EyeHead Integration Instruction

Manual

(Windows User Interface)

for use with Series 5000
Head Mounted Eye Tracker
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1. INTRODUCTION

The EyeHead™ Integration package, for use with head mounted eye trackers, enables integration of eye and head position data to compute point of regard. Point of regard is computed with respect to a room fixed (or cockpit fixed) scene space. The scene space is defined by a set of planes, consisting of one calibration plane and a variable number of additional, bounded planes. If the Stationary Scene Camera (SSC) option is included, then point of gaze in the environment can be superimposed on the image from a stationary (as opposed to head mounted) video camera.

The required hardware includes a head mounted eye tracker (eg. model 501) with magnetic head tracking (MHT) option and an MHT transmitter mount and Gimbal Pointer (EH-G). A laser pointer (EH-L) is also recommended. Required software is the standard EYEPOS (e5Win) with EyeHead™ Integration option (EH). All of the above additions to the basic eye tracker system (EH, MHT, EH-G, and EH-L) are included in an option package designated EH-S. The stationary scene camera capability, mentioned above, is an additional software option designated as EH-SSC.

The MHT electronics unit is normally plugged into a serial port labeled “HEAD TRACKER” on the model 5000 eye tracker control unit. Integrated Eye-Head data can be output in real time through another serial port (labeled “SERIAL OUT”) or recorded on the Eye Tracker Interface PC. The protocol for “SERIAL OUT” is described in section 6.

Installation of a magnetic head tracking system is discussed in Section 8 of this manual. Installation and placement of the transmitter mount and gimbal pointer assembly is described in section 9. Many of the procedures described below assume that the magnetic transmitter mount and gimbal pointer assemblies have been properly installed, and that the MHT unit is properly connected.
2. INTERFACE SOFTWARE

Software for EyeHead Integration is contained within the EYEPOS software supplied with the eye tracker, when the EyeHead Integration option is included. Please read section 3.6 of the model 501 Eye Tracker Instruction Manual for software installation instructions, and section 4 of the same manual for instructions on uploading software to model 5000 Control Unit and running the E5Win program on the Eye Tracker Interface PC.

The Eyehead pull down menu has the following selections:

<table>
<thead>
<tr>
<th>Eyehead</th>
<th>Setup...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gimbal Test</td>
</tr>
<tr>
<td></td>
<td>Integration</td>
</tr>
<tr>
<td></td>
<td>Data Display</td>
</tr>
<tr>
<td>Initialize</td>
<td></td>
</tr>
<tr>
<td>Enable Stationary Scene Camera</td>
<td></td>
</tr>
<tr>
<td>Stationary Scene Camera Target Points...</td>
<td></td>
</tr>
<tr>
<td>Head Environment...</td>
<td></td>
</tr>
<tr>
<td>Save Environment As...</td>
<td></td>
</tr>
</tbody>
</table>

The items in the “Setup” menu provide the program with information about the physical environment and various user selectable options. The remaining items enable various Eyehead program functions. The menu choices are all explained in the subsequent sections.
3. ENVIRONMENT SPECIFICATION

The EyeHead™ “environment” consists of the magnetic head tracker transmitter and up to 20 surfaces of interest. These surfaces are assumed to be flat (although curved surfaces may be approximated as one or more flat surfaces), and are assumed to be fixed (not moving) with respect to the magnetic transmitter. Typical surfaces include monitor screens, keyboards, poster displays, slide screens, walls, etc. It is recommended that the environment be arranged so that all surfaces are within the pointing range of the gimbaled laser pointer mechanism available from ASL (see section 9). If it is not possible for all surfaces to be within range of the pointing device, there are other ways to specify the location of such surfaces (consult ASL for details).

Before any EyeHead Integration can take place, all of the scene planes (flat surfaces) of interest must be defined in an "environment" file. The environment file is created or modified from the E5Win program (on the Interface PC) by using dialog windows under the “Eyehead, Setup” menu selection. Some of the information is typed into the dialog windows, and some necessary vector direction information can also be provided by pointing the gimbal pointer device, or holding the magnetic sensor directly on target points.

These procedures are described in the succeeding manual subsections. Before explaining the mechanics of entering environment information to the computer, the rules and theory for preparation of the physical environment are discussed below.

The surfaces in the environment must consist of a calibration surface (plane 0) and up to 20 additional scene planes. The calibration surface will contain 9 (or optionally 17) calibration target points for eye tracker calibration. It should subtend at least 20 degrees visual angle during calibration so that calibration target points can be separated by at least 10 degrees (see figure 3-1). Furthermore, during the eye tracker calibration procedure, it is best if the vector from the subject’s eye to the center target point (point 5) is roughly normal to the surface, and point 5 is roughly in the center of the subject’s field of view. In other words, the subject should be able to look at this surface "straight on" during calibration.

A coordinate frame must be assigned to the calibration surface, as shown in figure 3-2.
The coordinate frame y-z axes must lie on the surface with y-axis units increasing to the right and z-axis units increasing from top to bottom. (The x-axis is normal to the surface) The y and z-axes will often be referred to as "horizontal" and "vertical" axes respectively. The nine target points must have known y-z coordinates in this frame, expressed in inches (or centimeters). It is strongly suggested (although not required) that eye calibration point 5 be at the origin of the calibration plane coordinate frame ($y = 0, z = 0$).

![Figure 3-2. Calibration Plane](image)

All other designated scene surfaces must also have an associated coordinate frame and must conform to the same guidelines as the calibration scene plane, with the following exceptions:

1. The associated coordinate frame(s) need not have its origin in the center of the plane, although the real time display will place the scene plane's origin in the center of the screen. The scene surface must still coincide with the y-z plane of its coordinate frame.

2. There is no restriction on the orientation of the planes (whereas the calibration plane should be viewed "straight on" during calibration).

3. Only the calibration plane need have nine eye calibration target points.

A rectangular boundary must also be determined for each scene plane, including the calibration plane, and is specified by a top, bottom, left, and right coordinate. The top coordinate is the z value at the top edge of the surface (minimum z value on the surface); the bottom coordinate is the z value at the bottom edge of the surface (max z value).
Similarly, left and right coordinates are the minimum and maximum y values. This boundary specifies the possible eye point of gaze intersection area for that scene plane. **EXAMPLE:** if your scene plane was a 17in monitor, your scene boundary coordinates might be Top - 8, Left - 8, Right 8, Bottom 8.

**The calibration surface is designated as plane 0, and all other surfaces as planes 1 through 20.** When eye-head data is integrated, point of gaze values will be specified as a plane number, a y (horizontal) value and a z (vertical) value. The y-z values will correspond to the coordinate frame that is attached to the designated plane as described above.

Three points must be chosen on each plane to enable the computer to define that plane relative to the MHT source. Looking towards the scene plane from the MHT source, the three points should have the relative positions shown below. Note that the three points form an "L" shape, with A at the lower right, B at the vertex, and C at the upper left.

![Figure 3-3. Points "A", "B", and "C" used to define surface.](image)

The calibration scene may, optionally, have its three points defined as follows for convenience: Point A is equal to calibration target Point 9, point B is equal to calibration target point 7, and point C is equal to calibration target point 1. Other planes must simply adhere to the relative positioning described above. The coordinates of the three points must be expressed in inches (or centimeters).
3.1 Units

The user can choose to specify EyeHead environment parameters in either English, or Metric units. This choice is made on the Config menu, System Settings dialog window.

Find the check box titled "Use Metric System". If EyeHead parameters are to be specified in metric units, be sure that there is a check in this box. To use English units, be sure that the box is left unchecked.

If Metric units are selected, all distance parameters must be specified in centimeters. If English units have been selected, all distance parameters must be specified in inches.

3.2 EyeHead Setup

To begin specifying the environment for EyeHead Integration, pull down the EyeHead menu. Selection of the “Setup” sub-menu will bring up the “EyeHead Setup” dialog windows, as shown in figure 3-4. Selecting any of the four labeled tabs will bring up a window with items associated to that heading. Uses of items within each tabbed window are explained in the following subsections. When the OK or Apply button is clicked information entered in any of the tabbed dialog windows becomes part of the default environment file called e5000.env.
Figure 3-4. EyeHead Setup dialog windows. Each tab brings a different window to the front.

### 3.2.1 General Parameters

The General parameters window (in the foreground in figure 3-4) is used to specify parameters that deal with the EyeHead integration process as a whole, as opposed any particular scene plane.

