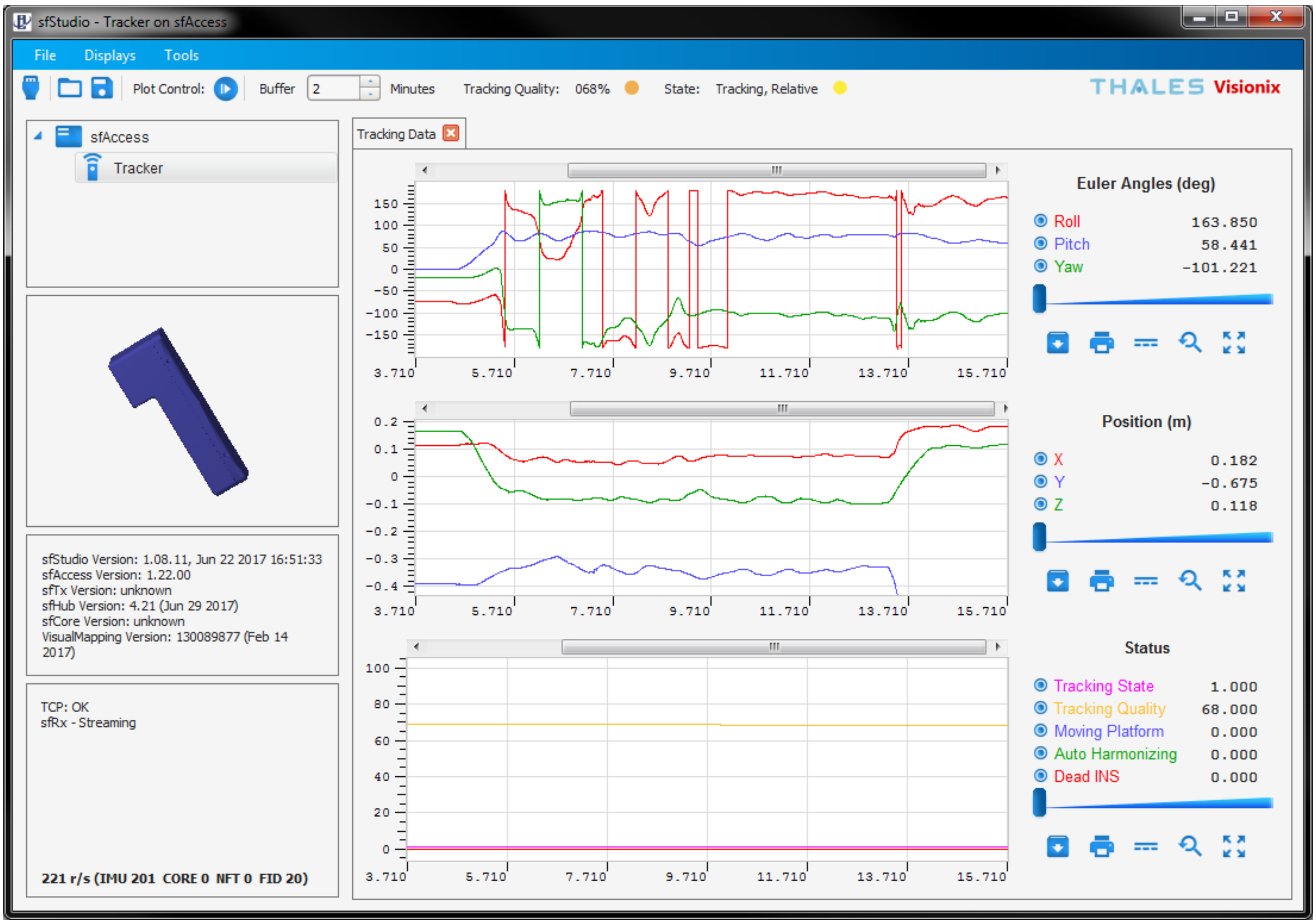
sfStudio User Guide



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MNL- 0020 (B)

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1 Introduction

The sfStudio software is primarily used for the set-up and analysis of optical inertial tracking. It is an excellent tool for viewing tracking data or troubleshooting the system. The software offers you access from your tablet or PC to the heart of the optical inertial data—letting you see fiducials and natural features in the environment that the tracker identifies, record a log of data from the device, watch data streaming into analytic graphic displays, and examine all motion data in a variety of graphical displays.

sfStudio was designed to be used with most InterSense optical inertial trackers. The IS-1500 uses a different architecture than legacy optical inertial trackers, such as the HObIT and IS-1200 series. For this reason, some displays and tools may only be able to be used with the IS-1500 or with legacy trackers.

2 Installation

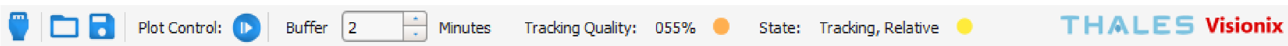
For first time set-up and installation of the IS-1500 system, it is recommended that the user follow comprehensive instructions provided in the IS-1500 User Guide (MNL- 0024) or IS-1500 Quick Start Guide (MNL-0026).

3 Main Menus, Displays, and Buttons

There are several universal menus, displays, and buttons in sfStudio for general use. The dropdown menus appear in a row along the top of the window. The main sfStudio toolbar is situated just below the dropdown menus. The sfStudio sidebar runs along the left-hand side of the window. Many of the display tabs in sfStudio contain graphs, each of which has a row of buttons that can be used to adjust the display or save data.

3.1 Main sfStudio Toolbar Display and Buttons

Along the top of the window, below the dropdown menus, is the main sfStudio toolbar:



 Launch sfHub and connect to the tracker

 Browse for and open a file already containing data and display that data in the graphs.

 Select a folder and save the data to a file.

 Plot Control button. Stop or restart the plotting of data from the sensor into the graphs. When you stop plotting data, sfStudio discards the data it does not plot.

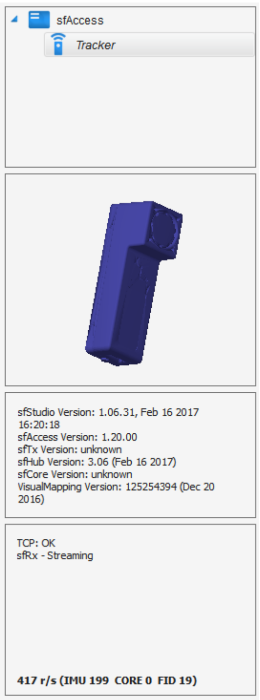
Increases or decreases the duration in minutes for which data is retained for in the graph buffer. sfStudio continuously adds data to the graph and retains it for the amount of time allotted by the buffer as long as you do not stop the process by clicking the Plot Control button. A longer buffer duration lets you collect larger samples of data.

Tracking State indicates which one of the following four modes the tracker is in.

State	Color	Descriptor	Indication
0	Grey	No Communication	There is no communication to sfHub and/or the tracker
1	Yellow	Tracking, Relative	The system is tracking without a global reference frame
2	Green	Tracking, Referenced	The system is tracking with a global reference frame
3	Red	Lost	The tracker is connected but is not tracking

The Tracking Quality metric, or TQ, indicates how good tracking is overall. A mid-range TQ does not necessarily indicate poor data, however. TQ is zero for States 0 and 3. In state 1 or 2, TQ is a function of pose uncertainty and feature (or target) count. Uncertainties are typically lower in State 1 than in State 2, so TQ will typically also be lower in State 1.

3.2 Sidebar Display



The sfStudio sidebar typically occupies the left-hand pane and is divided into four panes. When displayed in portrait mode, the sfStudio sidebar will instead appear at the bottom of the window. Once the software is connected to the InertiaCam, its data will populate as shown.

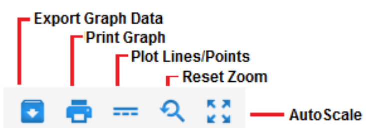
The top pane indicates that data is currently being viewed for the connected tracker. This can change if a logged data file is instead being viewed.

The second pane from the top shows an animated 3D model of the InertiaCam. The orientation of the model reflects the current orientation of the tracker and is useful for quick reference.

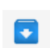
The third pane from the top provides information on the software versions currently in use.

The bottom pane provides connection information. When the connection is stable, TCP should read as OK as shown. The data records per second (r/s) are shown in blue. The IS-1500 will normally receive overall about 400r/s, with about 200 IMU r/s. When fiducials are in the field of view, 20 FID r/s is normal.

3.3 Graph Data Display Buttons and Manipulation



These icons appear below the graphs in several **Display** menu windows.

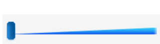
 **Export Graph Data** icon opens the **sfStudio** subdirectory. You can export the graph data to that directory (the default) or browse to another location and export it there. Save the data in a **.dat** file.

 **Print Graph** icon prints the graph.

 Plot Lines/Points icon changes the lines in graphs to individual points.

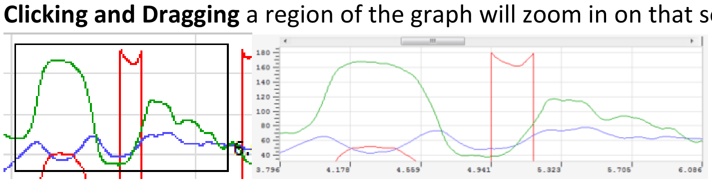
 **Reset Zoom** icon changes the graph to its original size.

 **AutoScale** icon changes the scale of the graph to fit its content.

 **Sliders** can be used to scale the graph.

Toggles to the left of each value show (green) or hide (white) their plots in the graph.

Clicking and Dragging a region of the graph will zoom in on that selection.



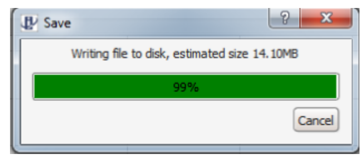
3.4 Dropdown Menus

There are three main dropdown menus- File, Displays, and Tools. The selections under Displays and Tools will open up new tabs. Some of these displays and tools (such as Constellation Display and Simple Visual Mapper Tool) will add additional dropdown menus in this row.

3.4.1 File Menu Options

The File Menu provides options related to connecting to the tracker and viewing log files.

- **Connect to Devices:** Like the  **Connect** button, launches sfHub and connects to the InertiaCam sensor.
- **Open Data Log File** Opens the **sfStudio** directory where you find folders that contain all data from the device captured over a particular period of time. The folders are named in the format **sfaLog_***dd_mm_yyy_hh_mm_ss*. The folder includes image data, inertial measurement unit data, and graphed statistics about position/orientation. You created this directory of files using **Tools → Start Data Logger** to start logging and **Tools → Stop Data Logger** to end logging. Also see the Data Logger section. Once you select a folder and then click the **Select Folder** button, sfStudio displays the data in graphical form under tabs such as **Optical Data Display** and **Tracking Data**. This feature is not available when using the InertiaCam.
- **Open Data File:** To view graphs of the data you saved using **File → Save To File**. You first open the sfStudio display tab where you want to see the data graphed, then open the data file using this menu option.
- **Save To File:** Creates a *data file* where it saves only graphed data, discarding the optical and IMU data. sfStudio presents a **Save File** dialog where you can navigate to where you want to save the data. By default, the dialog opens in the sfStudio folder, but it remembers the last directory you saved to and reopens in that location. Give the file a **.dat** (or **.bin**) extension and wait for the save process to complete.



- **Close Current:** Closes the open connection to the InertiaCam or closes the data log you have selected under **Stored Data** in the left-hand pane.
- **Exit:** Closes sfStudio.

