

# **Polaris Vicra User Guide**

Revision 2  
October 2005

**IMPORTANT**  
Please read this entire document  
before attempting to operate  
the Polaris Vicra System

### Revision Status

Revision Number	Date (DD/MM/YY)	Description
Revision 1	27/09/05	Initial release
Revision 2	19/10/05	minor updates

Part Number: IL-1070100

Copyright 2005 Northern Digital Inc. All Rights Reserved.

🍁 Printed in Canada.

---

Published by:

Northern Digital Inc.  
103 Randall Dr.  
Waterloo, Ontario, Canada N2V 1C5

Telephone: + (519) 884-5142  
Toll Free: + (877) 634-6340  
Global: + (800) 634 634 00  
Facsimile: + (519) 884-5184  
Website: www.ndigital.com

Copyright 2005, Northern Digital Inc.

All rights reserved. No part of this document may be reproduced, transcribed, transmitted, distributed, modified, merged or translated into any language in any form by any means - graphic, electronic, or mechanical, including but not limited to photocopying, recording, taping or information storage and retrieval systems - without the prior written consent of Northern Digital Inc. Certain copying of the software included herein is unlawful. Refer to your software license agreement for information respecting permitted copying.

## **DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES**

Northern Digital Inc. has taken due care in preparing this document and the programs and data on the electronic media accompanying this document including research, development, and testing.

This document describes the state of Northern Digital Inc.'s knowledge respecting the subject matter herein at the time of its publication, and may not reflect its state of knowledge at all times in the future. Northern Digital Inc. has carefully reviewed this document for technical accuracy. If errors are suspected, the user should consult with Northern Digital Inc. prior to proceeding. Northern Digital Inc. makes no expressed or implied warranty of any kind with regard to this document or the programs and data on the electronic media accompanying this document.

Northern Digital Inc. makes no representation, condition or warranty to the user or any other party with respect to the adequacy of this document or accompanying media for any particular purpose or with respect to its adequacy to produce a particular result. The user's right to recover damages caused by fault or negligence on the part of Northern Digital Inc. shall be limited to the amount paid by the user to Northern Digital Inc. for the provision of this document. In no event shall Northern Digital Inc. be liable for special, collateral, incidental, direct, indirect or consequential damages, losses, costs, charges, claims, demands, or claim for lost profits, data, fees or expenses of any nature or kind.

Product names listed are trademarks of their respective manufacturers. Company names listed are trademarks or trade names of their respective companies.



---

# Table of Contents

<b>Read Me First!</b> .....	<b>1</b>
Warnings .....	1
Cautions .....	2
Disclaimers .....	3
Contact Information .....	4
Updates .....	4
<b>About This Guide</b> .....	<b>5</b>
Organization of Content .....	5
<b>1 Polaris Vicra System Overview</b> .....	<b>6</b>
1.1 Introduction .....	6
1.2 Position Sensor .....	7
1.3 Host USB Converter .....	11
1.4 Power Adapter .....	12
1.5 Cables .....	12
1.6 Polaris Vicra Tools .....	13
1.7 Polaris Vicra System Software .....	14
1.8 Component Parts List .....	14
<b>2 Setting Up the Polaris Vicra System</b> .....	<b>15</b>
2.1 Unpacking the Polaris Vicra System .....	15
2.2 Polaris Vicra System Operating Environment .....	15
2.3 Mounting the Position Sensor .....	18
2.4 Mounting the Host USB Converter .....	19
2.5 Connecting the Hardware .....	19
2.6 Installing the Software .....	20
2.7 Installing the USB Drivers (Windows) .....	21
2.8 Linux Support .....	22
2.9 Keyed Features .....	24

<b>3</b>	<b>How the Polaris Vicra System Works</b>	<b>25</b>
3.1	Introduction	25
3.2	Information Returned by the Polaris Vicra System	25
3.3	Global Coordinate System and Measurement Volume	26
3.4	Marker Detection and Tool Tracking	28
3.5	Polaris Vicra System Tools	30
3.6	Tool Definition File	31
3.7	Tool Tracking Parameters	31
3.8	Tool Tip Offset	35
3.9	Reference Tool	36
3.10	Stray Marker Reporting	37
3.11	Phantom Markers	38
3.12	Passive Sphere Markers	38
3.13	Active Markers	39
3.14	Filter Spectral Response	39
3.15	Data Transmission Rate	40
3.16	Serial Port Emulation	40
<b>4</b>	<b>Using the Polaris Vicra System</b>	<b>41</b>
4.1	Getting Started: Tracking Tools	41
4.2	Information and Error Flags	42
4.3	Setting a Tool as Reference	44
4.4	Determining the Tool Tip Offset	45
<b>5</b>	<b>Error Flags and Codes</b>	<b>48</b>
5.1	Missing and Disabled Transformations	48
5.2	Tracking Errors and Flags	49
5.3	Polaris Vicra System LEDs and Audio Codes	51
<b>6</b>	<b>Maintenance</b>	<b>52</b>
6.1	Position Sensor	52
6.2	Cables and Connectors	53

---

<b>7</b>	<b>Setting the Infrared Light Sensitivity</b>	<b>54</b>
7.1	IR Light Sensitivity Levels	54
7.2	Changing the Sensitivity Level	55
<b>8</b>	<b>Calibration and Firmware</b>	<b>57</b>
8.1	Checking the Calibration of the Polaris Vicra System	57
8.2	Updating the Firmware	58
<b>9</b>	<b>Approvals</b>	<b>59</b>
9.1	Optical Radiation Safety	59
<b>10</b>	<b>Classifications</b>	<b>60</b>
<b>11</b>	<b>Technical Specifications</b>	<b>61</b>
11.1	Position Sensor	61
11.2	Host USB Converter	62
11.3	Power Adapter	63
<b>12</b>	<b>Electromagnetic Compatibility</b>	<b>64</b>
12.1	Electrostatic Discharge	64
12.2	Cables and Accessories	64
12.3	Guidance and Manufacturer's Declaration - Electromagnetic Emissions	65
12.4	Guidance and Manufacturer's Declaration - Electromagnetic Immunity	65
12.5	Recommended Separation Distances	68
12.6	RF Emissions	68
<b>13</b>	<b>Troubleshooting</b>	<b>70</b>
13.1	Introduction	70
13.2	System Indications	70
13.3	NDI ToolBox Error Messages	72
13.4	Common Problems	74

14 Return Procedure and Warranty .....	77
14.1 Return Procedure .....	77
14.2 Warranty .....	77
15 Abbreviations and Acronyms .....	79
16 Equipment Symbols .....	80
17 Glossary .....	81
18 Declaration of Conformity .....	84
Appendix A Polaris Vicra Calibration Performance and Methodology .....	85
A.1 Polaris Vicra Performance .....	85
A.2 Calibration Method .....	85



# List of Figures

Figure 1-1	Polaris Vicra Measurement Volume .....	6
Figure 1-2	Polaris Vicra System Setup .....	7
Figure 1-3	Position Sensor - Front View .....	8
Figure 1-4	Position Sensor - Rear View .....	9
Figure 1-5	Position Sensor - Serial Number Label .....	9
Figure 1-6	Host USB Converter.....	11
Figure 1-7	Host USB Converter Serial Number label .....	12
Figure 1-8	Sample Passive Tool .....	13
Figure 2-1	Position Sensor Mounting Details .....	18
Figure 2-2	Host USB Converter Mounting Details .....	19
Figure 2-3	Connecting Cables to the Host USB Converter.....	20
Figure 3-1	Position Sensor Global Coordinate System .....	26
Figure 3-2	Characterized Measurement Volume.....	27
Figure 3-3	Determining a Marker Position .....	29
Figure 3-4	Marker With Marker Normal .....	32
Figure 3-5	Maximum Marker Angle .....	32
Figure 3-6	Flowchart of Tool Tracking Parameters Use .....	34
Figure 3-7	Sample Calibrator.....	36
Figure 3-8	Phantom Markers .....	38
Figure 3-9	Filter Spectral Response.....	40
Figure 4-1	Tool Tracking Window .....	42
Figure 4-2	Partially Out of Volume Flag .....	43
Figure 4-3	Markers Information Pane - Missing Marker.....	43
Figure 4-4	Transformation Pane - Too Few Markers .....	43

Figure 4-5 Markers Information Pane - Exceeded Max Marker Angle . . . . . 44

Figure 4-6 Selecting a Reference Tool . . . . . 44

Figure 4-7 Selecting a Tool to Pivot . . . . . 46

Figure 4-8 Pivoting Technique . . . . . 47

Figure 4-9 Pivot Result Dialog . . . . . 47

Figure 6-1 How to Avoid Stressed Cables . . . . . 53

Figure 7-1 Infrared Light Sensitivity Levels . . . . . 55

Figure 13-1 Host USB Converter - Error LED Fault Chart . . . . . 72

Figure 18-1 EC Declaration of Conformity . . . . . 84

---

## List of Tables

Table 1-1	Component Parts List	14
Table 9-1	Electrical Safety	59
Table 9-2	Electromagnetic Compatibility	59
Table 10-1	Classifications	60
Table 11-1	Position Sensor - Technical Specifications	61
Table 11-2	Position Sensor - Operating Environmental Conditions	61
Table 11-3	Position Sensor - Transportation and Storage Environmental Conditions	62
Table 11-4	Host USB Converter - Technical Specifications	62
Table 11-5	Host USB Converter - Operating Environmental Conditions	62
Table 11-6	Host USB Converter - Transportation and Storage Environmental Conditions	62
Table 11-7	Power Adapter - Technical Specifications	63
Table 11-8	Power Adapter - Operating Environmental Conditions	63
Table 11-9	Power Adapter - Transportation and Storage Environmental Conditions	63
Table 12-1	Cables and Accessories That Maintain Compliance	64
Table 12-2	Manufacturer's Declaration for Electromagnetic Emissions	65
Table 12-3	Electromagnetic Immunity	65
Table 12-4	Electromagnetic Immunity - Not Life Supporting	67
Table 12-5	Recommended Separation Distances	68
Table 13-1	System Visual and Audio Indications	70
Table 13-2	NDI ToolBox Error Messages	73



---

## Read Me First!

This guide provides detailed information about using the Polaris® Vicra™ Optical Tracking System. Read this section before continuing with the rest of the guide.

### Warnings



---

In all NDI documentation, warnings are marked by this symbol. Follow the information in the accompanying paragraph to avoid personal injury.

---

1. Do not use the Polaris Vicra System in the presence of flammable materials such as anaesthetics, solvents, cleaning agents, and endogenous gases. Flammable materials may ignite, causing personal injury or death.
2. Do not transport or store the Position Sensor outside the recommended storage temperature range, as this may cause the system to go out of calibration. Reliance on data provided by an out of calibration Position Sensor may lead to inaccurate conclusions and may cause personal injury. A calibration procedure must be performed before using the Position Sensor after it has been transported or stored outside the recommended storage temperature range.
3. Do not protect or shield either the Position Sensor or tools with methods not approved by NDI. Non-approved methods will interrupt the optical path and degrade the performance of the system. Reliance on data provided by a Position Sensor without an uninterrupted optical path may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.
4. Radio frequency communications equipment, including portable and mobile devices, may affect the Polaris Vicra System and result in personal injury.
5. Do not use cables or accessories, other than those listed in this guide. The use of other cables or accessories may result in increased emissions and/or decreased immunity of the Polaris Vicra System and may result in personal injury.
6. Do not incorporate non-NDI components with the Polaris Vicra System. The accuracy of results produced by applications that incorporate non-NDI components with the Polaris Vicra System is unknown. If your application involves personal safety, reliance on these results may increase the possibility of personal injury.
7. All user maintenance must be done by appropriately trained personnel. Individual components of the Polaris Vicra System contain no user-serviceable parts. Maintenance by untrained personnel may present an electric shock hazard.
8. Do not attempt to bypass the grounding prong on the power cord by using a three-prong to two-prong adapter. The system must be properly grounded to ensure safe operation. Failure to do so presents an electric shock hazard.
9. Do not immerse any part of the Polaris Vicra System or allow fluid to enter the equipment. If fluids enter any part of the system they may damage it and present a risk of personal injury.

10. Do not sterilize the Polaris Vicra Position Sensor as this may cause irreversible damage to its components. Reliance on data provided by a damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.
11. Do not use the Position Sensor without inspecting it for cleanliness and damage both before and during a procedure. Reliance on data provided by an unclean or damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.
12. Do not use the Polaris Vicra System for absolute measurements; the system is designed for relative measurements only. Treating measurements as absolute may result in an incorrect interpretation of results. If your application involves personal safety, these incorrect interpretations increase the possibility of personal injury.
13. Do not use a wireless tool whose design does not conform to the Polaris Vicra System's unique geometry constraints. When a Polaris Vicra System attempts to track more than one wireless tool in the measurement volume, these unique geometry constraints ensure that they are distinguishable from each other. Reliance on data produced by two indistinguishable tools can lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.
14. Do not use a tool with a tip without first performing a pivot procedure to verify the tip offset. Reliance on data produced by a tool with an inaccurate tip offset may lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.
15. Do not use markers without inspecting them for cleanliness and damage both before and during a procedure. Reliance on data produced by unclean or damaged markers may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.
16. Do not obstruct the normal flow of air around the Position Sensor (for example, draping or bagging the Position Sensor). Doing so will affect the Position Sensor's operational environment, possibly beyond its recommended thresholds. Reliance on data provided by a Position Sensor that is outside of recommended thresholds may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.

## Cautions

---

**Caution!** In all NDI documentation, cautions are marked with the word "Caution!". Follow the information in the accompanying paragraph to avoid damage to equipment.

---

1. To ship the Polaris Vicra System, repack it in the original containers with all protective packaging. The provided packaging is designed to prevent damage to the equipment.
2. Make sure that the mains power is disconnected before connecting or disconnecting cables. Failure to do so may cause damage to the equipment.

3. Always place the Position Sensor on a rigid support system. If not supported, the Position Sensor may fall which will affect the calibration and damage the Position Sensor.
4. Use only 70% isopropanol and a lens cleaning solution formulated for multi-coated lenses (for example, AR66) to clean the Position Sensor. Other fluids may cause damage to the illuminator filters. Do not use any paper products for cleaning. Paper products may cause scratches on the illuminator filters.

## Disclaimers

1. Read the entire “*Polaris Vicra User Guide*” before attempting to operate the Polaris Vicra System.
2. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
  - a) this device may not cause harmful interference, and
  - b) this device must accept any interference received, including interference that may cause undesired operation.

See Section 12.6 on page 68 for further information.

3. The user must determine the suitability of the Polaris Vicra System for their own application.
4. The Underwriters Laboratories Inc. (UL) recognition of the Polaris Vicra System includes only the Polaris Vicra Position Sensor, Host USB Converter and the APS APS49ES-24021/Hitron HES49ES-24021 power adapter. This investigation does not include the use of any other power adapter or source with the Polaris Vicra System. Any such configuration will require further investigation. If the Polaris Vicra System is used in a medical application, the final end-use configuration must be independently investigated to the IEC 60601 family of standards and all applicable national differences.
5. This equipment has been investigated with regard to safety from electrical shock and fire hazard. The inspection authority has not investigated other physiological effects.
6. The Polaris Vicra Position Sensor requires a thermal stabilization period in order to provide reliable measurements. Up to 10 minutes are required for the optical components to reach operating temperature from a cold-start at normal room temperature. Testing should be conducted to determine the thermal stabilization time necessary specific to your application requirements. NDI recommends that a reference tool be used with its systems whenever possible, to ensure there is no drift in the measurement caused by time, settling and/or temperature.
7. Northern Digital Inc. has not investigated the implications of incorporating the Polaris Vicra Position Sensor with an automatic position device, or any other automated closed loop systems. Using the Polaris Vicra System in such an application is solely the responsibility of the user.
8. Northern Digital Inc. has not fully validated the Polaris Vicra Position Sensor in an MRI environment. If the Polaris Vicra Position Sensor is used in an MRI environment, the user is responsible for determining the performance of the system, including accuracy, in an MRI environment.

9. The Polaris Vicra System emits IR light that may interfere with IR controlled devices, such as operating room tables. It is recommended that you test the Polaris Vicra System if you intend to use it in an environment where other IR controlled devices are in use.
10. The Polaris Vicra Position Sensor is designed to ingress protection level IP54, but this evaluation was not included in the UL investigation.

## Contact Information

If you have any questions regarding the content of this guide or the operation of this product, please contact us:



**INTERNATIONAL HEADQUARTERS:  
NORTHERN DIGITAL INC.**

103 Randall Drive  
Waterloo, ON, Canada N2V 1C5

Phone: +1 (519) 884-5142  
Toll Free: +1 (877) 634-6340  
Global: + (800) 634-634-00  
Fax: +1 (519) 884-5184

Email: [polaris@ndigital.com](mailto:polaris@ndigital.com)  
Website: [www.ndigital.com](http://www.ndigital.com)

**EUROPEAN OFFICE:  
NDI EUROPE GmbH**

Fritz-Reichle-Ring 2  
D-78315 Radolfzell  
Germany

Phone: + 49 (77 32) 939 19 00  
Global: + (800) 634 634 00  
Fax: + 49 (77 32) 939 19 09

Email: [polaris@ndieurope.com](mailto:polaris@ndieurope.com)  
Website: [www.ndieurope.com](http://www.ndieurope.com)

**ASIA PACIFIC OFFICE:  
NDI ASIA PACIFIC**

Room 2603, 26th Floor  
Office Tower, Convention Plaza  
1 Harbour Road  
Wanchai, Hong Kong

Phone: + (852) 2802 2205  
Fax: + (852) 2802 0060

Email: [APinfo@ndigital.com](mailto:APinfo@ndigital.com)  
Website: [www.ndigital.com](http://www.ndigital.com)

## Updates

NDI is committed to continuous improvements in the quality and versatility of its software and hardware. To obtain the best results with your NDI system, check the NDI Support Site regularly for update information:

<http://support.ndigital.com>



## About This Guide

### Organization of Content

These sections explain how the system works and how to set it up for use. Read these sections **before** using the Polaris Vicra System:

- Polaris Vicra System Overview
- Setting up the Polaris Vicra System
- How the Polaris Vicra System works
- Using the Polaris Vicra System

These sections provide information that may be useful during the operation of the system:

- Error Flags and Codes
- Setting the Infrared Light Sensitivity
- Maintenance

These sections may be needed for occasional reference; typically, you will not need to refer to them during the day-to-day operation of the Polaris Vicra System:

- Calibration and Firmware
- Approvals and Classifications
- Technical Specifications
- Electromagnetic Compatibility
- Troubleshooting
- Return Procedure and Warranty
- Appendix A: Polaris Vicra Calibration Performance and Methodology

# 1 Polaris Vicra System Overview

## 1.1 Introduction

The Polaris Vicra System is an optical measurement system that measures the 3D positions of either active or passive markers affixed to application-specific tools. Using this information, the Polaris Vicra System is able to determine the position and orientation of tools within a specific measurement volume. A 3D representation of the measurement volume is shown below in [Figure 1-1](#).

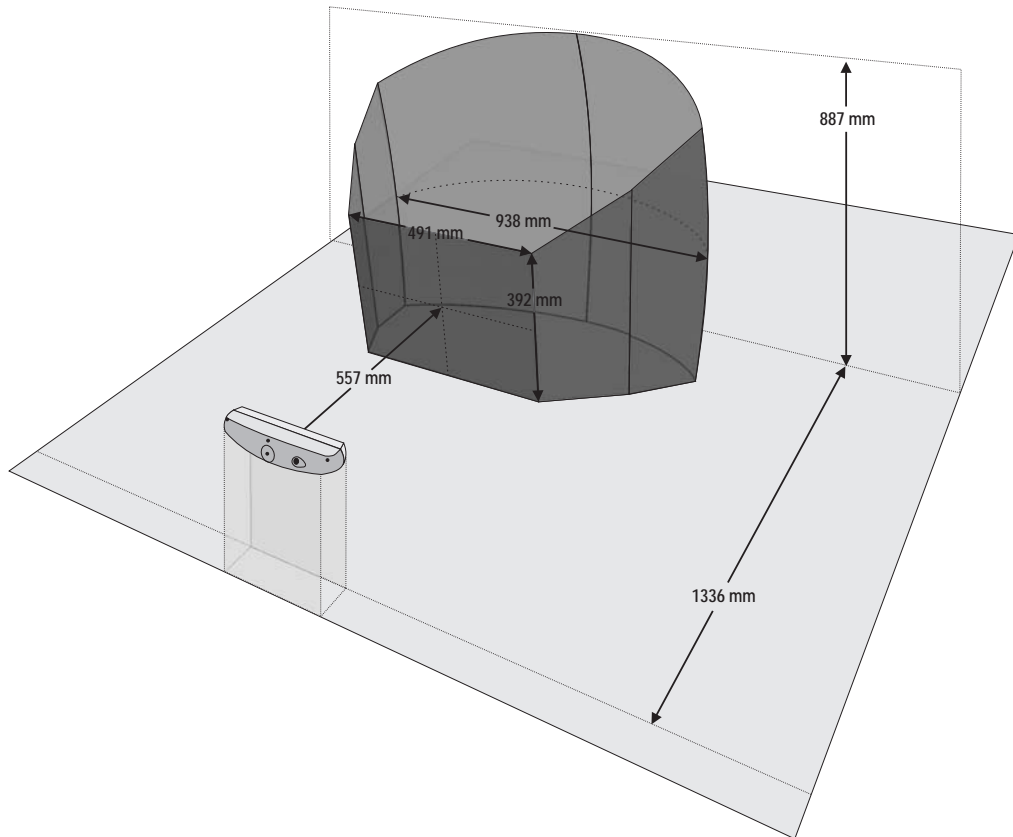


Figure 1-1 Polaris Vicra Measurement Volume

The system has applications in a range of industries, including:

- medical
- dental
- research

The system consists of a Position Sensor, a Host USB Converter, a power adapter, and cables, see [Figure 1-2](#). A host computer is also required to operate the system. The host computer must be approved to IEC60950 or IEC60601 standard and meet the following minimum specifications:

- Pentium Processor (>1GHz recommended)
- 256Mb Random Access Memory (RAM)

- 75Mb free disc space
- Windows 200/XP or Linux 2.6.8 or greater
- Screen resolution 1024x768 (1280x1024 recommended)

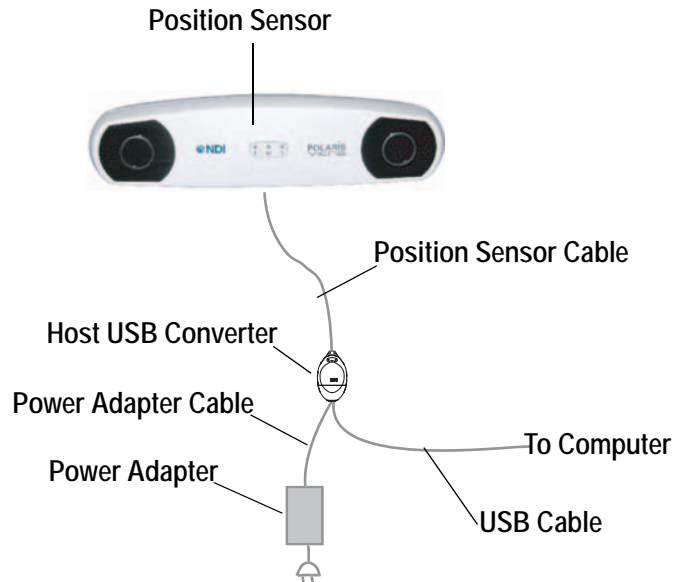


Figure 1-2 Polaris Vicra System Setup

## 1.2 Position Sensor

The Position Sensor is the main component of the Polaris Vicra System. An overview of its operation is as follows:

1. The Position Sensor emits infrared (IR) light from its illuminators, similar to the flash on a conventional camera.
2. The IR light floods the surrounding area and reflects back to the Position Sensor off passive sphere markers (passive mode) or triggers markers to activate and emit IR light (active wireless mode).
3. The Position Sensor then measures the positions of the markers, and calculates the transformations (the positions and orientations) of the tools to which the markers are attached.
4. The Position Sensor transmits the transformation data, along with status information, to the host computer for collection, display, or further manipulation.