- **MHT Transmitter offsets in Transmitter Coordinates**: The first item in the General window, “MHT Transmitter Offsets in Transmitter Coordinates” specifies any displacement between the magnetic transmitter and the center of the pointer gimbals. Normally the transmitter is at center of the gimbal (there is no displacement) and this vector should have all zero components. To accommodate environments with unusual physical constraints it is possible to separate the transmitter from the gimbal wand assembly, and this is discussed in section 3.7. If the transmitter is mounted in the standard fashion (on the transmitter mount that holds the gimbal wand assembly) be sure the “MHT Transmitter Offset in Transmitter Coordinates” values are set to zero.
• **MHT Sensor to Eye Vector** … The second item in the window, MHT Sensor to Eye Vector Coordinates in Sensor Coordinate Frame, is the vector from the MHT sensor to the eye in MHT sensor coordinates. The appropriate values are given for any helmet or headband supplied by ASL. (A description of methods for computing this vector is also available as ASL Technical Note 5028). Although the eye will not be in the same position, with respect to the helmet, for every subject, the EyeHead integration process is insensitive to small differences in the sensor-to-eye vector.

To enter the vector in the "General parameters" window, position the cursor in the appropriate box, and type in the coordinate value.

• **Final Scene Coordinate Units** The third item in the window specifies any offset or gain to be applied to the recorded point of gaze values. With default values of gain=1.0 and offset=0, recorded point of gaze values will correspond to the original scene plane coordinates for all planes. Any offset or gain specified will apply to all planes. Assuming English units have been selected (as described in section 3.1), non-default gain values can be used, for example, to obtain final output values in feet (gain=0.0833) instead of inches.

• **Options for Specifying Points A,B,C** The fourth item in the window is a set of radio buttons used to select the method for providing information about the locations of points A, B, and C, on each scene plane, with respect to the magnetic transmitter. The standard method is the first radio button choice ("Point with gimbal wand"). Except for section 3.7, the descriptions in this manual will assume that “Point with gimbal wand” has been selected. Alternate methods are described in section 3.7.

• **MHT Transmitter Center to End of Gimbal Pointer Magnitude** This value is the distance from the center of the Transmitter to the end of the Laser pointer, as shown in figure 3-5.

![Image of MHT Transmitter Center to End of Gimbal Pointer Magnitude](image)

**NOTE:** Wand Extension B is not standard and is provided upon request only.

**Figure 3-5. Transmitter center to end-of-laser distance.**

The distance from the end of the pointer to the transmitter is usually supplied by ASL with each system. *Excluding wand extension B, the MHT center to Gimbal pointer magnitude is 19.5 inches or 49.53cm. Note: Due to manufacturing inconsistencies the true measure will differ slightly for each wand.* It can also be easily measured with a ruler. Point the Gimbal Pointer straight ahead (roughly in the direction of the transmitter x-axis), and use
a ruler to measure the distance from the inner gimbal pivot point (center of the transmitter) to the measuring point at the end of the laser. Enter the value, in the selected units (inches or centimeters), next to "MHT Transmitter Center to End of Gimbal Pointer Magnitude ".

- **Miscellaneous Scene Plane Parameters**
  - Next to "Number of scene planes other than calibration plane", enter the number of scene planes to be defined in addition to the calibration plane. If only the calibration plane will be defined, this item should be set to 0.
  - "Real Time Graphics Grid Pattern Scale (units per div)" refers to the distance represented by the grid line spacing on the real time integration display. Type the desired value in inches (or centimeters). The function of the grid pattern display is discussed in more detail in section 3.4.
  - The check box labeled "Display Multiple Eye Position Cursors on the Grid" refers to the real time EyeHead Integration display, discussed in more detail in section 3.4. If this box is not checked, one cursor will be displayed showing point of gaze on whichever scene plane is being viewed. If this box is checked, a large cross always shows point of gaze with respect to scene plane 0, or an imaginary extension of scene plane 0. A slightly smaller cross shows point of gaze on other scene planes and an even smaller cross shows eye position with respect to the head. The multiple cursors provide more information, but can also be more confusing. It is recommended that this box be left unchecked (single cursor display) until some experience is gained with the system. Use the mouse to check, or uncheck the box.
  - The check box labeled "Record Integrated Eye-Head Data" determines what kind of data can be recorded on a disk file by the e5Win program (data recording is discussed in section 5). If this box is not checked, recorded data will be eye line of gaze with respect to the head, and MHT head position values. The data will not reflect the EyeHead Integration computations. Such files are referred to as "raw eye data" (or ".eyd") files. If the box is checked, and EyeHead Integration is enabled, recorded data will contain the results of the EyeHead integration process. These files are referred to as "eye-head" (or "ehd") data files. Eye-head data files record the scene plane being viewed, the coordinates of the subjects gaze point on that surface, the distance of the eye from the spot being fixated, and pupil diameter. It will usually be desirable to check this box so that integrated EyeHead data is recorded.

Click “OK” to save current selections and exit from the Setup sub-menu or select another tab to continue. Click “Cancel” to exit without saving changes to the window.

### 3.2.2 Calibration Scene Plane

Click on the tab labeled "Calibration Scene Plane" to enter data that applies only to the special "calibration" plane, also called plane0 (see figure 3-6).
Start by entering the Y and Z values of Point 1 with respect to the plane 0 coordinate frame. The dialog window has a space for a "y coord" and "z coord" for each target point. Be sure to carefully determine the coordinates of each target point, in inches (or centimeters), with respect to the y-z coordinate system assigned to the calibration plane (as previously discussed in section 3). Remember the recommendation to choose the origin of the calibration plane to be at target point number 5 so that point 5 will have the coordinates (0,0). Remember also that the y-axis is the horizontal axis when looking at the surface, and the coordinate values increase to the right. The z-axis is the vertical axis, and values increase downward. (The scene plane coordinate frame is discussed in section 3).

For example (assuming point 5 was at the origin) a Y value of -8 and a Z value of -6 would translate to Point 1 being located 8 inches to the left and 6 inches up from the origin (pt 5). Repeat the same for all nine calibration target points.

**Alternately**, and only if the points are symmetrically spaced,
- Enter the coordinates of Point 1 and 9
- Click "Auto Set Using Points 1 and 9" and the program will automatically fill in the remaining Y and Z values and a symmetric, evenly spaced pattern.
Click OK to save current selections and exit from the “EyeHead Setup” menu or continue by choosing another tabed heading.

### 3.2.3 Individual Scene Plane Parameters

Selecting the tab labeled **Individual Scene Planes** will bring up the dialog window shown in figure 3-7. This information in this dialog must be filled out for **all** scene planes, including the calibration plane.

![Individual Scene Plane Parameters Dialog](image)

**Figure 3-7.** EyeHead Integration Setup, Individual Scene Planes dialog window.

* The items displayed in the window, will contain information for **only the specified plane**. The desired Plane can be selected by clicking the down arrow next to “Scene Plane” box. A drop down window will open showing available scene plane numbers. Click the desired plane number.
The "Individual Scene Plane" window is used to enter:

- The magnitudes of the vectors from the MHT source to each of the scene plane points A, B, and C;
- The scene plane coordinates of points A, B, and C for each plane
- The boundaries of each plane.
- Manual offset values, which can be specified to correct offset errors in point of gaze results on any plane.

This information must be entered for all scene planes including the calibration plane. The calibration plane (surface with subject calibration target points) is plane number 0, and all additional planes are numbered sequentially, starting with 1. Remember that the number of additional scene planes was specified in the "General Parameters" window.

First be sure that the desired scene plane is selected, then fill in the information as described below.

- MHT-Transmitter-to-Point-Magnitude The first category is used to specify the distance from the magnetic transmitter to points A, B, and C on the current scene plane. The distance values are usually measured with a ruler. Note that this item is for use of the gimballed laser wand to specify points ABC. If one of the non-standard methods for entering point A, B, C information was selected in the General parameters dialog window (see section 3.2.1), then this first item in the Individual Scene Plane window will be gray, and can be ignored. See section 3.7 for explanation of the non-standard ABC entry options.

The measurements are most easily made using the gimballed laser pointing device. The gimbals attach to the MHT source (transmitter) mount. This pointing device is usually referred to as the "gimbal pointer" or "laser pointer". (Assembly and installation of the gimbal pointer device is described in section 9.

The values typed into this section are the distance from each point (A, B, and C) to the end of the laser. The distance from the laser to the transmitter ("MHT transmitter center to end of Gimbal Pointer Magnitude") was entered previously and will be automatically added when the system does its computations. It is displayed, for convenience, in this section.

To make a measurement, move the pointer so that the laser shines on one of the points, and measure the distance from the end of the laser pointer to the point on the scene plane. It will easiest to do this with two people, so that one person can "point" while the other measures. Repeat for each of the three points (A, B, and C) and type the resulting values, in inches (or centimeters), in the areas labeled "Point-A", "Point-B", and Point-C".

- Point ABC Coordinates in Scene Frame: This item category specifies the coordinates of points A, B, and C in the coordinate system that user has defined on the scene. For plane 0 the coordinates for calibration target points 9, 7, and 1 (lower right, lower left, and upper left) respectively can be automatically entered by clicking the corresponding button on the right.
For other planes, the point A, B, and C coordinate values must be carefully determined and entered. Remember that these are coordinates in the y-z plane assigned to the surface as described in section 3, and illustrated in figure 3-3). Remember also that the three points must form an "L" shape, with point A at the bottom right, point B at the vertex, and point C at the upper left.

