

InertiaCube2+™



Product Manual for use with InertiaCube2+ Serial and USB Interfaces

© 2012 InterSense, LLC / A Division of Gentex Corporation
700 Technology Park Drive, Suite 102
Billerica, MA 01821
Phone +1 781.541.6330 • Fax +1 781.541.6329
www.intersense.com



User Manual for InertiaCube2+ DLL Version 4.0 and higher

Contacting InterSense

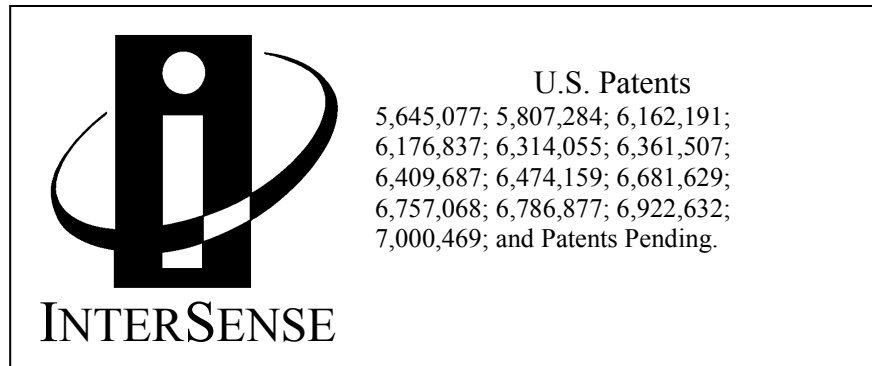
Please do not hesitate to contact us for any reason. We are here to help and we value your business.

InterSense, LLC / A Division of Gentex Corporation
700 Technology Park Drive, Suite 102
Billerica, MA 01821
USA

Telephone:	(781) 541-6330	email:	ISinfo@intersense.com
Fax:	(781) 541-6329	Internet:	www.intersense.com
Technical Support:	(781) 541-7624	email:	techsupport@intersense.com

Patents

The label below identifies the protection granted by the Government of the United States to InterSense for its products:



Trademarks

InterSense™, InertiaCube™, InertiaCube2+™, SoniDisc™, GEOS™, PULSAR™, CONSTELLATION™ are trademarks of InterSense, LLC. All other trademarks are the property of their respective owners.

Copyright © 2012

InterSense, LLC / A Division of Gentex Corporation

Regulatory Statements and Approvals

Precautionary Statements



Any changes or modifications to the InertiaCube2+ not expressly approved by InterSense, LLC or Gentex Corporation will void the warranty and any regulatory compliance issued for the system.



Do not drop or otherwise shock the tracking devices for they can be permanently damaged.



Do not bend, twist, pull strongly or tamper in any way with any part of the cabling.



Take care to avoid electric shocks. Do not plug-in or unplug the power cable with wet hands.



Please see Appendix C for Health and Safety warnings and guidelines

Regulatory Statements and Approvals

FCC Compliance Statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Warning

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Note: this equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Important: Changes or modifications to this product not authorized by InterSense, Inc. could void the EMC compliance and negate your authority to operate the product. This product was tested for EMC compliance under conditions that included the use of InterSense peripheral devices and InterSense cables and connectors between system components. It is important that you use InterSense peripheral devices, cables, and connectors between system components to reduce the possibility of causing interference to radios, TV sets, and other electronic devices. You can obtain InterSense peripheral devices, cables, and connectors from InterSense or through an InterSense Authorized Reseller.

*Responsible party (contact for FCC matters):
InterSense, LLC / A Division of Gentex Corporation
700 Technology Park Drive, Suite 102
Billerica, MA 01821*

Industry Canada Statement

This Class A digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

European Community

Complies with EN 55024:1998/A1:2001/A2:2003; EN 61000-3-2:2001;
EN 61000-3-3:1995/A1:2001 Class A ITE emissions requirements



TABLE OF CONTENTS

1	THEORY OF OPERATIONS	7
1.1	INERTIACUBE2+™ INTEGRATED INERTIAL INSTRUMENT	7
1.2	3-DOF GYROSCOPIC EARTH-STABILIZED ORIENTATION SENSING (GEOS™) ALGORITHMS	8
2	SPECIFICATIONS AND PERFORMANCE CHARACTERISTICS	10
2.1	PERFORMANCE SPECIFICATIONS	10
2.2	CONNECTION SCHEME	11
2.3	COMPATIBILITY	11
2.4	INERTIACUBE2+ COMPONENTS	12
2.5	UNPACKING THE INERTIACUBE2+ SENSOR	13
2.6	SOFTWARE	13
2.7	SETTING UP THE HARDWARE	15
2.7.1	<i>InertiaCube2+ placement</i>	15
2.7.2	<i>Computer/Power Connection</i>	16
2.7.3	<i>USB Connection to the InertiaCube2+</i>	16
3	ISDEMO: TESTING THE INERTIACUBE2+	18
3.1	USING ISDEMO	18
3.2	ISDEMO: MAIN WINDOW	19
3.3	FILE OPTIONS	20
3.4	COMMUNICATIONS OPTIONS	22
3.5	PARAMETER OPTIONS	23
3.6	DISPLAY OPTIONS	26
3.7	TOOLS OPTIONS	27
3.8	COMPASS CALIBRATION TOOL	30
3.9	MAGNETIC ENVIRONMENT CALIBRATION TOOL	34
3.9.1	<i>Theory of Operation</i>	34
3.9.2	<i>Algorithm</i>	35
3.9.3	<i>Starting Calibration Procedure</i>	35
3.9.4	<i>Calibration Procedure</i>	36
3.9.5	<i>Calibration Results</i>	37
3.9.6	<i>Testing and Tuning</i>	38
4	DEVELOPER'S INSTRUCTIONS	39
4.1	SAMPLE PROGRAM	39
5	APPENDIX A – FREQUENTLY ASKED QUESTIONS	40
6	APPENDIX B – USB DRIVER INSTALLATION	41
6.1	INTERSENSE USB ADAPTER INSTALLATION ON WINDOWS VISTA, XP, AND 2000	41
6.1.1	<i>Install InterSense Support Software</i>	41
6.1.2	<i>Installing USB Driver</i>	41

	<i>6.1.3 Changing COM Port Number</i>	48
7	APPENDIX C – TROUBLESHOOTING	49
8	APPENDIX D – HEALTH AND SAFETY WARNINGS AND GUIDELINES	50
9	APPENDIX E – CARE AND MAINTENANCE	52

1 Theory of Operations

Congratulations for buying the finest orientation tracker on the market! This technology offers you several advantages:

- Very low latency
- Unlimited range
- Smooth, jitter-free tracking

The InertiaCube2+ is an inertial 3-DOF (Degree of Freedom) orientation tracking system. It obtains its motion sensing using a miniature solid-state inertial measurement unit, which senses angular rate of rotation, gravity and earth magnetic field along three perpendicular axes. The angular rates are integrated to obtain the orientation (yaw, pitch, and roll) of the sensor. Gravitometer and compass measurements are used to prevent the accumulation of gyroscopic drift.

1.1 *InertiaCube2+™ integrated inertial instrument*

The InertiaCube2+ is a monolithic part based on micro-electro-mechanical systems (MEMS) technology involving no spinning wheels that might generate noise, inertial forces and mechanical failures. The InertiaCube simultaneously measures 9 physical properties, namely angular rates, linear accelerations, and magnetic field components along all 3 axes. Micro-miniature vibrating elements are employed to measure all the angular rate components and linear accelerations, with integral electronics and solid-state magnetometers. The magnetometers are included for optional yaw drift correction in the sourceless inertial orientation mode only. The geometry and composition of these elements are proprietary, but the functional performance of the multisensor unit can be understood sufficiently by reference to the equivalent diagram in Figure 1.

Figure 2 illustrates the basic physical principal underlying all Coriolis vibratory gyros. Suppose that the tines of the tuning fork are driven by an electrostatic, electromagnetic or piezoelectric drive to oscillate in the plane of the fork. When the whole fork is rotated about its axis, the tines will experience a Coriolis force $\underline{F} = \underline{\omega} \times \underline{v}$ pushing them to vibrate perpendicular to the plane of the fork. The amplitude of this out-of-plane vibration is proportional to the input angular rate, and is sensed by capacitive, inductive, or piezoelectric means to measure the angular rate.

By way of comparison, a conventional inertial measurement unit (IMU) senses 6 of these properties using 6 separate instruments (3 rate gyros and 3 linear accelerometers) each of which by itself would typically be larger, heavier, and more expensive than an InertiaCube. Unlike conventional rate gyro and accelerometer instruments, which must be carefully aligned on a precision machined tri-axial mounting block, the InertiaCube is a monolithic device with its orthogonal outputs factory calibrated to precise alignment. Being a digital device using serial cables, the InertiaCube2+ cabling and connectorization is relatively non-critical, and the cables can be extended to over 100 feet without fear of contaminating sensitive analog signals. The power consumption of the InertiaCube2+ is 100 mA at 6VDC, which makes it suitable for prolonged operation from small battery in future wireless applications. Figure 3 shows an InertiaCube2+.

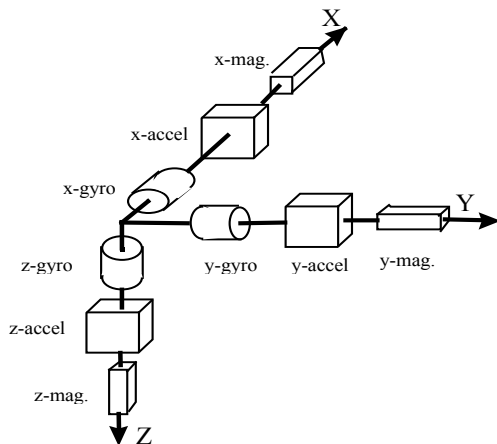


Figure 1: Functional diagram of InertiaCube2+

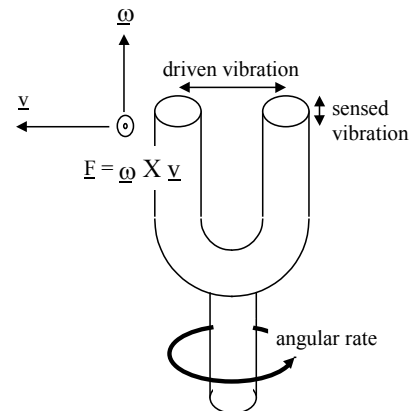


Figure 2: Principle of Coriolis vibratory Gyroscope



Figure 3: InertiaCube2+

1.2 3-DOF Gyroscopic Earth-stabilized Orientation Sensing (GEOS™) algorithms

Figure 4 shows the processing which is used to compute orientation using this sensor configuration. The basic computation of orientation from gyroscopic angular rates (in the top line of boxes) provides the very rapid dynamic response and high resolution of the system. The accelerometers and magnetometers are used to stabilize the orientation to the earth's gravitational and magnetic fields, thus eliminating the gradual but unbounded accumulation of gyroscopic drift errors. The Kalman filter uses an ever-evolving adaptive algorithm to discard the portion of the accelerometer measurements, which are due to actual motion instead of gravity. This is a very important step, because otherwise horizontal accelerations would result in very large transient pitch and roll errors known as “slosh”. The low cost sourceless trackers used in early consumer HMDs are inclinometer/compass devices, and are thus intrinsically slosh-prone to the point of being uncomfortable to use.

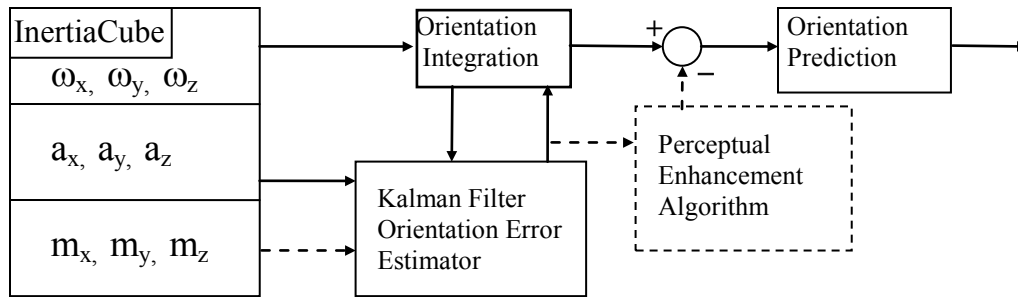
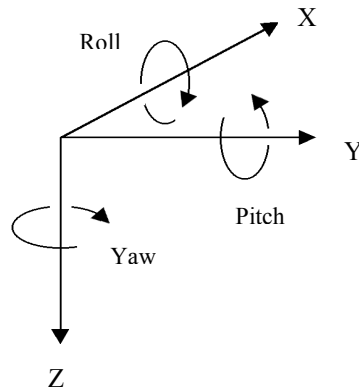


Figure 4:

GEOS mode tracking algorithm

In the default operating GEOS mode, the reference frame (hereafter referred to as Navigation frame or Nav frame or N frame) is the locally-level geographic frame with its x-axis pointing north, y-axis east, and z-axis down. The Euler angles reported by the tracker can be described as a sequence of rotations applied to the InertiaCube starting with its body axes initially aligned with the Nav frame axes and resulting in the current orientation. The sequence starts with a rotation by (+yaw) about the Z axis, followed by a rotation by (+pitch) about the new Y axis (i.e. body frame axis), followed by a rotation by (+roll) about the new X axis (i.e. body frame x axis)



The line from the magnetic field sensor outputs of the InertiaCube to the Kalman filter is a dotted line to indicate that the use of the magnetometers may optionally be disabled. The accelerometer measurements are sufficient to correct all the drift in pitch and roll, and the geomagnetic compassing function is only used to correct drift in yaw. In many fly-through applications absolute yaw referenced to magnetic north is not important and relative yaw tracking is sufficient. This is the case when the user can turn to face an object or rotate the virtual world to bring that object into view. In these situations it may be desirable to turn magnetic yaw compensation off if there are large variations in the direction of magnetic north over the tracking area. With the compassing turned off, the yaw value will drift a few degrees per minute. This drift is too slow to notice while it is happening, but the cumulative yaw error may eventually become noticeable if the user is seated in a fixed chair, and then it may be necessary to apply a Heading Boresight. When yaw compensation mode is disabled, the Nav frame axes are aligned instead to pseudo-north, pseudo-east, and down, where pseudo-north is simply the direction the InertiaCube2+ x-axis was facing on power-up or after application of a Heading Boresight command.