3.4.2 Displays Menu Options

The Displays dropdown menu provides a list of the available data display tabs. Each of the display tabs will be discussed in further detail in the Displays section. Not every display is universally applicable to all trackers. Some displays are available for use with only the IS-1500 or only legacy trackers. The available displays and a brief description are as follows:

- **VR Viewer:** Shows an AR preview with respect to North
- **Constellation Display:** Used to view and edit of constellation files
- **Optical Data Display:** Allows viewing of live optical data from the tracker, displays tracked fiducials and features
- **3D Data Display:** Shows the tracked path of the InertiaCam relative to the current world XY plane
- **Tracking Data:** Default data tab for sfStudio, showing graphs of orientation, position, and statuses
- **Tracker Sigma Data:** Graphs of the rotation and gyros bias sigmas, which measure accuracy uncertainty
- **Tracker IMU Data:** Graphs of the standard IMU outputs, angular velocity and linear acceleration, from the tracker
- **Platform Motion Data:** When tracking off of a moving platform, graphs the motion of that platform
- **AHRS Data:** Graphs of the orientation and rotation sigmas (not used for NFT)
- **Additional Data:** Graphs miscellaneous data, including delta T, IMU temperature, and exposure
- **Pose Recovery Stats:** Graphs data related to fiducial recognition and tracking when viewing a constellation
- **Harmonization Data:** Graph constellation rotation data when using a mobile constellation with its own IMU
- **PRA Sigmas:** Graphs rotation and position sigmas when viewing a constellation

3.4.3 Tools Menu Options

The Tools dropdown menu provides a list of the available tool tabs. Each of the display tabs will be discussed in further detail in later sections. Not every tool is able to be used with all trackers. Some displays are available for use with only with legacy trackers. The available tools and a brief description are as follows:

- **Port Configuration:** Opens the **Hardware Port Configuration Utility**, where you configure the port for your device or create alternative port configurations for a device. This tool is not used by most optical inertial systems. To request more information, contact Thales Visionix Technical Support.
- **Config File Editor:** Opens the **Configuration File Editor**, where you modify **.ini** files for a device. This tool is not used by most optical inertial systems. To request more information, contact Thales Visionix Technical Support.
- **Make Fiducials:** Opens the **Make Fiducials** tool, where you create a set of fiducials patterns that can be printed out and used in your environment. For more information, refer to the Make Fiducials Tool section of Creating a Custom Fiducial Constellation.
- **Low Level Access:** Opens the **Low Level Access** tool, where you can retrieve files from the tracker or host computer and transfer files to the tracker or host computer. You transfer files to and from the connected sensors as well as the processor.
- **Start Data Logger:** Selecting this menu entry starts the data logger. Once selected, the entry changes to **Stop Data Logger**. Once you start the logger, all action that the sensor takes is logged until you select **Stop Data Logger**. The data is stored in a data log file and includes not only the image of what the sensor was seeing, but also all of the graphed numeric data. You can display all the data in sfStudio. This feature is not available when using the InertiaCam.
- **Simple Visual Mapper:** Starts the **Simple Visual Mapper** for generating a map of the fiducials using the sensor. For details on this tool, refer to the Simple Visual Mapper section of Creating a Custom Fiducial Constellation.

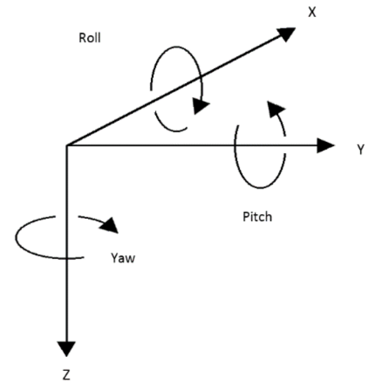
4 Displays

When a display is selected from the Displays dropdown menu, it is opened in a new tab. Some displays include their own toolbar and/or dropdown menu with settings specific to it. As mentioned previously, some displays are specific to the IS-1500 or legacy trackers.

4.1 Tracking Data

The Tracking Data display is the default display tabs for sfStudio. It displays the tracker orientation and position, as well as the tracking status.

The figure to the right shows the standard reference frame for both position and orientation of all InterSense tracker systems. The reference frame (also referred to as *navigation frame* or *nav frame*) is the locally level geographic frame with its X axis pointing forward, Y axis to the right, and Z axis down in the direction of gravity.



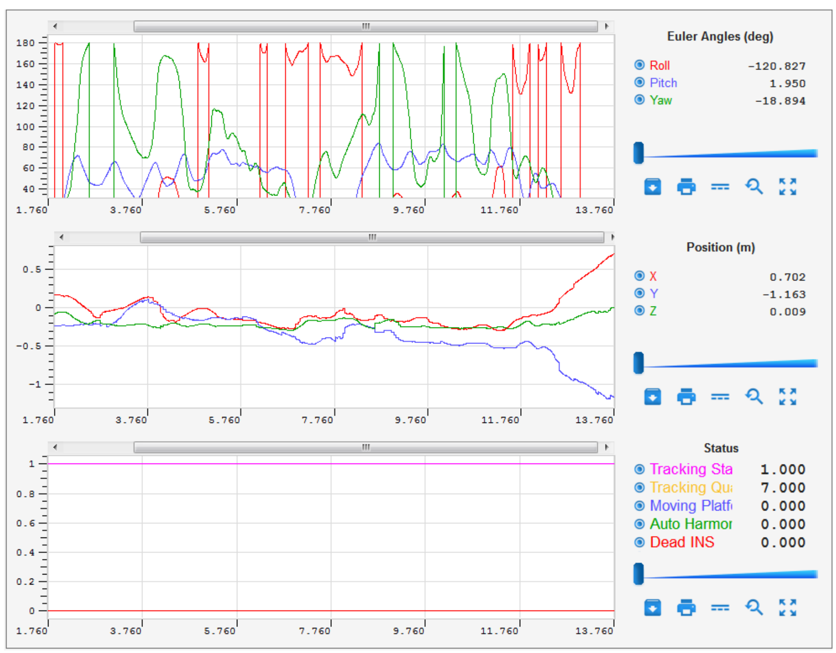
It is important to understand that when setting up any InterSense system, *the Z axis of the tracking system's nav frame will always point in the direction of gravity*. The X and Y axes may be set to any direction in relation to the Z axis.

It is normal for applications to make subsequent coordinate transformations that change the direction of the Z axis, but the underlying tracking system and inertial components maintain gravity as the reference for the Z axis.

The Euler angles that the tracker reports are a sequence of rotations applied to the tracking device starting with its body axes initially aligned with the nav frame axes and resulting in the current orientation.

To view and examine the tracking data, in the menu bar select **Displays → Tracking Data**. Three graphs are displayed:

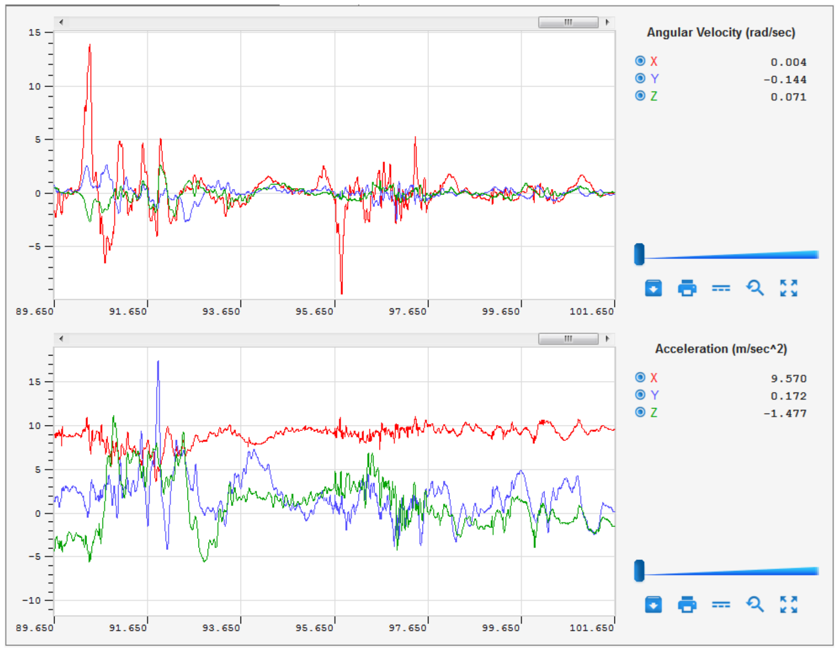
- **Euler Angles (deg)**: Shows the Euler angles of the **Roll**, **Pitch**, and **Yaw** values at which the sensor is rotating around the **X**, **Y**, and **Z** axes
- **Position (cm)**: Shows the position of the sensor on the **X**, **Y**, and **Z** axes
- **Status:** Displays tracker info on a vertical axis of −2.0 to +11.0, with the units varying by the statistic
  - **Tracking State**
  - **Tracking Quality**
  - **Other low-level info**



4.2 Tracker IMU Data

This display can be used with the IS-1500 and legacy trackers.

IMU refers to the inertial measurement unit within the tracker that is used to measure orientation. The information reported in this tab is the angular velocity and acceleration reported by the IMU. This is the data used to derive the yaw, pitch, and roll.



To examine the tracker's inertial data, in the menu bar, select **Displays → Tracker IMU Data**. Each chart contains three plots, **X** in red, **Y** in blue, and **Z** in green. The forces graphed are:

- **Angular Velocity:** Rate of angular change about each axis of the tracker's internal IMU coordinate reference frame inside the sensor.
- **Acceleration:** Linear acceleration in the navigation frame, in units of meters per second^2.

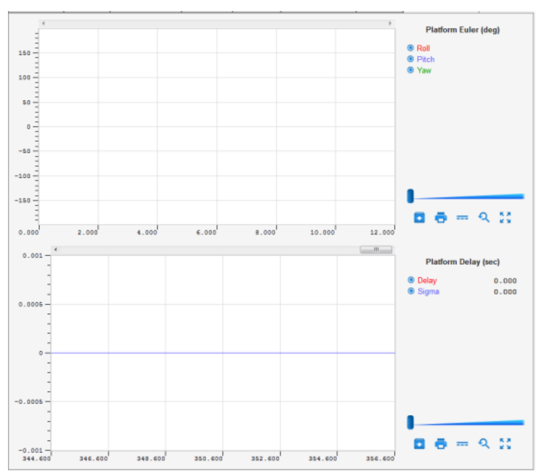
A straight line in both graphs typically indicates that the sensor is still. When the device moves, the values should be changing in each graph.

Both the graphs shown in the illustration here have been scaled by clicking the rightmost button to automatically scale the data for its most readable presentation.

4.3 Platform Motion Data

This display can apply to either NFT or fiducial tracking.

Platform motion data applies to a platform (or any object) where you have attached a NavChip for tracking motion of that platform (or object).

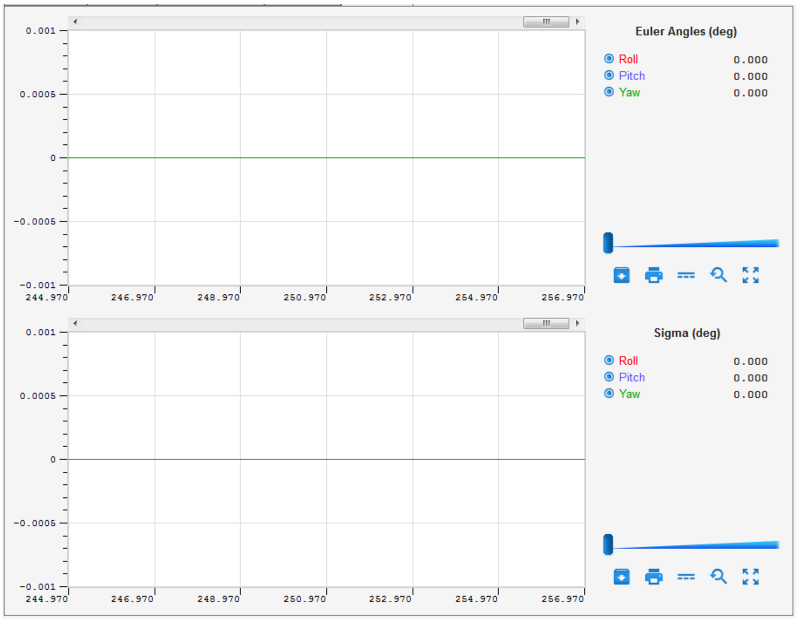


To view platform motion data, select **Displays → Platform Motion Data**. The **Platform Motion Data** display opens and shows graphs of two types of data:

- **Platform Euler (deg)**: Shows additional the motion of the platform that could contribute to inaccurate motion data from the sensor. Shows the platform motion in **Roll**, **Pitch**, and **Yaw** of Euler angles.
- **Platform Delay (sec)**: Shows the amount of delay in seconds that the motion of the platform introduces into the motion tracking data. This information includes both **Delay** in seconds and **Sigma**, the amount of error in seconds.

4.4 AHRS Data

This display applies to fiducial tracking using sfCore tracking mode. The Attitude and Heading Reference System (AHRS) tracks strictly orientation, without yaw correction, so significant drift in yaw is expected. To view and examine this data, in the menu bar, select **Displays → AHRS Data**.



Two graphs appear, both containing orientation data, showing **Roll** in red, **Pitch** in blue, and **Yaw** in green, graphed on a scale from −180° to 180° against a horizontal axis in seconds. The two graphs show:

- **Euler Angles (deg):** Roll, pitch, and yaw rotation in degrees.
- **Sigma (deg):** Standard deviation (error) in the Euler angles of the first graph.

4.5 Additional Data

This display can be used with the IS-1500 and legacy trackers.