**Point ABC Coordinates in Transmitter Frame:** Assuming that “Point with Gimbal Wand” was selected on the “General Parameters” window, the digital value boxes are “grayed out”. The vectors are computed by the system after the laser wand, containing the magnetic sensor, is pointed at points A, B, and C. The pointing procedure is initiated by clicking the “Set with Pointer” button. The procedure may require two people, one to aim the laser pointer and one to operate the computer. Note that "MHT-Transmitter-to-Point-Magnitude" and "Point ABC Coordinates in Transmitter Frame" values must always be properly entered (as described in the preceding paragraphs) before selecting “Set with Pointer”.

Click the “Set with Pointer” button.

A pop up window will appear.
The window will prompt “Aim Gimbal Pointer at Point A”. Aim the laser dot at Point A, and, holding the dot on point A, click “Set”. This will lock in the position of the magnetic sensor, for point a, and these digital values will be displayed next to the “Point A” label. Keep the laser spot centered on point A until the pop-up window prompt changes to point B, as shown below. Repeat for point B, and then for point C.

When the display returns to the point A prompt, either repeat the procedure if you think you made a mistake, or click “OK” to exit the procedure. Once “OK” is clicked, equations will be computed for the selected plane, and the pop up window will be closed. The digital values in the “Point A, B, C coordinates in transmitter frame” box should now correctly display the vectors that connect the transmitter with each point. The procedure applies only to the scene plane specified at the top of the “Individual Scene Plane” dialog window. Remember to do the above procedure for all scene planes.
• **Rectangular-Scene-Plane-Coordinates:** Enter the top, bottom, left, and right boundary coordinates for the current scene plane. These coordinates are expressed in inches (or centimeters), in the coordinate system defined for this scene plane. In other words the "top" of the plane is the distance of the top edge of the surface from the coordinate frame origin (along the z-axis, as illustrated in figure 3-3). In the case of plane 0, for example, this will usually be the distance above target point 5.

• **Manual Offset:** The "Manual Offset" values, the last item in the window, can be used later to correct remaining errors after the "Compute Plane eqns" procedure has been performed. These offset values should initially be set to zero.

### 3.3 Stationary Scene Camera Parameters (Optional)

Integrated eye-head data can be displayed as a point of gaze cursor, superimposed on the image from a stationary (as opposed to head mounted) video camera, or other scene video source.

![Eye Head Setup](image)

- **Scene Plane** Select the desired scene plane by clicking on the down arrow of the “Scene Plane” dialogue box or by clicking on the “Previous” or “Next” buttons.
• **Scene Plane Coordinates** Enter coordinates of the five Stationary Scene Camera Target Points for the given scene plane. **NOTE:** no two points can have the same vertical and horizontal coordinate.

• **Enable** Check the “Enable” box at the top right to enable the stationary scene camera for the given scene plane.

For a detailed explanation of how to set up an environment with a stationary scene camera, or equivalent video source, see section 7.

### 3.4 EyeHead (Grid Pattern) Display

When testing environment specifications, or when actually doing EyeHead Integration, data can be viewed, in real time, on a special EyeHead display. The EyeHead display replaces the "ScenePOG" display in the upper right section of the e5Win screen.

It will automatically appear when entering the Gimbal Test mode or EyeHead Integration mode (described in subsequent sections), but can also be toggled on and off with the "Data Display" selection on the EyeHead menu.

**Over View:** The EyeHead display is characterized by a grid pattern that covers the display window. The title of the display changes from "ScenePOG" to "EyeHead", and a numerical display appears just under the graphics window.

The center of the grid represents the origin of all scene planes. The nine calibration target points are displayed as small yellow circles on the grid pattern. The space between grid lines represents the scene distance specified in the "General Parameters" window (section 3.2.1). Red circles indicate POINTS ABC. (see figure 3.8).
The **EyeHead data window** displays the digital values of line gaze intersection points on one of the defined scene planes. It is located just under the graphics window to the left of the MHT Transmitter Offset column.

![Image of EyeHead interface](image)

**Figure 3-8.** Eye tracker Interface (e5Win) main window, when EyeHead Integration is enabled.

**Scene:** \( n \) is the number of one of the defined surfaces. It will be an integer value from zero to twenty, specifying the scene plane first intersected by the eye line of gaze vector. (If no intersections are found, scene plane 0 will be displayed by default, and the intersection coordinates will correspond to an infinite extension of plane 0.) The “**Scene**” number specifies the scene plane currently represented by the grid pattern. This **Scene** number and graphics window will change as the subjects point of gaze switches between defined scene planes. **Magn** is the distance of the eye from the point of gaze, displayed in the specified units (inches or centimeters). **Vpos** and **Hpos** are vertical and horizontal point of gaze coordinates. They represent \( y \) and \( z \) axis values of point of gaze on the designated scene plane, also in the specified units.

**Point of Gaze Indication** A cross will indicate point of gaze on the calibration surface. If "Display Multiple eye position Cursors...", in the General Parameters window, is not checked, the same cross will also indicate computed gaze point on any other defined scene plane. If "Display Multiple eye position
Cursors..." is checked, a slightly smaller cross will indicate position on planes other than plane 0, and an “x” will show eye position with respect to the head.

3.5 Checking environment specifications

It is easy to make a data entry error, and because the EyeHead environment is completely specified by the data and procedures in the “Setup” sub-menu (sections 3.2 and 3.3); it is important to check the correctness of the environment specifications. This check is easily accomplished with the "Gimbal Test" procedure. This procedure is most conveniently done with two people.

1.) Select the "Gimbal Test" from the EyeHead pull down menu or click the associated icon on the shortcut bar.

2.) A pop-up window will prompt:

Hold the pointer so that the laser spot is centered on calibration point 5 (center calibration point) on plane 0, and click “OK”. Continue to hold the pointer on point 5 until the pop-up window disappears.

3.) Check the environment. Use the laser to point to known coordinates on each scene plane and check the EyeHead grid pattern display. In the Gimbal Test mode, the gaze vector is assumed to be aligned with the pointer. The cross, on the grid pattern display, should correctly indicate the position of the laser spot. This can also be confirmed by checking the numerical display values.

If the EyeHead display does not correctly match pointer position, check values entered in the various Setup windows, check measured distances from the transmitter to points A, B, and C on the scene planes, and try re-doing the Gimbal pointing procedure for points ABC. *TIP: Common errors often include (-) negative signs incorrectly placed when specifying coordinates.

If a visible offset error is observed on any scene plane, and cannot be corrected by the steps suggested in the previous paragraph, then enter appropriate compensating offsets for that scene plane number in the "Individual Scene Plane" window. The offsets are expressed in the coordinate frame defined for that scene plane. This only works for errors that similar everywhere on the scene plane; for example, the cursor is always 1 inch to the right of the proper position.
4.) Exit from the Gimbal Test mode by again selecting "Gimbal Test" from the EyeHead menu or clicking on the shortcut icon. **Note:** Exiting Gimbal Test mode may also cause the system to exit from the EyeHead Integration mode, and therefore turn off the EyeHead grid pattern display. To re-enter EyeHead Integration mode, and reinstate the grid pattern display just click the EyeHead short cut icon, or click “Integration” on the Eyehead menu.

### 3.6 Environment File Handling

The system will always use the environment information in the file named e5000.env, in the current directory (the directory also containing e5Win.exe). The “Setup” sub-menu selections from the EyeHead pull down menu, described in sections 3.2 and 3.3, will always modify the file named e5000.env (or create one if none exists).

**Save Environment Files:** Environment files can be saved by using EyeHead menu "Save Environment As" selection. An environment file, saved under some different name, can once again be used for eye-head integration by using the EyeHead "Read Environment" selection. In this way multiple environment files can be created and used interchangeably without going through the environment specification process each time.

To save an environment file, click “Save Environment As” in the EyeHead pull down menu. When the windows browser appears create a file name other than e5000, and click “save”.

**Reading Environment Files:** To read an environment file select “Read Environment” from the EyeHead pull down menu. Browse to the desired file and click “Open”.
3.7 Separating the Transmitter from the Gimbal Pointer

In some constrained environments it may be convenient to mount the magnetic transmitter separately from the gimbal pointing assembly. For example, an obstruction may prevent the pointer from being aimed at a scene plane from the position of the magnetic transmitter. If the transmitter is not mounted in its standard position (at the center of the gimbal assembly), proceed as follows:

- Hold the small magnetic sensor exactly at the center of the gimbal assembly. The center of the assembly is the imaginary intersection of the two orthogonal gimbal hinges.
- Click “Set” button, with the sensor at the center of the gimbal assembly.

