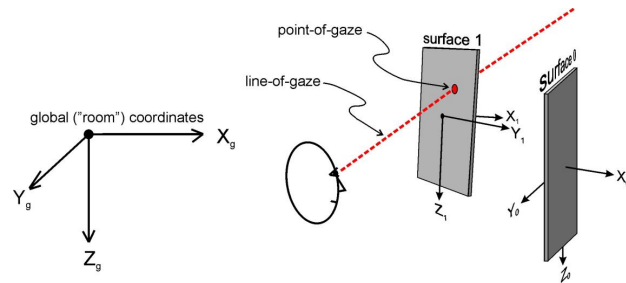


ET 3Space Manual

ET3SPACE WITH ETVISION WEARABLE OPTICS

MANUAL VERSION 1.7
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1. Introduction

The optional *ET3Space* feature for use with the *ETVision* eye tracker (*ETVision 3S*), enables integration of eye and head position data to compute point of gaze in a 3 dimensional (“3 space”) environment. Line-of-gaze is computed with respect to a room fixed (or cockpit fixed) 3 dimensional scene space. The environment, within the scene space, is defined by a set of up to 20 bounded planes numbered 0 through 19. Point-of-gaze is computed to be the point at which line-of-gaze first intersects one of the defined surfaces within its boundaries. If gaze does not intersect any defined surface within its boundary, the system reports the intersection with an infinite extension of plane 0.

In most cases each surface in an *ET3Space* environment can be defined essentially by supporting the *ETVision* optics so that the surface is visible to the scene camera, and clicking on 4 “definition points”.

The required hardware includes an *ETVision* eye tracker system, a head tracker system, and other accessories to fasten a head tracking sensor to the *ETVision* head gear and to help define the 3Space environment. The head tracker may be one of several commercially available motion capture systems (consult Argus Science for full list of possible motion capture systems). The other required accessories will vary depending on the type of head tracker used and the specific nature of the environment.

Required software is the standard *ETVison* application with *ET3Space* option (*ET3S*), and the software that comes with the particular head tracking system to be used. The Argus Science *ETRemote* application is not required, but may be useful if the primary visual target is a display monitor (see *ETRemote* manual for details).

In most cases the *ETVison* PC interfaces with the head tracker system via network or USB cable connection. Interface details depend on the type of motion capture system being used. Argus Science can provide a separate manual or technical note to document connections and procedures specific to each head tracker system for which *ETVision* has a standard interface. Consult Argus Science for details.

This manual is for *ETVision* software version 1.0.7.0 or higher.

Procedures for positioning optics and calibrating a participant do not depend on the *ET3Space* feature and are described in the *ETVision* manual. It is suggested that the user first practice setting up and calibrating a participant with the *ETVision* system, as described in the *ETVision* manual, without using the *ET3Space* feature. Once satisfied that proper performance is achieved as described in the *ETVision* manual, follow the instructions in this manual, and the Argus manual for the particular head tracker being used, to implement the *ET3Space* function.

2. Head Trackers

ETVision can interface to a number of motion capture systems that can be used to track head position and orientation. They are all a bit different from each other. Most connect via USB or network connection. Some require a separate PC to run the head tracker specific software and interface with the *ETVision* PC, and some have software that can be run on the *ETVision* PC along with the *ETVision* application. In most cases Argus Science provides a manual or technical note to document connections and procedures specific to a particular head tracker system. Consult Argus Science for details.

To make the proper physical connections, follow directions in *ETVision* manual and in the manual or tech note provided by Argus Science for the specific head tracker system being used.

If the motion capture system requires a serial connection, a USB to serial adapter (such as Keyspan model USA19 HS) must be used to connect to the standard *ETVision* laptop PC. If the head tracker communicates via network cable, and if the native network port on the *ETVision* PC is being used for communication with the *ETVision* Control Unit, then a USB to network adapter will be needed.

All tracking systems that are compatible with *ETVision*, *ET3Space* measure the position and orientation of some object with respect to the environment. When used as a “head tracker” the object being tracked is attached to the headgear worn by the subject.

Magnetic tracking systems measure the position and orientation of a sensor (or “receiver”) with respect to a stationary magnetic transmitter. Optical systems use a camera (or some sort of optical detector) to detect reflectors or small light emitters. These systems measure the position and orientation of some rigid structure containing multiple reflectors or emitters. Depending on the particular tracking system, the object being tracked may be referred to in the tracking system literature as “sensor”, “rigid body”, “object”, “tracking tool”, etc. ***In the *ETVision* software and in this manual the object being tracked will usually be referred to as the “sensor”.*** The tracking system measures the position and orientation of the sensor with respect to a room-fixed, Cartesian coordinate system defined by the head tracker system. This will be referred to as the “global coordinate system”.

Please refer to the Argus Science manual or tech note for the specific motion capture system being used

3. Background

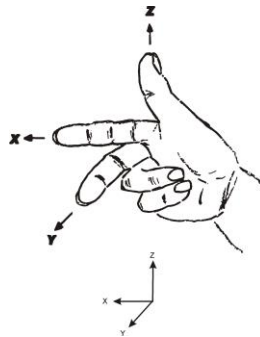
Before attempting to operate the *ET3Space* feature, it is necessary to understand some background concepts.

3.1 Reference Frames

The *ET3Space* “environment” consists of a “Global” (room fixed) coordinate system defined by the head tracker, 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 global coordinate system. Typical surfaces include monitor screens, keyboards, poster displays, slide screens, walls, etc.

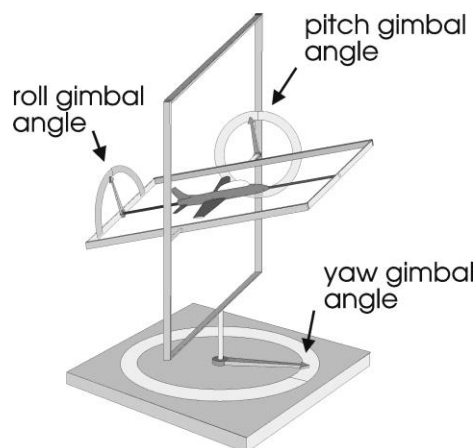
All position and orientation information used by *ET3Space* is expressed with respect to either the global coordinate system or imaginary coordinate systems “attached” to surfaces, to the *ETVison* head mounted scene camera, or to sensors used by the head tracker system.

All coordinate systems used by *ET3Space*, including the global coordinate system, are “right handed” Cartesian coordinate systems. This means the coordinate axes are orthogonal to each other and have the relationship shown below.



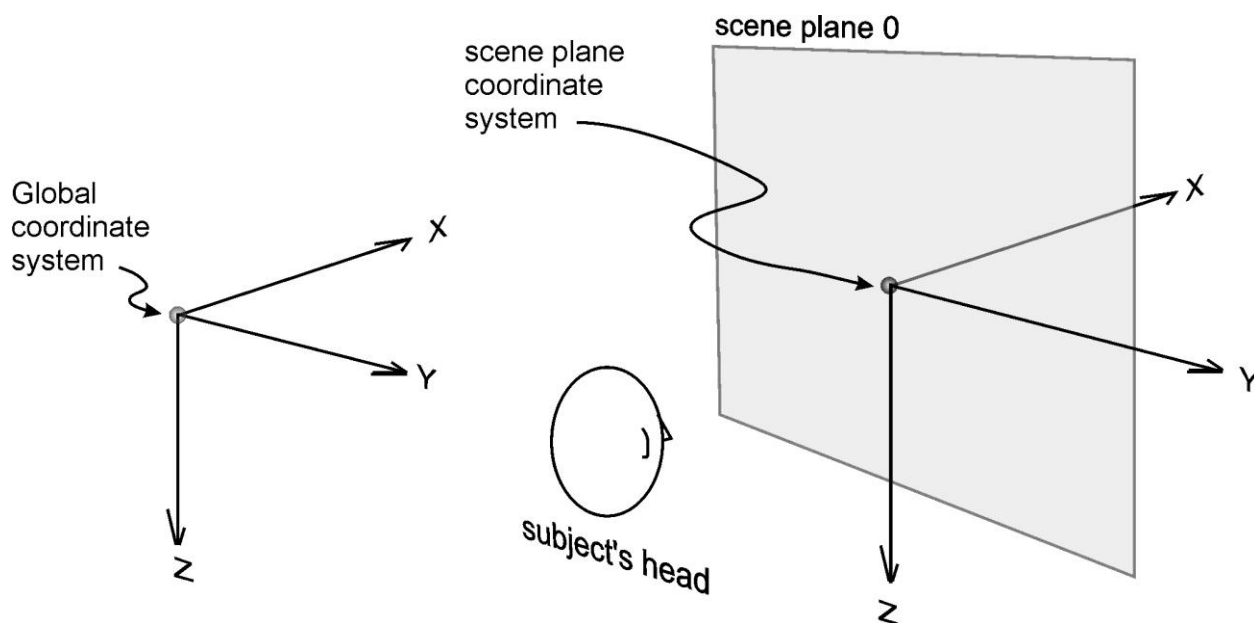
Orientation of one reference frame with respect to another is often expressed as a set of 3 “Euler” angles. When the axes are aligned, the angles are all zero. Other wise the angles describe 3 rotations that would be needed to align one with other. For instance head orientation is expressed as the set of rotations needed to move a coordinate frame aligned with global coordinates to an orientation aligned with the coordinates “attached” to the tracked object on the subject’s headgear.

Rotation about the object Z axis, is considered to be “azimuth” (or “yaw”) rotation; rotation about the object Y axis is “elevation” (or “pitch”); and rotation about the X axis is “roll”. These angles are called “Euler” angles and, to uniquely describe an orientation, must be interpreted as having a particular order. In this case, the order is azimuth, then elevation, and then roll. This concept is illustrated by sketch, below.



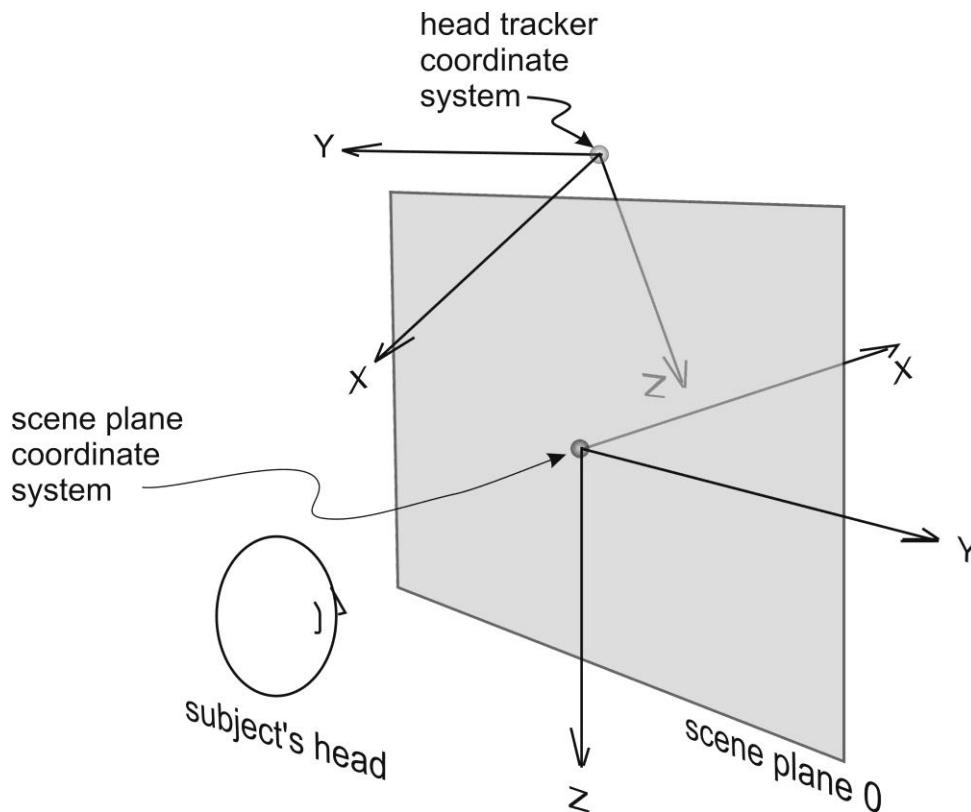
3.1.1 Global reference frame

For use with *ET3Space*, one of the standard positions and orientations for the global coordinate system and the calibration surface is shown below.



The origin is just behind the subject's central or standard position (usually the subject position during subject calibration and/or the position most central or usual during the subject's anticipated activities). The X axis points towards the direction faced by the subject and towards the calibration surface; the Y axis points towards the subject's right, and the Z axis points down. (Note that this is consistent with the "right hand" convention diagramed above if the hand is rotated so that the thumb points down). The global coordinate system does not have to conform precisely to this standard, but it is recommended that it be at least approximately as described above.

An alternate “standard” arrangement for the global coordinate system and calibration surface is shown below. This is often the most convenient arrangement when the primary viewing surface is a computer monitor being viewed by the subject. In this case the global coordinate system origin (head tracker coordinate system origin) is located just above the display surface with an X axis that points back towards the subject’s head.



The tracking systems used as head trackers usually have the means to specify the Global coordinate system origin and the axes pointing directions, although the specific method for doing this is a bit different for each system. In the case of magnetic systems, the global origin is usually the center of the magnetic transmitter. In the case of optical systems, the standard global coordinate system origin is sometimes attached to the system camera unit, and with other systems there is a procedure that involves placing an object, recognized by the tracker, at the desired origin point.

To choose the best location for the global coordinate system and to find instructions for specifying the position and orientation of the global reference frame, please refer to the Argus Science manual or tech note for the specific motion capture system being used, and to the tracker manufacturer’s literature.

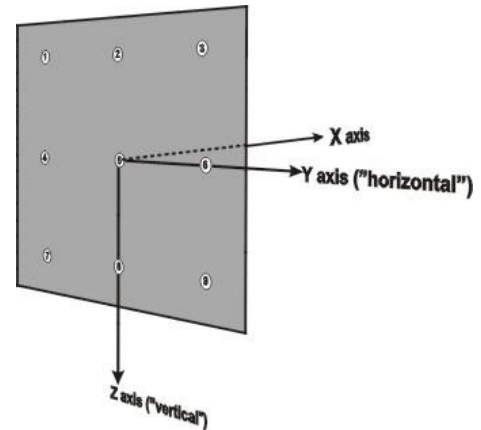
3.1.2 Scene Plane coordinate frames

Before any *ET3Space* calculations can take place, all of the scene planes (flat surfaces) of interest must be defined to the *ET3Space* system. The procedures for doing this 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 at least one surface designated as **plane 0** and up to 19 additional, sequentially numbered scene planes.

- An imaginary coordinate frame must be assigned to each 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.



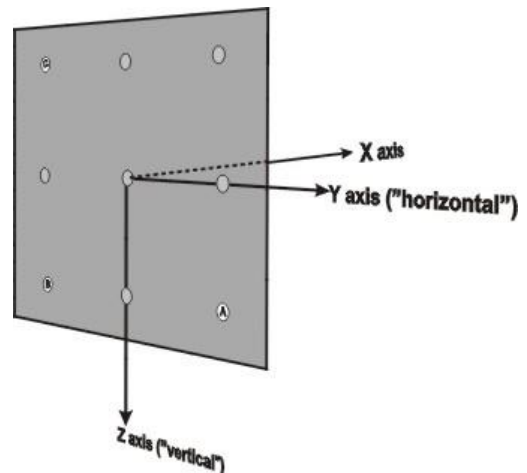
A rectangular boundary must also be determined for each scene plane, and is specified by top, bottom, left, and right coordinates. The top coordinate is the z value at the top edge of the surface (minimum z value on the surface); the bottom coordinate is the z value at the bottom edge of the surface (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. Since measured gaze coordinates can have some error, it is best, where possible, to specify boundaries that are slightly larger than the physical surface boundaries. If two defined surfaces "butt up" against each other then the true physical boundary must be used. EXAMPLE: if the scene plane is a monitor with physical dimensions of 16 inches x 10 inches (+/- 8 horizontal, and +/- 5 vertical), and the scene plane origin is defined to be the center, the scene boundary coordinates might be Top - 6, Left - 9, Right 9, Bottom 6.

The first surface specified is designated as plane 0, and all other surfaces as planes 1 through 19.

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 Global Reference Frame. These will be referred to as "scene plane definition points". They are labeled "A", "B", and "C", and form an L shape, with A at the lower right, B at the vertex, and C at the upper left, as shown on the diagram. A symmetrical fourth point, labeled "D", will be chosen by the application such that ABCD forms a parallelogram.



The 4 point pattern should cover a large percent of the area on which gaze will be measured, and each point should be a visible target or landmark on the surface. The scene plane coordinates of these

points can be determined by measuring along the axes lines of the coordinate frame assigned to the surface.

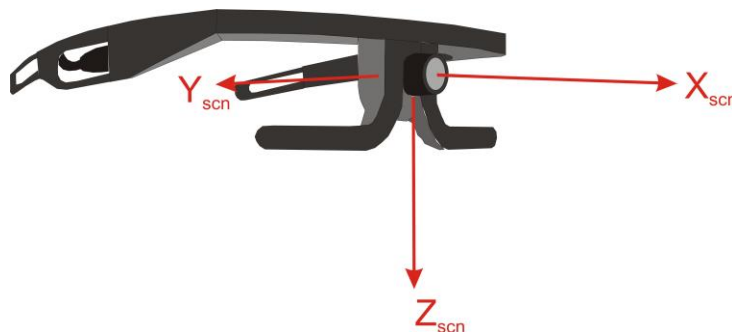
3.1.3 Sensor reference frame

In most cases, the “head tracker” system really tracks the position and orientation of a small object that, during normal operation, is attached to the subject’s headgear. During parts of the environment set-up procedure, it may temporarily be mounted to a pointing device (or an alternate tracked object may be attached to a pointing device). Different position tracking systems refer to this object as “sensor”, “rigid body”, “object”, “tracking tool”, etc. In this document it will be referred to as the “sensor”. There is an imaginary reference frame attached to the sensor, and the tracker system reports the position and orientation of this sensor coordinate frame with respect to the global coordinate frame.

When a “sensor” is used with a pointing device as part of the environment set-up procedure, it is important to know the precise position of the pointer tip (or in the case of a laser pointer, the origin and direction of the laser) with respect to this sensor coordinate frame. Whenever Argus Science provides both the sensor and pointing device, this information will be specified.

3.1.4 Scene camera reference frame

The *ETVision* system computes gaze with respect to an imaginary coordinate frame that is attached to the head mounted scene camera. As shown below, the scene camera coordinate frame (“scn”) has an X axis that points forward along the camera “line of sight” axis, a Y axis pointing towards the subject’s left (parallel to the camera pixel “rows”), and a Z axis pointing down (parallel to the camera pixel “columns”).



3.1.5 Sensor to Scene-Camera transform

As discussed in section 3.1.3, the head tracker system will have some sort of “sensor” that will be attached to the *ETVision* headgear and will have an imaginary reference frame (“sen”) attached to it. Since both the head tracker sensor and the scene camera are attached to head mounted optics their relative position and orientation remains constant. *ET3Space* computations require that the relationship (“transform”) between sensor and scene camera coordinates be known. In other words, it is necessary that a point known with respect to one of these reference frames can be also be determined with respect to the other.

In most cases Argus Science can provide the appropriate “sensor” mounting arrangement for use with head tracking systems that interface to with *ETVision*. For optical motion capture systems, this is

usually an assembly with reflective spheres that is provided by Argus Science and mounts to the *ETVision* optics frames, as shown below.