With the Additional Data display you can view and examine miscellaneous data, usual related to the tracker itself. To examine this data, in the menu bar, select **Displays → Additional Data.** You then see a series of charts that show data about several statistics, all graphed against a horizontal axis of seconds:

- **Tracker Angular Velocity (rad/sec)**: Angular velocity values for X in red, Y in blue, and Z in green, all values graphed on a scale of −18 to +18 radians per second.
- **Delta T (ms)**: Time elapsed between receiving IMU records that provide data. This graph is of protocols inside sfRxCore (scale 0 to 29 ms):
    - **sfCore ProcT** (red): Core processing time. Time elapsed for the processing of each piece of data from the tracker.
    - **sfRx DeltaT** (blue): Time elapsed between data arrivals. A steady stream of data produces a flat line.
    - **sfCore − sfRx** (green): Rate of data transmission between sfRx and sfCore.
- **NavChip Temp** (deg C): Temperature of NavChip in sensor. Should be between −40° and +85° C.
- **Optical Rate**: Sensor camera frame rate in Hz.
- **Exposure**: Length of camera exposure in microseconds.
- **Optical Mode**: Status of night vision, 0 for off, 1 for on. This is not applicable to the InertiaCam, which has only one mode.
- **CPU Temperature** (deg C): Temperature of sensor CPU, should be between −40° and +85° C. This is not applicable to InertiaCam trackers, which do not have an internal CPU.

4.6 *Pose Recovery Stats*

This display can be used with the IS-1500 and legacy trackers, though it mainly applies to the latter as it focuses on fiducial tracking data. When using the IS-1500, data is only plotted while viewing fiducials.

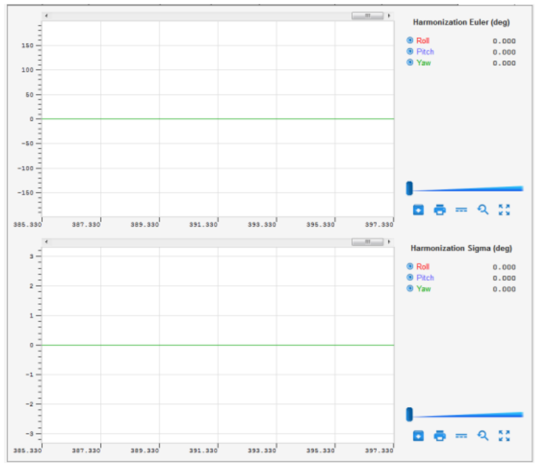
To view the Pose Recovery Stats, select **Displays → Pose Recovery Stats**. This display gives you output from the pose recovery algorithm (PRA), which determines the position and orientation of the tracker relative to the fiducial constellation. There are three graphs:

- **Pose Recovery Euler (deg)**: **Roll**, **Pitch**, and **Yaw** results.
- **Pose Recovery Position (cm)**: **X**, **Y**, and **Z** results.
- **Pose Recovery Data**
    - **nRecognized**: Number of fiducials decoded in the tracker's field of view. Can include false positives.
    - **nMatched**: Number of discovered fiducial IDs that match those defined in the constellation map file.
    - **nUsed**: Number of fiducials actively being used for tracking by the PRA, usually a maximum of 20.
    - **Delay**: Number of IMU data cycles between optical records.
    - **praMaxFitErr**: Pose Recovery Algorithm Maximum Fit Error. A fiducial's fit error is the difference between actual fiducial location and its expected location as defined by the map file. This value is the maximum fit error found, which is indicative of the accuracy of the map file. A high praMaxFitErr can indicate that individual fiducials have been displaced since the map file was created.

    - **praValid**: Whether pose recovery is valid, **1** for true, **0** for false. When pose recovery is valid, the system has achieved optical lock and can use the constellation to correct for drift.
    - **praMeasAccepted**: Whether pose recovery result was accepted, **1** for true, **0** for false.
    - **poseInnov**: (Pose Innovation) A normalized pose measurement. Since real image data is subject to noise and occlusions, the image could have erroneous or missing elements. To correct for these imperfections, this value is a measure of unexpected motion (innovation) of the pose state based on historical data.
    - **praCrossAxisSpan**: Measure of the spread between recognized fiducials in the field of view currently used by the PRA.
    - **praGdop**: Pose Recovery Algorithm Geometric dilution of precision. Indicates the geometric accuracy and thereby strength of the constellation. The lower the dilution, the more accurate the constellation geometry.
    - **praPdop**: Pose Recovery Algorithm Position dilution of precision. Indicates accuracy of the **X**, **Y**, and **Z** axes positions in the constellation. The lower the dilution, the more accurate the constellation positions.
    - **praOdop**: Pose Recovery Algorithm Orientation dilution of precision. Indicates the accuracy of the roll, pitch, and yaw values in the constellation. The lower the dilution, the more accurate the constellation orientation.

4.7 Harmonization Data

This display applies to fiducial tracking using HObIT trackers and legacy hardware only.



Harmonization data applies when the fiducial constellation is in motion. Usually this occurs because the map is inside a moving entity, such as an aircraft cockpit or another type of mobile vehicle. The system collects this data and uses it to compensate for that movement when correcting motion data for accuracy.

To view harmonization data, select **Displays → Harmonization Data**. This data displays in two graphs:

- **Harmonization Euler (deg)**—Shows harmonization differentials that could contribute to inaccurate motion data from the sensor. Shows the amount of **Roll**, **Pitch**, and **Yaw** in Euler angles to correct data for harmonization.
- **Harmonization Sigma (deg)**—Measures the level of uncertainty or possible error in values from tracker readings based on movement of the fiducials. The lower the uncertainty, the better the accuracy of he tracked data. Shows the amount of **Roll**, **Pitch**, and **Yaw** in degrees to correct data for harmonization

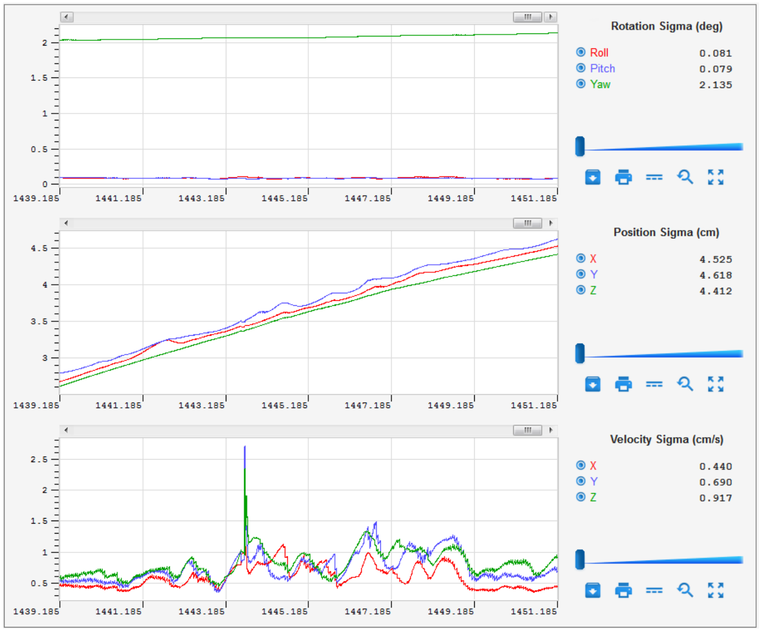
4.8 Tracker Sigma Data

Sigma data measures the level of uncertainty or possible error in values from tracker readings. The lower the uncertainty, the better the accuracy of the tracked data. The greater the error in one of these graphs, the less accurate the corresponding actual tracking data in the **Tracking Data** display.

IMUs are designed such that there is generally less drift in the roll and pitch data than the yaw data. Because of this, it is expected that the yaw sigma will increase at a greater rate than the roll and pitch data. This is especially true when there is no drift correction.

From the menu bar, select **Displays → Tracker Sigma Data**. The **Tracker Sigma Data** display shows three graphs that analyze the sigma error associated with motion tracking:

- **Rotation Sigma (deg):** Graph shows the error in the **Roll**, **Pitch**, and **Yaw** values from the Euler angles at which the sensor is rotating around the x, y, and z axes.
- **Position Sigma (cm):** Graph shows the error in the position of the sensor on the **X**, **Y**, and **Z** axes.
- **Velocity Sigma (cm/s):** Graph shows the error in the velocity of movement of the sensor along the **X**, **Y**, and **Z** axes



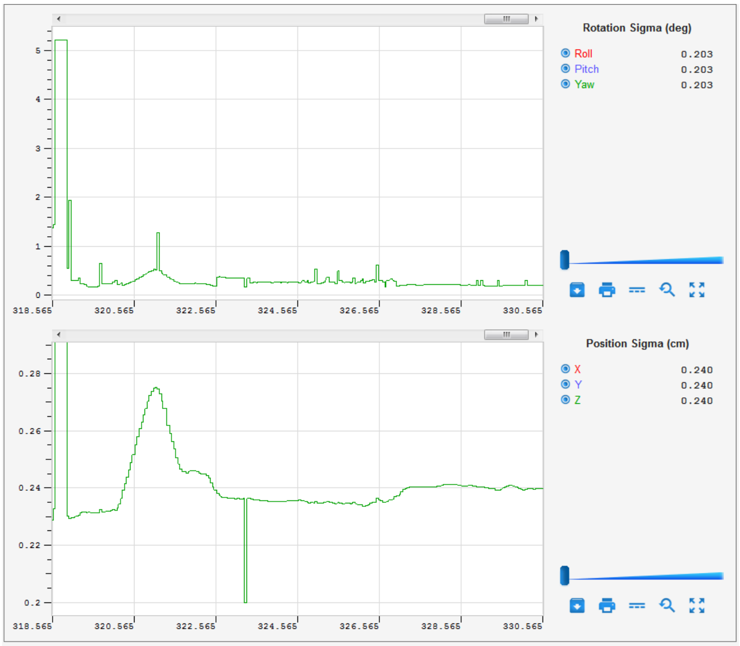
4.9 PRA Sigma Data

This display can be used with the IS-1500 and legacy trackers, though it mainly applies to the latter as it focuses on fiducial tracking data. When using the IS-1500, data is only plotted while viewing fiducials.

PRA (Pose Recovery Algorithm) sigmas are levels of uncertainty or possible errors that have occurred within the PRA algorithm. The lower the PRA sigmas, the greater the accuracy of the motion tracking data.

To view graphs of the errors that might have occurred in the pose recovery algorithm (PRA), select **Displays → PRA Sigma Data**. This display presents two graphs:

- **Rotation Sigma (deg)**—Uncertainty in the orientation of the sensor.
- **Position Sigma (cm)**—Uncertainty in the position of the sensor on the **X, Y,** and **Z** axes.

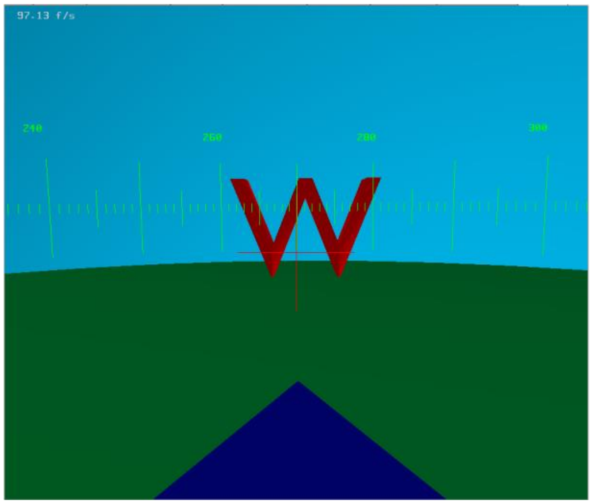


4.10 VR Viewer

This display can be used with the IS-1500 and legacy trackers. The VR Viewer used to preview what a virtual reality display would appear like using the tracker. The display provides an additional dropdown menu at the top of the sfStudio window.

In the menu bar, select **Displays → VR Viewer**. You then see a graphical imitation of the horizon with:

- An **N** showing the direction/location of North. North is defined by the positive X direction of the world reference frame.
- A cross-hair image showing where your device's camera is pointed.
- Tickers across the field showing the number of degrees to the left/right of North for your device's current location. As you move your device, the view in this display changes.
- A reading in the upper left corner that indicates the speed at which the VR Viewer is rendering graphics of the VR Viewer in frames per second.



After you select **Displays → VR Viewer**, the **VR Viewer** dropdown menu appears and offers two options, shown below.

- **Heading Tape**: On by default. Toggles on and off display of the tickers.
- **Field of View**: Sets the width of the field being viewed. Choose from sub options, of 10° through 70°, in 5° increments.

4.11 Constellation Display

This display is useful for both the IS-1500 and legacy trackers, but has limited functionality with the former. Because it is largely used as a tool for editing constellations, it will be discussed in greater detail in the Creating a Custom Fiducial Constellation section.

