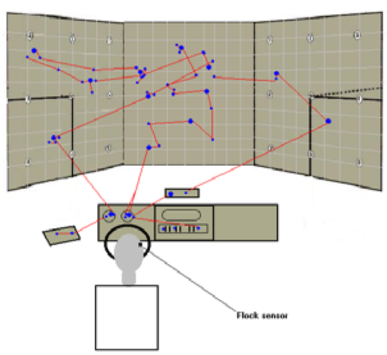
EyeHead Integration Manual

FOR USE WITH THE EYETRAC 6 SERIES H6 HEAD MOUNTED OPTICS

MANUAL VERSION 1.03
11 July 2007



Applied Science Laboratories
An Applied Science Group Company

175 Middlesex Turnpike
Bedford, MA 01730 USA
Tel: (781) 275-4000
Fax: (781) 275-3388
Email: asl@a-s-l.com
Support : techsupport@a-s-l.com
Web site: www.a-s-l.com

Table of Contents

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 gaze. Point of gaze 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 H6 with Head Tracking (HT) option, an HT Transmitter mount, and a pointing device (Gimbal Laser or Sensor Wand)). Required software is the standard ASL User Interface software with EyeHead™ Integration option (EHI). All of the above additions to the basic eye tracker system are included in the EyeHead option package from ASL. The stationary scene camera (mentioned above) and the scan converter are additional options available for the system that serve to bring in a video representation of the tracking environment.

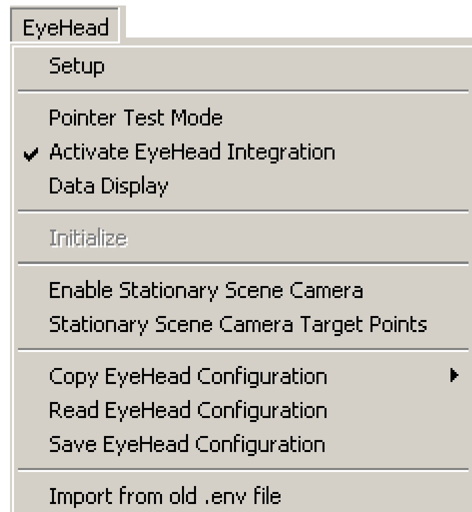
The HT electronics unit is normally plugged into a serial port labeled “HEAD TRACKER” on the model 6000 eye tracker control unit. Integrated Eye-Head data can be output in real time through another serial port (labeled “SERIAL OUT”) or recorded on the Eye Tracker Interface PC. The protocol for “SERIAL OUT” is described in Section 7 Serial Output Interface.

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.

A training video for EyeHead Integration setup is available for download form the Tech Support Website (http://techsupport.a-s-l.com) or on a CD that accompanied some systems.

2. Interface Software

Software for EyeHead Integration is contained was part of the User Interface software supplied with the eye tracker when the EyeHead Integration option is included. The User Interface software **must** have both Head Mounted Optics type selected and a Head Tracker type active from the Basic Configuration window for EyeHead Integration to be available.



The EyeHead pull down menu has the following selections:

The items in the Setup Menu contain the EyeHead configuration dialogs that provide the system 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.

Note: Set Target Points mode is **not** used in EyeHead Integration. Changing the Target Points from the Calibration > Set Target Points will have no valid effect.

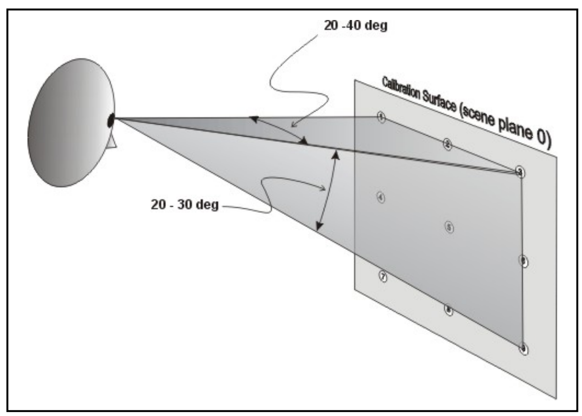
3. EyeHead Environment Specification

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 HT Laser Gimbal Pointer mechanism or the HT Pointer Wand (depending on which method is being used to define the surfaces; See Section 3.2.3.3 Options for Specifying Points A, B, C). If it is not possible for all surfaces to be within range of the pointing device, there are other, more difficult, ways to specify the location of such surfaces (consult ASL for details).

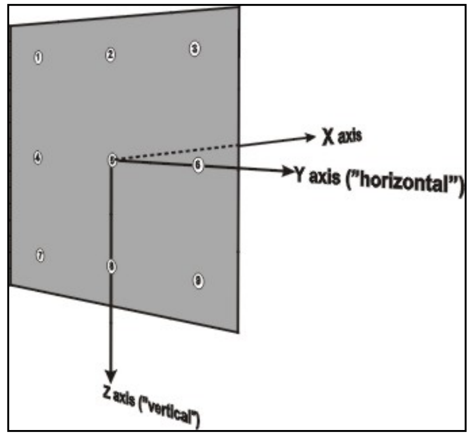
Before any EyeHead Integration can take place, all of the scene planes (flat surfaces) of interest must be defined in the User Interface software within the EyeHead > Setup dialog. The environment data is saved in the XML system file and can be saved separately. Various pieces of information are typed into the dialog windows by the user, and some necessary vector direction information is generally provided by pointing the gimbal pointer device, a pointing wand, or holding the magnetic sensor directly on target points.

These procedures are described in the succeeding manual sections. However, before explaining the mechanics of entering environment information into 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 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. 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 (perpendicular) 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 the figure. 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).



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).

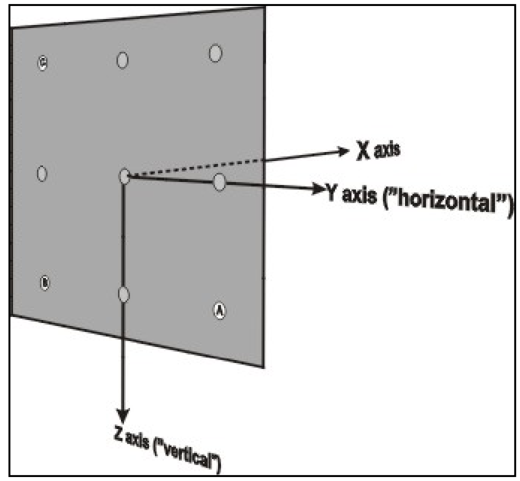
3. Only the calibration plane need have nine eye calibration target points.

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 coordinates. 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 17 inch 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.

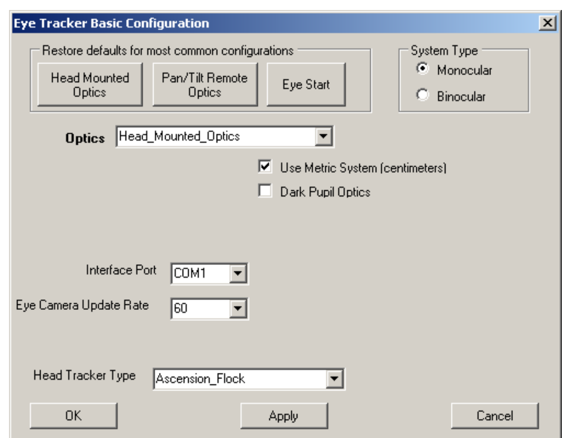
Three points must be chosen on each plane to enable the computer to define that plane relative to the Head Tracker (HT) source. Looking towards the scene plane from the HT source, the three points should have the relative positions shown in the drawing. Note that the three points form an "L" shape, with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



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 Standard, or Metric units. This choice is made in the Basic Configuration 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.

