NDI 6D Architect (Version 3) User Guide

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IMPORTANT
Please read this entire document before attempting to operate NDI 6D Architect

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Characterizing Aurora Tools

Read Me First

This document supports NDI 6D Architect Aurora®, Polaris Vicra® and Polaris Spectra™ Systems. The generic term “Polaris” is used throughout this document to refer to both Polaris Vicra and Polaris Spectra systems. Read this section before continuing.

Warnings

Warning!

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

1. Do not perform a pivot until you have read and understood how best to complete a pivot procedure. Refer to the “Polaris Tool Design Guide” or “Aurora Tool Design Guide” for detailed instructions and guidance. Failure to perform a pivot correctly may lead to an incorrectly defined tool tip offset, which may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.
2. Do not program the tool or use it in an actual application until you have tested its tool definition file and verified that, when applied to the tool, it returns appropriate data. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.
3. Do not interrupt the programming of an SROM device once it has started. A partially programmed SROM device will produce inaccurate transformations and possible personal injury.
4. Do not program a tool without first testing its tool definition file and reviewing its user-specified tags to ensure that the tool is properly characterized, and that its SROM device is not corrupted in any way. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.
5. Do not program a tool that has been dropped or damaged in any way during the characterization process, as the relative positions of its markers/sensor coils may have changed and are no longer accurately described by the tool definition file. You must perform another characterization using newly collected tool data. Programming a damaged tool without recollecting tool data will produce an incorrectly characterized tool, inaccurate transformations, and possible personal injury.
6. Do not program a tool until you have verified that you are applying the correct, corresponding tool definition file. If the tool definition file does not match the tool, the tool may still be tracked but will report incorrect data. This will produce inaccurate transformations and possible personal injury.
7. Make sure that markers are correctly identified in the tool definition file. Transformations for tools that are tracked using incorrect camera parameters will contain systematic errors and indicate incorrect positions for the tool. Incorrect tool positions may result in harm to a patient.

Disclaimers

1. NDI does not guarantee the accuracy of tool definition files produced from collecting tool data outside the characterized measurement volume.
2. Although NDI 6D Architect is designed to assist in testing the results of tool characterization, it does not dictate specific quality parameters. The user is solely responsible for the analysis of the results produced by a tool test.
3. Do not characterize a tool that includes non-NDI certified markers or sensor coils, as this may compromise the NDI measurement system’s performance and accuracy.

Questions?

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

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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 measurement system, check the NDI support site regularly for update information:

http://support.ndigital.com

Overview of NDI 6D Architect

This section provides the following topics:

1 About This Guide

The *"NDI 6D Architect User Guide"* provides instructions and explanations about the NDI 6D Architect software and the characterization process. Use this information when characterizing tools for Aurora Systems, Polaris Vicra Systems, or Polaris Spectra Systems.

Table 1-1 How This Guide Is Organized

Section	Description
Overview	This section explains the concepts and terminology you will need to know to use NDI 6D Architect properly.
Characterizing Polaris Tools	This section walks you step-by-step through NDI 6D Architect's characterization wizard, to help you characterize tools for use with the Polaris Vicra, and Polaris Spectra Systems.
Characterizing Aurora Tools	This section walks you step-by-step through NDI 6D Architect's characterization wizard, to help you characterize tools for use with the Aurora System.

Related Documentation

"Polaris Tool Design Guide"

"Aurora Tool Design Guide"

Because the NDI 6D Architect software is designed to support (but not dictate) tool characterization, you must be well-versed in tool design in order to make expert decisions about certain characterization settings provided by the software. You must also know tool design well enough to properly test and validate the tool once you have characterized it. Read the "*Polaris Tool Design Guide*" or the "*Aurora Tool Design Guide*" thoroughly before attempting to use this software. If you have any questions, contact NDI.

About the Polaris Family

In NDI 6D Architect, all Polaris System functionalities (and their accompanying instructions) also apply to Polaris Vicra Systems and Polaris Spectra Systems.

Quick Reference Cards

At the back of this guide are several full-page reference cards that outline the basic characterization procedures for Polaris tools and Aurora tools. Remove these cards and use them for quick reference when characterizing your tool.

2 Overview

This section explains the following concepts:

- What is NDI 6D Architect?
- What is Characterization?
- What is a Tool Definition File?
- What is a Rigid Body Definition?
- What is an SROM Device?
- What are User-Specified SROM Tags?
- What is a Local Coordinate System?
- Installing NDI 6D Architect
- Best Practices

2.1 What is NDI 6D Architect?

NDI 6D Architect is a software application program that provides an easy-to-use interface, designed to help you characterize tools and produce their respective tool definition files.

Table 2-1 Systems and Tools Supported by NDI 6D Architect

Measurement System	Tool Category	Tool Subcategory
Polaris Vicra	wireless tool	passive tool
		active wireless tool
Polaris Spectra	wired tool	markerless tool
		GPIO device
		active tool
	wireless tool	passive tool
		active wireless tool
Aurora	single sensor coil tool	single 5DOF tool
	dual sensor coil tool	dual 5DOF tool
		6DOF tool
	sensorless tool	sensorless tool

Use NDI 6D Architect to perform the following characterization tasks:

- produce tool definition files using several different methods
- view and edit tool definition files
- align local coordinate systems using several different methods
- assign normals, groups, and faces to Polaris tools

- test tool geometry
- test tool definition files against their associated tools
- program SROM devices and add user-defined parameters
- save data collection trials to use again or revisit
- view a real-time graphic representation of the tool's markers/sensor coils

2.2 What is Characterization?

Characterization **is the process of creating a file that describes a tool.** This file includes information such as the tool's marker/sensor coil placements and the location of its local coordinate system.

Without this information, an NDI measurement system cannot accurately interpret the data it has collected from the tool. It is one thing to find markers/sensor coils in a measurement volume; it is another to know that they belong to a particular tool, and where on that tool they are located.

2.3 What is a Tool Definition File?

The file that describes a tool is called the *tool definition file* (and is formatted as .rom). For wired tools, this file can be programmed into the tool itself so that whenever the tool is connected to an NDI measurement system, the tool definition file can be automatically retrieved and interpreted. In this manner, a system has instant access to information about the tool – information such as the placement of the tool's markers/sensor coils, the location of its end-tip, and its manufacturing data.

For wireless tools, the tool definition file is stored on a host computer and loaded into the NDI measurement system using API commands.

2.4 What is a Rigid Body Definition?

The first step in creating a tool definition file is to produce a *rigid body definition* — a description of the number and location of markers/sensor coils on the tool. Once you have this basic information, you can perform additional tasks to produce the final, comprehensive tool definition file.

Note For Aurora Systems, you can only create a rigid body definition for a 6DOF tool. No other type of Aurora tool definition file requires this information.

2.5 What is an SROM Device?

The *Serial Read-Only Memory (SROM) device* is a memory storage device located inside a wired tool. Use NDI 6D Architect to program the tool definition file onto the SROM device so that the tool can carry its own information. Whenever the tool connects to an NDI measurement system, the tool definition file is automatically retrieved from the SROM device for interpretation.

Note: Because the SROM device can only be programmed once, it is essential to review the tool definition file and test its accuracy before programming it onto the SROM device. NDI 6D Architect provides functionality to help you perform both these tasks.

What are User-Specified SROM Tags?

You can append several additional tags to a tool definition file, to further identify the parameters of the tool. These tags are not a result of the main characterization process, and are provided to allow you to customize the tool further.

2.6 What is a Local Coordinate System?

A *local coordinate system*, assigned to a tool, helps NDI measurement systems calculate the position and orientation of that tool in the characterized measurement volume. For more information about local coordinate systems, refer to the "*Polaris Tool Design Guide*" or the "*Aurora Tool Design Guide*".

2.7 Installing NDI 6D Architect

NDI 6D Architect uses an automatic installation wizard that, by default, stores all program files on **C:\Program Files\Northern Digital Inc\NDI 6D Architect**.

Insert the NDI 6D Architect CD into the host computer's CD drive, and follow the steps as directed by the installation wizard.

Note: NDI recommends that you close all other programs before installing NDI 6D Architect; once the installation is complete, you will be prompted to restart your computer.

Some NDI data files used and created by NDI 6D Architect are stored in the 'ndigital' directory. This directory is defined by the ND_DIR environment variable, and can typically be found in **C:\ndigital**. You must be able to read and write to this location.

Note: NDI recommends that this directory not be changed during installation.

System Requirements

To run NDI 6D Architect, you will need:

- Windows XP
- Pentium Processor
- 5 MB hard drive disk space for software and help files
- PC keyboard

System Recommendations

To run NDI 6D Architect, NDI recommends:

- ❐ 64 MB RAM
- ❐ Three-button mouse
- ❐ 17” monitor

2.8 Best Practices

This section discusses the “best practices” that you should consider when you characterize tools. Poor characterization procedures may lead to a tool that produces inaccurate transformations, which may ultimately result in personal injury.

6D Architect is designed to assist in tool characterization. It is not intended to provide design parameters. You must make expert decisions and evaluations based on the results produced by 6D Architect. You must therefore be knowledgeable in tool design and understand the significance of the tool design parameters. Refer to the *“Polaris Tool Design Guide”* or *“Aurora Tool Design Guide”*.

Use the tool definition test utility to test the tool design under both normal and unusual conditions (e.g. out of volume, partial occlusion, etc.). The tool definition test utility returns tool and marker status flag information that you can use to evaluate the performance of the design. For further information, refer to "Testing the Tool Definition File" on page 52 (Polaris) or "Testing the Tool Definition File" on page 100 (Aurora).

To ensure you correctly characterize a tool, use the following best practices.

Before characterizing a tool:

- Make sure the lenses on the Position Sensor are clean and not damaged.
- Make sure the markers or sensor coils on the tool are not damaged.
- Confirm the accuracy of the Position Sensor with the Accuracy Assessment Kit (AAK) before characterizing tools.
- Make sure the environment is representative of the environment in which the tool will be used.

While characterizing a tool:

- Orient the tool toward the Position Sensor to minimize off angle markers.
- Make sure the tool and Position Sensor/Field Generator do not move during data collection.
- Make sure that no disturbance or interference occurs during data collection. Examples of interference are background IR light, equipment vibration etc.
- Take multiple data collections in different areas of the volume.

After characterizing a tool:

- Make sure you thoroughly test the tool and examine the tool RMS error. Refer to the appropriate Tool Design Guide for information on testing tool design.

Characterizing Polaris Tools

This section explains the following topics and procedures:

3 Additional Polaris Concepts

This section explains additional concepts used when characterizing Polaris tools:

- What are Groups and Faces?
- What are Normals?
- What is Unique Geometry?

3.1 What are Groups and Faces?

A tool's markers are organized into groups and faces:

***Faces* are separate rigid bodies that together form the entire tool.** For example, a tool shaped as a cube can be described as six separate rigid bodies joined together along their edges. Each face is used for tracking. Each face must have at least three markers, and each marker must belong to at least one face.

***Groups* define which markers within a face can be detected simultaneously.** If markers within a face are less than 50 mm apart, they must be placed in separate groups so that they can be distinguished from each other by the Polaris System.

Only active tools use groups; passive and active wireless tools do not.

Note For detailed explanations of faces, groups and rigid bodies, see the "***Polaris Tool Design Guide***".

3.2 What are Normals?

Each marker and face on a tool has a *normal* vector, that defines the direction that marker or face is facing. With this information, the system can determine if any marker or face is pointing at an angle that no longer provides accurate data.

3.3 What is Unique Geometry?

Passive and active wireless tools require *unique geometry* — markers positioned in such a way that they cannot be misidentified when detected in the measurement volume. Wireless tools are not physically connected to the NDI measurement system. As such, the system cannot control the activation of markers or determine which marker is which on the tool face (as all markers are activated simultaneously). Unique geometry dictates that wireless tool markers must be placed in unique and identifiable ways so that each of them can be recognized by the system upon detection, without additional information required.

Active tools can also benefit from unique geometry constraints, but they do not require them.

Note For more information about the constraints of unique geometry, see the "***Polaris Tool Design Guide***".

4 Exploring the Polaris Main Window

When characterizing Polaris tools, NDI 6D Architect's main window provides you with the following functionality:

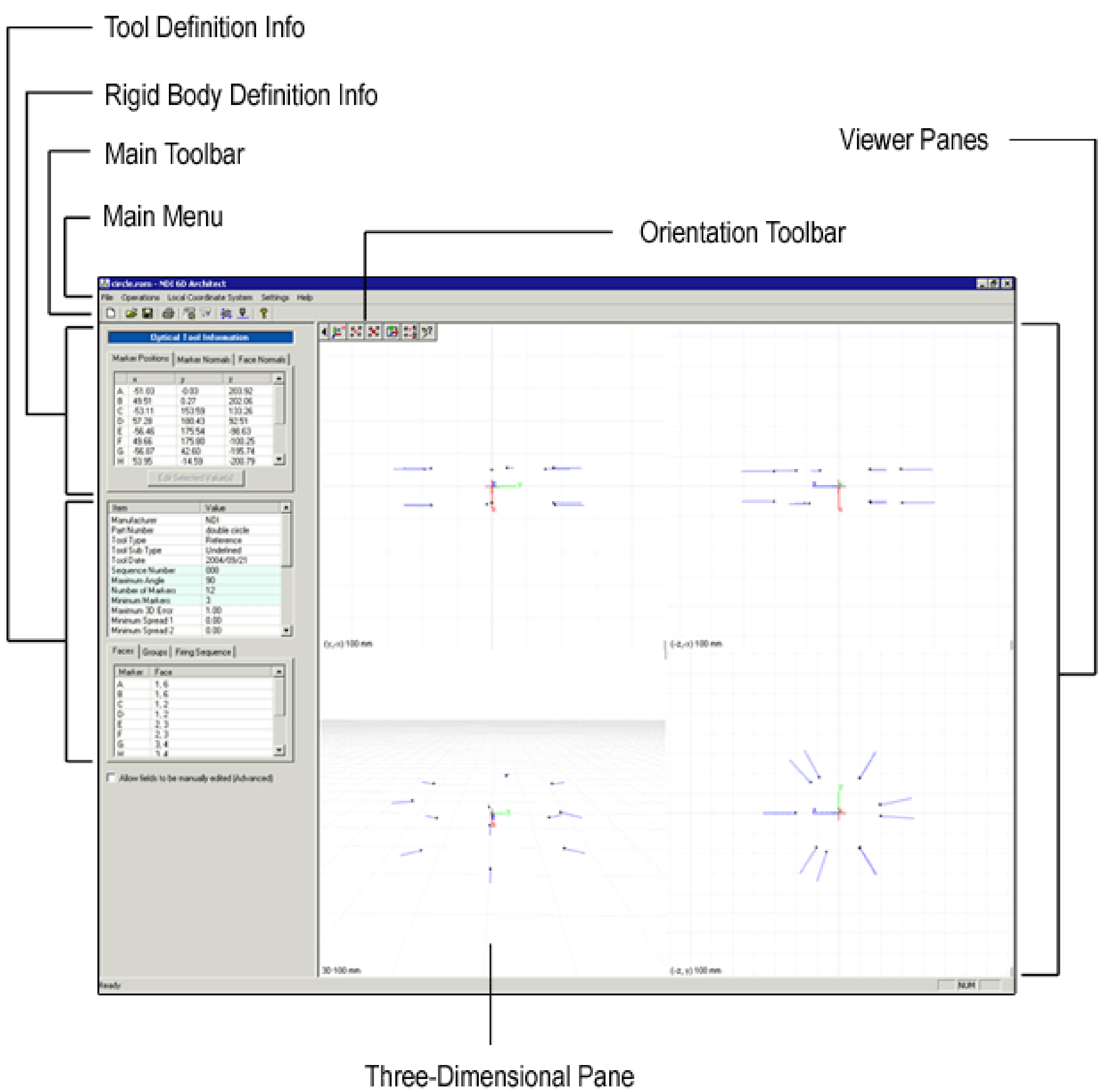


Figure 4-1 Polaris Main Window

4.1 Using the Viewer Panes

The *Viewer Panes* show a graphical representation of the tool's markers relative to its local coordinate system. When the tool is being tracked, these panes show, in real-time, the tool relative to the global coordinate system.

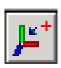
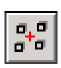
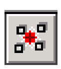
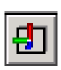
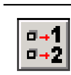
The default view of the Viewer Panes displays four separate panes. Three of the four panes provide a two-dimensional representation; the remaining pane provides a three-dimensional representation of the same information.

Note: If you experience any problems with the Viewer Panes, review the Windows settings related to your graphics card. Changing these settings may be the solution.

Manipulating Views

The following table describes the command icons provided to manipulate the Viewer Panes.