2 Specifications and Performance Characteristics

2.1 Performance Specifications

Degrees of Freedom:	3 (Yaw, Pitch, and Roll)
Angular Range:	Full 360° - All Axes
Maximum Angular Rate*:	1200° per second
Minimum Angular Rate*:	0° per second
Accuracy (RMS)*:	1° in yaw, 0.40° in pitch & roll at 25° C
Angular Resolution*:	0.01° RMS
Update Rate:	180 Hz
Minimum Latency:	2 ms for RS-232 (PC host OS dependent)
Prediction:	up to 50 milliseconds
Serial Rate:	115.2 kbaud
Interface:	RS-232 Serial USB (with Serial to USB converter)
Size:	36.6 mm x 27.7 mm x 18.8 mm 1.44 in x 1.09 in x 0.74 in
Weight:	17 grams (0.60 ounces)
Cable:	4.572 m (15 ft.) cable is provided. This cable is extendable to 22.86 m (75 ft.) w/ InterSense provided extension kits.
Power:	6 VDC via AC to DC adapter (included - specify country). InterSense USB to serial converter does not require AC to DC power adapter.
Power Consumption:	40 milliamps
O/S Compatibility:	.dll for Windows Vista/XP/2000 .so for Linux & SGI IRIX
Software Support	SDK with full InterSense API Windows control & connectivity software

2.2 Connection Scheme

The InertiaCube2+ simply plugs into the RS-232 or USB port of a computer. For RS-232 interfacing, the AC to DC power adapter is plugged into your main power and the 6 VDC power plug connects to the RS-232 serial port connector.

For USB interfacing, the InterSense USB to RS-232 serial converter is plugged into the USB port on the host computer. The InterSense USB to RS-232 serial converter will up convert the 5 VDC power from the USB port to a regulated 6 VDC power required by the InertiaCube2+. Other third-party USB to RS-232 serial converters may work with the InertiaCube2+, but typically require an external power source or main power adaptor.

Please refer to Appendix B or the InterSense Support CD for detailed instructions on installing and the configuration of the USB drivers for the InertiaCube2+.

2.3 Compatibility

The InterSense InertiaCube2+ is PC compatible with Windows Vista, XP, and 2000. Third party software using the standard InterSense .dll (isense.dll) is also supported. Please check with third party software providers or InterSense (techsupport@intersense.com) about specific software compatibility and support.

InterSense also provides support for Linux, SGI IRIX operating systems with a shared object library (.so) file included on the InterSense product CD.

Setting up your new InertiaCube2+

2.4 InertiaCube2+ Components



Standard InertiaCube2+ Components (power supply not shown)



Optional USB to RS232 Converter

2.5 Unpacking the InertiaCube2+ Sensor

The InertiaCube orientation sensors come with 15-foot cables that plug into the RS-232 serial port of a computer.

NOTE: The InertiaCube sensor is a precision instrument. Care must be taken when handling this device. Most of our customers attach the InertiaCube to devices that are more fragile than the InertiaCube and, hence, require that the whole system must be handled carefully. Although the product can withstand the normal wear and tear experienced by a premium HMD or other device, abrupt actions such as dropping it, or banging it against another object can permanently damage the InertiaCube.



InertiaCube2+ in packaging

2.6 Software

Test software and the InterSense Software Development Kit (SDK) delivered with the InertiaCube2+ are provided on the InterSense Support CD with the system. Use the auto install tool to extract and install the software.



The following software and drivers are installed from the InterSense Support CD:

1. In the core of all InterSense software is isense.dll which is installed in the Windows system directory.
2. Isdemo32.exe is installed in the InterSense\Programs folder. It provides a convenient graphical interface for testing and configuring the tracker.
3. InterSense Server Application (IServer.exe) provides multiple services to applications requiring tracker data. IServer runs in the system tray, reading the data from the connected devices at the maximum speed allowed by the operating system. That data is then made available to other applications that use the InterSense DLL to communicate with the tracker. This allows multiple applications running at the same time to read data from the same tracking device.
4. Joystick Emulation Drivers that can present any InterSense tracker as a joystick to the operating system. That means that games, like the Microsoft Flight Simulator, can use the tracker to control the line of sight. IServer reads tracker data in real time and passes it to the InterSense Joystick Driver, where it becomes available to all applications capable of reading joystick through DirectInput Interface.
5. JMouse program that allows any joystick device to control the "line of sight" in 3D applications, such as games, flight simulators, etc. It works by converting joystick movement to simulated mouse commands. JMouse uses DirectInput to detect and read data from joystick devices, so it requires DirectX version 8.0 or higher. To work with InterSense tracking devices, JMouse requires InterSense Joystick drivers and IServer.
6. InterSense SDK sample programs and instructions. The SDK folder contains InterSense libraries for WindowsCE (PocketPC), Linux and IRIX. Sample code is provided to demonstrate the SDK use in Microsoft Visual C++, Visual Basic, WindowsCE, Linux and IRIX applications.

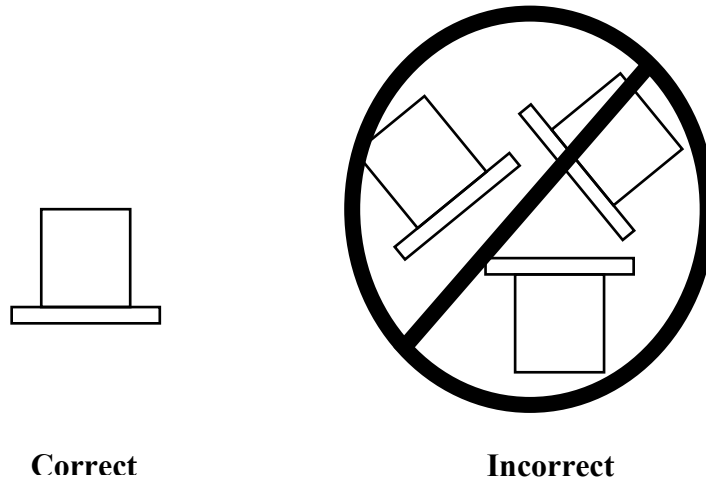
Please see the documentation on the InterSense Support CD for details.

Please refer to Appendix B or the InterSense Support CD for detailed instructions on installing and the configuration of the USB drivers for the InertiaCube2+.

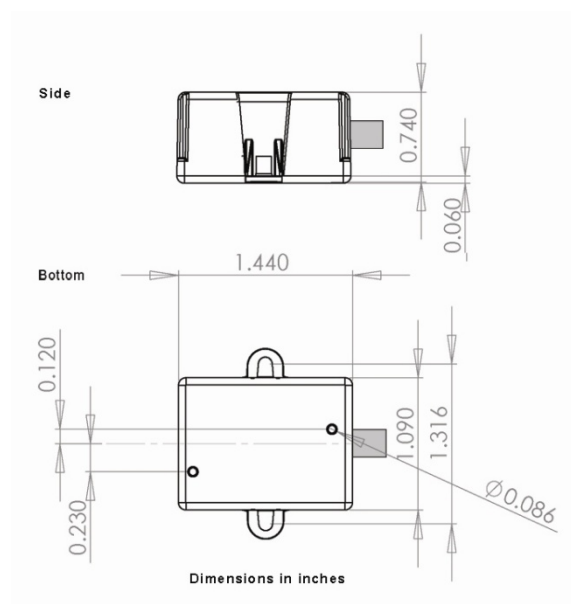
2.7 Setting up the Hardware

2.7.1 InertiaCube2+ placement

The InertiaCube is typically screwed or bolted to the object it is tracking (use of plastic or aluminum screws is recommended). As best as possible, locate the InertiaCube level to the ground in relation to its actual position during use:



Optimally, you would mount the InertiaCube2+ onto a base plate. In cases of anticipated vibration or physical shock, it is recommended that rubber-mounting pads be used. The mounting holes for the InertiaCube2+ are illustrated below. Diameter of each hole is 0.120 inches.

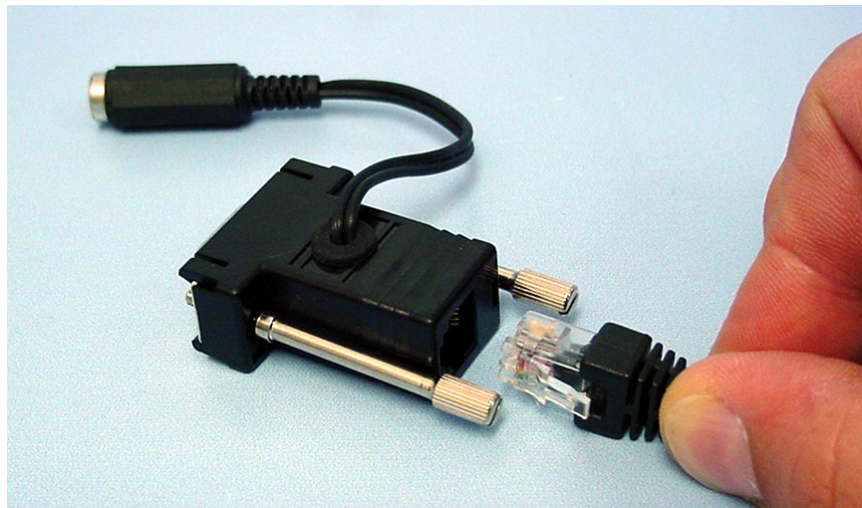


InertiaCube2+ Mechanical Drawing

The InertiaCube2+ comes with a 4.572 m (15') cable attached as standard. This cable plugs into the serial port connector. Extension cables are available. Contact InterSense to order extension cables.

2.7.2 Computer/Power Connection

The InertiaCube2+ is removed from packaging and plugged into the serial port connector as shown below.



Connection of InertiaCube2+ RJ12 cable to RS-232 serial port connector

Next the AC to DC power converter is connected to wall power and the 6 VDC power jack is plugged into the serial port connector jack.

Finally, the serial port connector is connected to your computer. Up to four (4) InertiaCubes can be connected to the PC using COM ports 1 thru 4.

2.7.3 USB Connection to the InertiaCube2+

The InertiaCube2+ can interface through the USB port of any computer running an operating system supported by InterSense. When connecting through USB Hubs, which in turn are connected to the host computer, latency will increase by approximately 5 to 8 ms. Latency through the USB interface is also dependent on the operating system used with the computer. Please contact our technical support (techsupport@isense.com) for questions related to USB latency and operating systems.

For optimum USB performance with the InertiaCube2+, we recommend use of the optional InterSense USB to RS-232 Serial Converter. To use, simply plug the RJ12 connector from the InertiaCube2+ cable into the USB to RS-232 Converter and then plug the USB connector into the host computer.



Connection of InertiaCube2+ cable to InterSense USB/Serial Converter

Please refer to Appendix B or the Product CD for detailed instructions on installing and the configuration of the USB drivers for the InertiaCube2+.

Tracker Use Guidelines

- Keep the InertiaCube(s) still for the first 10 seconds after starting your application software.
- It is recommended, though not required, that you wait for the InertiaCube to warm up (it achieves optimal performance after warming up for at least 15-20 minutes).
- The InertiaCube is tuned for normal head motion. Avoid shaking/vibration. Remember, this precision instrument uses angular rate sensors, which sense smooth, regular movement very well.

If you keep these guidelines in mind, your InertiaCube2+ will deliver superb performance.

3 ISDEMO: Testing the InertiaCube2+

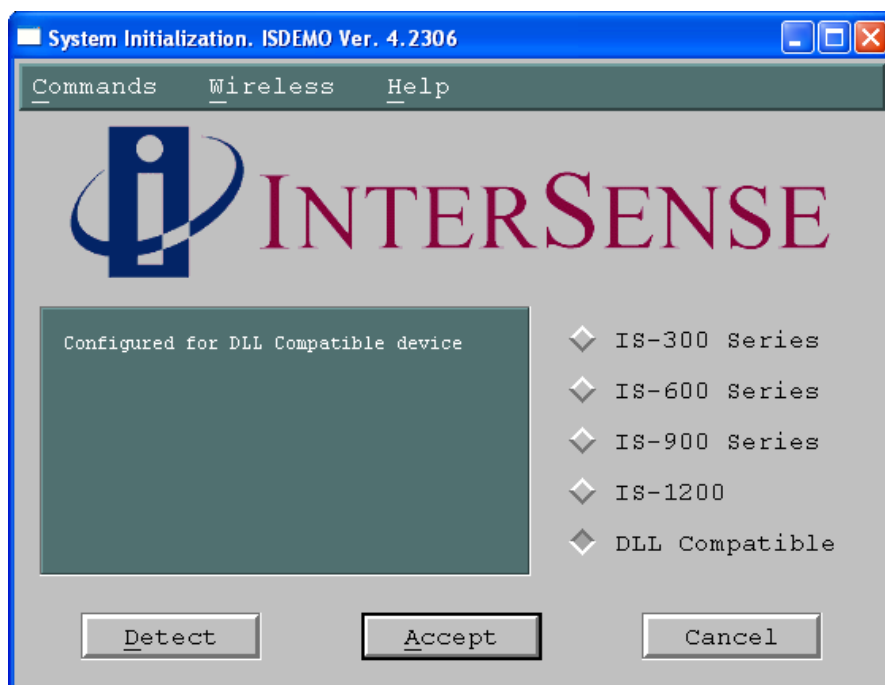
ISDEMO is included as a test and diagnostics tool. With it you can test all the features of your tracker. At the time of this publication, the latest release of ISDEMO is version 4.2306, though the documentation below for version 4.2306 below is valid for later releases. Please check with www.intersense.com/support to keep your version of ISDEMO up to date.

ISDEMO provides a convenient graphical interface to validate the communication of the InertiaCube2+ to the PC and test performance through the standard InterSense DLL. See Section 4, Developers Instructions, to learn how to interface the InertiaCube2+ to software applications.

3.1 Using ISDEMO

The first screen you'll see is the hardware selection window (shown below). The program creates a different interface depending on the tracker model selected. Select the *DLL Compatible* option and click *ACCEPT*.

Note: You must select DLL Compatible, or ISDEMO will not be able to correctly configure your tracker.