Perform all other procedures as described in the preceding sections. The software will now account for the separation between the transmitter and the gimbal assembly.
3.8 Alternate methods for entering points A,B,C

3.8.1 Place sensor directly on points

If the scene plane surface (or surfaces) are non metallic and the distance from the surface(s) to the magnetic transmitter is within the accurate range of the magnetic tracking device (about 36 inches for most versions); then the vectors from the transmitter to points A, B, and C can be determined by simply holding the sensor on the three points. **This works only if the surfaces are within range of the transmitter and are non metallic.**

To use the direct sensor placement technique make the following modifications to the procedures described in preceding sections.

1. On the General parameters dialog window (section 3.2.1), in the section labeled “Options for Specifying points A,B,C”, set the radio button to “Place sensor directly on points”.

2. When filling out the Individual scene plane dialog windows (section 3.2.3), ignore the sections labeled that “MHT-Transmitter-to-Point-Magnitude (for Gimbal ABC entry)” and “Point ABC Coordinates in Transmitter Frame (for manual ABC entry)”. These will be filled in automatically during the steps that follow.

3. The button in the **Point ABC Coordinates in Transmitter Frame** box will now be labeled “Set with sensor”. When this button is pressed, the pop up window will prompt to “Place sensor on point A”. Instead of pointing the laser at point A as described in section 3.3, hold the center of the sensor-mounting surface directly against point A. While the sensor is held against point A, click the “SET” button in the pop up window. As with the gimbal pointer procedure this may require two people. Be sure to continue holding the sensor against point A until the pop up window prompt changes to point B.

4. Repeat the previous step for points B and C.

5. Click “OK” to do the associated computations and exit.

6. If desired, enter a new plane number and repeat the procedure for points A, B, and C on the new plane.

3.8.2 Manual Entry (type in values)

In certain unusual situations the transmitter reference frame coordinates, for the vector connecting the transmitter to points A, B, and C, may already be known from some other procedure. In this case the vector components can simply be typed into the dialog window. **CAUTION:** The gimbal pointer and direct placement methods previously described are the only means provided by ASL for accurately determining these vectors. If the vectors are determined in some other way, care must be taken that they are determined accurately in the magnetic transmitter coordinate frame. If the vector coordinates are accurately known, make the following modifications to previously described procedures.
1. On the General parameters dialog window (section 3.2.1), in the section labeled “Options for Specifying points A.B.C”, set the radio button to “Manual entry”.

2. When filling out the Individual Scene Plane window (section 3.2.3), ignore the section labeled that “MHT-Transmitter-to-Point-Magnitude (for Gimbal ABC entry)”.

3. Enter the known vector coordinates in the section labeled “Point ABC Coordinates in Transmitter Frame (for manual ABC entry)”.

4. REAL TIME EYEHEAD INTEGRATION

Be sure that the eye tracker is running and that the MHT system is enabled and communicating with the eye tracker (section 8). With a valid c5000.env file in the current directory (section 3), enable real time EyeHead integration by selecting "Integration" from the “Eyehead” pull down menu or clicking the short cut icon.

The EyeHead Integration data window will appear on the screen, just to the left of the MHT Transmitter Offset data column, to show that the system is in the real time eye-head integration mode. The EyeHead grid pattern display, described in section 3.4, will automatically replace the "ScenePOG" display, in the upper right portion of the e5Win screen.

If an error message appears when “Integration” is selected from the EyeHead menu, simply proceed with subject calibration as described below, and enable the EyeHead mode after subject calibration is complete. (This should only occur if a subject calibration has never before been done since starting with a virgin environment file).

4.1 Subject Calibration With Head Mounted Scene Camera

For best results, the calibration pattern, during subject calibration, should subtend about 40 degrees visual angle horizontally and about 30 degrees vertically. These recommendations need not be strictly adhered to, but visual angles should not be less than half the recommended values, and should not exceed the recommended values by more than about 20%. As a guideline, the standard head mounted scene camera shows about 50 degrees visual angle horizontally. If the distance between points 4 (center left) and 6 (center right) is about 80% of the scene monitor screen, this will correspond to roughly 40 degrees visual angle.

(Remember that the subject should see point 1 at the upper left of the target pattern and point 9 at the lower right.)

Follow the normal procedure for eye tracker Subject Setup including Scene Camera Setup (calibration without a head mounted scene camera is described in the next section). Have the subject look at the calibration plane "straight on" and hold their head very still. If a scene camera is being used, the scene monitor must show all nine eye-calibration points on scene plane 0. In other words the scene camera must show all nine points with its field of view.

Using mouse on the Interface PC, perform “Set target points” on the nine calibration points visible on the scene monitor. It is very important that the subject's head remain absolutely still throughout this process. Because the subject must remain still, it is also very important that the set target procedure be done very
quickly. (With some practice, and using the mouse, it should be possible to enter the target point positions within 10 seconds.)

While still holding their head perfectly still, have the subject look at the nine target points on the calibration scene, and execute the normal eye tracker “Eye calibration”. After entry of data point 9, the system processes the calibration data. It is important that the subject maintain his head position for a second or two until the pop up Calibration window disappears. With some practice, the entire procedure from beginning of “Set target points” until the calibration is complete, should take no more than about 30 seconds.

**Check Calibration:** If the procedure to this point has been quick and the subject is able to continue holding his head still, it is suggested that a quick calibration check be performed before he moves his head. Simply have the subject look at the calibration target points and observe the scene monitor cursor. If it appears that a mistake has been made, and if the subject has not yet moved, the calibration procedure can be quickly repeated without redoing target sweep. **If the subject has moved, then target sweep must be repeated also.**

**Note:** that the calibration procedure is exactly the same as that described in section 5.3.2 of the Model 501 Eye Tracker Instruction Manual (“Stabilized Helmet/Scene Calibration”).

### 4.2 Subject Calibration With Out Head Mounted Scene Camera

Simply follow the instructions of section 4.2, but **skip** the “Set target points” procedure.

While holding his head perfectly still, have the subject look at the nine target points on the calibration scene, and execute the normal eye tracker “Eye calibration”. After entry of data point 9, it is important that the subject maintain his head position until the system finishes calculations. Since no target sweep is required, the procedure can be much faster than when a head mounted scene camera is used. With some practice, the calibration procedure should take no more than 10 seconds.

### 4.3 Real Time Display of Integrated Eye-Head Data

Integrated EyeHead data is displayed, in real time, on the PC screen, as described in this section, and by an optional stationary scene camera as described in section 7.

If the EyeHead Integration mode was not enabled before subject calibration (as described at the beginning of section 4) simply enable it now. If the MHT system was not enabled or was not properly communicating with the PC during subject Calibration, follow the directions in section 8 to properly enable MHT, then repeat the subject calibration procedure.

**Point Of Gaze Indacator:** If the EyeHead grid pattern display is not already enabled, select "Integration" on the EyeHead pull down menu. The subject's point of gaze should be displayed by a cursor on the grid pattern, and by the digital values in the "EyeHead" data window, as described in section 3.4.
Record Real Time Data: The same EyeHead data shown on the grid display can be recorded on the InterfacePC hard disk, as described in section 5, and output to a host computer via a serial port, as described in section 6.

Offsets: Offsets can be individually generated for each scene plane by changing the appropriate offset value in the "Individual Scene Plane" window. Adjustment of individual scene plane offsets will affect only the grid pattern display (and associated digital data) for that scene plane. If a head mounted scene camera is being used, the individual scene plane offsets will not affect the scene monitor cursor display. Use the “Eye Position Offset” selection under the Calibrate pull down menu to offset the head mounted scene camera display (as described in the Eye Tracker Instruction manual.)

To Adjust Individual Scene Plane Offsets:
• Pull down the Eyehead menu, select "Individual Scene Plane"
• Enter the desired plane number in the Scene Plane box
• Then enter the desired offset in the “Manual Offset” section (located in the bottom right).

Scene POG Graphic window: The EyeHead grid pattern display can be toggled on and off with the "Display" selection on the EyeHead menu, or the shortcut button labeled “DD”. Whenever the EyeHead display is not enabled, or the EyeHead display is toggled off, the standard "ScenePOG" display will appear in its place, and will show eye line of gaze with respect to the head.

Initialize: The EyeHead menu item "Initialize” is not used during normal system operation, but may occasionally be useful during test situations. The "Initialize" function performs an MHT boresight (see section 8), and does some other initialization tasks normally performed automatically after subject calibration. If, for example, the optics are focused on the model eye (as opposed to a real subject), the Initialize function (instead of the subject calibration procedure) can be used to cause a cursor to appear on the EyeHead display.
5. DATA RECORDING

Systems that have EyeHead integration capability can record two types of data file. The "raw" (non-integrated) eye and MHT data can be recorded; alternately, the results of the EyeHead integration can be recorded. It is usually the latter type of data file, referred to as EyeHead data, that is of most use.