In most cases, Argus Science also provides a file that defines the “sensor” coordinate frame to the motion capture system application, and a configuration file that defines the associated “sensor to scene-camera transform” to the *ETVision* application. The sensor coordinate system definition file provided is usually designed so that when the sensor is attached to the optics frames the sensor coordinate frame is exactly (or almost exactly) the same as the scene camera reference frame. In this case the vector connecting the origins of the two coordinate systems is simply zero, and the rotation needed to match orientation of the two coordinate systems is also zero.

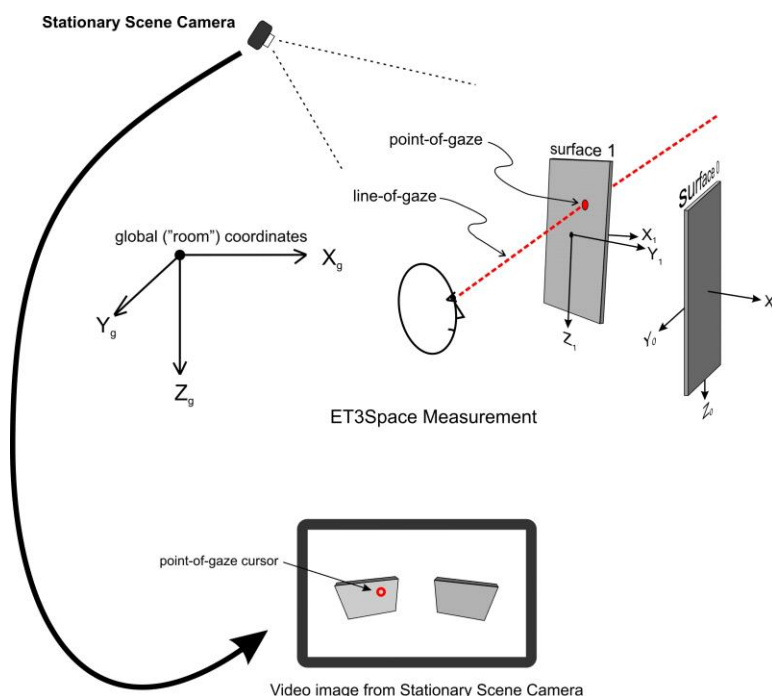
The sensor definition file to be uploaded to the motion capture system application is usually named “ArgusETVii_mmm.ext”, where *ii* is a version number, *mmm* is a calibration code that usually matches the last 3 digits of the *ETVision* system serial number, and *ext* is a file extension that depends on the motion capture system. The “sensor to scene-camera transform” file, to be read by the *ETVision* application, is usually named “name_mmm_sen2eye.xml”, where *name* is the name of the motion capture system being used for head tracking, and *mmm* is a calibration code that usually matches the last 3 digits of the *ETVision* system serial number. The vector connecting the origins of the sensor and scene camera coordinate frames is specified on the *Scene Plane Configuration* dialog (see section 6.5) and, as explained in the previous paragraph, will usually be (0, 0, 0). The specifics may differ depending on the particular motion capture system being used, and Argus Science provides a separate manual or technical note for each motion capture system supported by *ETVision*.

Please refer to the Argus Science manual or tech note for the specific motion capture system being used to find the details about the sensor coordinate frame and definition files provided for use with that system.

It is anticipated that the default “sensor to scene-camera transform” provided by Argus Science will usually be appropriate and sufficient, but if a “sensor to scene-camera transform” does need computed or modified, a procedure is described in Appendix C (section 16). The procedure involves the use of an optional pointer device that can be provided by Argus Science.

3.1.6 Stationary Scene Camera

It is possible to display and synchronously record video from an external camera. This feature is described in section 7.9 of the *ETVision* manual. When using *ET3Space*, if the external camera is stationary and if one or more of the *ET3Space* scene plane surfaces is visible in the camera field of view, then the scene plane boundaries can be designated on the camera image and a point-of-gaze cursor will be superimposed on the camera image when gaze is within these scene plane boundaries. If “Draw Fixation” is enabled on the *Video Source* dialog, then real-time fixation indicators will also be superimposed when fixations are detected on the scene plane.



As described in the *ETVision* manual, the external video source can be any video source recognized by Win10, on the *ETVision* PC, but is most commonly a Web cam with a USB interface. The *ETVision* application allows selection of either the default resolution and update rate for the video source, the highest resolution offered by the video source, or the fastest update rate offered by the video source. Video sources with up to 1080p resolution at 30 Hz, and USB3 interface, usually work without affecting system performance on a minimum spec *ETVision* PC. Depending on the capabilities of the *ETVision* PC, use of higher resolution external video may cause some slow down in gaze computation performance including overtimes (missed data fields) on the gaze data. Use of a higher bandwidth video source may slow gaze computation performance resulting in overtimes (missed data fields), depending on the capabilities of the *ETVision* PC.

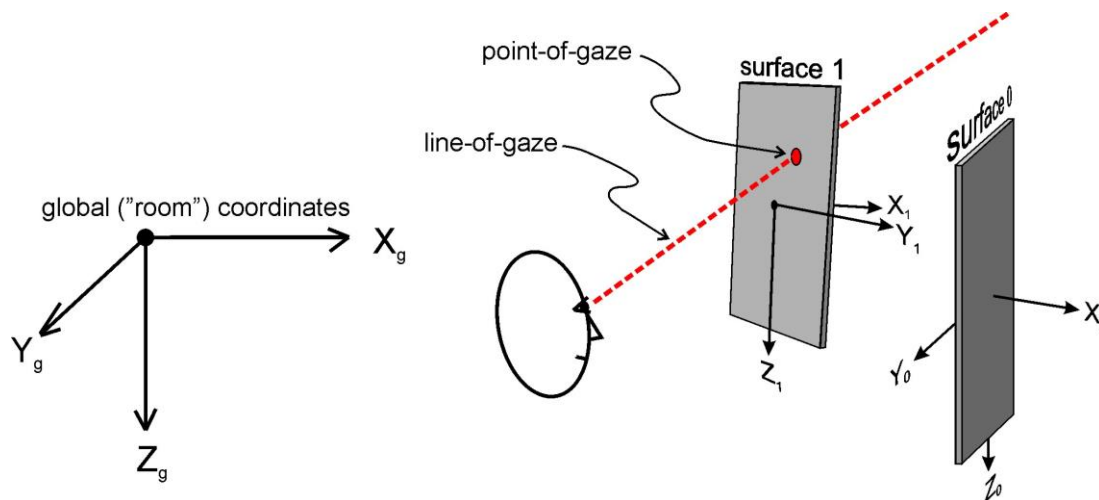
Instructions for setting up the *Stationary Scene Camera* feature with *ET3Space* are in Appendix D (section 17) of this manual.

3.2 Computations and data

During normal operation the system will continue to determine point-of-gaze with respect to the scene camera coordinate system, and will indicate gaze position on the head mounted scene camera image, just as it does when *ET3Space* is not enabled. The imaginary line from the scene camera (located between the eyes, near the bridge of the nose) to the point-of-gaze will be referred to as the cyclopean line-of-gaze. The *ET3Space* function will determine the location and orientation of this line in the global (“room”) coordinate system.

Since the *ET3Space* system also “knows” the position and orientation of defined surfaces in the environment (as described in the section 3.1.2), the system can determine which scene plane surfaces are intersected by this cyclopean line-of-gaze.

Point of gaze is considered to be on the first scene plane intersected by cyclopean line-of-gaze at a point within the scene plane boundaries. The Scene Plane number for that surface is reported as the “scene plane”. The line-of-gaze intersection point on that surface is considered to be the point-of-gaze, and point-of-gaze coordinates are reported with respect to the coordinate frame defined on that surface. . If line-of-gaze does not intersect any scene plane within its boundaries, the scene plane index is reported as “-1”, and the reported coordinates are the intersection of line-of-gaze with an infinite extension of scene plane 0.



The system will also determine the distance of the scene camera from the point-of-gaze, the location of each eye in the global coordinate system, and line-of-gaze direction of each eye in the global coordinate system. . Line-of-gaze direction is always specified as a “unit vector”, meaning its length ($\sqrt{x^2+y^2+z^2}$) is always 1.

All of the above information can be recorded or streamed, in real time, to an external device. The *ETVision*, *Data Display* window “POG Display” shows a real time plot of gaze point with respect to the coordinate frame defined for the surface containing the point-of-gaze. It also displays digital values showing the Scene Plane number of the surface containing the point-of-gaze, the gaze

coordinates with respect to that surface, and the distance from the head mounted scene camera to the point-of-gaze. Alternately the *Data Display* window can show a dynamic bar graph representing cumulative gaze time, fixation time, or other variables for gaze on each ET3Space scene plane.

The *Scene Image* window continues to display a cursor showing point-of-gaze on the head mounted scene camera image, just as it does when *ET3Space* is not enabled. If *ET3Space* is enabled, and if “Show Scene Plane” check box on the *Advanced Configuration* dialog is checked, the *Scene Image* window will also superimpose a rectangle showing the boundaries of each defined scene plane currently visible to the scene camera. These boundary boxes will move with the scene plane image as the scene camera moves.

If an external camera has been connected to *ETVision* and configured to designate *ET3Space* scene planes, a point-of-gaze cursor will also appear in the *Stationary Scene Camera* window whenever gaze is within one of the scene plane boundaries. If “Draw Fixations” is enabled on the *Video Source* dialog, real time fixations indicators will also be superimposed when gaze is within a scene plane boundary.

3.3 Units

The user can choose to specify *ET3Space* environment parameters in either English Standard, or Metric distance units. This choice is made on the *System Control Table, System Configuration* tab (shown in next section). Use the “Units” drop down menu to select either “inches” or “centimeters”. Angles are always given in “degrees”.

Whenever length values are entered on any dialog, the system will assume that they are being entered in the currently specified units (inches or centimeters). If the “Position Units” specification on the *System Configuration* dialog is changed, any values already entered will be converted to the new units.

3.4 Real-Time Fixations


Real-time fixation computations are described in sections 7.4.1 and 9.12 of the *ETVision* manual. When *ET3Space* is enabled the same fixation detection algorithm is employed, and uses the same adjustable parameters; however the frame of reference is an *ET3Space* scene plane. In other words, fixations are periods of gaze stability with respect to a scene plane rather than stability with respect to the head mounted scene camera.

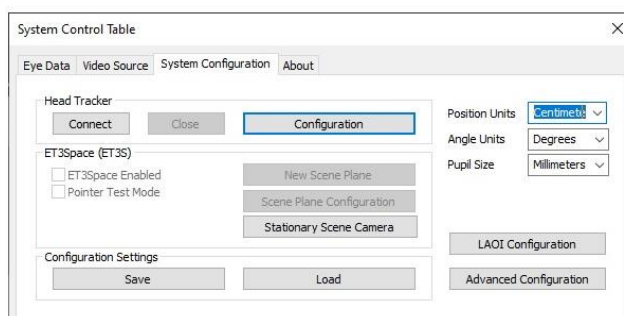
When *ET3Space* is enabled, fixation coordinates are reported as scene plane coordinate values rather than scene camera pixel coordinates. Measurement units are those specified on the *System Configuration* dialog.

When monitoring streaming data, a non-zero *fix_duration* value indicates an on-going fixation. If there is an ongoing fixation, the “Scene” value determines what scene plane it is on, and fixation coordinates are reported with respect to this scene plane coordinate frame. If LAOIs have been defined the *Gaze_LAOI* value determines which, if any, LAOI the fixation is in.

4. ET3Space Software


The *ET3Space* function is part of the *ETVision* application and will already be installed on the *ETVision* PC when the PC is supplied by Argus Science. Installation (if needed) and operation of the *ETVision* application is described in the *ETVision* manual.

Configuration and activation of the head tracker as well as environment set-up and activation of *ET3Space* are all initiated from the *ETVision*, *System Configuration Table*, *System Configuration* tab. The System Control Table is opened by clicking the  icon on the main menu bar.



The distance measurement units to be used when defining the environment, and for reported results, are specified with the drop down at the upper right of the dialog.

If Argus Science has provided a configuration file with a sensor to scene-camera transform for the particular head tracker system and sensor being used (usually *name_default_sensor2cam.xml*, where *name* is the head tracker type), click the “Load” button at the bottom of the dialog to select the supplied configuration file. Note that loading this file will only affect the sensor to scene-camera transform and will not change other configuration data.

Real-time display of *ET3Space* Data will be on a *Data Display* window that is opened by clicking the “Data Display” icon  on the main menu bar. (*Data Display* window shown below when head tracker not yet connected).

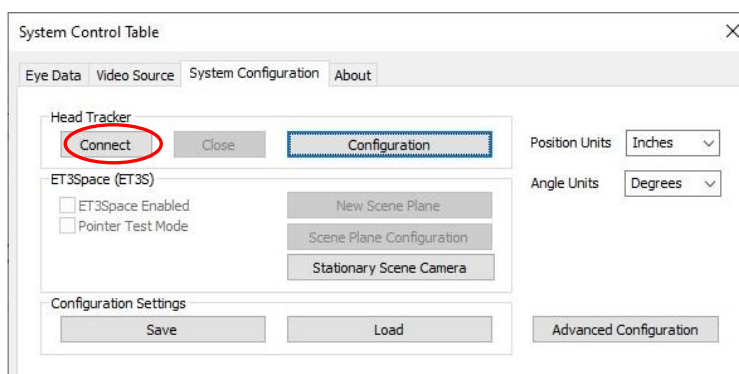


5. Enable communication with head tracker

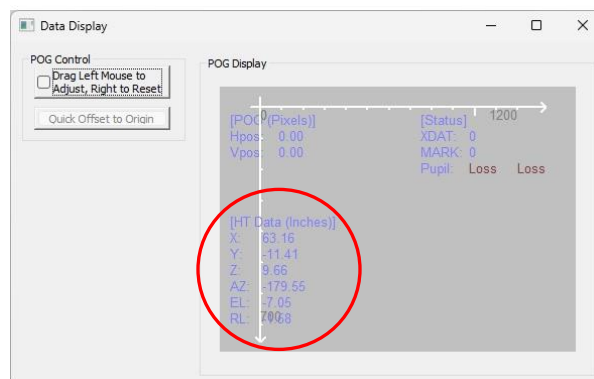
Be sure the head tracker and eye tracker are properly connected. A separate manual or Tech Note is provided by Argus Science with instructions specific for use of *ET3Space* with each particular type of motion capture system that can be used for head tracking with *ETVision*.

If Argus Science has provided a configuration file with a sensor to scene-camera transform for the particular head tracker system and sensor being used, click the “Load” button at the bottom of the dialog to select the supplied configuration file used (usually *name_default_sensor2cam.xml*, where *name* is the head tracker type). Note that this should only need to be done once, and will be remembered next time *ETVision* is launched.

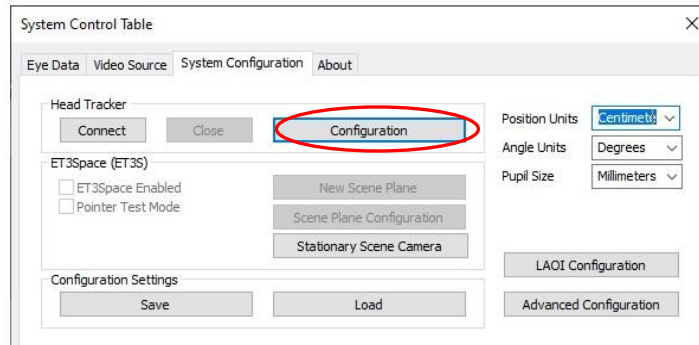
Select the *System Configuration* tab on the *System Control Table* window. If a head tracker is connected and has previously been configured, simply click the “Connect” button, in the “Head Tracker” box, to establish communication between the head tracker and the *ETVision*.



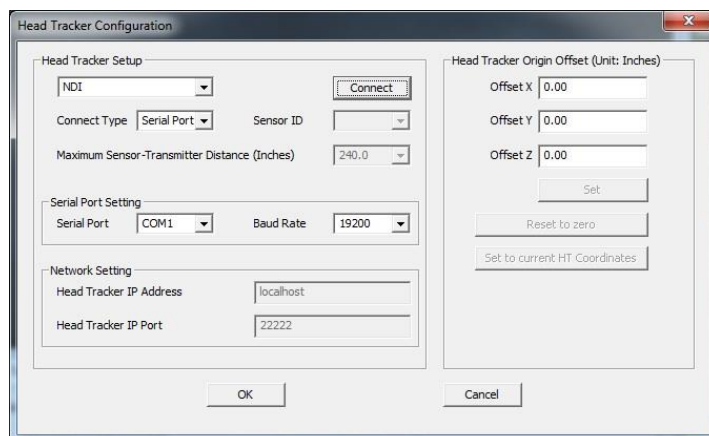
If successful, the “Connect” button will turn gray, and the “Close” button will become active. The “ET3Space Enabled” check box will also become active. If the *Data Display* Window is open, live head tracker data will appear on the *Data Display Screen*. The position units will be those indicated on the *System Configuration Table, System Configuration* tab dialog. Position values can be chosen to be either inches or centimeters. Orientation angles are always shown in degrees.



If using a head tracker for the first time, click the “Configuration” button, in the “Head Tracker” box.



The Head Tracker configuration dialog will appear as shown below.

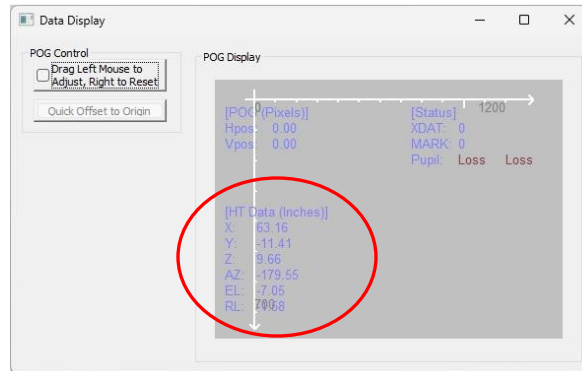


Choose the head tracker type and connection type from the drop-down menus. If a connection type is not supported for the chosen head tracker type, that selection will not be allowed. If the connection type is “Serial Port”, “Serial Port Setting” items become active and can be set appropriately. If the connection type is “TCP/IP”, “Network Setting” items become active. There is a manual or Tech Note devoted to each type of currently supported head tracker, and more detailed information about settings for that particular head tracker type is provided there. The “Head Tracker Origin Offset” values should normally be left at zero. (There may be unusual instances for which it will be convenient to have the head tracker report position from an origin other than the natural origin associated with the head tracker device.)

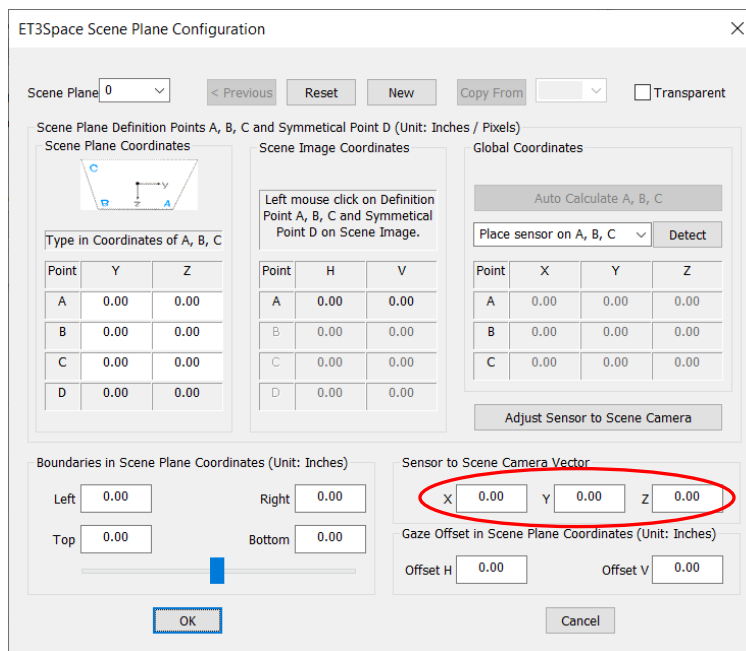
Assuming that the head tracker is properly connected, click the Connect button on the “Head Tracker Configuration” dialog, or click OK to close the “Head Tracker Configuration” dialog and click “Connect” on the *System Configuration* tab dialog. If communication with the head tracker is successfully established the “Connect” button on the *Head Tracker Configuration* dialog will change to “Close”. On the System Configuration dialog, the “Connect” button will turn gray, and the “Close” button will become active.