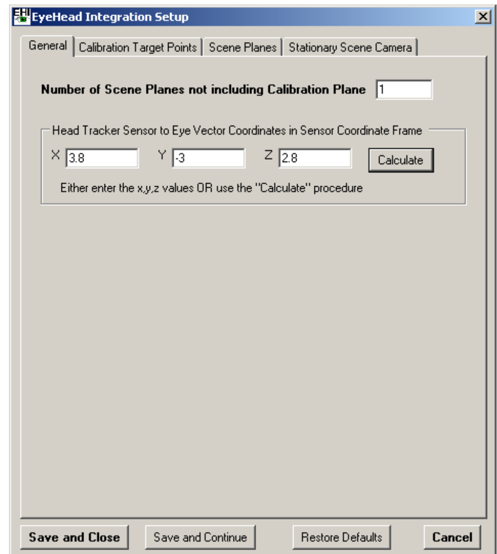
If Metric units are selected, all distance parameters must be specified in centimeters. If English units have been selected, all distance parameters must be specified in inches.

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 window. Selecting any of the 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 Save & Close or Save & Continue button is clicked information entered in any of the tabbed dialog windows becomes part of the default environment file.

3.2.1 General Tab

The General Tab selects and sets general information about the method and tools by which the EHI environment will be set up. Its parameters must be established first, and if they are changed midway through a configuration the entire EHI setup may need to be redone.



3.2.1.1 Number of Scene Planes

This value defines the number of scene planes (surfaces) that the operator will be defining. **The value entered here does not include the Calibration Scene Plane**. Therefore, if there were *only* the Calibration Scene Plane then this value would equal zero.

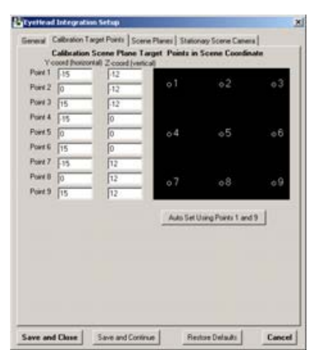
3.2.1.2 Head Tracker Sensor to Eye Vector Coordinates in Sensor Coordinate Frame

These values define the distance of the HT Receiver to the subject's eye in the sensor's coordinate system. The appropriate values are listed for any helmet or headgear supplied by ASL. If it is necessary, the method by which these values are calculated can be found in Appendix Section 11.1 Measuring the Sensor-to-Eye Vector.

Although the eye may not be in exactly the same position between subjects, the EHI process is insensitive to these small differences in the sensor-to-eye vector.

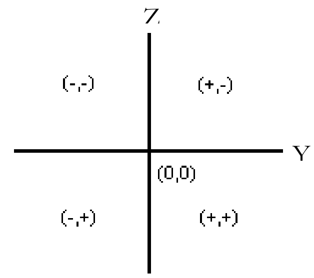
3.2.2 Calibration Target Points Tab

This tab sets the real world relational positions of the nine calibration target points. One surface in an EyeHead environment must be designated as the Calibration Scene Plane (also known as Scene Plane



0). This surface must be able to display the calibration target points as discussed in Section 4.1 Eye Tracker Subject Calibration.

The operator must measure and enter the relative horizontal and vertical coordinates on that scene's surface. Calibration Point 5, by convention, is usually defined as (0,0).

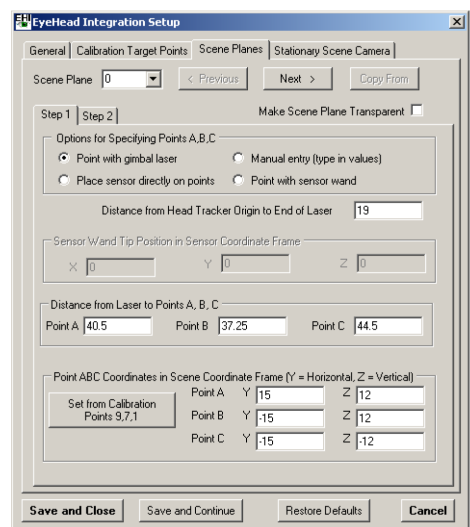


Horizontal (Y) values are positive to the right. Vertical (Z) values are positive down. Therefore, if the Point 5 defined as (0,0) convention is used, Calibration Point 1 will usually be (-,-) and Point 3 will usually be (+,-).

3.2.2.1 Auto Set Using Points 1 and 9

This button will take the values entered into Point 1 and Point 9 and extrapolate the other seven points symmetrically.

3.2.3 Scene Planes Tab



The Scene Planes Tab defines all of the spatial positions of each Scene Plane in the EyeHead environment. The items displayed in the window will contain information ***only*** for the plane specified in the Scene Plane selection field.

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. Recall that the number of additional scene planes was specified in the General Tab.

3.2.3.1 Scene Plane

This field sets and displays which Scene Plane is currently being defined. It will contain a value for each Scene Plane defined in the Number of Scene Planes field on the General EHI Tab (See Section 3.2.1.1).

Every Scene Plane in the environment must be selected and have all of the parameters of this tab defined in order for EHI to function properly.

3.2.3.2 Make Transparent

This selection causes the active Scene Plane to become transparent, or invisible, to the EyeHead environment. If this is selected, the system will not attribute any point of gaze calculations to this surface and will instead attribute them to any surfaces behind the transparent plane.

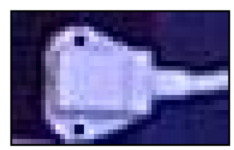
This is occasionally useful if the operator wishes to define surfaces that may not be present for all parts of a study.

3.2.3.3 Options for Specifying Points A, B, C

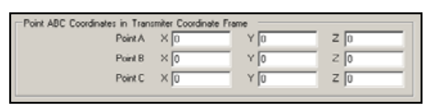
The method by which the EHI surfaces are defined must be selected. Once a technique is chosen, that method must be used for all EHI processes for the duration of the setup procedure.

- **Point with gimbal laser –** The laser gimbal is a mounting for the HT Transmitter device that allows a laser pointer to swing freely around the central point of the Transmitter. The HT Sensor is placed in a cup attached to the gimbal assembly. With this measurement method, the operator points the laser at the appropriate surface points and physically measures the distance from the end of the laser pointer to the surface point. It allows for specifying surfaces of greater distances.

- **Place sensor directly on points –** With this method, the operator places the HT Sensor directly on the surface points. All points must be within the range of the Transmitter's operational field. *This method is not recommended*.



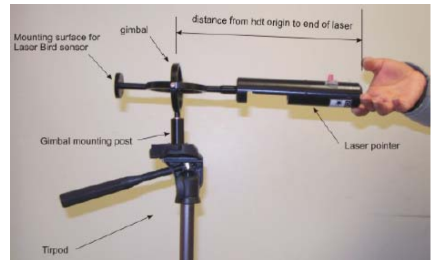
- **Manual entry –** With this method, the operator types the spatial coordinates into the system manually.



- **Point with sensor wand –** The sensor wand is a freely moving rod. One end contains a cup for placing the HT Sensor while the other head has a pointed tip for placing on the surface points. With this method, the operator places the tip of the wand on the appropriate surface points. This allows for easy specification of points that are relatively near or medium distances from the Transmitter.

The sensor end of the wand must remain within the range of the Transmitter's operational field.

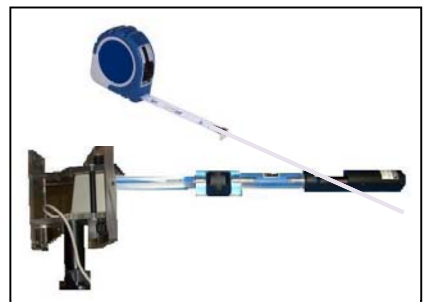
- **Point with inverted gimbal laser –** This option is designed to be used in special situations when the HT Sensor is mounted on the rear portion of a special gimbal assembly on the opposite side from the laser pointer. This is intended specifically for specific rare situations involving the Ascension Laserbird headtracker.