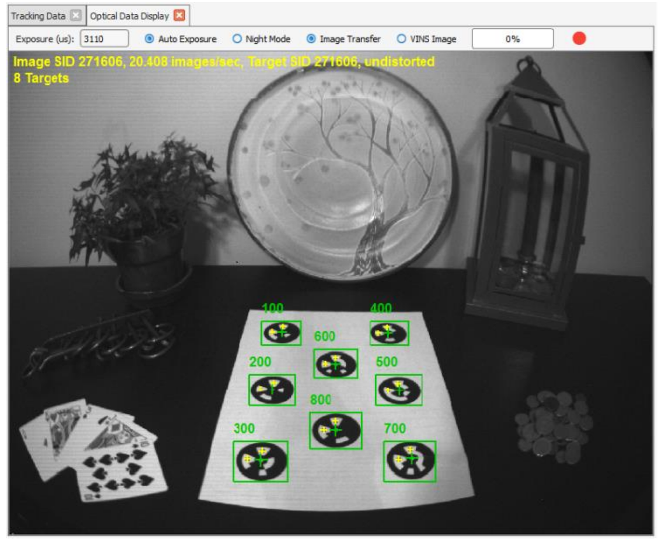
4.12 Optical Data Display

This display can be used with the IS-1500 and legacy trackers.

The Optical Data display is used to view the live camera feed from the tracker. It can also be used to show overlays for recognized fiducials and natural features. It is one of the most useful diagnostic tools for tracking, since the quality and number of tracked objects is directly correlated to the tracking accuracy. This display has its own toolbar at the top of the tab and provides an additional dropdown menu at the top of the sfStudio window.

4.12.1 Interacting with Optical Data

From the menu bar, select **Displays → Optical Data Display**. The **Optical Data Display** menu appears on the menu bar. To see optical data, in the tool bar along the top of the window, click the Image Transfer toggle. The circle turns green to show it is **On** and streaming live camera feed from the tracker.



As an experiment, pick up the InertiaCam and begin moving it around to examine the live feed. If connected to a mobile device, you can walk around with InertiaCam and its tablet or computer.

While using the Image Transfer toggle, bring fiducials into the field of view. Recognized fiducials will be highlighted with colored iconography, as shown in the figure to the right. The number indicates the fiducial ID, as defined by its unique pattern. Fiducial outlines can also be displayed while Image Transfer is disabled, but not when VINS Image is enabled.

When using the IS-1500, the natural features used by the VINS (Visual Inertial Navigation System) algorithm for tracking can also be viewed. In the tool bar, click the VINS Image toggle. The circle turns green to show it is **On**. Each enumerated box indicates a feature that the InertiaCam is using as a reference point to orient itself in the environment. The figure below shows the same objects when viewed with the VINS Image overlay enabled.

The VINS Image toggle does not enable or disable the algorithm itself, just the display. The fiducial and the natural feature tracking algorithms run continuously and simultaneously. Even though the fiducial overlays are not visible in the above image, the system is still tracking off of them. In the previous image, even though the display of VINS features is not enabled, the system is still using natural feature tracking.

Legacy trackers cannot use the VINS Image display since they do not use natural feature tracking.

4.12.2 Optical Data Toolbar

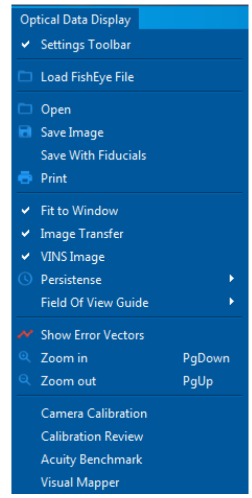
The Optical Data Toolbar contains a number of commonly used features and settings:

- **Exposure**: Automatically set to the number of microseconds of exposure the lens requires. By default, the IS-1500 is set to use automatic exposure. If the system is set to use manual exposure and the image is not clear, this number can be modified to temporarily change the exposure as required. Pressing the Enter key after entering the desire value in the field will apply the change. When the tracker is restarted, the exposure value and mode will revert back to the default mode and exposure defined by the sfHub.info file. Default exposure settings can be changed in the sfHub.info file.
- **Auto Exposure**: Toggles between auto-exposure and manual exposure modes. When the tracker is restarted, the exposure value and mode will revert back to the default mode and exposure defined by the sfHub.info file. Default exposure settings can be changed in the sfHub.info file.
- **Night Mode**: For InertiaCam, ignore this setting, as you cannot use the sensor at night. Click to toggle this setting on if you are using a tracker that can be used at night or in dark settings.
- **Image Transfer**: Click to toggle this setting **On** (green) and begin the image transfer process, showing live feed from the InertiaCam.
- **VINS Image**: VINS stands for Visual Inertial Navigation System—the system InertiaCam uses to identify features in the environment. Turns on numeric identifiers for each feature the IS-1500 is using as a reference point to orient itself in the environment.
- **Recording**: To record a series of frames, click the button. It becomes a square button that you can click at any time to stop recording images. The image frames are saved in .pgm format. To find the recorded frames, use the **Optical Data Display dropdown**, select **Open**, and browse in the installation directory to **sfStudio\Image-Capture**. Find a folder named in the format *dd_mm_yyyy_hh_ mm_ss* using date/time you recorded the data. Inside the folder select a **.pgm** file to view it.

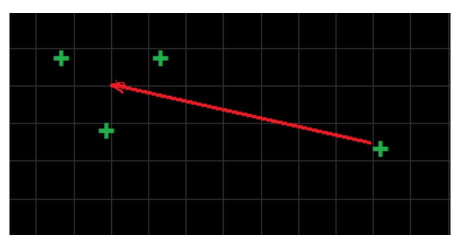
To save the image at any point, select **Optical Data Display → Save Image** (or **Save with Fiducials** to also capture the colored fiducial overlays) and select the desired save location.

4.12.3 Optical Data Dropdown Menu

The Optical Data Display dropdown menu offers several more options:



- **Settings Toolbar**: Toggles on and off the display of the Optical Data Toolbar. A check mark next to the menu option shows it is on.
- **Open**: Opens the image file of the constellation.
- **Save Image**: Saves the currently displayed image frame of the constellation. This option is only useful with Image Transfer enabled.
- **Save with Fiducials**: Performs the same function as Save Image, but will also include colored fiducial overlays if there are any recognized fiducials in view. Because fiducial overlays also appear with Image Transfer disabled, Save with Fiducials can also be used to show fiducial outlines against a black background.
- **Print**: Prints the current image shown to the printer you choose. As with Save Image, fiducial overlays will not be displayed.
- **Fit to Window**: Toggles on/off fitting the display to the window size on the screen. A check mark next to the menu option shows it is **On**.
- **Image Transfer**: Toggles on/off the transfer of the image the sensor is optically detecting to the screen display. A check mark next to the menu option shows it is **On**. Turning this setting **On** immediately initiates transfer of the image from the device. The streaming of the image continues until you toggle the setting **Off**. Image shows you what the sensor optically detects. Option available only on a tablet or PC with an InertiaCam connected through a USB port.
- **VINS Image**: Performs the same function as the VINS Image toggle to display colored overlays over each of the natural features identified by VINS.
- **Persistence**: Sets how frequently the position of the colored fiducial overlay is updated. This setting will not affect VINS features or the rate of the live Image Transfer feed.
    - When the persistence is set to **Last Frame**, the lowest setting, the position of the fiducial overlay will be generated live. Because fiducial data can be received after image data, sometimes the overlay will appear to flicker at this setting. Increasing the persistence can help smooth the fiducial overlay, but setting it too high can create the illusion of lag or drift of the overlay. For instance, setting the persistence to **10.0 sec** will allow fiducials that are no longer visible/identifiable to the system to remain present for up to10 seconds (or when the fiducial overlay positions are finally updated again).
    - Ideally, to best reflect the true fiducial data, it is most useful to set the persistence to Last Frame or the minimum setting required to prevent minor flickering.
- **Field of View Guide**: Choose **None**, **Outer Edge**, or **All** to indicate how many concentric circles to display as guides to examining the environment. Inner concentric circles represent from 45° to 75° in increments of 5°.
- **Show Error Vectors**: Shows inaccuracies in the view of the constellation by drawing a vector that begins at the expected location and has its arrow close to and pointing at the current location.
    - When displaying these vectors, a constellation shows three cross-hairs for each fiducial. The error vector appears in red (see left). You might have to zoom in to see the error vectors.



- **Zoom In (Page Down)**: Use multiple times to move the view closer incrementally. Page Down key also selects this option.
- **Zoom Out (Page Up)**: Use multiple times to back out incrementally. Page Up key also selects this option**.**
- **Camera Calibration, Calibration Review, Acuity Benchmark**: These are tools for Thales production use only and are not functional or supported with the standard software release.
- **Visual Mapper**: Opens the legacy visual mapper provided for viewing constellation maps created in earlier Thales Visionix software. This is for advanced user only, and it is highly recommended that the Simple Visual Mapper tool be used instead to form new maps (see the Simple Visual Mapper**Error! Reference source not found.** section).

4.13 3D Data Display

This display can be used with the InertiaCam. It is used to give an interactive visualization of the tracker's movement through 3D space. The display provides an additional path distance counter accompanied by a reset button.

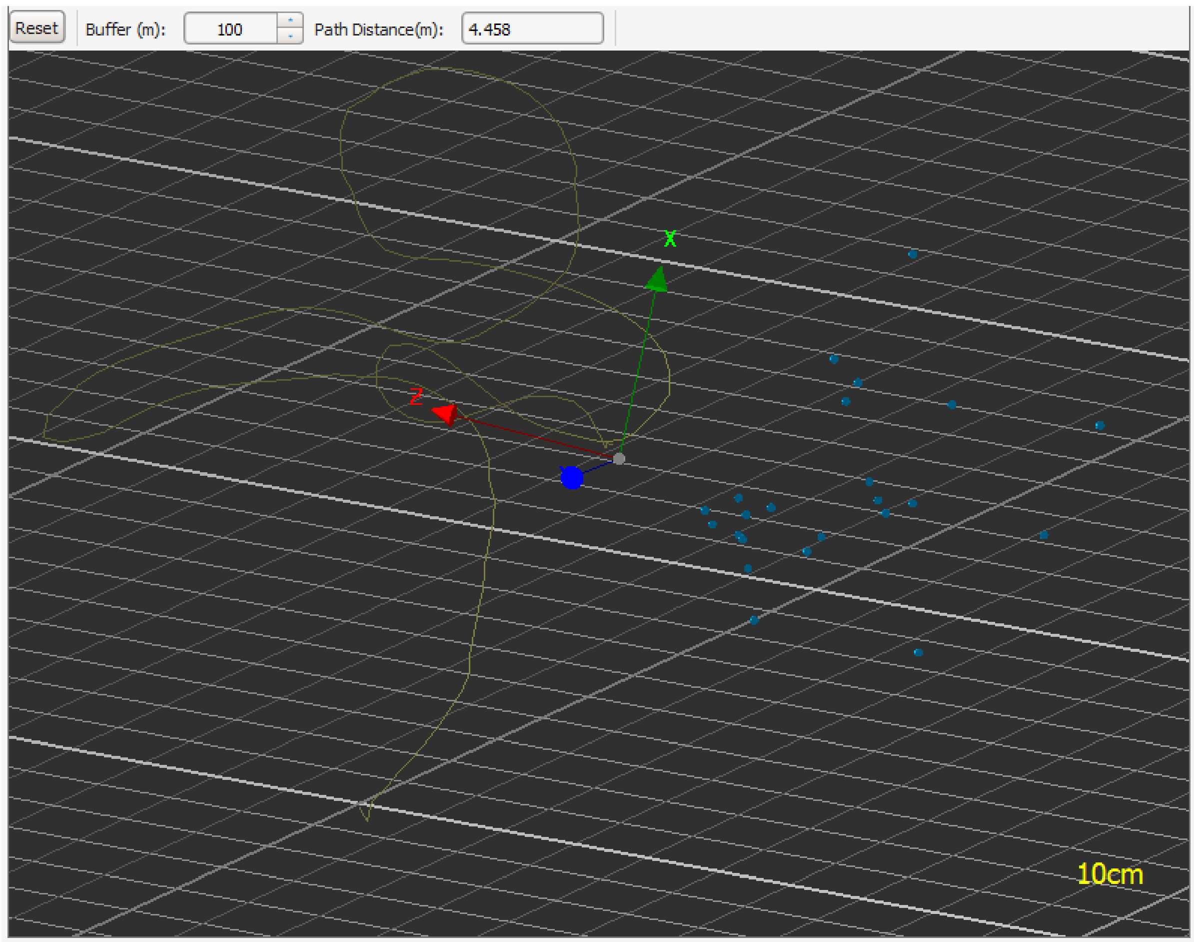
In the menu bar, select **Displays → 3D Data Display**. You then see a toolbar with:

- 

 Reset the onscreen yellow path and zero out the path distance counter.
- 

 Defines the maximum path length in meters. Can be changed by editing the value and pressing Enter.
- 

 The current path length in meters.



The display provides a 3D view, which can be rotated, panned, and zoomed using the left mouse, right mouse, and mouse wheel respectively.

The tracker is represented by the white ball, and the tracker's orientation is represented by the colored axes vectors. A yellow path is drawn following the tracker's position. The path has a resolution of 2.5cm, any less movement will not be reflected in the path.