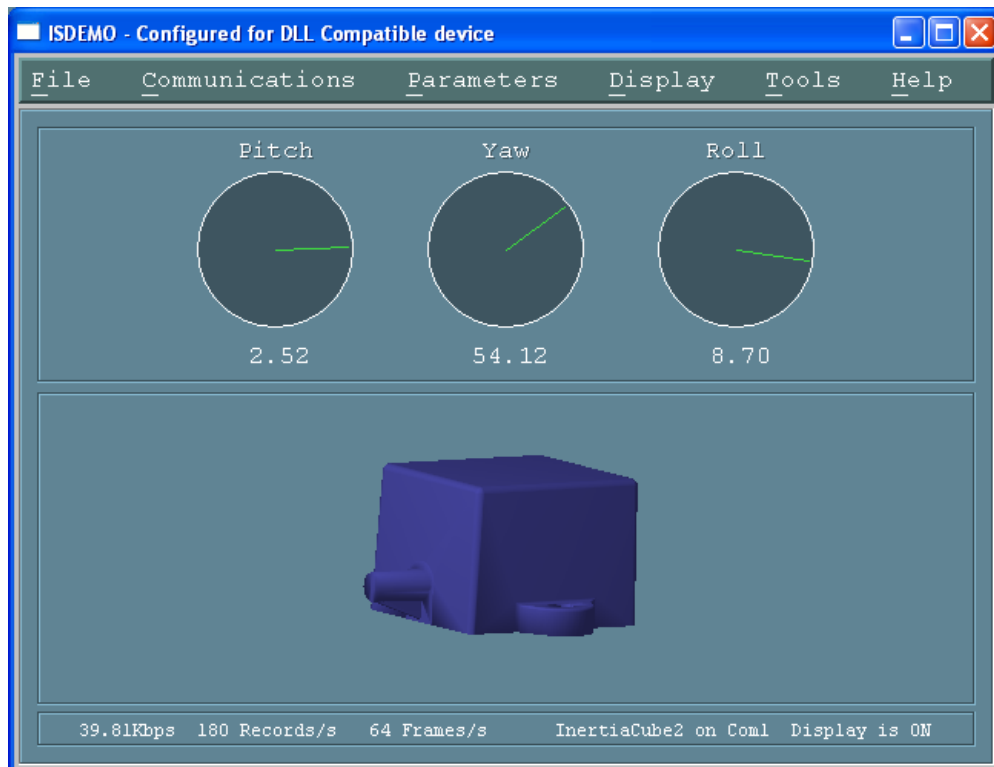
DLL Compatible

DLL compatible trackers include all of InterSense's tracking systems that use software applications programmed to the InterSense API which call functions through the InterSense DLL. Some InterSense trackers, like the InertiaCube2+, are only DLL compatible. The InterSense precision line of trackers (IS-900, IS-1200) can interface either directly through a serial port or via the DLL.

3.2 ISDEMO: Main window

ISDEMO has six primary menus in its main window:

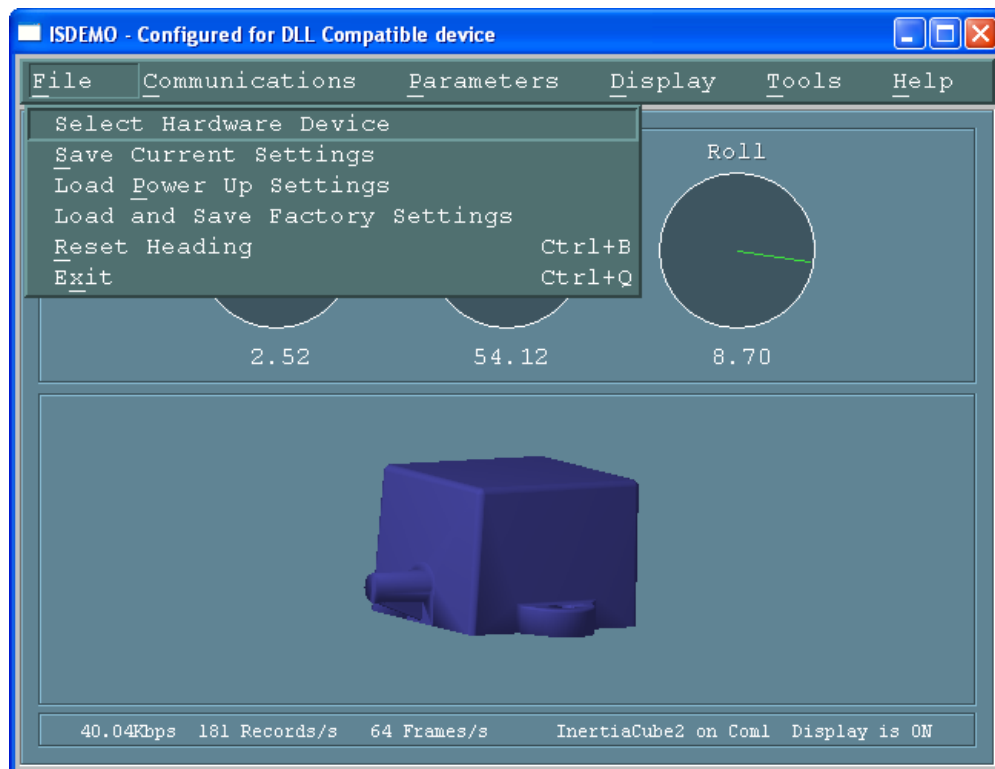
- File
- Communications
- Parameters
- Display
- Tools
- Help



3.3 File options

The *File* menu provides you with the following options:

Select Hardware Device
 Save Current Settings
 Load Power Up Settings
 Load and Save Factory Settings
 Reset Heading (Ctrl+B)
 Exit (Ctrl+Q)



Select Hardware Device

System Initialization window (also seen at initial start-up) is shown when *Select Hardware Device* is selected. Use this window to select or detect the tracker model connected to your computer.

Save Current Settings

Saves current settings to a file in the windows directory. The next time the tracker is turned on these settings will be restored.

Load Power Up Settings

Restores the InertiaCube settings to those present when you first powered up the tracker. All changes made to the settings since power up are lost.

Load and Save Factory Settings

This restores the system settings to the factory defaults.

Reset Heading

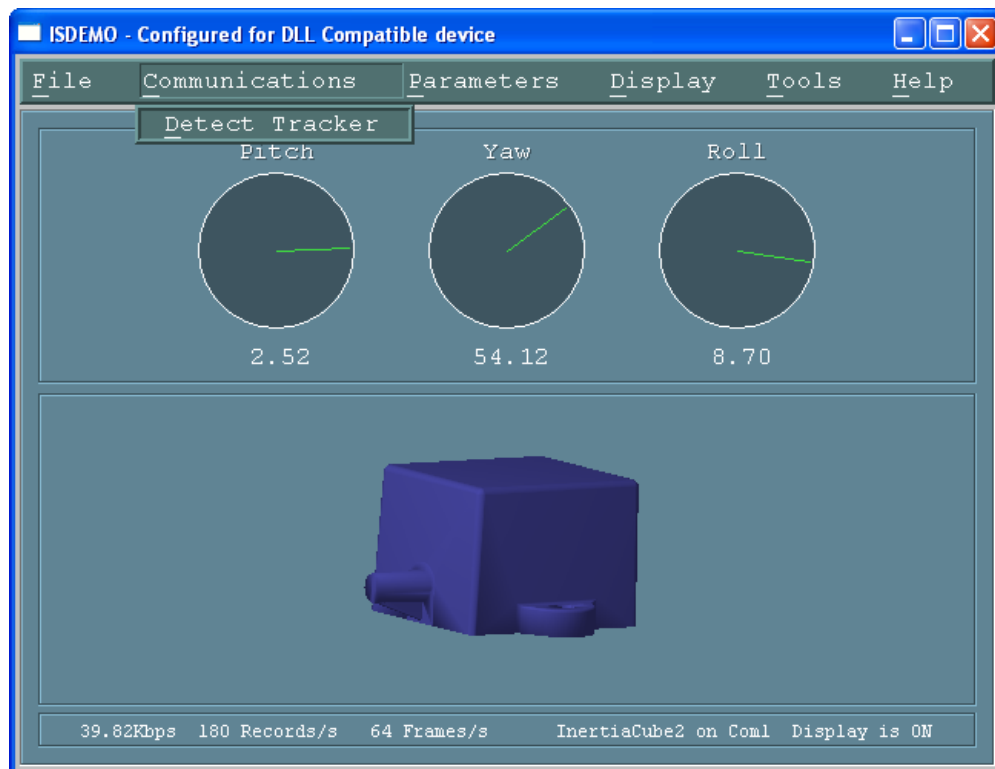
Resets the current heading to zero. Also known as a heading boresight.

Exit

Exits ISDEMO

3.4 Communications options

This menu item will connect the tracker through the DLL. The DLL will automatically detect an InterSense tracker connect to COM ports 1 through 4 on the PC. The baud rate of the InertiaCube2+ is fixed at 115,200 baud. Make sure the computers serial port is capable of supporting this baud rate. The first two rates (kbps and records/s) displayed at the bottom of the window show the InertiaCube2+ update rates. The third rate (frames/s) shows the graphics update rate based on the PC's hardware configuration.

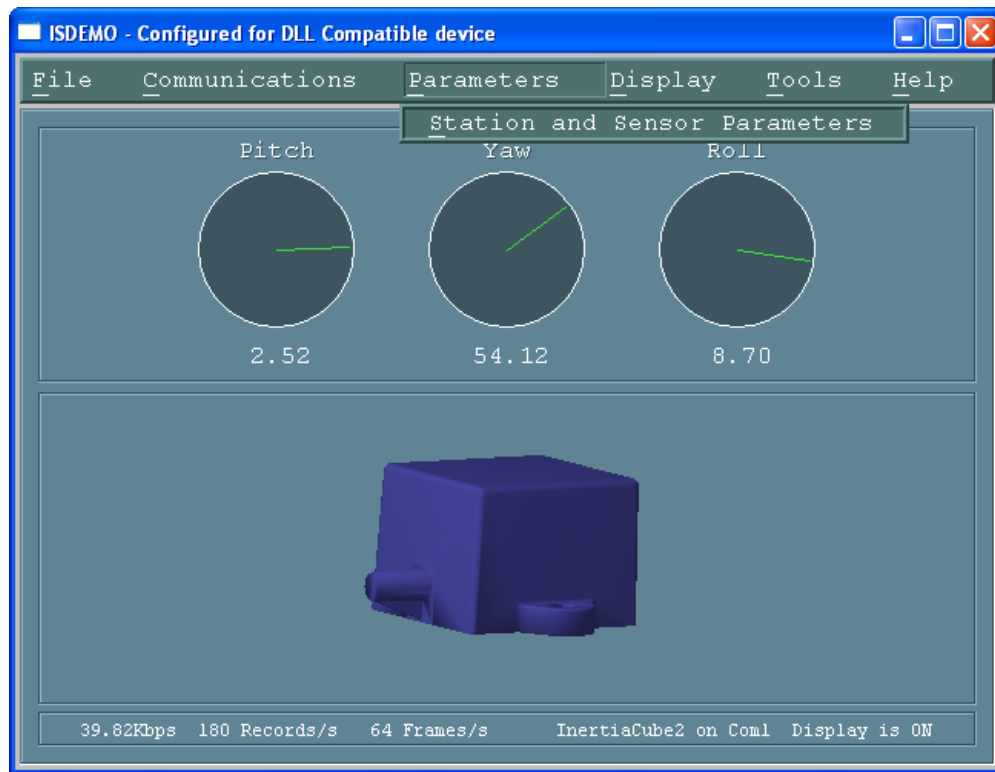


Detect Tracker

Will reinitialize the DLL and detect the connected tracking device(s).

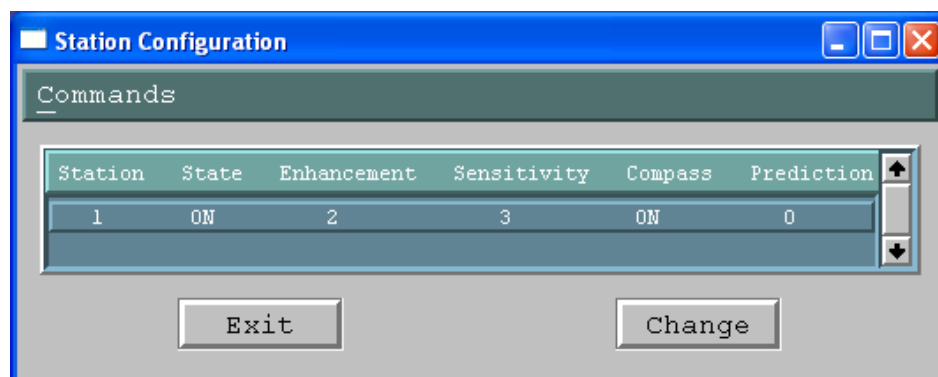
3.5 Parameter options

Parameters menu gives you access to the tracker configuration controls.



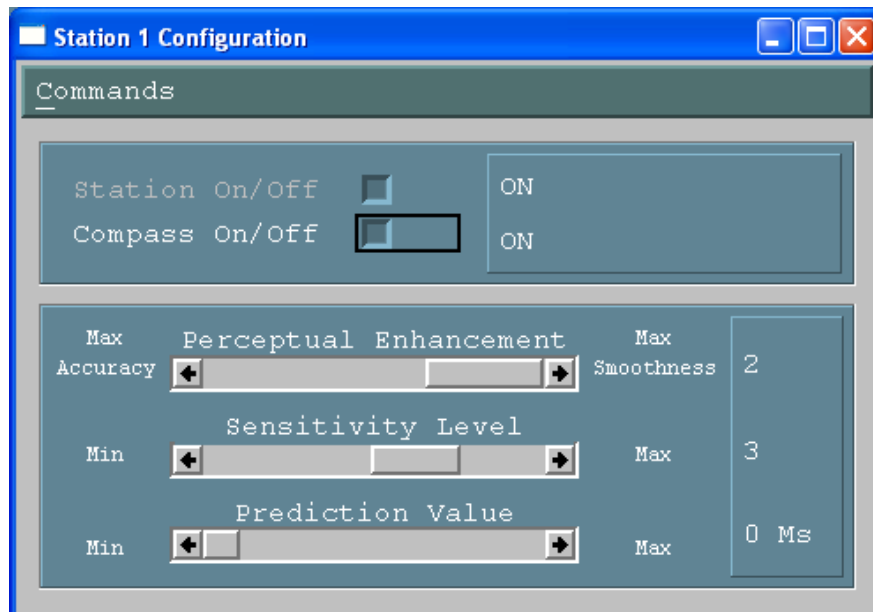
Station and Sensor Parameters

The window shown below allows you to configure the InertiaCube2+.