If data from more than one sensor is available from the motion capture device, select the appropriate “Sensor ID” number or “Body Name” from the pull down menu. Refer to the Argus Science manual with instructions specific to the motion capture system being used.

If the *Data Display* window is open in POG Plot mode, live head tracker data will appear at the lower left of the “POG Display” area. (Click the “Data Display” icon to open the Data Display window). See section 12 for a detailed description of the *Data Display* window.

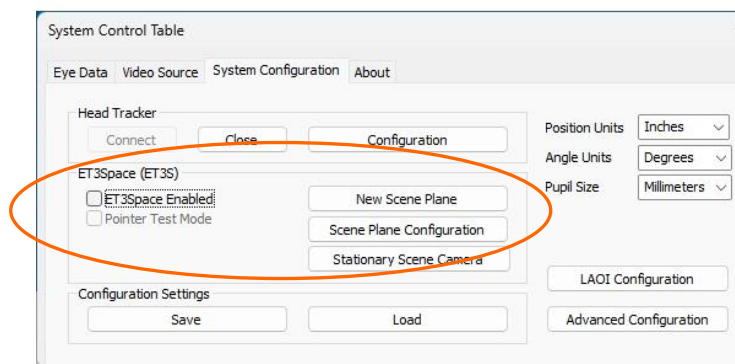


The “New Scene Plane” and “Scene Plane Configuration” buttons, on the System Configuration dialog, will now be enabled. Click the “Scene Plane Configuration” button to open the *Scene Plane Configuration* dialog and check to be sure the proper sensor to scene-camera vector is entered. If using a sensor to scene-camera transform supplied by Argus Science this will usually be (0, 0, 0), as shown below. Click OK to close the *Scene Plane Configuration* dialog.



6. Configure *ET3Space* Environment

The *ET3Space* environment parameters define the physical arrangement of surfaces with respect to a global coordinate system, and define the relationship between the head tracker sensor and the *ETVision* scene camera. Procedures to set these parameters and to enable *ET3space* are initiated from the “*ET3Space (ET3S)*” group box on the *System Control Table*, *System Configuration* tab.



Once a head-tracking device is enabled as described in the previous section, the *ET3Space* function can be enabled or disabled at any time by checking the box labeled “*ET3Space Enabled*”. *ET3Space* will provide meaningful data only once the environment has been

properly defined, but can be enabled either before or after environment parameters have been set. “*Pointer Test Mode*” can be used to help check that the *ET3Space* environment has been correctly defined, and is described in section 6.2.

The sensor to scene-camera transform needs be determined only once for a given head tracker sensor and mounting position. If this has already been done (or has been supplied by Argus Science for the components in use) scene plane surfaces can most easily be easily added to the environment specifications using the “*New Scene Plane*” button, as described in the next section. In most cases each surface is defined essentially by supporting the *ETVision* optics so that the surface is visible to the scene camera; then typing in the scene plane coordinates of 3 of the 4 definition points and clicking on the 4 “*definition points*” in the scene image.

The “*Scene Plane Configuration*” button brings up a more general dialog that can be used to define the sensor to scene-camera transform if necessary, and to modify or delete existing scene plane definitions. (It can also be used, instead of the “*New Scene Plane*” button, to add new scene planes to the environment.) Use of the *Scene Plane Configuration* dialog is described in section 6.5 and in the appendices.

Environment surfaces (“*scene planes*”) are numbered consecutively from 0 to a maximum of 19. The first surface defined will be “*Scene Plane 0*”, the next will be “*Scene Plane 1*”, etc. Scene plane numbers cannot be assigned out of order. In other words “*Scene Plane 2*” cannot be defined until there is a “*Scene Plane 1*”. If a scene plane is deleted the number assigned to all higher number scene planes will be decremented so that numbers remain consecutive.


If using the *ETVision* system with a head tracking device for the first time and if unsure whether a proper sensor to scene-camera transform has been provided by Argus Science, please consult Argus Science. To compute a new sensor to scene-camera transform see Appendix C (section 16).

6.1 Use *New Scene Plane* dialog to define a new environment

The following instructions assume that a proper “sensor to scene-camera transform” is part of the current configuration. If not already done, load the “sensor to scene-camera transform” file, provided by Argus Science for the head tracker being used, as described in sections 4 and 5. Set the sensor to scene-camera vector using the Scene Plane Configuration dialog, as described at the end of section 5. For most head tracker systems, this vector should be set to $(0, 0, 0)$. Refer to the Argus manual for the specific head tracker being used.

Be sure that the head tracker is sending data from the head gear mounted sensor to *ETVison*. (See section 5 and separate manual for specific head tracker being used.)

Decide on the origin, and the y (“horizontal”) and z (“vertical”) axes directions for the coordinate frame “attached” to each surface to be part of the *ET3Space* environment. Identify 3 visible “definition points” and a symmetrical 4th point on each surface, as described in section 3.1.2. These will be referred to as points A, B, C, and D, with A at the lower right, B at the lower left, C at the upper left, and symmetrical point D at the upper right. The four points should form a parallelogram with line AB parallel to CD and line BC parallel to DA. Write down the y and z (“horizontal” and “vertical”) coordinates of points A, B, and C with respect to the coordinate frame to be defined for that surface.

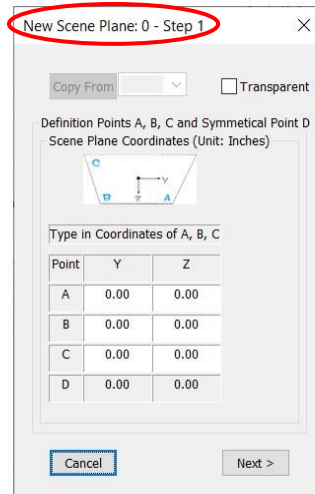
If *ET3Space* is not already enabled, left click to put a check mark in the “ET3Space Enabled” box on the System Configuration dialog. If the Data Display window is not open, it is suggested that it be opened before proceeding (click ), and that the “Show Scene Plane” check box, near the upper left of the *Data Display* window, in the “Display Control” group box, be checked. (See section 12 for a detailed explanation of the *Data Display* window.)

6.1.1 Define Scene Plane 0

Support the *ETVison* optics frame so that it will remain stationary, so that the center of Scene Plane 0 is close to the center of the scene camera image, and so that points A, B, C, and D are all in view. Although not a strict requirement, it is best if the camera visual axis is roughly perpendicular to the scene plane. In other words, the camera should view the scene plane from more or less “straight on”. If the scene camera axis is severely skewed with respect the scene plane perpendicular, results may be less accurate. It will also be best if the line connecting point A and B appears at least roughly aligned with the scene camera image horizontal axis, and the BC line is roughly aligned with the camera image vertical axis.

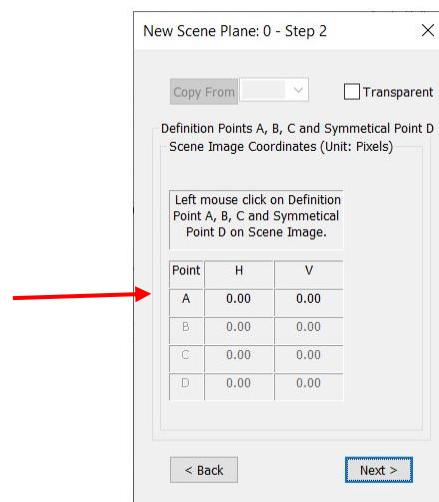
Be sure that the head tracker sensor is in the detectable volume of space and is sending data from the headgear mounted sensor to *ETVison*. If using an optical head-tracking device, be sure that the optical path from the sensor to the head tracker camera unit is not blocked.

1. Click the “New Scene Plane” button. A dialog titled “New Scene Plane: 0 - Step 1” will appear. If the dialog title has a scene plane number other than 0, the environment is not blank and the specified scene plane number will be added to previous scene planes. If attempting to start a new environment, click “Cancel” to close the dialog and follow the directions in Appendix A (section 14) to clear the previous environment before proceeding.



2. Type in the Y (“horizontal”) and Z (“vertical”) coordinates for points A, B, and C on Scene Plane 0. Once coordinates for all three points have been entered, the coordinates for a symmetrical point D will be entered automatically. Be sure that the point D target on the scene plane surface is really at the specified scene plane coordinates, since the point D coordinates are set by the program.

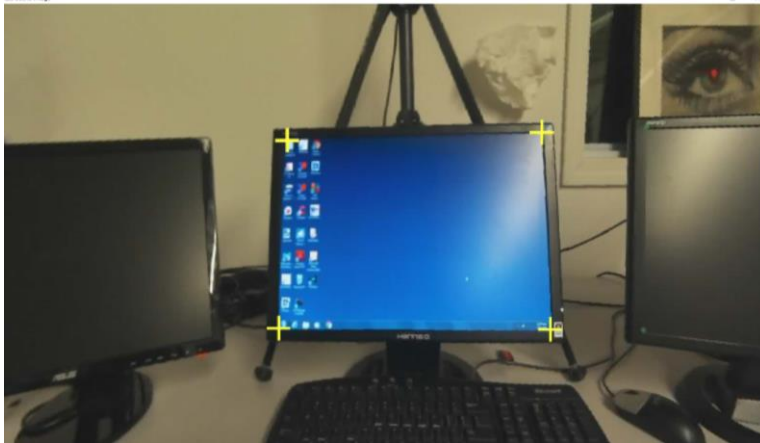
3. Click “Next”. “New Scene Plane: 0 - Step 2” dialog will appear, with the table row for “Point A” pixel coordinates highlighted.



4. Click on point A (lower right definition point) in the ETVision Scene image. A yellow cross will appear at the spot clicked, and the scene camera pixel coordinates for the point will appear in the dialog table. The “Create New ET2Space Scene Plane: 0” dialog will now highlight the row for point B pixel coordinates.

5. Repeat step 4 for points B, C, and D (lower left, upper left, and upper right, respectively). A yellow cross will appear at each spot clicked. Note that the points should be clicked in the order specified (A then B then C then D). **Tip:** click the maximize icon at the top right of the Scene Image

window to expand the image for most accurate designation of the definition points; then click the resize icon to return to the reduced size window so that the New Scene Plane dialog is once again visible.



New Scene Plane: 0 - Step 2

Copy From Transparent

Definition Points A, B, C and Symmetrical Point D
Scene Image Coordinates (Unit: Pixels)

Left mouse click on Definition Point A, B, C and Symmetrical Point D on Scene Image.

Point	H	V
A	910.78	532.29
B	458.19	530.24
C	472.21	222.65
D	896.77	209.63

< Back Next >

6. Be sure that the yellow crosses still appear superimposed on the point A, B, C, and D target locations in the scene image. If some do not, this means that the *ETVision* optics moved sometime during steps 4 and 5. In this case, repeat steps 4 and 5, being careful not to move the optics.

7. **Click Next.** A dialog titled “New Space Scene Plane: 0 - Step 3” will appear. Be sure that the *ETVision* optics still have not moved and be sure that the head tracker is still sending data from the head gear mounted sensor to *ETVision*. **Note:** If an “Auto Calculate A, B, C” button does not appear in “Step 3”, as shown, this usually means that the default “sensor to scene-camera transform” file has not been loaded. In this case, exit the “New Scene Plane” procedure by clicking the “X” at the upper right corner, and load the default “sensor to scene-camera transform” file as described in sections 4 and 5.

New Scene Plane: 0 - Step 3

Copy From Transparent

Definition Points A, B, C and Symmetrical Point D
Global Coordinates (Unit: Inches)

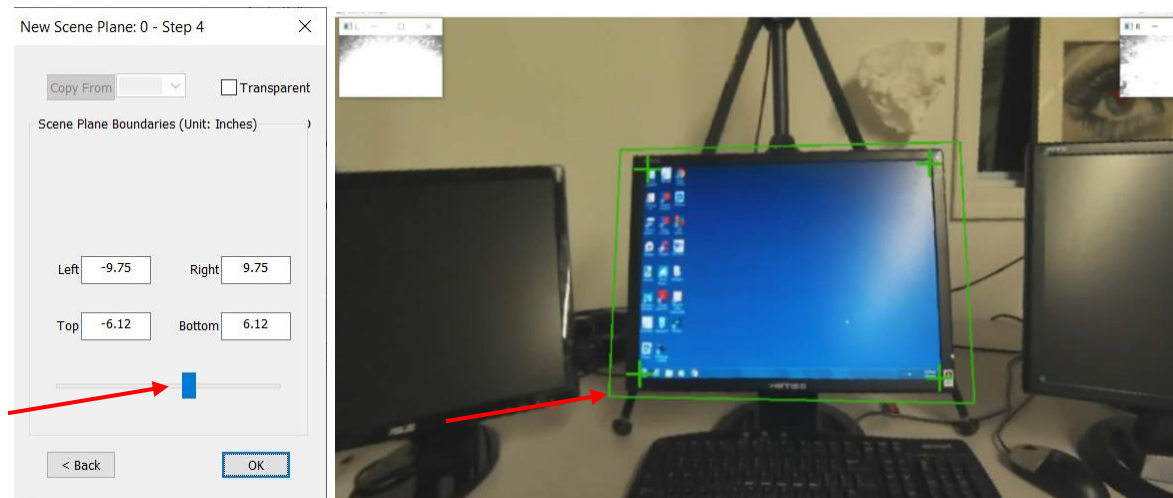
Auto Calculate A, B, C

Point	X	Y	Z
A	0.00	0.00	0.00
B	0.00	0.00	0.00
C	0.00	0.00	0.00

< Back Next >

8. Click the button labeled “Auto Calculate A, B, C”. The system will use the scene plane and scene camera coordinates for the definition points, the detected position and orientation of the sensor, and the known sensor to scene-camera transform, to compute the location of the definition points with respect to the global coordinate system. These computed values will appear in the Table at the bottom of the dialog.

9. **Click Next.** A dialog titled “New Scene Plane: 0 - Step 4” will appear. Click on the slider bar near the bottom. Assuming the “Show Scene Plane” box is checked, on the *Advanced Configuration* dialog, a dashed line box should appear on the *Data Display* “POG Display” and a superimposed rectangle should also appear over the Plane 0 surface on the scene camera image (*Scene Image* window). The rectangle should have vertices at (or very near) the 2 scene plane definition points that define the largest rectangle. This box defines the scene plane boundaries. **Use the slider to adjust the size of the boundary box.**



10. Alternately, type in boundary values. To define asymmetrical boundaries, type in the desired left, right, top, and bottom, coordinate values. Remember that these values are with respect to the coordinate frame defined on the scene plane surface. Assuming the origin is at the center of the desired surface, the left coordinate will be a negative value specifying a distance to the left of the origin (along the negative Y axis). The right boundary will usually be a positive value specifying a distance to the right of the origin (along the positive Y axis). The top boundary will usually be a negative value specifying a distance above the origin (along the negative Z axis), and the bottom boundary will usually be a positive value specifying a distance below the origin (along the position Z axis). The boundary box will always be rectangular with respect to the scene plane coordinate frame Y-Z plane.

Note: The boundary box may not appear rectangular with respect to the scene camera field of view because, if the surface is being viewed from an angle, the boundary lines are drawn to take account of perspective distortion.

Tip: If there is no other visual target near the an edge of the physical surface, it is suggested that the *ET3Space* boundary specified for that edge be a bit beyond the physical edge of the surface. This will lessen the chance that a small measurement error will cause gaze to be reported as off the surface when it is really just very close to the edge. Of course if two surfaces of interest touch, the real physical boundary must be specified.

11. Now move the optics. On the head mounted scene camera image, **the boundary box should follow the image of the scene plane** as long as the sensor remains in the detectable volume of space and is properly recognized by the head tracker. (Note that near the scene camera image edges, scene camera lens distortion may add some inaccuracy.) *Jitter in the boundary box position on the scene image is due to noise in the data being received from the motion capture system. Some noise is expected, but if excessive, check that the sensor is in a detectable position and orientation and, in the case of optical motion capture systems, that nothing is partially blocking the view of sensor reflectors by the motion capture camera unit.*

12. Click OK to close the “Create New ET3Space Scene Plane: 0” dialog.

6.1.2 Define additional scene planes

Now support the *ETVision* optics frame so that the center of Scene Plane 1 is close to the center of the scene camera image, and so that points A, B, C, and D on scene plane 1 are all in view. As with scene plane 0, be sure that the head tracker sensor is in the detectable volume of space and is sending data from the head gear mounted sensor to *ETVision*. If using an optical head tracking device, be sure that optical path from the sensor to the head tracker camera unit is not blocked.

Clicking the “New Scene Plane” button should bring up a dialog titled “New Scene Plane: 1 - Step 1” Follow the same steps as described above for scene plane 0. Repeat the procedure for any additional surfaces to be included in the environment.

Tip: On the “Step 1” dialog, if definition point coordinates for a scene plane are identical to those for a previously defined plane, select the previous scene plane number on the “Copy From” pull down menu, and click the “Copy From” button to automatically enter the same A, B, and C coordinates (rather than re-typing them).

6.2 Setting up a “Stationary Scene Camera”

When using *ET3Space*, scene plane boundaries can be designated on the image from an external video source and a point-of-gaze cursor can be superimposed on the camera image when gaze is within these scene plane boundaries. The video source must first be “connected” to *ETVision* using the *Stationary Scene Camera* dialog. Details are explained in Appendix D (section 17).

To enable display of a point of gaze cursor on the external video, each visible *ET3Space* scene plane surface must then be designated by specifying both the scene plane coordinates and the external video pixel coordinates of 4 points on the scene plane. This is also done using the *Stationary Scene Camera* dialog and a detailed explanation is in Appendix D (section 17).

If the “Show Scene Plane” box is checked on the *Advanced Configuration* dialog, a bounding box should appear superimposed on the image in the *Stationary Scene Image* window.

The results can be tested using the *ET3Space* “PointerTest Mode”. Enable “Pointer Test Mode” as described in the next section. If the optics frames are aimed so that the “pointer test cross” on the *Scene Image* window appears within one of the defined scene planes, the point-of-gaze cursor on the image in the *Stationary Scene Image* window should appear at the same position on that scene plane. The point-of-gaze cursor on the *Stationary Scene Image* window will have the same shape, color, and relative size as the cursor displayed on the optics mounted Scene Camera image

To record the external video along with gaze data, open the “Eye Data” tab on the System Control Table dialog, and be sure that “Auto-record SSC Video with Data File” is checked. The superimposed cursor can be set to display or to not display in real time and to display or not display on the video recording using the same “Scene Video Source” controls as for the head mounted scene camera display (see *ETVision* manual, section 9.4.2.2). The “Transparent” and “Quality” sliders on the “Scene Video Source” dialog do not apply to the external video.