Raw eye data consists of the horizontal and vertical orientation of the eye with respect to the head, and pupil diameter. If the MHT system is enabled, the file also includes the position and orientation or the magnetic sensor with respect to the head. Note that this information does not directly indicate what surfaces or objects in the environment are being viewed.

EyeHead data consists of the identification number of the scene surface being viewed, coordinates of the gaze point on that surface, the distance of the eye from the spot being fixated, and pupil diameter. Note that this information does indicate what the subject is viewing in the environment.

There is a check box on the EyeHead menu, "General parameters" dialog window, labeled "Record Integrated Eye-Head Data". If this box is checked and EyeHead integration is enabled, an “ehd” extension will automatically be appended to the filename and eye-head data will be recorded. When a data file is opened the “Save as Type” box will read “Eyehead file (*.ehd)”. Once the file has been opened the message in the information display section of the e5Win screen will be "DATA FILE: filename.ehd(PAUSED)".

If this box is not checked, or if EyeHead integration is not enabled, then raw eye and MHT data will be recorded. When a file is opened, the “Save as Type” box will read “Eyedat file (*.eyd)”, and an “eyd” extension will be appended to the filename. The information display will read "DATA FILE: filename.eyd (PAUSED)".
**CAUTION:** Once a non EyeHead data file is opened, it does not change to an EyeHead type file when EyeHead integration is enabled. To record EyeHead data, be sure EyeHead Integration is enabled before opening a data file.

Once a subject is calibrated, a data file can be opened from the main e5Win screen as described in the Model 501 manual. Open a new data file by selecting “new”; from the pull down File menu or by clicking the open file icon on the shortcut bar. Use the standard Windows file browser and dialog pop up to specify a directory and file name. Do not type an extension. The proper extension (“ehd” or “eyd”) will be automatically appended as described above.

After opening a file, type any desired text in the “Comment” field on the interface program screen and the text will be saved on the file. Once a file is opened, the file name will be displayed on the interface program screen just above the comment field. Initially the file name will be displayed in black letters with the message “(paused)” after the file name. To start recording data on the file click the record icon (right arrow icon on the shortcut bar) or select “Start Recording” from the File menu. The file name will change to red letters and the message following the file name will change to “(recording)”. The disk “bytes free” indicator will also change as disk space is used up.

Add one of 10 manual mark flags to the data at any time by clicking one of the numbered mark buttons.
(icons labeled 0 through 9) on the shortcut bar.

Stop recording by clicking the “recorder stop” icon (black square) on the shortcut bar or by selecting “Stop Recording” from the File menu. The file name will change back to black letters and the “(paused)” message will reappear. Start and stop recording as many times as desired. Each interval of continuous data (between a start and stop recording) is referred to as a data segment.

When recording to a file is finished, close the file by selecting "Close" from the File pull down menu, or clicking the close file shortcut button. The file name message in the information display section of the screen will disappear.

**Sample Rate:** Data samples are recorded 60 or 50 times per second with standard NTSC or PAL systems, or at 120 or 240 times per second on systems equipped with the high speed option. A program is provided to convert data files to ASCII format (part of the EYENAL software described below), for import to packaged statistical programs, etc. C language data access subroutines are also provided to enable users to write programs that access and process the recorded data.

**Analysis:** EyeHead data files can also be processed with the EYENAL analysis software to tabulate data, calculate fixations on each plane, specify areas of interest on each plane, match fixations and areas of interest. Also to compute various associated statistics, compute statistics for dwell times within areas of interest, and to plot fixation scan paths. See separate EYENAL manual for details.
6. SERIAL INTERFACE

Eye tracker data can be output through an RS232 port, labeled “Serial Out” on the model 5000 Eye Tracker Control Unit. The port is set to 57600 baud, 8 data bits, 1 stop bit, no parity. Other baud rates are also possible (consult ASL for details).

6.1 Interface Cable

The model 5000 Eye Tracker Control Unit “Serial Out” connector is a 9 pin male D type. Only "Transmit", "Receive", and "Ground" lines are used.

<table>
<thead>
<tr>
<th>SERIAL OUT</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>serial data from host to 5000CU</td>
</tr>
<tr>
<td>2</td>
<td>serial data from 5000CU to host</td>
</tr>
<tr>
<td>5</td>
<td>Ground</td>
</tr>
</tbody>
</table>

When making a cable, be sure that the eye tracker transmit line is connected to the external device receive line and visa versa. An example is shown below of wiring for a cable to connect the eye tracker “Serial Out” port to a standard 9 pin COM port on a PC.

9 pin female      9 pin female
2 ----------------- 2
3 ----------------- 3
5 ----------------- 5

6.2 Protocol and data format

The data output port can be set to use either a demand mode or a streaming mode. In the demand mode, the host computer requests a data field by transmitting a single byte of any value. In response, the eye tracker transmits a field of data. After a data request is received from the host, the eye tracker PC will begin to transmit the requested field within one update interval.

In the streaming mode, no data request is required. Data will continually stream from the “SERIAL OUT” port. The data is encoded, however, so that the first byte of a data field can be identified.

Encoding of the standard 8 byte data field is shown below
Note that most significant bit of the first data field byte is always set (1). The most significant bit of all other bytes in the data field are always reset (0). For the standard data set, the encoded data field is 10 bytes long rather than 8 bytes. The host computer must find 10 sequential bytes starting with a byte whose most significant bit is 1, then decode the data by reversing the encoding process shown above. Sample source code for decoding streaming data can be provided by ASL upon request. If eye-head integration is enabled, the data field will have the contents shown in Table 6-1. If eye-head integration is not enabled, raw eye and MHT values will be output as described in section 6 of the Eye Tracker Instruction manual.

Table 6-1. Standard EyeHead Integration Serial Out data field

<table>
<thead>
<tr>
<th>byte</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Status (0 = normal, &gt;0 = error condition)</td>
</tr>
<tr>
<td>2</td>
<td>Pupil diameter, most significant byte (0 = loss)</td>
</tr>
<tr>
<td>3</td>
<td>Pupil diameter, least significant byte</td>
</tr>
<tr>
<td>4</td>
<td>EyeHead Scene Plane number</td>
</tr>
<tr>
<td>5</td>
<td>Point of gaze horizontal (y) coordinate most significant byte (scene monitor coordinates)</td>
</tr>
<tr>
<td>6</td>
<td>Point of gaze horizontal (y) coordinate least significant byte</td>
</tr>
<tr>
<td>7</td>
<td>Point of gaze vertical (z) coordinate most significant byte</td>
</tr>
<tr>
<td>8</td>
<td>Point of gaze vertical (z) coordinate least significant byte</td>
</tr>
</tbody>
</table>

Note that if using the streaming mode, the list in Table 6-1 shows the data after decoding. Each coded data field read by the host will consist of 10 bytes.

Bytes 4-8 carry the same information displayed on the real time grid pattern display. Point of gaze coordinates are given with respect to the scene plane coordinate frame (the coordinate system defined on that surface as illustrated by figure 3-) designated by byte 4. The coordinate values are integers representing hundredths of inches (or centimeters). In other words, 10.2 inches (or centimeters) would be represented by the integer 1020.

The system can also be set to provide alternate data buffer contents. The buffer contents and the output mode (demand or streaming) are controlled by a value in the e5000.cfg file. View e5000.cfg (in the same directory as e5Win) with a text editor. Find the line that reads:
serial_data_output_format_type=

For the standard 8 byte output buffer, in demand mode, set the value after the equal sign to 1. For the same buffer contents, but in streaming mode, set the value to 129. For other alternatives, consult ASL. Resave the file as e5000.cfg.
7. STATIONARY SCENE CAMERA (Optional)

If the system is equipped with a stationary scene camera (SSC), or equivalent video source, then integrated eye-head data can be displayed as a point of gaze cursor, superimposed on the image from this stationary (as opposed to head mounted) video source. The head mounted scene camera that is a standard component of the model 501 head mounted eye tracking system can be removed from the head band (or helmet) and with the proper cable used as the stationary camera. If some other camera is used it may either be color or black and white, but must output composite video. In the USA, this will be NTSC format. In other countries it may be PAL format. Consult ASL if unsure.

Any type of lens may be used on the stationary scene camera, in order to best capture the field of interest, but if a very wide-angle lens with significant barrel distortion is used, there may be errors in cursor superposition roughly equivalent to the distortion.

If the subject is looking at a video image, the same video signal can be used directly as a “stationary scene camera” image showing a single surface. Similarly, if the subject is looking at a computer monitor (VGA image), a scan converter can be used to create a corresponding video signal which can be used directly as a “stationary scene camera” image showing a single surface. Note that a camera can be aimed to encompass several surfaces, for example, two side by side computer screens and a keyboard; whereas the scan converter signal or direct video signal will contain the image of only one surface. If there is only one surface of significant interest, and its image is available from a scan converter or other video source, then use of this signal is certainly the best approach.