---

**Note** For a more detailed description of how the Position Sensor detects markers, see [“Marker Detection and Tool Tracking” on page 28](#).

---

The Position Sensor can operate in two modes; passive mode and active wireless mode. The mode is automatically selected, controlled by settings in the tool definition file. (A tool definition file stores information about a tool.)

## Front View

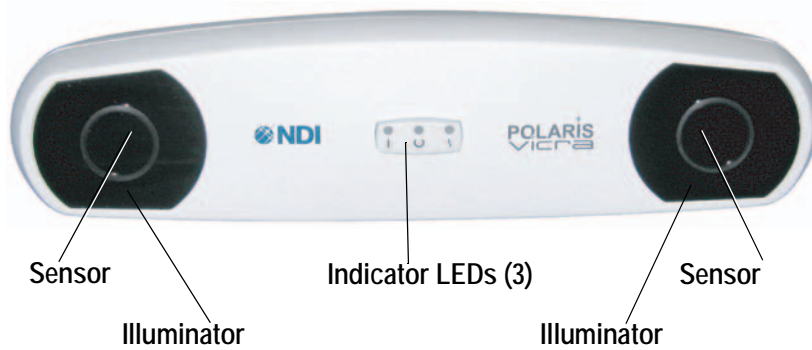





Figure 1-3 Position Sensor - Front View

The front of the Position Sensor incorporates the following components:

**Illuminator** Two arrays of infrared Light Emitting Diodes (IREDs) that provide IR light for the passive sphere markers or a “chirp” activation trigger for active markers.

**Sensor** Two sensors that each comprise a lens and CCD. They collect IR light that is reflected from passive sphere markers (passive mode) or emitted from active markers (active wireless mode).

**Indicator LED** Three LEDs that provide the following indications (left to right):

- **Power LED** : Flashes green during system warm-up. Steady green when system is ready for use.
- **Status LED** : Steady green when the communications connection is available.
- **Error LED** : Lights steady amber if a critical error is detected (Position Sensor must be returned to NDI). Flashes amber if a non-critical error is detected (for example, a firmware update is not completed).

---

**Note** If a non-critical error is detected (error LED is flashing), refer to the NDI ToolBox application to further diagnose the fault. (The nature of the error is described on the NDI ToolBox initial page.) If you are using your own applications, use the GET command to read the “Info.StatusAlert” parameter to check the alert status. Refer to the *“Polaris Application Program Interface Guide”* for further information.

---

## Rear View



Figure 1-4 Position Sensor - Rear View

The rear of the Position Sensor incorporates the components detailed below:

**Mount** 1/4" thread tripod mount, that incorporates three M3 x 0.5 mm x 8 mm threads.

**Connector (LEMO)** A 14 pin connector that provides power to the Position Sensor and allows communications to/from the Position Sensor.

---

**Note** It is good practice to disconnect mains power before connecting or disconnecting cables. Failure to do so may cause damage to the equipment.

---

## Serial Number Label

The serial number label is located on the bottom of the Position Sensor and shows the Item ID, model, serial number, and manufacture date of the Position Sensor.

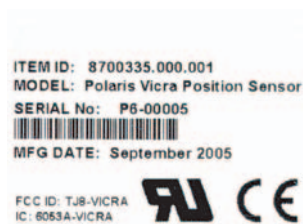


Figure 1-5 Position Sensor - Serial Number Label

## Audio Codes

In addition to the indicator LEDs, the Position Sensor emits audio tones to alert the user to events. The codes are interpreted as follows:

- Two tones are emitted on reset or when power is applied to the Position Sensor. (This feature can be disabled in NDI Tool Box software.)
- If the host computer does not send a command to the system within a given time, the Position Sensor will emit two quick tones every three seconds. (This feature is an application watchdog and is set by the API command HWCDOG.)

- The API command BEEP can be used to set up to nine tones as required. Refer to the “*Polaris Application Program Interface Guide*” for further details on setting the BEEP command.

### Bump Sensor

The Position Sensor houses a bump sensor that detects when the Position Sensor has been bumped above a shock limit broadly equivalent to a 200 mm to 254 mm drop onto a vinyl tiled concrete surface. If a bump is detected above this threshold, the error LED on the Position Sensor will flash, indicating that a non-critical error has been detected.

You can check the bump sensor status using NDI ToolBox application software. For further information on NDI ToolBox, refer to the online help.

Because a bump can affect the calibration of the Position Sensor, the system will not report transformations if the bump sensor has detected a bump, unless:

- the bump sensor has been cleared, or
- reply option 0x0800 is used with the TX or BX command.

---

**Note** See the “*Polaris Application Program Interface Guide*” for details on checking and clearing the bump sensor, and using the TX, BX and GET commands.

---

If a bump has been detected, NDI recommends that you perform an accuracy assessment procedure with the NDI Accuracy Assessment Kit (AAK), to ensure that the Position Sensor is still calibrated. For information on the accuracy assessment procedure and AAK, contact NDI or visit the support site at <http://support.ndigital.com>.

The bump sensor circuit derives its power from an internal battery that has an operational life of approximately 10 years. As the battery begins to lose power, the battery alert flag (in the Info.Status.Alerts parameter) will be set intermittently. This will cause the error indicator LED on the Position Sensor to flash. The intermittent indication is caused by the battery voltage fluctuating about the fault threshold level. (The Position Sensor must be returned to NDI to have the battery replaced.)

---

**Note** The bump sensor battery is a Lithium battery. If you dispose of the Position Sensor locally, make sure that you adhere to all applicable legislation and regulations relating to the disposal of Lithium batteries.

---

### Ingress Protection

The Position Sensor is designed to an ingress protection level of IP 54. The “5” denotes that the Position Sensor is protected against dust. The “4” denotes that the Position Sensor is protected against liquid sprayed in all directions. To maintain an ingress protection level of IP 54, the Position Sensor cable (attached to the Host USB Converter) must be plugged in. For details on connecting the system, see “[Connecting the Hardware](#)” on page 19.

## 1.3 Host USB Converter

The Host USB Converter provides the interface between the Position Sensor, the power adapter, and the host computer:

- The attached Position Sensor cable connects the Host USB Converter to the Position Sensor.
- The power adapter and USB cable plugs into the Host USB Converter.
- Modem status bits are provided see “[Serial Port Emulation](#)” on page 40.

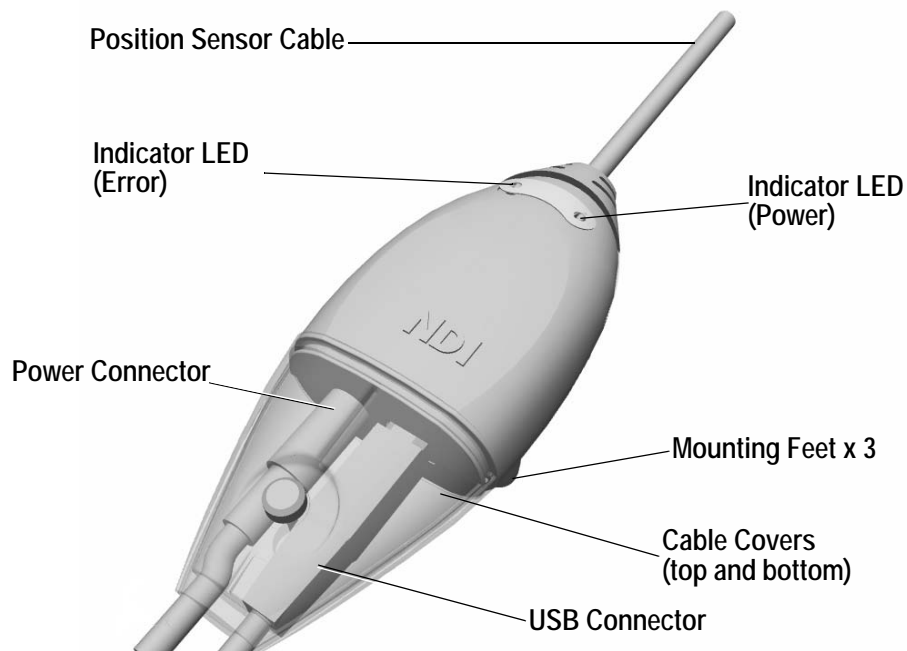


Figure 1-6 Host USB Converter

The Host USB Converter incorporates the sub-assemblies detailed below.

**Cable Covers:** Two covers (top and bottom) that are secured together by means of a thumbscrew. The covers retain the USB and power adapter cables in place.

**Position Sensor Cable:** Provides connection for data and power between the Position Sensor and Host USB Converter. This cable is permanently connected to the Host USB Converter and is either 4.5 m or 8 m, depending on the configuration of your system.

**Power Indicator:** Lights green when power is applied to the Host USB Converter.

**Error Indicator:** Lights amber when the Host USB Converter has detected a fault.

**Mounting Feet:** Three feet that incorporate an internal thread (M6 x 1 mm pitch x 4 mm depth) to allow the Host USB Converter to be attached to an external structure (for example, a cart). For free-standing use, rubber inserts are located in the mounting feet.

## Serial Number Label

The serial number label is located on the bottom of the Host USB Converter and shows the Item ID, model, serial number, and manufacture date of the Host USB Converter.



Figure 1-7 Host USB Converter Serial Number label

## 1.4 Power Adapter

The system is powered by an NDI supplied power adapter (Advanced Power Systems, part number APS49ES-24021/Hitron HES49ES-24021). The power adapter connects to the mains supply and provides DC power to the Position Sensor via the Host USB Converter. Alternatively, power may be supplied by a customer provided power adapter that meets the following criteria:

- medical grade, double insulated (required if end use will be in a medical environment)
- 12/24 V DC, 1.2 A output (40 W typical)
- Switchcraft part number 760 plug (or equivalent)

---

**Note** Please see disclaimer #4 on page 3 for information regarding the UL recognition and alternate power supplies.

---

**Note** If a non-NDI supplied power adapter is used, it should be chosen to suit the particular use and the resulting system configuration must be verified for electrical safety by an approved test laboratory. For further information contact NDI.

---

## 1.5 Cables

NDI supplies additional cables for use with the system:

**Position Sensor Cable:** Provides connection for data and power between the Position Sensor and Host USB Converter. This cable is permanently connected to the Host USB Converter and is either 4.5 m or 8 m, depending on the configuration of your system.

**USB Cable:** Provides connection for data between the host computer and Host USB Converter. This cable is a USB, A-B male, double shielded, 5 m cable.

**Power Adapter Output Cable:** Provides connection for power to the Host USB Converter. This cable is permanently connected to the power adapter and has a plug-in jack connector to connect to the Host USB Converter.

**Power Adapter Power Cable:** Connects the power adapter to the mains supply. This cable is a medical grade AC line cord.



## 1.6 Polaris Vicra Tools

The Polaris Vicra System utilizes wireless tools, which may be active or passive. Passive tools incorporate retro-reflective passive markers and active wireless tools incorporate IRED markers. The Position Sensor tracks tools based on the geometry of the markers on each tool. The system can track up to six compatible tools simultaneously and these may include both active wireless and passive tools.

The Position Sensor requires a tool definition file for each tool. A tool definition file describes a tool to the Position Sensor (including the tool's marker geometry). The tool definition file for a particular tool must be loaded from the host computer before the Polaris Vicra System can track that tool.

---

**Note** For more information on tool definition files, see [“Tool Definition File” on page 31](#). Polaris Vicra System tools are described in more detail in [“Polaris Vicra System Tools” on page 30](#).

---

**Note** For information on tool design and construction, refer to the *“Polaris Tool Design Guide”*.

---

### Passive Tools

Passive tools incorporate NDI passive sphere markers. The passive sphere markers have a retro-reflective coating that reflects IR light back to its source, instead of scattering it. As such, the IR light from the Position Sensor illuminators reflects off the markers directly back to the sensors.

Markers can be attached to an object such that the markers are fixed with respect to one another, to form a tool. The markers must be attached to the object using NDI mounting posts, which are manufactured to firmly hold NDI spheres. The Polaris Vicra System can track the positions and orientations of tools, and can also report the positions of individual passive spheres.

An example of a passive tool is shown in [Figure 1-8](#). The example shows a probe that incorporates four passive sphere markers.

For more information on passive sphere markers, see [“Passive Sphere Markers” on page 38](#).

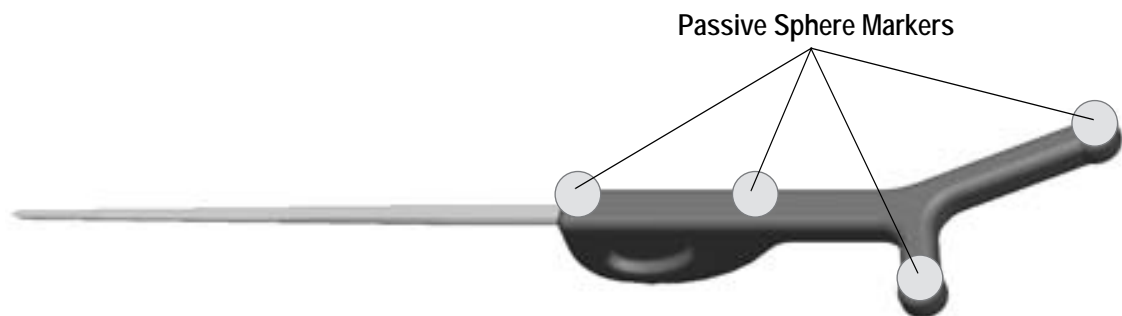


Figure 1-8 Sample Passive Tool

### Active Wireless Tools

Active wireless tools incorporate IRED markers that emit IR light. The markers are incorporated in tools that also house an IR receiver and a (battery) power source. The (previously loaded) tool definition file identifies it to the system as an active wireless tool.

The Position Sensor codes (“chirps”) the IR pulses emitted from its illuminators. These coded IR pulses are received by the IR receiver on the tool which then activates the IREDS. The Position Sensor receives the IR emitted by the IREDS and processes it in the same manner as passive tool reflections.

For more information on IRED markers, see “Active Markers” on page 39.

## 1.7 Polaris Vicra System Software

The following software is included on the Polaris Vicra CD. You can also download the software from the NDI Support Site at: <http://support.ndigital.com>.

**NDI CAPI Sample** A sample program written for Windows, and the source code for the program. This program provides an example of how to write programs to operate the Polaris Vicra System.

**NDI ToolBox** Use this program to configure, upgrade, troubleshoot, and test the Polaris Vicra System. For more information, see the NDI ToolBox online help.

---

**Note** NDI 6D Architect application software is located on the CD that accompanies the developer kit.

---

## 1.8 Component Parts List

The following is a list of components that are available with the Polaris Vicra System:.

Table 1-1 Component Parts List

Item	Part Number
Polaris Vicra Position Sensor	8800788.xxx.yyy
Polaris Host USB Converter (incorporating 4.5 m communications cable)	8800810.001
Polaris Host USB Converter (incorporating 8 m communications cable)	8800810.002
Polaris Vicra Power Adapter	4100139
Power Cord	7500010 (North America) or 7500012 (France/Belgium/Germany)
Universal Serial Bus (USB) A-B cable 2 m	2600596
Polaris Vicra CD	1800042
Polaris Vicra User Guide	IL-1070100

---

**Note** Additional components are available to support the Polaris Vicra System. Contact NDI for further details, or visit the Support site at <http://support.ndigital.com>.

---

## 2 Setting Up the Polaris Vicra System

### 2.1 Unpacking the Polaris Vicra System

The Polaris Vicra System is shipped with a Position Sensor, a Host USB Converter, a power adapter, cables, the Polaris Vicra CD, and documentation.

When unpacking the Polaris Vicra System, be sure to handle all system components with care. Keep the packaging in good condition; you will need to use it if the system ever needs to be returned to NDI for repair.

---

**Note** See [“Return Procedure” on page 77](#) for instructions on returning your system to NDI.

---

### 2.2 Polaris Vicra System Operating Environment

In order for the Polaris Vicra System to operate correctly, the system must be set up in an environment that meets the following criteria:



#### Warnings

**Warning!**

Read the following warnings before using the Polaris Vicra System, to avoid the risk of personal injury.

- 1. Do not use the Polaris Vicra System in the presence of flammable materials such as anaesthetics, solvents, cleaning agents, and endogenous gases. Flammable materials may ignite, causing personal injury or death.**
- 2. Do not protect or shield either the Position Sensor or tools with methods not approved by NDI. Non-approved methods will interrupt the optical path and degrade the performance of the system. Reliance on data provided by a Position Sensor without an uninterrupted optical path may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.**
- 3. Radio frequency communications equipment, including portable and mobile devices, may affect the Polaris Vicra System and result in personal injury.**
- 4. Do not use cables or accessories, other than those listed in this guide. The use of other cables or accessories may result in increased emissions and/or decreased immunity of the Polaris Vicra System and may result in personal injury.**
- 5. Do not incorporate non-NDI components with the Polaris Vicra System. The accuracy of results produced by applications that incorporate non-NDI components with the Polaris Vicra System is unknown. If your application involves personal safety, reliance on these results may increase the possibility of personal injury.**
- 6. Do not attempt to bypass the grounding prong on the power cord by using a three-prong to two-prong adapter. The system must be properly grounded to ensure safe operation. Failure to do so presents an electric shock hazard.**

7. **Do not immerse any part of the Polaris Vicra System or allow fluid to enter the equipment. If fluids enter any part of the system they may damage it and present a risk of personal injury.**
8. **Do not sterilize the Polaris Vicra Position Sensor as this may cause irreversible damage to its components. Reliance on data provided by a damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.**
9. **Do not use the Position Sensor without inspecting it for cleanliness and damage both before and during a procedure. Reliance on data provided by an unclean or damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.**
10. **Do not use the Polaris Vicra System for absolute measurements; the system is designed for relative measurements only. Treating measurements as absolute may result in an incorrect interpretation of results. If your application involves personal safety, these incorrect interpretations increase the possibility of personal injury.**
11. **Do not obstruct the normal flow of air around the Position Sensor (for example, draping or bagging the Position Sensor). Doing so will affect the Position Sensor's operational environment, possibly beyond its recommended thresholds. Reliance on data provided by a Position Sensor that is outside of recommended thresholds may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.**

## Cautions

**Caution!** Read the following cautions before using the Polaris Vicra System to prevent the risk of damage to the system.

1. **Make sure that the mains power is disconnected before connecting or disconnecting cables. Failure to do so may cause damage to the equipment.**
2. **Always place the Position Sensor on a rigid support system. If not supported, the Position Sensor may fall which will affect the calibration and damage the Position Sensor.**

## Operating Environment

- There must be a clear line of sight between the Position Sensor and the tools to be tracked. The tools must be inside the characterized measurement volume. Refer to [Figure 3-2 on page 27](#) for the dimensions of the characterized measurement volume.
- Make sure that sources of background IR light in the 800 nm to 1100 nm range (e.g. sunlight, some operating room lights) are minimized. The Position Sensor is sensitive to IR light. Since the Position Sensor functions by detecting IR light reflected from, or emitted by, markers, other sources of IR light can interfere with the Polaris Vicra System.
- Make sure that there are no large reflective surfaces within the field of view (described on page 26). For example, the gantry for a magnetic resonance imaging (MRI) machine has a

large reflective surface. It can be draped with non-reflective material to eliminate reflections.

- Make sure that the tools do not have flat reflective surfaces. Certain tool shapes and surfaces can cause reflections that may interfere with the Polaris Vicra System. For more information, see the “*Polaris Tool Design Guide*”.
- The system requires a warm-up time from storage temperature to operating temperature equivalent to 10 minutes plus one minute for every 1°C of difference between storage temperature and operating temperature. (If the temperature difference is within 5°C, the warm-up time will be 10 minutes.)  
For example, if the system is stored at -10°C and moved to a location at +30°C, the warm-up time will be 10 minutes, plus an additional 40 minutes to account for the difference in temperature.
- The operating environment is as close as possible to 20°C. The Polaris Vicra System is characterized at 20°C and is therefore most accurate at this temperature.
- If the system is to be used in an MRI environment, contact NDI for information on response of the system.

## 2.3 Mounting the Position Sensor

The Position Sensor is mounted via a built-in 1/4" thread tripod mount, or 3 (user supplied) M3 x 0.5 mm pitch x 9 mm screws. [Figure 2-1](#) shows the Position Sensor dimensions and mounting arrangement.