6.3 Checking Environment Configuration with “Pointer Test”

Once some or all scene planes have been added to the environment, use “Pointer Test” mode to check *ET3Space* function without actually measuring eye movements. “Pointer Test” mode will use the *ETVision* optics unit, but does not require that it be worn by a person.

Be sure that the head tracker is enabled and is successfully communicating with *ETVision*. Be sure that the head tracker is sending data from the head gear mounted sensor to *ETVision*.

If not already opened, open the *ETVision, Data Display* window by clicking the “Data Display” icon .

On the System Configuration dialog, be sure that *ET3Space* is enabled, and left click the “Pointer Test Mode” check box to enable Pointer Test Mode. A black cross (“pointer test cross”) will appear at the center of the scene image display, superimposed on the video image. As the optics are moved, the cross will remain at the center of the camera image.

A message will appear prompting the user to aim the pointer at the origin of scene plane 0. Hold the *ETVision* optics so that the head tracker sensor is in the detectable volume of space, and so that the “pointer test cross” appears over the origin point of the scene plane 0 surface coordinate frame (usually the center of the surface). With the optics held in this position, click “OK” on the message dialog.

If the optics remain in this position (“pointer test cross” aimed at the Scene Plane 0 reference frame origin point), the “ET3Space POG Data” at the upper left of the Data Display window should indicate “Scene: 0” with gaze coordinates hovering near (0,0). The Data Display plot should also show a point near (0,0).

Aim the pointer test cross at known points on each scene plane surface to be sure the system reports the proper scene plane number and location on the surface. For example, if the cross is aimed at a point that is 2 inches to the right of the Scene Plane 1 coordinate frame origin and 3 inches below the origin, the Data Display window should indicate “Scene: 1” and gaze coordinates should hover near “Hpos: 2.0”, “Vpos: 3.0”. The “Magn:” value should correctly indicate the distance from the scene camera to the indicated point on the surface. Note that the system should report “gaze” to be on a scene plane only if the “pointer test cross” is within the bounding rectangle specified for that scene plane. If Stationary Scene Camera is set-up and enabled, the cursor on the Stationary Scene Camera image should appear at the position being indicated by the test cross on the optics mounted Scene Camera image.

If the system reports correctly on all but one scene plane (or some subset of the scene planes defined), use the “Scene Plane Configuration” dialog to re-define that surface as described in Appendix B (section 15). When re-defining a scene plane be sure that the head tracker is reporting correctly during the part of the procedure that calls for clicking on points A, B, C, and D. If the system reports incorrectly on all scene planes and re-defining them does not solve the issue, it is possible that the sensor to scene-camera transform is incorrect and needs to be recomputed as described in Appendix C (section 16).

Before moving on to set-up a subject, remember to exit pointer test mode by un-checking the “Pointer Test Mode” check box.

6.4 Environment Configuration Backup

When the *ETVision* program is closed, the Head Tracker configuration, *ET3Space* environment specification, and Network Interface configuration are automatically saved, and restored next time the program is opened. This data can also be explicitly saved, at any time, by the user, in a user named XML type file. After a successful environment set-up, it is strongly recommended that this be done. Configuration files saved in this way can be re-loaded by the user at any time.

On the System Control Table, System *Configuration* Tab, click the “Save” button, under “Configuration Settings”, and use the resulting browser dialog to select a file name and directory. The “Save as Type” specification should usually be left as “XML files”. In this case, an “.xml” extension will automatically be added to the file name.

To re-load this configuration at a later time, click “Load” on the same *Advanced Configuration* dialog, and select the previously saved file.

After successfully setting up an *ET3Space* environment, it is probably prudent to explicitly save the configuration before starting to take important subject data. If someone accidentally changes something, it will always be possible to return to the saved state.

Note that saving the configuration in this way saves all *ETVision* configuration parameters including the current Head Tracker configuration settings, the current sensor to scene-camera transform, and current subject calibration. Loading a saved configuration restores all of these parameters.

6.5 Using the *Scene Plane Configuration* Dialog

The instructions for creating a new environment as described in section 6.1 assume that *ET3Space* currently has no environment specifications. To clear all previous environment specifications, see instruction in Appendix A (section 14).

Alternately, an existing environment can be modified using the *Scene Plane Configuration* dialog, and this is described in Appendix B (section 15). Note that existing environment specifications can always be saved for future use, before deleting, as described in the previous section.

ET3Space computations require that the relationship (“transform”) between sensor and scene camera coordinates be known. In other words, it is necessary that a point known with respect to one of these reference frames can be also be determined with respect to the other.

The precise nature of the sensor assembly and its mounting position on the *ETVision* optics unit may differ somewhat depending on the head tracker system being used, and of course this affects the sensor to scene-camera transform. The transform supplied by Argus Science for a particular motion capture system (head tracker) will usually be adequate, but if the transform needs to be modified or re-

computed, this can be done using the *Scene Plane Configuration* dialog, as described in Appendix C (section 16).

If using a rigid body and associated rigid body file provided by Argus Science, all three coordinates for the “Sensor to Scene Camera Vector” (near bottom right of *Scene Plane Configuration* dialog) should usually be set to 0.00. See the Argus Science manual or tech note for the specific motion capture system being used.

7. Subject Set-up and Calibration

Follow the directions in the *ETVision* manual to set-up the optics on a participant and to calibrate the participant. Subject calibration is done using the head mounted scene camera image and does not depend on either the head tracker or the *ET3Space* function. In fact, the participant can be calibrated in a room or space that is completely separate from the *ET3Space* environment. Most often, however, it will be most convenient to calibrate the participant when in their “standard” position in the *ET3Space* environment.

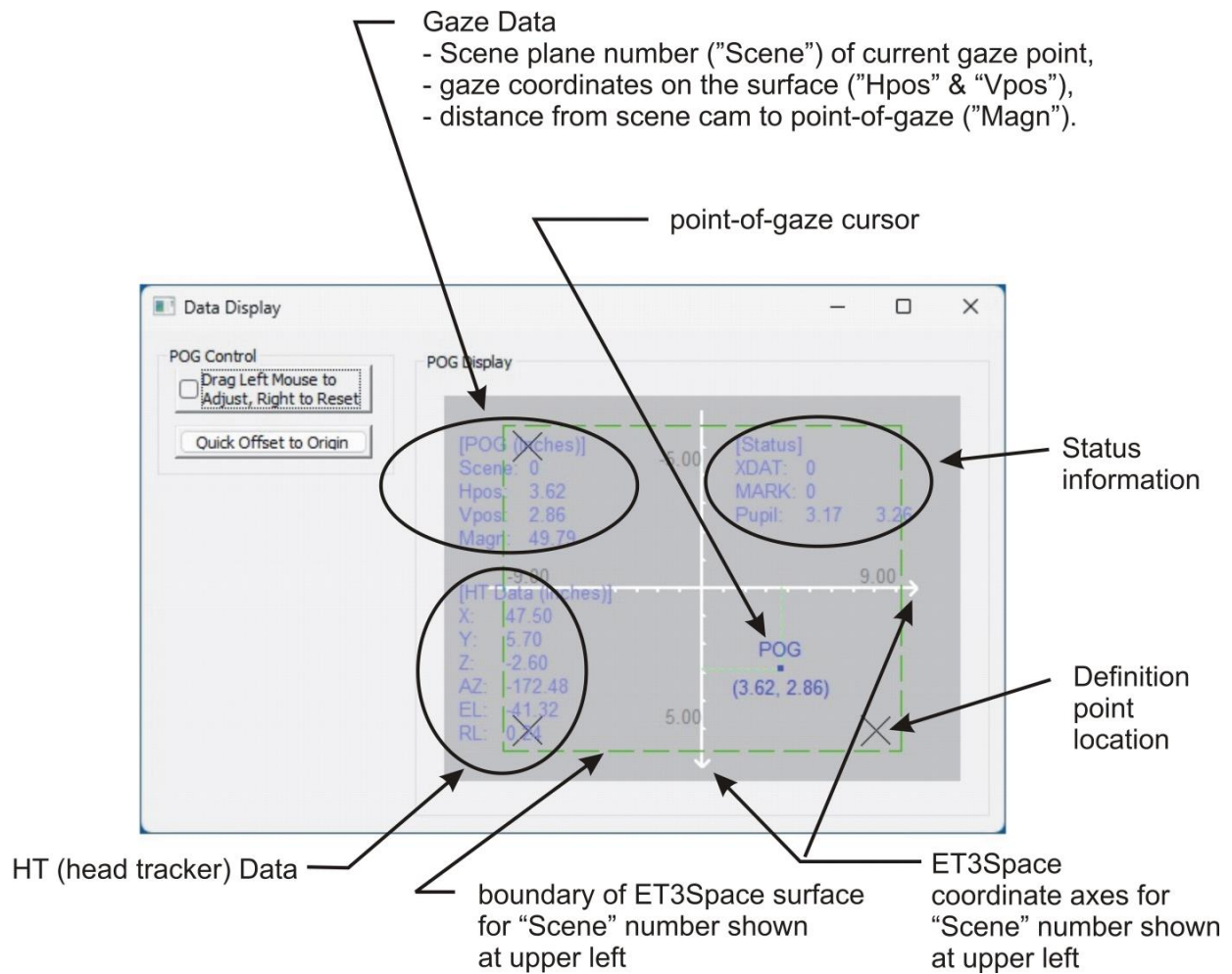
Once satisfied that point-of-gaze cursor on the head mounted scene camera image shows suitable accuracy, be sure that the head tracker is recognizing the head tracker sensor and is sending the sensor position data to *ETVision*. Be sure that *ET3Space* is enabled (*System Configuration dialog*, “*ET3Space Enabled*” box checked), and be sure that “*Pointer Test Mode*” is not enabled (*System Configuration dialog*, “*Pointer Test Mode*” check box not checked).

If not already opened, open the *ETVision, Data Display* window by clicking the “*Data Display*” icon  on the main menu bar.

8. Monitor Performance

The point-of-gaze cursor on the scene image window shows gaze with respect to the head mounted scene camera and is the measurement being made by just the *ETVision* eye tracker. This measurement does not depend on the motion capture system or the *ET3Space* function, and is one of the inputs to the *ET3Space* function.

The result of the *ET3Space* computation is shown by the position of the boundary rectangles shown for defined surfaces on the Scene Image window, and by the point-of-gaze coordinates on the *Data Display* window “POG Display”. On the "POG Display", the value labeled “Scene:” specifies the surface containing the computed point-of-gaze, and the plot and digital coordinates show the point-of-gaze position with respect to the scene plane coordinates. Individual display features can be enabled or disabled from the *Advanced Configuration* dialog (See section 12 for detailed explanation of Data Display window, and related *Advanced Configuration* controls).



To illustrate the relation between head mounted scene camera image and the *Data Display* window “POG Display” assume that the origin of Scene Plane 0 is centered in the head mounted scene camera field of view, and the subject is fixating that point. The scene image cursor should appear superimposed on that point, at the center of the scene image, and the *Data Display* window should indicate “Scene: 0” with coordinates hovering near (0,0). Now assume that the subject rotates his or her head to the right, but continues to fixate the origin point on Plane 0. On the *Scene Image Window*, the Plane 0 surface will appear to move the left, and the point-of-gaze cursor should also move towards the left so that it is still superimposed on the origin point of the surface. The superimposed rectangle showing the defined surface boundary should move with the surface image. The plot point on the *Data Display* window, however, should appear to remain in the same position and the Point-of-gaze coordinates should continue to hover near (0,0).

After subject calibration, check performance by having the subject fixate the center of a scene plane (or some other point with known coordinates) and continue to fixate that point while rotating their head 5 or 10 degrees to either side. Verify the behavior described in the previous paragraph.

Have the subject fixate one or more known points on each defined surface. Small offset errors observed on the *Data Display* coordinates can corrected as described in the next section.

Jitter in the boundary box position, on the *Scene Image* window, is due to noise in the data being received from the motion capture system. Some noise is expected, but if excessive, check that the sensor is in a detectable position and orientation and, in the case of optical motion capture systems, that nothing is partially blocking the view of sensor reflectors by the motion capture camera unit.

9. Manual offset correction

There will sometimes be a small offset in the *ET3Space* data which may differ for each defined scene plane surface. *ET3Space* has a separate manual offset correction capability for each scene plane. There is a quick offset capability that requires the subject to look at the origin of a scene plane, a way to drag the POG cursor to make the correction, and also a place to type in a manual offset correction value on the set-up dialog for each scene plane.

If *ET3Space* is enabled, the *Data Display* window, “POG Display” will show the number of the scene plane on which gaze is currently detected, and the point-of-gaze with respect to that scene plane. If point of gaze on any particular scene plane appears to have an offset error (error of about the same amount and direction over whole surface), it can be corrected by the following methods.

*Note: The following offset correction procedures assume that ET3Space is enabled, and apply only to the ET3Space data (as shown on the *Data Display* window, “POG Display”). To manually offset the *ETVision* data specifying gaze with respect to the head mounted scene camera image, temporarily uncheck the “ET3Space Enabled” check box on the *System Configuration* dialog, and follow the manual offset instruction in the *ETVision* manual. Remember to re-enable *ET3Space* afterwards.*

To correct an offset with a single mouse click, have the subject look at the origin point on the scene plane in question (or if in pointer test mode, aim the pointer test cross hair at the origin point); verify, on the *Data Display* window “POG Display”, that the system is detecting gaze on that scene plane; and click the button labeled “Quick Offset to Origin”. The appropriate data offset will automatically be entered to place gaze at the scene plane origin. The cursor on the “POG Display” should snap to the scene plane origin and the digital POG values should snap to (0,0). (The POG cursor on the image from the head mounted scene camera, on the *Scene Image* window, will not be affected).

Note that this feature can be used routinely to maximize *ET3Space* data accuracy on all scene planes. Right after subject calibration, ask the subject to look at the origin of each scene plane and click the “Quick Offset to Origin” button each time, as described above.

To correct an offset by dragging the POG, click the button labeled “Drag Left Mouse Button to Adjust” and left drag in the “POG Display” area. Observe the *Data Display* Window, POG cursor, and drag it to the correct position. When the “Drag Left Mouse Button to Adjust” is on, the offsets can be reset to zero by dragging with the right mouse button in the “POG Display” area.

Note that when the “Drag Left Mouse Button to Adjust” feature is on, the mouse cannot be used to adjust the scale and origin of the “POG Display” area graphics. These capabilities are restored when the “Drag Left Mouse Button to Adjust” feature is turned off. To disable the “Drag Left Mouse Button to Adjust” function, and protect against accidentally creating offsets, click the button to un-depress it.

ET3Space offsets for each scene plane can also be typed into the *Scene Plane Configuration* dialog. If digital values displayed on the *Data Display* window are offset from the known point of gaze

coordinate by a given amount, type in the negative of that amount. For example, if the subject has been asked to look at a scene plane origin point (0,0) and the horizontal point of gaze coordinate is showing 5.0 on that scene plane, rather than 0, type in -5.0 as the horizontal offset correction for the scene plane in question.

Note that if *ET3Space* is enabled, all of the above methods affect only the scene plane on which the system currently detects point of gaze, and affects only *ET3Space* data. If the *Scene Image Screen* is showing the image from a head mounted scene camera, the POG cursor on this image will not be affected.

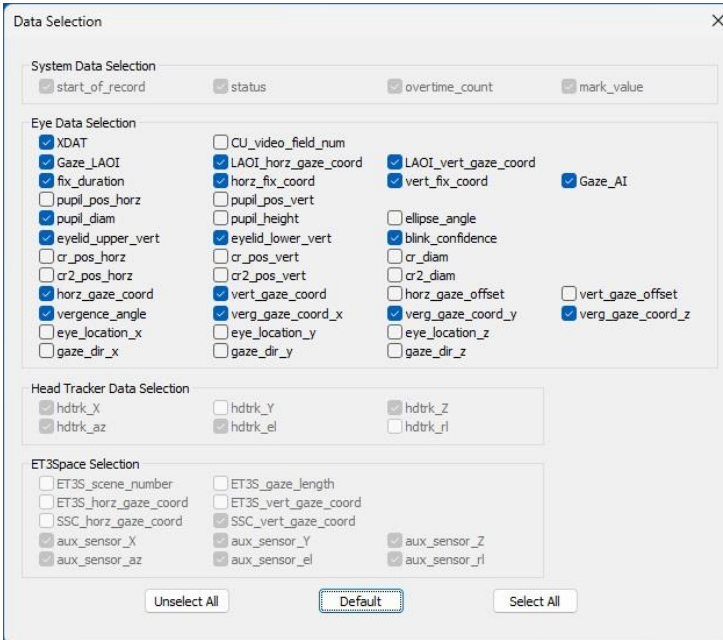
10. Data Collection

Digital data and video file recording by the *ETVison* program is described in the *ETVison* manual, and the procedure is the same when *ET3Space* is in use. The difference is that when *ET3Space* is enabled, the digital data file will be given an “ehd” extension (instead of “eyd”), and additional data items will be available for recording. Although binary eyd format is recommended for most applications, it is also possible to record data in “csv” text format (rather than “eyd” binary format) and this is explained in the *ETVison* manual.

In addition to the data items described in the *ETVison* manual, head position and orientation data is available from the head tracker, and the results of the *ET3Space* computations are available. The latter include the number of the scene plane on which each gaze sample is calculated to fall, the y (“horizontal”) and z (“vertical”) coordinates of gaze with respect to the scene plane coordinate frame defined for that surface, the distance of the head mounted scene camera from the point of gaze, the position of each eye with respect to the global reference frame, and the direction of gaze with respect to the global reference frame.

The video (.wmv) files will be exactly the same whether or not *ET3Space* is enabled.

To see the data available for digital recording, select the *Eye Data* tab on the *System Control Table* and click the “Data Selection” button.



The “Data Selection” items are the same as those described in the *ETVison* manual. If a head tracker is enabled, the “Head Tracker Data Selection” items will also be available (not grayed out). If *ET3Space* is enabled, most of the “ET3Space Selection” data items will be available as well. The default data items, if a head tracker and *ET3Space* are enabled, include all of the default “Eye Data

Selection” items (see *ETVision* manual); all of the “Head Tracker Data Selection” items; ET3S_Scene_number, ET3S_gaze_length, ET3S_horz_gaze_coord, and ET2S_vert_gaze_coord from the “ET3Space Selection” list. A more complete description of all data items can be found in Appendix D (section 17).

Note that **horz_gaze_coord** and **vert_gaze_coord**, under “Eye Data selection”, describe gaze with respect to the head mounted scene camera field of view, in scene camera pixel units; while **ET3S_horz_gaze_coord** and **ET3S_vert_gaze_coord**, under “ET3Space Selection”, describe point of gaze on the designated scene surface in real distance units (inches or centimeters) with respect to the scene plane coordinate frame.