It is possible to use both a head mounted scene camera and a stationary scene camera in such a way that the system can be quickly switched to display the image for one or the other with an appropriate point-of-gaze cursor. In this case the video signals from both cameras should be connected to the inputs of a video switch, and the video switch output can then be connected to the “Remote” scene connector on the Eye Tracker control unit. Consult ASL for further detail.

7.1 Installation

If the camera supplied as a head mounted scene camera will be used as the stationary camera, consult ASL for instructions for removing the camera and mounting.

If a camera is to be used (as opposed to direct use of a video signal being viewed by the subject), aim the stationary scene camera so that it captures the field of interest. This may include part of one scene plane, an entire scene plane, or several scene planes. Try to orient the camera so that the horizontal axes of scene planes viewed by the SSC do not appear tilted more than about 45 degrees with respect to the scene monitor horizontal axis. Try to make the scene plane of most interest appear as straight as possible in the stationary scene camera image.

Once properly positioned, take care that the camera is well secured and is not likely to be moved accidentally.
7.2 Stationary Scene Camera Environment Setup

Over View: The SSC cursor can be correctly superimposed only on the video image of surfaces defined as EyeHead scene planes, and also defined as part of the stationary scene camera environment. It is necessary to define the positions of 5 points on each scene plane that will be part of the SSC environment. All 5 points must be visible on the SSC video image, and must have known coordinates on their respective scene plane coordinate systems.

The 5 points should form a pattern with points 1 and 2 near the upper left and upper right corners, respectively, point 3 near the center, and points 4 and 5 near the lower left and right corners, and should cover most of the area visible on the SSC image of a particular plane.

The known locations of the 5 points on the scene surface and also on the scene camera field will be used by the computer to determine a transform from scene plane to scene camera coordinates. In order to obtain a unique solution for the transform equations, the points should be chosen so that there are 5 different vertical scene plane coordinate values and 5 different horizontal coordinate values. In other words point 2 should not have exactly the same vertical coordinate as point 1 (in the scene plane coordinate system), and point 5 should not have exactly the same vertical coordinate as point 4. Similarly, point 1 should not have exactly the same horizontal coordinate as point 4, nor should point 2 have the same horizontal coordinate as point 5. An example is shown in figure 7-1. Note that no two points are on the same horizontal or vertical grid line.

![Figure 7-1. Example of stationary scene camera target points. Grid lines represent the scene plane coordinate axes](image)

The sets of 5 points used to define the stationary scene camera environment will be referred to as stationary scene camera (or SSC) points.
Before proceeding, be sure that the "Number of Scene Planes not including Calibration Plane" has been entered correctly in the EyeHead menu, General parameters dialog window (see section 3.2.1).

### 7.2.1 Enter Scene Plane Locations of SSC Points

1. Pull down the EyeHead menu and select Setup

2. Choose the tab labeled "Stationary Scene Camera".

3. The first item in the Stationary Scene Camera dialog window is a scene plane number. Use the drop down list (down arrow next to the number box), or the “Previous” or “Next” buttons to select the desired scene plane.

4. Enter the y (horizontal) and z (vertical) coordinates for each of the 5 SSC points previously discussed. The coordinates are specified in the coordinate frame assigned to the scene plane, as discussed in section 3.
5. Check the box labeled “enable”. If this box is not checked, the system will not attempt to display a stationary scene camera cursor when a subject looks at this scene plane. If a scene plane is not visible on the stationary scene camera video image, then this enabling check box should always be off. If the scene plane is visible, or partially visible, and will be part of the stationary scene camera environment, turn the check box on.

6. Click “OK” to save changes made to the window and exit. To repeat the procedure for another scene plane click the “Next” button or the down arrow on the scene plane dialogue box and select desired plane.

7.2.2 Enter Scene Camera Locations of SSC Points

**Overview:** SSC point locations on the stationary scene camera image are entered with by clicking on scene monitor images of these points with a mouse controlled cursor. It is very similar to the “Set target” procedure used with the head mounted scene camera.

Before proceeding, be sure the stationary scene camera is properly connected and aimed as previously described. If connected through a video switch, set the switch so that the stationary scene camera image is the one displayed. Be sure that the scene monitor is set to normal (as opposed to reverse sweep video). **Be sure that all information has been entered as described in section 7.2.1.**

1. Pull down the Eyehead menu, and select "Stationary Scene Camera Target Points".

2. A pop-up window appear: Use the “Prev” and “Next” buttons to set “Scene Plane” to the desired scene plane number.

3. Click the “Set” radio button

4. If necessary drag the “Stationary Scene Camera Target Points” pop up window away from the POG graphics window (on the main Interface program window). When the mouse is in the POG graphics window, it should now control the scene monitor cursor. Using the mouse move the scene monitor cursor over SSC point 1 for the indicated scene plane, and left click. Note that
the pop up window shows the SSC point coordinates, previously typed into the EyeHead Set up dialog as described in section 7.2.1.

5. The “Target Point” window will automatically advance to point 2. Move the cursor to SSC point 2 for the current scene plane and left click again.

6. Repeat the procedure for all 5 SSC points on the current plane. Points can be entered out of sequence by using the up/down arrows next to the “Target Point”. (just as with the regular “Set target points” procedure for a head mounted camera.)

To abort the procedure, click “Cancel”.

To check the positions of the five SSC points entered for the indicated plane:
- Click the “Check” radio button on the “Stationary Scene Camera Target Points” pop up window
- Use the up/down arrows set the “Target Point” number on the pop up window
- Observe the position of the cursor superimposed on the Scene Monitor

To continue the procedure, (after all five points have been correctly entered for the indicated scene plane) click the “Next” button to advance to the next scene plane. Be sure to do the procedure for all other planes that have a Check in the enabling check box discussed in the previous section. When points have been entered for all necessary scene planes, click OK. The mapping computations will be performed, and the pop up window will close.

Note: the computations cannot be done correctly unless the coordinates for the current scene plane have been correctly entered as described in the previous section. These coordinates must be entered, as described in section 7.2.1, before doing the procedure described in this section.

If the SSC points for the current plane do not include 5 different horizontal, and 5 different vertical coordinate values, as described in section 7.2.1, a pop-up error message may appear saying "non-unique solution”. If this occurs, click OK to erase the message box, and check SSC point coordinates.

7.2.3 Check SSC Environment Specification
As with the Eye-Head parameters discussed in section 3, it is easy to make a mistake in entering stationary scene camera parameters; therefore SSC setup should also be checked with the gimbal pointer. In order to check the stationary scene camera setup, the Eye-Head environment must already have been properly specified as described in sections 3.2 and 3.3.

1. Install the magnetic sensor in the gimbal wand, and enter the gimbal test mode as describe in section 3.5. If both head mounted and stationary scene cameras are connected through a video switch, set the switch so that the stationary scene camera image is the one displayed. Be sure that the scene monitor is set to normal (as opposed to reverse sweep video).

2. Select "Enable Stationary Scene Camera" from the EyeHead pull down menu, or click the SSC icon to turn on the stationary scene camera mode. Once enabled there will be a check mark
displayed next to the this item in the EyeHead pull down menu. **Be sure to enable SSC as just described.** If not enabled it will not appear to be working even if the environment has been properly set up.

3. Use the laser pointer on the gimbal wand to point at the surfaces that are part of the SSC environment, and watch the scene monitor. A cursor, superimposed on the video image from the stationary scene camera, should correctly indicate the spot pointed to by the laser.

If the cursor does not appear to correctly follow the laser spot:
- Check to see if the cursor on the Interface program EyeHead (grid pattern) display correctly follows the laser pointer.
- If the cursor on the grid pattern display follows the pointer than an error was made in SSC environment specification. Re-Check procedures in section 7.2.
- If the grid pattern display does not correctly follow the pointer, check EyeHead environment specification as described in sections 3.2 and 3.3

### 7.3 Using SSC during Real Time Eye-Head Integration

**Overview:** The following instructions assume that all installation and setup procedures have been completed, as described in sections 7.1 and 7.2.

Select "Enable Stationary Scene Camera" from the Eye-Head menu or click the SSC button on the shortcut bar. It can only be enabled when eye-head integration is enabled. ("Gimbal test" is a special case of EyeHead integration mode, and SSC can be enabled).

Once SSC is enabled, be sure that video from the stationary scene camera is being displayed on the scene monitor, and that the scene monitor is in the normal (not the reverse video sweep) mode. SSC can be disabled by clicking SSC disable on the “Eyehead” menu, or clicking the SSC button.

**The SSC feature will not work during eye tracking unless enabled as described above.**

When SSC is enabled, the scene monitor cursor will reflect point of gaze with respect to the expected stationary scene camera image. When SSC is not enabled, the cursor will reflect point of gaze with respect to the expected head mounted scene camera field.

To use the SSC capability:

1. Enable eye-head integration (if not already enabled) by selecting "Integration" from the Eye-Head menu or by clicking the EHI icon.