3.2.3.4 Distance from Head Tracker Origin to End of Laser

Availability: Point with Laser Gimbal method selected

If using the Laser Gimbal, the operator must enter the distance from the center of the Transmitter (origin) to the tip of the laser pointer. This value is added to the measured values in HT Pointer Tip to Point Magnitude below to calculate the HT Transmitter to Point distance.

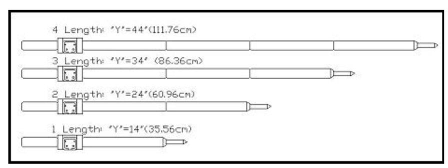


3.2.3.5 Sensor Wand Tip Position in Sensor Coordinate Frame

Availability: Point with sensor wand selected

These values define the location of the sensor wand tip with respect to the center of the HT Sensor.

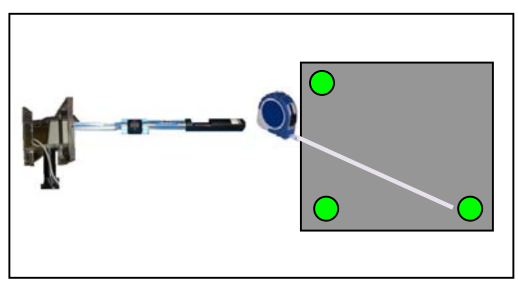
For the standard Sensor Wand, X and Z equal 0 while Y is 4 + 10 inches per section.



3.2.3.6 Distance from Laser to Points A, B, C

Availability: Point with Laser Gimbal method selected

If the Point with Laser Gimbal method of defining surfaces is being used, the operator must enter the distance from the end of the laser to each of the three defining points. The distance values are usually measured with a ruler or tape measure.

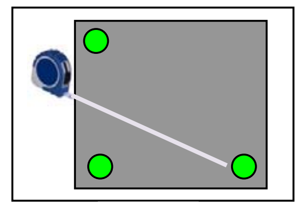


For optimal results, the laser should be pointed at the dot being measured at the time of measurement.

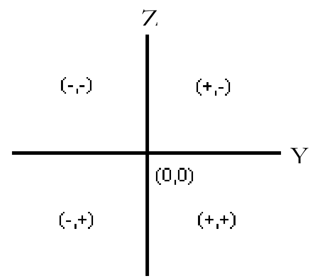
The values typed into this section are the distance from each point (A, B, and C) **to the end of the laser**. This value is added to the HT Transmitter Center to End of Gimbal Pointer Magnitude value in order to calculate the distance of each point to the center of the Transmitter. This information is necessary for defining the physical location of the surface in space.

3.2.3.7 Point ABC Coordinates in Scene Coordinate Frame

These values define the locations of the three surface-defining points in the Scene Plane's coordinate system.



In some cases, particularly if the Scene Plane being defined is the calibration scene plane (Plane 0), it may be simpler to use the calibration points. In this case, the operator can copy the values from the Calibration Target Points values (See Section 3.2.2) by pressing the *Set from Calibration Points 9,7,1* button.



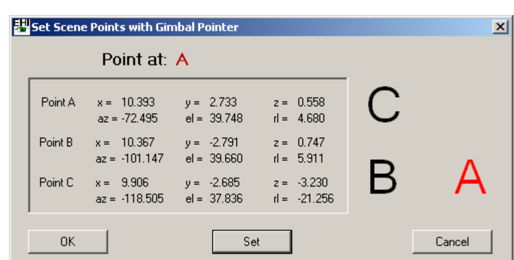
Remember also that the three points must form an "L" shape, with point A at the bottom right, point B at the vertex, and point C at the upper left.

3.2.3.8 Point ABC Coordinates in Transmitter Coordinate Frame

These values define the locations of the three surface-defining points in the HT Transmitter's coordinate system.

These values are set by way of tool selected in the Options for Specifying Points A, B, C selection on the General Tab (See Section 3.2.3.3).

If you have one of the three non-manual entry methods selected, press the *Set With …* button to display the Set Scene Points window.



Using the method defined, point or place the tool at each appropriate point in turn and press the SET button when the pointer is held steady. When the system is ready for the next point, the next Letter will be highlighted. If you believe that you may have made a mistake or not held the pointer steady, you may repeat the procedure. When all three points have been defined, press OK to exit this dialog.

The digital values in the “Point ABC 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 Scene Plane Tab. Remember to do this procedure for all scene planes.

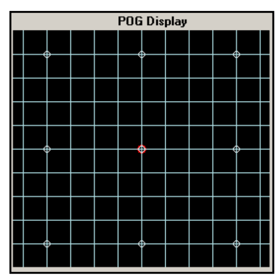
3.2.3.9 Rectangular Scene Plane Boundary

These values set the edges of a Scene Plane surface in terms of the Scene Plane’s coordinate system. This controls the location at which gaze is determined to “fall off” a surface. Any calculated values beyond these edges will be calculated to intersect with farther surfaces along the gaze vector or on the universal Scene Plane 0.

3.2.3.10 Manual Offset

This field will introduce an offset of the entire coordinate frame for the current Scene Plane by the specified amount. This is to attempt to correct for a systematic misplacement of the defined Scene Plane (usually due to measurement errors) without having to redo the entire measurement of that plane. This option should be used cautiously only when there is an across-the-board systematic offset of an entire plane’s coordinate frame.

3.2.3.11 Real Time Graphics Grid Scale



This value defines how many units (default inches) are represented by each grid line in the EHI Point of Gaze Display on the main interface screen.

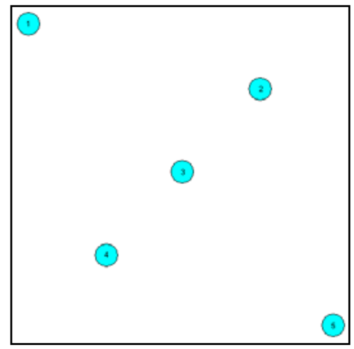
3.2.4 Stationary Scene Camera

Integrated EyeHead data can be displayed as a point of gaze cursor, superimposed on the Scene Out image.

For each Scene Plane for which the operator wants this video output, five points on the surface must be defined.

No two points in this pattern can have the same horizontal and vertical coordinates or the overlay will fail to properly function.

For each of the five points on each Scene Plane, enter the Y/Z coordinates in that Scene Plane's coordinate system. The recommended layout of these points is a zigzag pattern as shown to the right.

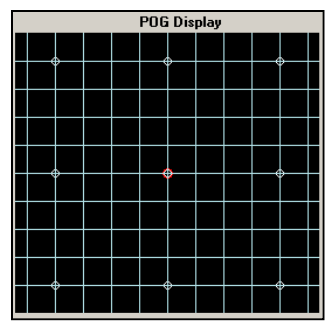


Additional Stationary Scene Camera configuration must also be performed in the Stationary Scene Camera Target Points window (See Section 6.2 Stationary Scene Camera Software Configuration).

Check the "Enable" box at the top right to enable the stationary scene camera for the selected scene plane. The system will not display a cursor for this scene plane unless it is enabled.

For a detailed explanation of how to set up an environment with a stationary scene camera, or equivalent video source, see Section 6 Stationary Scene Camera (Optional).

3.3 EyeHead (Grid Pattern) Display

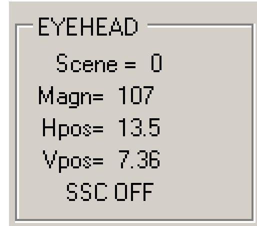


When testing environment specifications or conducting EyeHead Integration tracking, data can be viewed in real time in the POG Display window on the main interface screen. The POG Display window will change to EyeHead Mode, displaying a calibrated grid as defined in the Real Time Graphics Grid Scale (See Section 3.2.3.11).