The grid consists of 2 line thicknesses that scale with the display zoom.

- Thin lines are drawn at the intervals distance indicated in yellow in the bottom left corner. In the image above, they are drawn every 10cm.
- Thick lines are drawn at every 10 thin lines, or 10 times the indicated distance. In the image above, they are drawn every 1m.

5 Capturing Tracking Data

In sfStudio, there are three main methods of collecting tracking data, each with their own advantages.

- **Data Logger**: This is the most extensive method of data capture offered by sfStudio. Once initiated, the tool collects unprocessed binary information until recording is stopped. While this is one of the easier methods and captures the most data, it can be computationally taxing and the data collected is not easily parsed. The data logger is not available when using the InertiaCam.
- **Saving a Data File**: This option saves all of the graph data stored in the temporary buffer, as defined in the main sfStudio toolbar. This is useful for collecting information on all of the data plots.
- **Export Graph Data**: This is the simplest option for capturing specific data points. It captures only the plots that are currently displayed in a particular graph. The resulting file can be easily parsed or imported into a program such as Microsoft Excel.

5.1 Data Logger

The Data Logger tool allows for the capture of tracking data over a period of time. Once the Data Logger is started, it continually records data until it is stopped. The tracking data recorded by the Data Logger is the unprocessed binary information passed to sfStudio from sfHub (or sfRxCore in legacy version of the sensor fusion software suite). Of all the ways to record or save tracking data, the Data Logger tool is the most comprehensive. The resulting file is referred to as a Data Log File, not be confused with a Data File created by saving the information stored in the graph data buffer.

To use the Data Logger:

1. Connect to the tracker to begin receiving tracking data.
2. In the dropdown menu bar select **Tools → Start Data Logger**. Until it is stopped in Step 3, the tool will be continually recording data as you continue tracking.
3. When you have recorded the data you want, in the menu bar select **Tools → Stop Data Logger**. The Data Log File now contains data from this particular slice of time.

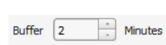
To later view the data from the data log file:

1. Open the sfStudio display tab where you want to see the data graphed, then select **File → Open Data Log File**.
2. An **Open File** dialog pops up, focused on the **sfStudio** subdirectory, containing subfolders named for the date and time you created the log. The folders are in the naming convention **sfaLog**_*mm_dd_yyyy_hh_ mm_ss*. These directories contain the data logs, named **sfaMeta.log**, **sfaSub.log**, and **sfaTrk.log**.
3. Also see the **Open Data Log File** option in the File Menu Options section.

5.2 Saving a Data File

Another method of capturing data is to use the **Save to File** option in the **File** dropdown menu. Instead of continuously recording data, this option will save the tracking information stored in the buffer defined in the toolbar. The Save to File option will create a .dat or .bin Data File containing only the graph data. Note that Data Files and Data Log Files are two different entities. The former is created with the Save to File option while the latter is generated by the Data Logger tool.

To create a data file:

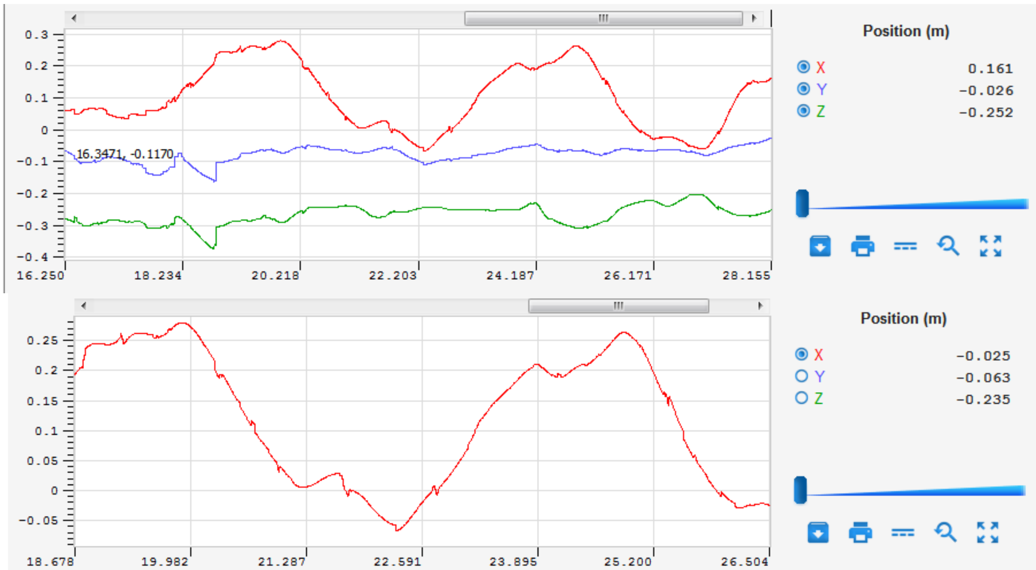
1. Set the buffer in the main sfStudio toolbar to the desired time interval. 

2. Begin tracking to fill the buffer with the desired data.
3. Pause the flow of the buffer by using the Pause/Play  button in the main sfStudio toolbar.
4. In the menu bar select **File → Save To File**.
5. Navigate to the file directory where you want to save the data and save the file with a .dat or .bin extension.

To later view the graph of the data from the saved data file, open the sfStudio display tab where you want to see the data graphed, then open the data file by selecting **File → Open Data File**.

5.3 Exporting Graph Data

Each sfStudio graph has a set of buttons associated with it, as shown in the Graph Data Display Buttons and Manipulation section. Most of these buttons are used to manipulate the graph display. The **Export Graph Data** button allows the user to save only the data plots currently within the time frame shown in the graph. Additionally, only the currently displayed attributes will be saved. For example, in the figure below, using Export Graph Data on the graph on the top will save all the plots for X, Y, and Z position from 16.250 seconds to 28.155 seconds. The bottom image shows the same graph, manipulated to zoom in on a section of the data with the Y and Z plots toggled off. Using Export Graph Data on the bottom graph will only save the plot for X position from 18.678 seconds to 26.504 seconds (the values that extend out of view below or above will also be included).



To export the graph data:

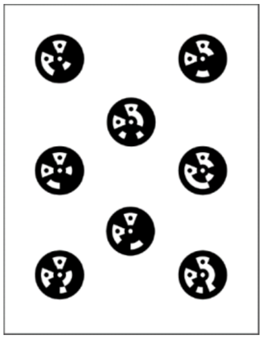
1. Set the buffer Buffer 2 Minutes in the main sfStudio toolbar to ensure the interval.
2. Begin tracking to fill the buffer with the desired data.
3. Pause the flow of the buffer by using the Pause/Play button in the main sfStudio toolbar.
4. Manipulate the display of the graph with the desired plots as described in the Graph Data Display Buttons and Manipulation section.
5. Use the **Export Graph Data** button.
6. Navigate to the file directory where you want to save the data and save the file with a .dat or .bin extension.

To later view the graph of the data from the saved data file, open the sfStudio display tab where you want to see the data graphed, then open the data file by selecting **File → Open Data File**.

This file can also be easily parsed or imported to other applications for analysis, such as Microsoft Excel.

6 Creating a Custom Fiducial Constellation

6.1 Overview



InterSense optical inertial trackers are capable of tracking off of fiducials. InterSense **fiducials** are circular black-and-white patterns that act as known physical landmarks for the system. A fiducial **constellation** refers to the layout of all fiducials in a tracked area. For example, the image to the right shows a scaled down version of the default IS-1500 constellation. Constellations and their fiducials provide predetermined points of reference for the tracker.

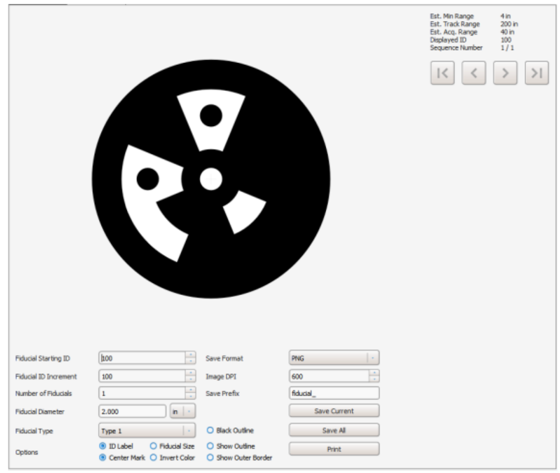
Fiducials are the only features used for tracking with legacy optical inertial trackers, such as the HObIT and IS-1200 series. As such, a fiducial constellation is required when using legacy trackers. For the IS-1500, use of fiducial constellations are still recommended to enable another level of drift correction and set a fixed world reference frame for the system.

If the provided constellation poster does not meet the needs of an application, a custom constellation and corresponding map file can be created. There are several steps to creating and using a custom fiducial constellation. Before you use the InertiaCam to track motion with fiducials, you must place fiducials in strategic locations in your environment, as explained in the **Fiducial Constellation Setup Guide**. When using the IS-1500, constellation density requirements are not as strict as they are for other InterSense optical-inertial trackers. For example, rather than needing to cover a continuous area such as a poster or a room, fiducials can instead be placed in clusters at key landmarks throughout a commonly tracked area. Fiducial patterns can be created using the Make Fiducials Tool.

You then need to create a digital map file of the fiducials that reflects the physical layout of the fiducials. The map file includes a list of the IDs of the fiducials in the constellation and their expected positions and orientations. While tracking, the map enables the system to cross reference the observed fiducials with the expected layout. The tracker's position and orientation relative to the constellation is then able to be calculated.

Once the map is complete, the mapper automatically saves it on your computer. If desired, the saved map can be edited using the Constellation Display. This is useful for changing the orientation and location of the origin, which naturally changes the orientation and origin of the global reference frame.

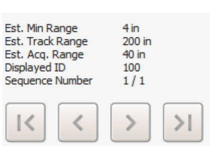
6.2 Make Fiducials Tool



To open the tool from the menu bar, select **Tools → Make Fiducials**. Then fill in the following information:

- **Fiducial Starting ID**: Assign ID number of the first fiducial.
- **Fiducial ID Increment**: Set the number to increment by from one fiducial ID number to the next. It is recommended to start at ID 100 and increment by 100 for IDs of 100, 200, 300, etc. Fiducial ID increments must always be a multiple of 10.
- **Number of Fiducials**: Set number to create, up to 654, that should have the same diameter.
- **Fiducial Diameter**: Choose measurement units from the drop-down list. Then set the diameter you want. You fill out this screen once and create set of fiducials all with the same diameter. If you need additional fiducials with a different diameter, you need to repeat this entire process for that set.
- **Fiducial Type**: You can create only **Type 1**. The style of fiducial shown here is the only style available in sfStudio.
- **Options**: Choose the type of printout by clicking the corresponding circle to fill it (appears green):
- **ID Label**: Includes Fiducial ID number.
- **Center Mark**: To help with positioning. Not recommended for general use since changes to the center eye can negatively impact fiducial recognition and may lead to poor performance.
- **Fiducial Size**: Diameter of the fiducial.
- **Invert Color**: Inverts black and white. Most trackers, including the IS-1500, are configured to recognize fiducials with a white center eye. Fiducials with inverted colours may not be identified by the tracker.
- **Show Outline**: Displays outline only.
- **Show Outer Border**: Turning off removes the white outer border. Not recommended for general use since removing whitespace around the edges can negatively impact fiducial recognition and may lead to poor performance.
- **Save Format**: Choose format to save fiducials in, **.svg**, **.png**, **.jpg**, or **.bmp**.
- **Image DPI**: Choose the number of dots per inch for printing. For usable quality, **600** is the minimum recommended setting.
- **Save Prefix**: Enter a prefix to add to the file name.

Click **Save Current** to save the fiducial currently displayed or **Save All** to save them all. When using Save All, fiducials are automatically saved to the sfStudio subfolder of the Software Folder in the installation directory.



To view the fiducials in the set, click  or  (to the upper right) to move backward or forward and see one fiducial at a time.

To print the fiducials, click the **Print** button in the lower right corner. sfStudio will print all the fiducials in the set, with only one fiducial per page.