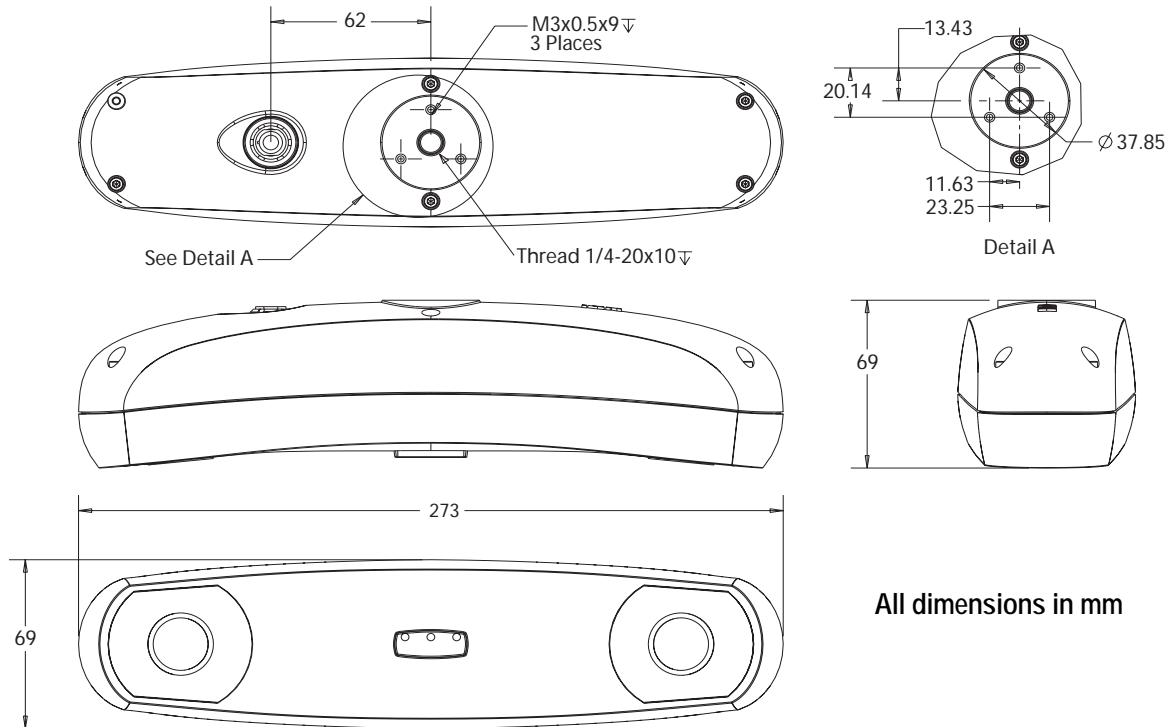


Figure 2-1 Position Sensor Mounting Details

## 2.4 Mounting the Host USB Converter

The Host USB Converter can be free-standing or may be mounted via M6 x 1 mm pitch x 4 mm deep threaded holes located in the three mounting feet. [Figure 2-2](#) shows the Host USB Converter mounting arrangement, with dimensions.

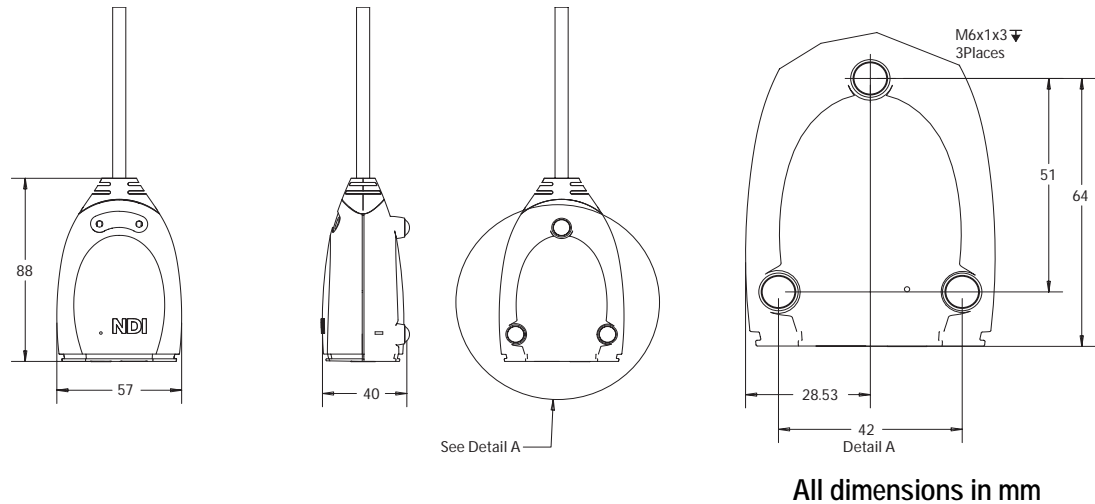


Figure 2-2 Host USB Converter Mounting Details

## 2.5 Connecting the Hardware

---

**Note** It is good practise to disconnect the mains power before connecting or disconnecting cables.

---

1. Connect the Position Sensor cable (attached to the Host USB Converter) to the connector located on the back of the Position Sensor. Align the red marking on the Position Sensor connector with the red marking on the cable connector (the double keys of the connectors should be aligned).
2. Connect the USB cable B plug and power adapter cable to the Host USB Converter, as shown in [Figure 2-3](#).
3. Locate the top and bottom cable covers in place on the Host USB Converter. Secure the covers with the thumbscrew, as shown in [Figure 2-3](#).

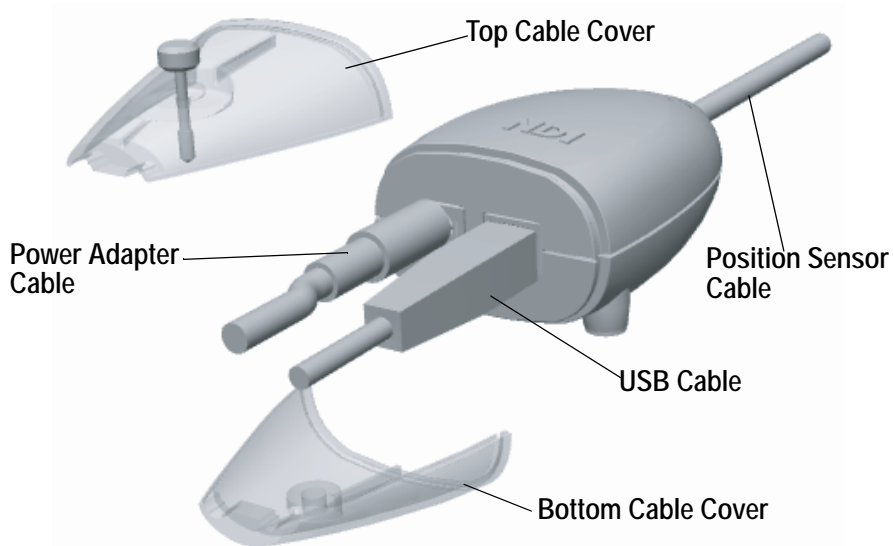


Figure 2-3 Connecting Cables to the Host USB Converter

4. Plug the USB cable A plug into the host computer.
5. Make sure all the cables are connected firmly, and placed where they will not be stressed, stepped on, or bent.
6. Plug the power cable into the power adapter and plug the power cable into the power mains and turn on the mains.

The Polaris Vicra System will begin a diagnostic evaluation. During this evaluation, the LEDs on the Position Sensor will flash. When the diagnostic evaluation is complete, the Position Sensor will emit two tones and the power LED on the Position Sensor will light.

---

**Note** The Position Sensor initially communicates to the host computer at 9600 baud. If you are using the NDI ToolBox application it will increase the baud rate as high as possible. If you are using your own application, the baud rate can be set using the "COMM" API command. Refer to the "*Polaris Application Program Interface Guide*".

---

## 2.6 Installing the Software

The NDI software is located on the Polaris Vicra CD. You can also download the software from the NDI Support Site at

<http://support.ndigital.com>.

---

**Note** The Polaris Vicra CD does not contain NDI 6D Architect. That software application is located on the CD that accompanies the developer kit.

---

### NDI Combined API Sample

To install NDI Combined API Sample, copy the contents of the "CombinedAPISample" folder from the Polaris Vicra CD onto the host computer.



---

## NDI ToolBox (Windows Installation)

---

**Note** For information on Linux support, refer to [“Linux Support” on page 22](#).

---

To install NDI ToolBox: Follow the on-screen instructions from the auto-run window that appears when you insert the Polaris Vicra CD into the drive. Alternatively, on the Polaris Vicra CD, browse to Windows\ToolBox\ directory and double-click install.exe.

Once you start the installation from the install page, a wizard appears. Follow the on-screen instructions to complete the process. The default installation location is C:\Program Files\Northern Digital Inc.\ToolBox

---

**Note** The installation of NDI ToolBox also includes installing the drivers for the Host USB Converter. The default installation location is C:\Program Files\Northern Digital Inc.\ToolBox\USB Driver.

---

---

**Note** The NDI ToolBox installation includes a Java virtual machine (VM) for Windows and Linux systems. The Java VM included in the NDI ToolBox installation is fully compatible with NDI ToolBox. Other versions of Java VM may cause NDI ToolBox to exhibit unusual or unpredictable behaviour.

---

## 2.7 Installing the USB Drivers (Windows)

The Windows driver model consists of two parts; low-level USB and high-level virtual serial port. It appears as a Windows serial port, COMx (where x is enumerated) and emulates a standard PC serial port such that the Host USB Converter may be communicated with as a standard RS-232 device.

---

**Note** For information on Linux support, refer to [“Linux Support” on page 22](#).

---

When you first connect the NDI Host USB Converter to the host computer, you will need to install drivers for the Host USB Converter. There are two sets of drivers for the Host USB Converter:

- the first set of drivers enables the Host USB converter to work with the host computer
- the second set of drivers sets up the USB port where the Host USB Converter is connected to emulate a serial port

### Driver Location

If you have already installed NDI ToolBox, the USB drivers were installed as part of that installation. By default, the drivers are located at C:\Program Files\Northern Digital Inc.\ToolBox\USB Driver. (See [“NDI ToolBox \(Windows Installation\)” on page 21](#).)

The drivers are also located on the Polaris Vicra CD in the USB Driver folder.

### Installing the USB Drivers

1. When you first connect the Host USB Converter to the host computer, the **Found New Hardware** wizard will begin automatically.

2. When prompted, select the option that allows you to specify the drivers' location. ("Install from a specific list or location" in Windows XP, "Search for a suitable driver" in Windows 2000.)
3. Browse to the folder containing the drivers, either on the host computer or on the Polaris Vicra CD. Windows will automatically select the correct drivers from the folder.
4. Click **Next** and **Finish** as required to complete the installation.

---

**Note** Windows XP only: After you have selected the folder containing the USB drivers, a warning may appear, indicating that the drivers have not passed Windows Logo testing. Click "Continue Anyway".

---

5. Once the first set of drivers is installed, the **Found New Hardware Wizard** will launch a second time. Follow steps 2 to 4 above to install the second set of drivers.
6. The system will now appear to be connected through a virtual COM port.

Host USB converters are interchangeable on the same USB port, without having to re-install drivers or losing the COM port previously established.

The Windows COM number assigned can be changed after installation as follows:

1. Launch **Device Manager**
2. Navigate to **Ports (COM & LPT)**
3. Right click on the Host USB Converter
4. Select the **Properties** pop-up menu
5. Select the **Port Settings** tab
6. Click on the **Advanced Settings** button
7. From the dialog box that is displayed, select the **Com Port Number** drop down field
8. Reassign the COM port as necessary
9. Select **OK** to save the changes

Windows will remember this mapping even if the Host USB Converter is unplugged from the USB port. When the Host USB Converter is reconnected to the host computer, the COM port mapping will be re-established (if it is plugged into the same USB port).

## 2.8 Linux Support

### Introduction

This section provides information on Linux support for the Polaris Vicra System and covers the following:

- USB Drivers
- NDI ToolBox

## Installing the USB Drivers

The Linux driver model is a kernel level driver that supports the USB to serial conversion. It appears as a Linux device file “/dev/ttyUSBx” (where x is enumerated) and emulates a standard PC serial port such that the USB device may be communicated with as a standard RS-232 device. NDI has provided a patch to the 2.6.8 kernel driver source files.

These instructions are based on the Linux 2.6.8 kernel. The following changes are captured in the `ftdi.patch` file.

In the directory `/usr/src/linux-2.6.8-24/drivers/usb/serial`:

1. `ftdi_sio.c` - added NDI Host USB Converter Product ID (PID) to supported devices tables, added aliasing of 19.2K baud for the Host USB Converter to use 1.2Mbaud as required by NDI ToolBox.
2. `ftdi_sio.h` - added the define for the USB PID for the Host USB Converter.

Apply the patch to an unmodified kernel as follows:

1. logon as root user.
2. `cd /usr/src/linux-2.6.8-24.`
3. `patch -p1 < ftdi.patch.`
4. rebuild the kernel following the instructions specific to the kernel.
5. the NDI Host USB Converter when connected will appear as `"/dev/ttyUSBx"`, where 'x' is the part number.

Host USB converters are interchangeable on the same USB port, without having to re-install drivers or losing the device file enumeration previously established.

## NDI ToolBox

Install NDI ToolBox as follows:

1. On the Polaris Vicra CD, browse to `Linux/ToolBox/install.bin`.
2. Follow the on-screen instructions to complete the process. The default installation location is `<user_account>/ToolBox`.
3. The installation of NDI ToolBox also downloads the kernel patch file to apply to drivers for the Host USB Converter. The default download location is `<user_account>/ToolBox/kernel-2.6.8-usb-patch`.

---

**Note** The NDI ToolBox download includes a Java virtual machine (VM) for Windows and Linux systems. The Java VM included in the NDI ToolBox download is fully compatible with NDI ToolBox. Other versions of Java VM may cause NDI ToolBox to exhibit unusual or unpredictable behaviour.

---

## 2.9 Keyed Features

In addition to the base configuration, certain options are available as keyed features for the Polaris Vicra System. For example the ability to use multiple versions of firmware is a keyed feature. For information on current keyed features and how to purchase them, please contact your nearest NDI location. See Contact Information on page 4 for your nearest NDI location.

Refer to NDI ToolBox application software online help for details on retrieving your current system configuration and for installing additional keyed features.

## 3 How the Polaris Vicra System Works

### 3.1 Introduction

This chapter provides details on how the Polaris Vicra System works. The information is not absolutely necessary in order to use the system, but it can help increase your technical understanding of the system. For information on how to use the system, refer to [“Using the Polaris Vicra System” on page 41](#).

### 3.2 Information Returned by the Polaris Vicra System



**Warning!**

Do not use the Polaris Vicra System for absolute measurements; the system is designed for relative measurements only. Treating measurements as absolute may result in an incorrect interpretation of results. If your application involves personal safety, these incorrect interpretations increase the possibility of personal injury.

When the Polaris Vicra System is tracking tools, it returns information about those tools to the host computer. The system by default returns:

- **the position of each tool’s origin**, given in mm, in the coordinate system of the Position Sensor (see [“Global Coordinate System” on page 26](#))

**Note** Transformations with respect to a reference tool (described on page 36), and transformations for a probe with a tool tip offset (described on page 35) are calculated using application software such as NDI ToolBox.

- **the orientation of each tool**, given in quaternion format. The quaternion values are rounded off, so the returned values may not be normalized
- **an error value** for each tool transformation. This RMS value, given in mm, is the result of the least squares minimization between the marker geometry in the tool definition file and the tool’s measured marker positions
- **the status of each tool**, indicating whether the tool is out-of-volume, partially out-of-volume, or missing. It also indicates whether the port handle corresponding to each tool is enabled and initialized. For more information on port handles, see the *“Polaris Application Program Interface Guide”*
- **the frame number** corresponding to each tool transformation
- **the system status**, which includes some of the system errors described in [“Tracking Errors and Flags” on page 49](#)

If requested, the system can also return:

- tracking errors and flags (described in [“Tracking Errors and Flags” on page 49](#)). (Some tracking errors and flags are returned by default.
- marker status information, such as whether a particular marker was used to calculate a tool transformation

- transformations for tools that are outside of the characterized measurement volume
- positions of stray passive markers

NDI ToolBox displays most of this returned information (except for the port handle information).

---

**Note** For information on the API commands used to request tracking information from the Polaris Vicra System, see the "*Polaris Application Program Interface Guide*".

---

### 3.3 Global Coordinate System and Measurement Volume

#### Global Coordinate System

The Polaris Vicra Position Sensor uses a coordinate system with an origin located at the Position Sensor and axes aligned as shown in [Figure 3-1](#). This global coordinate system is defined during manufacturing and cannot be changed.

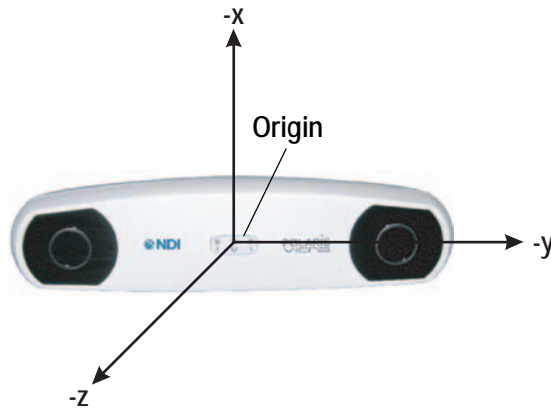


Figure 3-1 Position Sensor Global Coordinate System



**Warning!**

Do not use the Polaris Vicra System for absolute measurements; the system is designed for relative measurements only. Treating measurements as absolute may result in an incorrect interpretation of results. If your application involves personal safety, these incorrect interpretations increase the possibility of personal injury.

---

The Polaris Vicra System will report the transformations of tools in the global coordinate system. However, if you are using a reference tool, software can calculate and report transformations in the local coordinate system of the reference tool. For more information on reference tools, see [“Reference Tool” on page 36](#).

#### Field of View and Characterized Measurement Volume

The **field of view** is the total volume in which the Polaris Vicra System can detect a marker, regardless of accuracy.

The **characterized measurement volume** is a subset of the field of view. It is the volume where data was collected and used to characterize the Polaris Vicra System Position Sensor. The dimensions of the characterized measurement volume are illustrated in [Figure 3-2](#).

Within the characterized measurement volume, the Polaris Vicra System can measure a single marker with an accuracy of 0.25 mm RMS. The accuracy of measurements reported outside the Polaris Vicra characterized measurement volume is unknown. The Polaris Vicra System is specifically designed to NOT report these measurements; however, you can request such information by applying additional API commands to application software. You enable this additional functionality at your own discretion. The Position Sensor's performance is determined using the calibration methodology described in [Appendix A on page 85](#).

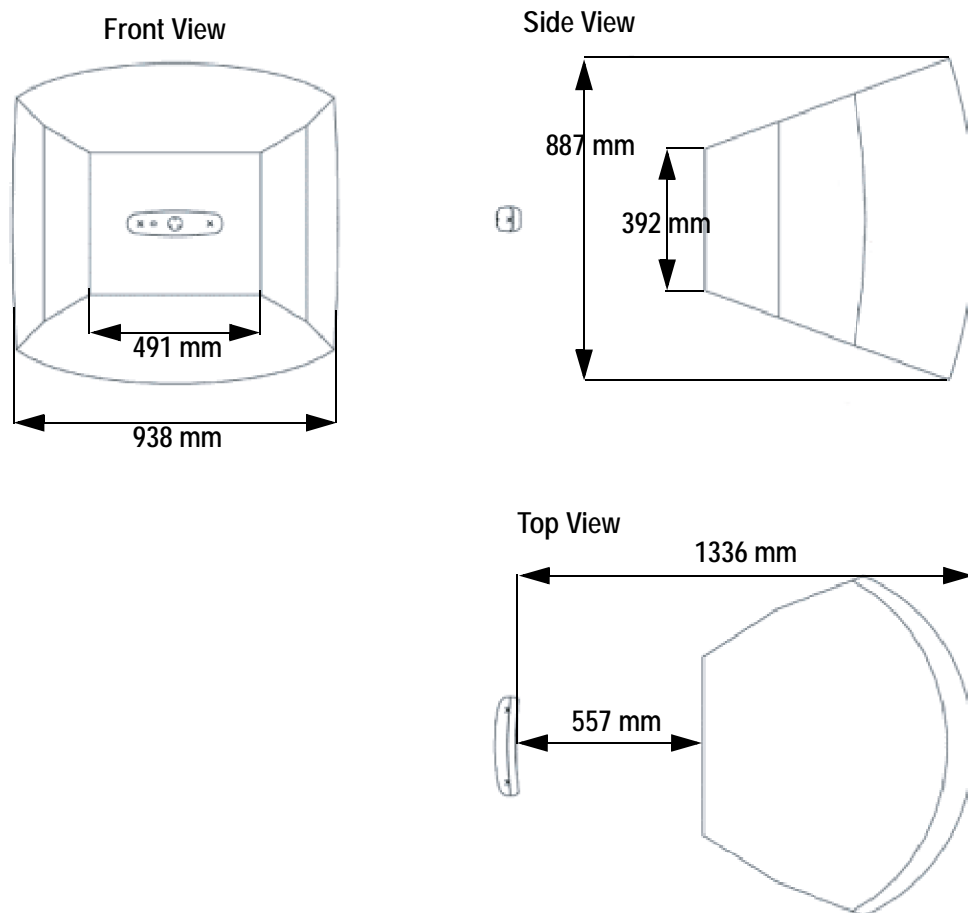


Figure 3-2 Characterized Measurement Volume

#### Out of Volume and Partially Out of Volume

A tool is flagged as **out of volume** if all of its markers are outside of the characterized measurement volume, but the system can still detect the tool.

By default, the Polaris Vicra System reports tools with markers that are outside of the characterized measurement volume as MISSING. You can tell the Polaris Vicra System to report the

transformations of these tools using reply option 0x0800 with the BX or TX command. See the “*Polaris Application Program Interface Guide*” for details.

A tool is flagged as **partially out of volume** if:

- less than the minimum number of markers (a parameter in the tool definition file) are inside the characterized measurement volume, and
- at least one marker on the tool is inside the characterized measurement volume

For example, consider a five-marker tool, with three markers inside the characterized measurement volume and two markers outside the volume. If the minimum number of markers is set to 3, the tool is considered to be inside the volume. If the minimum number of markers is set to 4 or 5, the tool will be flagged as partially out of volume.

## 3.4 Marker Detection and Tool Tracking

### Detecting Markers

The Position Sensor detects active and passive markers using different methods. Active markers are triggered by a 20 Hz “chirp” signal emitted by the Position Sensor illuminators, which causes the active markers to emit IR for the integration time. (The chirp signal is only a trigger.)

To detect passive markers, the Position Sensor’s illuminators flood the surrounding area with IR for the whole integration time by flashing at 20 Hz (similar to the flash on a camera). The passive sphere markers have a retro-reflective coating that reflects the IR directly back to the Position Sensor instead of scattering it.