Double clicking on the Station line or clicking the Change button will bring up the Station Configuration window where changes can be made.

Station Configuration window



Station ON/OFF

The station is always ON and data records will be sent continuously. The InertiaCube2+ can not be turned off.

Compass

This controls the state of the compass component of the InertiaCube2+. When compass is ON, the readings produced by the magnetometers inside the InertiaCube are used as absolute reference orientation for yaw. Metallic objects and electronic equipment in close proximity to the InertiaCube can affect the magnetometers. If compass is OFF, no heading compensation is applied.

Perceptual Enhancement Level

In order to provide the best performance for a large range of applications, three levels of perceptual enhancement are available. None of the modes introduce any additional latency.

Mode 0 provides the best accuracy. The inertial tracker uses gyros to measure angular rotation rates for computing the sensor's orientation. To compensate for the drift, tracker uses accelerometers to measure the actual physical position and orientation of the sensor. That data is then used to compute the necessary correction. In Mode 0 correction adjustments are made immediately, no jitter reduction algorithms are used. This results in most accurate output (not recommended for head tracking) with lower RMS error. Use this mode for accuracy testing or for any application that requires best accuracy.

Mode 1 provides accuracy similar to that of mode 0, with an addition of a jitter reduction algorithm. This algorithm reduces the accuracy by only a small amount and does not add any latency to the measurements. Mode 1 is recommended for augmented reality applications (i.e. overlaying or mixing both virtual and real objects in a visualization system.)

Mode 2 is recommended for use with HMD or other immersive applications. The drift correction adjustments are made smoothly and only while the sensor is moving, so as to be transparent to the user.

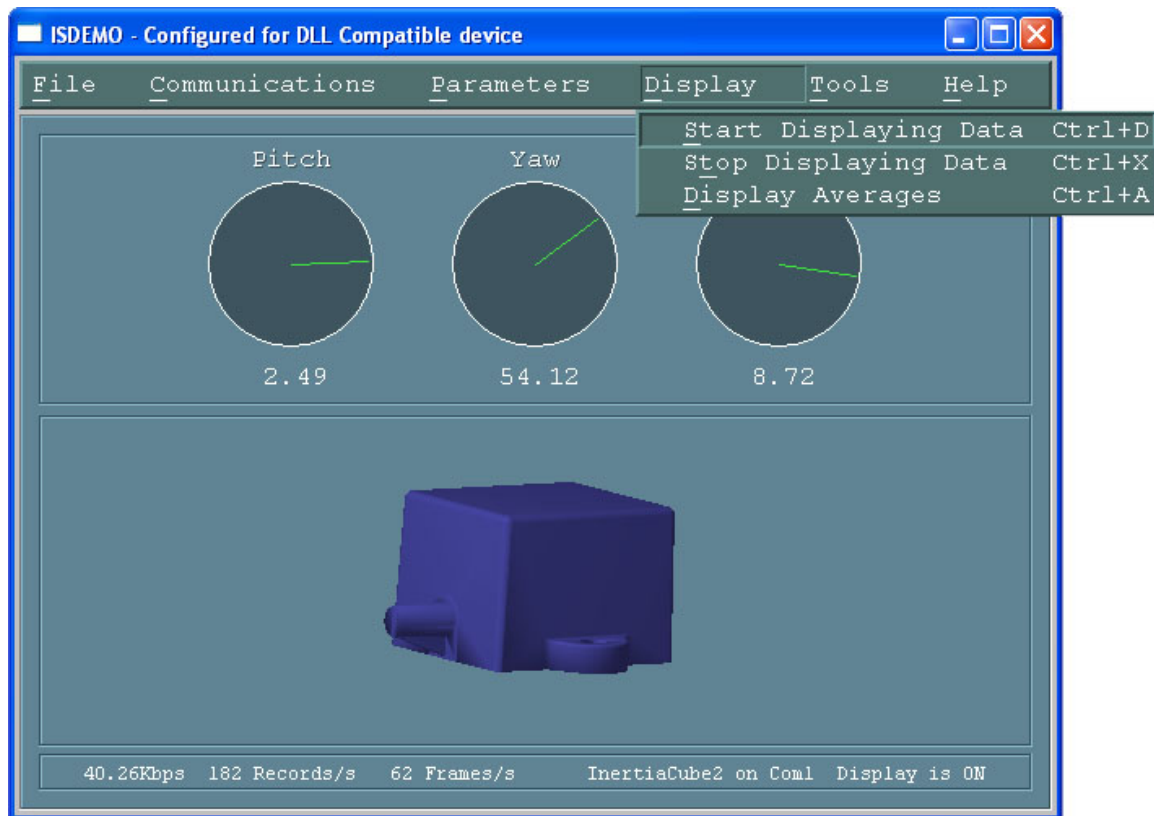
Sensitivity Level

Use this setting when Perceptual Enhancement Level is set to 1 or 2. It controls the minimum angular rotation rate picked up by the InertiaCube. Default is level 3. Increasing sensitivity does not increase latency during normal movements. It may, however, result in some small residual movements for a couple of seconds after the sensor has stopped. If your application requires sensitivity greater than the maximum provided by this control, you must use Perceptual Enhancement level 0 or 1 instead.

Prediction Value

The InertiaCube2+ can predict motion up to 50 ms into the future, which compensates for graphics rendering delays and further contributes to eliminating simulator lag.

3.6 Display Options



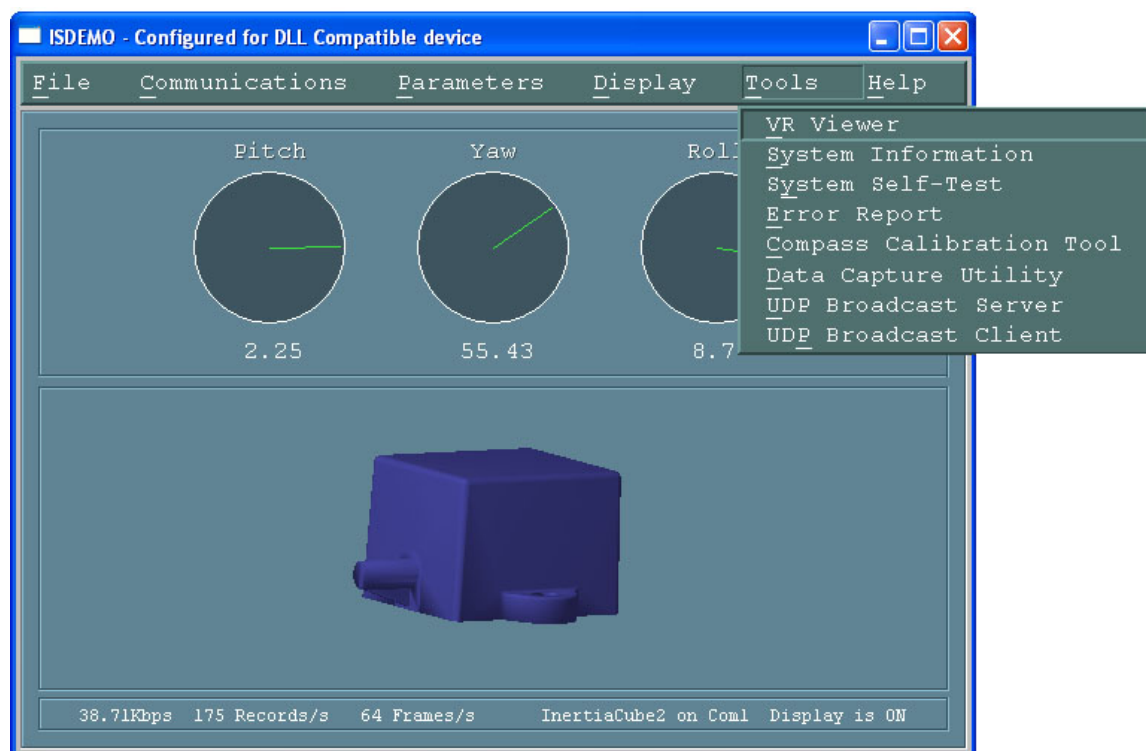
Start (and Stop) Displaying Data

To display orientation data being received from the tracker, use the *Start Displaying Data* option in the *Display* menu or press Ctrl-D.

Display Averages

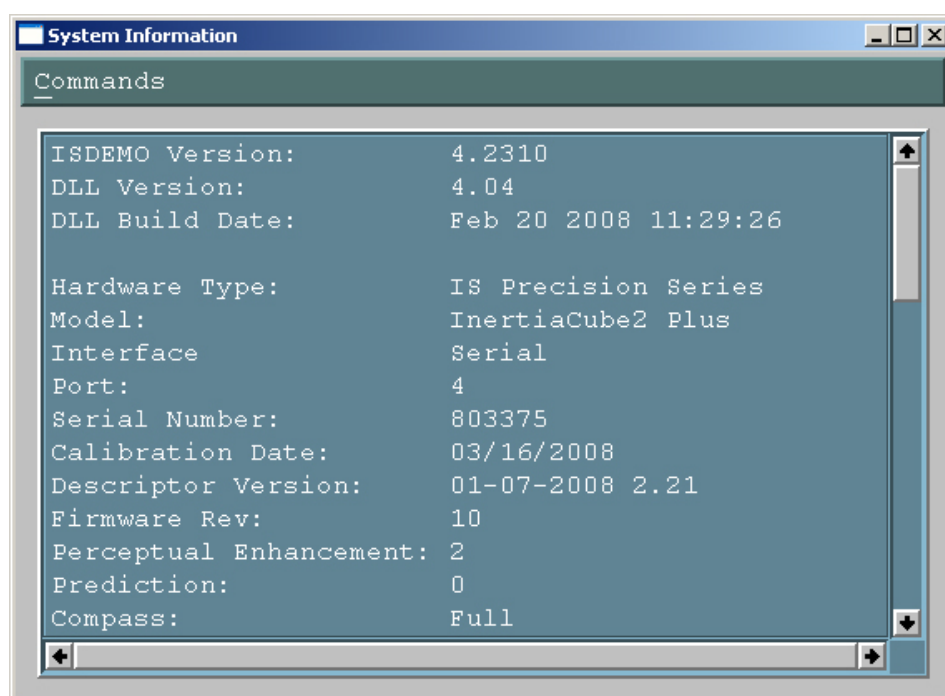
This will display average data collected after the display is turned on. To reset, stop and start displaying data or press the Space bar on the keyboard.

3.7 Tools Options



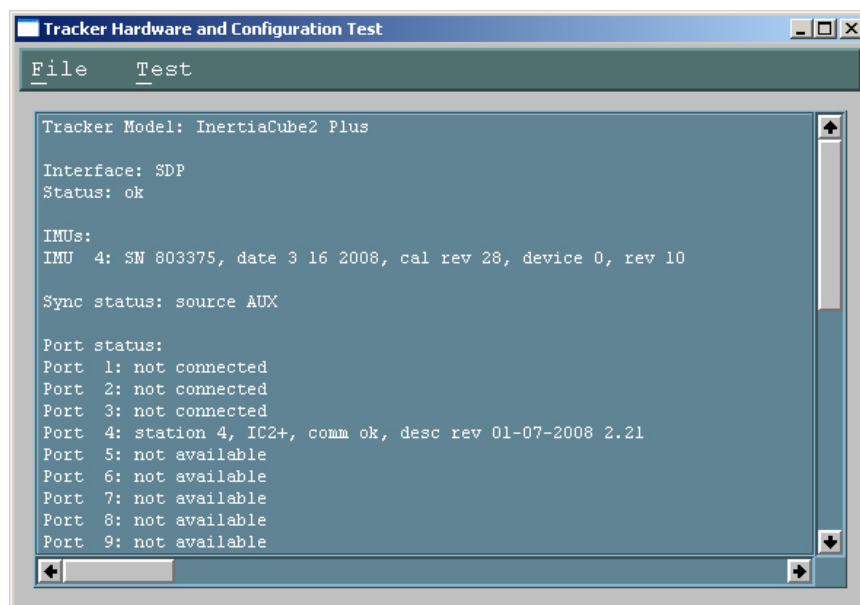
System Information

This window provides a summary of the InterSense tracker hardware and software configuration



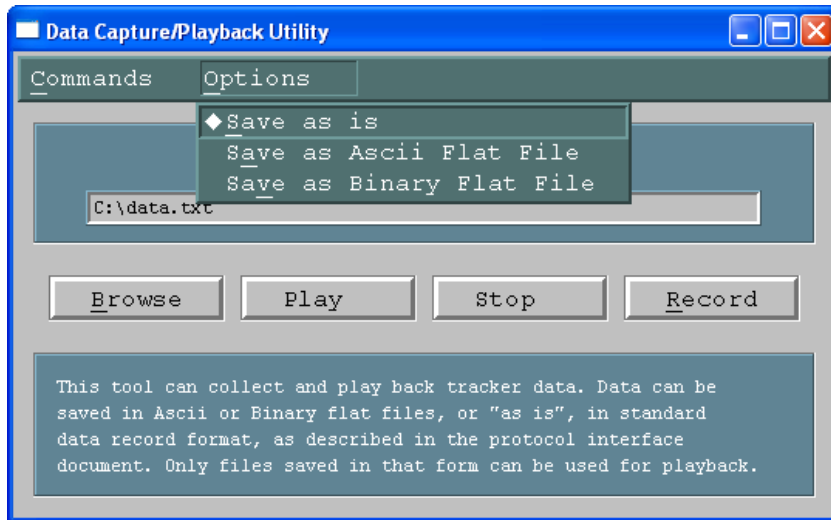
System Self Test

Its purpose is to detect and display information on all the connected hardware and compare it to the user configuration to evaluate it for errors. This tool was primarily designed for troubleshooting the system when hardware failure is suspected.