Table 4-1 Explaining the Orientation Toolbar

Command Icon	Description
	Toggles the menu display
	Resets the view back to the default position
	Moves the view to the geometric centre of the markers
	Locks or unlocks the view to the geometric centre of the markers
	Toggles the view by 90° about the z-axis
	Toggles between different marker display types
	Launches the navigation help

The following tables describe keyboard and mouse shortcuts you can use to manipulate the Viewer Panes:

Table 4-2 Two-Dimensional Pane Functionality

Change to Viewer Pane	Action
Move view	Hold left mouse button + drag
Zoom in	Hold right mouse button + drag up
Zoom out	Hold right mouse button + drag down

Table 4-3 Three-Dimensional Pane Functionality

Change to Viewer Pane	Action
Zoom in	Hold ‘Z’ + left mouse button + drag up
Zoom out	Hold ‘Z’ + left mouse button + drag down
Rotate view	Hold right mouse button + drag
Rotate view around the x-axis	Hold ‘Y’ + left mouse button + drag
Rotate view around the y-axis	Hold ‘P’ + left mouse button + drag
Rotate view around the z-axis	Hold ‘R’ + left mouse button + drag

Table 4-4 Common Functionality

Change to Viewer Pane	Action
Reset view to the tool origin	Press ‘O’
Reset view to geometric centre of markers	Press ‘C’
Lock/unlock the view to geometric centre of markers	Press ‘L’
Change measurement volume display style (full, full without border-lines, mesh, and hidden)	Press ‘V’
Maximize/minimize a pane	Double-click the pane

4.2 Using the Main Toolbar

The following table describes the command icons on the main toolbar:

Table 4-5 Explaining the Main Toolbar

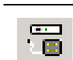
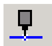
Command Icon	Description
	Loads a new blank tool definition file into the software and launches the characterization wizard. For more information, see "Step One: Select Tool Type and Method" on page 16.
	Opens an existing tool definition file
	Saves the tool definition file
	Prints the contents of the main window
	Tests the tracking of a tool within the measurement volume. For more information, see "Testing the Tool Definition File" on page 52.
	Programs the tool definition file to an SROM device. For more information, see "Programming the SROM Device (Active Tools Only)" on page 58.
	Defines a local coordinate system. For more information, see "Step Five: Align the Local Coordinate System" on page 44.

Table 4-5 Explaining the Main Toolbar

Command Icon	Description
	Launches the pivot alignment wizard used to calculate a tool-tip offset. For more information, see "Using the Pivot Wizard" on page 63.
	Provides information about the software version

4.3 Using Menu Items

The following table describes the main window's menu items:

Table 4-6 Description of Main Window Menu Items

Menu Item	Submenu Items	Description
File	New	Closes currently open file and opens the characterization wizard
	Modify	Allows you to modify the current tool definition file by opening the characterization wizard and populating its screens with the current tool definition file's data.
	Open	Opens an existing tool definition file
	Save	Saves current changes to a tool definition file
	Save As	Saves a copy of the current tool definition file
	Close	Closes current tool definition file and opens a new blank tool definition file
	Print	Prints the current tool definition file's values
	Print Setup	Opens a standard print setup page
	Load Tool Definition File From Device	Allows you to open a tool definition file stored on a tool currently connected to the system.
	Recent File List	Lists up to four of the latest tool definition files used
	Exit	Closes NDI 6D Architect

Table 4-6 Description of Main Window Menu Items

Menu Item	Submenu Items	Description
Operations	Run Auto-Characterization File	This option allows to you open, review, edit and apply an auto-characterization file. For more information, see "Auto-Characterization" on page 60.
	Test Tool Geometry	Tests the tool to ensure that it meets tool geometry constraints. For more information, see "Testing Tool Geometry" on page 54.
	Test Tool Definition File	Tests the current tool definition file against a connected tool. For more information, see "Testing the Tool Definition File" on page 52.
	Program SROM Device	Writes the current tool definition file to a connected tool's blank SROM device. For more information, see "Programming the SROM Device (Active Tools Only)" on page 58.
	Add User-Specified SROM Tags	Allows you to add additional user-specified SROM tags to a tool definition file. For more information, see "Programming User-Specified Tags" on page 56.
Local Coordinate System	Define Local Coordinate System	Opens the Define Local Coordinate System dialog. For more information, see "Step Five: Align the Local Coordinate System" on page 44.
	Pivot the Tool	Opens the pivot alignment wizard. For more information, see "Using the Pivot Wizard" on page 63.
Settings	Polaris	Opens the Polaris System Settings dialog. For more information, see "Opening the Characterization Wizard" on page 15.
	Aurora	This option is not available for Polaris Systems.
	Build Algorithm Constraints	Allows you to review the constraints applied to each iteration of the build. Changing these settings can have large effects on the results of the rigid body build. For instructions, see "3. Set the build parameters" on page 33.
	Pivot Parameters	Allows you to review the constraints applied to each pivot collection used to calculate the tool tip offset. For more information, see "Adjusting Pivot Parameters" on page 63.
Help	Contents	Opens NDI 6D Architect Online Help.
	About NDI 6D Architect	Opens the software description page.

5 Before You Start: Adjust System Settings

Use the following instructions to set up your system settings and start the characterization wizard.

5.1 Adjusting Polaris Communication Settings

To achieve the best results for collection trials, tool testing, and programming SROM devices, review and adjust the communication settings for your system:

1. From the main menu, select **Settings** > **Polaris**. The Polaris System Settings dialog appears.

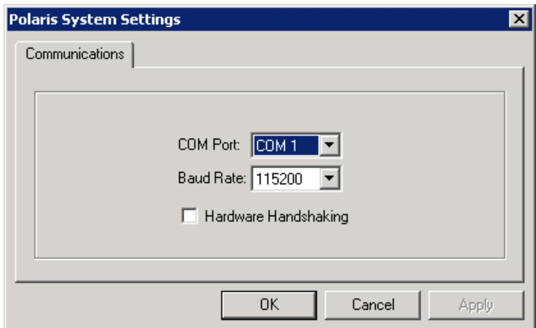


Figure 5-1 Polaris System Settings Dialog

2. From the drop-down list provided, specify the **COM Port** that the Polaris System uses to communicate with the host computer.
3. From the drop-down list provided, specify the highest possible **Baud Rate** for the communication between the host computer and the Polaris System.
4. (Recommended) Enable **Hardware Handshaking**. Hardware handshaking uses RTS and CTS serial port pins to control data flow.

Note If you are using a wireless connection with a Polaris Vicra System, or a Polaris Spectra System, do not enable hardware handshaking.

5. Click **OK**.

5.2 Opening the Characterization Wizard

Note At the back of this guide are several pull-out reference cards designed to help you as you proceed with the characterization procedure. Be sure to remove them for quick reference as you work.

To start the characterization process, open the NDI 6D Architect characterization wizard. From the main menu, select **File** > **New** and proceed to the first step, "Step One: Select Tool Type and Method" on page 16.

6 Step One: Select Tool Type and Method

When you start the characterization wizard, the following dialog appears. This first screen not only welcomes you to the characterization wizard, but acts as a portal to the rest of the wizard's functionality. Tasks and procedures that the wizard will guide you through are customized according to the kind of tool you are characterizing, and the method you select:

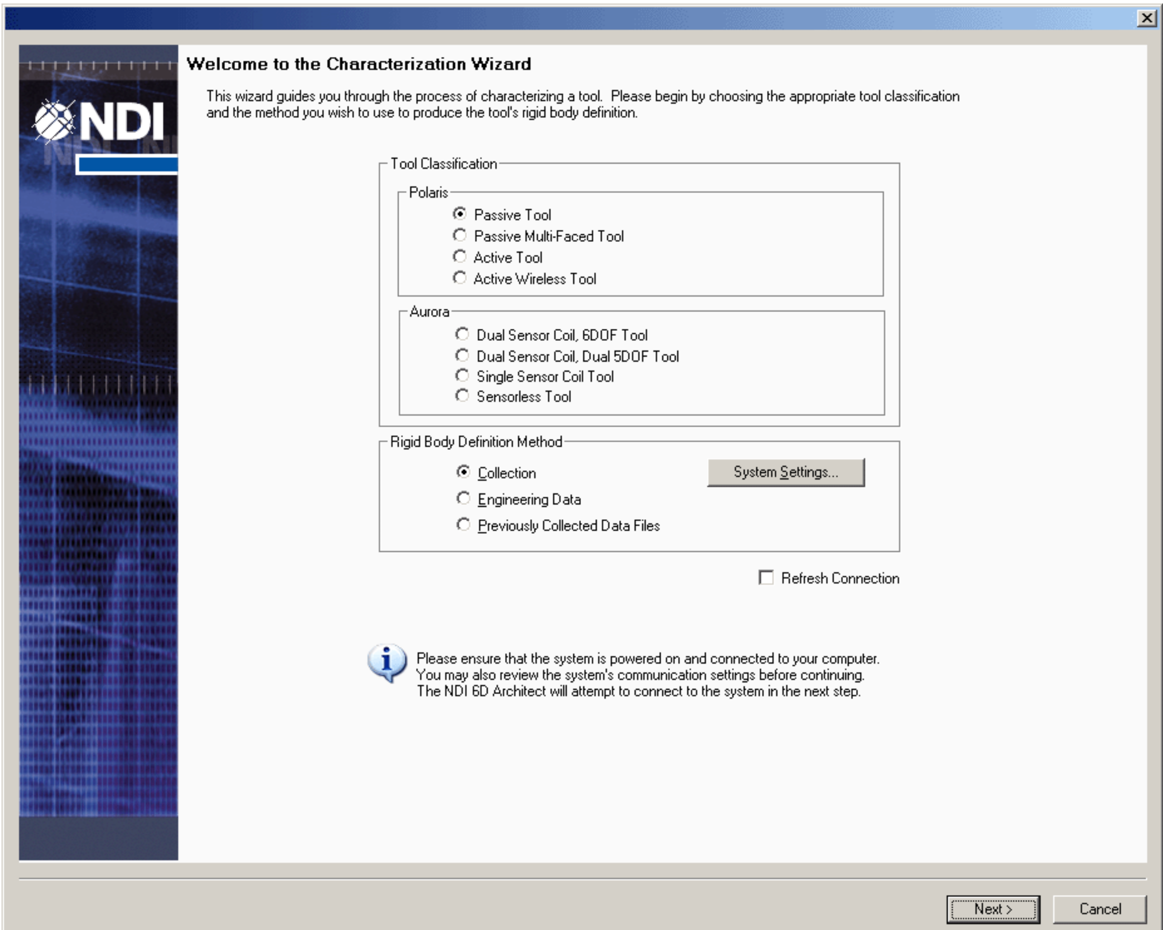


Figure 6-1 Welcome to the Characterization Wizard

1. In the **Tool Classification** section, select the type of **Polaris** tool that you are characterizing. If you want to characterize a markerless tool, select **Active Tool**. In later steps, you can indicate that the tool has no markers.

Note: For information about tool types, refer to the ***"Polaris Tool Design Guide".***

2. Select the appropriate **Rigid Body Definition Method** that you will use to produce the rigid body definition:

Table 6-1 Rigid Body Definition Methods

Method	Description
Collection	Gather information about the tool by measuring it with a Polaris System.
Engineering Data	Using the engineering specifications used to manufacture the tool, manually enter the tool's marker information.
Previously Collected Data Files	Skip the collection process and use the data from saved collection trials instead.

Note If you are characterizing a multi-faced passive tool, select Engineering Data. For more information, see "Characterizing Complex Multi-Faced Passive Tools" on page 27.

3. If you change the system that you are using to characterise tools with, check the **Refresh Connection** checkbox.
4. Click **Next**.

6.1 Additional Collection Settings

If you selected **Collection** as your method of producing a rigid body definition, NDI 6D Architect connects to your measurement system and searches for tools. The Tool Collection Settings appears:

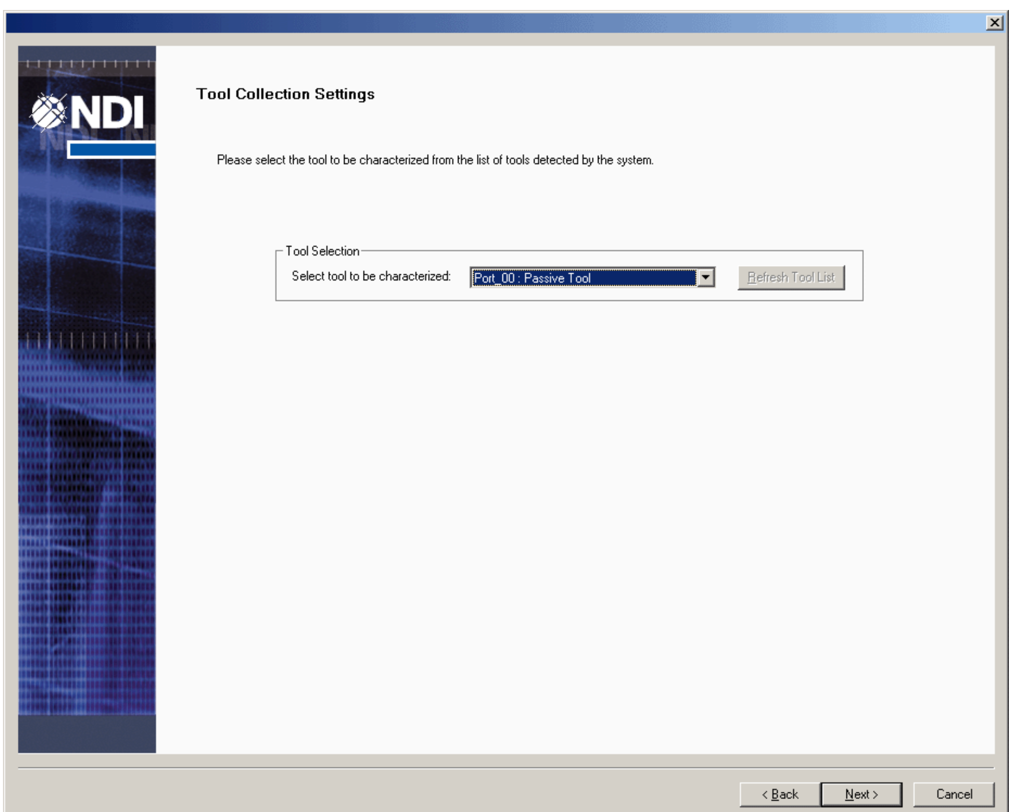


Figure 6-2 Tool Collection Settings

5. From the **Tool Selection** drop-down list, select the tool you are characterizing from the list of tools detected by the system. If you are characterizing a passive tool, select **Port_0A: Passive Tool**.

Note Click Refresh Tool List if you change tool ports or tool connections at any time during this step.

7 Step Two: Enter Tool Parameters

Once you have chosen the kind of tool you are characterizing, the characterization wizard will ask you to define basic tool parameters. These include a part number, a manufacturer name, and serial number settings. These parameters become part of the tool definition file when it is produced at the end of the characterization procedure.

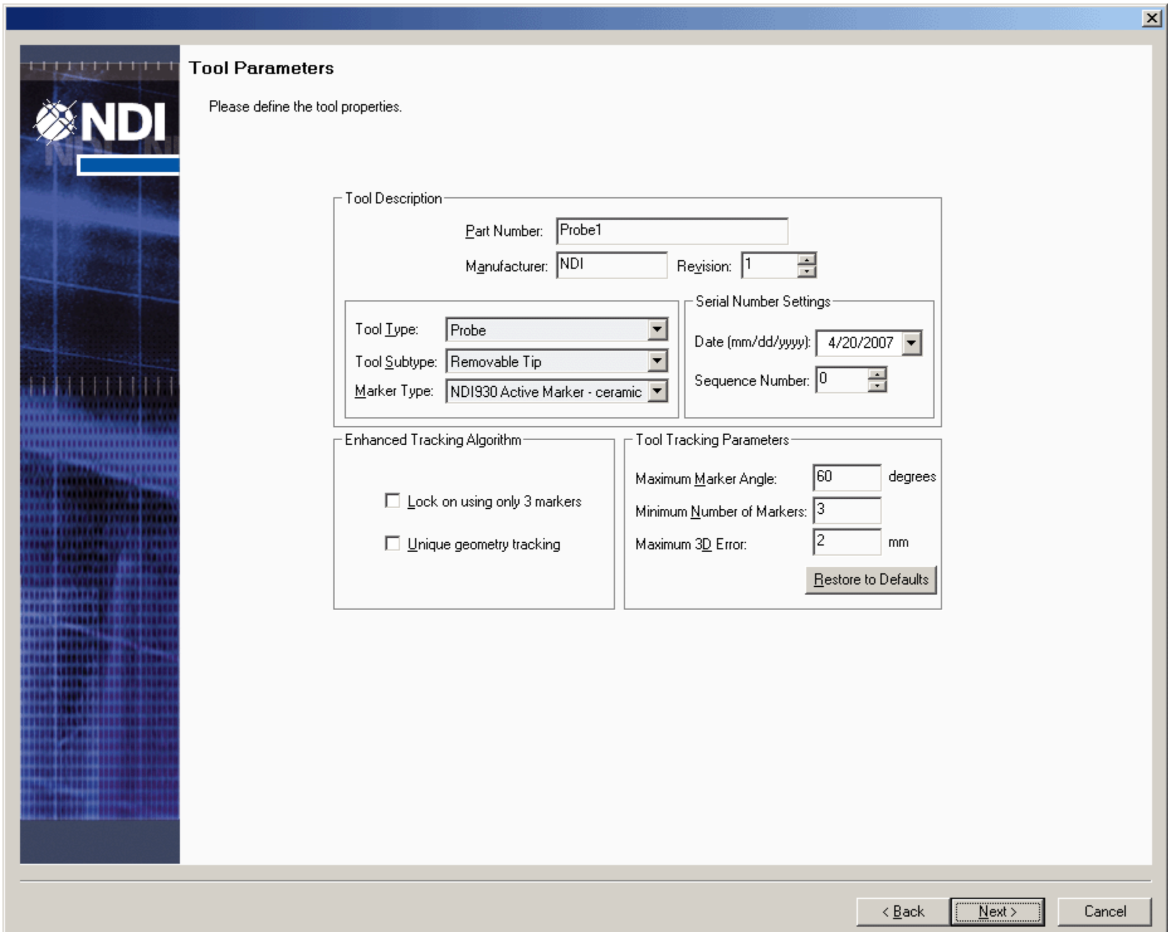


Figure 7-1 Polaris Tool Parameters

All tool parameters are retained for subsequent builds, so you do not need to enter them for each tool. The only exception is the sequence number, which is used to produce a unique serial number for each tool being characterized.