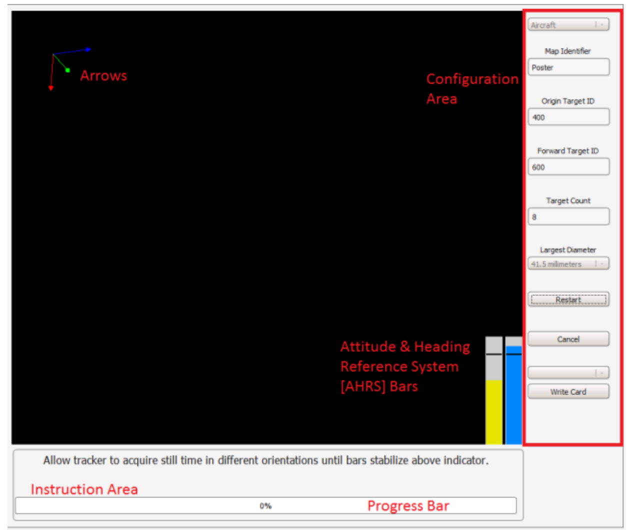
6.3 Simple Visual Mapper

Before the system can track off of the newly laid out constellation, you then need to create a digital map file of the fiducials that reflects the physical layout of the fiducials. The map file includes a list of the IDs of the fiducials in the constellation and their expected positions and orientations. While tracking, the map enables the system to cross reference the observed fiducials with the expected layout. The tracker’s position and orientation relative to the constellation is then able to be calculated.

The Simple Visual Mapper (SVM) tool is used to create constellation map files. After entering basic data about the constellation, the tracking process is initiated. The tracker is moved over the fiducials in the environment. The system optically detects and identifies those fiducials while AHRS inertial data from the IMU is used to calculate the fiducial positions. It then sends the data to the Simple Visual Mapper, which forms a map of the constellation of fiducials. In SVM, as you translate the InertiaCam across the fiducials, you can watch the map of the constellation form. As the mapping process proceeds, SVM continually provides instructions to guide you. For instance, if it cannot visualize a fiducial very well, it asks you to focus longer on that particular fiducial. Once the map is complete, the tool automatically saves it on your computer.

When the system is mapping tracking will change to sfCore Mode. Effectively, the IS-1500 will act like a legacy tracker in sfCore Mode, and all of the sfStudio displays respond accordingly. It is normal for the Tracking State to change to be Lost (3) during mapping.

6.3.1 SVM Main Interface



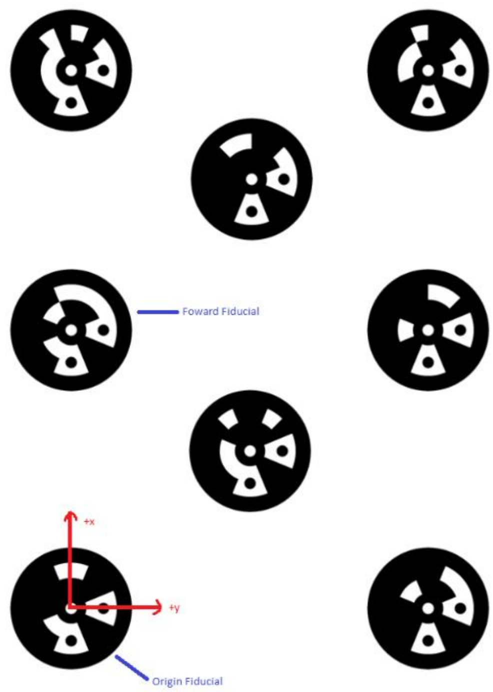
In the sfStudio menu bar, select **Tools → Simple Visual Mapper**. The **Simple Visual Mapper** will open in a new tab.

There are several components of the display:

- Constellation Area
- Configuration Area
- Attitude & Heading Reference System (AHRS) Bars
- Instructions Area
- Progress Bar

Each of these will be explained as they become relevant through the mapping process.

6.3.2 Configuration Fields



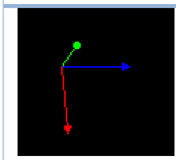
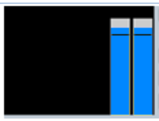
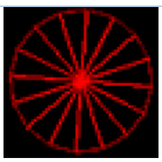
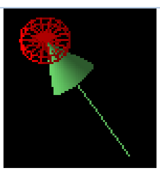
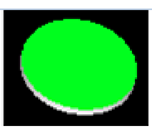
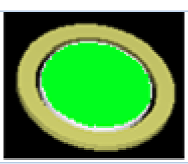
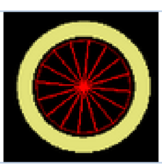
There are several fields in the Configuration Area that need to be entered before mapping begins. These fields provide the system with a foundation of data on which to calculate fiducial information and build the map. Entering some fields incorrectly can cause the mapping process to fail or produce an inaccurate (and therefore unusable) map.

- The dropdown at the top of the Configuration Area is the **Preset Dropdown**. It contains a list of presets as defined in SVM.ini. Selecting a preset will allow the user to automatically populate the following fields.
- To assign a name to the map, enter it for the **Map Identifier**.
- Choose a particular fiducial's center to be the origin (0, 0, 0 coordinates) of the constellation. This fiducial will become the Origin Fiducial, and its ID is the **Origin Target ID.**
- To set the direction of the x axis, select a Forward Fiducial. The **Forward Target ID** is the ID of this fiducial. The vector from the center of the Origin Fiducial to the center of the Forward Fiducial will become the positive X axis.
- The **Target Count** is the number of fiducials in the environment.
- To help the InertiaCam find fiducials, the diameter of the largest fiducial in the environment must be known. The sizes (in millimeters) listed in the **Largest Diameter** dropdown of the Configuration Area are all standard sizes of fiducials. You must choose the size that matches the exact diameter of the largest fiducial to within 5% accuracy or tracking becomes inaccurate and could fail.

After clicking the **Connect** button in the upper left corner of the Simple Visual Mapper to connect to the tracker and entering the Configuration Fields, the **Start** button can be clicked to begin the mapping process. If you decide you are not getting good data, you can then start over by clicking the **Restart** button that now appears. To cancel any work you have done so far, click **Cancel**.

6.3.3 SVM Symbology

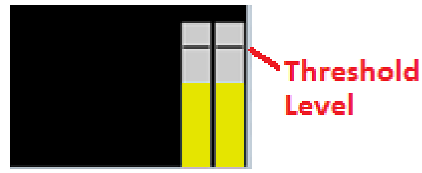
In the **Constellation Area**, you see multiple types of images that represent information about the constellation.

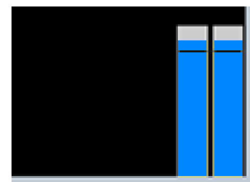
Graphic	Purpose
	**Arrows.** These arrows show the orientation of the coordinate x (forward, green), y (right, blue), and z (down, red) axes of the constellation.
	**AHRS bars.** Yellow AHRS bars that are below the threshold line indicate that the tracker is receiving inaccurate orientation data. If this occurs while mapping , it could be due to excess shaking or movement speed.
	The blue and almost completely filled AHRS bars indicate that the tracker is currently finding accurate data because you are translating the device over the fiducials at an appropriate rate.
	Wagon-wheel shaped image of a fiducial. Indicates the tracker needs to see more images of the fiducial. Spend more time with that fiducial in the tracker's field of view.
	The green pointer arrow on a wagon wheel representing the location of a fiducial. Shows the best direction to turn and face the tracker's camera on the fiducial to garner more information from it.
	Filled-in image of a fiducial. Indicates the mapper has all information required about the fiducial.
 	Halo around image of fiducial. Means the system is currently able to recognize the fiducial.

6.3.4 *Mapping*

Once sfStudio is connected to the tracker (Tracking State 1) and the Configuration Fields have been input, the mapping process can begin.

1. With the settings in **Configuration Area** filled out, click the **Start** button. The Tracking State will change to Lost (3) as tracking enters sfCore mode.
2. Two bars in the lower right corner of the dark **Constellation Area** appear.





   a. When these **AHRS** (Attitude and Heading Reference System) **Bars** first appear, the mapper is initializing the Kalman Filter, so for a moment the bars appear empty, before they respond to you moving the tracker.
   b. The AHRS Kalman Filter's purpose is to ensure accurate pitch and roll data from the device and use it to calculate fiducial orientation and position.
   c. The AHRS bars are initially yellow and not filled, but instead partially filled to below the top or below the threshold line near the top of the bars, as shown here.
   d. Both bars must be filled above the black lines to being mapping. To fill the bars, set the tracker against a still surface for a few seconds. Then rotate the tracker about 90° along any axis and make it still for another few seconds. Repeat this process along each axis until the bars both become blue.

3. Once the bars have become blue, face the tracker towards the constellation, starting near the origin fiducial. This movement will likely cause the bards to drop below the threshold again, so keep the InertiaCam still for a few more seconds to allow the bars to recover.

4. Translate the device over the fiducials at a distance that lets it view at least six fiducials at a time.
   a. If you hold the InertiaCam too close or too far away, it does not optically detect enough fiducials, and you might see a message in the **Instructions Area** indicating that fact.
   b.
   c. You often see instructions in the **Instructions Area** that provide guidelines on how to proceed, as shown in the next figure. (See General Tips for Mapping Technique and Fiducial Placement

It is very important to understand that the success of the mapping process entirely depends on technique and good fiducial placement. The following points should always be kept in mind during the mapping process. Note that these tips are during the data collection phase, after the tracker has been exercised and the AHRS levels are blue.
It is very important to understand that the success of the mapping process entirely depends on technique and good fiducial placement. The following points should always be kept in mind during the mapping process. Note that these tips are during the data collection phase, after the tracker has been exercised and the AHRS levels are blue.

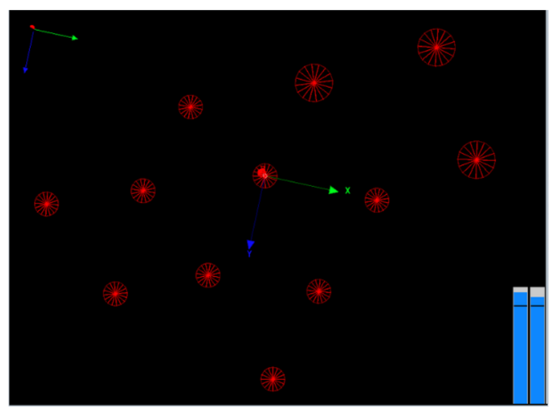
1. **Move slowly.** During mapping, the tracker relies much more heavily on IMU data than normal. Moving too quickly will increase the potential for gravity scatter errors, meaning that the tracker is unsure of the direction of gravity because data from the accelerometers may be inaccurate.
2. **Never move the constellation during the tracking process.** The constellation needs to be on a stable, immobile surface for mapping to succeed. This and fast movement are the primary causes for gravity scatter failures.
3. **Keep as many fiducials in the field of view as possible.** It is a common instinct to put the tracker closer to a fiducial to gather better data on it. However, in practice the more fiducials the system can see surrounding the fiducial, the better. In order to determine the location of a fiducial, the system needs compare it to the positions and angles of the other fiducials in the constellation.
4. **For very large constellations, focus on completing one region before moving on to the next.** The more data and the more accurate the data the system has on its surrounding fiducials, the more quickly it will determine information on any incomplete fiducials. Taking this approach will likely reduce the amount of time spent on mapping.

5. **View the fiducials from several angles.** In order to calculate where a fiducial is in space, the system needs to view the fiducial from several angles. It is sometimes helpful to imagine a dome over the constellation and to track along the curvature of it.
6. Try not move the tracker when there are not enough fiducials in the field of view. The only exception to this is to move it back to where there are enough fiducials in the field of view.
7. **If needed, place temporary fiducials in the mapping environment.** In many cases, users are unable to place permanent fiducials in a region because it may be movable, blocks vision, contains important text, etc. However, as long a surface can remain still during the mapping process and cannot be damaged by stickers or tape, temporary fiducials can be placed for mapping purposes and removed once mapping is complete. These temporary fiducials can also be removed later from the map file. **This is especially important for fiducials in corners, at odd angles, or that are isolated.** This technique also allows for bridging gaps between clusters of fiducials that do not have overlapping fields of view. Adding temporary fiducials, even of different sizes, around these problematic regions can allow a user to meet the requirements of the fifth tip.

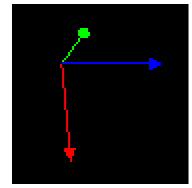
If all else fails, one thing to keep in mind is that not all constellations require the same quality metrics. The SVM software is distributed with a set of thresholds for precision that are designed to meet the needs of most constellations. However, an 8”x12” tracked area with 96 12mm fiducials is ultimately going to have much tighter precision requirements compared to a 7’x15’ tracked area with 96 127mm fiducials. If it is believed that the constellation is properly designed and the above tips do not make a difference, contact technical support to ask about changing the precision requirements for SVM.

   d. Interpreting Messages in the Instruction Area.)
   e. Whenever the **AHRS Bars** to the lower right turn yellow and fall below the threshold line, it means that you are moving the tracker too fast or that excess shaking is interfering with its ability to find and identify the fiducials. When this happens, keep the tracker still until the bars are near the threshold line and turn blue again. If the bars are continually slipping below the threshold, slow down the pace at which you are moving the tracker.

5. After about 1 minute, you see a map of the fiducials appear in the **Constellation Area**, as in the figure to the right.