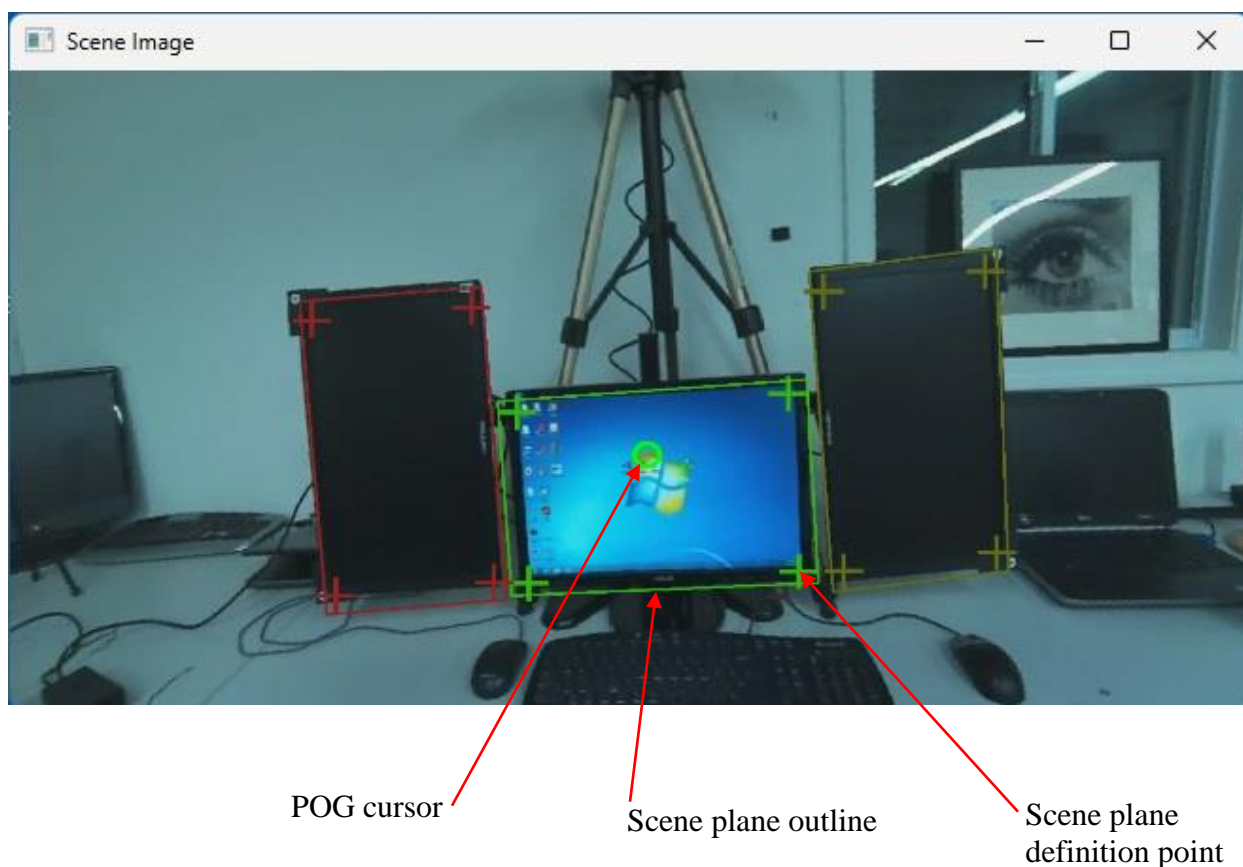
Left click to check or uncheck any available data items, and left click the close symbol at the upper right to close the *Data Selection* dialog.

The *ETAnalysis* program, available from Argus Science, can be used to view, process and analyze data recorded with *ET3Space*. *ETAnalysis* can also be used to make an XML file version of the binary digital data for import to *Microsoft Excel*, and a text version of digital data files for import to other applications or processing by user created applications. A separate instruction manual is provided for *ETAnalysis*.

11. Scene Image window

When *ET3Space* is enabled, the *Scene Image* window can show scene plane boundary outlines and definition point crosses that track the images of *ET3Space* scene plane surfaces. These superimposed indicators can be enabled or disabled by check boxes on the *Advanced Configuration* dialog (*System Control Table, System Configuration* tab, “Advanced Configuration” button). The check boxes are under the “Display Control” group on the dialog, and are labeled “Show Scene Plane” and “Show Definition Points”. The same check boxes enable or disable the corresponding displays on the *Data Display* window, as described in the next section.

In all other respects, the *Scene Image* window shows the same information as when *ET3Space* is not enabled (see *Scene Image* window description in *ETVision* manual). Note that the point-of-gaze cursor shown on the *Scene Image* window shows gaze with respect to the head mounted scene camera, and does not depend on *ET3Space* calculations.

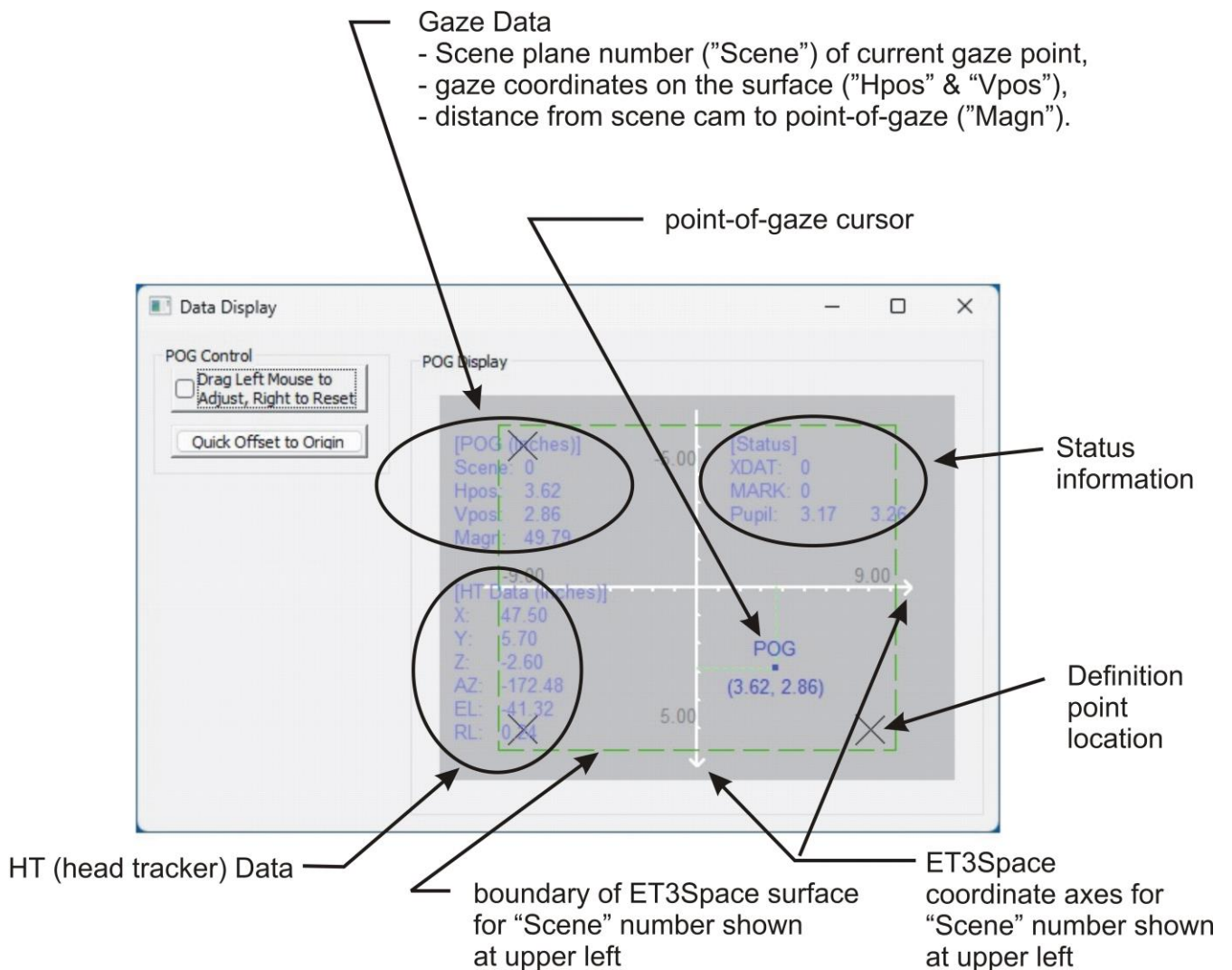


12. Data Display Window

The *Data Display* window has 3 modes: off (display not shown), POG Plot mode, and Bar Plot mode. Clicking the Data Display icon on the *ETVision* tool bar, cycles between the 3 modes (, ,).

12.1 POG Plot mode

In POG plot mode, the *Data Display* window displays the digital data available from the *ET3space* function as well as a graphical point-of-gaze (POG) display. The “Adjust Gaze” group box contains controls for entering manual offset corrections to the point-of-gaze data.



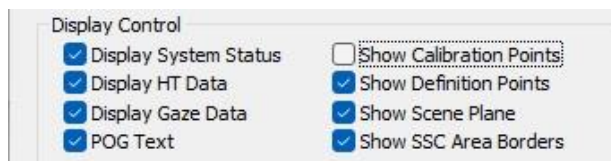
12.1.1 “POG Display” area

The POG Display area plots point-of-gaze as a moving spot on a display area that represents the current scene plane surface.

If *ET3Space* is enabled, the POG positions represent the gaze position on the scene plane surface specified by the current scene plane number. The units are inches or centimeters from the scene plane origin, along the scene plane y (“horizontal”) and z (“vertical”) axes. These axis lines are shown on the plot and labeled with distance units (inches or cm). In this case the default position for axes origin point is the center of the POG Display area, since the (0,0) point is usually at the center of an *ET3Space* scene plane. Scene plane definition points, can also be shown for the current scene plane as described below.

If the manual offset function has not been enabled (see section 9), the mouse can be used to left drag the axes display origin to different positions on the display area. The mouse wheel can be used to zoom in or out. Right dragging the mouse in the area restores default origin position and zoom.

The POG cursor and coordinate axes are always shown. Other content items are enabled or disabled by check boxes on the “Display Control” section of the *Advanced Configuration* dialog (*System Control Table*, *System Configuration* tab, “Advanced Configuration” button).



These items include the following:

System Status: a set of values at the top right corner of the POG display include external data values (XDAT), manual event mark values (MARK), and pupil diameter values (Pupil) for left eye and right eye. (See *ETVision* manual for explanation of these data items).

HT: The head tracker position and orientation data is displayed at the bottom left of the POG display. Units of measure are those selected on the *System Configuration* dialog, and the reference frame is the “Argus” global coordinate frame. The relation between the “Argus” global coordinates and those reported on the motion capture device is explained in the manual or tech note provided by Argus Science for the specific head tracker system being used.

Gaze Data: the *ET3space* scene plane number and gaze position values are displayed at the upper left corner of the POG display. “Scene:” specifies the scene plane number on which gaze is currently detected. Hpos and Vpos represent a Y axis and Z axis position with respect to the coordinate frame defined on the specified scene plane (see scene plane coordinate frame explanation in section 3.1.2). Units of measure (centimeters or inches) are those selected on the *System Configuration* dialog. Note that this is the same information displayed as “POG text” just below the point-of-gaze dot on the X-Y plot.

POG text: digital horizontal and vertical coordinate values will appear just below the POG dot and travel with it. These values are in the form “ (h, v) ”, where h is the horizontal coordinate and v is the vertical, and are the same as the *ET3space* “Gaze Data” coordinates described above.

Scene Plane Definition Points: location of scene plane definition points on the specified scene plane are shown as gray Xs. (See section 3.1.2 for explanation of “definition points”). Note: the “Show Definition Points” check box also enables and disables the definition point crosses superimposed on the head mounted scene camera image (*Scene Image* window).

Scene Plane: green dotted lines show the boundary of the specified scene plane with respect to the *ET3Space* scene plane coordinates. Note: the “Show Scene Plane” check box also enables and disables the scene plane boundary superimposed on the head mounted scene camera image (*Scene Image* window).

Note: “Show Calibration Points” and “Show SSC Area Boundaries” check boxes relate only to displays on the *Scene Image* and *Stationary Scene Image* windows.

A set of check boxes on the *Advanced Configuration* dialog determine “POG Display” content.

The POG Display area plots point-of-gaze as a moving spot on a display area that represents the current scene plane surface. If “POG text” is enabled, digital horizontal and vertical coordinate values will appear just below the POG dot and travel with it. These values are in the form “ (h, v) ”, where h is the “horizontal” coordinate and v is the “vertical”.

If *ET3Space* is enabled, the POG positions represent the gaze position on the scene plane surface specified by the current scene plane number. The units are inches or centimeters from the scene plane origin, along the scene plane y (“horizontal”) and z (“vertical”) axes. These axis lines are shown on the plot and labeled with distance units (inches or cm). In this case the default position for axes origin point is the center of the POG Display area, since the (0,0) point is usually at the center of an *ET3Space* scene plane. If the appropriate boxes are checked, scene plane boundaries, and scene plane definition points, are also shown for the current scene plane.

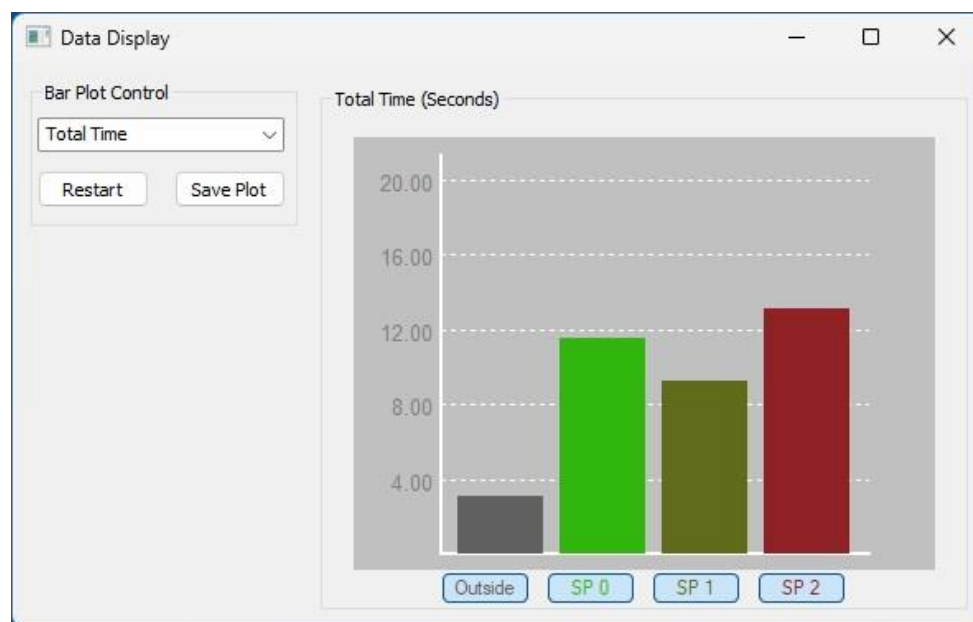
12.1.2 “POG Control” group

The buttons in the “POG Control” group are used to control the manual offset function, as described in section 9.

12.2 Bar Plot mode

When in the Bar Plot mode, the Data Display window will show a continuously updating bar plot. A pull down menu, under “Bar Plot Control”, determines the variable plotted. When *ET3Space* is enabled, one bar is labeled “Outside” to indicate the category of “gaze not in within the boundaries of any ET3Space scene plane”. Other bars will represent each scene plane in the *ET3Space* environment. These are labeled “SP n ”, where n is the scene plane number.

When “Bar Plot Control” is set to “Total Time”, each bar represents cumulative gaze time spent on the labeled scene plane. The vertical plot axis indicates the amount of time spent on that scene plane since the Bar Plot mode display was activated. The start time can be reset by clicking the “Restart” button in the “Bar Plot Control” box.



In addition to “Total Time”, the “Bar Plot Control” pull down menu can be used to set the bar plot variable to “Number of Fixations”, “Average Fixation Duration”, “Total Fixation Time”, “Time to first fixation”, “Average left pupil diameter”, or “Average right pupil diameter”.

To save a snap shot of the current bar plot, click the “Save Plot” button. The bar plot will temporarily freeze. Use the browser window that appears to save an image file (jpg, bmp, or png) of the current bar plot. While the plot display is frozen, the bar plot times are still accumulated in the background, and when the browser window is closed, the live bar plot updates will resume.

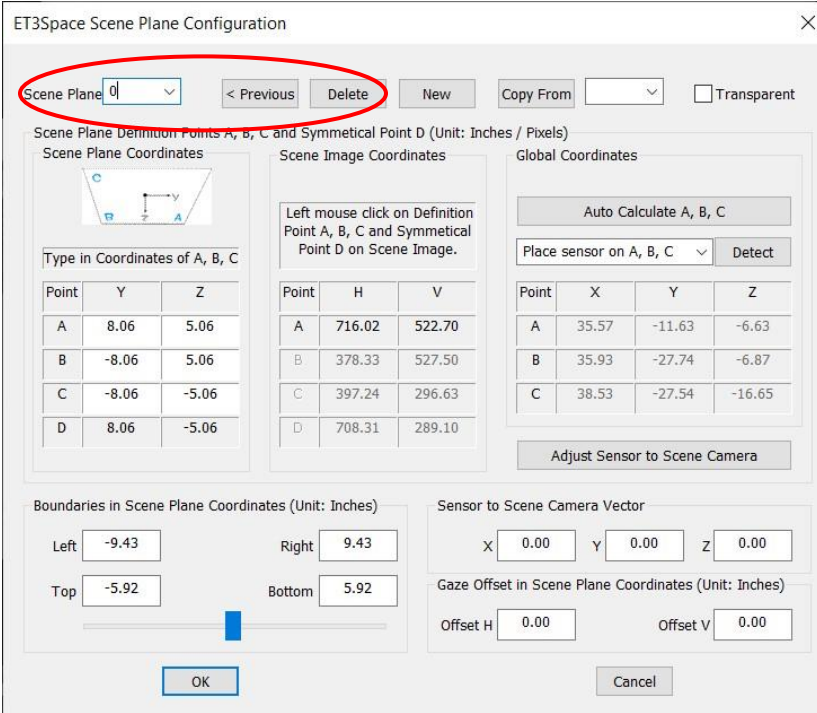
13. Communication with external devices

ETVision can send real time data, including *ET3Space* data, to external devices via local area network. The data items sent will be the list of items selected on the *Data Selection* dialog described in section 10. External devices can also control data recording by *ETVision*, and can send external data to be recorded by *ETVision* along with gaze data. Detailed instructions are in the *ETVision* manual and a separate manual called *NetworkComWithETVision*.

Argus Science provides a program called *ETRemote* which can communicate with *ETVision* from an external Win 7 or Win 10 PC via LAN connection. Instructions for using *ETRemote* are provided in a separate manual (*ETRemote_with_ETV*).

14. Appendix A – Use *Scene Plane Configuration* dialog to clear (delete) environment

Click the “Scene Plane Configuration” button on the *System Configuration* dialog to bring up the *ET3Space Scene Plane Configuration* dialog.



ET3Space Scene Plane Configuration

Scene Plane: 0 | < Previous | Delete | New | Copy From: | Transparent

Scene Plane Definition Points A, B, C and Symmetrical Point D (Unit: Inches / Pixels)

Scene Plane Coordinates

Type in Coordinates of A, B, C

Point	Y	Z
A	8.06	5.06
B	-8.06	5.06
C	-8.06	-5.06
D	8.06	-5.06

Scene Image Coordinates

Left mouse click on Definition Point A, B, C and Symmetrical Point D on Scene Image.

Point	H	V
A	716.02	522.70
B	378.33	527.50
C	397.24	296.63
D	708.31	289.10

Global Coordinates

Auto Calculate A, B, C

Place sensor on A, B, C | Detect

Point	X	Y	Z
A	35.57	-11.63	-6.63
B	35.93	-27.74	-6.87
C	38.53	-27.54	-16.65

Adjust Sensor to Scene Camera

Boundaries in Scene Plane Coordinates (Unit: Inches)

Left: -9.43 | Right: 9.43
Top: -5.92 | Bottom: 5.92

Sensor to Scene Camera Vector

X: 0.00 | Y: 0.00 | Z: 0.00

Gaze Offset in Scene Plane Coordinates (Unit: Inches)

Offset H: 0.00 | Offset V: 0.00

OK | Cancel

On the “Scene Plane” pull down menu, at the upper left of the dialog, click the down arrow to see the list of existing scene planes. Select the highest number scene plane on the list, then click the “Delete” button just to the right. The Scene Plane number will decrement to the previous scene plane. Click “Delete” again. Repeat until Scene Plane number is 0. Clicking “Delete” for Plane 0 will not change the indicated Scene Plane number, but all of the items in the tables below will change to zeros.