1. Enter the user-specified **Part Number** for your tool. This field will accept any character up to a maximum of 20.
2. Enter the **Manufacturer** name for your tool. This field will accept any character up to a maximum of 12.
3. Enter the user-specified **Revision** number of your tool. This field will accept any integer between 0 and 999.

4. From the drop-down list provided, select the appropriate **Tool Type**:

Table 7-1 Selecting Tool Types

Tool Type	Description
Reference	A tool whose local coordinate system is used as a frame of reference in which other tools are tracked
Probe	A commonly used tool with a tip, meant to be used as a pointer
Button Box/Foot Switch	A markerless tool meant to be used as a switch or a foot pedal. This option is not available for passive tools.
Software Defined	Select this option if you want your application software to identify and acknowledge the tool type instead of storing this information on the tool's SROM device
Microscope Tracker	A special type of reference tool, usually attached to a microscope
Calibration Device	A special type of reference tool used to verify the calibration of an instrument's tip location, and possibly the instrument's diameter and vector
Isolation Box	A special type of tool that maintains electrical isolation between the tool and the Tool Interface Unit
C-Arm Tracker	A special type of reference tool generally attached to fluoroscope devices
GPIO Device	A device that incorporates four configurable input/output lines.

5. From the drop-down list provided, select the appropriate **Tool Subtype**. Make this selection according to the kind of tip the tool has: Undefined, Fixed Tip, or Removable Tip.
6. From the drop-down list provided, select the **Marker Type** used in your tool's design.
7. Specify the different **Serial Number Settings** provided:
    - Enter the **Date** that the tool was characterized (today). This field will accept any date as its value.
    - In the **Sequence Number** field, enter the number of the tool in the sequence of tools created on the same date, and of the same part number. This field accepts any integer between 0 and 1023.

    The software will use these settings to automatically produce a unique serial number for your tool.
8. (Optional) Enable the appropriate **Enhanced Tracking Algorithm** settings:
    - If you want to reduce the acquisition time for a tool with four or more markers, enable **Lock using only 3 markers**. For more information about the effects of this option, see the "*Polaris Tool Design Guide*".

- If you are characterizing an active tool that qualifies as a unique geometry tool, enable **Unique geometry tracking** to reduce acquisition time. This option is selected by default for passive tools and active wireless tools, as they must always obey unique geometry constraints.

Note All Enhanced Tracking Algorithm options are disabled for Button Box/Foot Switch and GPIO tools.

9. Set tracking constraints for the tool using **Tolerance Parameters**:

Table 7-2 Setting Tolerance Parameters

Setting	Description
Maximum Marker Angle	The maximum angle that the marker can be facing away from the Position Sensor. This field will accept an integer between 0 and 90. The default value for passive markers is 90°; the default value for active markers is 60°. Note that increasing the default setting will affect accuracy.
Minimum Number of Markers	The number of markers per face that must be detected before an NDI measurement system can return a transformation. This field's default value is 3. Note that you can also enter 0 for a markerless tool.
Maximum 3D Error	The maximum difference (in millimetres) between the marker's expected and measured positions. If the 3D error for a marker exceeds this value, its measurement data will not be used to calculate the tool's transformation. This field will accept any floating point value between 0.05 and 10, with a default of 0.5.

10. (**GPIO Devices only**) If you select **GPIO Device** from the **Tool Type** drop-down list, the **GPIO Settings** section appears (in place of the **Enhanced Tracking Parameters** and **Tool Tracking Parameters**).

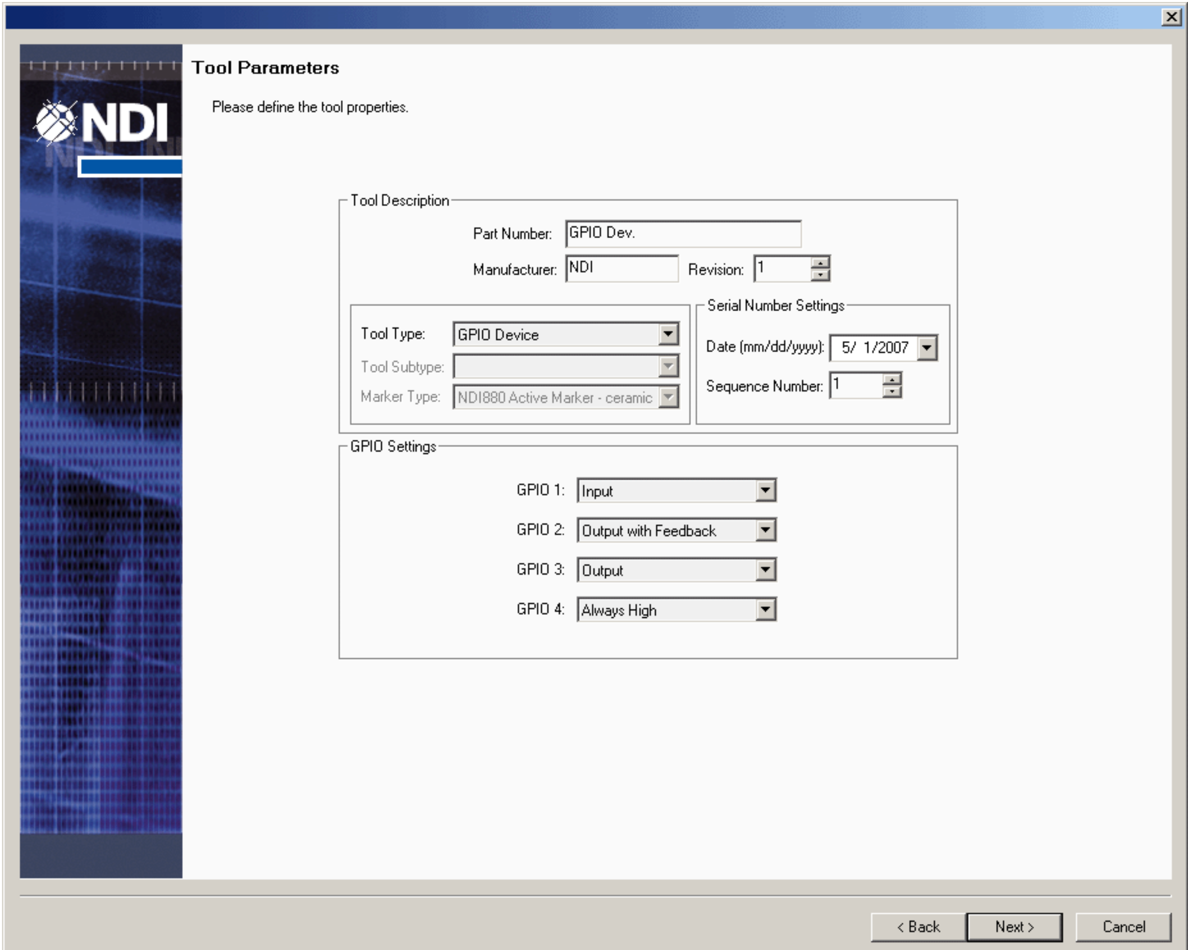


Figure 7-2 Polaris Tool Parameters - GPIO Settings

11. Configure each line of the GPIO device as required, from the associated drop-down options list. The available options are:
    - Input
    - Output
    - Always High
    - Output with Feedback

Note The GPIO 4 line can only be configured as Output or Always High.

12. Click **Next**.

7.1 Defining Marker Setup

Note This step is only required for active tools. If you are characterizing a passive tool, the wizard will jump directly to "Additional Step for Passive Tools Only" on page 26.

If you are characterizing an active tool, you will need to define the tool's wiring matrix and assign its markers, switches and LEDs accordingly:

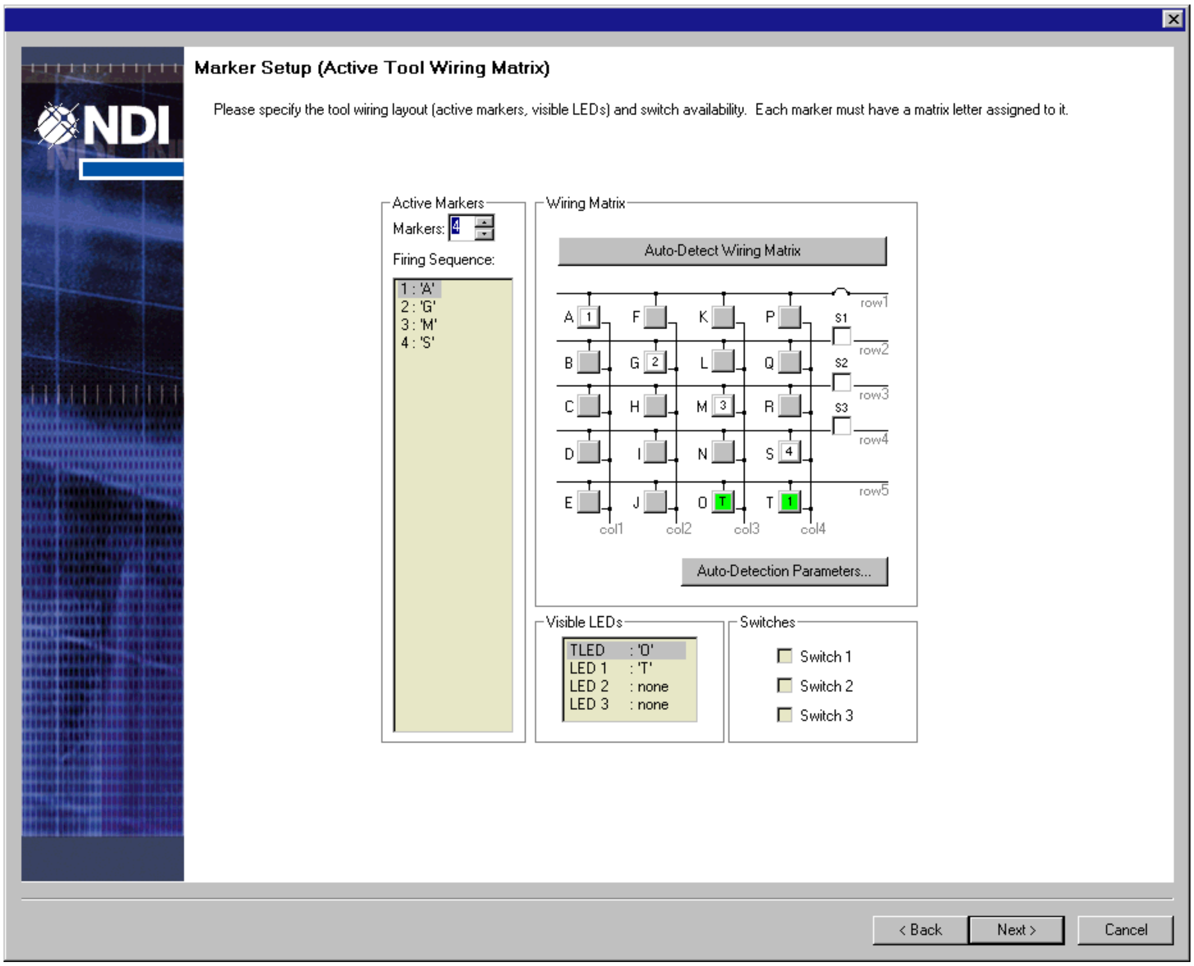


Figure 7-3 Marker Setup (Active Tool Wiring Matrix)

1. (Optional) Click **Auto-Detect Wiring Matrix** to automatically populate the wiring matrix diagram, and then skip to step 6. This option is only available if you are performing a collection.

   Using Auto-Detect will only produce an approximation, and may not correctly reflect the tool's marker wiring. You can change the parameters used to detect IREDs and LEDs; see "Adjusting Auto-Detect Parameters" on page 24.

2. Using the selection arrows provided, indicate the number of **Markers** on your tool. If you are characterizing a markerless tool, enter "0".

3. Set the **Firing Sequence** for the markers: right-click or double-click an entry in the Firing Sequence list to assign it a wiring matrix location, or simply drag and drop the entry to the correct position in the matrix diagram.
4. Set the location for the tool's **Visible LEDs**: right-click or double-click an entry in the Visible LEDS list to assign it a wiring matrix location, or drag and drop the entry to the correct position in the matrix diagram.

   If a visible LED is assigned to the very first position in **Visible LEDs** list, it will be used as a Tracking LED (TLED). Tracking LEDS are not user-controlled; they will turn on only when the system can calculate a valid transformation.
5. Enable the different **Switches** to specify which switch positions are occupied.
6. Click **Next**.

Adjusting Auto-Detect Parameters

Note These are advanced settings; if you are unsure of the intended result, do not perform this procedure and continue with the assigned default settings.

Review and adjust the thresholds used by NDI 6D Architect when it interprets collected data:

1. Click **Auto-Detection Parameters**. The following dialog appears:

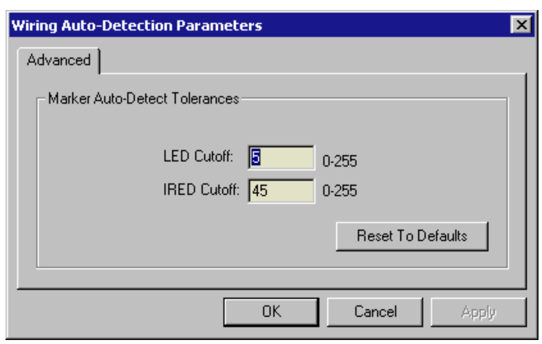


Figure 7-4 Wiring Auto-Detection Parameters Dialog

2. In the **LED Cutoff** field, specify the value used by NDI 6D Architect to determine if a tool's wired object is an LED (and not a marker). This unitless value represents a measured amount of current, and falls within the range of 0 to 255.

   NDI 6D Architect measures the amount of current drawn by a tool's wired object. If the resulting value is less that the LED cutoff, then it is assumed to be nothing. If the value is more than the LED cutoff and less than the IRED cutoff, then the object is assumed to be an LED.
3. In the **IRED Cutoff** field, specify the values used by NDI 6D Architect to determine if a tool's wired object is an IRED.

   NDI 6D Architect measures the amount of current drawn by a tool's wired object. If resulting value is more than the IRED cutoff, then the object is assumed to be a marker. If the value is more than the LED cutoff and less than the IRED cutoff, then the object is assumed to be an LED.

4. Click **OK**.

8 Additional Step for Passive Tools Only

Note This step is not required for active tools. If you are characterizing an active tool, turn to "Step Three: Produce a Rigid Body Definition" on page 30 for the next step in the characterization process.

If you are characterizing a passive tool, the following page will appear. You must complete this screen before you can produce the tool's rigid body definition.

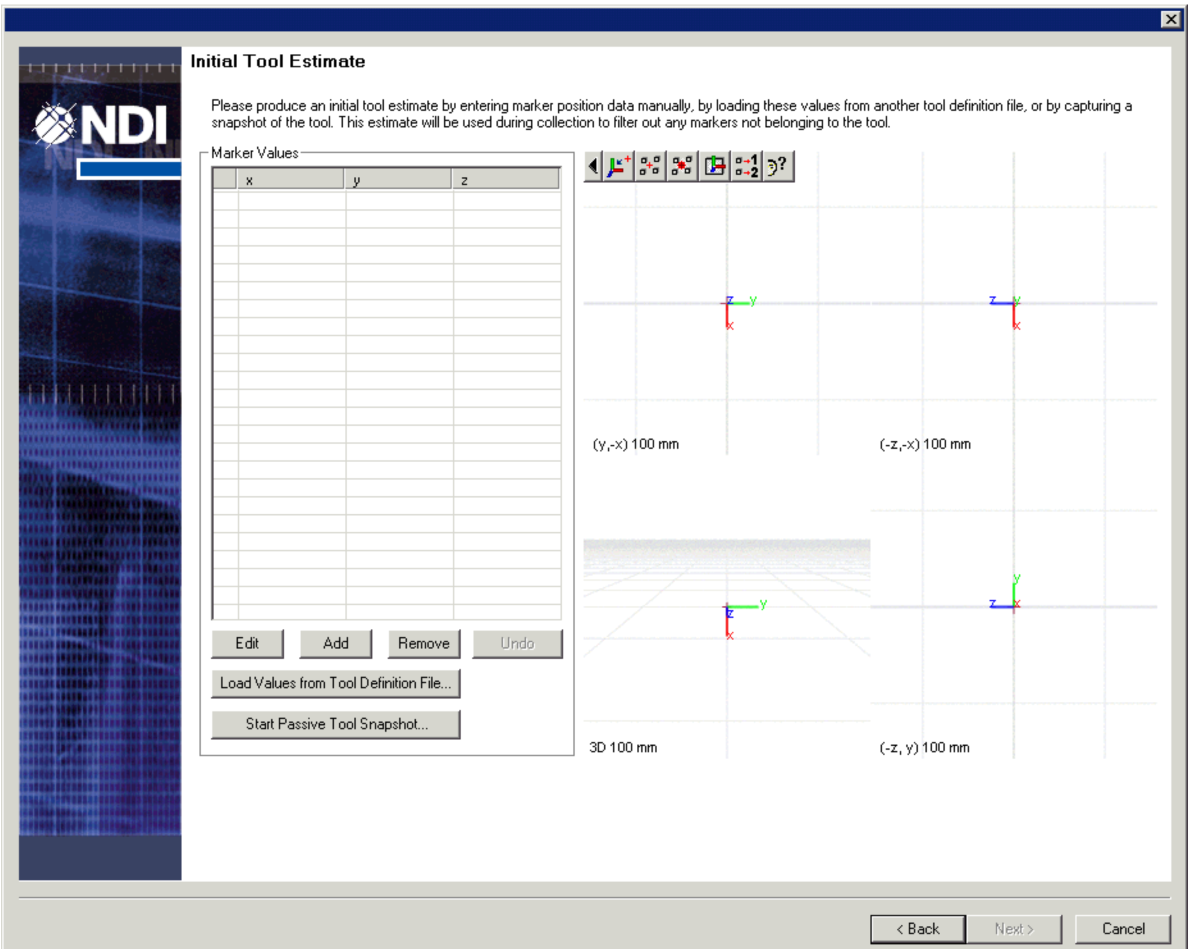


Figure 8-1 Initial Tool Estimate

8.1 What is an Initial Tool Estimate?

Problem

Tracking passive tools runs the risk of collecting *phantom marker data* — marker data produced by the collection process, not by an actual marker. In other words, when collecting data from a passive tool, you will invariably pick up extraneous information that could be misleading.