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

The EyeHead display is characterized by a grid pattern that covers the display window. The center of the grid represents the origin of the current scene plane. The nine calibration target points are displayed as small yellow circles on the grid pattern when the Calibration Scene Plane (Scene Plane 0) is being displayed. The space between grid lines represents the scene distance specified in the "General Parameters" window (See Section 3.2.3.11 Real Time Graphics Grid Scale). Red circles indicate the Points ABC that define the current Scene Plane surface (See Section 3.2.3 Scene Planes Tab).

3.4 The EyeHead Data Frame



This frame on the main interface window displays the digital values of gaze intersection location on the defined scene planes.

3.4.1 Scene

The Scene value is the Scene Plane number that the system is calculating as the intercept surface of the line of gaze. 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 designated by default, and the intersection coordinates will correspond to an infinite extension of Plane 0. The Scene number also specifies the Scene Plane currently being presented in the POG Display grid pattern. The Scene number and graphics window will change as the subject's Point of Gaze moves between the defined scene planes.

3.4.2 Magn

Magn (Magnification) is the distance of the eye from the Point of Gaze, displayed in the specified units (inches or centimeters).

3.4.3 Vpos and Hpos

These values are the vertical and horizontal point of gaze coordinates. They represent the y and z axis values of point of gaze on the current designated Scene Plane. The values are given in the systems current units (inches or centimeters).

3.5 Checking environment specifications

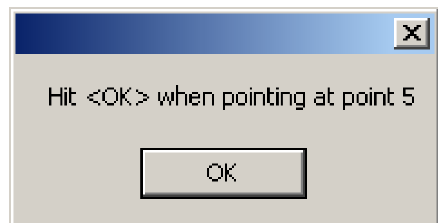
Because it is fairly easy to make a data entry error, and because the EyeHead environment is completely specified by the data and procedures in the EyeHead Setup Menu (See Section 3.2 EyeHead Setup), it is important to check the veracity of the environment specifications. This check is easily accomplished with the **Pointer Test** procedure. This procedure is most conveniently done with two people.

3.5.1 Pointer Test

The Pointer Test uses the mechanism used to define the Scene Plane surfaces (Laser Gimbal or EHI Sensor Wand) to mimic a gaze vector for testing purposes. This allows the user to test the accuracy of the system definitions and Head Tracker calculations without adding the extra variability of a subject Eye Tracker calibration.

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

2.) The software will prompt you to aim the pointer at Calibration Point 5.



Hold the Pointer so that the laser spot or the tip of the Sensor Wand is centered on Calibration Point 5 (center calibration point) on Scene Plane 0, and click OK while the pointer is stable. Continue to hold the pointer on point 5 until the pop-up window disappears.

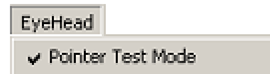
3.) Check the environment. Direct the Pointer to point at known coordinates on each scene plane while checking the EyeHead grid pattern display. In the Pointer Test mode, the gaze vector is assumed to be aligned with the pointer. The POG Indicator cross on the grid pattern display should correctly indicate the position of the pointer. This can also be confirmed by checking the numerical display values.

If the EyeHead display does not correctly match the pointer position, check values entered in the various Setup windows, check the distances measurements from the transmitter to points A, B, and C on the scene planes, and try re-doing the Point Definition 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 (See Section 3.2.3.10 Manual Offset). The offsets are expressed in the coordinate frame defined for that scene plane. This only works for errors that are similar everywhere on the scene plane. For example, if the cursor is always 1 inch to the right of the proper position.

4.) Exit from the Gimbal Test mode by again selecting Pointer Test from the EyeHead menu or clicking on the shortcut icon.



3.6 Stationary Scene Camera (optional)

If the user wants to receive a video feed of the stimuli or environment with a superimposed Point of Gaze cursor, a Stationary Scene Camera (SSC) must be configured.

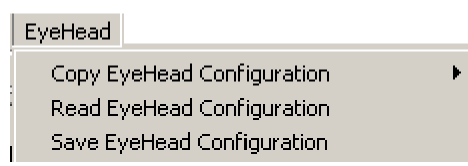
Any video feed can be used for the SSC. The most common types are a fixed video camera viewing the environment or a video image from a single computer screen intercepted and relayed via a Scan Converter.

In both cases, the video is input into the system by way of the Remote Scene port on the back of the ASL Control Unit. The output video is sent by way of the Scene Out port.

To set up a Stationary Scene Camera, see Section 6 Stationary Scene Camera (Optional) and Section 3.2.4 Stationary Scene Camera.

3.7 Environment Configuration Backup

The system will always save the EyeHead environment information to the default XML file and restore it on Eye Tracker start-up. The user can also save environment information to a separate file by selecting the EyeHead menu command “Save EyeHead Configuration.” Information from this user-specified file can be restored later by executing the menu command “Read EyeHead Configuration.”



3.7.1 Save Environment File

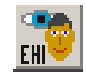
The environment configuration can be backed up and stored by saving it to a separate XML file. This is done by using the EyeHead menu selection Save EyeHead Data. An XML file, saved under a different name, can later be used for EyeHead Integration by using the Read EyeHead Configuration selection. In this way multiple environment files can be created and used interchangeably without going through the environment specification process each time. Keep in mind that if the position of any of the surfaces or the Head Tracker Transmitter changes then these environmental configurations will be invalid.

3.7.2 Reading Environment Files

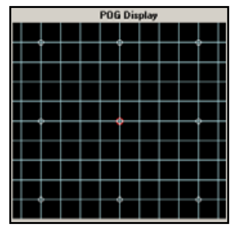
To read an environment configuration from an XML file select Read EyeHead Configuration from the EyeHead pull down menu. Browse to the desired file and click Open. The system will replace the EyeHead Configuration stored in the active file E6000.XML with the EyeHead Configuration from the loaded file.

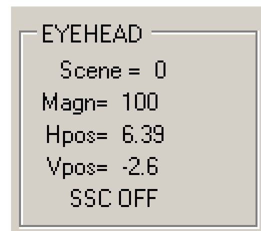
4. Collecting Data with EyeHead Integration

Be sure that the eye tracker is running and that the Head Tracker system is enabled and communicating with the eye tracker (See Section 8 Head Trackers). With a valid EyeHead Environment configured (See Section 3 EyeHead Environment Specification), enable real time EyeHead Integration by selecting *Activate EyeHead Integration* from the EyeHead pull down menu or clicking the short cut icon.



The POG Display window will switch to EyeHead Integration mode as described in Section 3.3 EyeHead (Grid Pattern) Display and the EyeHead Digital Data Frame will become active on the main interface window (See Section 3.4 The EyeHead Data Frame).





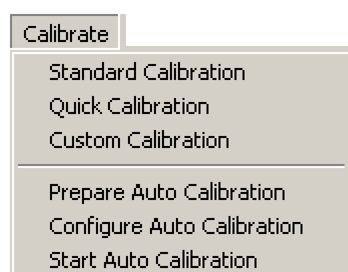
4.1 Eye Tracker Subject Calibration

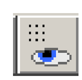
Apply the Head Mounted Optics to the subject as described in the HMO Manuals and Training Guides. Ensure proper discrimination on the Pupil and Corneal Reflection. Remember that the subject's head must remain within the tracking range of the Head Tracker in order for EHI to function properly. The subject's head need not remain stationary for the calibration process to be successful, however increased accuracy will be experienced when there is fairly limited head motion.

The Calibration procedure for EyeHead Integration is the same procedure used for other types of Eye Tracking methods. The system uses the 9 Calibration Points of Scene Plane 0 for its calibration.