Click “OK” to close the dialog, and proceed to create a new environment as described in section 6.1.

15. Appendix B – Use *Scene Plane Configuration* dialog to modify the environment

If an entirely new environment is to be created, the easiest way is probably to delete any current environment, as described in the previous section, and use the procedure in section 6.1; although an entirely new environment can also be created from the *ET3Space Scene Plane Configuration* dialog if desired.

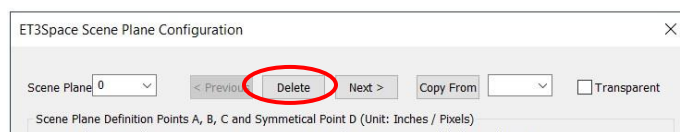
If only some of the scene planes need to be modified (perhaps because the physical surfaces have moved, etc) this can be most easily done using the *Scene Plane Configuration* dialog, without affecting planes that do not need to be modified. If surfaces are unchanged, but the head tracker global coordinates have moved (for example if the camera unit on an optical head tracker has moved), this is also a case where it may be easiest to use the *Scene Plane Configuration* dialog to modify the scene planes, since the A, B, C, D scene plane coordinates will not have changed and are already entered.

Click the “Scene Plane Configuration” button on the *System Configuration* dialog to bring up the *Scene Plane Configuration* dialog. On the “Scene Plane” pull down menu, at the upper left of the dialog, select the scene plane to be modified.

Note: *Do not click the “Adjust Sensor to Scene Camera” button unless following the Appendix C (section 16) instructions for computing the sensor to scene-camera transform.*

15.1 Delete Scene Plane

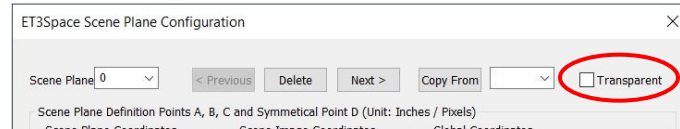
To delete the scene plane, simply click the “Delete” button. Note that identification numbers for any higher number scene planes will be decremented. For example, if planes 0 through 5 have been defined and plane 3 is deleted, the previous “Plane 4” will now become “Plane 3” and the previous “Plane 5” will become “Plane 4”. After deleting a scene plane either click “OK” to implement changes and close the dialog, “Cancel” to close the dialog without implementing changes, or use the pull down menu to select another scene plane to modify.



15.2 Change Transparency Status

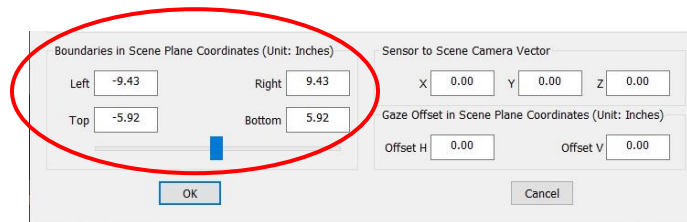
To make the existing scene plane transparent, or to restore a transparent scene plane to non-transparent status, check or uncheck the “Transparent” box. A transparent scene plane will be ignored by ET3Space computations. In other words gaze will never be reported as being on a “transparent” scene plane. If line-of-gaze intersects both a transparent scene plane and another non-transparent scene plane behind it (further away from the subject), gaze will be reported as being on the non-transparent plane. This feature may be useful if an environment contains removable surfaces that will sometimes

be present and sometimes not. If changing the transparency status is the only modification to be made, click OK to close the dialog, or use the pull down menu to select another scene plane to be modified. (Note that if a removable surface is put back in place, it must be restored to exactly the position it had when the scene plane was defined; other wise it will be necessary to continue with steps to re-defined the plane as described in section 15.5.)



15.3 Modify Scene Plane boundaries

To modify the boundaries of an existing scene plane, either use the slider to symmetrically expand or contract the boundaries, or type in boundary values. (To also see the boundaries superimposed on the head mounted scene camera image, be sure that “Show Scene Planes” is checked on the *Data Display* window).

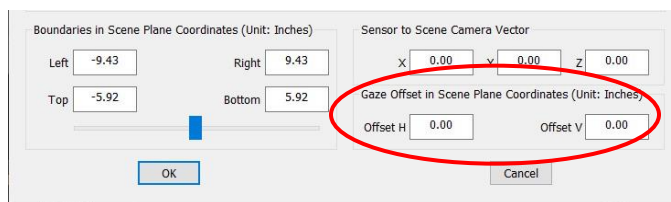


Remember that boundary values are with respect to the coordinate frame defined on the scene plane surface. Left and right boundaries are specified with respect to the scene plane Y (“horizontal”) coordinate, and top and bottom boundaries with respect to the Z (“vertical”) coordinate. If there is no other visual target near the an edge of the physical surface, it is suggested that the *ET3Space* boundary specified for that edge be a bit beyond the physical edge of the surface. This will lessen the chance that a small measurement error will cause gaze to be reported as off the surface when it is really just very close to the edge. Of course if two surfaces of interest touch, the real physical boundary must be one specified.

After modifying boundaries, either proceed with other modifications, click “OK” to implement changes and close the dialog, “Cancel” to close the dialog without implementing changes, or use the pull down menu to select another scene plane to modify.

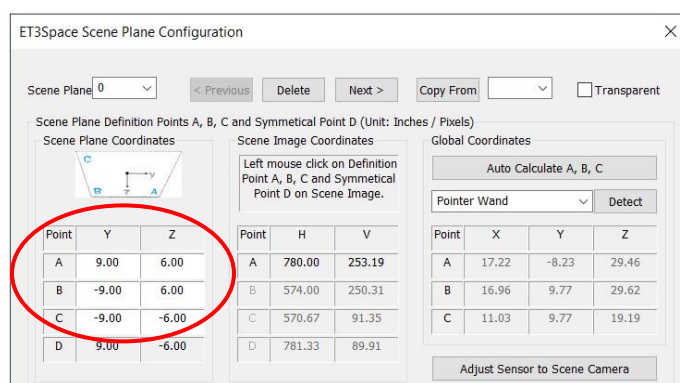
15.4 Enter a manual point-of-gaze offset for the scene plane

Type in manual offset values to correct point-of-gaze measurement on the specified scene plane. Manual offsets corrections are explained in section 9. Either click “OK” to implement changes and close the dialog, “Cancel” to close the dialog without implementing changes, or use the pull down menu to select another scene plane to modify.

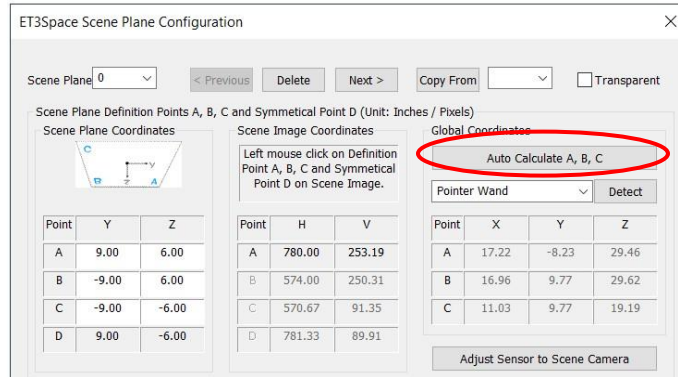


15.5 Modify scene plane definition points to re-define plane

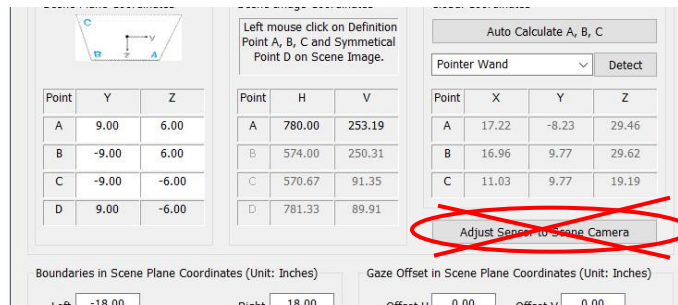
1. Support the *ETVision* optics frame so that it will remain stationary, so that the center of the specified Scene Plane is close to the center of the scene camera image, and so that points A, B, C, and D are all in view. Be sure that the head tracker sensor is in the detectable volume of space and is sending data from the head gear mounted sensor to *ETVision*. If using an optical head tracking device, be sure that optical path from the sensor to the head tracker camera unit is not blocked.
2. At the middle left of the dialog, type in the scene plane coordinates for points A, B, and C. The system will automatically compute coordinates for a symmetrical point D, so that ABCD forms a parallelogram. (If another defined scene plane has exactly the same A, B, and C scene plane coordinates, the “Copy From” pull down, near the top right of the dialog can be used to enter these values from the other scene plane, but be aware that all other scene plane parameters will be copied as well).



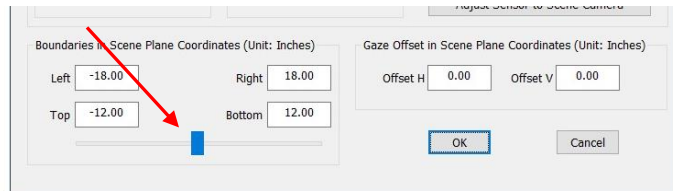
3. Next, on the scene image window, left click on the image of point A (lower right), then point B (lower left), then point C (upper left), and finally point D (upper right). As this is done, the pixel coordinates of each point clicked in the scene image will appear in the “Scene Image Coordinates” table, near the center of the dialog. Be sure the optics do not move during this process, and be sure that the head tracker continues to report the position of the sensor that is mounted to the optics.
4. Now click the “Auto Calculate A, B, C button. Information produced by the preceding steps, and the known sensor to scene-camera transform, will be used to compute the global coordinates of points A, B, and C. Three points define a plane, and the global coordinates of these three points will be used to compute the scene plane equation (equation that specifies the position and orientation of the plane) with respect to the global coordinate system.



Do not click the “Adjust Sensor to Scene Camera” button. This is used only when computing the sensor to scene-camera transform as described in Appendix C (section 16).



Click on the “Boundaries...” slider at the bottom left of the dialog to see the boundary rectangle, and either use the slider to symmetrically expand or contract the rectangle, or type in left, right, top and bottom coordinates to specify the bounding rectangle. To see boundary lines superimposed on the image from the head mounted scene camera, be sure that “Show Scene Planes” is checked on the *Data Display* window. See section 15.3, for more details about scene plane boundaries.



Click “OK” to implement changes and close the dialog, click “Cancel” to close the dialog without implementing changes, or use the pull down menu to select another scene plane to modify.

5. Now move the optics. If “Show Scene Planes” is checked on the *Data Display* window, a superimposed boundary box should follow the image of the scene plane, on the head mounted scene camera image, as long as the sensor remains in the detectable volume of space and is properly recognized by the head tracker. (Note that near the scene camera image edges, scene camera lens distortion may add some inaccuracy.) It is also suggested that “Pointer Test” be used, as described in section 6.2, to verify proper performance of the modified scene plane definition.

15.6 Define Scene plane without using head mounted scene camera

There may be occasions where an environment has been carefully mapped using a motion capture system, and the precise global coordinates of scene plane definition points A, B, and C are known. In this case, use the Scene Plane Configuration dialog to type the scene plane coordinates and global coordinates of A, B, and C in their respective tables. Type in scene plane boundaries at lower left of the dialog. DO NOT click either the “Auto Calculate A, B, C” or the “Adjust Sensor to Scene Camera” buttons. Click “OK” to exit the Scene Plane Configuration dialog. The necessary computations will be done using the typed in values.

16. Appendix C – Use *Scene Plane Configuration* dialog to compute Sensor to Scene-Camera Transform

ET3Space computations require that the relationship (“transform”) between sensor and scene camera coordinates be known. In other words, it is necessary that a point known with respect to one of these reference frames can be also be determined with respect to the other.

Argus Science provides a sensor mount, sensor definition file, and corresponding default sensor to scene-camera transform for most motion capture systems that can be used with *ETVision*. These components and corresponding files provided by Argus Science are usually appropriate for good performance. If a different sensor or sensor mounting arrangement is used, or if the sensor to scene-camera transform need to be re-computed for some other reason, this can be done as described below.

The required transform information has two components. The system needs to “know” the vector that connects the origin of the “sensor” coordinate frame to the origin of the scene camera coordinate frame. It also needs to “know” the orientation (axes directions) of the sensor coordinate frame with respect to the scene camera coordinate frame.

16.1 Sensor to Scene Camera Vector

The “sensor to scene-camera vector” is the vector, specified in the sensor coordinate frame, which connects the origin of the “sensor” mounted to the optics frames and the scene camera coordinate origin. When using the sensor definition supplied by Argus Science for a particular head tracker and sensor, the nominal value of this vector will usually be zero; and in reality will usually be close enough to the nominal value that there will be no need to re-compute it. The nominal vector specification (usually [0,0,0]) is entered on the Scene Plane Configuration dialog. Although it appears on the dialog for each scene plane, there is only one “sensor to scene-camera vector”. Changing this value on any scene plane dialog changes it on all of the scene plane dialogs.

If not using a sensor and sensor definition file supplied by Argus Science, consult Argus Science for instructions to calculate the sensor to scene camera vector.

16.2 Sensor to Scene Camera Orientation transform

It is anticipated that the default “sensor to scene-camera transform” provided by Argus Science will usually be appropriate and sufficient. There are small physical variations from unit to unit and Argus Science usually provides rigid body and sensor to scene camera transform files that are optimized for each system. If using a “sensor” that is different from the one provided by Argus Science or if the orientation transform from one coordinate system to the other needs to be re-computed for some other reason this can be done with the procedure described in the subsections below.

This procedure will require use of the optional pointer with attached “sensor” or “sensor mount” supplied by Argus Science, or an equivalent device, as well as the optics frame with attached sensor. For optical motion capture systems the “sensors” are usually rigid body objects equipped with

reflectors. **Before proceeding, please see the Argus Science manual or tech note for the specific motion capture system being used.**

16.2.1 Determine Global Coordinates of definition points

It will be necessary to directly use a motion capture system “sensor” to find the global coordinates of 3 “definition points” (A, B, and C) on a scene plane. This will require either that a “sensor” be fastened to a pointer in a way such that the position of the pointer tip is known with respect to the sensor coordinate system. In most cases Argus Science can provide a pointer device appropriate for motion capture systems compatible with *ETVision*. In some cases there will be a separate sensor (separate from the one attached to the *ETVision* optics) for use with the pointer device, and in other cases the sensor must be removed the *ETVision* optics and mounted to the pointer. Please refer to the Argus Science manual or tech note for the specific motion capture system being used. The image below shows the pointer device available from Argus Science for use with most optical motion capture systems.



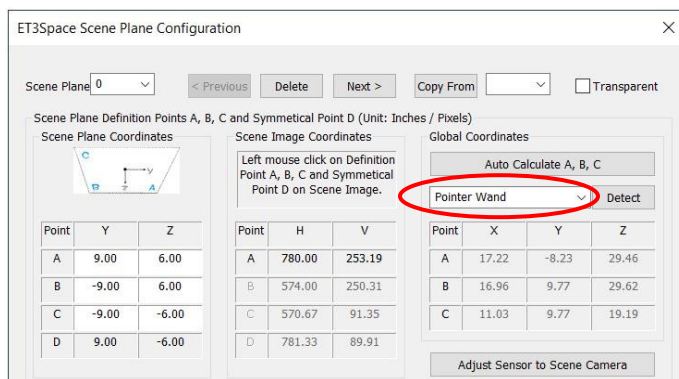
It will be necessary to insure that the motion capture system is reporting the position and orientation of the pointer device sensor to *ETVision*. In some cases this will require using the motion capture device application to specify the sensor data to be output, and in other cases the *ETVision* head tracker configuration dialog can be used to select the appropriate sensor. Once again, the proper procedure is specified in the Argus Science manual or tech note for the specific motion capture system being used.

Set up a physical surface such that the pointer mounted sensor can be properly detected by the motion capture system while touching the A, B, and C definition points on the surface. Note that this does not need to be one of the surfaces that will be used in the environment during subject data collection. In fact, this procedure need not even occur in the same place, so long as the same motion capture device is used. The important thing is that the pointer device can be used to very accurately determine the position of the surface definition points with respect to the motion capture system global coordinates.

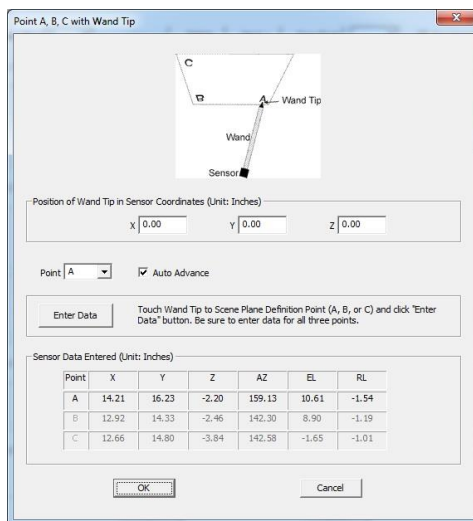
Click the “Scene Plane Configuration button, on the *System Configuration* dialog, to open the *ET3Space Scene Plane Configuration* dialog. If using a surface that is already part of a defined

environment, use the pull down menu at the upper left of the dialog to specify the Scene Plane number for that surface. If using a special surface put in place for this purpose that is not one of the already defined surfaces, first use the pull down menu to select the highest scene plane number, then click “Next” to increment the Scene Plane number and set up a new “blank” dialog for a new surface. Alternately, delete all existing Scene Plane definitions to start with a blank Plane 0 dialog.

Under “Global Coordinates”, near top right of dialog, use the pull down menu to select the pointing method. This will usually be “Pointer Wand”. Other methods are available in the pull down list for unusual situations that preclude use of the pointer wand. Consult Argus Science for more information about these alternate methods.



Click the “Detect button”. Assuming “Pointer Wand” was selected as the method, this will bring up a dialog window labeled “Point A, B, C with Wand Tip”.



Argus Science provides separate manuals or Tech Notes describing things that are specific to particular types of supported head tracker systems. Consult the appropriate document for sensor mounting instructions specific to the head tracker being used, and also for the vector coordinates that specify the location of the wand tip. Type the wand tip position coordinates in the boxes provided. Be sure to type values in the units indicated. (Units of measure were chosen on the *System Configuration* dialog.)

If necessary, remove the sensor from the subject headgear and mount it to the pointer wand. If a different sensor has been provided for use with the pointing device be sure that the motion capture system is reporting the position and orientation of this pointing device sensor to *ETVision*. (Consult the Argus Science manual for the particular motion capture device being used).

The “Point” prompt will first default to “A”. Touch the wand tip to point A and click the “Enter Data” button. This procedure will usually require two people, one to hold the wand and another to click the “Enter Data” button. Before entering data, be sure that the head tracker sensor is within the proper operating range and is generating valid data. With optical tracking systems, it is often important for the person holding the wand to take care to stand in a position that does not block the reflectors (or emitters) from the tracker camera field of view.

Each time data is entered the sensor position and orientation measured by the tracking system will be entered in the table at the bottom of the dialog, and the “Point” prompt will advance. Touch the wand tip to the indicated point, and click “Enter Data”. To enter data out of order, use the drop down menu to select a point before entering data.