2. Enable SSC by selecting “Enable Stationary Scene Camera.” from the Eye-Head menu or by clicking the SSC icon.
3. Calibrate as described in section 4.2.

**Note:** as long as the MHT system is enabled, eye-head integration and SSC modes can be enabled after subject calibration if desired; they need not be enabled before calibration.

To use a head mounted scene camera instead of the stationary scene camera, simply be sure that SSC is **not** enabled. If using both a head mounted scene camera and stationary scene camera, connected through a video switch as described near the beginning of section 7, be sure to use the head mounted scene camera during calibration. After calibration, simply switch the video switch to the desired image, and click the SSC button on or off so that the POG cursor will correspond to the image being displayed (stationary scene camera or head mounted camera, respectively).
8. MAGNETIC HEAD TRACKER

Overview: The magnetic head tracker (MHT) unit comes individually packaged. The package contains a control box, a source module (transmitter) with cable and connector, a sensor module with cable and connector, and a manual with one or more floppy disks. The MHT system is usually either an Ascension “Flock of Birds” or a Polhemus “3 Space Tracker”, “ISOTRAK” or “FASTRAK” type system. Consult ASL for comparative details. Cable connection diagrams that include the MHT system can be found in section 3.2 of the model 501 manual.

Transmitter and sensor: The transmitter (source) and sensor modules attach to the clearly labeled connectors on the MHT electronics unit. See the manual packaged with the MHT system for details.

MHT Interface cable: Connect one end of the provided MHT interface cable (red/yellow color code) to the RS232 port on the MHT control unit. Connect the other end of the MHT interface cable to the model 5000 Eye Tracker Control Unit connector labeled “Head Tracker”.

Dip switch settings: Set the DIP switches on the MHT electronics unit for 19200 Baud RS232 communications (consult manufacturer’s manual packaged with the MHT system for proper DIP switch settings).

Power On/Off: The Ascension Flock has no power switch. The AC plug must be disconnected to power down. The “fly/standby” switch must be in the “fly” position during use, but this is not a power switch. Polhemus devices may or may not have a power switch in the electronics unit depending on the model and date of manufacture. When power cycling any device using the power cord, be sure to use the AC wall socket, not the DC connector that connects the external power supply to the electronics unit.

Self Test: Most units have a self test mode when first powered up, and provide feedback to indicate successful (or unsuccessful) self test. Read the manufacturer’s manual to determine the feedback code. For example, the Ascension Flock has a front panel light that blinks several times and then remains solidly on if the self test finds no errors. The light will continue to blink if the self test fails. If the MHT unit self test fails, power down the unit, check all connections, then try again. Consult ASL if still unsuccessful.

MHT Pull Down Menu: The pull down MHT menu on the E5WIN screen has the following choices:

Enable/Disable: Use the "Enable/Disable" selection to start communication between the MHT system...
and the eye tracker computer. If communication is successful the MHT data display should appear in the bottom right of the e5Win screen. The “Enable/Disable” selection is a toggle switch, so once the MHT system is enabled, the “Disable” menu selection will appear.

Set Boresight: Not for use with EyeHead Integration, see explanation at the end of this section.

Reset MHT: this selection will send the same MHT initialization command string that is automatically sent during the MHT enable operation. The affect of any previous boresight (discussed above) will be canceled.

Select MHT System: The type of MHT system being used must be specified in the E5WIN user interface program

1. Select the MHT pull down menu
2. Choose “Select MHT System”
3. click the down arrow in the pop up window and specify current MHT system
4. click “OK”

MHT Data Display: The MHT data display consists of 3 position and 3 orientation values. The position values are the position of the magnetic sensor with respect to the transmitter x, y, and z-axes. The orientation values are the azimuth ("az"), elevation ("el"), and roll ("rl") angles (often called Euler angles) that describe the orientation of the sensor axes with respect to the transmitter axes. Position values are expressed in inches, and orientation values are expressed in degrees.

If the MHT system is communicating properly with the eye tracker computer, the MHT display values should change when the sensor moves, and should match the actual position of the sensor with respect to the transmitter. Actually, the values will probably be constantly changing, even when the sensor is stationary, due to noise in the system.

Communication between the MHT system and the eye tracker computer can be verified by checking the displayed MHT values on the e5Win screen data window. Remember that the position values should correspond to the distance between the center of the sensor and the center of the transmitter along each transmitter coordinate axis. The orientation angles represent the orientation of the sensor coordinate frame with respect to the transmitter frame.
If values seem reasonable, move the sensor, and check to see if values have changed in the proper direction. If values still seem reasonable, the MHT system is probably communicating properly with the eye tracker. Proceed with the task at hand as described in the main manual.

If values do not seem reasonable, select "Reset MHT" from the MHT pull down menu and try again. If still not reasonable, disable MHT from the pull down menu, power cycle the MHT electronics unit, re-enable MHT from the pull down menu, and try again.

It is not necessary to understand MHT “boresight” in order to successfully operate the system with EyeHead Integration. The “boresight” menu item under the MHT menu can be ignored for all normal system operation. However, since the term is used, some additional explanation of "boresight" is provided below.

The origin of the sensor coordinate frame is in the center of the sensor. Upon power up, or after a reset, the sensor coordinate frame x axis extends away from the sensor cable, and the z-axis extends down from the sensor mounting surface. If looking in the positive x direction with the z-axis pointing down, the sensor y-axis extends to the right. The MHT system reports the orientation of the sensor coordinate frame with respect to the transmitter coordinate frame. In other words, if the sensor is held so that sensor axes are aligned with transmitter axes, the MHT system will report zero orientation angles.

If the sensor is held still in any orientation, and the boresight command is issued, the sensor axes will be rotated to align with transmitter axes. The sensor coordinate frame will maintain this new orientation, with respect to the physical sensor, until a reset is issued or until the unit is power cycled.

If using the EyeHead Integration feature the “Set boresight” and “Reset MHT” selections need never be used. EyeHead Integration will automatically perform these functions when necessary. It may however occasionally prove useful for trouble shooting or testing as directed by ASL.
9. TRANSMITTER MOUNT & GIMBAL PIONTER ASSEMBLY

A system with EyeHead Integration software usually includes a plastic-mounting bracket for the magnetic transmitter, which is also designed to support a gimbaled, laser-pointing device. Different versions of the mounting bracket, for different model head tracking systems, are described in more detail in sections 9.1 and 9.2. In either case, the user must arrange for an appropriate support surface to hold the mounting bracket.

The mounting assembly requires a stable nonmetallic, vertical surface. The easiest method is probably to use a wooden post, supported by a heavy metal or wooden base plate, shown in figure 9.1. Such a post can be made from American standard 4" by 4" lumber (actual cross section us about 3.5 inches square), or something roughly equivalent. The mounting surface should be at least 3 inches wide. The transmitter mounting assembly can be fastened to the wooden post with standard, wood or wallboard screws (e.g. 1.75 inch, number 8 wood screw, or wallboard screw). Any other method for placing a non metallic, mounting surface in the proper position is also acceptable. For example, a wooden or plaster wall is an appropriate mounting surface so long as there is not a large metal beam in the wall near the mounting place. Other acceptable materials for a mounting surface include plastics, fiberboard, Formica, etc.

The transmitter is fairly heavy, and must not move once the system is calibrated for particular environment geometry, so the mounting arrangement should be quite sturdy.

Optimal placement for the transmitter, with respect to the subject, is also shown on the sketch in figure 9.1. When the subject is wearing the helmet or headband with the magnetic sensor attached, and is in the nominal center (most normal) position, the sensor should be about 5 - 10 inches from the transmitter. It
is suggested that the transmitter be roughly “straight and level”, with the x-axis pointing towards the subject and the z-axis pointing down.

### 9.1 Transmitter Mount & Gimbal (for Ascension Flock of Birds)

The Ascension transmitter is roughly a cube approximately 3.25 inches square, with flanges and mounting holes at its base, and a cord extending from the rear of the base. The origin of the transmitter coordinate system is the center of the set of coils imbedded in the block. The nominal "straight and level" orientation is mounting side (flanges and mounting holes) facing down. In this orientation the positive x axis extends out of the face opposite to the cord, the positive z-axis extends down, and, if facing in the positive x direction, the positive y-axis extends to the right.

The unit will correctly measure the position and orientation of the sensor with respect to the transmitter when the sensor is within 36 inches of the transmitter, and in the hemisphere defined by positive x values in the transmitter coordinate system. Large metallic objects or devices that produce electromagnetic emissions near the transmitter or sensor may produce errors or noisy data.

The system is usually shipped from ASL with the transmitter already installed in a mounting assembly consisting of a back plate that can be fastened to a mounting surface, a bottom plate, a top plate, and two support posts that extend between the top and bottom plates (see figure 9.2). If transmitter is not already installed in this assembly:

1. Fasten the top plate, bottom plate, and support bracket to the back plate with screws provided.

2. Insert the transmitter between the two plates with its mounting base against the bottom plate and the cord extending towards the back plate.