For both active and passive markers, the Position Sensor collects IR for a period of time called the **integration time**. This acts like an electronic shutter. The system makes automatic adjustments to the integration time so that the intensity of the brightest IR detected is set to a maximum value, and the intensity of all other IR detected falls below this value. This process is called **dynamic range control**.

The system distinguishes between potential marker data and background IR using a value called the **trigger level**. The trigger level is the minimum IR intensity considered to be valid marker data. Background IR that falls below the trigger level is rejected by the Position Sensor. The trigger level generally increases with integration time; see “[Setting the Infrared Light Sensitivity](#)” on page 54 for more details.

### Acquiring and Tracking Tools

When the Polaris Vicra System first begins tracking a tool, or whenever a tool goes missing, it must “acquire” the tool. (For information on why a tool goes missing, see “[Missing and Disabled Transformations](#)” on page 48.) To acquire tools, the Polaris Vicra System first measures the positions of all the visible markers.

IR light hits the Charge Coupled Devices (CCDs) in the Position Sensor. If the system is unable to detect individual IR sources, or has detected more IR sources than it can process, it will report an error, see “[Tracking Errors and Flags](#)” on page 49. Otherwise, the system will calculate the position of the IR sources.



To determine the position of an IR source, the Position Sensor calculates a line between the source of IR and each sensor (displayed as dotted lines in [Figure 3-3](#)). Where the lines cross each other, the Polaris Vicra System calculates the **line separation**. (The distance between the lines.) (In a theoretical case the lines will intersect exactly, but in the modelled “real world” case they will be apart.) If the line separation at this point is less than a predefined limit, the Polaris Vicra System considers the point to be a possible marker position. Otherwise, the point is discarded.

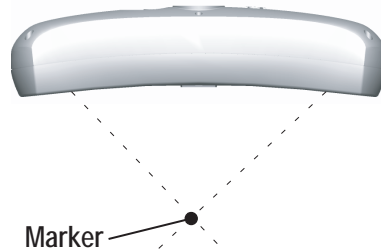


Figure 3-3 Determining a Marker Position

Once the system has measured the positions of all the markers, it calculates the segment length (the distance between two markers) for each pair of markers, and the angle between each segment. It compares this data with the marker geometry data in each tool definition file (described on page 31), to determine which markers belong to which tool. The unique geometry requirements, described in the “*Polaris Tool Design Guide*”, allow the Polaris Vicra System to distinguish between tools. Any markers that are not part of a tool are considered stray markers (this may include phantom markers). See “[Stray Marker Reporting](#)” on page 37 for more details on stray markers and phantom markers.

The Polaris Vicra System has “acquired” a tool once it has matched the **minimum number of markers** (a parameter in the tool definition file) for the tool and can calculate a transformation for the tool. Once a tool has been acquired, the Position Sensor tracks it using a predictive algorithm.

### Three Marker Lock On

If the “3 marker lock on” option is enabled in the tool definition file, the Polaris Vicra System will acquire and track the tool as long as it can detect at least three markers. The system will not report the transformations unless the minimum number of markers is used to calculate the transformation.

For example, consider a four-marker tool with the “3 marker lock on” option enabled. If the system can only detect three of the markers on the tool, it will continue to track that tool but will only report transformations if the minimum number of markers is set to 3. If the minimum number of markers is set to 4, the system will continue to track the tool in the background, but will report the tool as MISSING. Selecting 3 marker lock on in this case will result in the tool transformations being reported faster, once the minimum number of markers becomes visible, because the system does not have to spend time re-acquiring the tool.

---

**Note** For more details on the “3 marker lock on” option, see the “*Polaris Tool Design Guide*”.

---

## 3.5 Polaris Vicra System Tools



**Warning!**

---

Do not use a wireless tool whose design does not conform to the Polaris Vicra System's unique geometry constraints. When a Polaris Vicra System attempts to track more than one wireless tool in the measurement volume, these unique geometry constraints ensure that they are distinguishable from each other. Reliance on data produced by two indistinguishable tools can lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.

---

Tools used with the Polaris Vicra System are wireless, and incorporate either active or passive markers. The system can track up to six tools at a time. The Position Sensor tracks tools based on marker geometry, which is specified in the tool definition file for each tool. A tool definition file must be loaded before the Polaris Vicra System can track its associated tool. For more information on tool definition files, see [“Tool Definition File” on page 31](#).

Tools are available from NDI for use with the Polaris Vicra System. Contact NDI for more details.

### Tool Characteristics

Tools used with the Polaris Vicra System have the following characteristics:

- A 5DOF (five degrees of freedom) tool has between three and six markers. All the markers on a 5DOF tool are collinear. The Polaris Vicra System will report the 3D position and 2D orientation of a 5DOF tool.
- A 6DOF (six degrees of freedom) tool has between three and six markers that are not collinear. The Polaris Vicra System will report the 3D position and 3D orientation of a 6DOF tool.
- The geometry of each tool must follow the unique geometry constraints. Tools must have different marker geometries from one another, so the Position Sensor can distinguish between them. A marker geometry that is the mirror image of another tool's marker geometry is not considered unique. For more details on unique geometry constraints and marker geometry, see the *“Polaris Tool Design Guide”*.
- A multi-faced tool (which is also 6DOF) can have up to six faces, totalling a maximum of 20 markers. Each face on a tool is treated as a separate rigid body which complies with the following constraints:
  - It has a maximum of eight markers
  - It complies with the unique geometry constraints
  - It has a different marker geometry from the other faces on the tool.
- Each tool has its own local coordinate system. This is defined during the tool characterization process, and is often dependent on the tool's intended use.

### Multi-Faced Tool Tracking

When the Polaris Vicra System is tracking a multi-faced tool, it tracks only one face at a time. The face being tracked is returned with reply option 0x0002 of the BX and TX commands, and is reported in NDI ToolBox (see the online help in NDI ToolBox for more details).

Each face is assigned a face normal in the tool definition file (described on page 31). The face normal is a vector pointing in the same direction as the tool face, to let the Polaris Vicra System know the direction each tool face is facing. The system will track the face most directly oriented to the Position Sensor (i.e. the face with the smallest angle between the face normal and the sensors in the Position Sensor). If the minimum number of markers are not visible on the face most directly oriented to the Position Sensor, the system will attempt to track another face.

The system has a hysteresis of  $2^\circ$  when determining whether to switch faces. The system will determine the angle between the sensors and each face of the tool. If the face with the smallest angle is  $2^\circ$  smaller than the current face's angle, the system will switch to the new face.

## 3.6 Tool Definition File

A **tool definition file** (formatted as .rom) describes a tool to the Position Sensor. The information stored in the tool definition file includes the geometry of the tool's markers, the tool's manufacturing data, information on marker and face normals, groups and faces definitions, and the parameters used to track tools. For more information on the parameters used to track tools, see Tool Tracking Parameters below.

A tool definition file must be loaded into the system (by the host computer) before the Polaris Vicra System can track its associated tool. If the Polaris Vicra System is measuring the positions of stray markers (described in [“Stray Marker Reporting” on page 37](#)), at least one tool definition file must be loaded in order for the Position Sensor illuminators to emit IR light.

Tool definition files can be created in NDI 6D Architect. The procedure used to create a tool definition file is called **tool characterization**. For more information on tool characterization, see the *“Polaris Tool Design Guide”* and the *“NDI 6D Architect User Guide”*.

## 3.7 Tool Tracking Parameters

The following tool tracking parameters are specified in the tool definition file (described on page 31). The flow chart on page 34 describes how the Polaris Vicra System uses the tool tracking parameters to determine which markers to use to calculate a tool transformation, and when to return a transformation.

For information on how to change the tool tracking parameters and what values to use, see the *“Polaris Tool Design Guide”* and the *“NDI 6D Architect User Guide”*.

### Maximum 3D Error

The **maximum 3D error** parameter specifies the maximum allowable 3D error for each marker on the tool. The maximum 3D error is the difference between the measured and expected location of a marker on a tool. The expected location of a marker on a tool is specified in the tool definition file (described on page 31).

If the 3D error for a particular marker is greater than the specified maximum 3D error value, the data from that marker will not be used to determine the tool transformation.

## Maximum Marker Angle

The **maximum marker angle** parameter specifies the maximum allowable angle between a marker and each sensor on the Position Sensor. The default maximum marker angle for passive sphere markers is 90° and for active markers it is 60°. Each marker has an associated normal vector, which is defined in the tool definition file. A marker normal is a vector of length 1, and points in the same direction as the marker, as illustrated in [Figure 3-4](#).

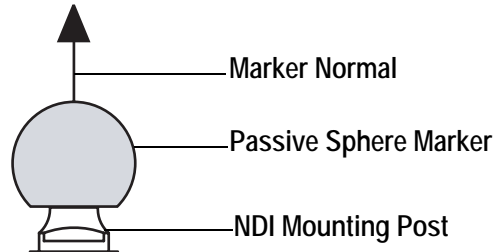


Figure 3-4 Marker With Marker Normal

The Polaris Vicra System uses the marker normal to determine whether the maximum marker angle has been exceeded. The system measures the angle between the marker normal and each sensor, in both the Position Sensor’s *xy*- and *yz*-planes. (The Position Sensor’s coordinate system is described in “[Global Coordinate System](#)” on page 26.) The Position Sensor then compares these measured angles to the maximum marker angle, as illustrated in [Figure 3-5](#).

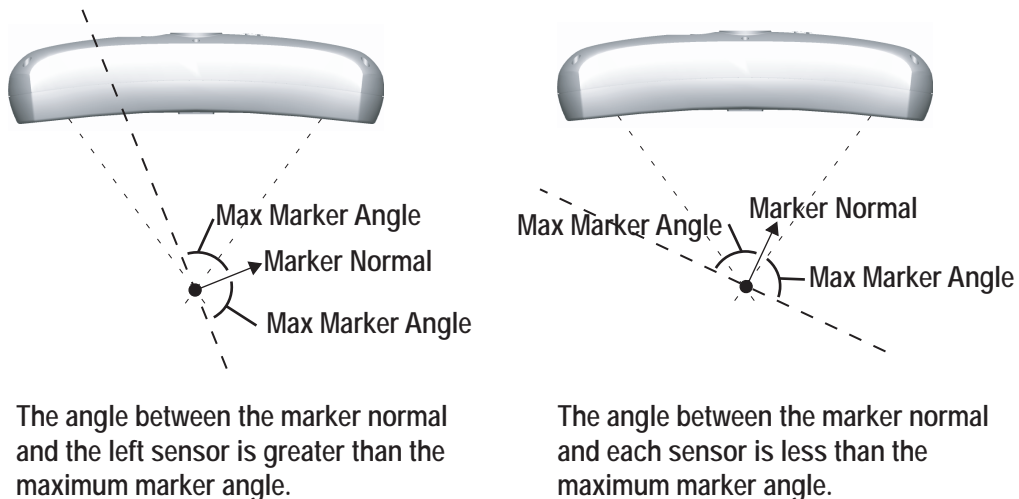


Figure 3-5 Maximum Marker Angle

If the angle between a marker normal and a sensor is greater than the specified maximum marker angle, the data from that marker will be not be used to determine the tool transformation.

The further a marker is from the Position Sensor, the smaller the angle it can be turned and still be within the maximum marker angle.

## Minimum Number of Markers

The **minimum number of markers** parameter specifies the minimum number of markers that the Position Sensor must use in the calculation of a tool transformation in order to return the

transformation. If fewer markers than the minimum number of markers are used in the calculations, then the tool will be reported as MISSING.

For example, consider a four-marker tool that has three markers inside the characterized measurement volume, and one marker outside of the characterized measurement volume. If the minimum number of markers parameter is set to 3, the Polaris Vicra System will report transformations for the tool (as long as the other tool tracking parameters are satisfied). If the minimum number of markers parameter is set to 4, the Polaris Vicra System will report the tool as MISSING.

---

**Note** You can tell the Polaris Vicra System to report the positions of tools that have less than the minimum number of markers inside the characterized measurement volume by using reply option 0x0800 with the TX or BX command. This may reduce the accuracy of the transformations. See the "*Polaris Application Program Interface Guide*" for details.

---

## Minimum Spread

The **minimum spread** parameters specify the minimum size 3D box that must contain all the markers used in the calculation of a tool transformation. The length, width, and height of this box must be greater than the specified Minimum Spread 1, Minimum Spread 2 and Minimum Spread 3 parameters, respectively, or else the system will not return a transformation.

This setting is optional. For more details on the minimum spread parameter, see the "*Polaris Tool Design Guide*".

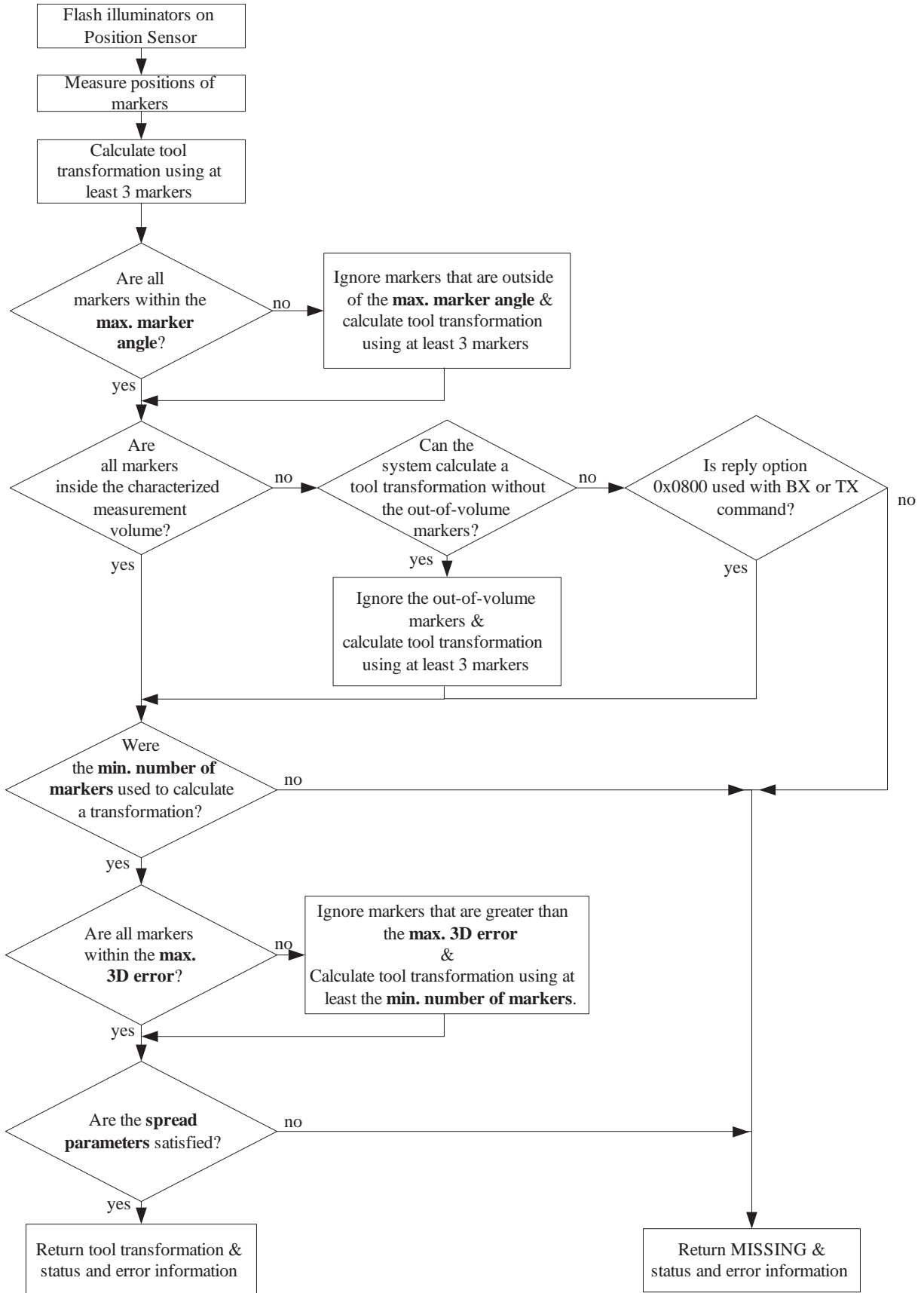


Figure 3-6 Flowchart of Tool Tracking Parameters Use

## 3.8 Tool Tip Offset



**Warning!**

---

Do not use a tool with a tip without first performing a pivot procedure to verify the tip offset. Reliance on data produced by a tool with an inaccurate tip offset may lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.

---

The **origin** of a tool is defined as part of the tool's local coordinate system in the tool definition file. When the Position Sensor tracks a tool, it reports the transformations of the origin of the tool.

In certain circumstances, it is useful to track a point on the tool other than the tool's origin. In particular, it is useful to track the location of the tip of a probe. It is possible to define the tool's origin at the tip of the probe; however, if the tool is later bent, the origin will no longer be located at the tip.

NDI recommends determining the **tool tip offset** of the tool, prior to each use. The tool tip offset is the vector between the tip of the tool and the origin of the tool. Application software can apply the tool transformations reported by the Polaris Vicra System to the tool tip offset, in order to determine the location of the tool tip.

---

**Note** The Polaris Vicra System always tracks the origin of the tool. It is the application software, not the Polaris Vicra System, that calculates the location of the tool tip.

---

Determining the tool tip offset prior to each use ensures that the location of the tool tip is known as accurately as possible. The tool tip offset can be determined either by using a calibrator, or by performing a pivoting procedure.

### Using a Calibrator

A calibrator is a rigid body that incorporates three or more markers and a clamping mechanism. The clamping mechanism allows another tool (usually a probe) to be clamped into place. An example of a calibrator is illustrated in [Figure 3-7](#). To use a calibrator to determine the tool tip offset of a probe, clamp the probe in place on the calibrator. The origin of the calibrator is defined at the point where the tool tip will rest. The Polaris Vicra System can then measure the positions of the probe's origin and the calibrator's origin. The application software compares these measurements to determine the tool tip offset of the probe.

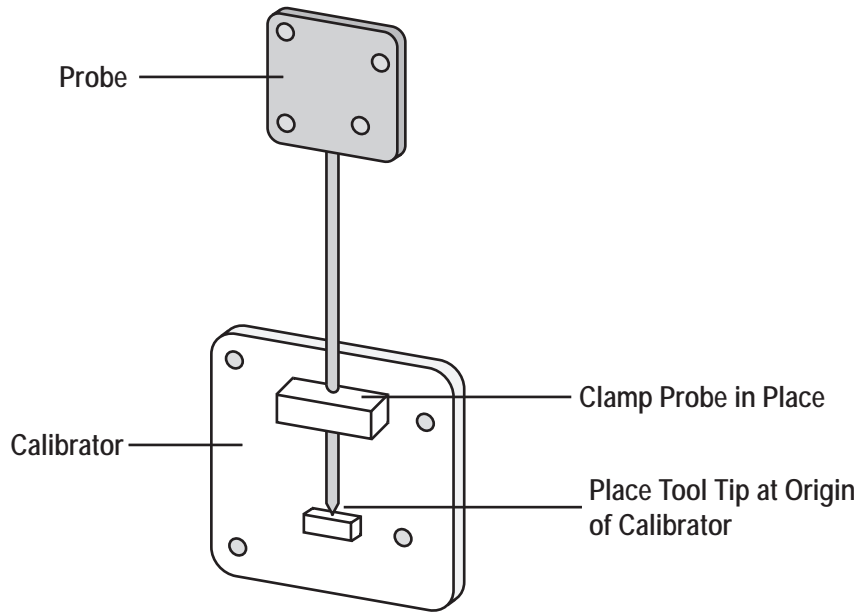


Figure 3-7 Sample Calibrator

### Pivoting

You can also determine the tool tip offset using a process called pivoting, using either NDI ToolBox or NDI 6D Architect software. During the pivoting procedure, the Polaris Vicra System will measure the positions of the markers while you pivot the tool. The software collects this data, and uses it to determine the tool tip offset. Instructions on how to pivot a tool are detailed in [“Determining the Tool Tip Offset” on page 45](#). In addition the procedure is also detailed in the *“NDI 6D Architect User Guide”* and online help, and in the NDI ToolBox online help.

## 3.9 Reference Tool

A reference tool is a tool whose local coordinate system is used as the global coordinate system in which other tools are tracked. The Polaris Vicra System tracks all the tools, including the reference tool, and reports the transformations in the coordinate system of the Position Sensor (described on page 26). Software (such as NDI ToolBox) then calculates and reports the positions and orientations of all other tools with respect to the position and orientation of the reference tool.

---

**Note** Use a reference tool to ensure minimal drift in the measurements produced; specifically, drift caused by time, settling and/or temperature.

It is the application software, not the Polaris Vicra System, that calculates the tool transformations with respect to the reference tool.

---

For example, in neurosurgery the reference tool can be attached to the patient’s head. Then a registration procedure is performed that defines the reference tool’s position relative to the patient’s head. From then on, if either the patient’s head or the Position Sensor shifts, the measurements are



not affected since they are reported with respect to the patient's head (the reference tool) and not with respect to the Position Sensor.

If the Polaris Vicra cannot track the reference tool (for example, if the reference tool is occluded), then the software will not be able to calculate the transformations of other tools with respect to the reference tool.

### 3.10 Stray Marker Reporting

A stray marker is a marker that is not part of a rigid body. For example, by placing stray markers on a patient's chest, the markers may be used to gate/track the patient's breathing in order to time radiation therapy.

If the stray marker reporting functionality is enabled, the Polaris Vicra System will report tool transformations, as well as 3D data (position only, no orientation information) for up to 50 markers that are not used in tool transformations (including phantom markers, described below). It is then necessary to eliminate phantom markers within the application software, and verify that the stray markers are within the characterized measurement volume.

It is important to be aware of the potential hazards associated with using the stray marker reporting functionality. The hazards are as follows:

- An external IR source, for example, an IR transmitter or incandescent light, may be identified as a stray marker. The position of a stray marker may be incorrectly identified and return incorrect data.
- No marker identification is possible from frame to frame. It is therefore the user's responsibility to devise a method to keep track of which 3D position belongs to which marker in which they are interested.
- A stray marker does not have any angular position to know if marker normals are being exceeded.
- There are no built in checks to determine if the 3D result is a real marker or a phantom marker, generated by other IR sources or markers in view of the Position Sensor. The system tries to reject markers by the use of the line separation qualifier, but if several markers are in a line parallel to the horizontal plane of the Position Sensor, phantom markers may still be generated that are within the line separation qualifier.
- Partial occlusion cannot be detected, or compensated for. The partial occlusion is not detected by the Position Sensor, but the user may be able to detect the apparent shift if the marker position can be constrained in the application software. For example, the marker position has to be constrained along a vector and its position relative to another marker is supposed to be fixed within some tolerance.