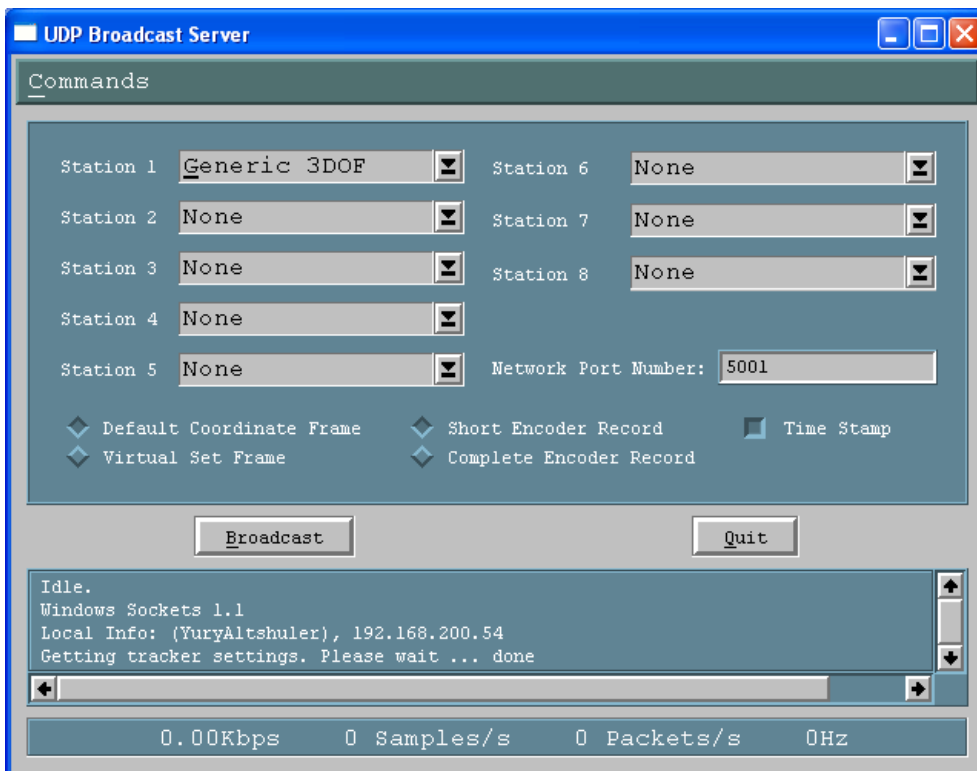
Data Capture/Playback Utility

ISDEMO has the ability to write the data it receives from the tracker to a file. To utilize this feature you must first specify the name and location of the output file. To start data collection, select *Record*. Data can be saved *As Is*, or in an ASCII or binary flat file. When Flat File option is selected, only tracker data is saved, one line per update cycle. To import data to Excel or Matlab the output format must be set to ASCII or the *ASCII Flat file* option must be used. Previously recorded data can be displayed through ISDEMO by selecting *Play*. Playback option will only work on files saved with the *As Is* option.



UDP Broadcast Server

This tool is used to broadcast tracker data over the network using UDP packets. Other machines on the network run client software that receives this data.

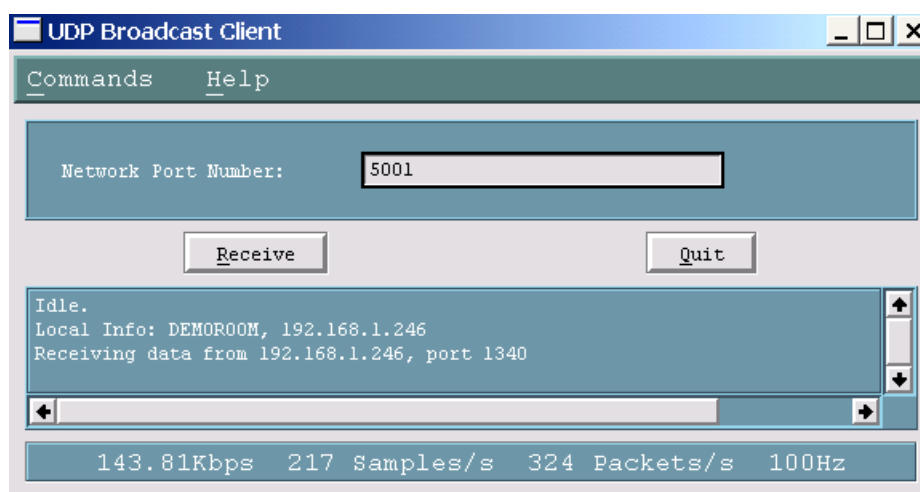


Client software can only receive data, so stations and output records have to be configured here. Depending on available hardware, select one of the 4 available options for each of the stations:

None	Station is OFF and no data will be received from it.
Generic 6DOF	Only position and orientation data is available. Use this option with the InertiaCube2+

NOTE: A unique Network Port number, not used by any other computer on the network, should be assigned to the server. All client applications, including the ISDEMO, should use that number to receive data. Default is 5001, and should not be changed unless there is a conflict.

UDP Broadcast Client ISDEMO itself can be a UDP client. Simply enter the port on which data is transmitted and press Receive. As UDP packets are received, data can be displayed in the main window of ISDEMO.

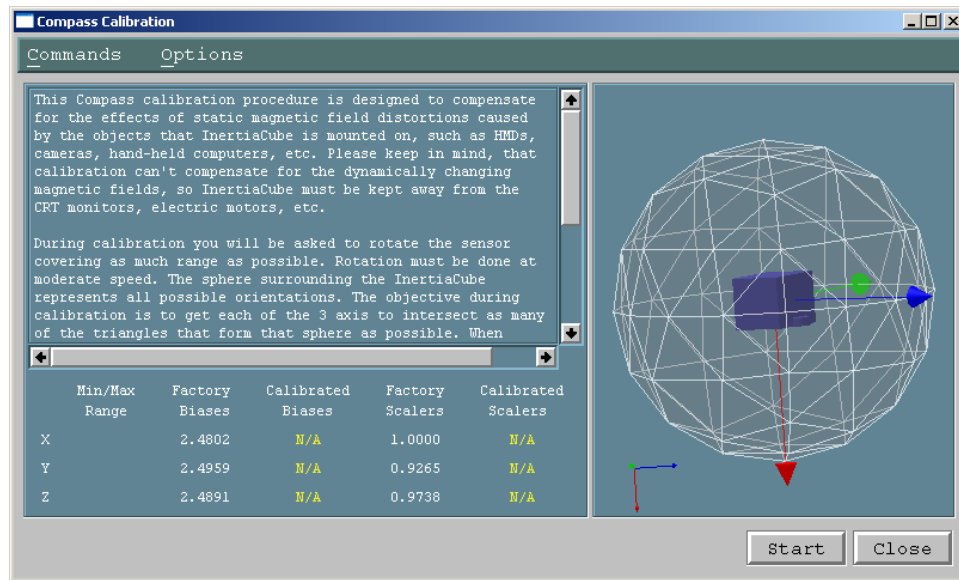


Help Facility Not currently supported in this ISDEMO release. All help information is contained in this manual.

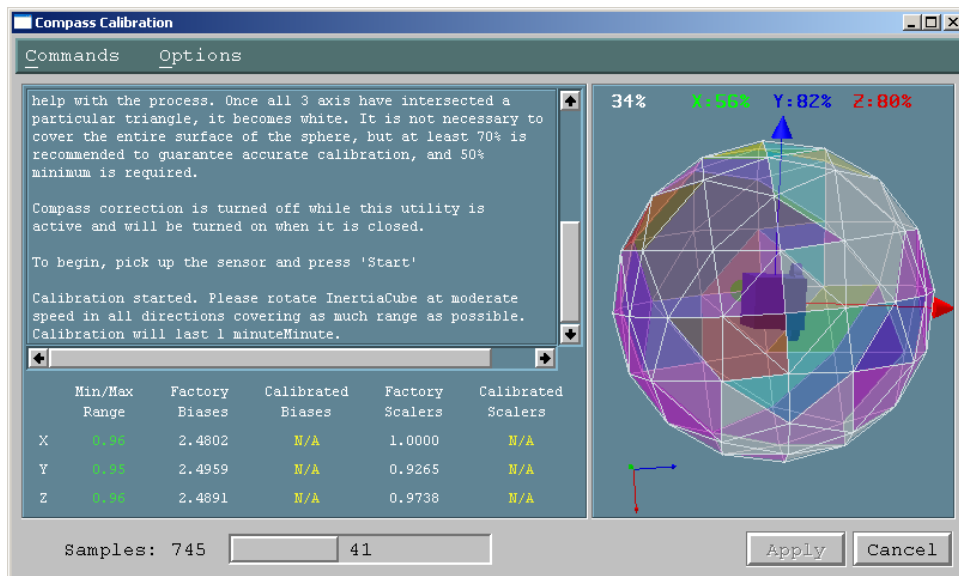
3.8 Compass Calibration Tool

Use the compass calibration procedure to compensate for the effects of static magnetic field distortions caused by objects that the InertiaCube is mounted on (i.e. HMDs, cameras, hand-held computers, etc.). ***Please keep in mind that calibration can't compensate for dynamically changing magnetic fields***, so the InertiaCube must be kept away from CRT monitors, electric motors, and anything that has a moderate to strong electric current flowing through it.

Note: Compass calibration is not available when the InertiaCube2+ is connected to the InertiaCube Processor. The InertiaCube2+ must be connected directly to the Windows PC running ISDEMO.

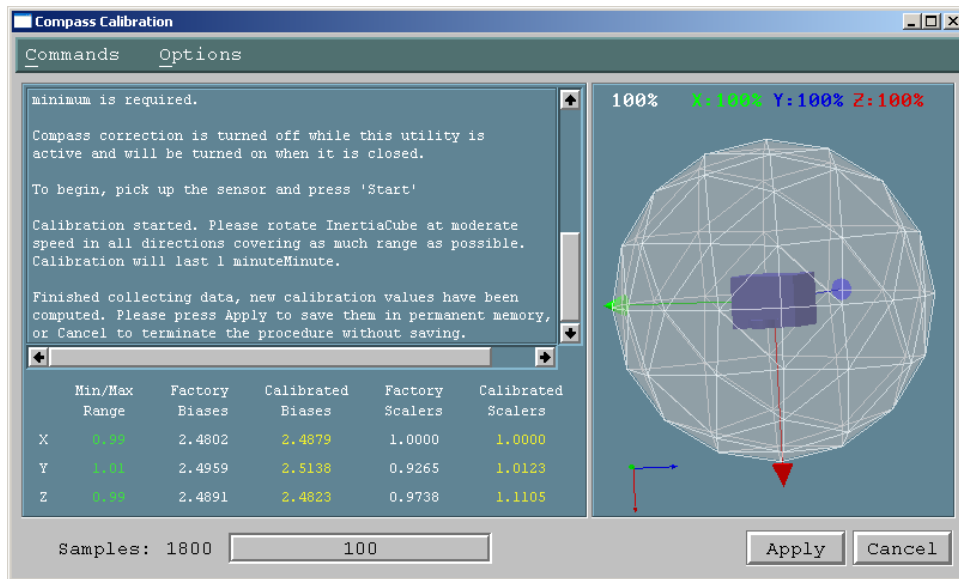


During calibration, you will be asked to rotate the sensor covering as much range as possible. Rotation must be done at moderate speed. The sphere surrounding the InertiaCube represents all possible orientations. The objective during calibration is to get each of the 3 axes to intersect as many of the triangles that form that sphere as possible. When a surface triangle in this sphere is intersected, it acquires the color component of the intersecting axis, providing a visual cue to help with the process. Once all 3 axes have intersected a particular surface triangle, it becomes white. It is not necessary to cover the entire surface of the sphere with white during calibration, but at least 70% is recommended to guarantee accurate calibration, and 50% minimum is required.



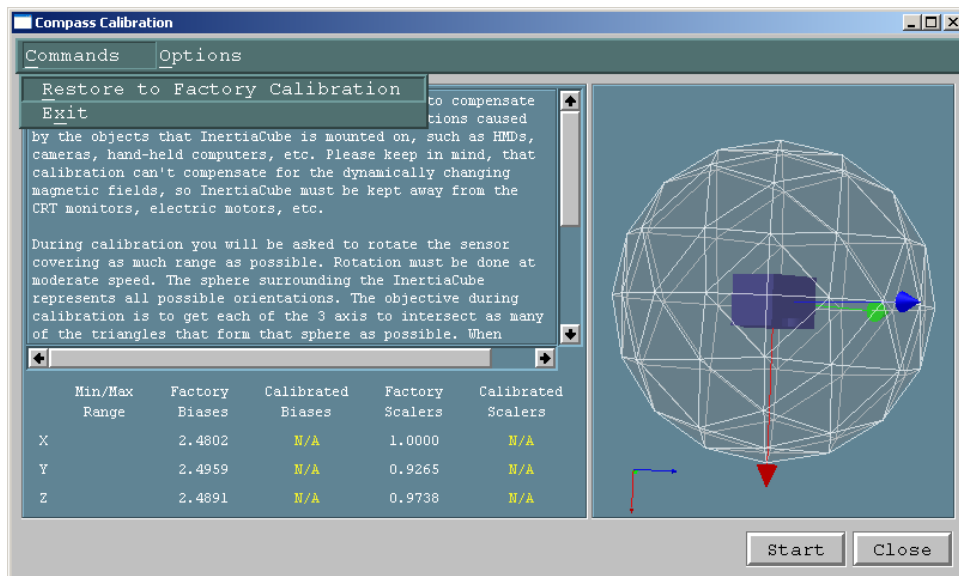
Compass correction is turned off while this utility is active and will be turned on when it is closed.

To begin the compass calibration, pick up the sensor and press 'Start' button. When the calibration is complete, the 'Start' button becomes an 'Apply' button. The new computed calibrated values are displayed in the window and are applied to the Flash RAM when the 'Apply' button is pressed. Press the 'Cancel' button to abort the calibration procedure without saving any new values to the Flash RAM in the InertiaCube2+. Once the values are applied, the 'Apply' button is replaced with the 'Start' button the 'Cancel' button is replaced with the 'Close' button. 'Close' closes the calibration window.