3. Fasten the two support posts between the top and bottom plates with nylon screws provided.

4. Using the provided nylon bolts and hex key, bolt the transmitter mounting holes to the bottom plate. Note that the hex key must be inserted though the access holes provided in the top plate.
Mount the back plate to a stable, non-metallic surface using the mounting holes in the back plate. Metal screws can be used here if needed. It is suggested that the assembly be mounted so that the transmitter will be behind, and slightly above the subject's head. When the subject is wearing the helmet with magnetic sensor attached and is in the nominal center position, the sensor should be about 5 - 10 inches from the transmitter. It is suggested that the transmitter be roughly "straight and level", with the x-axis pointing towards the subject and the z-axis pointing down.

The rectangular gimbal assembly is fastened to the top and bottom plate of the transmitter mount with two pivots (see figure 9-3).

1. Thread the top pivot into the top of the inner gimbal, if not already attached. If the bottom pivot is attached to the gimbal, remove the bottom pivot by removing the plastic screw.

2. Rest the top pivot in the indent on the top mounting plate (just above the center of the transmitter).

3. Insert the bottom pivot between the inner gimbal and the bottom plate, so that its point fits in the indent on the bottom plate, and fasten it with the plastic screw provided.
9.2 Transmitter Mount & Gimbal (for Polhemus 3space or Isotrak)

The Polhemus transmitter (or source) is a black or tan block 2.4 inches long, 1.4 inches high, and 1.4 inches wide. It has flanges and mounting holes at its base, and a cord extending from the rear of the base. The origin of the transmitter coordinate system is the center of the set of coils imbedded in the block. The nominal "straight and level" orientation is mounting side (flanges and mounting holes) facing up. In this orientation the positive x axis extends out of the face opposite to the cord, the positive z-axis extends down, and, if facing in the positive x direction, the positive y-axis extends to the right.

The unit will correctly measure the position and orientation of the sensor with respect to the transmitter when the sensor is between 4 and 24 inches from the transmitter, and in the hemisphere defined by positive x values in the transmitter coordinate system. Large metallic objects or devices that produce electromagnetic emissions near the transmitter or sensor may produce errors or noisy data.

The system is usually shipped from ASL with the transmitter already installed in an acrylic mounting assembly consisting of a back plate that can be fastened to a mounting surface, a top plate, two side plates, and a small bottom plate. Four screws are also provided to fasten the assembly to a mounting surface.
The assembly must be mounted to a stable, non-metallic, surface. It is suggested that the assembly be mounted so that the transmitter will be behind, and slightly above the subject's head. When the subject is wearing the helmet with magnetic sensor attached and is in the nominal center position, the sensor should be about 5 - 10 inches from the transmitter. It is suggested that the transmitter be roughly "straight and level", with the x-axis pointing towards the subject and the z-axis pointing down. Note that this implies a vertical mounting surface.

To attach the assembly to a mounting surface:

1. Remove the mounting assembly rear plate from the rest of the mounting assembly.

2. Fasten the rear plate to a stable nonmetallic surface using the four countersunk holes and the screws provided.

3. Reattach the rest of the assembly to the rear plate. The transmitter should be fastened to the top plate (transmitter mounting surface facing up), and the cord should extend towards the mounting surface.

4. Two clips are provided which can be fastened to the mounting surface just below the source mount assembly, and can be used to strain relieve the wire.

If the transmitter mount is not assembled when shipped, proceed as follows:

1. Fasten the rear plate to a stable nonmetallic surface using the four countersunk holes and the screws provided.

2. Attach the top and side pieces of the mount assembly to the rear piece using the provided nylon screws (four 10-32 x 1/2, and two 10-32 x 1).

3. Attach the magnetic source to the under surface of the mount top piece using three provided 10-32 x 1 screws. The source should be mounted so that the wire exits towards the mounting surface at the rear of the mount assembly.

4. Attach the small bottom piece of the mount assembly to the side pieces using four of the provided 10-32 x 1/2 screws. Be sure that the countersunk hole faces down, and the edge with a curved radius faces front (away from the mounting surface).

Locate the gimbal assembly. The gimbal assembly is fastened to the top and bottom plate of the transmitter mount with two black, Delrin pivots. The pivots fit in the countersunk holes on the top and bottom pieces of the transmitter mount assembly. To attach the gimbal assembly:

1. Remove the white, round head, 1/4-20 screw to remove the top pivot.

2. Hold the gimbal in place, so that the bottom pivot fits in the indent on the bottom plate.
3. Slide the top pivot into place, so that it fits in the indent on the top plate, and replace the 1/4-20 screw to fasten it.

4. Adjust the tension by turning the bottom pivot so that it is "finger tight".

9.3 Pointer Wand
Locate the wand with the laser pointer at one end. If the wand contains the "pen laser" type of pointer, the laser assembly has a small button that must be held down to activate the laser. **CAUTION:** This is a class II laser. Do not look directly at the laser source or its mirror reflection. Look only at its reflection on diffuse surfaces.

If the laser assembly is not yet fastened to the wand, notice that there is a holder or "cup" for the sensor in the wand (see figure 9-3). Notice also that the wand has a short section on one side of the cup (extension A in figure 9-3), and a longer section on the other side (extension B in figure 9-4). The laser will fasten to the long end of the wand, in other words the end farthest from the cup.

![Diagram of wand and laser assembly](image)

**Figure 9-4.** Wand and laser assembly shown mounted to Ascension Flock type transmitter mount. Note: Wand extension B is not standard and is supplied only upon request.

The wand fastens to the gimbal with a fastener that has a threaded stud on one end and a larger smooth stud on the other. The threaded end screw into the gimbal elevation arm, and the other end slides into a socket at the end of wand extension A. Two set screws in wand extension A, fasten the wand to the stud. First screw the threaded end of the stud onto the gimbal arm. Then slide the wand socket over the smooth end of the stud being sure to push the wander firmly against the gimbal arm. Tighten the set screws with a hex wrench. Be sure to tighten the sets crews quite firmly.

The magnetic sensor must be mounted in the cup for part of the environment specification procedure as described in section 3.3 of this manual. If a shorter wand is more convenient, simply remove the longer wand extension (extension B), and fasten the laser holder directly to the sensor cup. This might be appropriate if the physical environment is very cramped or if one of the scene plane surfaces is very close to the transmitter. Whatever the configuration used, be sure the correct length (distance from end of the laser holder to the center of the magnetic transmitter) is correctly entered in the Individual scene plane.
parameters dialog window as described in section 3.2.3. For the standard wand mounted on the Ascension Flock type gimbal, this measurement will be about 36 inches when using the full wand (31 inches for the wand plus 5 inches from the outer edge of the azimuth gimbal to the azimuth hinge). The value will be about 19.5 inches if the wand extension B is removed. For the Polhemus 3 Space Tracker type gimbal these measurements will be 35 and 18.5 inches respectively. These values can vary slightly from sample to sample and users are advised to check the measurements with a ruler.

When not using the pointer for "Gimbal Setup", as described in section 3 this manual, the pointer can be removed from the gimbal assembly if desired. To remove the pointer wand, loosen the set screws at the gimbal end of the wand and slide the wand off of the stud. The entire gimbal assembly may also be removed from the source mount if desired.

### 9.4 Laser Assembly

CAUTION: The pen laser is a class II laser. Do not look directly at the laser source or its mirror reflection.

The pen laser itself is a small plastic tube with a small removable panel for inserting batteries. When used in the gimbal pointer, it is important that the laser beam is well aligned with the pointer; in other words, it must be parallel to the imaginary line connecting the sensor and the transmitter origin. To accomplish this, the laser barrel is fastened to a black, Delrin, laser holder with 8 adjustable set screws. Note that the pen laser barrel may appear to be cocked at large angle within the holder. This is because the laser beam is not necessarily aligned with the pen laser barrel.

If not fastened when shipped, fasten the laser holder to the long end of the pointer wand. It is fastened with a stud identical to the one that fastens the wand to the outer gimbal arm. The stud is threaded at one end and smooth on the other. The threaded end screws into the wand, and the smooth end slides into a socket on the laser holder. Two set screws on the laser holder secure the laser holder to the stud.

The laser holder assembly has a cutout, exposing the battery panel on the pen laser. To change batteries, gently remove the plastic battery panel, insert replacement batteries, and replace the panel. Try not to pull or push on the pen laser hard enough to dislodge the setscrews holding it in position within the Delrin holder assembly.

If the laser should become misaligned remove the laser assembly from the wand. Insert the rear end of the laser holder in a lathe (or other device that rotates about a true center). Mark the position of the laser spot on a diffuse (non-mirror) surface at least a foot in front of the laser (eg. a board at the far end of the lathe). Turn the lathe slowly, by hand, while watching the laser spot on the surface. Adjust the set screws until the spot remains stationary as the lathe is turned.