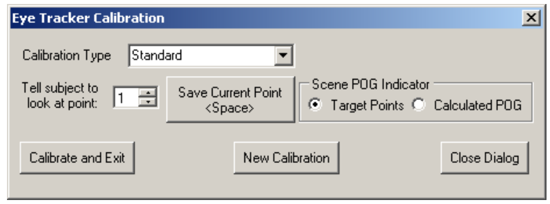
4.1.1 Calibration Procedure

Selecting Standard Calibration, Quick Calibration, Custom Calibration, Prepare Auto Calibration, or Start Auto Calibration will open the Eye Tracker Calibration window in the appropriate mode. From the Eye Tracker Calibration window, you can also change the calibration type to any of these modes by way of the Calibration Type item.





The currently active calibration point (that which the system is waiting for a calibration about) is displayed in the Calibration Point item. The currently active point can be changed with the arrows on the box or by typing the desired number into the box.

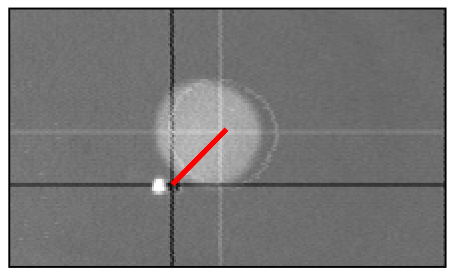


To store the calibration for the current point, press the Save Point button or press the spacebar on the keyboard. This will take the currently computed eye feature (Pupil and CR) positions and the Subjects head position and use them as the values for the current point in computing the Point of Gaze calibration.

The newly input points are not used to compute POG until the Calibrate and Exit button is pressed.

4.1.2 Understanding Calibration

The raw data measured by the Eye Tracker is the separation between the pupil center and the corneal reflection (CR) center. The relation between these raw values and eye line of gaze differs for each subject and for different optical units and scene camera positions. The purpose of the eye calibration is to provide data that will allow the Eye Tracker processor to account for individual subject differences. The objective is to have the subject look at (fixate) on each of the nine calibration points. This procedure must be performed for every subject. In EyeHead Integration, this information is combined with Head Position tracking in order to compute the appropriate relationships.



In most calibration procedures, when a subject is known to be looking at a specific point (either because of instruction or by another inductive method) the operator tells the system to calibrate (note the current pupil/CR relationship)

4.2 Checking the Calibration

If the calibration has been successful, the system should accurately track both the surface the subject is looking at and the location on that surface where their gaze intersects.

It is recommended that the operator test a calibration's accuracy by first having the subject look at the calibration points on Scene Plane 0. If these are accurate, all other Scene Planes should follow suit.

This can be checked by having the subject look at points on those Planes as well. For the operator, it will be most revealing to use the ABC points on these planes, as these points will be visible as red circles in the POG Display.

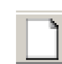
5. Data Recording

While EyeHead Integration mode is active, data is recorded in the EyeHead file format with the extension .ehd (as opposed to the standard Eye Data file format of .eyd).

The EyeHead .ehd file will record the raw eye data that 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.

More useful to the operator, the .ehd file will record the Integrated Scene Plane EyeHead data which 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 the pupil diameter.

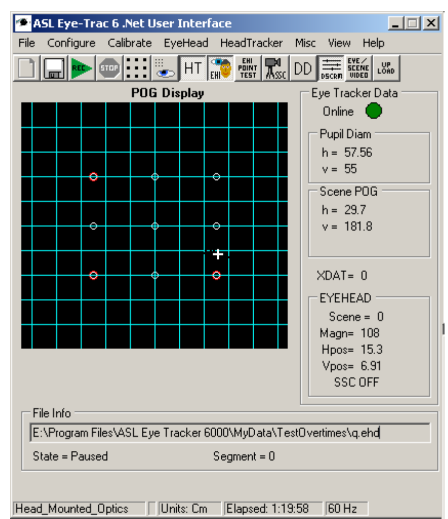
5.1 Opening a New Data File



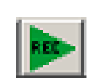
From the File pull-down menu, the New Data File item will open a New File dialog to create and open a new data file for recording eye tracker data. When EyeHead Integration is active, this file will automatically be an .ehd file.

After naming the file and pressing Save, you will be asked to enter a File Description. This description will be saved in a header with the data file and will be visible with EyeNal.

When a data file is open, the file path and name will be listed in the File Info section of the Main window. Additionally, the activation state of the toolbar will alter to disallow creating new data file, allow closing of the data file, and activate the Record button



5.2 Starting and Stopping Recording



To record data to the opened data file, the operator must select Start Recording or press the Start Recording Quickbutton. Immediately upon selecting Start Recording, the Interface software will begin writing data to the data file in real time.

Alternatively, the XDAT cable can be used to start and stop recording. See the Interface Software Manual for details.

Start Recording creates a new Segment within the data file. Therefore, for each instance that recording is started and stopped, a new Segment will be created.

The File Info section of the Main interface window will indicate that the system is in a recording state. It will also indicate the current segment number.

Note: It is critical that you calibrate the subject before recording data or the recorded data will be meaningless.

Stop Recording will pause writing data to the data file. Each instance of starting and stopping recording will create a new Segment within the data file.

The File Info section of the Main interface window will indicate that the system is in a paused state. It will also indicate the segment number of the previously recorded segment.

You must stop recording in order to close a data file or exit the software.

5.3 Close Data File

When you are finished recording data after an experimental session, you must close the data file. This finishes crucial file terminator writing and removes the interface software's write access to the file.

The data file will not be available to access by other software until it has been closed.

6. Stationary Scene Camera (Optional)

If the system is equipped with a Stationary Scene Camera (SSC), or equivalent video source, then integrated EyeHead data can be displayed as a Point of Gaze cursor superimposed on the video image from this fixed video source. The Head Mounted Scene Camera that is a standard component of the Model H6 Head Mounted eye tracking system can be removed from the headband (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 North America, this will be NTSC format. In other locations 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 to mimic the function of 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 that can be used directly to mimic 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 the best approach.

6.1 Scene Camera Installation

6.1.1 Optical Camera

If the scene image is to be captured using a camera, 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 greater than approximately 45 degrees with respect to the scene monitor horizontal axis. Attempt to make the scene plane of most significant interest appear as straight as possible in the stationary scene camera image.

The external SSC is connected to the ASL Control Unit by way of the Remote Scene port. Within the Interface Software, the Video Source setting found in the Advanced Configuration window should be set to Remote Scene Connector.

Once properly positioned, ensure that the camera is well secured and is not likely to be moved or redirected accidentally.

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

6.1.2 Scan Converter

Connect the stimulus computer (or other image producing system) to the Scan Converter, the stimulus display monitor, and the ASL Control Unit as shown.

The Scan Converter is connected to the ASL Control Unit by way of the Remote Scene port. Within the Interface Software, the Video Source setting found in the Advanced Configuration window should be set to Remote Scene Connector.

6.2 Stationary Scene Camera Software Configuration

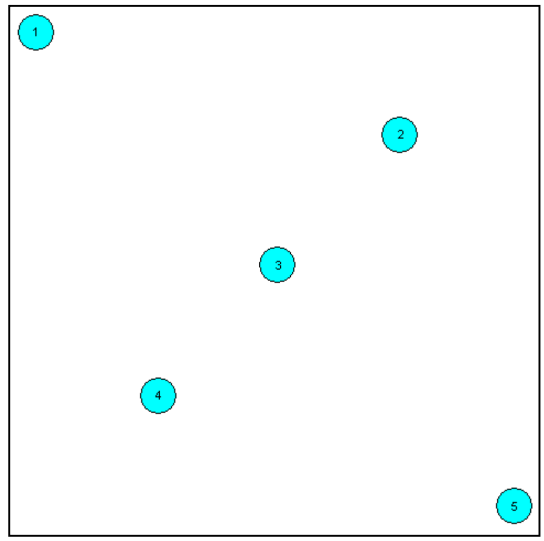
The video signal input through the Remote Scene port on the ASL Control Unit (See Section 6.1 Scene Camera Installation) can be output over the Scene Out port with a cursor indicating the Point of Gaze superimposed on the image. While using EyeHead Integration, the system requires additional configuration in order to properly superimpose the POG indicator on this feed.