Note that the values that appear in the table at the bottom of the dialog are the position of the sensor when data was entered, not the position of point A, B, or C. The values in the table can be checked to make sure that they are sensible. For example if an optical tracker was blocked when one point was entered, the values may be zero, or some other impossible value. Points can be repeated if necessary. Be sure to enter valid data for all three points, then click OK to close the dialog.

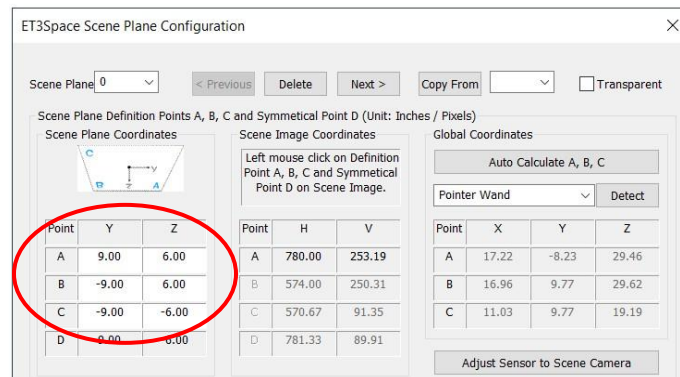
The *ET3Space Scene Plane Configuration* dialog will still be displayed, and should now show the correct global coordinates for points A, B, and C under the “Global Coordinates” heading. Knowledge of the Global reference frame origin and axes directions can be used to check that these values make sense. (Do the coordinates specify roughly the right directions and distances from the Global origin?). If the values do not seem sensible, repeat the procedure, being sure that wand tip position is specified properly and that the head tracker is making a valid measurement for all points.

16.2.2 Specify definition points in scene plane coordinates and camera coordinates

If the motion capture sensor was removed from the head gear to mount to the pointing device, re-mount the sensor on the *ETVision* optics head gear. **If a different sensor was used for the pointing device, reset the motion capture device (or *ETVision* “head tracker configuration”) so that information about the headgear-mounted sensor is once again reported to *ETVision*.** Refer to the separate Argus Science manual or tech note for the specific motion capture device being used.

1. Support the *ETVision* optics frame so that it will remain stationary, so that the center of the Scene Plane is close to the center of the scene camera image, and so that points A, B, C, and D are all in view. Be sure that the head tracker sensor is in the detectable volume of space and is sending data from the head gear mounted sensor to *ETVision*. If using an optical head-tracking device, be sure that optical path from the sensor to the head tracker camera unit is not blocked.

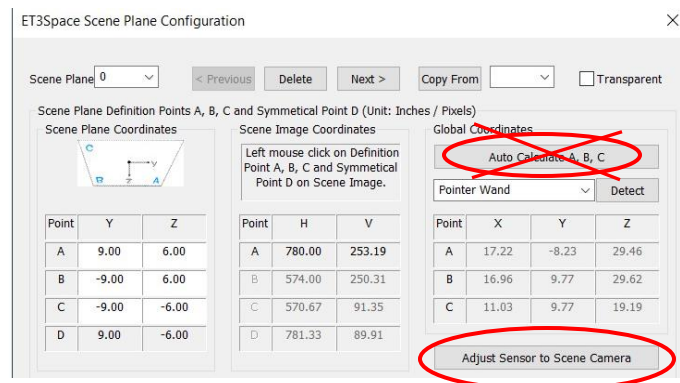
2. At the middle left of the dialog, type in the scene plane coordinates for points A, B, and C. The system will automatically compute coordinates for a symmetrical point D, so that ABCD forms a parallelogram.



3. Next, on the scene image window, left click on the image of point A (lower right), then point B (lower left), then point C (upper left), and finally point D (upper right). As this is done, the pixel coordinates of each point clicked in the scene image will appear in the “Scene Image Coordinates” table, near the center of the dialog. Although not shown on the dialog, the position of sensor with respect to global coordinates is also saved. Be sure the optics do not move during this process, and be sure that the head tracker continues to report the position of the sensor that is mounted to the optics.

Do not click the button labeled “Auto Calculate A, B, C”.

4. Click the button labeled “Adjust Sensor to Scene Camera”. The scene plane coordinates and camera coordinates, and global coordinates of the definition points, as well as the global position and orientation of the sensor, are all used to compute the sensor to scene-camera transform.



5. Click on the “Boundaries...” slider at the bottom left of the dialog, be sure “Show Scene Planes” is checked on the *Data Display* window, and look at the boundary rectangle on the Data Display window and superimposed on the head mounted scene camera image. If the slider is not moved, it should have vertices touching (or very near) the two definition points that result in the largest rectangle. If the optics are now moved, with the sensor remaining the detectable volume of space, the

bounding box superimposed on the head mounted scene camera image should move as though attached to the physical surface.

If the behavior is not as described in step 5, above, then the procedure has not worked properly in some respect and must be repeated. In this case, first try repeating steps 1-4 just above, since this can be done quickly. If that is not sufficient repeat the procedure from the beginning. Take special care that the motion capture sensor is within the proper operating range and is generating valid data during all steps of the procedure. In the case of optical systems, take special care nothing interrupts the line of sight between the camera unit (or units) and the sensor.

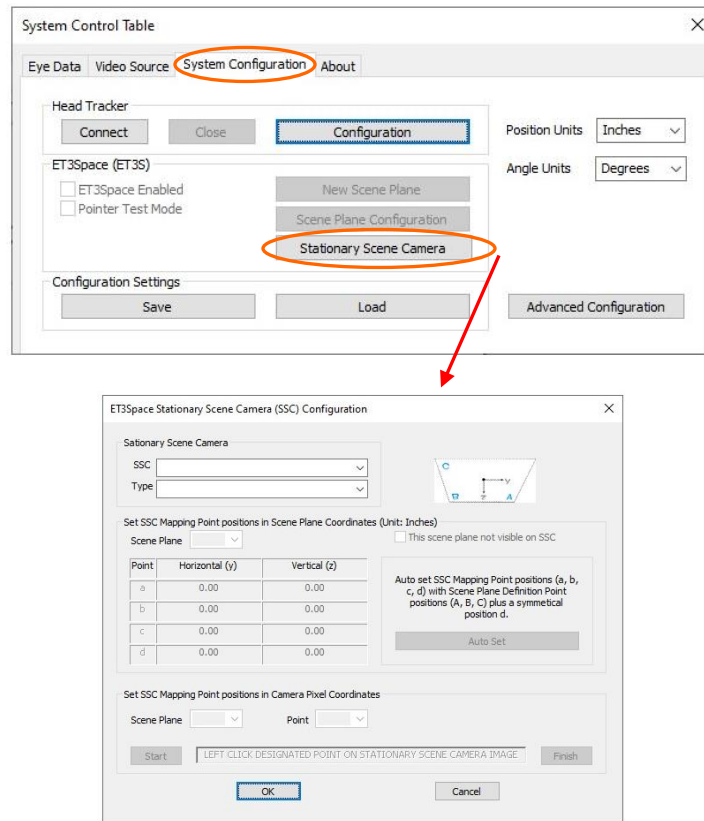
If the procedure appears to be successful, save a copy of the configuration file at this point (see section 6.4) so that the sensor to scene-camera transform just computed can be restored if necessary.

If a special surface was put in place for the sensor to scene-camera transform procedure that will not be part of the normal environment, it can now be physically removed and its definition in *ET3Space* deleted or designated as “transparent”. If the surface used for the sensor to scene-camera transform procedure is one that will be part of the normal environment, it has now been properly defined. Any other previously defined scene planes should now be redefined, or defined from scratch as described in previous sections.

17. Appendix D – Stationary Scene Camera

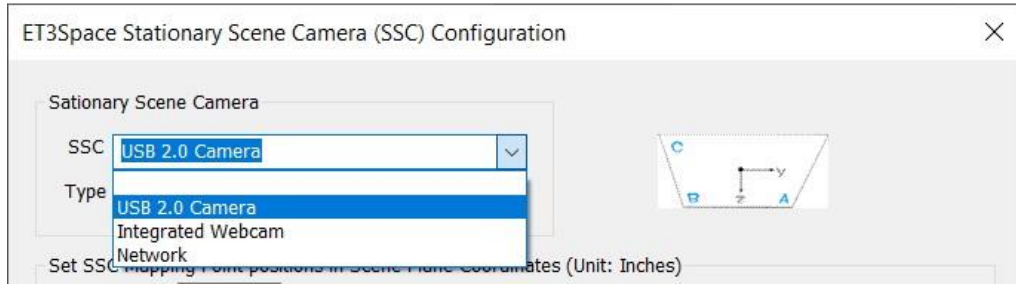
17.1 Connect the external video source to ETVision

To connect an external video source to *ETVision*, first open the “System Configuration” tab on the *System Control Table* dialog. Under the “ET3Space” group box, left click the “Stationary Scene Camera” button to open the *ET3Space Stationary Scene Camera Configuration* dialog.

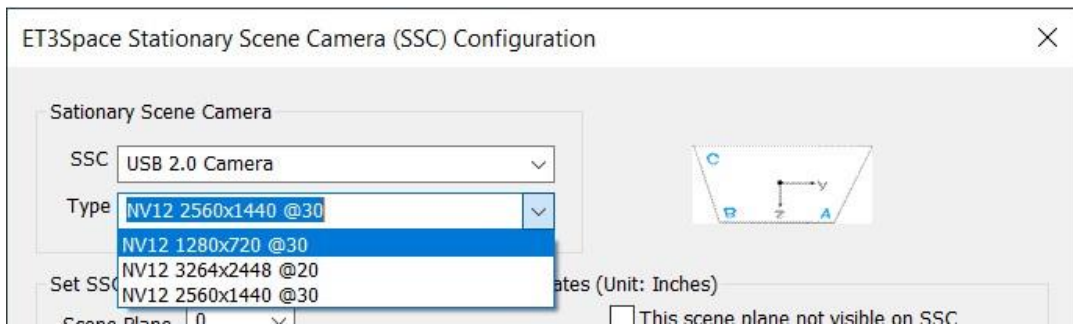


Be sure that the external video source is powered on and connected to the *ETVision* PC so that it can be detected by Windows 10. Usually this means that a USB cable connects the external camera to a USB3 port on the *ETVision* PC.

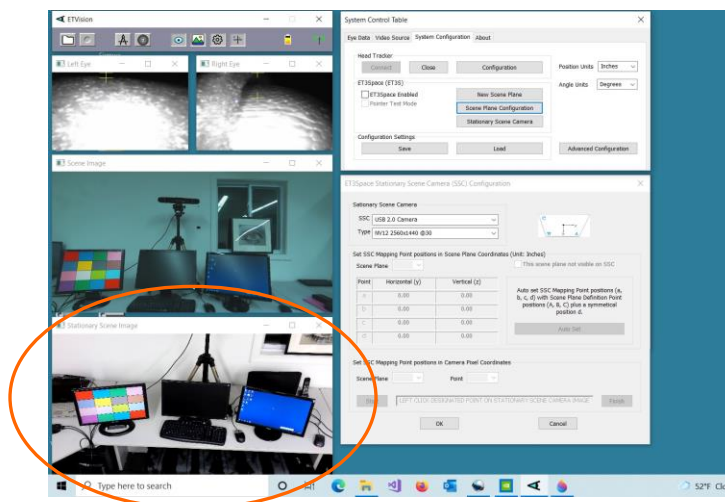
Use the “SSC” pull down menu to see the video sources recognized by Windows 10. One of the choices will usually be the camera built into the *ETVision* laptop (“Integrated Webcam”), and should also include any other external video sources recognized by the operating system. In the example below, “USB 2.0 Camera” is a USB web cam connected to the *ETVision* laptop, “Integrated Webcam” is the camera built into the laptop, and “Network” is a video source detected on the local area network. If *ETRemote* is being used to send video from an external computer display to *ETVision*, this video will be available as the “Network” selection. Left click to select the desired video source from the pull down menu. Note that the top choice is always blank, and selecting the blank indicates that no external video will be used.



Use the “Type” pull down menu to select the camera update rate and resolution. The *ETVision* application will detect the choices available from the video source selected, and will present three options: the video source default; the choice with highest available resolution; and the choice offering the highest available update rate. Select one of the “Type” choices by left clicking the item.



The video from the selected source will appear in a new window below the head mounted scene camera video window, as shown circled in the screenshot, below.



The other items on the dialog, below the "Stationary Scene Camera" group box, apply only to use with *ET3Space*, and will be grayed out when *ET3Space* is not in use. (See the *ET3Space* manual for an explanation of these items.)

Once the external video source and type have been selected, the *ET3Space Stationary Scene Camera Configuration* dialog can be closed by clicking "OK".

To record the external video along with gaze data, open the "Eye Data" tab on the System Control Table dialog, and be sure that "Auto-record SSC Video with Data File" is checked. The external video file will start and end recording at the same time as the digital gaze data. Note that unless *ET3Space* is being used, a point-of-gaze indicator is not superimposed on the SSC video. As an example, the SSC video feature may be useful, without *ET3Space*, to record an external video of an athlete whose gaze is being tracked.

To disconnect the external video source from *ETVision*, open the *Stationary Scene Camera Configuration* dialog, pull down the SSC menu, and select the blank at the top of the list.

17.2 Designate scene planes on the *Stationary Scene Camera* image

Assuming that the external video image includes a view of one or more scene planes that have been defined as described in section 6.1, designate these planes as follows.

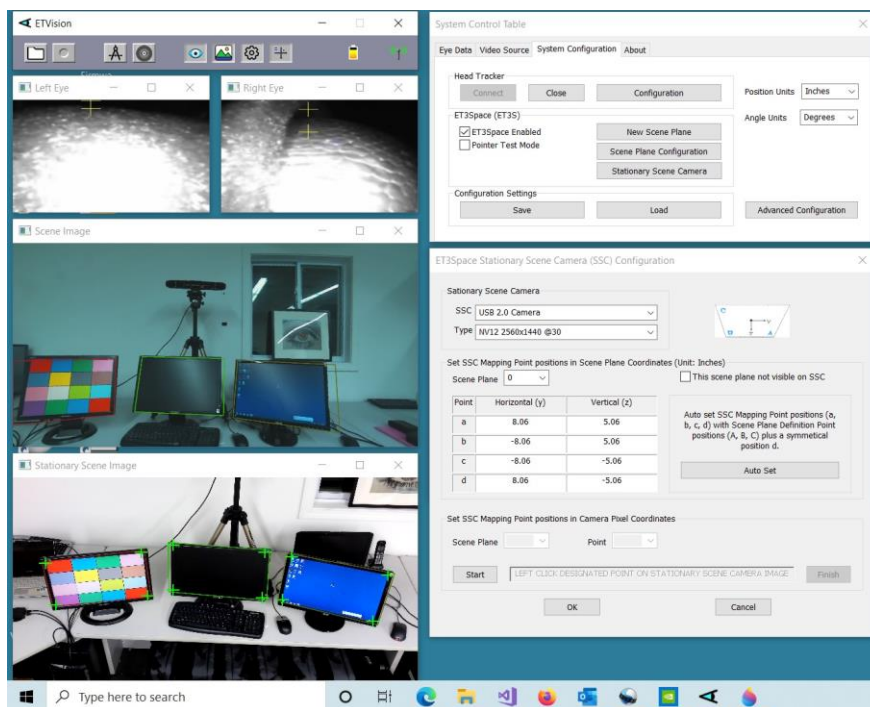
It is usually most convenient to use the same 4 points used as the A, B, C, and D definition points when defining the scene plane (see sections 3.1.2 and 6.1), but other points can be used so long as they are visible on the Stationary Scene Camera image and their *ET3Space* scene plane coordinates are known.

Open the *ET3Space Stationary Scene Camera Configuration* dialog as described in the previous section. Under "Set SSC Mapping Point Positions in Scene Plane Coordinates", use the "Scene Plane" pull down menu to select a scene plane number. To use the same 4 points previously used to define the scene plane, simply click the "Auto Set" button. To use different points, type in the *ET3Space* scene plane coordinates for each point. Repeat this procedure for each *ET3Space* scene plane visible on the Stationary Scene Camera image.

Under "Set SSC Mapping Point Positions in Camera Pixel Coordinates", select the lowest "Scene Plane" number for which scene plane coordinates were entered (as described in the previous paragraph). Click "Start". The "Point" field will default to "a". Left click the Stationary Scene Camera image on the mapping point indicated by the "Point" field. After each click, the "Point" field will advance to the next point. After point "d" is entered, the "Scene Plane" field will advance to next number. Repeat the procedure for each visible scene plane, then click "Finish".

If the "Show SSC Area Borders" box is checked, on the *Advanced Configuration* dialog (*System Control Table*, *System Configuration* tab, "Advanced Configuration" button), a bounding box should appear superimposed on the scene plane image in the *Stationary Scene Image* window.

Click “OK” to close the dialog.

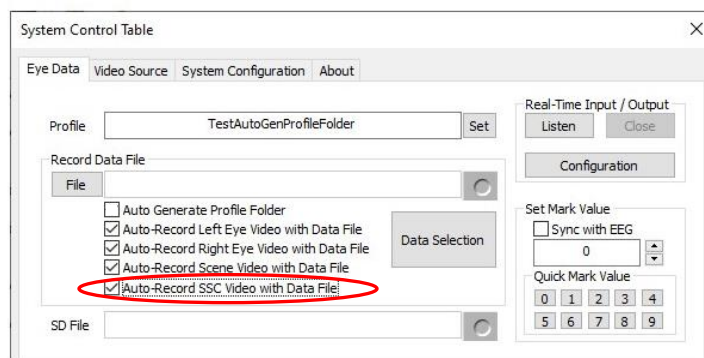


The results can be tested using the ET3Space “PointerTest Mode”. Enable “Pointer Test Mode” as described in section 6.3. If the optics frames are aimed so that the “pointer test cross” on the *Scene Image* window appears within one of the defined scene planes, the point-of-gaze cursor on the *Stationary Scene Image* window should appear at the same position on that scene plane.

The point-of-gaze cursor on the *Stationary Scene image* will have the same shape color and relative size as the cursor displayed on the optics mounted Scene Camera image (see section 9.4.2.2 of the *ETVision* manual).

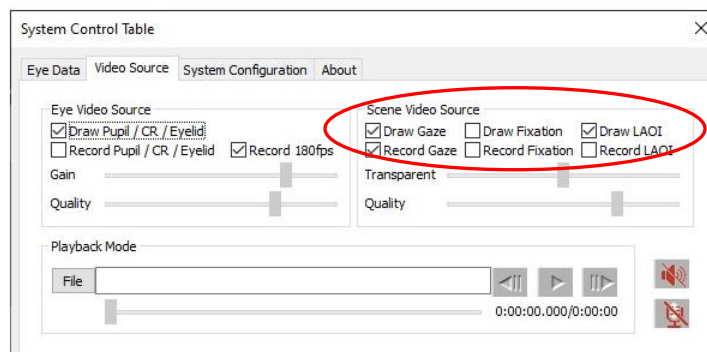
17.3 Record the Stationary Scene Camera video

To record the Stationary Scene Camera video along with gaze data, open the “Eye Data” tab on the System Control Table dialog, and be sure that “Auto-record SSC Video with Data File” is checked.



The resulting SSC video file will have the same name as the gaze data file, but with “SSC” appended to the end of the file name. The SSC video file will start and end recording at the same time as the digital gaze data.

The superimposed POG cursor and real-time fixation indicator can be set to display or to not display in real time and to display or not display on the video recording using the same "Scene Video Source" controls as for the head mounted scene camera display (see *ETVision* manual, section 9.4.2.2). The “Transparent” and “Quality” sliders on the "Scene Video Source" dialog do not apply to the external video.