Normally, phantom markers are filtered out by the tool's tool definition file — if a marker is not identified in the tool definition file as being part of the tool, the system automatically discards its collected data from consideration.

But how does a system track a passive tool correctly *before* the tool's tool definition file actually exists? Specifically, what if you want to produce a passive tool's rigid body definition using either collection or previously collected data?

Solution

The characterization wizard provides an additional step for passive tool characterization, prior to producing the tool's rigid body definition: applying a tool estimate. **A *tool estimate* is a temporary definition file that describes the markers associated with your passive tool.**

You can produce a tool estimate in one of two ways:

- collect a "snapshot" of the passive tool, consisting of only a few frames
- apply a previously created tool definition file of a similar tool with identical geometries (within less than 1 mm)
- enter the tool's engineering data and skip the rigid body definition process altogether

Note: You can only collect a snapshot if you are using the collection method to produce the rigid body definition. In addition, you can only collect a snapshot if all markers on the tool can be seen at once, and if all segments on the tool are unique.

8.2 Characterizing Complex Multi-Faced Passive Tools

Most multi-faced passive tools can be characterized as you would a single-face passive tool: produce an initial tool estimate and use it to collect data for the rigid body definition. However, more complicated tool designs can still cause difficulties in collecting accurate data, regardless of the initial tool estimate.

A multi-faced passive tool is considered complex if:

❒ more than six markers are visible in a single pose

❒ not all markers on the tool are visible in a single pose

To characterize a complex multi-faced passive tool, you can only produce a tool definition file by entering engineering data. However, you can improve upon the tool definition file created with this method by using collection as well.

1. Start the characterization wizard and in the first step, select **Passive Multi-Faced Tool** as the tool type and **Engineering Data** as the method for producing a rigid body definition.
2. Complete the remaining tool characterization steps and produce a tool definition file for the multi-faced passive tool.
3. Save the tool definition file and close the characterization wizard.
4. From the main window, select **File > New**.
5. In the first step, select **Passive Multi-Faced Tool** as the tool type and **Collection** as the method for producing a rigid body definition.
6. Click **Next**.

7. Re-enter the multi-faced passive tool's parameters.
8. Click **Next**.
9. When prompted to create an initial tool estimate, click **Load Values from Tool Definition File**.
10. Select the .rom file saved in step 3.
11. Click **Next**.
12. Produce a rigid body definition using collection.
13. Complete the remaining steps of the characterization process, and produce a final tool definition file for the multi-faced passive tool.

8.3 Producing a Tool Estimate Using a Snapshot

1. Click **Start Passive Tool Snapshot**. The Initial Tool Estimate page changes to include two new buttons: **Take Snapshot** and **Cancel Snapshot**.

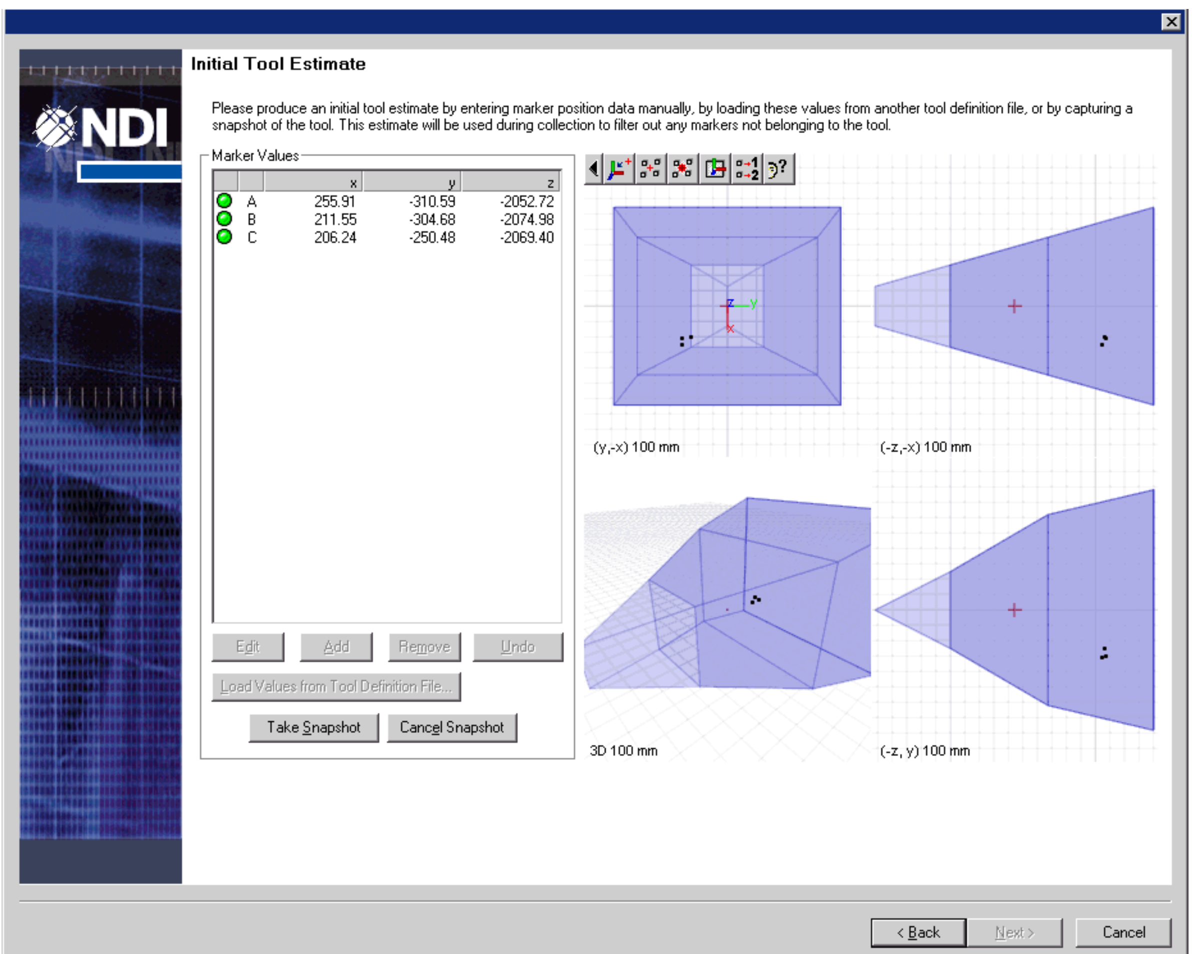


Figure 8-2 Snapshot Buttons Enabled

2. Place the tool in the measurement volume. Use the Viewer Panes and the automatically populated coordinate fields to find the best position and orientation.

The display should only show the markers on the tool; if there are phantom markers detected, rotate the tool slightly to eliminate them from the list.

3. Click **Take Snapshot**. The system collects a brief 10-frame collection of the tool's markers and automatically populates the dialog with the collected marker coordinates.
4. Edit the Marker Values table as necessary.
5. When you are satisfied with the Marker Values table entries, click **Next**. Now you can proceed with the characterization process (and produce a rigid body definition using the collection method).

8.4 Producing a Tool Estimate Using an Existing Definition File

1. Click **Load Values from Tool Definition File**.
2. From the window that appears, select the tool definition file of an identical tool that has already been characterized. The theory is that because the tools have identical geometries, one tool's tool definition file can be used to create a reasonably accurate tool estimate of the second.
3. Click **Open**. The system opens the selected definition file and returns you to the Tool Estimate dialog. The Marker Values table is automatically populated with the other tool's marker coordinates.
4. Edit the Marker Values table if necessary.
5. When you are satisfied with the Marker Values table entries, click **Next**. Now you can produce a rigid body definition using data collection or previously collected data files.

8.5 Producing a Tool Estimate Using Engineering Data

You can use the **Edit, Add** and **Remove** buttons to enter engineering data about the passive tool's markers directly into the Marker Values table. In this manner, you are producing a rigid body definition directly from this step, and the characterization wizard will continue with assigning faces once you click **Next**. See "Step Four: Assign Groups and Faces" on page 42 for the next set of instructions.

9 Step Three: Produce a Rigid Body Definition

Produce the tool's rigid body definition. This task is performed using the method you selected in the first screen of the characterization wizard: collection, previously collected data files, or engineering data.

Note: If you are characterizing a passive tool, you will need to produce an initial estimate before you can create a rigid body definition. For instructions and explanations, see "Additional Step for Passive Tools Only" on page 26.

9.1 Producing a Rigid Body Definition With Collection

Build a rigid body definition by measuring the tool's marker locations with a Polaris System. This method involves the following steps:

1. Set the save parameters.
2. Collect the data.
3. Set the build parameters.
4. Perform the rigid body build.

1. Set the save parameters

Each collection trial will be saved to separate files in a specified directory. You must indicate where it will be saved and what to call it.

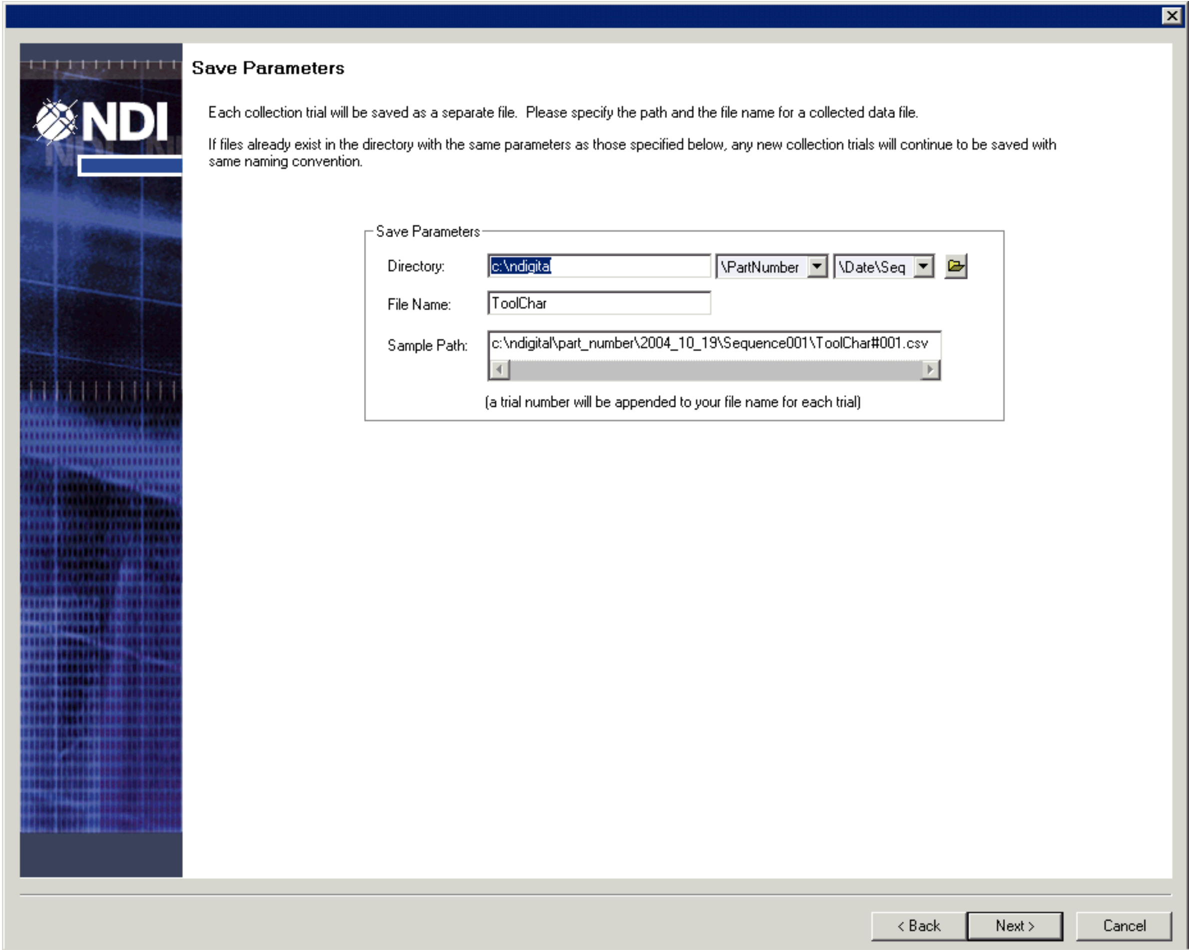


Figure 9-1 Save Parameters

1. Using the browse button, specify the **Directory** where each collection trial will be saved.
2. NDI 6D Architect automatically produces a file for each collection trial that you perform. You can add variables such as **\Pathname** or **\Date\Seq** to this process, so that the file produced includes this information. Use the two additional drop-down lists provided to select these variables. This information will be appended to the directory’s name when the file is saved.
3. Enter a **File Name**. Notice that the **Sample Path** field now displays the pathname that would be created by the software.
4. Once you are satisfied with the settings and their results, click **Next**.

2. Collect the data

Once you have set the save parameters, the characterization wizard opens the Data Collection page:

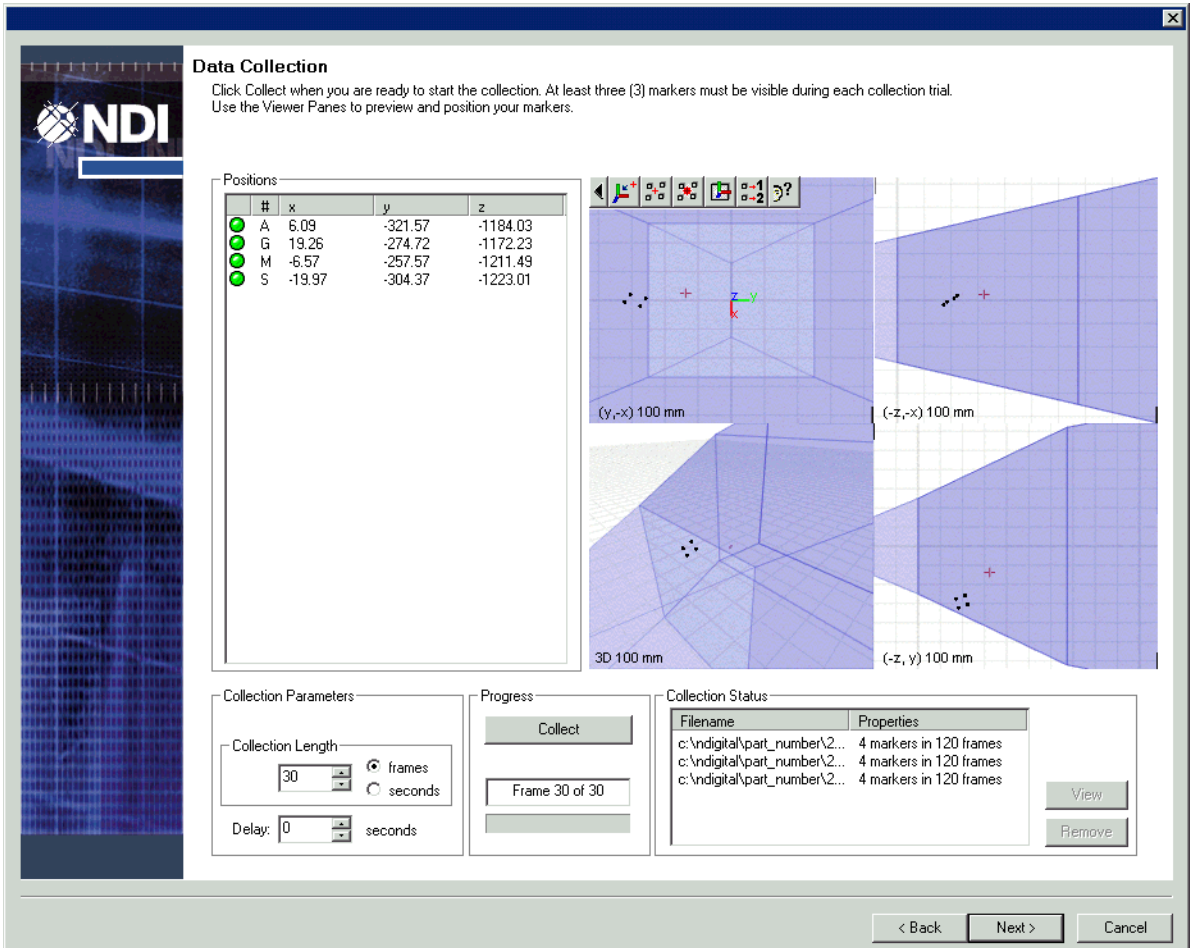


Figure 9-2 Data Collection

Note If more than one measurement volume type is available with your Polaris System, a pop-up dialog will prompt you to select a measurement volume type from a drop-down list. Make the appropriate selection and click OK.