6.2.1 Attaching Scene Planes to the Video

The SSC cursor can be correctly superimposed *only* on the video image of surfaces defined as EyeHead Scene Planes. Each Scene Plane must be attached to the video signal as discussed below.

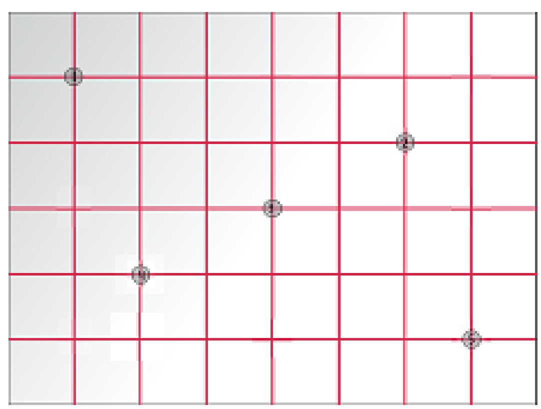
Regions in the video image that do not have a Scene Plane attached may not yield a completely accurate representation of the POG position. Scene Planes that are not attached to a portion of the video field will not be represented by a POG indicator.

The known locations of 5 points on the Scene Plane surface will be defined in terms of their relative positions on the scene camera field. This relationship will be used by the computer to determine a transformation from the Scene Plane to the Scene Camera coordinates.



For each Scene Plane that will be part of the SSC environment, it is necessary to define the positions of 5 points on each Scene Plane surface. All 5 points must be visible on the SSC video image, and must have known physical coordinates within their respective Scene Plane coordinate systems (See Section 3 EyeHead Environment Specification). These points will be defined in the Stationary Scene Camera tab of the EyeHead Setup window. (See Section 3.2.4 Stationary Scene Camera).

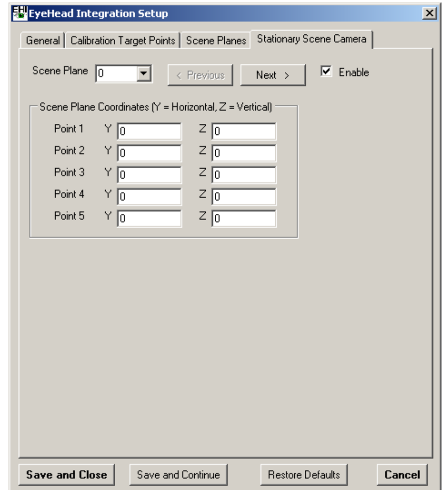
The 5 points should form a pattern with points 1 and 2 near the upper left and upper right corners, respectively, point 3 near the center, and points 4 and 5 near the lower left and right corners. The points should cover most of the area visible on the SSC image of a particular plane.



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, no two points should have the same horizontal or vertical coordinates. Point 2 should not have exactly the same vertical coordinate as Point 1 (in the scene plane coordinate system). Point 5 should not have exactly the same vertical coordinate as Point 4. Point 1 should not have exactly the same horizontal coordinate as Point 4. Point 2 should not have the same horizontal coordinate as Point 5. Again note that no two points are on the same horizontal or vertical grid line.

The sets of 5 points used to define the stationary scene camera environment will be referred to as stationary scene camera (or SSC) points.

6.2.2 Enter Scene Plane Locations of SSC Points



The spatial coordinates of the 5 Points must be defined for each Scene Plane in terms of that Scene Plane's coordinate system. This is done in the EyeHead Setup window under the Stationary Scene Camera tab. See Section 3.2.4 Stationary Scene Camera.

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 EyeHead Environment Specification.

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.

To repeat the procedure for another scene plane click the "Next" button or the down arrow on the scene plane dialog box and select desired plane.

6.2.3 Enter Scene Camera Locations of SSC Points

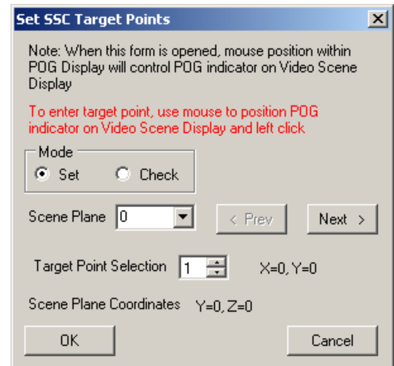
After the Scene Plane coordinates are set for each of the SSC Points (See Section 6.2.2 Enter Scene Plane Locations of SSC Points), the Point's locations must be specified with respect to the Scene Camera image.

The SSC point locations on the stationary scene camera image are entered by clicking on scene monitor images of these points with a mouse-controlled cursor. It is very similar to the "Set Target Points" procedure used during Regular system operation mode (non-EHI).

Before proceeding, be sure that the Stationary Scene Camera is properly connected and aimed as described in Section 6.1 Scene Camera Installation.

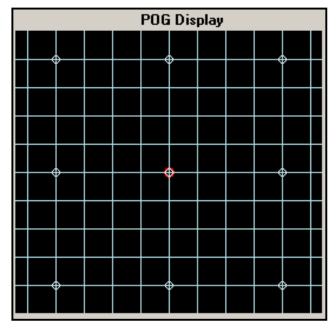
From the EyeHead menu, select Stationary Scene Camera Target Points. This will open the Set SSC Target Points window.

While this window is active and in Set Mode, moving the mouse cursor over the POG Display window will control the POG cursor on the Scene Out video feed.



While in Set Mode, pressing the left mouse button while in the POG Display will cause the currently selected SSC Target Point on the currently selected Scene Plane to be set to that location on the Scene Out video location.

For each of the 5 Points on each Scene Plane depicted in the SSC, move the cursor over the location of the point in the video image. Press the left mouse button when in the correct location. This will define the video coordinates for the current point. The "Target Point Selection" field will automatically advance to the next point.



Repeat the procedure for all 5 SSC points on the current Scene Plane. Points can be entered out of sequence by using the up/down arrows next to the "Target Point Selection."

To check the accuracy of the positions of the five SSC points entered for the indicated plane, switch to Check Mode and use the Scene Plane field and Target Point Selection field to scroll through all of the points.

Note: the computations cannot be done correctly unless the coordinates for the current scene plane have been correctly entered as described in Section 6.2.2 Enter Scene Plane Locations of SSC Points. These coordinates must be entered **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 6.2.1 Attaching Scene Planes to the Video, 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.

6.2.4 Check SSC Environment Specification

As with the other EyeHead parameters, it is easy to make a mistake in entering stationary scene camera parameters. Therefore, the SSC setup should also be checked with the Pointer Test mode. In order to the check the stationary scene camera setup, the Eye-Head environment must already have been properly specified as described in Section 3 EyeHead Environment Specification.

Select Enable Stationary Scene Camera from the EyeHead menu or click the *SSC Quickbutton* to activate the Stationary Scene Camera mode.

Enter Pointer Test Mode as discussed in Section 3.5.1 Pointer Test.

Direct the Pointer 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 position pointed to.

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 Pointer location. If the cursor on the grid pattern display correctly follows the pointer then an error was likely made in SSC environment specification. Re-Check the procedures from Section 6.2.2 Enter Scene Plane Locations of SSC Points and Section 6.2.3 Enter Scene Camera Locations of SSC Points.

If the grid pattern display does not correctly follow the pointer, check the EyeHead environment specifications from Sections 3.2 EyeHead Setup.

6.3 Using SSC during Real Time Eye-Head Integration

Select "Enable Stationary Scene Camera" from the EyeHead menu or click the *SSC Quickbutton*. The SSC can only be enabled when EHI is enabled.

When SSC is enabled, the scene monitor cursor will reflect point of gaze with respect to the EyeHead Integration computed POG location.