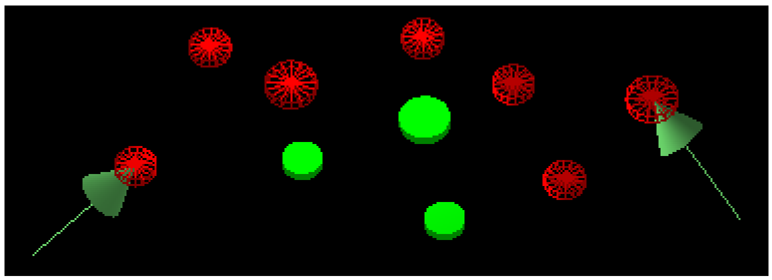


   a. Initially, fiducials appear like red wagon wheels. When fiducials represented by wheels appear, the system is still gathering data about those fiducials. Later, when the system has gathered enough data about a fiducial, it will turn green.
   b. A wide yellow halo forms around the rim of fiducials currently in the field of view.
   c. The X, Y, and Z reference frame arrows appear on the origin fiducial. The X axis will be in the direction of the forward fiducial and the Z axis will point towards gravity
   d. The Simple Visual Mapper automatically adjusts the scale and orientation of the map during the mapping process.



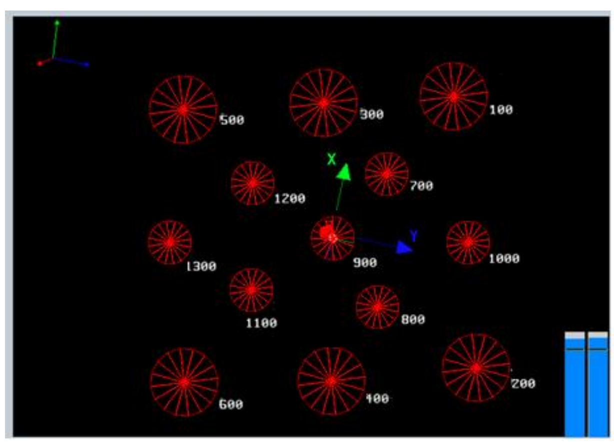
6. To view the constellation at a different angle, you can:
    a. Move the mouse while holding down the right mouse button to keep in the same orientation, but change its position.
    b. Zoom in and out using the mouse wheel.
    c. Move the mouse while holding down the left mouse button to rotate the constellation's orientation.
    d. The **Arrows** in the upper right corner show the direction of the x (green), y (blue), and z (red) axes of the constellation, to reflect the current orientation of the constellation display.

7. If you see large green pointer arrows (like those shown in the figure below) appear near a wheel for a particular fiducial, each pointer indicates that you should view the fiducial from that angle so it can gather more data on it. If you see no pointer arrows, but the wheel still appears like a wagon wheel, you need to let the InertiaCam examine the fiducial for longer.

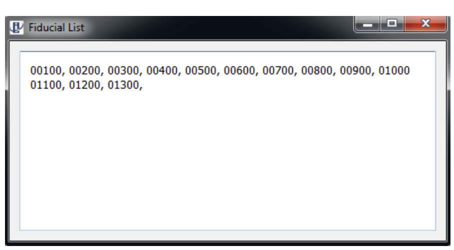


8. If you have trouble completing the mapping process, you might solve the problem by translating the InertiaCam across the environment more. However, if the constellation cannot be filled in, the instructions indicate it is not complete, or some fiducials do not show up, it is possible that one or more fiducials are damaged and you may need to replace them.

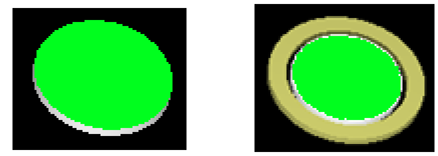
9. If you want to see the ID numbers of the fiducials in the map as shown below, go to the upper left corner of the window and click the **Simple Visual Mapper** menu. In this menu you can choose to toggle on or off **Show Hardware IDs**. When the option is on, the fiducial ID numbers display in the map.



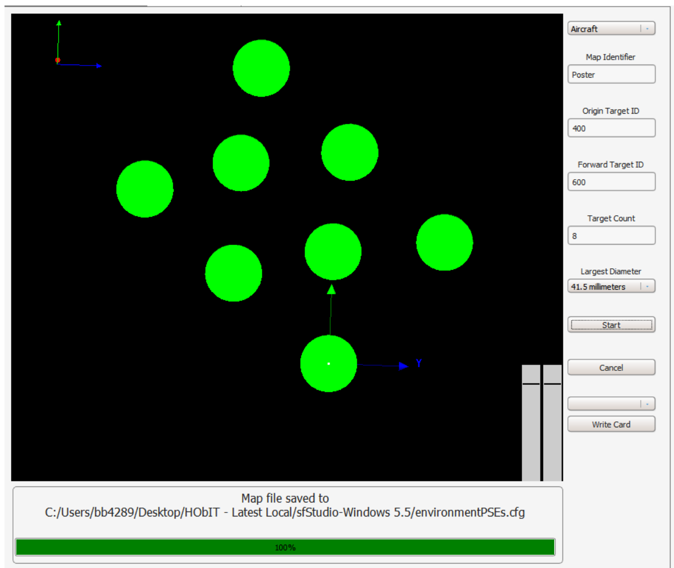
10. To retrieve a list all of the fiducial IDs from a particular map, you can open a list box containing them by going to the **Simple Visual Mapper** menu and choosing **Simple Visual Mapper → Get Fiducial List**.



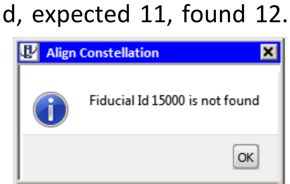
11. Continue translating across the fiducial area until the **Progress Bar** indicates the mapping is 100% complete.
    a. When the Simple Visual Mapper has all the information it requires to map the fiducial, it appears filled in, like the leftmost one shown here. When the mapper can optically detect the fiducial, you see a halo around that fiducial, like the rightmost one shown here.
    b. When the entire map is complete you see the progress bar completely filled in and a message in the **Instructions Area** indicating the map is complete.



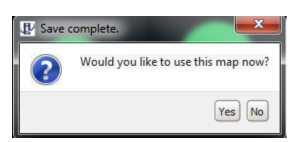
Tracker has collected sufficient information to map both of these fiducials. The halo around the right-most one indicates it is also visible to the mapper.



12. The preceding illustration shows a completed map.
    a. If the map does not complete, it could be because you entered a value in **Target Count** higher than the number of fiducials in the constellation. If you did, mapping does not complete, because the mapper continues to look for fiducials that do not exist.
    b. If you entered a **Target Count** in the **Configuration Area** that is lower than the number of fiducials the mapper is finding in the constellation, you receive a message reading, 'Unexpected fiducials found, expected 11, found 12. Please confirm your configuration and constellation match.'
    c. Even after the map is complete you can receive an error message if you entered an incorrect value in **Origin Target ID** or **Forward Target ID**. The mapper then displays a message saying that it did not find that fiducial ID.



13. Once complete, a prompt will appear asking if the map should be used now for tracking.
    a. If so (recommended), the constellation is automatically sent to the sfHub folder when using the IS-1500 or to the tracker when using legacy hardware.
    b. If not, the constellation will eventually need to be sent to sfHub using the Constellation Display, Low Level Access, or manually copied in order to be used for tracking.
    c. In either case, a copy of the map will be saved to a subdirectory where it can be accessed for future use.



6.3.5 General Tips for Mapping Technique and Fiducial Placement

It is very important to understand that the success of the mapping process entirely depends on technique and good fiducial placement. The following points should always be kept in mind during the mapping process. Note that these tips are during the data collection phase, after the tracker has been exercised and the AHRS levels are blue.
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8. **Move slowly.** During mapping, the tracker relies much more heavily on IMU data than normal. Moving too quickly will increase the potential for gravity scatter errors, meaning that the tracker is unsure of the direction of gravity because data from the accelerometers may be inaccurate.
9. **Never move the constellation during the tracking process.** The constellation needs to be on a stable, immobile surface for mapping to succeed. This and fast movement are the primary causes for gravity scatter failures.
10. **Keep as many fiducials in the field of view as possible.** It is a common instinct to put the tracker closer to a fiducial to gather better data on it. However, in practice the more fiducials the system can see surrounding the fiducial, the better. In order to determine the location of a fiducial, the system needs compare it to the positions and angles of the other fiducials in the constellation.
11. **For very large constellations, focus on completing one region before moving on to the next.** The more data and the more accurate the data the system has on its surrounding fiducials, the more quickly it will determine information on any incomplete fiducials. Taking this approach will likely reduce the amount of time spent on mapping.
12. **View the fiducials from several angles.** In order to calculate where a fiducial is in space, the system needs to view the fiducial from several angles. It is sometimes helpful to imagine a dome over the constellation and to track along the curvature of it.
13. Try not move the tracker when there are not enough fiducials in the field of view. The only exception to this is to move it back to where there are enough fiducials in the field of view.
14. **If needed, place temporary fiducials in the mapping environment.** In many cases, users are unable to place permanent fiducials in a region because it may be movable, blocks vision, contains important text, etc. However, as long a surface can remain still during the mapping process and cannot be damaged by stickers or tape, temporary fiducials can be placed for mapping purposes and removed once mapping is complete. These temporary fiducials can also be removed later from the map file. **This is especially important for fiducials in corners, at odd angles, or that are isolated.** This technique also allows for bridging gaps between clusters of fiducials that do not have overlapping fields of view. Adding temporary fiducials, even of different sizes, around these problematic regions can allow a user to meet the requirements of the fifth tip.

If all else fails, one thing to keep in mind is that not all constellations require the same quality metrics. The SVM software is distributed with a set of thresholds for precision that are designed to meet the needs of most constellations. However, an 8”x12” tracked area with 96 12mm fiducials is ultimately going to have much tighter precision requirements compared to a 7’x15’ tracked area with 96 127mm fiducials. If it is believed that the constellation is properly designed and the above tips do not make a difference, contact technical support to ask about changing the precision requirements for SVM.

6.3.6 Interpreting Messages in the Instruction Area

Messages in the **Instructions Area** guide you on how to proceed:

- Acquire images of fiducials.
    - Let the tracker spend more time viewing the fiducials to gather information.
- Acquire more images of unfilled fiducials.
    - Let the tracker spend more time viewing the fiducials that still look like wagon wheels—are not filled in.

- Allow tracker to acquire still time in different orientations until bars stabilize above indicator.
  - The AHRS bars are then partially filled to below the lower threshold (shown in yellow). Place the tracker on its side for several seconds, then turn the tracker on another side, waiting several seconds. Repeat until the AHRS bars fill.
- Fiducial ID #### is not found.
  - You entered an **Origin Target ID** or **Forward Target ID** in the **Configuration Area** that is not in the constellation. Correct that number and restart the mapping process.
- Gravity Scatter failure. Tracker movements are too fast or constellation moved while mapping.
  - The fiducials or the objects they are attached to might not be remaining stationary enough for the system to acquire accurate data. Take action to stabilize the environment and ensure fiducials and objects do not move during the mapping process.
  - This message can also appear if AHRS bars fall below the threshold several times during mapping.
- Mapping accuracy below recoverable threshold, recommend restarting.
  - An error has rendered the map unusable and you need to restart the mapping process. You might not have entered an accurate value for the largest fiducial diameter. If the underlying problem persists, the mapping process may automatically cancel.
- Mapping complete.
  - The progress bar has filled and the map file has been saved to the **sfStudio** directory or the designated SaveDirectory.
- Not enough visible fiducials.
  - You are holding the tracker too close to, too far away from, or at the wrong angle for it to optically detect the constellation. Ideally, the tracker should view at least six fiducials at a time to gather information.
- Precision failure. Tracker too far from targets. If persistent, check camera calibration.
  - You should be close enough to the fiducials that the tracker can view at least six of them. This message can appear if the camera lens is dirty, the fiducials are damaged, or the camera might be out of calibration. For details on recalibrating the camera, contact Technical Support.
- Remain still until bars become blue.
  - Allow the tracker to remain still until the AHRS recovers.
- Reprojection failure. Recommend restarting. If persistent, check intrinsic calibration.
  - The system is having trouble reflecting what it optically detects in the map. If the problem persists, to check the intrinsic calibration contact Technical Support.
- Slow Down. Remain still until bars become blue.
  - The AHRS bars appear in yellow and filled to below the threshold line to indicate that you are moving the tracker too quickly for it to gather information.
- Target diameter failure. Verify target diameters are accurate and largest diameter is set.
  - Be sure that the diameter of the largest fiducial is set to accurate value.
- Translate across constellation to fill in missing fiducials.
  - The system has not yet seen every fiducial. Translate the tracker across the constellation, specifically over fiducials that have not yet appeared in the map.
- Unexpected fiducials found, expected [TargetCount], found [TargetCount+#]. Please confirm your configuration and constellation match.
  - The number you entered for the **Target Count** in the **Configuration Area** does not match the number of fiducials the mapper has found in the constellation. Count the fiducials again, then enter the correct number and restart the mapping process.
- View fiducials from angles represented by green arrows.
  - Green pointer arrows appear on some fiducials that appear as wagon wheels. The system can gather more information if you face it in the direction that the green arrows point for each individual fiducial that it needs more information about.