To enable the stray marker reporting functionality, use the 0x1000 reply option with the BX or TX command. This reply option returns out-of-volume information along with the 3D data. See the "*Polaris Application Program Interface Guide*" for details.

In order for the Position Sensor to measure stray markers, a tool definition file must be loaded, and the associated port handle must be initialized and enabled, even if no tools are being tracked. The Position Sensor illuminators emit IR light only when a tool definition file is loaded.

### 3.11 Phantom Markers

Phantom markers are the result of the calculation that the Polaris Vicra System uses to determine the position of a source of IR. They appear, and are reported as, markers but they do not actually exist; they are phantom markers.

To determine the position of a source of IR, the Position Sensor calculates a line between the source of IR and each sensor (displayed as dotted lines in [Figure 3-8](#)). Where the lines cross each other, the Polaris Vicra System calculates the **line separation** (the distance between the lines). If the line separation at this point is less than a predefined limit, the Polaris Vicra System considers the point to be a possible marker position.

Phantom markers are reported when the imaginary lines calculated from the sensors intersect in more than one place with a line separation less than a predefined limit. This generally occurs when two or more markers are in the same plane as the sensors. For example, in the case of two coplanar markers, there will be four mathematical solutions, as illustrated in [Figure 3-8](#). Two are the actual marker locations and two are the phantom marker locations. One phantom marker will usually be closer to the Position Sensor than the actual markers and the other phantom marker will be farther away from the Position Sensor than the actual markers.

The number of phantom markers increases with the number of coplanar markers. When there are  $n$  coplanar markers, there will be up to  $n \cdot (n - 1)$  phantom markers.

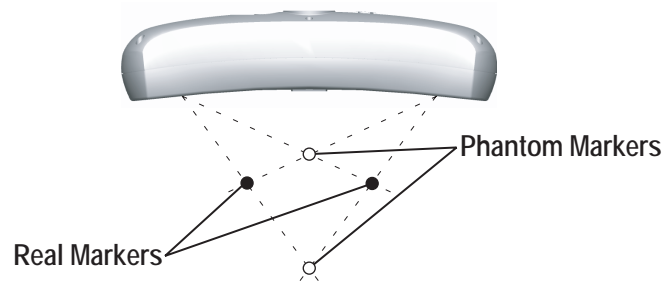


Figure 3-8 Phantom Markers

When the stray marker reporting functionality is not enabled, the Polaris Vicra System can eliminate phantom marker solutions. The system matches the marker position solutions to the known marker geometry of the tools, as described in [“Marker Detection and Tool Tracking”](#) on page 28. The unused solutions are phantom markers, reflections, or other IR sources, and are not reported by the system.

When the stray marker reporting functionality is enabled, it is necessary to eliminate the reported phantom markers using application software.

### 3.12 Passive Sphere Markers

NDI passive sphere markers have a retro-reflective coating that reflects IR light back to its source instead of scattering it. The IR light from the Position Sensor illuminators reflects off the passive markers directly back to the sensors.

The Polaris Vicra System can report the positions of passive markers individually, and calculate the position and orientation of tools that incorporate them. The measured position is the centre of the marker. When a passive sphere marker is attached to an NDI mounting post, the centre of the sphere is located at the top of the mounting post.

The passive markers can only be sterilized one time. NDI does not recommend that a passive marker be used if it has been sterilized more than once, as multiple cycles of sterilization may adversely affect the marker's performance. Testing has shown that there is no significant degradation in the performance of these markers after one cycle of ETO, STERRAD 100S, or STERIS SYSTEM 1 sterilization. The passive markers cannot be autoclaved. Pre-sterilized passive sphere markers are also available; contact NDI for details.

**Warning!**

---

Do not use markers without inspecting them for cleanliness and damage both before and during a procedure. Reliance on data produced by unclean or damaged markers may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.

---

**Caution!**

---

Do not handle the passive sphere markers with bare hands as this will leave residue from skin that affects the marker's reflectivity. Take care not to drop or scuff the markers, as this also affects the reflectivity of the markers.

---

### 3.13 Active Markers

Active markers are physically smaller than passive sphere markers. They consist of an Infrared Light Emitting Diode (IRED) mounted on a ceramic base. The Position Sensor codes (“chirps”) the IR pulses emitted from its illuminators. These coded IR pulses are received by the IR receiver on the tool which then activates the IREDs. The Position Sensor receives the IR emitted by the IREDs and processes it in the same manner as passive tool reflections.

Active markers are mounted in active wireless tools. The ceramic base allows them to be sterilised by auto-claving as required. The power for active wireless tools is supplied by battery. For detailed information on active markers and active wireless tools, refer to the *“Polaris Tool Design Guide”*.

### 3.14 Filter Spectral Response

The lenses on the Position Sensor filter out visible light, allowing only certain amounts of light at specific frequencies to pass through to the CCDs. The CCDs are sensitive only to light below certain frequencies. The result is a band pass filter from 800 nm to 1100 nm. Environmental light in this range can affect the performance of the Polaris Vicra System. The more intense the environmental light in this range, the higher the probability that it will interfere with the system.

**Note**

---

It is important to reduce environmental IR, to prevent interference with the system. Some operating room lights may emit IR.

---

The amount of light at various frequencies that passes through the lenses to the CCDs, and then is detected by the CCDs, as illustrated in [Figure 3-9](#).

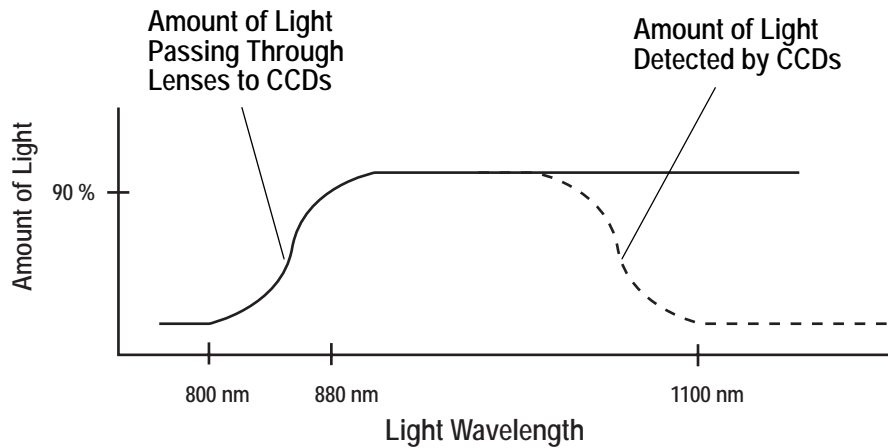


Figure 3-9 Filter Spectral Response

### 3.15 Data Transmission Rate

The Polaris Vicra System can achieve an internal tool transformation update rate of 20 Hz. The host update rate (the rate at which the host computer receives data) is dependent on the following factors:

**Baud Rate** The baud rate specifies how fast data is transferred from the system to the host computer. At lower baud rates, the host computer may not receive tool transformations at 20 Hz.

**API command reply length** The more data the system must return with every transformation, the slower the host update rate. The amount of data returned with each transformation increases as you track more tools and select more options.

**Application speed** The host transmission rate can vary according to how often the application asks for data, and how often the graphical user interface (in particular, graphics) need to be updated.

### 3.16 Serial Port Emulation

The Host USB Converter emulates a standard PC serial port, such that the host application may communicate with the Polaris Vicra System as if it was a standard RS-232 device. A feature of this is that the following modem status bits are used as follows:

- The Data Set Ready (DSR) will be set when the Host USB Converter senses that a Position Sensor is connected (power must also be connected to the Host USB converter).
- The Ring Indicator (RI) will be set when a fault condition is showing on the Host USB Converter error indicator.

If your operating system cannot set the serial port rate directly to 1.2 Mbaud, an aliased 19200 baud rate is provided to enable you to run at the higher speed. Do not use the COMM API command's baud rate selection of "2" (in this case COMM 2xxxx) but instead use a selection of "7" (COMM 7xxxx).

## 4 Using the Polaris Vicra System

This chapter is intended as a tutorial to demonstrate the basic functionality of the Polaris Vicra System using NDI ToolBox. The tutorial is designed for first time users of the system to:

- set up the system to track tools
- observe error and information flags while tracking tools
- track using a reference tool
- pivot a tool to determine the tool tip offset

For more detailed information on NDI ToolBox, refer to the NDI ToolBox online help.

### 4.1 Getting Started: Tracking Tools



This section describes how to set the system up to track tools.

#### To Set Up the System

1. Set up and connect the hardware, as described in [“Connecting the Hardware” on page 19](#).
2. Install the drivers for the Host USB Converter, as described in [“Installing the USB Drivers \(Windows\)” on page 21](#).
3. Open NDI ToolBox.
4. If NDI ToolBox does not automatically connect to the system, select **File > Connect to > (COMx)** (For further details on installing the software, refer to [“Installing the Software” on page 20](#).)

#### To Track Tools

In NDI ToolBox:

1. If the tool tracking utility is not open, click  to open it.
2. Click  to load the tool definition files for the tools you want to track.
3. In the dialog that appears, browse to the desired tool definition file(s). Hold down **Ctrl** and click to select more than one file.
4. Click **Open**.

Once a tool definition file has been loaded, the Polaris Vicra System will automatically attempt to track the tool.

5. Move the tool throughout the characterized measurement volume, making sure the markers on the tool face the Position Sensor.

As you move the tool, the symbol representing the tool in the graphical representation will move to reflect the tool's position.

## 4.2 Information and Error Flags

This section describes how to trigger some of the most common flags. Tracking errors, warnings, and marker information for each tool are displayed in the bottom right section of the tool tracking utility.

### To View Information and Error Flags

1. Set up the system to track tools, as described in “Getting Started: Tracking Tools” on page 41.
2. For each loaded tool definition file, there is a tab in the bottom right section of the tool tracking utility. Select a tab to display tracking information for a particular tool.

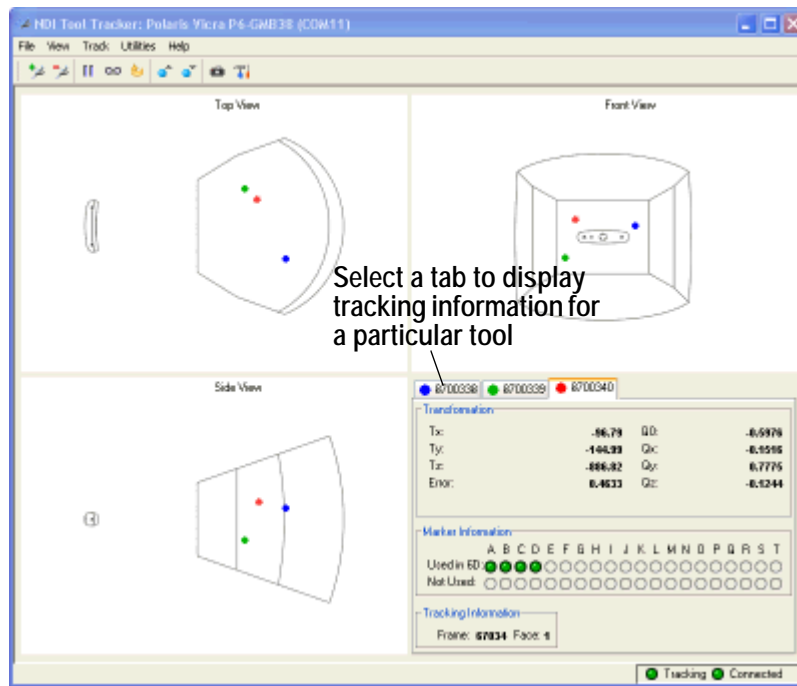


Figure 4-1 Tool Tracking Window

“Partially Out of Volume” and “Out of Volume” flags:

Move the tool to the edge of the characterized measurement volume.

As you move the tool to the edge of the volume (some markers are in the volume and some out), NDI ToolBox will display the message “Partially Out of Volume.” Once the tool is completely outside of the volume (all markers are outside the volume), NDI ToolBox will display the message “Out of Volume.”



Figure 4-2 Partially Out of Volume Flag

“Too Few Markers” flag:

1. Position the tool inside the characterized measurement volume, with the markers facing the Position Sensor.
2. Cover one or more markers, without touching them.

The Position Sensor will no longer be able to detect the covered markers.

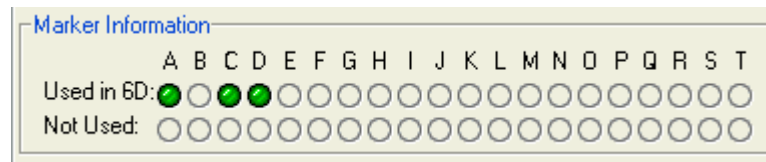


Figure 4-3 Markers Information Pane - Missing Marker

If the Position Sensor cannot detect the minimum number of markers, NDI ToolBox will display the message “Too Few Markers” and will not report a transformation.

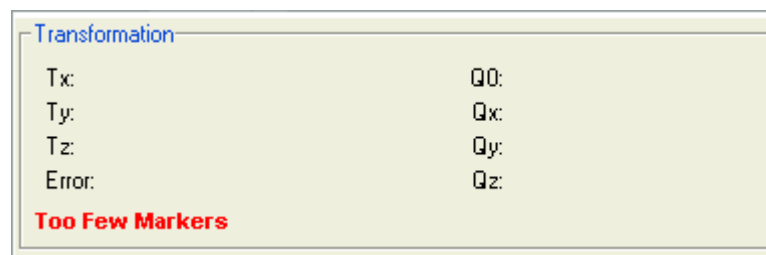


Figure 4-4 Transformation Pane - Too Few Markers

“Exceeded Maximum Marker Angle” flag:

1. Position the tool inside the characterized measurement volume, with the markers facing the Position Sensor.
2. Turn the tool gradually until the markers are no longer facing the Position Sensor.

Once a marker has exceeded the maximum marker angle, NDI ToolBox will display a blue indicator in the Not Used section of the marker information.

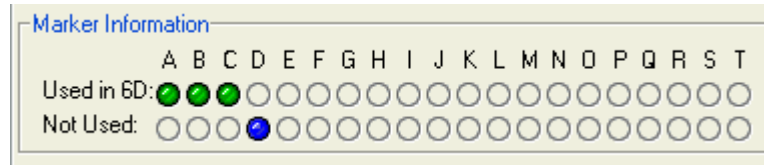



Figure 4-5 Markers Information Pane - Exceeded Max Marker Angle

### 4.3 Setting a Tool as Reference

This section describes how to set a tool as reference. When you set a tool as reference, all the other tools will be tracked with respect to the reference tool.

#### To Set a Tool as Reference

1. Set up the system to track tools, as described in “Getting Started: Tracking Tools” on page 41.
2. Click  to load tool definition files for at least two tools.
3. For each loaded tool definition file, there is a tab in the bottom right section of the tool tracking utility. Select the tab corresponding to the tool you want to set as reference.

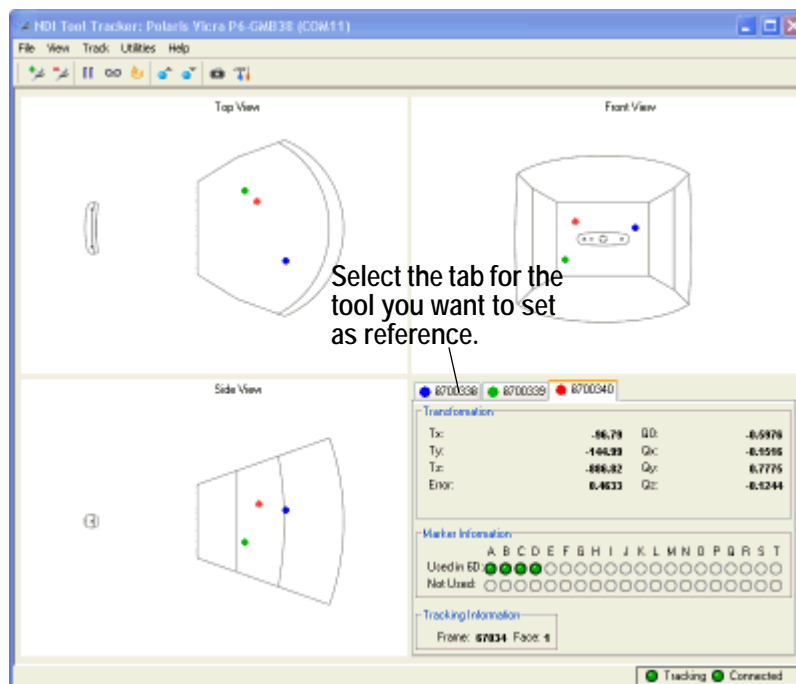
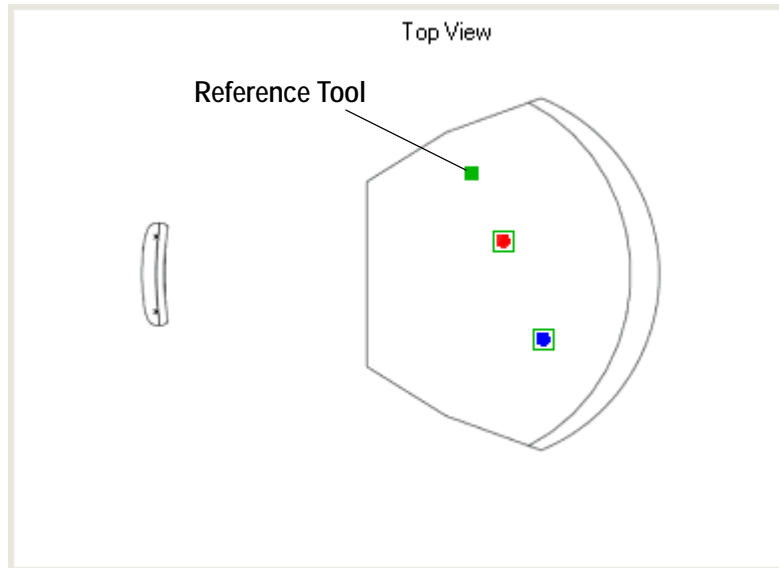


Figure 4-6 Selecting a Reference Tool

4. Right click on the tool tab, then select **Global Reference**.

The reference tool will appear as a square in the graphical display. The other tools will be displayed inside a square, that is the colour of the reference tool. The positions and orientations of other tools will now be reported in the local coordinate system of the reference tool.






---

**Note** The Polaris Vicra System still calculates the tool transformations in the coordinate system of the Position Sensor. The NDI ToolBox software then calculates and reports the tool transformations with respect to the reference tool.


---

## 4.4 Determining the Tool Tip Offset

This section describes how to determine the [tool tip offset](#) of a probe or pointer tool by pivoting. Once NDI ToolBox has calculated the tool tip offset, it can report the position of the tip of the tool, instead of the position of the origin of the tool. See [“Tool Tip Offset” on page 35](#) for more details.

### To Set Up the System to Pivot

You will need a divot in which to rest the tool tip while you pivot the tool. The size and shape of the divot must match the tool tip, to ensure that the tip does not move. For example, a probe with a 1 mm ball tip requires a hemispherical divot with a 1 mm diameter in which to pivot.

1. Set up the system to track tools, as described in [“Getting Started: Tracking Tools” on page 41](#).
2. Click  to load a tool definition file for the probe or pointer tool.
3. For each loaded tool definition file, there is a tab in the bottom right section of the tool tracking utility. Select the tab corresponding to the tool you want to pivot.

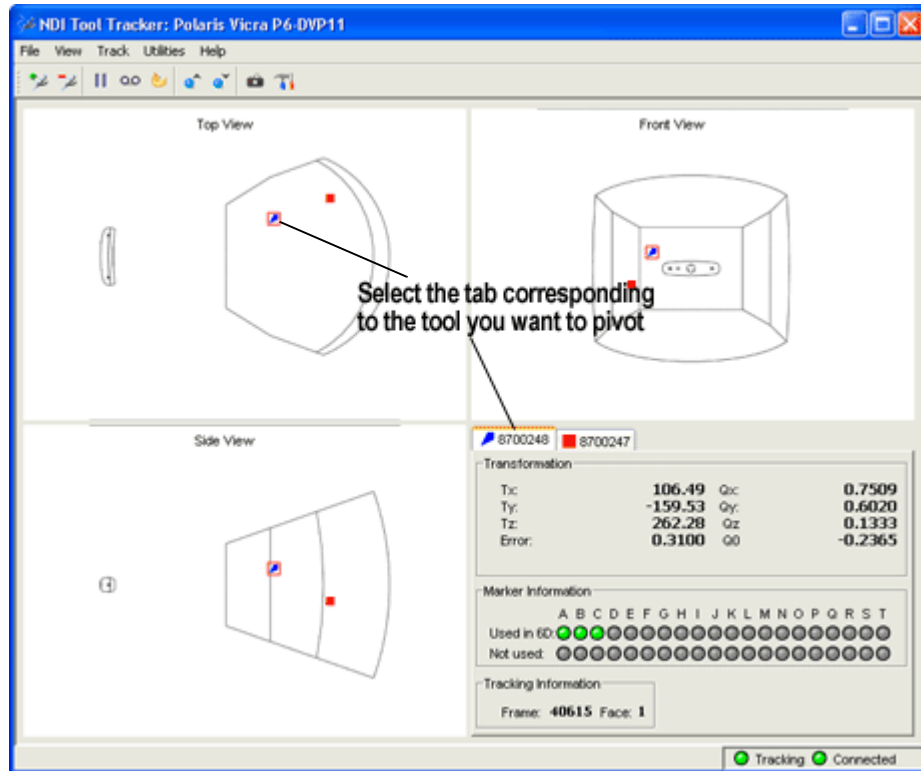



Figure 4-7 Selecting a Tool to Pivot

4. Click  to open the **Pivot** dialog.
5. Select a start delay of about 5 seconds and a duration of about 20 seconds.

#### To Pivot the Tool

1. Place the tool tip in the divot.
2. Ensure that the tool is within the characterized measurement volume, and will remain within the volume throughout the pivoting procedure.
3. Click **Start Collection** in the **Pivot tool** dialog.
4. Pivot the tool in a cone shape, at an angle of 30° to 60° from the vertical.
  - a) Keep the tool tip stationary, and ensure that there is a line of sight between the markers on the tool and the Position Sensor throughout the pivoting procedure.
  - b) Pivot the tool slowly until the specified pivot duration time has elapsed.