7. Serial Output Interface

Eye tracker data can be output through an RS232 port, labeled Serial Out on the model 6000 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).

7.1 Interface Cable

The model 6000 Eye Tracker Control Unit Serial Out connector is a 9 pin male D type. Only the "Transmit", "Receive", and "Ground" lines are used.

SERIAL OUT	Signal
3	serial data from host to 6000CU
2	serial data from 6000CU to host
5	Ground

This cable is equivalent to a standard RS-232 cable (straight through). 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.

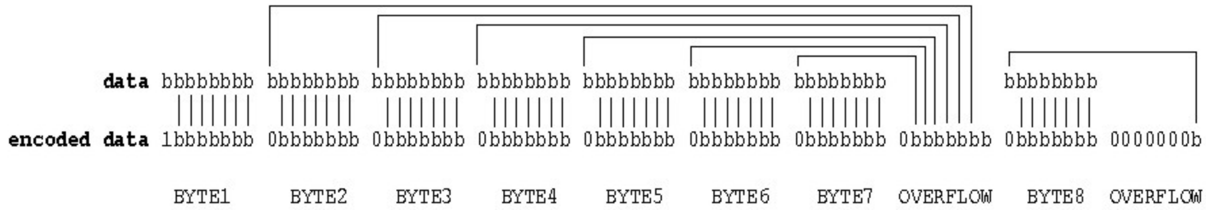
9 pin male		9 pin female
2	-	2
3	-	3
5	-	5

7.2 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 is 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 and 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 7-1. 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 7-1. Standard EyeHead Integration Serial Out data field

byte	**description**
1	Status (0 = normal, >0 = error condition)
2	Pupil diameter, most significant byte (0=loss)
3	Pupil diameter, least significant byte
4	EyeHead Scene Plane number
5	Point of gaze horizontal (y) coordinate most significant byte (scene monitor coordinates)
6	Point of gaze horizontal (y) coordinate least significant byte
7	Point of gaze vertical (z) coordinate most significant byte
8	Point of gaze vertical (z) coordinate least significant byte

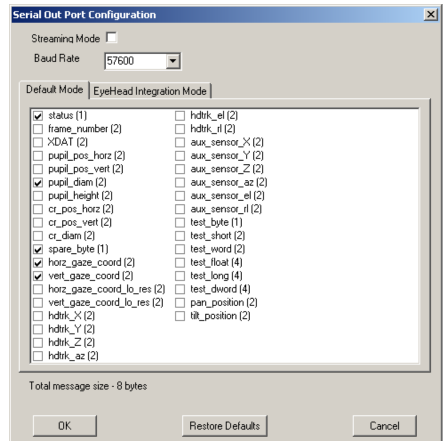
Note that if using the streaming mode, the list in table 7-1 shows the data after decoding. Each coded data field read by the host will consist of 10 bytes.

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 on that surface as defined in Section 3.2) 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.

7.3 Serial Port Configuration

Eye tracker data can be output through an RS-232 port, labeled "Serial Out" on the Eye Tracker Control Unit. This port can be connected to a PC serial port.

The Eye-Trac 6000 Control Unit "Serial Out" connector is a 9 pin male D type. Only "Transmit", "Receive", and "Ground" lines are used. The port is set to 8 data bits, 1 stop bit, no parity. The maximum baud rate is 57600, which is set by default.



Beware that serial cables come in two types: "Modem" and "Null Modem". The appropriate cable ("Modem") connects pin 2 at one end to pin 2 at the other, and pin 3 at one end to pin 3 at the other. A "Null Modem" cable connects pin 2 on one end with pin 3 on the other end. It is intended for connecting between two PCs and will not work with the eye tracker.

Note: The "Serial Out" cable appropriate for connecting to a PC is identical to the cable that connects Eye Tracker "Controller" port to the Interface PC.

The Serial Out port is always active so long as any items are checked in the Serial Out Port Configuration window.

Serial Out user selections are saved in the file *E6000.cfg* located in the same folder with Eye Tracker program.

7.3.1 Streaming Mode

If Streaming Mode checkbox is checked, eye tracker will send a packet of data with every execution cycle. The cycle time is defined by the Eye Camera frequency. For example, an eye tracker with a 60 Hz camera will send a serial output packet 60 times a second. Higher camera speeds (120, 240, 360Hz) will cause the eye tracker to send more data packets per second.

If Streaming Mode is not checked, eye tracker is in "On-Demand" mode, which means it will send data upon request by the receiving computer's application.

Most applications will require Streaming Mode. Please refer to the user's manual for your receiving software to determine the appropriate transmission format.

7.3.2 EyeHead Integration Mode

These tabs select between Serial Out format elements available for EyeHead Integration, or standard eye tracker modes.

In the EyeHead Integration tab, select the appropriate elements to output over the Serial Out port. The items will be output in the order of top to bottom on the table. The number in parentheses denotes the number of data bytes output by that selection. “Total message size” indicates the total number of bytes that is transmitted during each output sample (the length of the “word” being sent).

8. Head Trackers

The Head Tracker (HT) unit comes individually packaged. The package contains a control box, a source module (Transmitter) with cable and connector, a sensor module (Receiver) with cable and connector, and a manual with one or more floppy disks. The HT 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. Other Head Tracker types, including the Ascension LaserBird and the NDI Optotrack, may be available for use with EyeHead Integration. Note that the Optical Tracker FR1 available for the Video Head Tracker for the R6 Pan/Tilt system *cannot* be used for EyeHead Integration.

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

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

DIP switch settings: Set the DIP switches on the HT electronics unit for 19200 Baud RS232 communications (consult manufacturer's manual packaged with the HT system for proper DIP switch settings). *These settings will be factory preset for systems purchased through ASL.*

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 HT unit self-test fails, power down the unit, check all connections, then try again. Consult ASL if still unsuccessful.

MHT Data Display: The HT 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 (or centimeters if *Use Metric System* is enabled), and orientation values are expressed in degrees.

If the HT system is communicating properly with the eye tracker computer, the HT 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 system and environmental noise.

Communication between the HT system and the eye tracker computer can be verified by checking the displayed HT values on the Eye Tracker Interface 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.

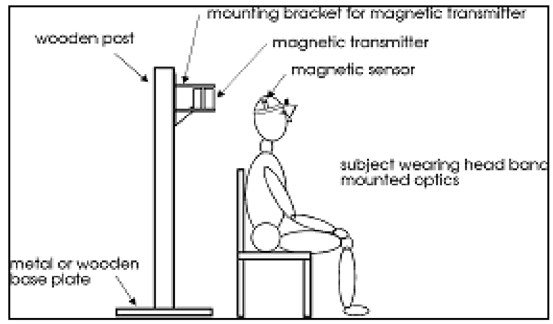
If the values seem reasonable, move the sensor and check to see if values have changed in the proper direction. If the values still seem reasonable, the HT system is probably communicating properly with the eye tracker.

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

9. Transmitter Mount & Laser Gimbal Assembly

A system with the EyeHead Integration option usually includes a plastic-mounting bracket for the magnetic transmitter, which is also designed to support a gimbaled, laser-pointing device. 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. Such a post can be made from American standard 4" by 4" lumber (actual cross section is 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.