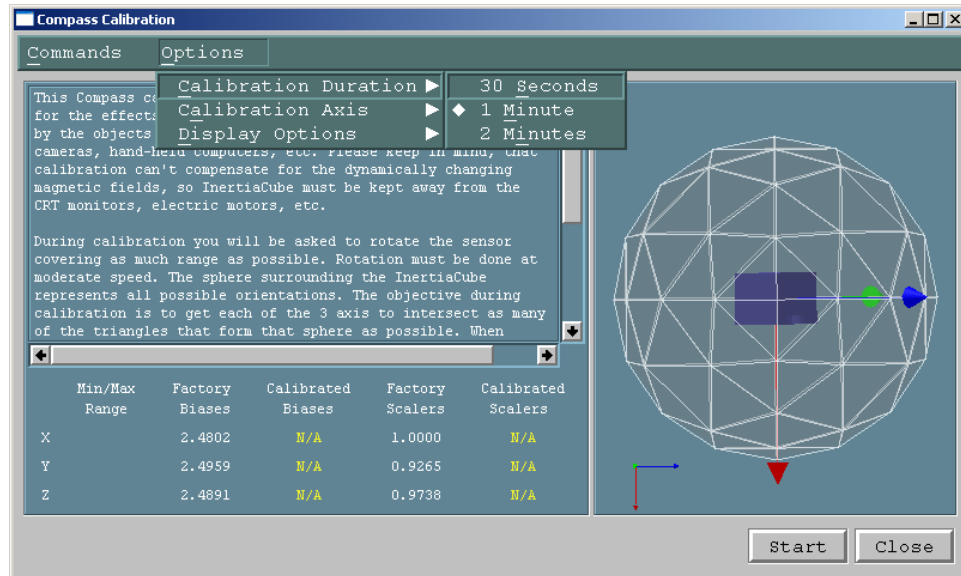
Compass Calibration → Commands

The *Commands → Restore to Factory Calibration* menu provides a way to restore the original factory calibration to the InertiaCube2+. The factory calibrated biases and scalar data, which is stored in Flash RAM, is displayed for each axis in the Compass Calibration window.



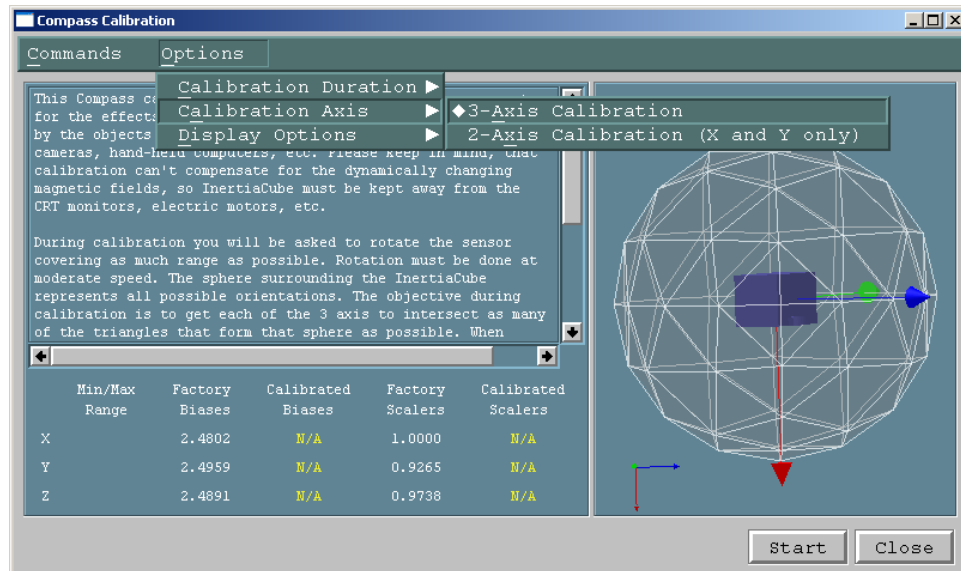
Compass Calibration → Options → Calibration Duration

The default calibration process duration is 1 minute, but a longer (2 minutes) or shorter (30 seconds) can be selected.



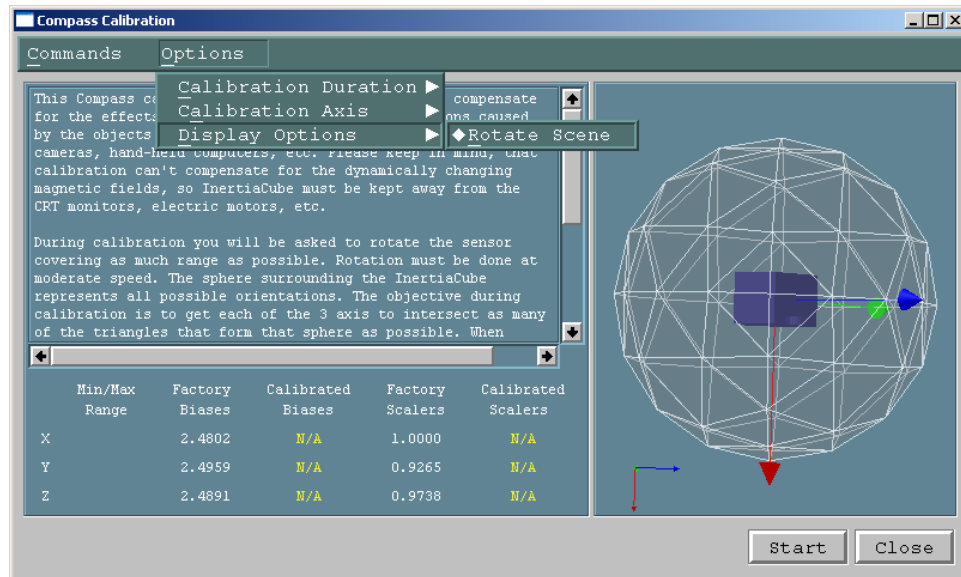
Compass Calibration → Options → Calibration Axis

By default, a full 3-axis magnetometer calibration is performed when selecting the 'Start' button. For special cases where the mounted InertiaCube2+ will only rotate about the z-axis (i.e. on a vehicle) a 2-axis magnetic calibration can be selected.



Compass Calibration → Options → Display Options

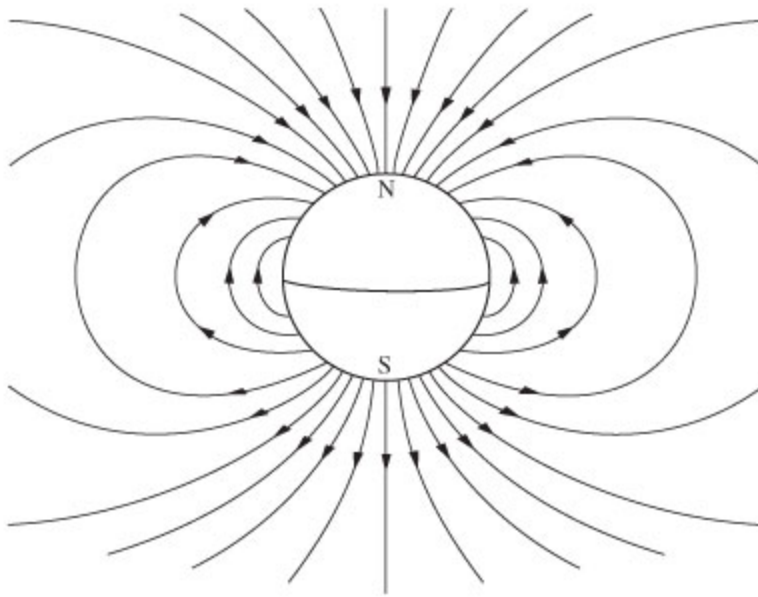
The *Rotate Scene* display option is selected by default. It keeps the sphere in the window moving with a slight oscillation to provide a visual reference to the progress of calibration process.



3.9 Magnetic Environment Calibration Tool

3.9.1 Theory of Operation

The InterSense InertiaCube sensors measure the Earth's magnetic field along three perpendicular axes to calculate the direction of magnetic north. This data is used as reference for yaw (heading), and prevents any drift accumulation in the inertial system. As with any compass, local disturbances of the Earth's magnetic field can corrupt data and cause errors in the sensor output. By characterizing and storing normal magnetic field values it is possible to detect such disturbances and prevent them from negatively affecting tracking performance. The Magnetic Environment Calibration Tool was developed to measure the normal magnetic inclination and field strength for a particular environment, store it in permanent sensor memory, and tune how it affects integration of compass data in tracking algorithms.



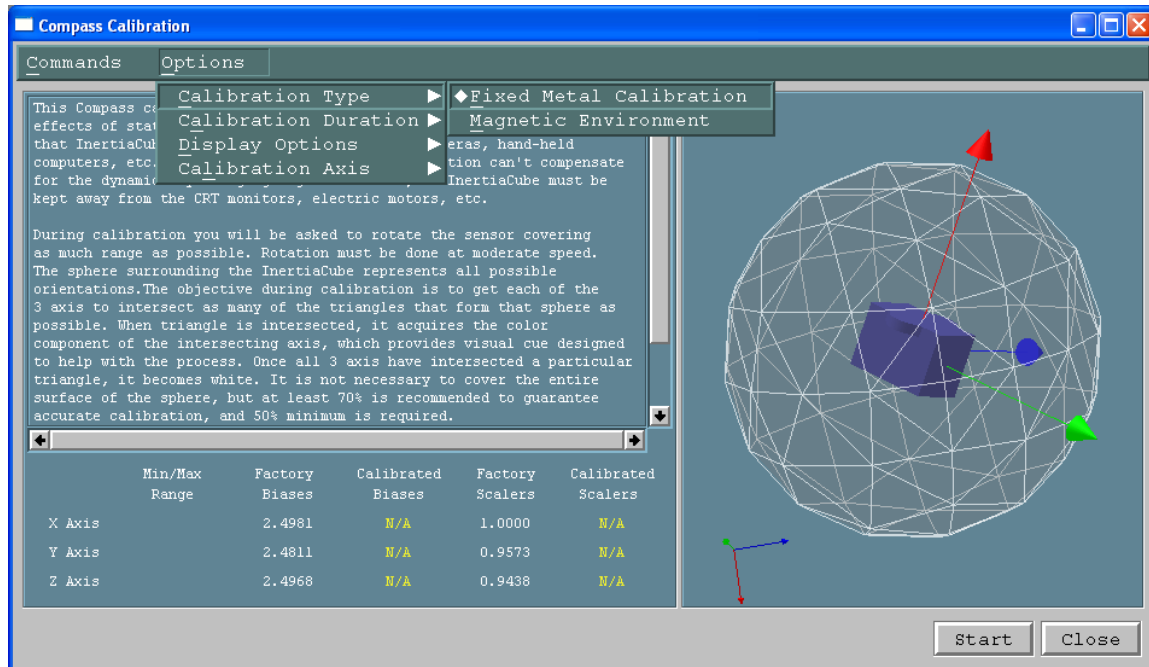
The Earth's field is closely approximated by the field of a dipole magnet positioned at the centre of the Earth. Magnetic inclination (dip angle) is the angle that the geomagnetic field is tilted with respect to the surface of the earth. Magnetic inclination varies from 90° at the magnetic poles (perpendicular to the surface) to 0° at the magnetic equator (parallel to the surface). The strength of the field at the Earth's surface ranges from less than 0.3 gauss to over 0.6 gauss, depending on the location. Both dip angle and field strength can also be affected by building materials and other sources, therefore calibration will only be valid at the specific location where it was performed.

3.9.2 Algorithm

The InterSense 3-DOF tracking algorithm uses Kalman filters to estimate and correct drift and errors based on data from the reference sensors, in this case the magnetometer. The Kalman filters assign “noise” values to the inputs based on the known sensor characteristics and other parameters; discounting the affect of the compass on the output. When nominal values for magnetic field inclination and strength are known it will use them to calculate “quality” of the magnetometer data. This calculation uses tuning parameters and is based on how much the compass data deviates from the calibrated values. When the input falls outside of the range allowed by the tuning parameters no compass data is used. The system can continue to accurately track orientation using only gyro data until magnetic interference is removed and the compass data can be used again.

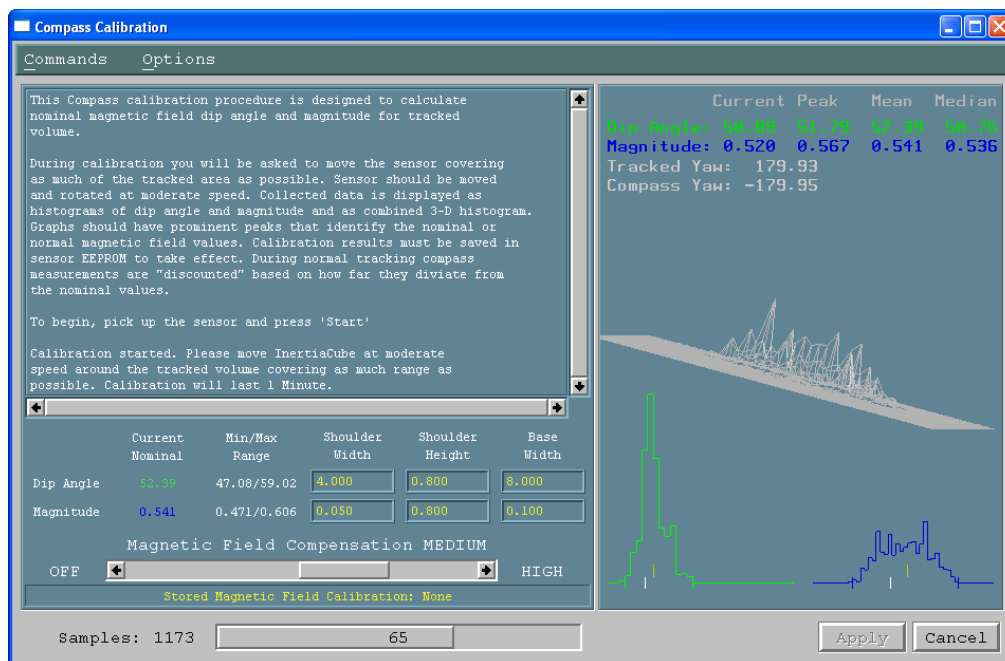
3.9.3 Starting Calibration Procedure

The Calibration Tool is located in the Tools menu of the main ISDemo window. The type of calibration can be selected in from the Options Menu.



