Speaker -	+ Power	- Power	---------	------
Meter	Ground	Meter +	Meter -	Ground	------	------
Hold	Ground	Hold Switch	Gear Switch	Spoiler Switch	--	------
Datacom	+ 5 Volts	Data from L-NAV	-----	Data to L-NAV	------	Logic Ground
Remote (Optional Aux. PC Board,)	GO key	RIGHT arrow	LEFT arrow	Logic Ground	DOWN arrow	UP arrow

7.7 Modular Cables and Connector

The L-NAV uses USA standard modular telephone-style connectors and cable. Factory supplied cables should be used when possible. We strongly discourage use of cheap, consumer grade cable, connectors, and tools for this work. For custom installations, Cambridge sells quality supplies at our cost:

Part #	Description	Price
XE 034	4 pin AMP RJ Crimp Tool with 50 plugs	$30
XE 035	6 pin AMP RJ Crimp Tool with 50 plugs	$30
XE 036	RJ Modular Cable Tester	$40

We recommend ferrite beads on all cables to minimize radio interference.
Note the orientation of connectors on all Cambridge modular cables:



8. Specifications

Size: 3.3" (84 mm) height and width, 7.7" (196 mm) depth behind panel;
Fits Standard 3 1/8" (80 mm) instrument panel cutout.
Choice of 3 1/8" (80 mm) or 2 1/4" (58 mm) diameter vario readout.

Weight: Computer unit: 1.5 lbs. (0.7 Kg), Vario readout: 0.6 LB (0.27 Kg)

Power: 8 to 16 volts at 0.14 to 0.18 Amps depending on audio level

Processor: 80C552 with 64 Kbytes ROM, 32 Kbytes RAM, and 1 Kbit EEPM

Backup Battery: Lithium Coin Cell, type BR2325

Datacom: Industry Standard RS-232 voltages and protocols

Airspeed: Thermistor flow sensor, Range 0 to 170 kts (0 to 300 km/hr)

Variometer: Thermistor flow sensor with standard external 0.45-liter flask

Altitude: Piezoresistive Sensor, Range +26,000 Ft (8,000 meters)

Acceleration: Closed Loop mass-balance type, Range ±5g, Resolution 0.01g