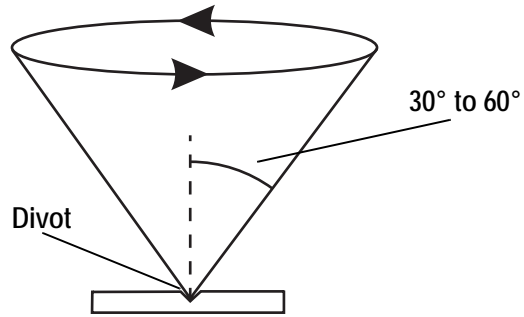


Figure 4-8 Pivoting Technique

When the pivot is complete, the **Pivot Result** dialog appears. Click **Apply Offset** to report the position of the tip of the tool.

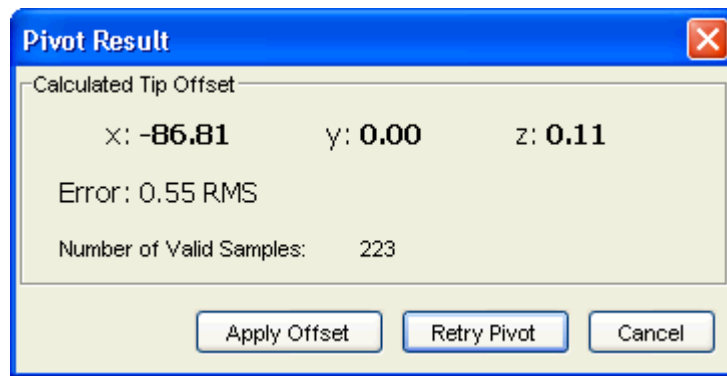


Figure 4-9 Pivot Result Dialog

## 5 Error Flags and Codes

This chapter lists error flags that the Polaris Vicra System may return, and what each one means. It also lists the LED and audio indications output by the Position Sensor.

### 5.1 Missing and Disabled Transformations

Normally, the Polaris Vicra System reports a position, orientation, and error value for every transformation. If the system cannot return a transformation, it will report the tool as MISSING or DISABLED.

#### Missing Transformations

The system reports a tool as MISSING if it cannot calculate a transformation for the tool. The system may be unable to calculate a transformation if:

- the system cannot detect the minimum number of markers
- less than the minimum number of markers are inside the characterized measurement volume. By default, the Polaris Vicra System only reports the transformation of markers and tools inside the characterized measurement volume. You can tell the Polaris Vicra System to report the positions of markers outside the characterized measurement volume, using reply option 0x0800 with the TX or BX command. See the “*Polaris Application Program Interface Guide*” for details. See “[Tool Tracking Parameters](#)” on page 31 for a description of this parameter.
- less than the minimum number of markers are within the maximum marker angle or the maximum 3D error
- the spread parameters are not satisfied
- there is a system error (described on page 49)

#### Disabled Transformations

The system reports a tool as DISABLED if the port handle corresponding to the tool was not enabled, has been disabled, or is unoccupied. A port handle is unoccupied if it has been allocated, but you have not yet associated a tool definition file with that port handle. See the “*Polaris Application Program Interface Guide*” for more details on port handles.

## 5.2 Tracking Errors and Flags

Many of the following errors and flags are displayed in NDI ToolBox. They are all returned with the TX and BX commands (using reply options 0x0001 and 0x0002).

### System status flags

**System Communication Synchronization Error** indicates communication problems between internal sub-components of the system.

**Diagnostic Pending** Indicates a change in any of the alerts flags. The flag is persistent until the alerts parameter are read. Reading the alerts parameter automatically clears the flag. By default transformation data is not returned when this flag is set.

**Temperature** System is out of specified operating temperature range or not yet warmed up. By default transformation data is not returned when this flag is set. The flag will automatically be cleared as soon as the system is back in the specified operating temperature range.

### Port status flags

**Out of Volume** The out of volume flag is set for a marker or tool that is completely outside of the characterized measurement volume, but can still be detected by the system. The flag is set regardless of whether the reply option 0x0800 for the TX or BX command is used. (Reply option 0x0800 enables the reporting of the positions of tools and markers that are outside of the characterized measurement volume. See the “*Polaris Application Program Interface Guide*” for details.)

**Partially Out of Volume** The partially out of volume flag is set for a tool if less than the minimum number of markers are inside the characterized measurement volume, and at least one marker on the tool is inside the characterized measurement volume. See “[Tool Tracking Parameters](#)” on page 31 for a description of the minimum number of markers parameter.

**Algorithm Limitations** Indicates that during parts of the algorithm used for 2D/3D/6D calculations a limitation has been detected (for example buffer full). This does not mean that an error occurred or that the tools will not track properly.

If the flag is transient, i.e. it comes on for only a few frames during the beginning of tracking or during a disruption of the scene (blocking/unblocking), no actions need to be taken.

If the flag persists and the tool does not track, changing the scene (removing tools and/or markers) or simply re-arranging the scene should resolve the problem.

**IR Interference** Indicates that one of the sensors has detected an object that is bright enough to be considered a marker but is too large. (For example, this flag can be triggered by two passive sphere markers being close together.) This may not affect tracking in which case it can be ignored. If one or more tools do not track and the flag persists the scene should be examined for the root cause of the flag (for example by taking a video capture with NDI ToolBox).

**Processing Exception** Indicates that an exception has been detected in the firmware. Transformation data will be invalid as long as the flag persists. The system may self-recover from this condition, depending on the scene. The flag typically comes on when the system is overloaded, ie it cannot handle the scene. Remove some tools and/or markers from the scene to prevent this flag from being triggered.

**Fell Behind While Processing** Indicates that the system cannot keep up with processing the data. This flag comes on when the system is overloaded. Remove some tools and/or markers from the scene to prevent this flag from being triggered.

**Data Buffer Limitations** The systems' internal data buffers cannot hold all incoming data. This flag comes on when the scene is overloaded or, in rare cases, if the scene is arranged in an unfavourable way (many markers lined up in a horizontal line).

Re-arranging the scene or removing tools/markers will remove this flag.

---

**Note** This flag is different from "Algorithm limitations" as "Data buffer limitations" means that real raw data is lost. In the case of the "Algorithm limitations" flag the system has all raw data, but does not have enough buffer to process it. Both flags are very scene dependent and are independent of each other, however both typically only come on in heavily loaded scenes.

---

### Tool information flags

**Bad Transformation Fit** Indicates that although enough markers are visible, the tool transformation could not be calculated due to fit constraints.

**Not Enough Acceptable Markers for Transformation** The system does not have enough "good" markers to calculate a transformation for this tool.

**IR Interference** This flag is a combination of the "IR interference" and "Data buffer limitation" flags in the port status flags. It is kept for backward compatibility with Polaris. NDI recommends that instead you use the port status flags.

**Fell Behind While Processing** This is a copy of the flag "Fell behind while processing" in the port status flags. It is kept for backward compatibility with Polaris. NDI recommends that instead you use the port status flags.

**Processing exception** This is a copy of the flag "Processing exception" in the port status flags. It is kept for backward compatibility with Polaris. NDI recommends that instead you use the port status flags.

### Marker Information

The marker information returned with option 0x0002 of the TX and BX commands are 4-bit numbers that indicate if and how a marker was used in the tool transformation or, if it was not used, it provides an indication why it was rejected for the tool transformation. For a detailed explanation of the marker information see the *"Polaris API Guide"* (TX and BX commands).

---




**Note** If option 0x0008 (3D position of markers on tools) is used, NDI recommends that you use the 3D information only in combination with the marker information reported in option 0x0002. Option 0x0008 will report all markers associated with a tool, regardless of individual marker status. The marker information can provide further indication about the "quality" of the reported 3D position.

---

## 5.3 Polaris Vicra System LEDs and Audio Codes

The Polaris Vicra System components are equipped with LEDs and audio codes to communicate the system status.

### Position Sensor LEDs

- **Power LED** :  
Flashes green during system warm-up.  
Steady green when system is ready for use.
- **Status LED** :  
Steady green when the communications connection is available.
- **Error LED** :  
Lights steady amber if a critical error is detected (Position Sensor must be returned to NDI).  
Flashes amber if a non-critical error is detected (for example, a firmware update is not completed).

---

**Note** If a non-critical error is detected (error LED is flashing), refer to the NDI ToolBox application to further diagnose the fault. (The nature of the error is described on the NDI ToolBox initial page.) If you are using your own applications, use the GET command to read the "Info.StatusAlert" parameter to check the alert status. Refer to the *"Polaris Application Program Interface Guide"* for further information.



---

### Position Sensor Audio Codes

Two tones are emitted by the Position Sensor after it has been powered up or reset and has completed initialization. You can disable this feature using the NDI ToolBox software.

If the host computer does not send a command to the system within a given time, the Position Sensor will emit two quick tones every three seconds. (This feature is an application watchdog and is set by the API command HWCDOG.)

### Host USB Converter LEDs

- **Power** :  
Lights green when power is being supplied to the Host USB Converter.
- **Error** :  
Lights amber when the Host USB Converter has detected a fault.

## 6 Maintenance

User maintenance of the Polaris Vicra System is limited to the following procedures:

1. Cleaning the Position Sensor
2. Care of cables and connectors

The Position Sensor is the only system unit that requires special consideration. The power adapter and Host USB Converter can be cleaned by following standard procedures.

### Maintenance Warnings

Before doing any maintenance on the Polaris Vicra System, read the following warnings:



- 1. All user maintenance must be done by appropriately trained personnel. Individual components of the Polaris Vicra System contain no user-serviceable parts. Maintenance by untrained personnel may present an electric shock hazard.**
- 2. Do not use the Position Sensor without inspecting it for cleanliness and damage both before and during a procedure. Reliance on data provided by an unclean or damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.**
- 3. Do not immerse any part of the Polaris Vicra System or allow fluid to enter the equipment. If fluids enter any part of the system they may damage it and present a risk of personal injury.**
- 4. Do not sterilize the Polaris Vicra Position Sensor as this may cause irreversible damage to its components. Reliance on data provided by a damaged Position Sensor may lead to inaccurate conclusions. If your application involves personal safety, these inaccurate conclusions increase the possibility of personal injury.**

### 6.1 Position Sensor

Regularly inspect the Position Sensor for cleanliness. The Position Sensor and particularly the illuminator filters and lenses, should be cleaned only when necessary. The frequency of cleaning must be determined by the user. This may include “in-use” cleaning.

---

**Caution!** Use only 70% isopropanol and a lens cleaning solution formulated for multi-coated lenses (for example, AR66) to clean the Position Sensor. Other fluids may cause damage to the illuminator filters. Do not use any paper products for cleaning. Paper products may cause scratches on the illuminator filters.

---

To clean the Position Sensor, follow the procedure detailed below:

1. Remove dust from each illuminator filter and lens, using a photographic lens duster (brush). Gently wipe the surface in one direction only, by pulling the brush across the surface.
2. Gently wipe the illuminator filters and lenses with disinfectant wipes containing 70% isopropanol. Continue cleaning the remainder of the Position Sensor, taking care not to wipe



debris from the Position Sensor case onto the illuminator filters or lenses. Avoid prolonged contact between the wipes and the Position Sensor.

3. Clean the illuminator filters and lenses, using a commercial lens cleaning solution formulated for multi-coated lenses (for example, AR66) and a clean knitted microfibre optical cleaning cloth (for example, Hitecloth). Avoid prolonged contact between the lens cleaner and the illuminator filters and lenses.

## 6.2 Cables and Connectors

To avoid damage to cables, make sure the cables are not bent at sharp angles.

**Caution!** Make sure that mains power is disconnected before connecting or disconnecting cables. Failure to do so may cause damage to the equipment.

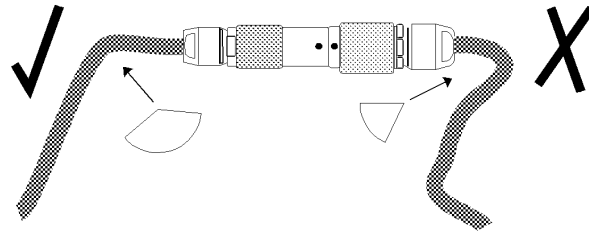


Figure 6-1 How to Avoid Stressed Cables

The Polaris Vicra System incorporates a number of different connectors:

- self-locking circular connector
- USB connector
- jack connector

Handle the connectors with care, paying particular attention to the points detailed below:

- Pull connections apart by gripping the connector. Do not pull them apart by tugging on the cable as this can damage the connecting cable and connector pins.
- Do not leave cable connectors where they will get damaged, particularly on the floor, where they can easily be stepped on or rolled over by heavy equipment.
- Do not put heavy objects on cables or cable connectors.
- Never force a connection.
- On LEMO connectors, make sure that the red dots on the connectors are lined up with each other before connection (the double keys of the connector should be aligned).

## 7 Setting the Infrared Light Sensitivity

### 7.1 IR Light Sensitivity Levels

The IR light sensitivity level determines how sensitive the Polaris Vicra System is to IR light.

#### Background IR Light

**Background IR light** is IR light that is not reflected (passive) or emitted (active) from a marker, but is detected by the Polaris Vicra Position Sensor. Background IR light can be direct (light bulbs, sunlight) or indirect (reflections off shiny surfaces or draping). In particular, IR light in the 800 nm to 1100 nm range can interfere with the Polaris Vicra System's ability to track tools. For example, some types of operating room lights emit IR light that is detected as background IR.

The **IR light sensitivity level** controls the Polaris Vicra System's ability to tolerate background IR light.

#### Trigger Level and Integration Time

The **integration time** is the time in which the Polaris Vicra Position Sensor collects IR light.

The **trigger level** is the minimum IR light intensity considered to be valid marker data. The Polaris Vicra System uses the trigger level to distinguish between marker data and background IR light. IR light that falls below the trigger level is rejected by the Position Sensor. The trigger level increases with the integration time. In general, as the sensitivity level increases, so does the trigger level.

During operation, the Polaris Vicra System makes adjustments to the integration time so that the intensity of the brightest IR light detected is set to a maximum value, and the intensity of all other IR light detected falls below this value. Changing the sensitivity level does not change this maximum value. Thus, when the sensitivity level changes, the integration time does not change but the trigger level does.

The relationship between trigger level and integration time for each sensitivity level is illustrated in [Figure 7-1](#).

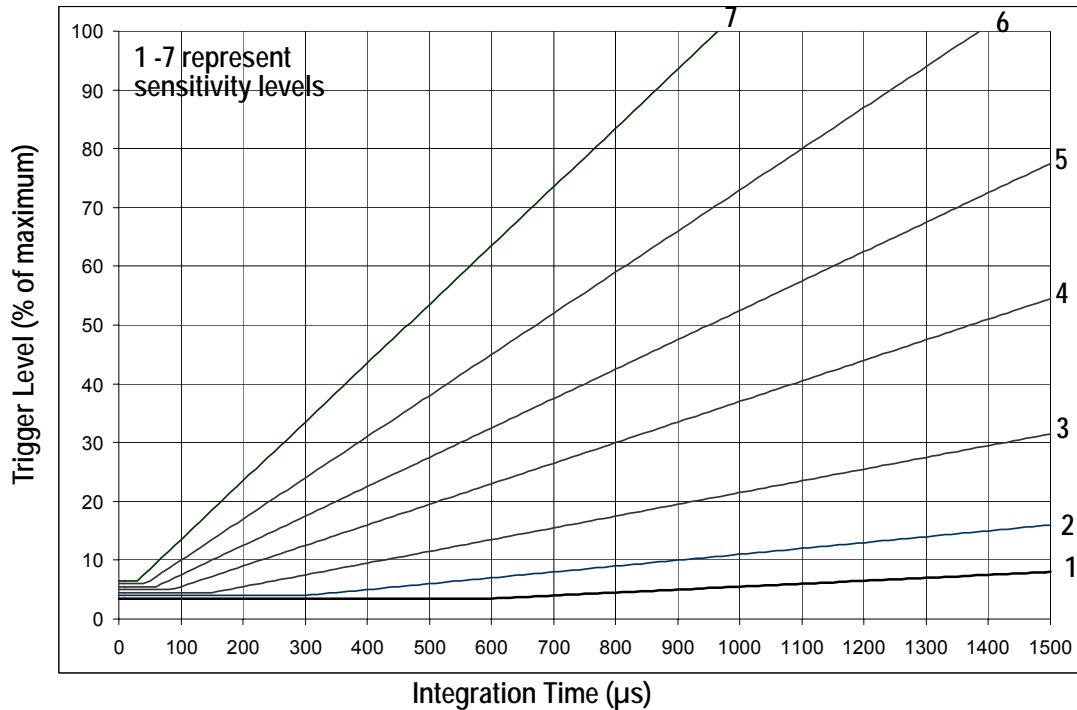


Figure 7-1 Infrared Light Sensitivity Levels

## Sensitivity Levels

There are seven sensitivity levels; with each increasing level number, the ability of the system to tolerate background IR light increases. Increasing the sensitivity level makes the system performance more robust in the presence of background IR light; however, it increases the chance that a tool cannot be tracked properly because it may have a marker that is not bright enough. Low marker brightness can be caused by, for example, the surface of a marker becoming partially occluded by fluids or other materials, thus reducing the reflectivity of the marker.

Level 4 is the default sensitivity level for the Polaris Vicra System and should work well in most situations.

## 7.2 Changing the Sensitivity Level

### Checking for Background IR Light

If a tool is tracking intermittently or not tracking at all, check the **IR interference** flag in the port status and in the tool information returned with the BX or TX command. If the IR interference flag is intermittently or constantly on for any of the tools, there may be background IR present. Alternatively, you can check for the “Interference” flag in the tool tracking utility of NDI ToolBox, or use the image capture utility in NDI ToolBox to capture images of the IR detected by the system.

## Choosing a Sensitivity Level

Choose a sensitivity level of 5, 6 or 7 if:

- If the "IR Interference" flag in the Port Status flags is on persistently

AND

- tools don't track

AND

- re-arranging the scene doesn't help.

Choose a sensitivity level of 3, 2 or 1 if:

- If a tool doesn't track

AND

- all markers are clearly in view AND clean

AND

- no other error flags are giving any indication for why the tool is not tracking

(NDI experience shows that there should not be any reason for going to a level lower than 4.)

---

**Note** The sensitivity levels do NOT change the way centroid extraction is performed and therefore can NOT solve tracking problems with tools embedded in background IR. Sensitivity level adjustment only helps when tool and background IR are in different physical locations.

---

Use the default sensitivity level 4 unless the system is experiencing interference from background IR light. If the system is experiencing such interference, check the environment for causes (for example, reflections). If it is not possible to eliminate the source of the background IR light, then start with a low sensitivity level and increase the level until the tools track reliably.

The system may actually be tracking a tool even when the tool's IR interference flag is on. You should still increase the sensitivity level, since the behaviour of the system in this case is dependent on the setup. (For example, moving the tool to another part of the measurement volume may prevent it from being tracked properly.)

## Changing the Sensitivity Level

You can change the IR sensitivity of the Polaris Vicra System using either NDI ToolBox or the SENSEL command.

The NDI ToolBox software can be used to select a sensitivity level, and to program a sensitivity level as the default setting in the Position Sensor memory.

The SENSEL command is used to temporarily select a sensitivity level. The level set using the SENSEL command persists until a RESET or INIT command is issued. The SENSEL command can also be used to query the currently active level. For more information on the SENSEL command, see the "*Polaris Application Program Interface Guide*".

## 8 Calibration and Firmware

### 8.1 Checking the Calibration of the Polaris Vicra System

The Position Sensor is calibrated at NDI, using the methodology described in [Appendix A](#). Over time, it is possible for the Position Sensor to lose calibration. A periodic calibration check should be performed on the Position Sensor. The frequency of the calibration check depends on the specific application and environment in which the Position Sensor is used.

If the Position Sensor begins to lose calibration, it may lose the ability to track some tools before others. This is due to the various constraints used by the Polaris Vicra System, which make certain tool designs more sensitive to loss of calibration than others. For example, consider a tool that has several similar segment lengths or similar angles between segments, or has segment lengths similar to those of another tool. An out-of-calibration Position Sensor may not be able to determine which markers belong to which tool, because the segment lengths will be measured less accurately. In this case, the system will report the tools as missing. (See [“Marker Detection and Tool Tracking” on page 28](#) and the *“Polaris Tool Design Guide”* for details on segment lengths and angles.)

NDI’s Accuracy Assessment Kit can be used as an aid in determining whether a Position Sensor is performing acceptably for the user’s application. For all calibration procedures, return the Position Sensor to NDI. This practice ensures that all calibrations are conducted in accordance with procedures established specifically for the Polaris Vicra Position Sensor. See [“Return Procedure” on page 77](#) for instructions on returning equipment to NDI.

#### Line Separation and Calibration

The Position Sensor line separation (described on page 28) can sometimes be an indication that a Position Sensor is out of calibration, but is not necessarily the best indicator and cannot always detect calibration loss. For example, suppose one of the sensors was to shift towards the centre of the Position Sensor while maintaining its horizontal alignment. In this case, the Position Sensor would be out of calibration without any change in line separation, and the reported position of the tool would be shifted.

If the Position Sensor is measuring high line separation values, it may be an indication of loss of calibration. Line separation alone should not, however, be used as a test for calibration loss.

#### Bump Sensor

The bump sensor detects when the Position Sensor has been bumped above a shock limit broadly equivalent to a 200 mm to 254 mm drop onto a vinyl tiled concrete surface. A bump can cause the system to lose calibration; however, it is not the only cause of calibration loss. Checking the bump sensor status should be part of your regular calibration check.

You can use the GET command to check the bump sensor status. The bump status is indicated in bit 0x00200000 of the “Info.Status.Alerts” parameter. You can also check the bump sensor status using NDI ToolBox.

Because a bump can affect the calibration of the Position Sensor, the system will not report transformations if the bump sensor has detected a bump, unless:

- the bump sensor has been cleared, or
- reply option 0x0800 is used with the TX or BX command.

---

**Note** See the "*Polaris Application Program Interface Guide*" for details on checking and clearing the bump sensor, and using the TX, BX and GET commands.

---

If a bump has been detected, NDI recommends that you perform an accuracy assessment procedure with the NDI Accuracy Assessment Kit (AAK), to ensure that the Position Sensor is still calibrated. For information on the accuracy assessment procedure and AAK, contact NDI.