3.9.4 Calibration Procedure

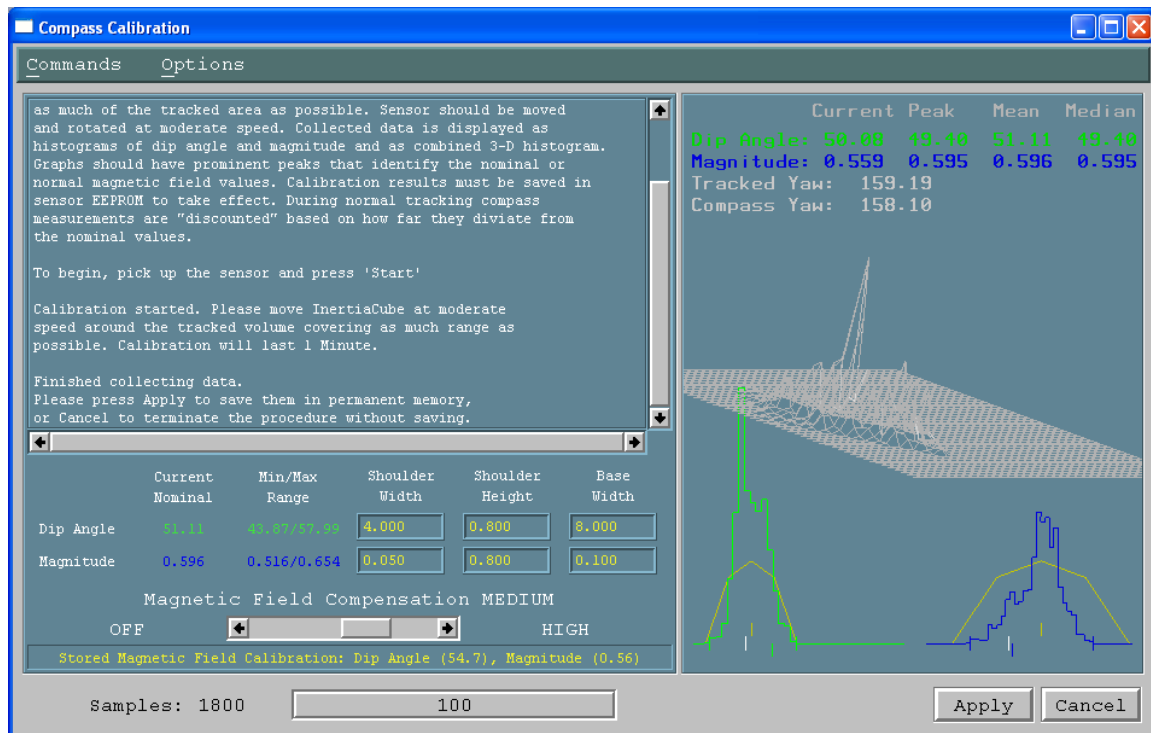
During the calibration procedure, the system collects magnetic field data and displays it in the form of histograms for inclination (dip angle) and field strength (magnitude). A third 3-dimensional histogram is a combination of both data sets, and provides additional visual feedback. The Dip Angle data is displayed in green throughout the interface; Magnitude data is in blue. Tuning parameters and graphs are in yellow.



You can select calibration duration from the Options menu, default is 1 minute. During calibration, the sensor should be moved and rotated at a moderate speed, covering as much of the tracked volume as possible. It should be kept away from any potential sources of magnetic interference, such as metal furniture, electronics, etc. Histograms should have pronounced peaks.

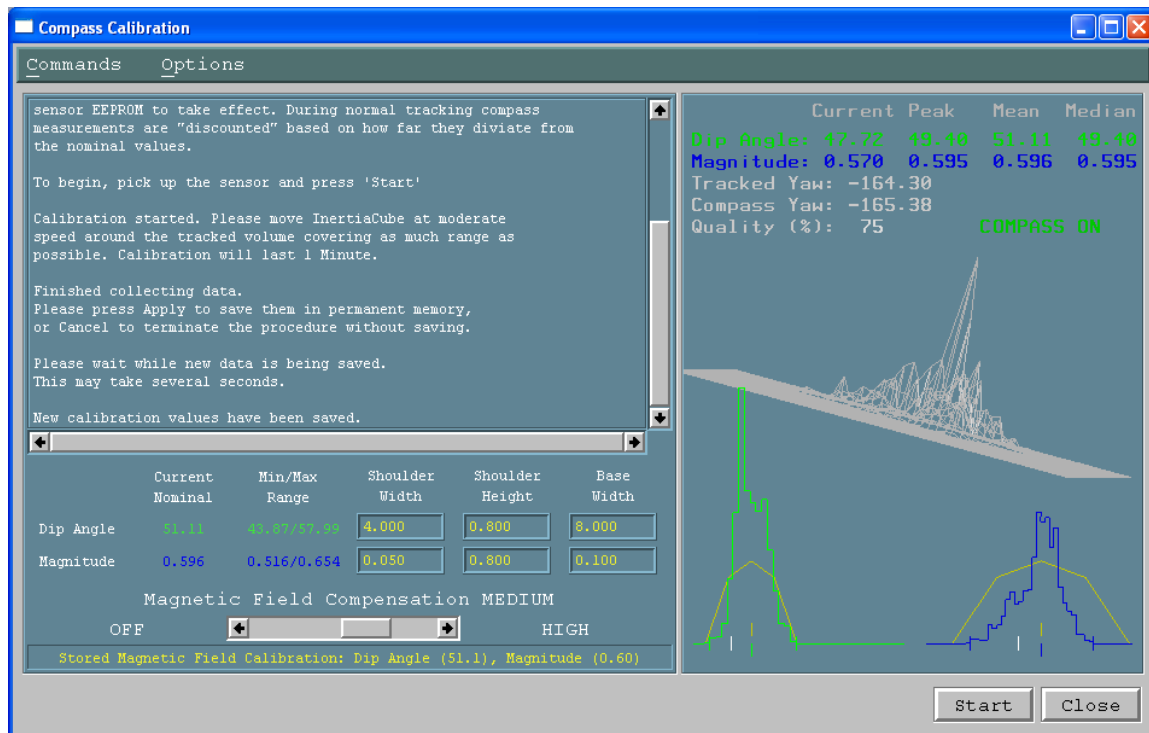
3.9.5 Calibration Results

After the end of the calibration period a new Dip Angle and Magnitude are calculated and can be store in the sensor's EEPROM by pressing the Apply button. The interface is updated and the tuning parameters are displayed in the form of a yellow line, covering what is now considered usable compass data. To adjust the tuning parameters, use the Magnetic Field Compensation slider control at the bottom of the screen.



3.9.6 Testing and Tuning

After calibration data is stored in the sensor's EEPROM, the system will be able to start calculating compass data quality and display it on the screen. It also displays 2 different Yaw values, first is the normal output of the sensor, second is the pure compass yaw as reported by the sensor. By comparing the values when magnetic interference is introduced you can determine the effectiveness of the calibration and select the appropriate Magnetic Field Compensation factor. In a very clean magnetic environment a higher level of compensation may be appropriate. This will guarantee that compass data is heavily discounted whenever data diverges from the stored nominal values. If you expect a lot of interference, a lower value of compensation may be appropriate, allowing for more compass data to be used. The system can track well without the use of compass for some time before any significant drift accumulation. However, it is important to allow the Kalman filter algorithm to use enough compass data to maintain stability and accuracy. The default value is Medium and it works well under most conditions.



4 Developer's Instructions

For InterSense SDK Version 4.0 or higher.

Please refer to the document ‘dll_api.pdf’ located in the SDK folder for further details, functions, and sample code. This document describes the interface to be used by the application software to initialize and retrieve data from the InterSense devices using the ISENSE.DLL. This dynamic link library is provided to simplify communications with all models of InterSense tracking devices. It can detect, configure, and get data from up to 32 trackers. The DLL maintains compatibility with existing devices, and also makes the applications forward compatible with all future InterSense products (new DLLs may be required, but the application will not need to be recompiled).

4.1 Sample Program

The DLL is distributed with sample programs written in C and C# (for Windows) to demonstrate usage. It includes a header file with data structure definitions and function prototypes. Most of the API description below can also be obtained from the header file.

main.c	Main loop of the program. All API calls are made from here.
isense.c	DLL import procedures. This file is included instead of an import library to provide compatibility with all compilers.
isense.h	Header file containing function prototypes and definitions. This file should not be modified.
types.h	Header file containing data type definitions.

Appendix A – Frequently Asked Questions

- Q1. What is the maximum length of the cable between the InertiaCube2+ and the computer?

The cable between the InertiaCube and the computer has been tested to a length of 15 feet. InterSense can provide longer cables. Please contact your sales representative for information.

- Q2. Does the InertiaCube have batteries? How often do they have to be changed?

The InertiaCubes do not contain batteries. When remotely powered with 4 AA Alkaline Batteries (6 VDC), batteries should be changed after 8 hours of continuous use.

- Q3. Are all the interconnection cables shielded?

Yes.

- Q4. What is the MTBF of each component separately?

Based on supplier data, the MTBF for the InertiaCube2+ is estimated at 5 years.

- Q5. What type of shock can the InertiaCube2+ sustain?

These InertiaCube is designed to withstand a maximum acceleration of 500 g. This means that a direct impact on the devices is not recommended. The InertiaCubes can withstand a higher level of shock if installed on the inside of an object, or mounted on rubber.

- Q6. What are the PIN assignments on the DB9 on the InertiaCube2+?

Pin	Function
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

Currently, the InertiaCube2+ uses four wires; RX, TX RTS, and GND.

- Q7. Do you have any advice about working with software packages?

Consult with the software vendor or contact InterSense techsupport@intersense.com.

- Q8. How do I know whether I have the latest release of ISDEMO?

Check our web site, the URL is <http://www.intersense.com/support.html>. Click on the ISDEMO.ZIP hypertext link. We always post the latest release for you to download.

6 Appendix B – USB Driver Installation

6.1 *InterSense USB Adapter Installation on Windows Vista, XP, and 2000*

InterSense USB Adapter utilizes FTDI USB UART device. This document details installation of the FTDI Win2k Drivers and was prepared using FTDI documentation. FTDI is the registered trademark of the Future Technology Devices International Ltd.

Future Technology Devices International Ltd.
St. George's Studios,
93 - 97 St George's Road,
Glasgow G3 6JA
Scotland U.K.

Web Site URL - <http://www.ftdichip.com>

6.1.1 *Install InterSense Support Software*

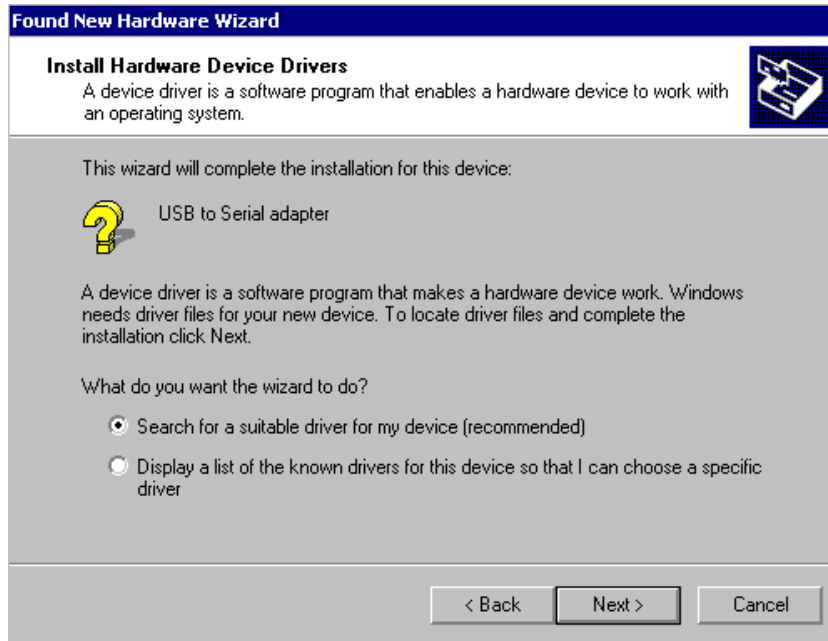
Install InterSense support software from the included CD. This step must be completed before attempting to install the drivers. FTDI Drivers are installed onto your hard drive under InterSense\Drivers\USB (FTDI).

6.1.2 *Installing USB Driver*

1. Plug in InterSense USB Adapter into available USB port. Windows will start the “Found New Hardware Wizard”. Click “Next” to start driver installation.



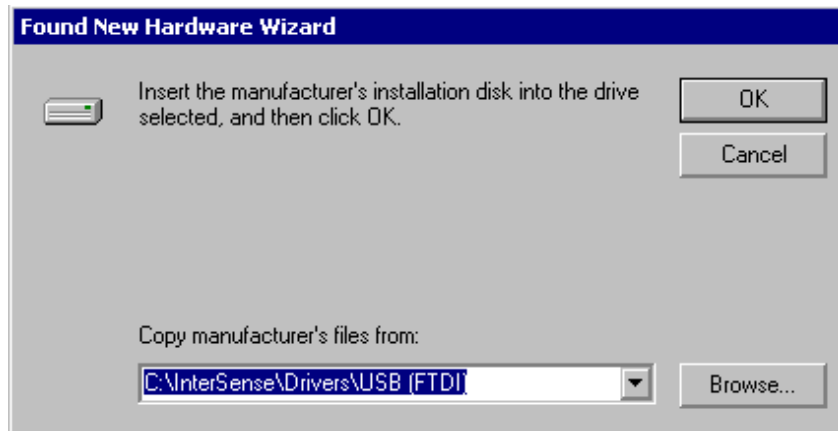
2. Select “Search for a suitable driver” and click “Next”.



3. Select “Specify a location”, click “Next”.



4. The default InterSense installation folder is C:\InterSense, if during installation you selected a different location your path will be different.