1. Set the **Collection Length** in either **Frames** or **Seconds**.
2. Specify a **Delay** if you want the system to wait before beginning the collection trial.
3. Position the tool in the measurement volume. Notice the following changes to the Data Collection dialog fields:
   - The **Positions** section is populated with the identifying name, tracking status, and position data for each marker on the tool.
   - The Viewer Panes show the measurement volume and the tool's markers in real-time. This can also help you position the tool correctly.

If you get a message indicating that the collection was not static even though the tool did not move, this could be an indication that one of the markers measured was positioned incorrectly in the measurement volume.

For every collection, ensure that each marker in the pose is pointing at the Position Sensor as directly as possible. Make sure that only markers that are fully visible and facing the Position Sensor are measured; cover poorly positioned markers if required.

4. Click **Collect**. The collection trial begins and the **Collect** button becomes a **Stop** button during collection. Note that you can stop a trial at any time by clicking this button; however, any data collected for that trial will be erased.

   Once the collection trial is finished, the software will check the data to make sure that the tool did not move. Once the data has been confirmed, the system saves the file and adds it to the **Collection Status** list.

5. Continue performing collections for each position of the tool that you require to measure.
6. (Optional) Select a collection trial from the **Collection Status** list, and click **View** to open a playback window:

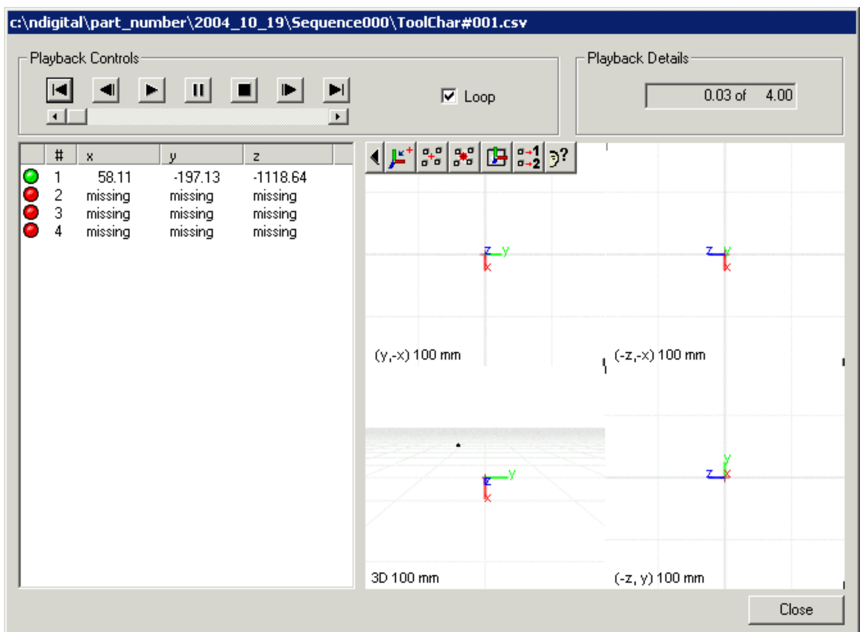


Figure 9-3 Playback Window

   Use the controls provided to play back the collection trial in real-time, then click **Close** to return to the Data Collection dialog.

7. Click **Next** when you are satisfied with the results.

3. Set the build parameters

Now that you have collected the tool data, you need to specify how this data will be processed, to produce the rigid body definition.

Note These parameters are used to create the rigid body definition, and are not used when tracking a tool in an actual application. These settings are not stored anywhere in the tool definition file.

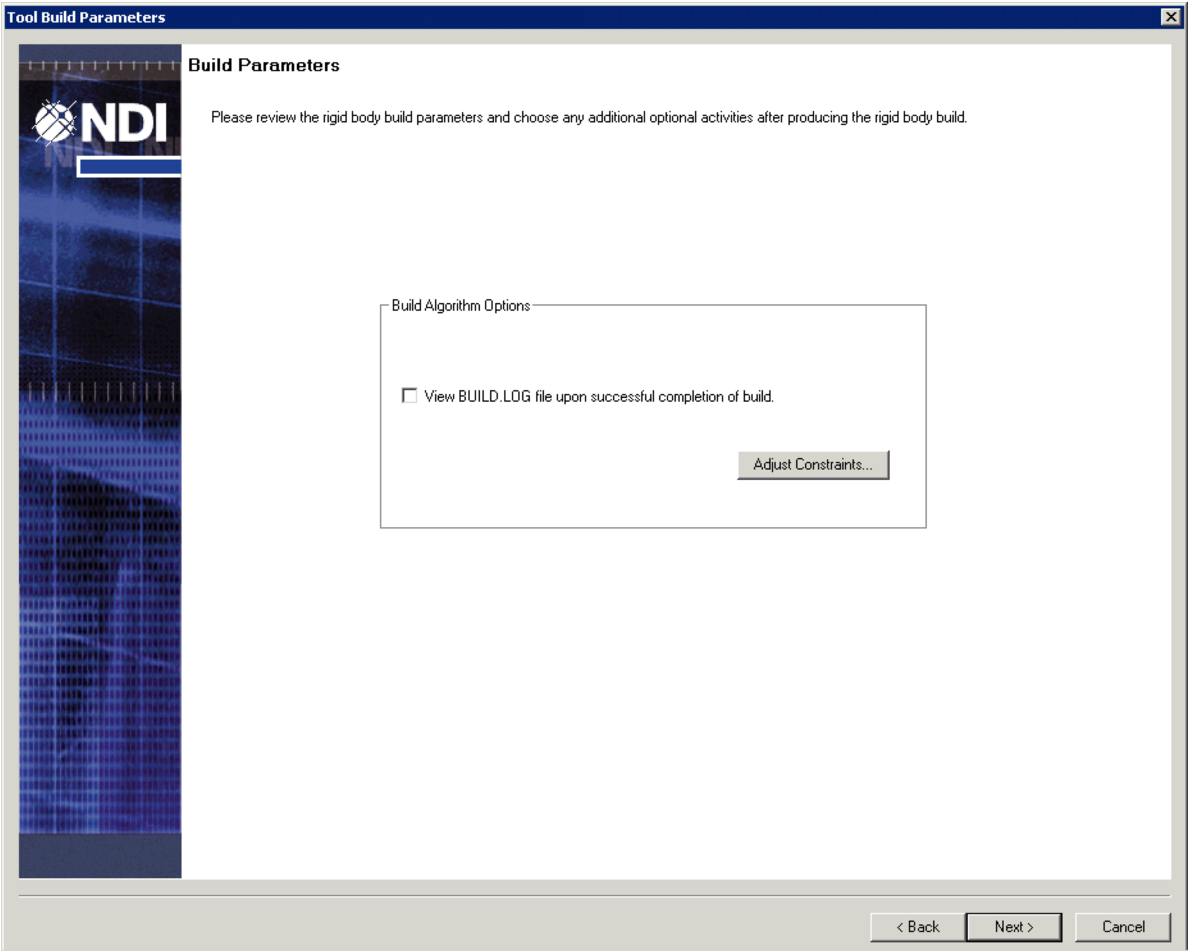


Figure 9-4 Build Parameters

1. If you want to see the results of the build in greater detail once it is complete, enable **View BUILD.LOG file upon successful completion of build**.
2. (Optional) Click **Adjust Constraints** to review the constraints applied to each iteration of the build:

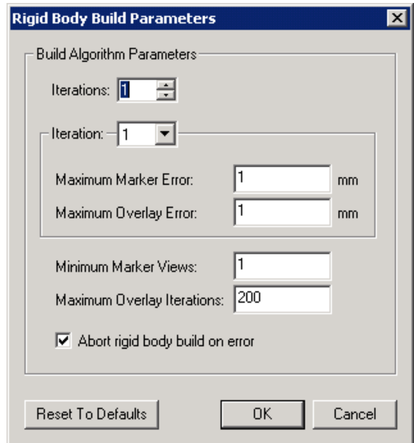


Figure 9-5 Rigid Body Build Parameters Dialog

a) Indicate the total number of **Iterations** you want for the build. This field accepts any value between 1 and 10.

b) From the **Iteration** drop-down list, select a particular iteration. Its values populate the **Maximum Marker Error** and **Maximum Overlay Error** fields:

Table 9-1 Individual Iteration Algorithm Constraints

Field	Description
Maximum Marker Error	The maximum allowable difference, in millimetres, between the marker's expected and observed positions. If a marker in any view has a 3D error greater than this value, a new estimate of the rigid body definition is computed without that marker.
Maximum Overlay Error	The maximum allowable RMS error for overlay transformations, in millimetres. This value is used to exclude an entire view's data from determination of a rigid body definition.

c) Adjust the **Maximum Marker Error** and **Maximum Overlay Error** for the currently selected iteration accordingly. For best results, start broadly with the initial iteration, then gradually narrow the constraints for each subsequent iteration.

d) For the overall build, set the **Minimum Marker Views** and **Maximum Overlay Iterations** values:

Table 9-2 Overall Algorithm Constraints

Field	Description
Minimum Marker Views	The minimum number of collection trials in which a marker must be visible. If the number is not met, the creation of the rigid body definition will fail.

Table 9-2 Overall Algorithm Constraints

Field	Description
Maximum Overlay Iterations	The maximum number of overlay attempts the build algorithm should use to determine a rigid body definition.

e) (Optional) The **Abort Rigid Body build on error** options allows you to check against the above constraints. If any values exceed their constraints, the calculation returns as failed and a warning dialog appears. If this option is disabled, the calculation will proceed regardless of the returned values.

f) Click **OK**.

3. Click **Next**.

4. Perform the rigid body build

Now that you have finished adjusting the build parameters, the characterization wizard initiates a build and displays a window showing the time, iteration number, and status:

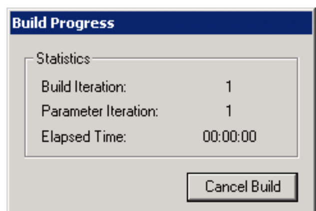


Figure 9-6 Build Progress Dialog

9.2 Producing a Rigid Body Definition With Previously Collected Data

You can produce a rigid body definition with previously collected tool data. This method involves the following steps:

1. Select the file.
2. Set the build parameters.
3. Perform the rigid body build.

1. Select the file

Select several previously-collected data trials using the Data File Selection page:

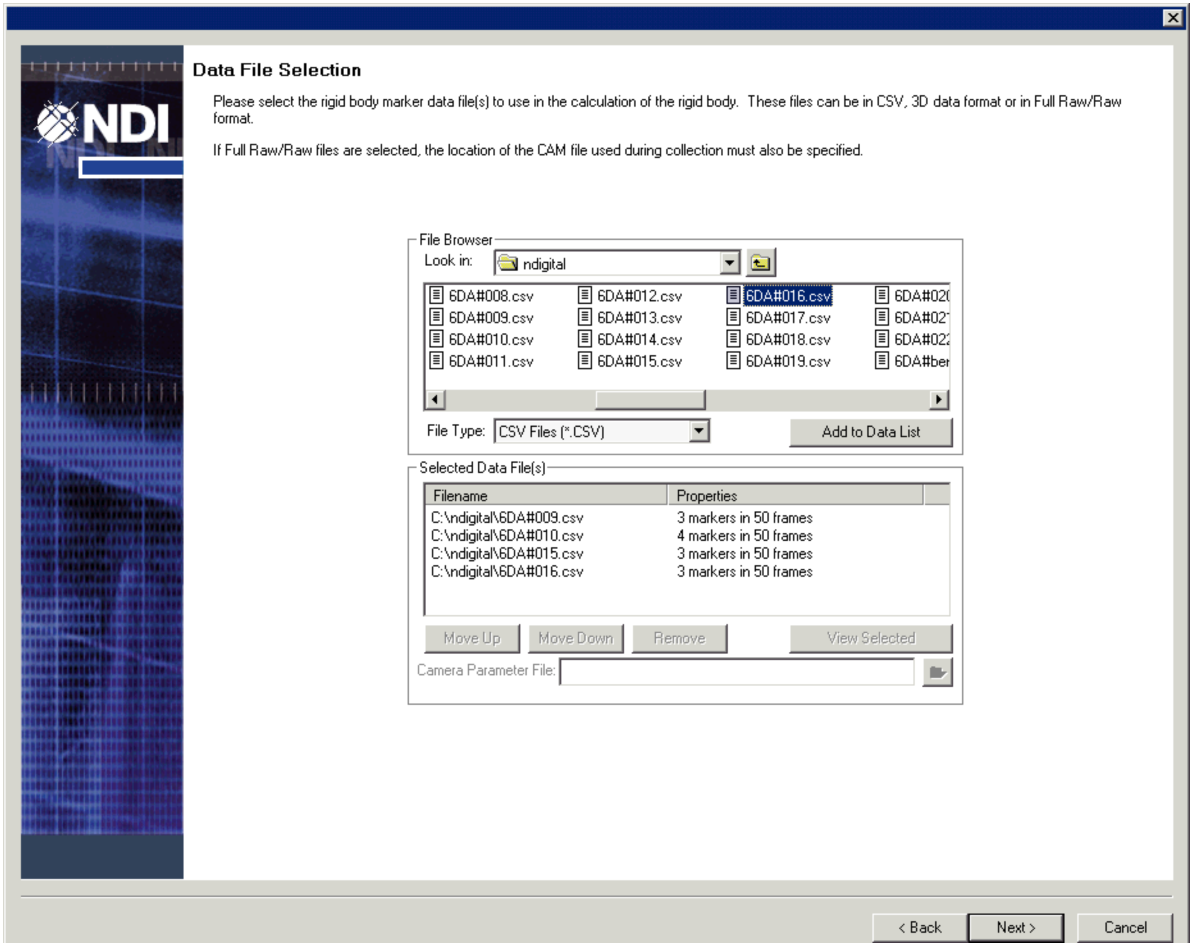


Figure 9-7 Data File Selection

1. Using the **File Browser** window, browse to and open the file containing the required data collection trials.
2. Click **Add to Data List** to move the contents of the file to the **Selected Data File(s)** list.
3. (Optional) In the **Selected Data File(s)** list, click **Remove** to delete any data trials from consideration.
4. Click **Next** once you are satisfied with the files selected.

2. Set the build parameters

Now that you have collected the tool data, you need to specify how this data will be processed, to produce the rigid body definition.

Note These parameters are used to create the rigid body definition, and are not used when tracking a tool in an actual application. These settings are not stored anywhere in the tool definition file.