## 8.2 Updating the Firmware

The Polaris Vicra System's firmware is stored in an EPROM flash memory device in the Position Sensor. The latest firmware can be downloaded from the NDI Support Site at

<http://support.ndigital.com>.

Update the Polaris Vicra System's firmware using NDI ToolBox. (See the NDI ToolBox online help for further information.)

The system incorporates a safe boot loader that will perform verification of the control firmware in the Position Sensor's memory prior to loading and executing it. It has been included to provide a fall back if a future control firmware upgrade fails. A field firmware upgrade could fail, due to communication or power faults. In these cases, the Position Sensor will still be able to start up by running the safe boot loader. This will provide minimal support, to allow the user to retry the control firmware upgrade.

## 9 Approvals

The Polaris Vicra System (consisting of a Position Sensor, Model P6, Power Adapter and a Host USB Converter), qualifies for the following approvals.

Table 9-1 Electrical Safety

Standard	Description
EN60601-1 (1990) Second Edition plus A1:93, A2:95, A12:93 and Corr:94	Medical Electrical Equipment Part I: General Requirements for Safety
CAN/CSA-C22.2 No. 601.1-M90 (R2001)	Medical Electrical Equipment Part I: General Requirements for Safety
UL 60601-1, First Edition, dated April 25, 2003.	Medical Electrical Equipment Part I: General Requirements for Safety

Table 9-2 Electromagnetic Compatibility

Standard	Description
CISPR 11/EN55011 FCC Part 15, Class B	Class B, Group 2, ISM Equipment
IEC60601-1-2:2001	Medical Electrical Equipment, Part 1: General Requirements for Safety—Collateral Standard: Electro-Magnetic Compatibility - Requirements and Tests.

### 9.1 Optical Radiation Safety

The Polaris Vicra Position Sensor has been assessed against the IEC Standard 60825-1 and the Euronorm EN60825-1 and found not to pose a potential hazard to the eye under any foreseeable viewing condition.

**Note** The Polaris Vicra System emits IR light that may interfere with IR controlled devices, such as operating room tables. It is recommended that you test the Polaris Vicra System if you intend to use it in an environment where other IR controlled devices are in use.

## 10 Classifications

Table 10-1 Classifications

Classification	Description
Electric shock protection	Class I - no applied parts
Degree of Protection from electric shock	Not classified
Degree of Protection against ingress of solids and liquids	Position Sensor designed to IP 54
Flammable atmosphere	Not suitable for use in the presence of a flammable anaesthetic mixture with air, oxygen or nitrous oxide
Mode of operation	Continuous when supplied by mains
Method of sterilization or disinfection	Not suitable for sterilization



# 11 Technical Specifications

This chapter provides technical specifications on each of the system units.

## 11.1 Position Sensor

Table 11-1 Position Sensor - Technical Specifications

Specification	Value
Dimensions	273 mm x 69 mm x 69 mm
Weight	<1 kg
Mounting	1/4" thread tripod mount, or 3 M3 x 0.5 mm x 9 mm screws
Host Interface	USB (1.1 and 2.0 compatible)
Maximum Update Rate	20 Hz
Input Voltage	26 VDC
Power Consumption	13.5 W (approx.)

Table 11-2 Position Sensor - Operating Environmental Conditions

Environmental Condition	Value
Atmospheric Pressure	70 kPa to 106 kPa
Relative Humidity	30% to 75%
Temperature	+10°C to +30°C (See note below)

The system requires a warm-up time from storage temperature to operating temperature equivalent to 10 minutes plus one minute for every 1°C of difference between storage temperature and operating temperature. (If the temperature difference is within 5°C, the warm-up time will be 10 minutes.)

For example, if the system is stored at -10°C and moved to a location at +30°C, the warm-up time will be 10 minutes, plus an additional 40 minutes to account for the difference in temperature.



**Warning!**

Do not transport or store the Position Sensor outside the recommended storage temperature range, as this may cause the system to go out of calibration. Reliance on data provided by an out of calibration Position Sensor may lead to inaccurate conclusions and may cause personal injury. A calibration procedure must be performed before using the Position Sensor after it has been transported or stored outside the recommended storage temperature range.

**Caution!** To ship the Polaris Vicra System, repack it in the original containers with all the supplied protective packaging. The provided packaging is designed to prevent damage to the equipment.

**Table 11-3 Position Sensor - Transportation and Storage Environmental Conditions**

Specification	Value
Atmospheric Pressure	50 kPa to 106 kPa
Relative Humidity	10% to 90% non-condensing
Temperature	-10°C to +50°C

## 11.2 Host USB Converter

**Table 11-4 Host USB Converter - Technical Specifications**

Specification	Value
Dimensions	88 mm x 57 mm x 39 mm
Weight	0.35 kg
Mounting	Free standing or secured via internal threads (M6 x 1mm pitch 3 mm depth) in (three) mounting feet
Input Voltage	24 VDC
Output Voltage	26 VDC
Power Consumption	<2 W

**Table 11-5 Host USB Converter - Operating Environmental Conditions**

Environmental Condition	Value
Atmospheric Pressure	70 kPa to 106 kPa
Relative Humidity	30% to 75%
Temperature	+10°C to +30°C

**Table 11-6 Host USB Converter - Transportation and Storage Environmental Conditions**

Specification	Value
Atmospheric Pressure	50 kPa to 106 kPa
Relative Humidity	10% to 90% non-condensing

Table 11-6 Host USB Converter - Transportation and Storage Environmental Conditions

Specification	Value
Temperature	-10°C to +50°C

### 11.3 Power Adapter

Table 11-7 Power Adapter - Technical Specifications

Specification	Value
Dimensions	125 mm x 62 mm x 32 mm
Weight	0.37 kg
Mounting	Free standing
Input Voltage	100 VAC to 240 VAC, 50/60 Hz
Output Voltage	24 VDC @ 2.1 A
Power Consumption	48 W (max.) (24 W typical)

Table 11-8 Power Adapter - Operating Environmental Conditions

Environmental Condition	Value
Atmospheric Pressure	70 kPa to 106 kPa
Relative Humidity	30% to 75%
Temperature	+10°C to +30°C

Table 11-9 Power Adapter - Transportation and Storage Environmental Conditions

Specification	Value
Atmospheric Pressure	50 kPa to 106 kPa
Relative Humidity	10% to 90% non-condensing
Temperature	-10°C to +50°C

## 12 Electromagnetic Compatibility



Radio frequency communications equipment, including portable and mobile devices, may affect the Polaris Vicra System and result in personal injury.

### 12.1 Electrostatic Discharge

Care should be taken to mitigate the production of electrostatic charges, to avoid any damage to the equipment that could cause incorrect data to be returned, (possibly resulting in personal injury). These measures can include, but are not limited to, appropriate air conditioning, humidification, conductive floor coverings, attire.

It is not a good practice to use the Polaris Vicra System either adjacent to, or stacked with, other equipment. Check that the Polaris Vicra System is operating normally if it is used either adjacent to, or stacked with, other equipment.

### 12.2 Cables and Accessories

The following table lists the cables and accessories that may be used with the Polaris Vicra System while still maintaining compliance to the emissions and immunity requirements of IEC60601-1-2:2001.



Use of cables or accessories, other than those listed in the following table, may result in increased emissions and/or decreased immunity of the Polaris Vicra System and may result in personal injury.

Table 12-1 Cables and Accessories That Maintain Compliance

Name	NDI P/N	Type	Shield	Notes
Cable AC Line Cord, Medical Grade	7500010	North American	No	Mains to Power Adapter
Cable AC Line Cord	7500012	France/Belgium/Germany	No	Mains to Power Adapter
USB cable	2600596	USB, A-B male, double shielded, 2 m	Yes	Computer to Host USB Converter
Power Adapter	4100139	Switch Mode, 100-240 VAC input, 24 VDC, 40 W output	NA	NA

## 12.3 Guidance and Manufacturer's Declaration - Electromagnetic Emissions

The Polaris Vicra System meets the electromagnetic environments listed below. The customer or the user of the Polaris Vicra System should ensure that it is only used in such an environment.

Table 12-2 Manufacturer's Declaration for Electromagnetic Emissions

Emissions Test	Compliance	Electromagnetic Environment Guidance
RF emissions CISPR11	Group 2	The Polaris Vicra System must emit electromagnetic energy in order to perform all its intended functions. Nearby electronic equipment may be affected.
RF emissions CISPR11	Class B	The Polaris Vicra System is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes
Harmonic emissions IEC61000 3-2	Class A	
Voltage fluctuations/ flicker emissions IEC61000-3-3	Complies	

## 12.4 Guidance and Manufacturer's Declaration - Electromagnetic Immunity

The Polaris Vicra System is intended for use in an environment that meets the requirements outlined by the manufacturer's declaration for electromagnetic immunity (See [Table 12-3 on page 65](#)). The customer or the user of the Polaris Vicra System should ensure that it is only used in such an environment.


Table 12-3 Electromagnetic Immunity

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±6 kV contact ±8 kV air	Observe precautions when connecting or disconnecting cables at ports identified with the ESD warning symbol

Table 12-3 Electromagnetic Immunity (Continued)

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
Electrical Fast Transient (EFT)/burst IEC 61000-4-4	±2 kV for power supply lines. ±1 kV for I/O lines	±2 kV for power supply lines. ±1 kV for I/O lines	Care must be taken to route all patient-coupled cables away from high power, high current or other cables or sources that may induce electrical fast transients into the patient-coupled cables. If such interference is suspected, the cables should be re-routed and/or the source of the interference shielded or otherwise isolated.
Surge IEC 61000-4-5	±1 kV differential mode	±1 kV differential mode	
	±2 kV common mode	±2 kV common mode	
Dips/Interruptions/ Variations on power supply input IEC 61000-4-11	<5% $U_t$ for 0.5-cycles	<5% $U_t$ for 0.5-cycles	
	40% $U_t$ for 5-cycles	40% $U_t$ for 5-cycles	
	70% $U_t$ for 25-cycles	70% $U_t$ for 25-cycles	
	<5% $U_t$ for 5 sec	<5% $U_t$ for 5 sec	
Power frequency (50/60Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.

Table 12-4 Electromagnetic Immunity - Not Life Supporting

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 V	<p>Portable and mobile RF communications equipment should be used no closer to any part of the Polaris Vicra System, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.</p> <p>Recommended separation distance:</p> $d = \left(\frac{3.5}{3}\right)\sqrt{P}$ <p>See <a href="#">Table 12-5 on page 68</a></p>
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	3 V/m	<p><math>d = \left(\frac{3.5}{3}\right)\sqrt{P}</math> 80 MHz to 800 MHz</p> <p><math>d = \left(\frac{7}{3}\right)\sqrt{P}</math> 800 MHz to 2.5 GHz</p> <p>where 'P' is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and 'd' is the recommended separation distance in metres.</p> <p>Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey<sup>a</sup>, should be less than the compliance level in each frequency range<sup>b</sup>. Interference may occur in the vicinity of equipment marked with the following symbol:</p> <div style="text-align: center;">  </div> <p>See <a href="#">Table 12-5 on page 68</a>.</p>

**Note**  $U_t$  is the AC mains voltage prior to the application of the test level.

**a** - Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast, cannot be accurately predicted. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location where the Polaris Vicra System is used exceeds the applicable RF compliance level above, observe the system to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the Polaris Vicra System.

**b** - Over the frequency range of 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

---

**Note** At 80 MHz and 800 MHz, the higher frequency range applies.

These guidelines may not apply to all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people. If an electromagnetic interference is suspected, it is the responsibility of the user to assess the electromagnetic environment in their location.

---

## 12.5 Recommended Separation Distances

The Polaris Vicra System is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the Polaris Vicra System can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the Polaris Vicra System, as recommended below according to the maximum output power of the communications equipment.

Table 12-5 Recommended Separation Distances

Rated maximum output power of transmitter (watts)	Separation distance according to frequency of transmitter (metres)		
	150kHz to 80MHz $d = \left(\frac{3.5}{3}\right)\sqrt{P}$	80 MHz to 800 MHz $d = \left(\frac{3.5}{3}\right)\sqrt{P}$	800 MHz to 2.5 GHz $d = \left(\frac{7}{3}\right)\sqrt{P}$
0.01	0.117	0.117	0.233
0.1	0.369	0.369	0.737
1.0	1.17	1.17	2.33
10	3.69	3.69	7.38
100	11.67	11.67	23.33

For transmitters rated at a maximum output power not listed above, the recommended separation distance (d) in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

---

**Note** At 80 MHz and 800 MHz, the higher frequency range applies.

These guidelines may not apply to all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

---

## 12.6 RF Emissions

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.

---

**Note** This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

---

**Notes** CE Mark: This is a Class B product. In a domestic environment, this product may cause radio interference, in which case the user may be required to take adequate measures.

Changes or modifications not expressly approved by Northern Digital Inc. could void the user's authority to operate the equipment.

To satisfy FCC and IC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended.

The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Industry Canada Compliance Statement: This class B digital apparatus meets the requirements of the Canadian Interference-Causing Equipment Regulations.

Avis de Conformité à la réglementation d'Industrie Canada: Cet appareil numérique de la classe B respecte toutes les exigences du règlement sur le matériel brouilleur du Canada.

---

# 13 Troubleshooting

## 13.1 Introduction

This section provides possible solutions to common problems and answers some frequently asked questions. For further information regularly check the NDI Support Site at:

<http://support.ndigital.com>

If you cannot find the answer to your question here or on the support site, contact NDI at the address shown at the front of this guide.

The majority of problems that may occur with the Polaris Vicra System can be grouped into one of the following categories:

- A system hardware failure (for example a faulty Position Sensor or cable)
- A tool error (for example, dirty markers)
- Environmental conditions (for example, incidental IR light)
- User error (for example, obscuring the optical path)

Certain faults may be indicated by system LEDs or audio tones, or by means of error messages in NDI ToolBox application software. These indications and messages are detailed in the following paragraphs.

## 13.2 System Indications

The LED indicators on the Position Sensor and Host USB Converter provide a visual indication of system status. In addition the Position Sensor emits audio tones that provide an audible indication of system status. Refer to table 13-1 below to interpret the system visual and audio indications.

Table 13-1 System Visual and Audio Indications

Indication	Meaning	Action
Position Sensor: Power LED is off	Position Sensor voltage out of range	1. Refer to Figure 13-1. If necessary proceed to 2 below. 2. Check for green power LED on Host USB Converter. If lit, check/replace the Position Sensor. If not lit, check/replace the power adapter, cables and Host USB Converter
Position Sensor: Power LED is flashing	Normal indication during warm-up	No action required
Position Sensor: Error LED is flashing	A recoverable system fault has been detected	Refer to the NDI ToolBox error message and table 13-2. (If you are using your own application, use the “Info.Status.Alert” parameter in the GET command)

Table 13-1 System Visual and Audio Indications (Continued)

Indication	Meaning	Action
Position Sensor: Error LED is lit	A non-recoverable system fault has been detected	Replace the Position Sensor
Position Sensor: two audio tones emitted	Normal indication when power is initially applied to the system or the system is reset	No action required
Host USB Converter: Error LED is lit	A fault has been detected by the Host USB Converter	Refer to Figure 13-1 for action

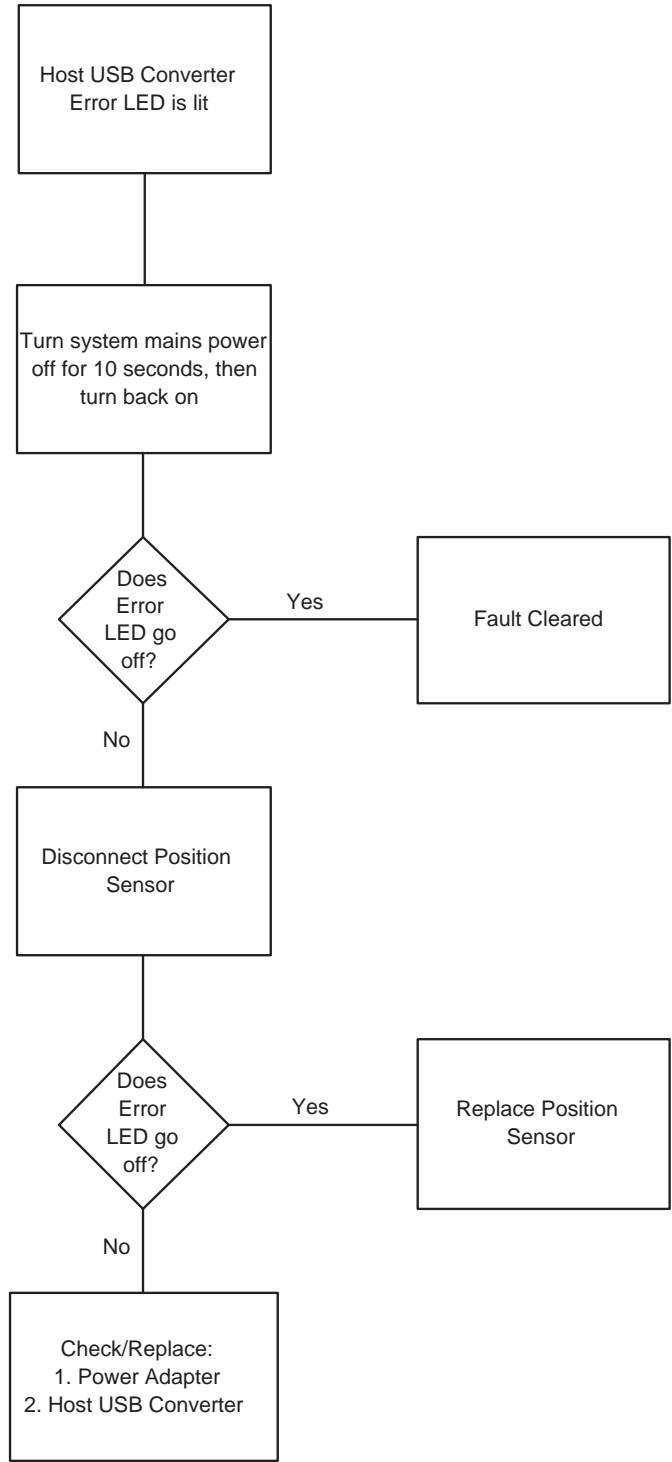


Figure 13-1 Host USB Converter - Error LED Fault Chart

### 13.3 NDI ToolBox Error Messages

The NDI ToolBox application software displays a box around the appropriate icon and an associated error message in the status message area for a number of possible system fault conditions. The

messages should be read in conjunction with the system LED and audio indications shown in Table 13-1. A list of error messages that may be displayed in NDI ToolBox is shown in Table 13-2

**Table 13-2 NDI ToolBox Error Messages**

ToolBox Icon	ToolBox Message	Action
Hardware	“Unable to initialize the system” and “Non-recoverable memory fault. Return for service”	Replace Position Sensor
Hardware	“Unable to initialize the system” and “Sensor calibration fault. Return for service”	Replace Position Sensor
Hardware	“Power fault. Check power supply, USB converter and cables”	1. Refer to Figure 13-1. If necessary proceed to 2 below. 2. Check for green power LED on Host USB Converter. If lit, check/replace the Position Sensor. If not lit, check/replace the power adapter, cables and Host USB Converter
Hardware	“Sensor hardware fault. Return for service”	Replace Position Sensor
Hardware	“Illuminator hardware fault. Return for service”	Replace Position Sensor
Hardware	“Illuminator hardware fault. Return for service”	Replace Position Sensor
Hardware	“Cable fault. Check USB converter and cables”	Check/replace Host USB Converter
Hardware	“Incompatible firmware versions” and “System programming fault. Firmware update required”	Reload/update firmware
Hardware	“Unable to initialize the system” and “Recoverable memory error. Check settings and save”	Reload/update firmware
Bump status	“Bump detector battery fault. Return for service”	Replace Position Sensor or be aware that bumps will not be detected
Bump status	“Serious bump detected. Accuracy assessment recommended”	System accuracy assessment recommended. Contact NDI for details.
Temperature	“Internal temperature above calibrated operating range”	Allow Position Sensor to cool down
Temperature	“Internal temperature below calibrated operating range”	Allow Position Sensor to reach operating range
Temperature	“Temperature compensation fault. Return for service”	Replace Position Sensor
No icon	“Control firmware missing or corrupted” and “Unable to initialize the system”	Reload/update firmware
No icon	“Internal flash memory is full”	Replace Position Sensor

---

**Note** If you are using your own applications, use the GET command to read the “Info.StatusAlert” parameter to check the alert status. Refer to the *“Polaris Application Program Interface Guide”* for further information.

---

## 13.4 Common Problems

The following paragraphs lists specific problems and a possible solution.

### **The tool is inside the measurement volume, but the software reports that the tool is partially out of volume**

This may mean that less than the **minimum number of markers** (a parameter in the tool definition file) are inside the characterized measurement volume, but at least one marker on the tool is inside the characterized measurement volume.

For example, consider a four-marker tool, whose minimum number of markers parameter is set to 4. If three of the tool’s markers are inside the characterized measurement volume, and the other marker is outside the characterized measurement volume, the Polaris Vicra System will continue to track the tool, but the accuracy is unknown, and the tool will be reported as partially out of volume.

### **The system doesn’t track tools at the back of the characterized measurement volume**

If the system will track at the front of the measurement volume but not at the back, the Position Sensor may be damaged, or calculating high line separation values. For more details on line separation, see [“Marker Detection and Tool Tracking” on page 28](#). You can check the line separation values using the 3D command. See the *“Polaris Application Program Interface Guide”* for details.

### **Other IR-based devices are not working properly**

Using the Polaris Vicra System in the same room as other IR-based devices may cause these other devices to malfunction. The Position Sensor’s illuminators flood the surrounding area with IR light, which could saturate other IR receiving devices, preventing them from properly receiving other IR signals.

It may be possible to synchronize other devices with the Polaris Vicra System, so that IR signals from the other devices are not being emitted at the same time as the illuminators emit IR. Contact NDI Technical Support for details or visit the support site at <http://support.ndigital.com>.

### **The Polaris Vicra System is tracking some tools, but not others**

As the Position Sensor begins to lose calibration, it may lose the ability to track some tools before others. This is due to the various algorithm constraints used by the Polaris Vicra System, which make certain tool designs more sensitive to loss of calibration than others. Consider, for example, a tool that has several similar segment lengths or similar angles between segments, or has segment lengths similar to those of another tool. The out-of-calibration Position Sensor may not be able to determine which markers belong to which tool, and so will report the tools as missing. (See [“Marker Detection and Tool Tracking” on page 28](#) and the *“Polaris Tool Design Guide”* for details on segment lengths and angles.)