5. Click "Next" to install the driver.





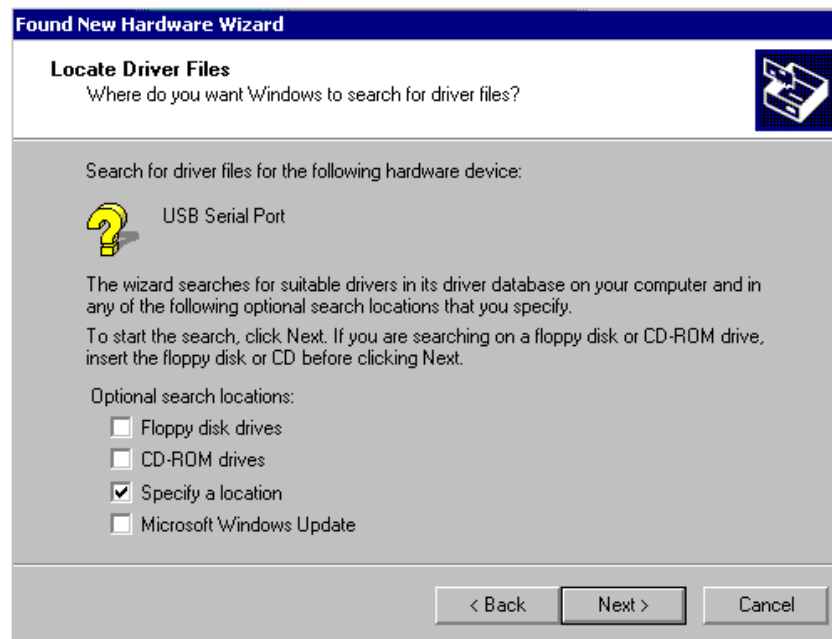
6. Next Windows will automatically start installation of the USB Serial Port



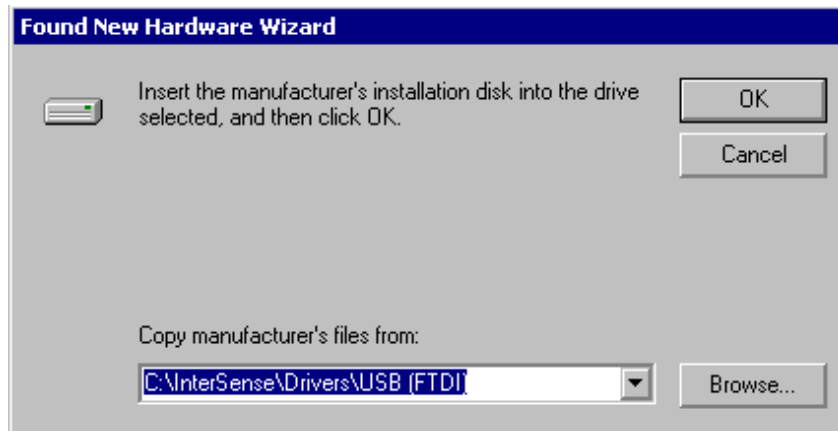
7. Select “Search for a suitable driver”, click “Next”.



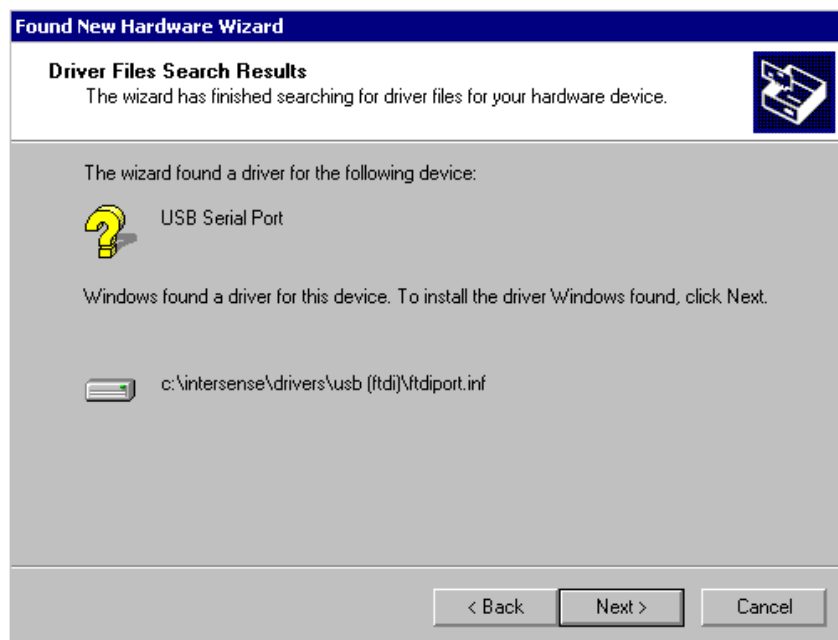
8. Select “Specify a location”, click “Next”.

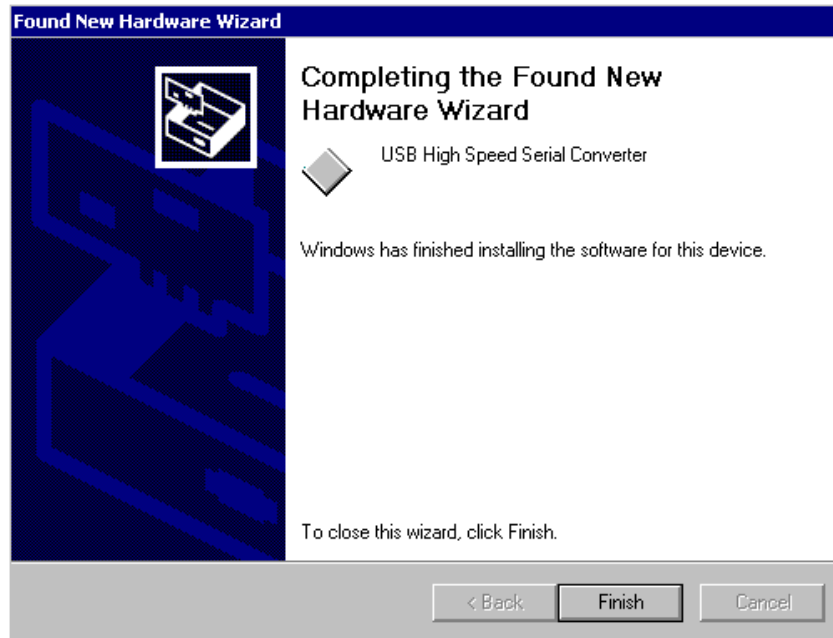


9. The default InterSense installation folder is C:\InterSense, if during installation you selected a different location your path will be different.



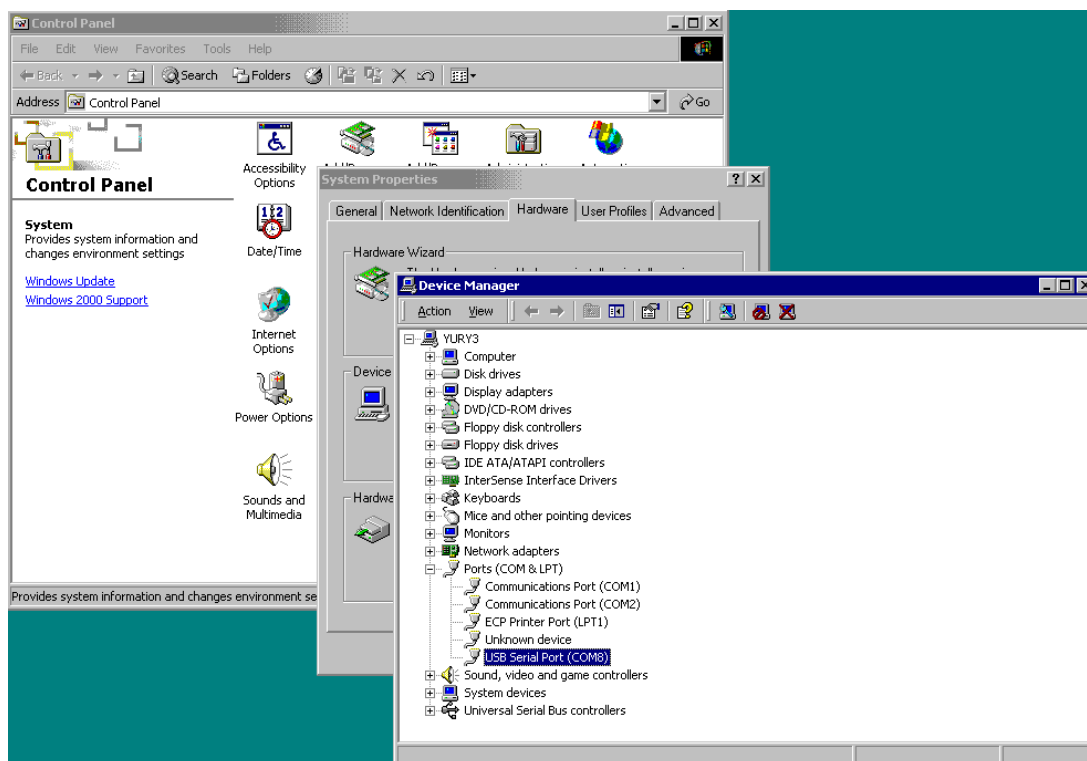
10. Click "Next" to install the driver.





6.1.3 Changing COM Port Number

1. InterSense software supports COM Port numbers 1 through 10, so it may be necessary to change the default port number assigned to the USB Adapter. From Control Panel select “System”, go to the Hardware tab and open Device Manager. Open the “Ports” section. Double-click on “USB Serial Port” to open Properties window.



2. In the Com Port Properties window select “Port Settings”, click “Advanced”. Choose the Com Port number and click “OK”.

7 Appendix C – Troubleshooting

<u>Problem</u>	<u>Reason/Solution</u>
ISDEMO doesn't work!	<p>Most common reasons (not in any order):</p> <ol style="list-style-type: none"> 1) Connected to wrong COM port plug on the back of the computer. 2) The selected serial port is captured by another program and can't be opened by ISDEMO. 3) Serial port not capable of running at 115,200 baud rate. This is usually due to older computers that cannot run at 115,200 baud. The problem is a lack of a proper UART such as the 16550. 4) Incorrect port settings - use <i>autodetect</i> for Com parameters. 5) Not using <i>Start Displaying Data</i>. It may be necessary to select <i>Stop Displaying Data</i> first.
ISDEMO is running, but system does not track	<p>Check for the following:</p> <ol style="list-style-type: none"> 1) The InertiaCube2+ is not plugged in. 2) The InertiaCube2+ was plugged in <i>after</i> power up and a detect command has not been issued
InertiaCube2+ interference	<p>Check for the following:</p> <ol style="list-style-type: none"> 1) Placement directly on top of metal. You should place the InertiaCube an inch or two away.
Orientation is drifting uncontrollably	<ol style="list-style-type: none"> 1) Make sure that InertiaCube2+ is properly plugged in. 2) Keep InertiaCube2+ still for 10 seconds after connecting with ISDEMO or DLL. 3) Compass is turned off in ISDEMO.

8 Appendix D – Health and Safety warnings and guidelines

Important:

Most of the side effects described in this section usually only occur when a tracking device, like an InertiaCube2+, is used with personal displays or 3D glasses. The symptoms listed below are usually referred to as “Simulator Sickness”.



Read and follow the user instructions.

Before using InertiaCube2+, read and follow the user instructions. In exceptional circumstances, failure to read and follow the user instructions could result in possible side effects that may lead to accidental injury during or after use.



Recommended.

For use only by persons 15 years of age or older. This system should not be used by:

- Persons under the influence of drugs and alcohol.
- Pregnant women.
- Persons suffering from a heart condition
- Persons with a history of epilepsy.



Take frequent breaks.

It is recommended that InertiaCube2+ should be used for no more than one hour at a time. After that you should take a 15-minute rest break before re-use regardless of how you feel. If you feel uncomfortable at any time, stop using immediately.



Rest after using.

Rest for at least 15 minutes after using InertiaCube2+ even if you feel fine and have experienced none of the symptoms described below. If you have experienced any undesirable effects or symptoms, rest until they are completely gone. Do not walk, drive, ride a bike or operate equipment until you have rested, otherwise you risk injury to yourself and others.



Epilepsy and seizures.

A very small part of the population has a condition that may result in epileptic seizures or loss of consciousness. If you or anyone in your family has epilepsy or has experienced seizures or loss of consciousness, do not use InertiaCube2+ without first consulting your physician. Persons who have not experienced seizures or loss of consciousness may still have an epileptic condition. We recommend that a non-user is always present when InertiaCube2+ is being used.

**Additional possible risks of harm.**

While tracking technology has been used for many years, the range of sensors that are used to calculate positional and angular data continues to develop. Over the last twenty years a considerable amount of research has been conducted into possible side effects induced in users of real time computing systems that include various types of tracking sensors. This research has reported the symptoms described below from some users of these systems.

InertiaCube2+ has been designed using the latest sensor technologies and we believe that the possibility of such symptoms occurring has been minimized. However, it is not possible to design for the individual characteristics of each user and it is possible that users will experience one or more of the side effects described below. Historic research shows that the effects or symptoms ordinarily occur during and immediately after use and should diminish quickly once the user stops using the system.

We want you to make an informed and responsible choice about using the InertiaCube2+. Accordingly, we warn you that even if you read and follow the User Instructions, you may experience one or more of the following effects or symptoms if you use InertiaCube2+ with a personal display: eye strain, altered vision, eye or muscle twitching, headaches, neck and shoulder strain, nausea and vomiting, disorientation, dizziness, impaired balance and stability, drowsiness, fainting, fatigue, sweating, extreme paleness, impaired hand-eye or other co-ordination.

Each effect or symptom, if it occurs, should be temporary and may last from a few minutes to 30 minutes.

9 Appendix E – Care and Maintenance

Care and Cleaning

Recommended cleaning materials are the same as those for computers. Antistatic cloths can clean the components and reduce static electricity. Cleaning solutions should be applied to the cloth and not directly on any part of the system components.

Phone & email support

Any questions regarding the care and maintenance of your InertiaCube2+ can be handled by phone (781) 541-7624 or by email techsupport@intersense.com. Please see the Support page at www.intersense.com for the technical support contact information.

Returns to InterSense

If you need to return a component to InterSense for replacement or repair, contact InterSense prior to shipment to obtain a Return Authorization (RA) number. When calling, please look on the back of IS-900 Processor to provide the serial number and the serial number of any devices you need to return to help us complete the RA process. To request an RMA please use the link below and follow the instructions:

<http://www.intersense.com/rma>

Please note that InterSense will not be responsible for materials returned without an RMA number clearly marked on the outside of the shipping package.

Batteries

There are no batteries in the InertiaCube2+ system. Contact InterSense for custom remote battery packs.

Electrical power

6 VDC, 40 mA