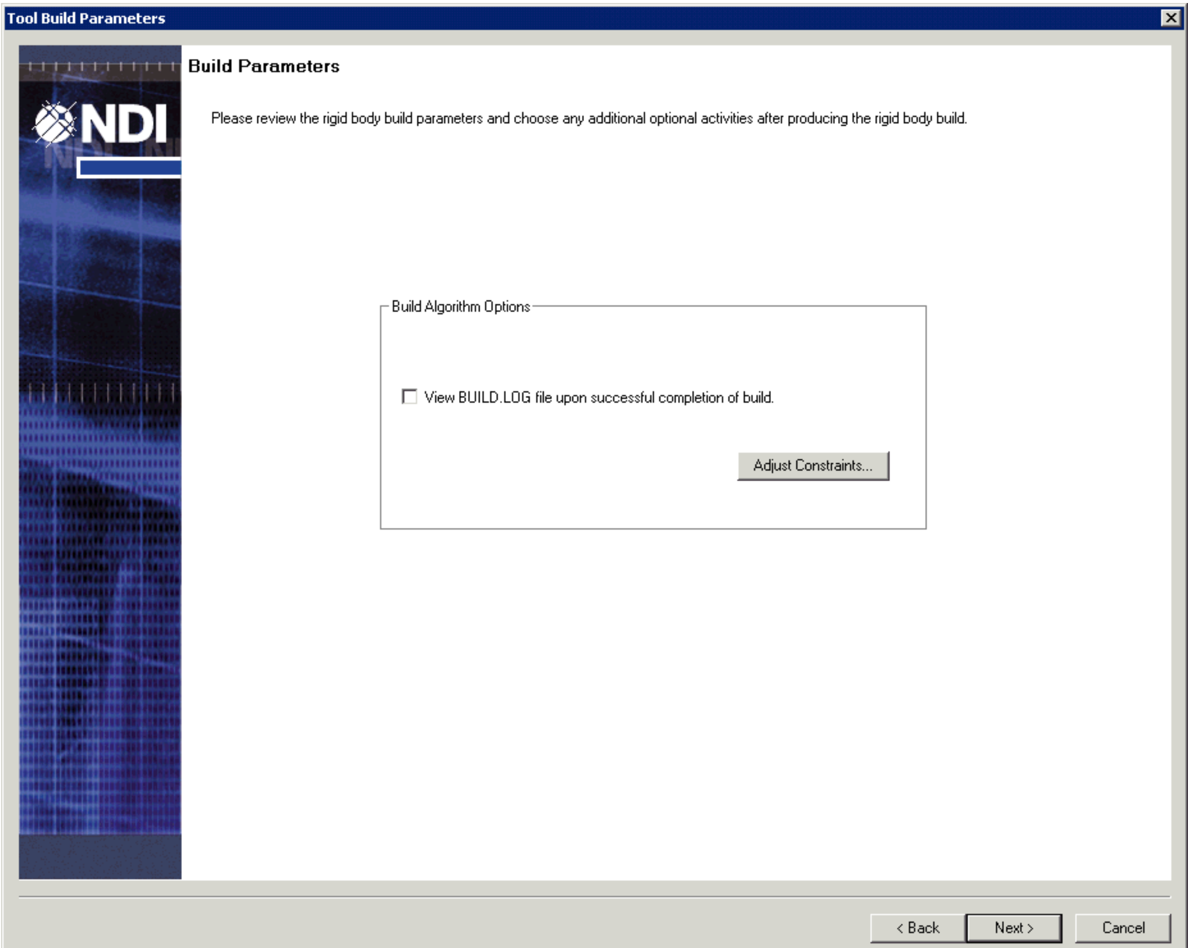


Figure 9-8 Build Parameters

1. If you want to see the results of the build in greater detail once it is complete, enable **View BUILD.LOG file upon successful completion of build**.
2. (Optional) Click **Adjust Constraints** to review the constraints applied to each iteration of the build:

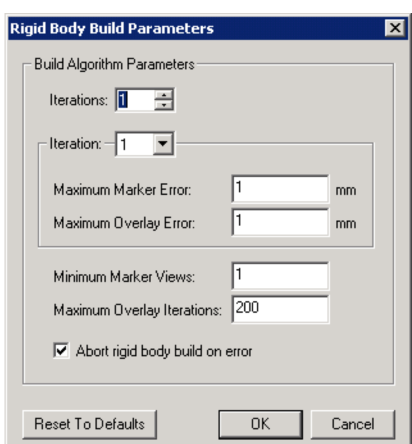


Figure 9-9 Rigid Body Build Parameters Dialog

a) Indicate the total number of **Iterations** you want for the build. This field accepts any value between 1 and 10.

b) From the **Iteration** drop-down list, select a particular iteration. Its values populate the **Maximum Marker Error** and **Maximum Overlay Error** fields:

Table 9-3 Individual Iteration Algorithm Constraints

Field	Description
Maximum Marker Error	The maximum allowable difference, in millimetres, between the marker's expected and observed positions. If a marker in any view has a 3D error greater than this value, a new estimate of the rigid body definition is computed without that marker.
Maximum Overlay Error	The maximum allowable RMS error for overlay transformations, in millimetres. This value is used to exclude an entire view's data from determination of a rigid body definition.

c) Adjust the **Maximum Marker Error** and **Maximum Overlay Error** for the currently selected iteration accordingly. For best results, start broadly with the initial iteration, then gradually narrow the constraints for each subsequent iteration.

d) For the overall build, set the **Minimum Marker Views** and **Maximum Overlay Iterations** values:

Table 9-4 Overall Algorithm Constraints

Field	Description
Minimum Marker Views	The minimum number of collection trials in which a marker must be visible. If the number is not met, the creation of the rigid body definition will fail.
Maximum Overlay Iterations	The maximum number of overlay attempts the build algorithm should use to determine a rigid body definition.

e) (Optional) The **Abort Rigid Body build on error** options allows you to check against the above constraints. If any values exceed their constraints, the calculation returns as failed and a warning dialog appears. If this option is disabled, the calculation will proceed regardless of the returned values.

f) Click **OK**.

3. Click **Next**.

3. Perform the rigid body build

Now that you have finished adjusting the build parameters, the characterization wizard initiates a build and displays a window showing the time, iteration number, and status:

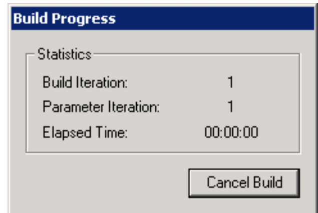


Figure 9-10 Build Progress Dialog

9.3 Producing a Rigid Body Definition With Engineering Data

You can skip the build process altogether if you enter the final rigid body definition data using the tool's design and engineering data:

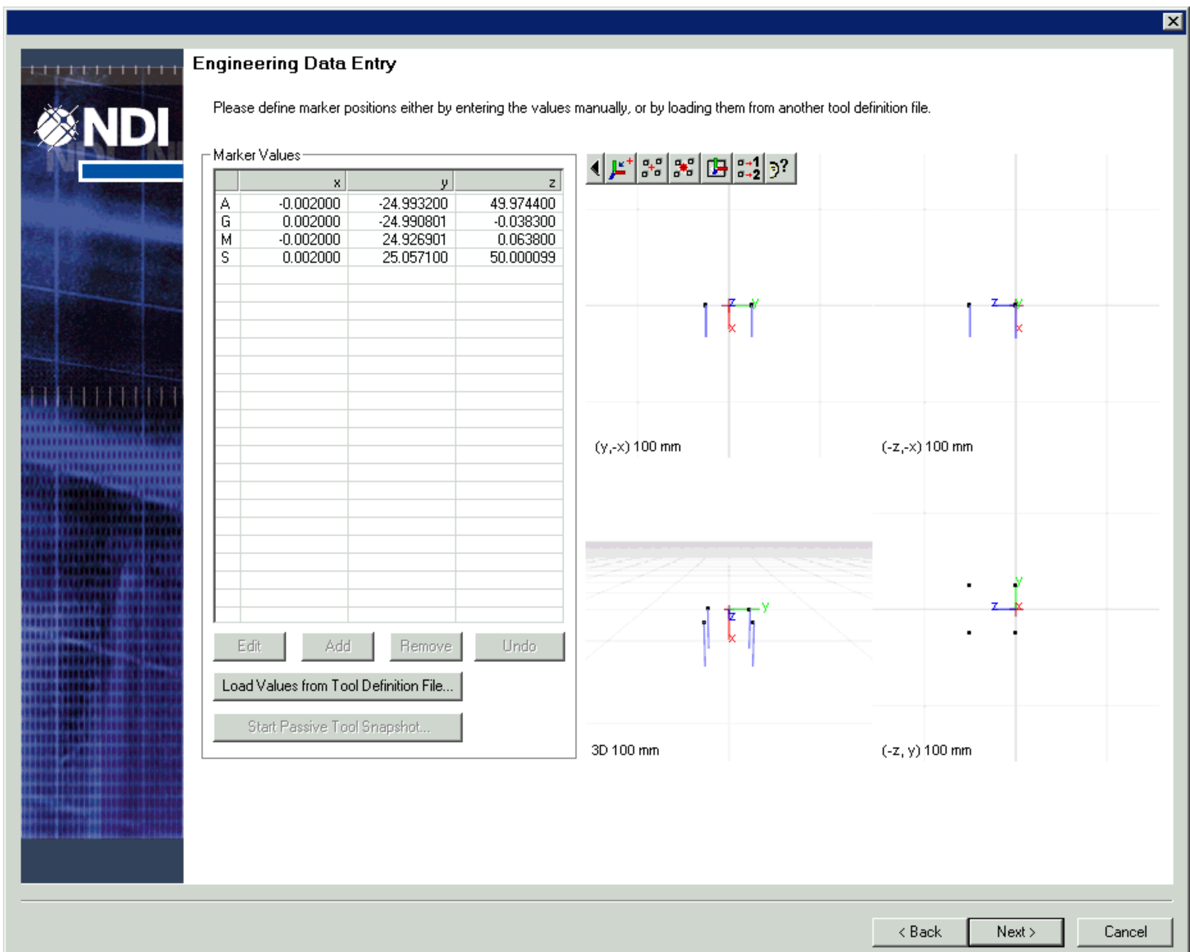


Figure 9-11 Engineering Data Entry

1. Click **Add** or **Remove** to add or remove markers from the Marker Values table.
2. Select individual markers in the list, and click **Edit** to enter their position values manually.

3. (Optional) Click **Load Values from Tool Definition File** and select the desired tool definition file from its home directory. The software will read its stored information and enter marker values into the Marker Values table.
4. Click **Next**.

10 Step Four: Assign Groups and Faces

Once the tool's marker positions have been defined, organize them into groups and faces. For more information about groups and faces, refer to the *"Polaris Tool Design Guide"*.

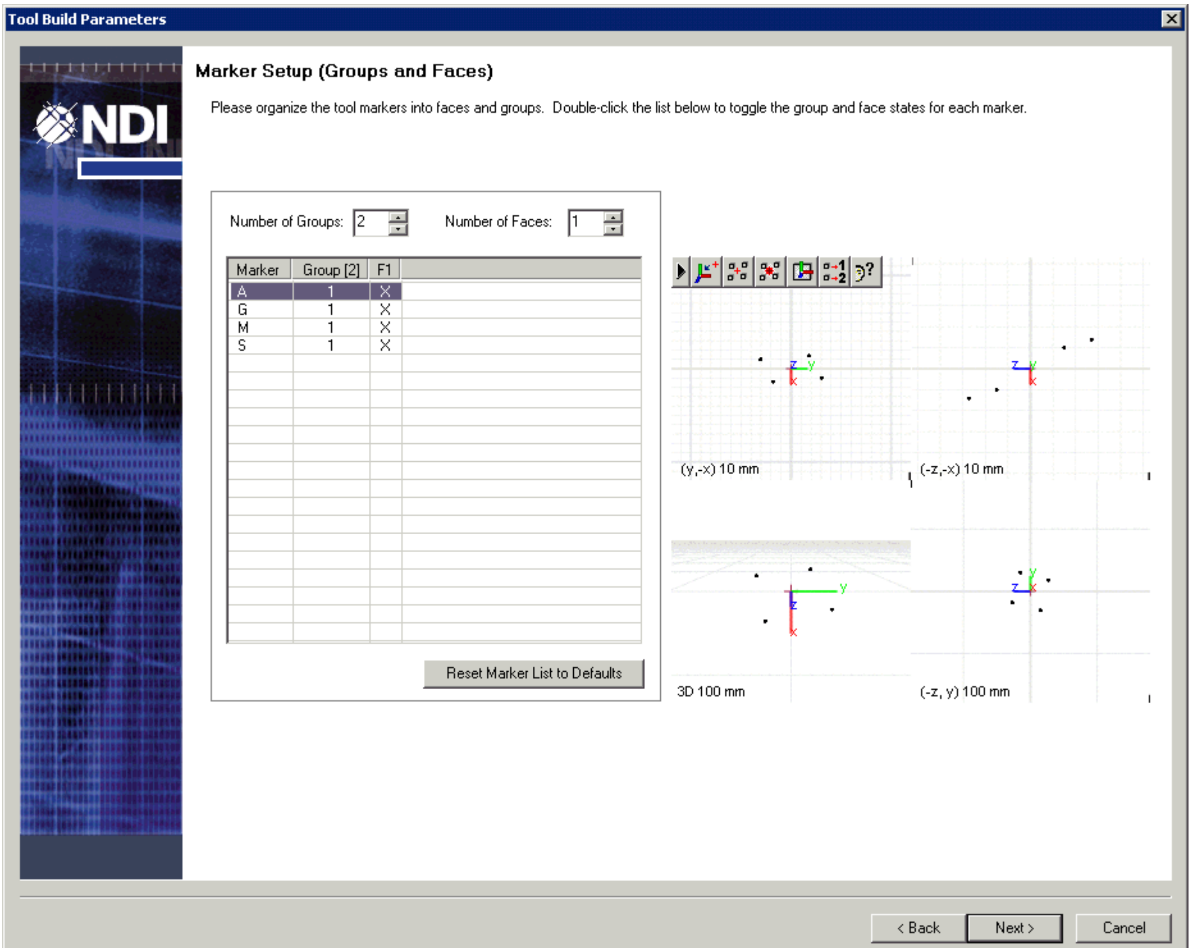


Figure 10-1 Marker Setup (Groups and Faces)

1. Define the **Number of Groups** found on the entire tool, with a minimum of 1 and a maximum of 2.

Note This option is only enabled for active tools; passive tools cannot have more than one group.

2. Define the **Number of Faces** on the tool, with a minimum of 1 and a maximum of 8.

3. Use the table provided to indicate which group and face each marker belongs to:
   - select a marker in the list and press **G** to toggle between groups
   - select a marker in the list and press **1** through **8** to toggle between faces
   - check your selections against the information displayed in the Viewer Panes (your changes are highlighted in different colours)
4. When you are satisfied with your changes, click **Next**.

11 Step Five: Align the Local Coordinate System

The next step in the characterization process is to ensure that the tool's local coordinate system is correctly aligned. You can perform this step by allowing the software to calculate coordinates based on specific constraints. You can also enter the coordinate values manually.

The characterization wizard provides you with a graphic representation of each axis and origin value that you enter, to help you review your adjustments.

Note For more information about local coordinate systems and where best to align them, refer to the "***Polaris Tool Design Guide***".

11.1 Aligning a Local Coordinate System Using Alignment Constraints

You can set specific constraints and then ask the software to calculate a local coordinate system that best fits these requirements.

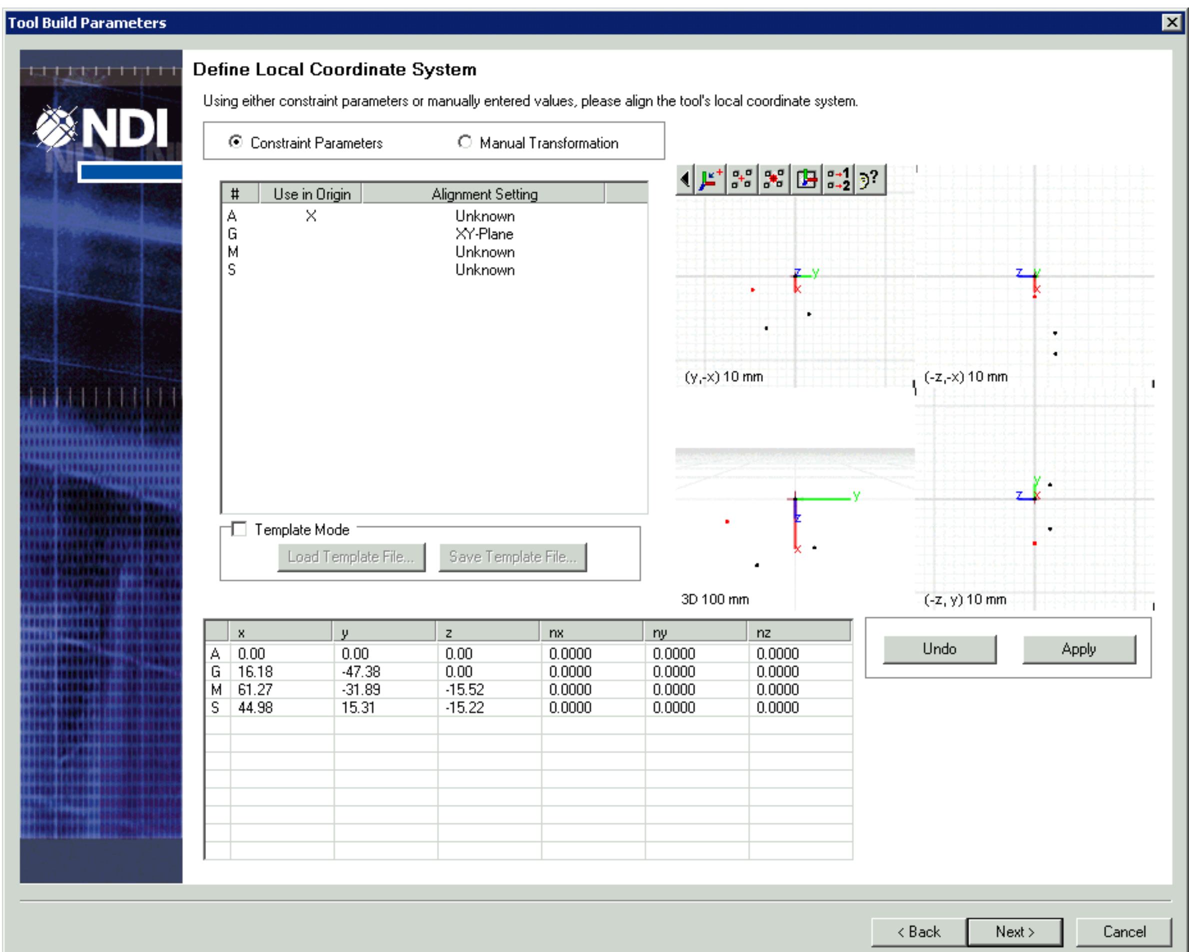


Figure 11-1 Defining a Local Coordinate System Using Constraints

1. Select **Constraint Parameters**.

2. Select one or more markers from the table, and perform one or more of the following:
   - **To assign a marker as the origin of the local coordinate system**, double-click that marker's entry in the **Use In Origin** column. If you select more than one marker as the origin of your tool, the software will place the origin at the geometric centre of your selections.
   - **To place a marker onto an axis**, right-click the marker's entry under **Alignment Setting**. Use the list that appears to constrain the marker to be on any positive or negative x, y, or z-axis.
   - **To align a marker with an axis plane,** right-click that marker's entry under **Alignment Setting**. Use the list that appears to constrain the marker to any quadrant of any plane.
3. Click **Apply** to calculate a local coordinate system that best matches the parameters that you have set. The system will display this coordinate system in the Viewer Panes, and update the coordinates of each marker in the table at the bottom of the dialog.
4. (Optional) If you want to either save these alignment settings to a template or open an existing alignment template and apply it to your tool, select **Template Mode** and use the **Save Template File** and the **Load Template File** buttons, respectively.