6.3.7 Changing and Adding Presets in the SVM.ini File

For users that will frequently need to make similar environments, it may be beneficial to create presets that automatically populate the configuration fields. The Presets listed in the **SVM.ini** file (and explained in the table below) modify the content of the Preset dropdown menu at the top of the **Configuration Area**.

Presets	Settings
MapIdentifier	Name you want to assign the map. This will not affect the file name the map is saved as, which is always environmentPSEs.cfg.
TargetCount	Number of fiducials in the constellation.
OriginID	Fiducial ID of the origin fiducial.
ForwardID	Fiducial ID of the fiducial in the positive X direction of the origin (used for aligning the constellation).
LargestDiameter	Diameter in millimeters of the largest fiducial in the constellation.
RearTarget	If set to 1, reverses the direction of the X axis. Used when the forward fiducial is in the negative X direction instead of the positive X direction.

To modify the items shown in the **Preset** menu:

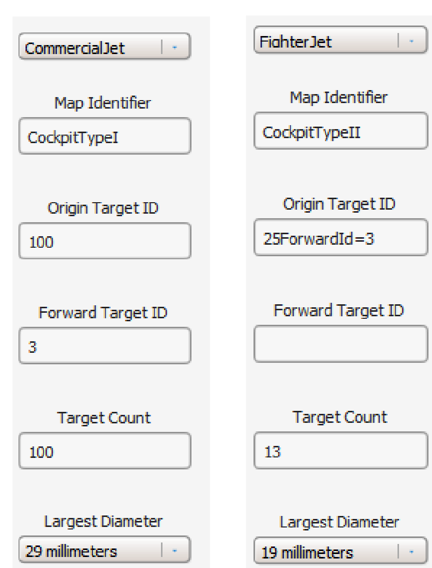
1. Find the **SVM.ini** file in the **sfStudio** subdirectory of the software installation folder and open it in a text editor.
2. The file contains several sections. Scroll to the bottom section with the title **Presets**. Within that section you find headings in square brackets that you can customize.
3. Create new presets in this section by using the following format:

```
[PresetName]
MapIdentifier=
TargetCount=
OriginId=
FowardId=
LargestDiameter=
RearTarget=
```

4. For instance, for two aircrafts, one commercial and one military, you could define two cockpit types:

```
[CommercialJet]
MapIdentifier=CockpitTypeI
TargetCount=10
OriginId=1
ForwardId=3
LargestDiameter=29

[FighterJet]
MapIdentifier=CockpitTypeII
TargetCount=13
OriginId=2
ForwardId=3
LargestDiameter=19
```

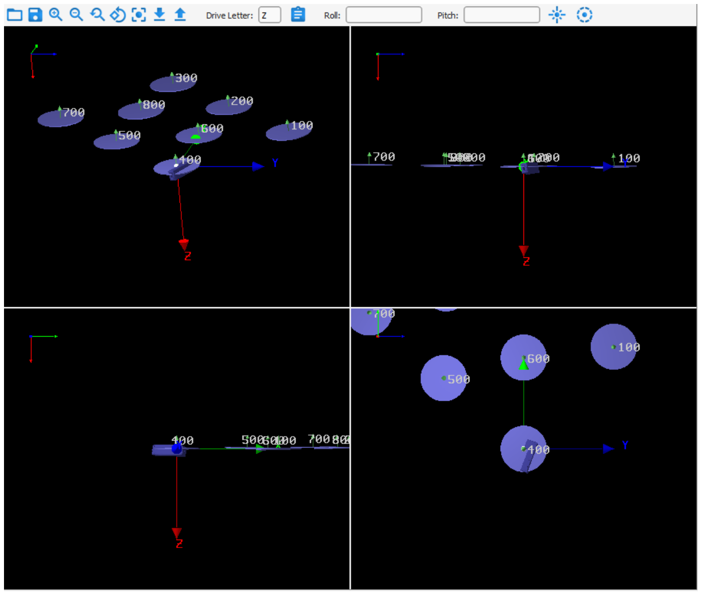


5. Each field left blank will appear blank when the preset is selected in SVM.
6. Save the changes in the **SVM.ini** file.
7. Restart sfStudio and open SVM to see the changes in the menu. The figures to the right how the data about each example preset defined here appears in SVM when you select that type from the **Preset dropdown** menu.

6.4 Editing Constellations

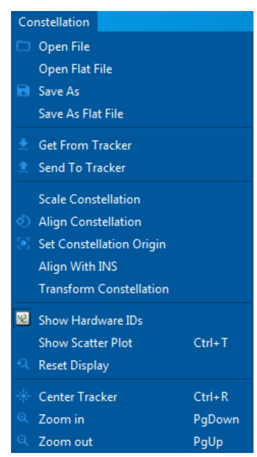
You can use the Constellation Display in sfStudio to generate a 3D view of the constellation, generated by map file the system is currently using. If the map file was created correctly using SVM, the constellation shown should reflect the physical placement of the fiducials. Additionally, the Constellation Display can be used to edit constellation files.

From the menu bar, select **Displays → Constellation Display**. After clicking the blue arrow (**Get from Tracker**) button or using the **Open File** option, the **Constellation Display** opens a dark constellation area divided into quadrants displaying the fiducial layout, as shown in the figure below.



6.4.1 Constellation Display Menu

The Constellation Display adds a dropdown menu at the top of the main window. Options from this menu are useful for opening and editing constellations.



- **Open File**: Opens a **File Open** window where you can navigate to the directory containing constellation files. Find the constellation file you want to open, by default named **environmentPSEs.cfg**, and click **Open**. The constellation appears in the **Constellation Display** area.

- **Open Flat File**: Opens a **File Open** window where you navigate to the directory containing flat file constellations (**.txt** files), select the flat file, and click **Open**. The constellation appears in the **Constellation Display** area. You use this option to open constellations from earlier Thales Visionix mapper products that are in this format. If an older constellation is not in the **.cfg** file format, you can open its flat file and then save it to the newer **.cfg** format using **Constellation → SaveAs.**

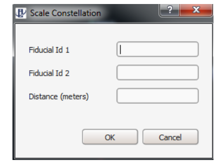
- **SaveAs**: Saves the constellation data into a PSE file with a **.cfg** extension (**environmentPSEs.cfg** is the default file name). You can later reload this file to view the constellation by using **Constellation → Open File**. If you have multiple constellations, be sure to make the file name unique. Later you can send this file to the tracker.

- **Save As Flat File**: Saves the constellation data in a flat file (**.txt**). To ensure you save the constellation, you should always use the **Save As** option, rather than flat file format. The flat file option exists only for compatibility with legacy Thales Visionix products.

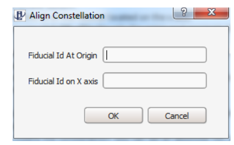
- **Get from Tracker**: Retrieves the constellation from the tracker and displays it in the Constellation window. See the illustration to the right of how the data displays in the orthographic view (upper left quadrant) and in a view of each axis (other three quadrants). In the orthographic view, the green arrows on each fiducial are normal (perpendicular) vectors. To store the file on your computer, you need to use **Constellation → SaveAs**.

- **Send to Tracker**: Use this option after you load a constellation into the **Constellation Display** using **Constellation □ Open File**. The **Send to Tracker** option sends the constellation file to the tracker. Once the map file is sent to the tracker, the system will be able to track off of the corresponding constellation.

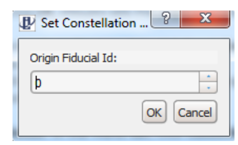
- **Scale Constellation**: In the menu bar, click **Constellation → Scale Constellation**. The **Scale Constellation** popup window appears.
    - Enter the IDs of two fiducials and the distance in meters between them.
    - After you click **OK**, sfStudio realigns not only those two fiducials, but all other fiducials in the constellation accordingly.



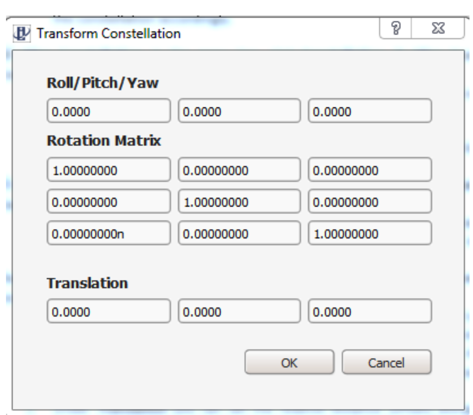
- **Align Constellation**: In the menu bar, click **Constellation → Align Constellation**. The **Align Constellation** popup window appears.
    - Enter the ID of the fiducial whose center is located at the desired 0,0,0 point in the coordinate system.
    - Enter the ID of the fiducial located on the x axis.
    - After you click **OK**, sfStudio sets the origin and reorients the constellation to align with the x axis.



- **Set Constellation Origin**: In the menu bar, click **Constellation → Set Constellation Origin**. The **Set Constellation Origin** popup window appears.
    - Enter the ID of the fiducial whose center is the origin of the coordinate system (0,0,0). This does not change the x axis, but sets only the origin.



- **Transform Constellation**: In the menu bar, click **Constellation → Transform Constellation**. The **Transform Constellation** popup window appears.
    - To modify the constellation, you can set an absolute roll, pitch, and yaw in the first row, if you know those values.
    - To apply a rotation matrix, use the three rows below roll, pitch, and yaw. The values are the amount of clockwise rotation of the x, y, and z axes, in that order, that you want. If you do not know the values for the rotation matrix, after you enter the **Roll/Pitch/Yaw** values and click **OK**, sfStudio populates the rotation matrix for you. To enter a cosine or sine value, calculate it and enter the number.
    - Under **Translation** you can set the relative distance (offset) along x, y, and z axes that you want to move the constellation to change its location. When you click **OK**, the dialog box closes and sfStudio applies the changes to the constellation.
    - To save the changed constellation, select **Constellation → Save As** and enter a PSE file name with a **.cfg** extension.



- **Show Hardware IDs**: Toggles on or off the option to show fiducial IDs in the constellation display. When the option is on, you see a check mark next to the menu option.

- **Reset Display**: Returns to the pre-zoom isometric view of the constellation and to the original x, y, and z axes.

- **Center Tracker (Ctrl+R)**: Places the tracker in the center of the constellation graphic.

- **Zoom In (Page Down)**: Makes the view progressively more of a close-up of the constellation each time you select it. Choose multiple times to move your view closer in increments. Also use the Page Down key to select this option.

- **Zoom Out (Page Up)**: Expands how much of the total constellation you can see by displaying it as if you were backing away from it. Choose multiple times to see the display progressively less zoomed in on (less close up). Also use the Page Up key to take this action.

6.4.2 *Constellation Display Toolbar*

The Constellation Display also has a toolbar, shown above, to quickly access commonly used features:

- The initial nine icons in the Constellation Display Bar correspond to the menu entries of the **Constellation** menu.

- Drive Letter: Z **Disk Drive Letter**: Use to save the map of the constellation to any type of external storage device, such as a compact flash (CF) card.
  - Select the drive the device is attached to from this drop-down list.
  - Then click the **Write Card** button to save the map to the device. The drives you see in the drop-down list include all drives on the computer that sfStudio finds have devices attached. If you attach a storage device or card to the computer after sfStudio is running, the software automatically adds it to the drop-down list.

- Roll: Pitch: **Roll and Pitch Fields**: These fields are equivalent to the **Roll** and **Pitch** fields in the **Transform Constellation** window.

- **Harmonize Yaw**: Clicking this icon is equivalent to automatically setting the **Yaw** values in the **Transform Constellation** window. This icon harmonizes (aligns) the yaw of the constellation using data the InertiaCam sensor gathers. When the harmonization is complete, the software displays the **Transform Constellation** window populated with the InertiaCam sensor data. You do not change the data; it is display only. When you click **OK**, you confirm acceptance of the data and close the window.

- **Harmonize All**: Harmonizes (aligns) the constellation using all the settings you enter for **Roll**, **Pitch**, and **Yaw** in the **Transform Constellation** window and/or any yaw harmonization data from using the icon button. You see the constellation change in keeping with the new alignment information. You might use this icon button, for example, when you map an aircraft that is sitting on the ground. Odds are that the aircraft will be pitched forward a few degrees, a condition that will not exist when the aircraft is in flight. If you harmonize the constellation you created from the grounded aircraft, that action compensates for the aircraft's position during mapping to prevent the constellation from being pitched forward.