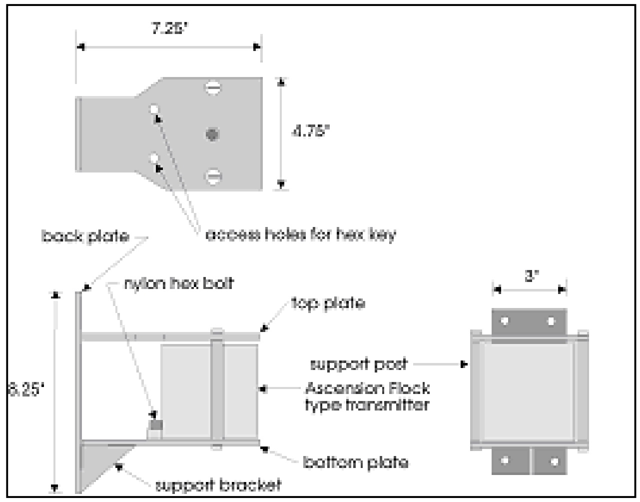
The Transmitter is fairly heavy, and must not move once the system is calibrated for a particular environment's geometry, so the mounting arrangement should be quite sturdy.

Optimal placement for the transmitter, with respect to the subject, is also shown on the sketch in figure above. When the subject is wearing the Head Mounted Optics 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. 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.

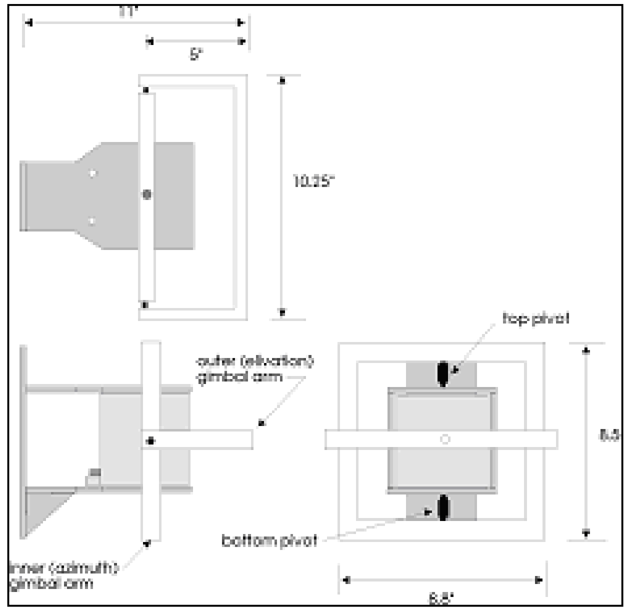
2. Insert the transmitter between the two plates with its mounting base against the bottom plate and the cord extending towards the back plate.

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 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.



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 3 Space 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.

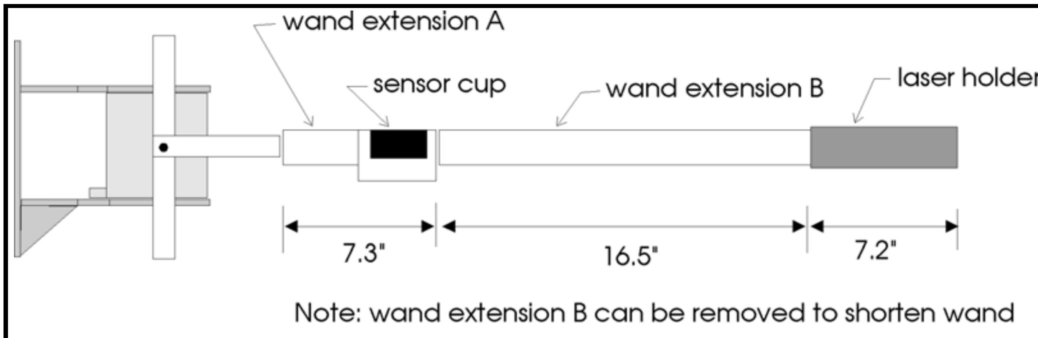
3. Slide the top pivot into place, so that it fits in the indent on the top plate, and replace the 1/4-20 screw to fasten it.

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

9.3 Laser Pointer Assembly

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. Notice also that the wand has a short section on one side of the cup (extension A), and a longer section on the other side (extension B). The laser will fasten to the long end of the wand, in other words the end farthest from the cup.



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 screws into the gimbal elevation arm, and the other end slides into a socket at the end of wand extension A. Two setscrews 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 wand firmly against the gimbal arm. Tighten the setscrews with a hex wrench. Be sure to tighten the setscrews quite firmly.

The magnetic sensor must be mounted in the cup for part of the environment specification procedure. 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 Scene Planes Tab. 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 of this manual, the pointer can be removed from the gimbal assembly if desired. To remove the pointer wand, loosen the setscrews at the gimbal end of the wand and slide the wand off the stud. The entire gimbal assembly may also be removed from the source mount if desired.

9.4 Laser Pointer

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 setscrews. 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 setscrews 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 (e.g. 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 setscrews until the spot remains stationary as the lathe is turned.

10. 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 the separate EYENAL manual for details.

11. Appendices

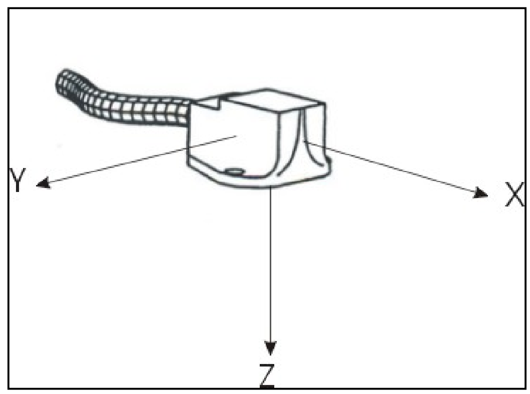
11.1 Measuring the Sensor-to-Eye Vector

This section describes the process for determining the Sensor-to-Eye Vector (See Section 3.2.1.2 Head Tracker Sensor to Eye Vector Coordinates in Sensor Coordinate Frame). For all head units provided by ASL, this value will be provided for the customer, and should be listed on a label attached to the head unit.

The sensor to eye vector can be estimated using a ruler and knowledge of the sensor coordinate system, or can be determined using the magnetic system itself.

11.1.1 Measurement Estimation with a Ruler

The coordinate system attached to the Ascension "Flock of Birds" magnetic sensor is shown in figure 1. With the sensor fastened in place on the head gear, and the headgear in place on a human subject, measure along the x-axis from the center of the sensor to a point even with the eye. "Even with the eye" means the point on the x-axis from which a line perpendicular to the x-axis would intersect the eye being monitored. This will be the x value. Repeat this for the y- and z-axes. If you measure in the negative direction along any axis, the corresponding coordinate value will be negative.



The process involves estimation because it will be impossible to place a ruler directly on the points being measured. Aligning the ruler with the direction of a given axis will be estimation as well.

11.1.2 Measurement using Magnetic Tracker Data

Place the headgear, with magnetic sensor attached, on a Styrofoam (or other non metal material) model head. Alternately, use a wooden "Q-tip" swab, or other non-metal object to mark the position of the eye when the headgear is worn by a subject. For example, it is usually possible to tape a "Q-tip" swab to the helmet liner (or headband forehead strap), such that the white "Q-tip" is near the usual eye location. *[While a subject is wearing the headgear, just note the position and length needed for the Q-tip. Tape it on once the headgear is removed. Do not hold the Q-tip near a person's eye.]*

Boot the system, and support the headgear so that the magnetic system Az, El, and Rl angles (as displayed on the e5win screen) are very close to zero. (It will not be possible to make the values exactly zero). The position (as opposed to the orientation) of the headgear does not matter, so long as the sensor and the eye location are within 36 inches of the transmitter center.

With Az, El, and Rl values nearly zero, record the MHT x, y, and z values displayed on the e5Win screen. Let us call these the "position 1 values". Being careful not to move the headgear, remove the sensor from its mounting plate, and hold it at the eye position on the Styrofoam head, or the marked eye position if some other marking method was used. With the sensor held at approximately the eye position, again record the MHT x, y, and z values displayed on the e5Win screen. Let us call these the "position 2 values".

Subtract the position 1 values from the position 2 values to compute the x, y, and z values of the sensor to eye vector. A very rough application of the ruler estimation method described above can be used as a check to see that the values are sensible.