Note: Notice that when you enable Template Mode, more specific values are represented in the Positions table. These allow you to specify constraints to a greater degree.

5. Repeat this procedure to adjust your entries as required.
6. Click **Next**.

11.2 Aligning a Local Coordinate System Manually

Instead of assigning constraints and then allowing the software to calculate a local coordinate system, you can directly enter the coordinates yourself.

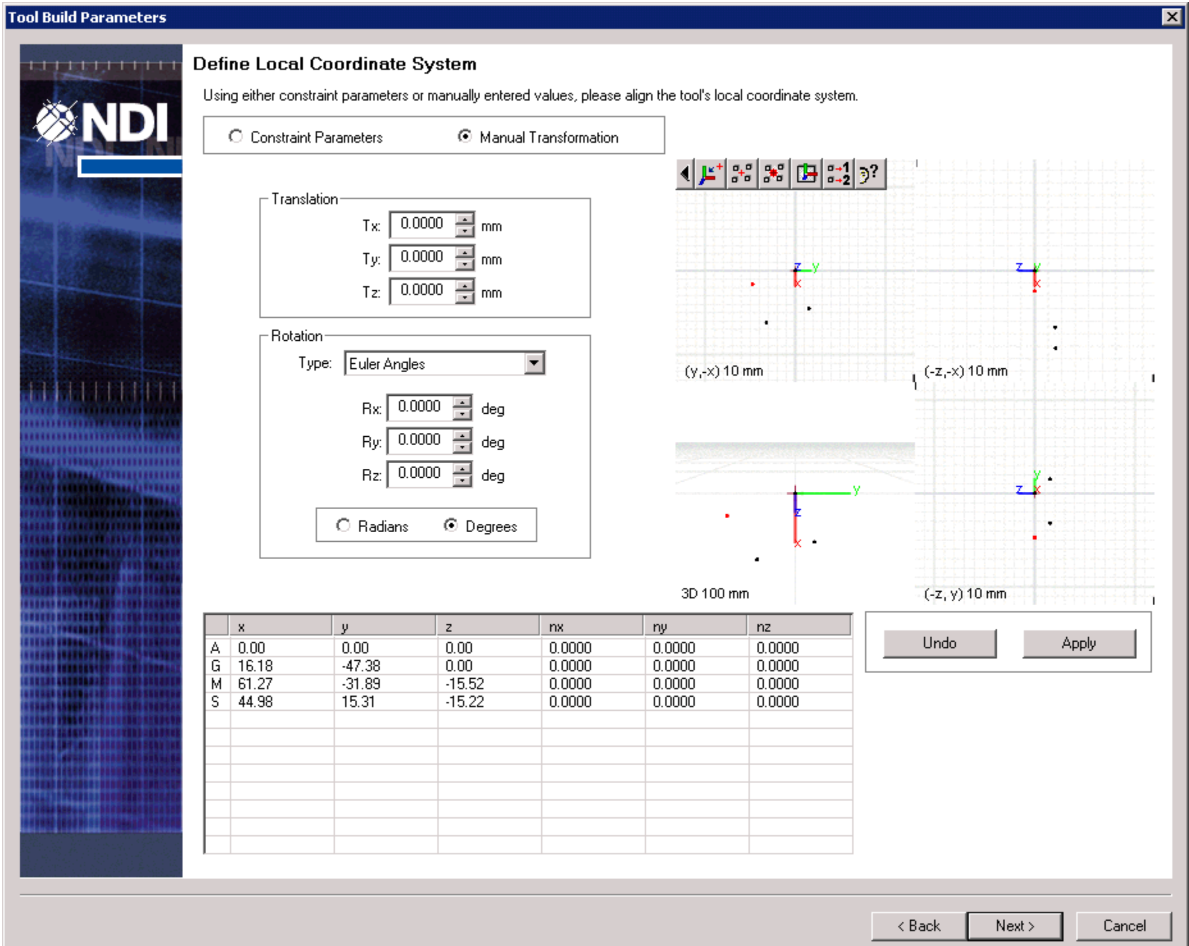


Figure 11-2 Defining a Local Coordinate System Manually

1. Click **Manual Transformation**.
2. In the **Translation** section, use the coordinate fields provided to translate the origin of the local coordinate system.
3. In the **Rotation** section, use the fields provided to rotate the local coordinate system.

Note Use the Type drop-down list to select the format of the rotation values. The Rotation Matrix and Quaternion selections are advanced options. The easiest and most intuitive way to rotate coordinate systems is to use Euler Angles.

4. Click **Apply** to display the local coordinate system that you have described in the graphic window. The software will also update each marker coordinate in the window at the bottom of the dialog, to reflect the resulting local coordinate system.
5. Repeat this procedure to adjust your entries as required.
6. Click **Next**.

12 Step Six: Define Normals

For each marker and face on your tool, you will need to assign a normal vector that defines the direction in which they are facing. The characterization wizard can provide you with suggested values for each normal, and a real-time graphic display to help make adjustments.

The Normal Settings page provides a table listing each marker and face and their corresponding normal coordinates.

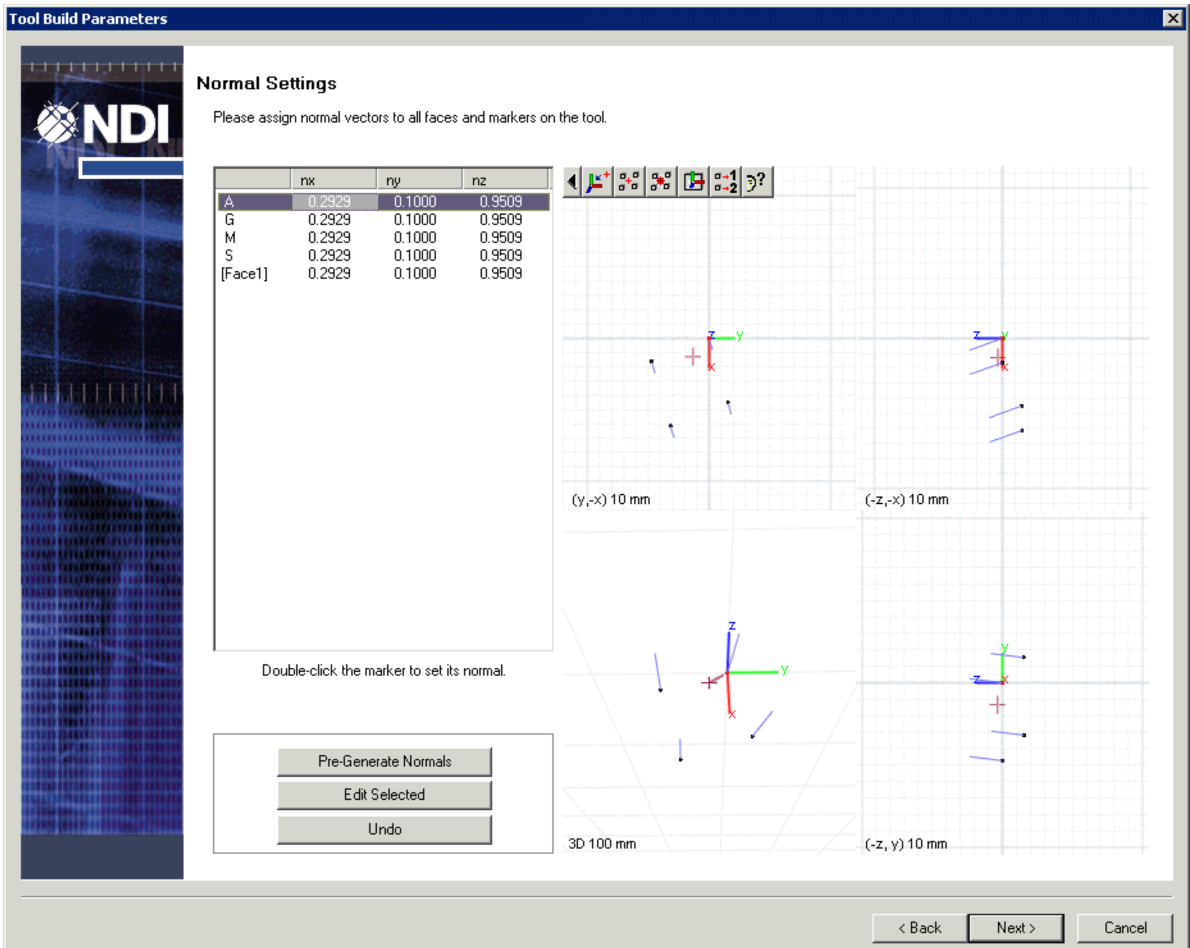


Figure 12-1 Normal Settings

About the Pre-Generate Function

Right-clicking a single marker or face and selecting **Pre-Generate Normals** will calculate a suggestion for that single marker or face. Alternatively, clicking the **Pre-Generate Normals** button will calculate suggestions for the entire tool. *Either of these methods may not produce correct values, but they will guide you in determining some that are.*

Use the following “pre-generate” process to produce normals fast and efficiently:

1. Pre-generate normals for all faces on your tool. Generate normals for faces *before* any markers, as the software suggests a marker normal based on the normal of the face that marker belongs to.

2. Review and adjust the produced normals as required.

3. Pre-generate normals for all markers on the tool.
4. Adjust the produced normals as required.

The following step-by-step procedure describes how to perform this task in greater detail:

1. In the table, right-click on a face and select **Pre-Generate Normals**. Notice that when you select a face, the Viewer Panes grey out all markers that are not part of that selection.

Note: You can pre-generate normals for more than one face at a time: select multiple faces by holding down the SHIFT key.

2. Evaluate the produced suggestion, and adjust the value until you are satisfied with the results. As a general rule, a face normal is perpendicular to the face. To change a value, select its table entry and click **Edit Selected**. You can also right-click a table entry and select from one of the following options:

Table 12-1 Normal Adjustment Options

Adjustment Option	Description
Set normals independently	Changes made to this marker/face normal will not be applied to any other marker/face.
Set selected normals to same value	Changes made to one of the selected markers/faces will be applied to all other selected markers/faces. Their normals will be identical.
Set selected normals to marker vector value	Produces a marker normal using a vector drawn through the marker centre from the tool's origin.
Set opposite direction	Reverses assigned coordinates so that the normal points in the opposite direction.
Pre-generate normals	Produces a suggested normal for each marker, based on the normal of the face(s) that marker belongs to. Refine this suggested normal to produce your final selections.

3. Once you are satisfied with the face normals assigned, you can adjust individual marker normals. For a single face, right-click each of its markers in the table and select **Pre-Generate Normals**.

Note: You can pre-generate normals for more than one marker at a time: select multiple markers by holding down the SHIFT key.

4. Evaluate the produced suggestions, and adjust each value until you are satisfied with the results. Although face normals are typically perpendicular to their faces, individual marker normals do not need to be perpendicular to the face that the marker is assigned to.

   To assist you in evaluating and assigning marker normals, NDI 6D Architect automatically calculates centroid and, when possible, plane equation values. Displayed in the text box under the marker list, these values are calculated depending on how many markers you select from the list.

Table 12-2 Marker Information Provided By NDI 6D Architect

Number of Markers Selected	Values Automatically Provided
1 marker	none
2 markers	coordinates of the centroid distance between the two markers
3 markers	coordinates of the centroid coefficients of an imagined plane that the three markers would create
4 or more markers	coordinates of the centroid

Use these suggested values when evaluating normals. For example, the first three coefficients listed for an imagined plane can be used as coordinates for a vector perpendicular to that imagined plane.

5. Once you are satisfied with each marker normal, click **Next**.

13 Step Seven: Complete the Characterization

Before you can complete the characterization process, the wizard offers you several selections for final tasks. If nothing is selected, the wizard closes and the software populates the main window with the tool definition file that you have created.

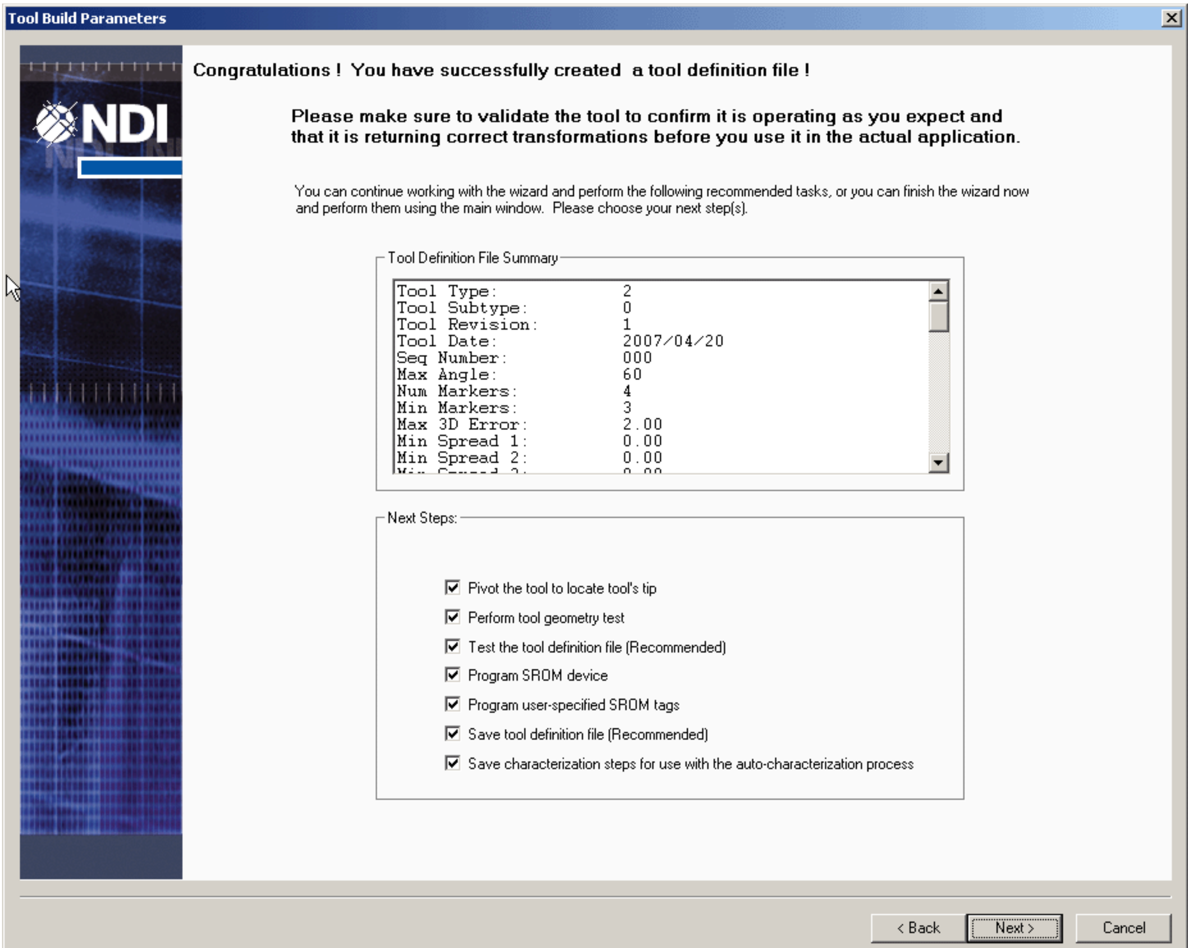


Figure 13-1 Complete Characterization

1. Review the **Tool Definition File Summary** table to make sure that all the tool definition file data that you have just created is as you expect. If there are any obvious errors or omissions, use the **Back** button to return to the appropriate characterization wizard step and edit its contents.

2. From the **Next Steps** list, select the additional tasks that you wish to perform. NDI 6D Architect will tailor any further characterization wizard screens to match these selections.

Table 13-1 Next Steps

Option	Description
Pivot the tool to locate tool’s tip	Perform a pivot to calculate tool tip offset. For instructions, see "Using the Pivot Wizard" on page 63.

Table 13-1 Next Steps

Option	Description
Perform tool geometry test	Test the tool definition file to ensure that it meets tool geometry requirements. For instructions, see "Testing Tool Geometry" on page 54.
Test the tool definition file	**NDI recommends that you perform this task. It is selected by default.** Test the tool definition file against the actual tool to ensure that you have performed the characterization properly. For instructions, see "Testing the Tool Definition File" on page 52.
Program SROM device	**This option is only available for active tools connected to the Polaris System.** Program the tool definition file onto the SROM device, so that the tool can carry its own information. For instructions, see "Programming the SROM Device (Active Tools Only)" on page 58.
Save Tool Definition File	**NDI recommends that you perform this task. It is selected by default.** Use the save dialog provided to save your tool definition file to a directory.
Program user-specified SROM tags	Append additional tags of information to the tool definition file. For instructions, see "Programming User-Specified Tags" on page 56.
Save characterization steps for use with the auto- characterization process	For more information about this selection, see "Auto-Characterization" on page 60.

3. Click **Next**.

13.1 Testing the Tool Definition File

Note NDI recommends that you perform this task; it is selected by default.

Test the tool definition file by using it to track its associated tool in the measurement volume. You can review the results in real-time using the Tool Definition Test dialog, to help you evaluate the accuracy of the tool definition file.