17.4 Record and stream SSC data

The pixel coordinates of the gaze cursor displayed on the real-time SSC video can also be recorded on the digital gaze data file and can be streamed an external device along with other gaze data. To record or stream these coordinates, select “SSC_horz_gaze_coord” and “SSC_vert_gaze_coord” on the Data Selection dialog (see section 7.8.1.1 of *ETVision* manual). Note that it is not necessary to record these values on the data file to analyze or display gaze with respect to the SSC image in *ETAnalysis*.

18. Appendix E – Recorded and Transmitted Data Items

18.1 Data Item List

The first 5 bytes of a data record in a data file recorded by *ETVision*, or real time data packet transmitted by *ETVision*, always contain the following items. *The “Byte Position”, “Type”, and “Size” columns apply to streaming binary data and binary (“eyd” and “ehd”) files. On “csv” (comma separated value) files all these values appear as text integers, except for the first data item listed, which is replaced by a text floating point time value.*

Data Item	Byte position	Type	Size (bytes)
start_of_record	1	Byte	1
status	2	Byte	1
overtime_count	3	UInt16	2
mark_value	5	Byte	1

The items in the table below are selectable (see section 10). Whichever items have been selected will appear, in the order listed, on both data files recorded by *ETVision* and real time streaming data packets transmitted by *ETVision*. Note that some items that have “left” and “right” eye values have only one corresponding entry in the selection table that selects both “left” and “right” values. For example the “pupil_pos_horz” check box selects both “left_pupil_pos_horz” and “right_pupil_pos_horz”. Some items are available only when using the optional *ET3Space* feature, and some items have a different definition or coordinate frame when using the optional *ET3Space* feature. *The “Byte Position”, “Type”, “Size”, and “Scale Factor” columns apply to streaming binary data and binary (“eyd” and “ehd”) files. On “csv” (comma separated value) files “XDAT”, “CU_video_field_num”, and “ET3S scene_num” appear as text integers, and all other values appear as properly scaled, text floating point numbers.*

Data Item	Type	Size (bytes)	Scale Factor	Comment
XDAT	UInt16	2	1	Always available
CU_video_field_num	UInt16	2	1	Always available
left_pupil_pos_horz	UInt16	2	1	Always available
right_pupil_pos_horz	UInt16	2	1	Always available
left_pupil_pos_vert	UInt16	2	1	Always available
right_pupil_pos_vert	UInt16	2	1	Always available
left_pupil_diam	UInt16	2	0.01	Always available
right_pupil_diam	UInt16	2	0.01	Always available
left_pupil_height	UInt16	2	0.01	Always available
right_pupil_height	UInt16	2	0.01	Always available
eyelid_upper_vert_left	UInt16	2	1	Always available
eyelid_upper_vert_right	UInt16	2	1	Always available
eyelid_lower_vert_left	UInt16	2	1	Always available
eyelid_lower_vert_right	UInt16	2	1	Always available
blink_confidence_left	UInt16	2	1	Always available
blink_confidence_right	UInt16	2	1	Always available
left_cr_pos_horz	UInt16	2	1	Always available
right_cr_pos_horz	UInt16	2	1	Always available

left_cr_pos_vert	UInt16	2	1	Always available
right_cr_pos_vert	UInt16	2	1	Always available
left_cr_diam	UInt16	2	1	Always available
right_cr_diam	UInt16	2	1	Always available
left_cr2_pos_horz	UInt16	2	1	Always available
right_cr2_pos_horz	UInt16	2	1	Always available
left_cr2_pos_vert	UInt16	2	1	Always available
right_cr2_pos_vert	UInt16	2	1	Always available
left_cr2_diam	UInt16	2	1	Always available
right_cr2_diam	UInt16	2	1	Always available
horz_gaze_coord	Int16	2	0.1	Always available
vert_gaze_coord	Int16	2	0.1	Always available
horz_gaze_offset	Int16	2	1	Always available
vert_gaze_offset	Int16	2	1	Always available
vergence_angle	Single	4	1	Always available
verg_gaze_coord_x	Single	4	1	Definition depends on whether ET3S enabled
verg_gaze_coord_y	Single	4	1	Definition depends on whether ET3S enabled
verg_gaze_coord_z	Single	4	1	Definition depends on whether ET3S enabled
hdrtk_X	Int16	2	0.01	Available only if head tracker installed
hdrtk_Y	Int16	2	0.01	Available only if head tracker installed
hdrtk_Z	Int16	2	0.01	Available only if head tracker installed
hdrtk_az	Int16	2	0.01	Available only if head tracker installed
hdrtk_el	Int16	2	0.01	Available only if head tracker installed
hdrtk_rl	Int16	2	0.01	Available only if head tracker installed
ET3S_scene_number	Byte	1	1	Available only if ET3S enabled
ET3S_gaze_length	Single	4	1	Available only if ET3S enabled
ET3S_horz_gaze_coord	Single	4	1	Available only if ET3S enabled
ET3S_vert_gaze_coord	Single	4	1	Available only if ET3S enabled
SSC_horz_gaze_coord	Single	4	1	Available only if ET3S enabled
SSC_vert_gaze_coord	Single	4	1	Available only if ET3S enabled
left_eye_location_X	Int16	2	0.01	Coord frame depends on whether ET3S enabled
right_eye_location_X	Int16	2	0.01	Coord frame depends on whether ET3S enabled
left_eye_location_Y	Int16	2	0.01	Coord frame depends on whether ET3S enabled
right_eye_location_Y	Int16	2	0.01	Coord frame depends on whether ET3S enabled
left_eye_location_Z	Int16	2	0.01	Coord frame depends on whether ET3S enabled
right_eye_location_Z	Int16	2	0.01	Coord frame depends on whether ET3S enabled
left_gaze_dir_X	Int16	2	0.001	Coord frame depends on whether ET3S enabled
right_gaze_dir_X	Int16	2	0.001	Coord frame depends on whether ET3S enabled
left_gaze_dir_Y	Int16	2	0.001	Coord frame depends on whether ET3S enabled
right_gaze_dir_Y	Int16	2	0.001	Coord frame depends on whether ET3S enabled
left_gaze_dir_Z	Int16	2	0.001	Coord frame depends on whether ET3S enabled
right_gaze_dir_Z	Int16	2	0.001	Coord frame depends on whether ET3S enabled
aux_sensor_X	Int16	2	0.01	Available only for certain head trackers
aux_sensor_Y	Int16	2	0.01	Available only for certain head trackers
aux_sensor_Z	Int16	2	0.01	Available only for certain head trackers
aux_sensor_az	Int16	2	0.01	Available only for certain head trackers
aux_sensor_el	Int16	2	0.01	Available only for certain head trackers
aux_sensor_rl	Int16	2	0.01	Available only for certain head trackers
left_ellipse_angle	single	4	1	Always available
right_ellipse_angle	single	4	1	Always available
Gaze_LAOI	UInt32	4	1	Always available
LAOI_horz_gaze_coord	single	4	1	Always available

LAOI_vert_gaze_coord	single	4	1	Always available
fix_duration	single	4	1	Always available
horz_fix_coord	single	4	1	Coord frame depends on whether ET3S enabled
vert_fix_coord	single	4	1	Coord frame depends on whether ET3S enabled
Gaze_AI	UInt32	4	1	Always available

18.2 Data Item Explanation

Data values accessed directly from binary streaming data, or directly from binary (eyd or ehd) data files must be scaled by the factors listed in the previous section to represent the units described in the data item explanations. For example, to convert a gaze coordinate value to the scene camera pixel units described, first convert the integer value to a float and then multiply by 0.1.

Data items on csv (comma separated value) files are properly scaled as they appear on the file, and all data (from any file type) viewed using on Argus Science ETAnalysis application are properly scaled as shown. See Appendix I of the *ETVision* manual for csv file description.

Start of record byte (binary eyd and ehd files only) – fixed value 0xFA. On csv files, the first data item is a time value, in seconds, represented as a floating point number, and starting with 0.000 for the first data record.

Status byte – contains eye tracer status information.

Bit	Meaning (if 1)
0	Not used
(least significant)	
1	Head tracker enabled
2	Right eye Corneal Reflection 1 found
3	Right eye Pupil Found
4	Left eye Corneal Reflection 1 found
5	Left eye Pupil Found
6	Right eye Corneal Reflection 2 found
7	Left eye Corneal Reflection 2 found

overtime count, 2 bytes, unsigned integer. Shows how many records were lost prior to this one. Typically contains the value zero.

Mark value byte – will be last integer “Mark” value entered by user.

XDAT – 16 bit integer set by external device.

CU video field number – Internal field (or record) number kept by system. It is the number of eye camera frames received from the eye cameras since the *ETVision* program was activated, and rolls over to 0 after every 180 frames. Useful mostly for debugging purposes.

pupil_pos – coordinates proportional to horizontal (0.00 to 320.00) and vertical (0.00 to 240.00) pupil position with respect to the eye camera field of view.

Pupil_diam – value proportional to diameter of the pupil image on the eye camera. More specifically, the value is major axis of the ellipse shape identified as the pupil image. Note that this value is computed to a fraction of a pixel. Note also that this value will not be affected by degree of image ellipticity, and will not change (except for measurement noise) if the diameter of the actual pupil does not change and camera to eye distance does not change. This pixel value is the value displayed on the *ETVision* application (on the *Data Display* window), and the value shown by the Argus Science data analysis program, *ETAnalysis*.

Pupil_height – the minor axis of the ellipse shape identified as the pupil image. Note that unlike “pupil diam” (major ellipse axis) the minor axis of the ellipse image shape will change length as degree of ellipticity changes due to eye movement, even if true pupil diameter remains constant.

ellipse_angle – the angle of the major axes of the pupil ellipse (ellipse shape identified as the pupil image) with respect to the eye camera horizontal axis. Reported values range from + 90 degrees to – 89.99 degrees. (Note that +90 and –90 degrees defines the same ellipse orientation).

eyelid_lower_vert – best estimate of the vertical position of the lower eyelid boundary, directly below the pupil center. The position is reported with respect to the eye camera field of view, in camera pixel units. The range is from 1 at the top of the camera field of view to 239 at the bottom. A value of 0 means that no position was detected. If the bottom boundary of the iris is exposed, the system may sometimes report the position of the bottom of the iris instead of the lower eyelid. In these cases the lower eye lid and iris bottom are usually very close to each other.

eyelid_upper_vert – best estimate of the vertical position of the upper eyelid boundary, directly above the pupil center. The position is reported with respect to the eye camera field of view, in camera pixel units. The range is from 1 at the top of the camera field of view to 239 at the bottom. A value of 0 means that no position was detected. If the top boundary of the iris is exposed, the system may sometimes report the position of the top of the iris instead of the upper eyelid. In these cases the upper eye lid and iris top are usually very close to each other.

blink_confidence – Estimated probability that an eye blink is in process. The range is 0 – 100. 0 indicates that either the system is very sure that the eye lids are opened and the pupil is exposed, or the pupil is undetected for some reason other than a blink. Higher values indicate increasing probability that a blink is in progress. Note that if the pupil remains undetected for a time that is much longer than a typical blink, the blink confidence will change to a low value, indicating that something other than a blink must be preventing pupil recognition.

cr_pos -- coordinates proportional to horizontal (0.00 to 320.00) and vertical (0.00 to 240.00) corneal reflection position with respect to the eye camera field of view.

cr_diam – Diameter of the corneal reflection image in eye camera pixels.

gaze_coord – horizontal and vertical coordinates of computed point of gaze with respect to the head mounted scene camera 1280 x 720 pixel field-of-view (fov). Note that fractional pixel positions are represented. Also note that the values are signed. Negative values represent positions to the left, or above the scene camera fov, while values greater than 1280 horizontal or 720 vertical represent

positions to the right of, or below the camera fov. The reported values have been processed by the adjustable smoothing filter described in Appendix D of the *ETVision* manual.

gaze_offset – Manual offset added to horizontal or vertical gaze coordinate in scene camera pixel units.

vergence angle – The angle, in degrees, between the left and right eye lines of gaze.

verg_gaze_coord – When ET3Space is not enabled, these are the X, Y, and Z coordinates for the computed point of gaze expressed in the scene camera coordinate frame. The scene camera coordinate frame has its origin at the scene camera lens aperture; with an x axis pointing along the camera optical axis; a y axis pointing to the subject's right, parallel to the horizontal camera pixel rows; and a z axis pointing down, parallel to the camera pixel columns. The coordinate values correspond to real distance values with units of either inches or centimeters depending on the "Position Units" selected on the *System Control Table, System Configuration* tab. When ET3Space is enabled, these are the X, Y, and Z coordinates specifying a unit vector (vector with a total length of 1) in the direction of gaze and expressed in the *ET3Space* global coordinate system. In other words, a line from the scene camera to the point of gaze should have the direction defined by this unit vector.

hdtrk – X, Y, Z position values and azimuth, elevation, and roll orientation values received by the *ETVision* system from a head tracker. Position values are in units of inches or centimeters (depending on which unit system was set in *ETVision*, "System Configuration" dialog). Angles are in degrees.

ET3S_scene_number – number of scene plane first intersected by line of gaze, as computed by the *ET3Space* feature. If gaze is not detected to be within the boundaries of any defined scene plane, *ET3S_scene_number* is "-1".

ET3S_gaze_length – Distance from the head mounted scene camera to the point of gaze on the scene plane designated by *ET3S_scene_number*, as computed by the *ETVision, ET3Space* function. The value has units of either inches or centimeters (depending on which unit system was set in *System Configuration* dialog).

ET3S_gaze_coord – The point of gaze in scene plane coordinates, on the scene plane designated by *ET3S_scene_number*, as computed by *ET3Space*. Coordinates are with respect to the coordinate frame defined on the scene plane by the *ET3Space* environment specifications. The "horizontal" value is the Y scene plane coordinate, and the "vertical" value is the Z coordinate. The units are either inches or centimeters (depending on which unit system was set in *System Configuration* dialog). If *ET3S_scene_number* is "-1" (gaze not within any defined scene plane boundary), then the reported coordinates are gaze intersection with an infinite extension of scene plane 0.

SSC_gaze_coord – The horizontal and vertical pixel coordinate of point-of-gaze on the "Stationary Scene Camera" image. These values are meaningful only if the Stationary Scene Camera feature has been enabled and set up as described in this manual.

eye_location – When *ET3Space* is **not** enabled, these are X, Y, and Z coordinates specifying the location in space, of each eye with respect to the scene camera coordinate system. It does not depend on eye pointing direction. The units are inches or centimeters (depending on which unit system was set in *System Configuration* dialog). When *ET3Space* is **enabled**, these are X, Y, and Z coordinates specifying the location in space, of each eye with respect to the *ET3Space* “global coordinate system”. This location is computed, by the *ET3Space* feature, based on data received from the head tracker, and knowledge of the location of each eye with respect to the head tracker sensor. It does not depend on eye pointing direction.

gaze_dir – When *ET3Space* is **not** enabled, these are X, Y, and Z coordinates specifying a 3 dimensional unit vector (vector with a total length of 1) in the direction of line-of-gaze for each eye, represented with respect to the scene camera coordinate system . When *ET3Space* is **enabled**, these are X, Y, and Z coordinates specifying a 3 dimensional unit vector (vector with a total length of 1) in the direction of line-of-gaze for each eye, represented with respect to the *ET3Space* “global coordinate system”.

aux_sensor – Not available with most head trackers. Consult Argus Science.

eyelid_lower_vert – best estimate of the vertical position of the lower eyelid boundary, directly below the pupil center. The position is reported with respect to the eye camera field of view, in camera pixel units. The range is from 1 at the top of the camera field of view to 239 at the bottom. A value of 0 means that no position was detected. If the bottom boundary of the iris is exposed, the system may sometimes report the position of the bottom of the iris instead of the lower eyelid. In these cases the lower eye lid and iris bottom are usually very close to each other.

eyelid_upper_vert – best estimate of the vertical position of the upper eyelid boundary, directly above the pupil center. The position is reported with respect to the eye camera field of view, in camera pixel units. The range is from 1 at the top of the camera field of view to 239 at the bottom. A value of 0 means that no position was detected. If the top boundary of the iris is exposed, the system may sometimes report the position of the top of the iris instead of the upper eyelid. In these cases the upper eye lid and iris top are usually very close to each other.

blink_confidence – Estimated probability that an eye blink is in process. The range is 0 – 100. 0 indicates that either the system is very sure that the eye lids are opened and the pupil is exposed, or the pupil is undetected for some reason other than a blink. Higher values indicate increasing probability that a blink is in progress. Note that if the pupil remains undetected for a time that is much longer than a typical blink, the blink confidence will change to a low value, indicating that something other than a blink must be preventing pupil recognition.

Gaze_LAOI -- 32 bit integer specifying which currently defined Live Areas of Interest (LAOIs), if any, contain the current point of gaze. If no LAOIs are defined (see *ETVision* manual, section 7.4), this value will always be zero. Currently defined LAOIs are always numbered in the order that they appear on the “List” drop down menu, on the *LAOI Configuration* dialog. The first LAOI at the top of the list is 0, and next is 1, the next is 2, and so on. Each data record includes an integer value with each bit corresponding to one of the currently defined LAOIs. Bit 0 (the least significant bit) corresponds to LAOI 0, bit 1 corresponds to LAOI 1, etc. If gaze is not detected to be within an LAOI, the corresponding bit will be 0 on that data record. If gaze is detected to be within an LAOI, the corresponding bit will be 1.

LAOI_gaze_coordinate – single precision floating point values corresponding to horizontal and vertical gaze coordinates with respect to a “Live Area of Interest” (LAOI) coordinate system defined by the user. These coordinates are reported only when gaze is detected to be within the LAOI boundary. If gaze is not within the boundary of an LAOI or is in an LAOI with no defined coordinate system, the values will be “0.0”. If gaze is within multiple overlapping LAOIs, LAOI gaze coordinates are reported for the lowest numbered LAOI for which a coordinate system has been defined.

fix_duration – single precision floating point value representing the current duration, in seconds (to the nearest 0.001 sec), of an on-going fixation, as determined by the real-time fixation detection algorithm (see *ETVision* manual, section 9.12). If there is not an “on-going” fixation, the value is 0.0. Note that when *ET3Space* is enabled, fixations are determined as periods of gaze stability with respect to an *ET3Space* scene plane. When *ET3Space* is not enabled the fixation frame of reference is the head mounted scene camera.

fix_coord -- single precision floating point value representing the horizontal and vertical coordinates of an "on-going" fixation as determined by the real-time fixation detection algorithm (see *ETVision* manual, section 9.12). When *ET3Space* is enabled these coordinates specify a position with respect to the *ET3Space* scene plane coordinate frame, with units of centimeters or inches as determined by the *System Configuration* dialog. When *ET3Space* is not enabled, these coordinates represent a position on the head mounted scene camera 1280 x 720 pixel field-of-view (fov). If there is not an “on-going” fixation, the values are 0.0. Note that since even 0.0 is a valid coordinate point, the absence of an on-going fixation can only be determined by fix-duration value of 0.0.

Gaze_AI – Integer value specifying the type of AI object detection bounding box that contains the point-of-gaze cursor (see *ETVision* manual, section 7.4.3). The integer value is the index number of an object in the AI object detection model being used by *ETVision*. If gaze is not within any AI object bounding box, Gaze_AI is 0. If “AI Auto Object Detection” is not enabled, Gaze_AI is always 0. Note that if AI object bounding boxes overlap gaze can be inside more than one. In this case the system determines which bounding box center is closest to the gaze point and Gaze_AI reports the index for that object type.