---

See “[Checking the Calibration of the Polaris Vicra System](#)” on page 57 for more details about calibration.

## Reflections and other IR Sources

Reflections and other IR sources may cause markers to become “lost” in the background IR light. These reflections and sources should be eliminated or minimised as much as possible. Reflections occur when IR light from the illuminators is reflected off surfaces such as:

- drapes - ensure that drapes are placed such the reflections are minimised
- reflective surfaces - minimise reflective surfaces in the environment
- tools - design and manufacture tools in non-reflective materials. Refer to the “*Polaris Tool Design Guide*” for further information.

Other sources of IR light, such as operating room lights, should be considered when positioning the system in order to minimise interference from such devices.

## What happens if the markers are partially blocked from the view of the Position Sensor?

The Polaris Vicra System requires a clear line-of-sight to the markers. Anything that interferes with the line-of-sight can reduce the measurement accuracy. The magnitude of the errors that are caused by partial occlusion of the markers depends on the number of markers, the geometry of the tool, and the severity of the occlusion. Errors caused by partial occlusion can have exactly the same magnitude for active and passive tools. However, there is more opportunity to partially occlude the passive markers because they are larger than active markers. When designing a new tool, it is important to consider the effect of partial occlusion on its accuracy. The values used for these parameters will also depend on the design of the tool. The best value is usually determined through experimentation. See the “*Polaris Tool Design Guide*” for further information on tool design.

## Why is the tool reported as missing?

A tool may be reported as missing if:

- it has been rotated so that too few markers are visible to the Position Sensor
- the tool is no longer in the field of view
- the tool is damaged, for instance if it is bent
- the condition of the markers has deteriorated, for instance scuffed, or occluded with foreign matter.

## The Position Sensor seems too warm

The Position Sensor will be warm to the touch during normal use. If the temperature goes out of range an error message will be shown in NDI ToolBox application software.

### **The Virtual Serial Port cannot be opened**

If you cannot open the virtual serial port, check the system connections, the Host USB Converter and the host PC USB port.



## 14 Return Procedure and Warranty

### 14.1 Return Procedure

In the event that you need to return equipment to NDI for repairs, you will need to fill out a Return Materials Authorization (RMA) request form at the NDI Support Site at <http://support.ndigital.com>. NDI will contact you with RMA information and shipping instructions. Any materials you are returning to NDI should be shipped in their original packaging.

You are responsible for the shipping costs of returning equipment to NDI, whether or not the equipment is covered under warranty. When the equipment is received at NDI, it will be inspected to determine whether the required repair is covered under warranty. NDI can provide you with a quote of repair costs either before or after repairs have been made. If the equipment is covered under warranty, NDI will pay the return shipping costs. If the equipment is not covered under warranty, you are required to pay the return shipping costs.

### 14.2 Warranty

Unless otherwise agreed to in writing by NDI, the warranty is as follows, and applies only to the original purchaser.

---

**Note** This warranty is also posted on the NDI Support Site at <http://support.ndigital.com>.

---

#### Hardware

NDI warrants to the Buyer that NDI's hardware product(s) will be free from defects in material and workmanship only for a period twelve (12) months from the date such product(s) is/are shipped from NDI to the Buyer.

This warranty does not apply to product(s) normally consumed in Buyer's operations or which have a normal life inherently shorter than the above-stated warranty period. Without limiting the generality of the foregoing, the following products shall have the following warranty periods:

product or components thereof which are re-chargeable batteries . . .	90 days from shipment
infrared emitting diode (IRED) markers or product(s) which contain IRED markers (other than illuminators on Position Sensors) . . . . .	90 days from shipment
single use, disposable reflective (passive-type) markers . . . . .	prior to first use but no more than 90 days from shipment

#### Software

NDI's software product(s) is/are licensed and provided "as is, where is" without warranty of any kind. NDI makes no warranties, express or implied, that the functions contained in the software product(s) will meet the Buyer's requirements or that the operation of the programs contained therein will be error free.

## General Provisions Applicable to Warranty

NDI's obligations under this warranty shall be limited to repairing or replacing (at NDI's option) the product(s), EXW (Incoterms 2000) NDI's plant (Waterloo, Ontario, Canada). Any original parts removed and/or replaced during any repair process shall become the property of NDI. This warranty shall apply only to the original Buyer [being that person or legal entity which has contracted directly with NDI for the supply of the product(s)]. Repair work shall be warranted on the same terms as stated herein except such warranty shall be for a period of sixty (60) days or for the remainder of the unexpired warranty period, whichever is longer. In respect of any product(s) supplied hereunder which are manufactured by others, NDI gives no warranty whatsoever, and the warranty given by such manufacturers, if any, shall apply.

The obligations of NDI set forth in this warranty are conditional upon proper transportation, shipping, handling, storage, installation, use, maintenance and compliance with any applicable recommendations of NDI. Without limiting the generality of the foregoing, this warranty shall not apply to defects or damage resulting from: fire; misuse; abuse; accident; neglect; improper installation; improper care and/or maintenance; lack of care and/or maintenance; customer supplied software interfacing; modification or repair which is not authorized by NDI; power fluctuations; operation of hardware product(s) outside of environmental specifications; improper site preparation and maintenance; permitting any substance whatsoever to contaminate or otherwise interfere with optics; and any other cause beyond the control of NDI. The obligations set forth in this warranty are further conditional upon the Buyer promptly notifying NDI of any defect and, if required, promptly making the product(s) available for correction. NDI shall be given reasonable opportunity to investigate all claims and no product(s) shall be returned to NDI without NDI first providing the Buyer with a return material authorization number and shipping instructions. All product(s) returned to NDI shall be packaged in the containers originally used by NDI to ship the product(s) to the Buyer.








NDI, for itself, its agents, contractors, employees, providers, and for any parent or subsidiary of NDI, expressly disclaims all warranties, express or implied, including, without limitation, of merchantability or fitness for a particular purpose.

The foregoing warranty is the entire warranty of NDI. NDI neither assumes nor authorizes any person, purporting to act on its behalf, to modify or to change this warranty, or any other warranty or liability concerning the product(s).

## 15 Abbreviations and Acronyms

Acronym or Abbreviation	Definition
5DOF	5 Degrees Of Freedom
6DOF	6 Degrees Of Freedom
AAK	Accuracy Assessment Kit
API	Application Program Interface
CCD	Charge Coupled Device
CRC	Cyclic Redundancy Check
DSR	Data Set Ready
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPROM	Erasable Programmable Read Only Memory
FCC	Federal Communications Commission
IC	Industry Canada
IR	Infrared Light
IREL	InfraRed Light Emitting Diode
LED	Light Emitting Diode
MRI	Magnetic Resonance Imaging
NDI	Northern Digital Inc.
OR	Operating Room
PROM	Programmable Read Only Memory
RF	Radio Frequency
RMA	Return Materials Authorization
RMS	Root Mean Square
USB	Universal Serial Bus

## 16 Equipment Symbols

Symbol	Meaning	System Components
	Hardware Attention! Consult accompanying documents.	Position Sensor Host USB Converter
	On (power: connection to the mains supply)	Position Sensor Host USB Converter
	Status	Position Sensor
	Error	Position Sensor Host USB Converter
	Direct Current	Host USB Converter
	USB Port	Host USB Converter
	Connection Port	Position Sensor

---

## 17 Glossary

### 3D RMS Error

The RMS error is the square root of the sum of the squares of the measurement errors. This can be approximated by the square root of the mean square added to the standard deviation squared of the errors.

### Calibration

Calibration is the process of establishing, under specified conditions, the relationship between values produced by an NDI measurement system and corresponding known values established by a device that is traceable to a national standard.

### Characterized Measurement Volume

The characterized measurement volume is the volume within the detection region where accuracy is within specified limits. NDI cannot guarantee measurement accuracy outside this region.

### Faces

Tool faces are separate rigid bodies that make up a tool.

### Field of View

The field of view is the total volume in which the Polaris Vicra System can track a marker, regardless of accuracy.

### Firmware

Firmware is a computer program stored in an NDI hardware device and controls the Polaris Vicra System.

### Flash EPROM

Flash Electrically Erasable Programmable Read Only Memory (EEPROM) stores control parameters and system information within the Position Sensor. The information programmed to the Flash EEPROM is retained even after the system is turned off.

### Frame

A frame contains the measured positions of the markers in the field of view at a particular point in time.

### Global Coordinate System

The global coordinate system is the Polaris Vicra coordinate system. The global coordinate system is used by the Polaris Vicra as a frame of reference against which tool transformations are reported. By default, the global coordinate system's origin is set at the Position Sensor

---

## **Illuminator Ring**

The illuminator ring is a ring of IR light emitting diodes that surround the sensor lenses on the Position Sensor. These flood the area in front of the Position Sensor with IR light, which is reflected back to the Position Sensor by the passive markers.

## **Line Separation**

To determine the position of an IR source, the Position Sensor calculates a line between the source of IR and each sensor. The line separation is the distance between these two lines where they cross.

## **Local Coordinate System**

A local coordinate system is a coordinate system assigned to a specific tool or rigid body.

## **Maximum 3D Error**

Maximum 3D error applies to individual markers. It specifies, in the tool definition file, the maximum allowable difference between the measured and expected location of a marker on a tool or rigid body.

## **Maximum Marker Angle**

Maximum marker angle is used to determine if a marker will be used in the calculation of a rigid body or tool. If the marker is determined to be farther off-angle to the Position Sensor than the maximum marker angle, this data is not used to determine the rigid body or tool.

## **Passive Marker**

A passive marker is a retro-reflective passive sphere that reflects IR light emitted by the Position Sensor.

## **Pivoting**

Pivoting is a procedure (of rotating a tool about its tip) used to determine the tool tip offset.

## **Position Sensor**

The Position Sensor is the component of the Polaris Vicra System that provides a source of IR light for passive markers, collects marker position data from both active and passive markers, calculates tool transformations, and sends the results to the host computer.

## **Quaternion**

A quaternion is a compact representation of rotations, or correspondingly, orientations in 3D space (rather than having to use orthogonal matrices).

## **Reference Tool**

A reference tool is a tool or rigid body whose local coordinate system is used as a frame of reference in which other tools are reported/measured.

**Rigid Body**

A rigid body is an object on which three or more markers are fixed relative to one another.

**Tool Definition File**

A tool definition file stores information about a tool or rigid body. This includes information such as the placement of the tool's markers, the location of its origin, and its manufacturing data. A tool definition file is formatted as .rom for tools.

**Tool Tip Offset**

The tool tip offset is the vector between the tip of the tool and the tool origin.

**Transformation**

A transformation is a combination of translation and rotation values that describe a change of the tool or rigid body in position and orientation.

**Unique Geometry Tool**

Unique geometry tools incorporate markers positioned in such a way that, when detected in the measurement volume, the tool can be uniquely identified from other tools.

# 18 Declaration of Conformity

Figure 18-1 is a copy of the EC Declaration of Conformity for the Polaris Vicra System.



## EC DECLARATION OF CONFORMITY

**Manufacturer:** NORTHERN DIGITAL INC.

**Address:** 103 Randall Drive  
Waterloo, Ontario  
Canada N2V 1C5

**Equipment Type:** Opto-Electronic Spatial Measurement System

**Trade Name:** Polaris® Vicra™

**EEC Directive(s):** The above mentioned product conforms with the requirements of the following European Council Directive(s):

**89/336/EEC – EMC Directive**  
**73/23/EEC – Low Voltage Directive**  
**1999/5/EC – R&TTE Directive**

Dated at Waterloo, Ontario, Canada this 19<sup>th</sup> day of August 2005.

NORTHERN DIGITAL INC.

per:

A handwritten signature in black ink, appearing to read "David G. Crouch", is written over a horizontal line.

David G. Crouch  
President

---

FM-10098 Rev 001

Figure 18-1 EC Declaration of Conformity



## Appendix A Polaris Vicra Calibration Performance and Methodology

Standard industry practice dictates that all measurement and testing instruments should be periodically calibrated to ensure they are operating within tolerances acceptable to the user and/or the user's customers.

The user must establish a calibration procedure and interval that is appropriate for the accuracy requirements of their application.

The Position Sensor is a highly specialized instrument developed exclusively by NDI. For all calibration procedures, return the Position Sensor to NDI. This practice ensures that all calibrations are conducted in accordance with procedures established specifically for the Polaris Vicra Position Sensor.

---

**Note** The NDI Accuracy Assessment Kit (AAK) can be used in the field as an aid to determine whether a Position Sensor is performing acceptably for the user's application.

---

If, at any time, a concern should arise that the Position Sensor is not measuring accurately, it should be returned to NDI.

---

**Note** The calibration procedure at NDI applies to single markers and cannot be directly applied to an application that uses tools with several markers.

---

### A.1 Polaris Vicra Performance

The Polaris Vicra System performance is determined by a statistical analysis of the 3D Euclidean distance error between the reported position of an NDI marker and its true position, based on measurements taken throughout the entire Polaris Vicra System's measurement volume. Acceptance criteria for the Polaris Vicra System's performance are based on the RMS values of the accuracy and repeatability.

The **3D RMS volumetric accuracy acceptance criterion** is less than or equal to 0.25 mm, based on a single marker stepped through a statistically representative set of positions throughout the measurement volume, using the mean of 30 samples at each position at 20°C.

The **3D RMS repeatability acceptance criterion** is less than or equal to 0.20 mm, based on total samples of a single marker stepped through a statistically representative set of positions throughout the measurement volume, using 30 samples per position at 20°C.

### A.2 Calibration Method

The following method is used to calculate the Polaris Vicra System's accuracy and repeatability:

An NDI marker is accurately moved to each of  $n$  locations  $(X_i, Y_i, Z_i)$  spread throughout the measurement volume. The mechanism that moves the marker is assumed to have an accuracy that is at least 10 times better than the measured accuracy of the Polaris Vicra System. This assumption allows the errors in the marker positioning to be ignored.

At each of the  $n$  locations, the Polaris Vicra System takes  $m$  readings of the marker's 3D position  $(x_{ij}, y_{ij}, z_{ij})$ .

The **accuracy of the Polaris Vicra System** is calculated as the RMS variation of the mean of  $m$  readings about the true 3D location calculated across all  $n$  locations throughout the measurement volume.

The **repeatability of the Polaris Vicra System** is calculated as the RMS variation of the  $m$  readings about the average of the 3D readings at each location  $n$ . This RMS variation is calculated across all  $n$  locations throughout the measurement volume.

**3D average measurements:**

$$x_{i\text{average}} = \frac{\sum_{j=1}^m x_{i,j}}{m}, \quad y_{i\text{average}} = \frac{\sum_{j=1}^m y_{i,j}}{m}, \quad z_{i\text{average}} = \frac{\sum_{j=1}^m z_{i,j}}{m}$$

$$\text{3D RMS accuracy} = \sqrt{\frac{\sum_{i=1}^n \left[ (x_{i\text{average}} - X_i)^2 + (y_{i\text{average}} - Y_i)^2 + (z_{i\text{average}} - Z_i)^2 \right]}{n}}$$

$$\text{3D RMS repeatability} = \sqrt{\frac{\sum_{i=1}^n \left[ \sum_{j=1}^m \left[ (x_{i,j} - x_{i\text{average}})^2 + (y_{i,j} - y_{i\text{average}})^2 + (z_{i,j} - z_{i\text{average}})^2 \right] \right]}{n \cdot m}}$$

# Index

## Symbols

.rom file, 31

## Numerics

3 marker lock on, 29

3D RMS error, 81

5DOF, 30

6D Architect

installation, 21

6DOF, 30

## A

AAK, 85

accessories, 64

accuracy, 27

accuracy assessment kit, 10, 57, 58, 85

acquiring tools, 28

active wireless tools, 13

approvals, 59

audio codes, 9, 48, 51

## B

background IR light, 16, 54, 55

battery, 10

baud rate, 20

boot loader, 58

bump sensor, 10

bump sensor battery, 10

## C

cables, 12

connecting, 19

cables and accessories, 64

cables and connectors, 53

calibration, 57, 81, 85

calibration method, 85

calibrator, 35

CAPi Sample, 14

installing, 20

cautions, 2, 16

CCD, 28

characterization, 31

characterized measurement volume, 26, 81

classifications, 60

codes, 48

component parts list, 14

connecting hardware, 19

coordinate system

global, 26, 81

local, 30, 82

## D

data transmission rate, 40

declaration of conformity, 84

decontamination policy, 77

detecting markers, 28

disabled transformations, 48

disclaimers, 3

drivers

USB, 21

## E

electrical safety, 59

electromagnetic compatibility, 64

electromagnetic emissions, 65

electromagnetic immunity, 65

electrostatic discharge, 64

EMC, 79

EMI, 79

environment, 15

EPROM, 81

error, 25

maximum 3D, 82

error codes, 48

error flags, 42, 48

error indicator

Host USB Converter, 11, 51

Position Sensor, 8

errors

out of volume, 49

## F

face, 81

face normal, 31

- field of view, 26, 81
- firmware, 81
- Firmware Update Utility
  - installation, 21
- flags, 25, 48
  - out of volume, 49
- flash EPROM, 81
- frame, 81
- frame number, 25

## G

- geometry, 30
- global coordinate system, 26, 81

## H

- hardware warranty, 77
- host computer
  - specifications, 6
- Host USB Converter, 11
  - connecting, 19
  - error indicator, 11
  - mounting, 11
  - operating environmental conditions, 62
  - part number, 14
  - power indicator, 11

## I

- illuminator filter, 8
- illuminator ring, 82
- illuminators, 7, 28
- indicator LED, 8, 11, 51
  - communications, 51
  - error, 8, 51
  - power, 8, 51
  - status, 8
- information and error flags, 42
- infrared light sensitivity, 54, 55
  - API command SENSEL, 56
- ingress protection, 10
- installing
  - software, 20
  - USB drivers, 21
- integration time, 28, 54
- IR light, 16
- IRED, 79

## K

- keyed features, 24

## L

- LED, 11
- lights, 11
- line of sight, 16
- line separation, 29, 38, 57
- Linux support, 22
- local coordinate system, 30, 82

## M

- maintenance, 52
- marker
  - detection, 28
  - passive, 82
  - phantom, 38
- marker geometry, 30
- marker Information, 50
- marker normal, 32
- markers, 32
  - stray, 37
- maximum 3D error, 31, 82
- maximum marker angle, 32, 82
- measurement volume, 6, 26
- minimum number of markers, 29, 32
- minimum spread, 33
- missing transformations, 48
- mounting
  - Host USB Converter, 11
  - Position Sensor, 9
- mounting post, 32
- MRI, 17

## N

- NDI, 79
- NDI 6D Architect
  - installation, 21
- NDI CAPI Sample, 14
  - installing, 20
- NDI Firmware Update Utility
  - installation, 21
- NDI Sensitivity Utility
  - installation, 21
- NDI ToolBox, 8, 14

error messages, 72  
 installing, 21  
 normals  
   face, 31  
   marker, 32

## O

offset, 35  
 operating environment, 16  
 operating environmental conditions  
   Host USB Converter, 62  
   Position Sensor, 61  
   power adapter, 63  
 optical radiation safety, 59  
 orientation of tool, 25  
 origin of a tool, 35  
 out of volume, 27, 49  
 overview, system, 6

## P

parameter  
   minimum number of markers, 32  
   minimum spread, 33  
 parameters, 31, 34  
   maximum 3D error, 31  
   maximum marker angle, 32  
 part number  
   Host USB Converter, 14  
   position sensor, 14  
   Power Adapter, 14  
   USB cable, 14  
 partially out of volume, 27  
 parts list, 14  
 passive marker, 82  
 Passive Sphere Markers, 38  
 passive sphere markers, 32  
   sterilization, 39  
 passive tools, 13  
 phantom markers, 38  
 pivot, 45  
 pivoting, 36, 82  
 port status flags, 49  
 position of tool, 25  
 Position Sensor, 7, 28, 82  
   cleaning, 52  
   connector, 9  
   front view, 8  
   mounting, 9  
   operating environmental conditions, 61  
   rear view, 9

  technical specifications, 61  
   temperature, 75  
 Position Sensor cable, 12  
 post, 32  
 power adapter, 12  
   operating environmental conditions, 63  
   technical specifications, 63  
   transportation and storage environmental conditions, 63  
 power adapter cable, 12  
 power indicator  
   Host USB Converter, 11, 51  
   Position Sensor, 51  
 power LED, 8

## Q

quaternion, 25

## R

reference tool, 36, 44, 82  
 resolution, screen, 7  
 return procedure, 77  
 RF, 79  
 rigid body, 83  
 RMA number, 77  
 RMS error, 25

## S

safety  
   electrical, 59  
   optical radiation, 59  
 screen resolution, 7  
 SENSEL command, 56  
 sensitivity to IR light, 54, 55  
   API command SENSEL, 56  
   changing the IR sensitivity level, 55  
 Sensitivity Utility  
   installation, 21  
 sensor, 8  
 separation distances, 68  
 set as reference, 44  
 setting a tool as reference, 44  
 software, 14  
   installing, 20  
   NDI CAPI Sample, 14  
   NDI ToolBox, 14  
   ToolBox, 56

- warranty, 77
- specifications
  - host computer, 6
- status
  - marker, 25
  - system, 25
  - tool, 25
- status LED, 8
- stray markers, 26, 37
- strober voltage, 54
- support site, 4
- system indications, 70
- system overview, 6
- system software, 14
- system status, 25

## T

- temperature, 17
- tip offset, 35
- tool definition file, 13, 31, 83
- tool information flags, 50
- tool tip offset, 35, 45, 83
- tool tracking parameters, 31, 34
- tool tracking utility, 41
- ToolBox, 14, 56, 75
  - installing, 21
- tools, 13
  - 5DOF, 30
  - 6DOF, 30
  - acquiring, 28
  - geometry, 30
  - multi-face, 30
  - tracking, 28
  - using as reference, 36, 82
- tracking error, 25

- tracking flags, 25
- tracking tools, 28, 41
- transformation, 83
- transformations
  - out of volume, 26
- transportation and storage environmental conditions
  - Host USB Converter, 62
  - Position Sensor, 62
  - power adapter, 63
- trigger level, 28, 54

## U

- unique geometry, 30, 83
- unpacking the system, 15
- update information, 4
- USB, 79
- USB cable, 12
- USB drivers, 21

## V

- virtual serial port, 76

## W

- warnings, 1
- warranty, 77
  - general provisions, 78
  - hardware, 77
  - software, 77