1. Before you can test the tool definition file, you must indicate which tool to track. The following dialog appears automatically:

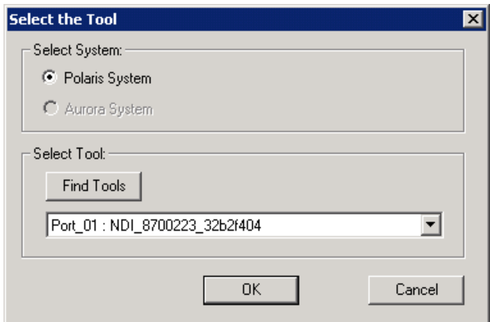


Figure 13-2 Select the Tool Dialog

2. Select **Polaris System**.
3. Click **Find Tools** to automatically populate the drop-down list with all tools found in the characterized measurement volume.
4. Select the tool that is associated with your tool definition file. If you are characterizing a passive tool, select **Port_0A: Passive Tool**.
5. Click **OK**. The Tool Definition Test Page appears:

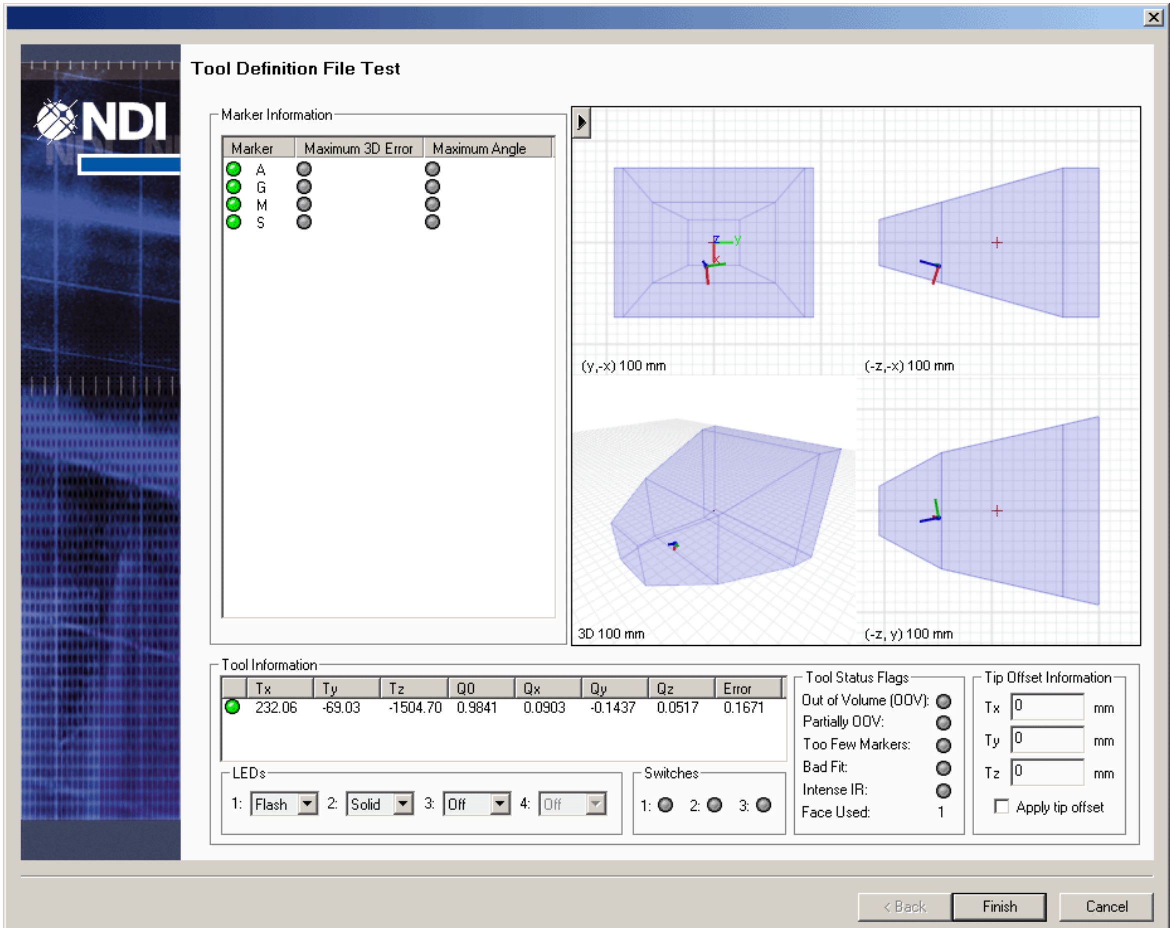


Figure 13-3 Tool Definition File Test

6. Position the tool in the measurement volume. The system tracks the tool using the tool definition file, and NDI 6D Architect populates the dialog fields with the resulting information:

Table 13-2 Tool Definition Test Results

Results	Description
Marker Information	This table displays whether or not a marker is tracking within the maximum marker angle and maximum 3D error constraints stored in the tool definition file. Use this information to assess the accuracy of the tool's normals and local coordinate system.
Tool Information	This table displays tool tracking information such as its coordinates and 3D RMS error for each transformation.
LEDs	Use these drop-down lists to change the state of specific LEDs. Notice that only the LEDs indicated in the tool definition file are enabled for these edits. If the tool is a GPIO device, use the four drop-down lists under the **LEDs** section to toggle the output state of GPIO lines 1 to 4.

Table 13-2 Tool Definition Test Results

Results	Description
Switches	These lights indicate when a switch is engaged. Notice that only the switches indicated in the tool definition file are enabled. If the tool is a GPIO device, the three lights under the **Switches** section report the input state of GPIO lines 1 to 3. (GPIO line 4 cannot be used as an input and thus is not shown.)
Tool Status Flags	This section displays tracking status information such as Out of Volume, Too Few Markers, and Bad Fit.
Tip Offset Information	Use this section to test tip offset vectors. Manually enter offset values in the coordinate fields provided, then enable **Apply Tip Offset**. You can prepare a set of values to test by first pivoting the tool. For more information about pivoting, see "Using the Pivot Wizard" on page 63.

Note If you have positioned the tool near the edge of the measurement volume and the Maximum 3D Error status light turns on, it may mean that one of the tool's markers is actually out of volume. If the tool is positioned well into the measurement volume and this status light turns on, you are only exceeding Maximum 3D Error constraints.

13.2 Testing Tool Geometry

NDI 6D Architect can test the tool geometry constraints and the design constraints of your tool using the tool definition file associated with it. The software will perform two tests:

Test 1: Testing Against NDI Recommendations

The software tests your tool to ensure that it meets the following sets of constraints:

- ❒ the design constraints of minimum segment lengths between markers
- ❒ that the tool taken as a whole conforms to unique geometry constraints
- ❒ that each face on a multi-faced tool conforms to unique geometry constraints
- ❒ that when two tools are being tracked at the same time, they both conform to unique geometry constraints, such that they are distinguishable from each other
- ❒ that when two tools are being tracked, each of their faces conform to unique geometry constraints such that they are distinguishable from each other

The thresholds for both design constraints and unique geometry constraints are listed in the "*Polaris Tool Design Guide"*.

Test 2: Testing Against Manufacturing Allowances

The software performs the same test using NDI's design and unique geometry constraints, but with slightly relaxed thresholds that take into account tool manufacturing allowances.

Passing/Failing Tests

- If your tool design passes both tests, your tool will track reliably.
- If your tool design fails Test 1 but passes Test 2, your tool will likely track; however, efforts should be made to redesign the tool to pass both tests, to increase its tracking reliability.
- If your tool design fails both tests, you should reconsider its design. Refer to the "*Polaris Tool Design Guide" for guidance.*

Note NDI provides strict design and unique geometry constraints for marker placements on tools. These constraints do not take into account manufacturing allowances. It is the tool designer's responsibility to consider manufacturing allowances when planning marker placements, so that the tool can pass NDI's constraints. For more information, see the "***Polaris Tool Design Guide***".

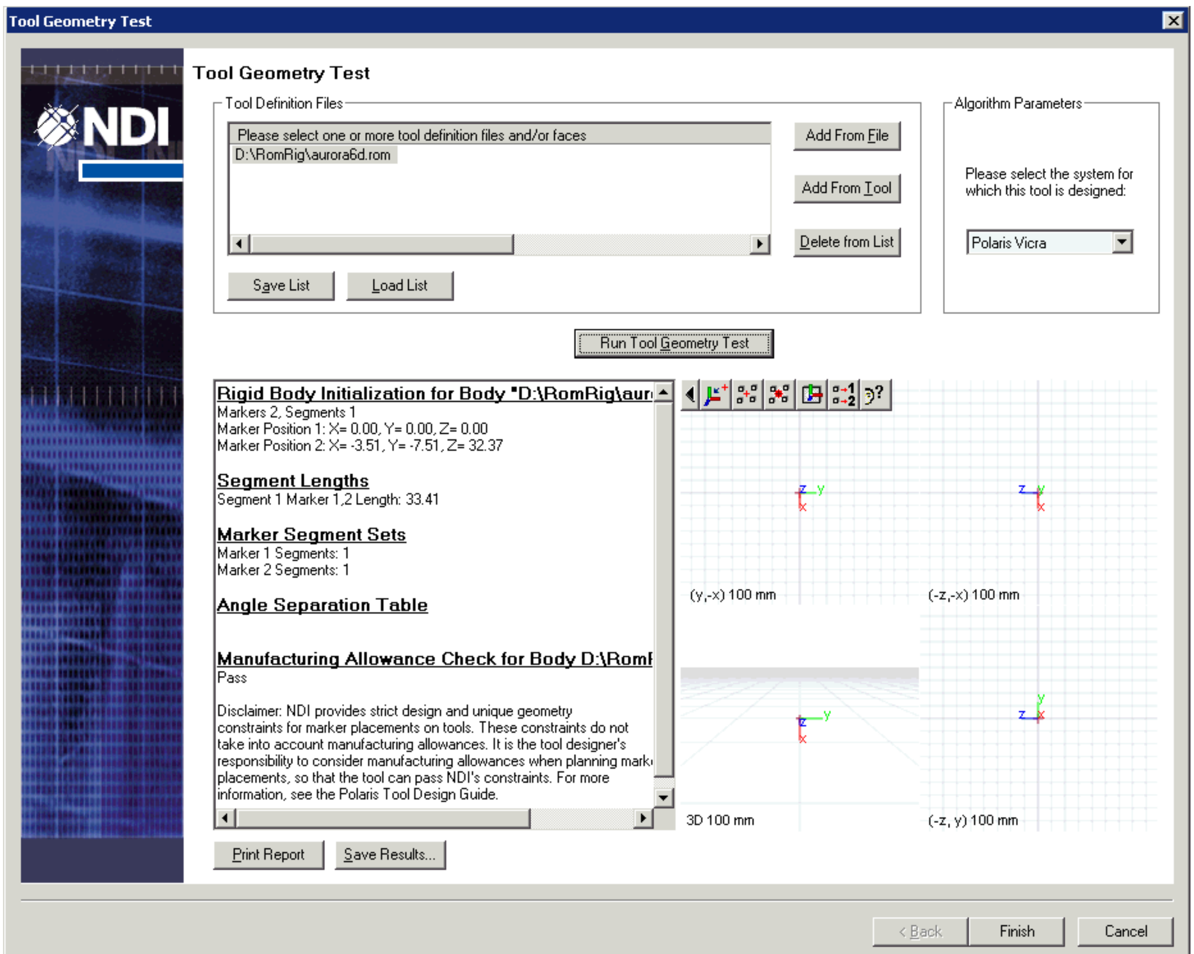


Figure 13-4 Tool Geometry Test

1. Specify which tool definition file you want to test by adding it to the **Tool Definition Files** list:
   - browse to the file using **Add From File**
   - load a file from a connected tool using **Add From Tool**

If you want to test multiple tools against each other, you must add all their tool definition files to this list.

Note The software automatically breaks down a multi-faced tool definition file into separate faces, in order to test them against each other for unique geometry.

2. (Optional) Click S**ave List** to save your selections for future unique geometry tests. You can also click **Load List** to open a previously saved session.
3. In the **Tool Definition Files** list, select one or more entries to indicate which tools and/or faces you wish to test.

   If you select more than one entry, your selections will be tested against each other. Hold down **Ctrl** while selecting, to pick multiple entries.
4. In the **Algorithm Parameters** section, use the drop-down list provided to select the type of Polaris System you are testing with. The software will automatically apply specific unique geometry parameters appropriate to that selection, so that your tool is being tested with the correct pass/fail criteria.
5. Click **Run Tool Geometry Test**. The system will report the results and errors found (in red).

Note During the test, the Run Tool Geometry Test button changes to Stop Test, so you can interrupt the procedure if needed.

13.3 Programming User-Specified Tags

You can append additional tags to a tool's tool definition file, to further identify the parameters of your tool.

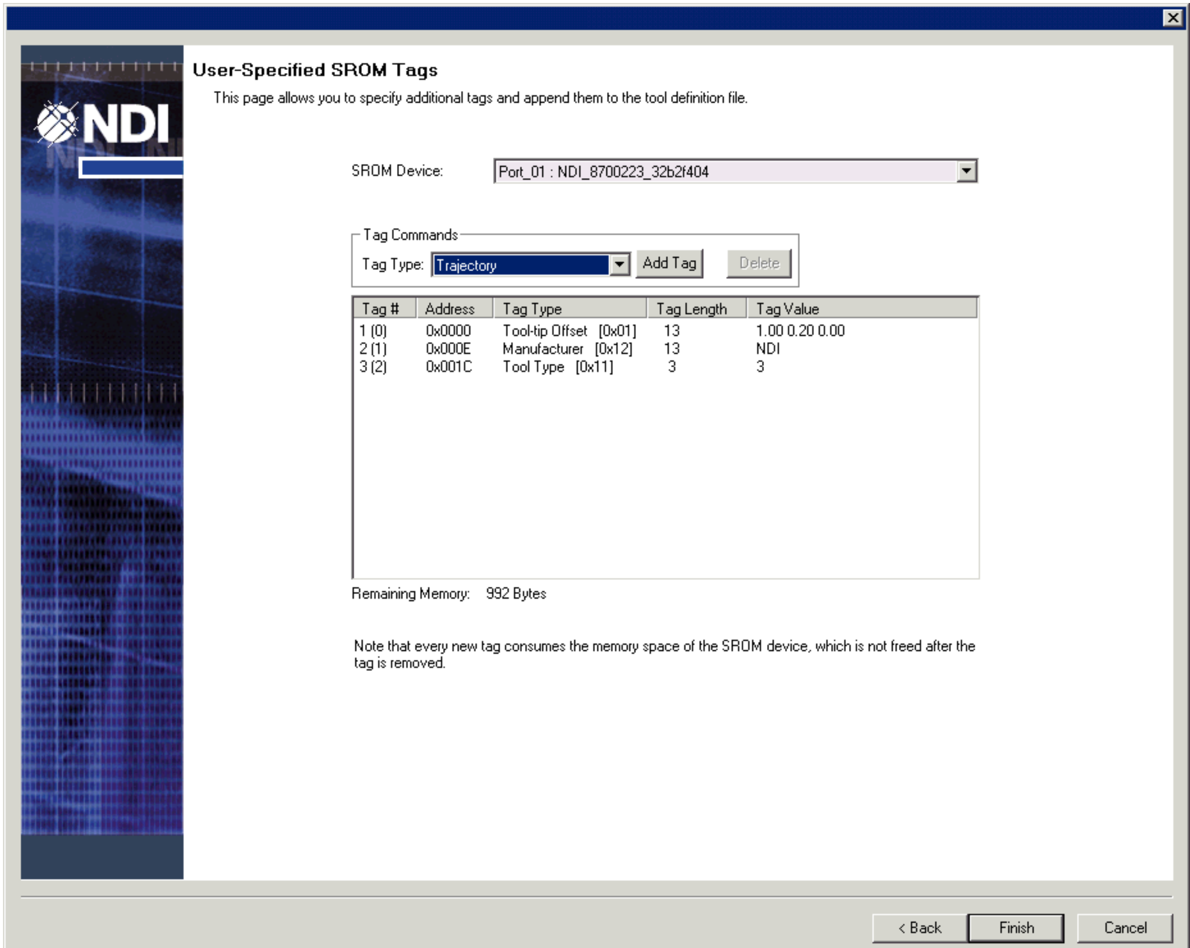


Figure 13-5 User-Specified SROM Tags

The User-Specified SROM Tags dialog provides the following details about each SROM tag:

Table 13-3 SROM Tag Information

Column	Description
Tag #	The first number lists the currently existing tags. The bracketed number is a zero-based index of all tags on the ROM (including any previously deleted tags).
Address	The tag address in memory
Tag Type	The tag description with corresponding tag identification
Tag Length	The tag length in bytes
Tag Value	The tag contents

Note If pre-existing tags exist with your tool definition file, that information will appear in the table.

1. Choose a **Tag Type** from the drop-down list provided:

Table 13-4 Tag Types

Tag Type	Description
Tool-tip Offset	If your tool has an end-tip, this tag stores its location using x, y, and z coordinates.
Trajectory	This tag sets the tool's trajectory, and consists of quaternion coordinates. **Note: Make sure that quaternions are normalized. Failure to do so may result in the unwanted scaling of tool transformations.**
Tool Type	This tag assigns a tool type number to the tool, with a maximum value of 65,535.
Manufacturer	This tag assigns a manufacturing name to the tool, with a maximum of 12 characters.
Binary Data	This tag allows you to store user-defined binary data on the tool's SROM device.
Icon	This tag allows you to store an icon on the tool's SROM device.

2. Click **Add Tag**. A brief dialog will appear with the appropriate data fields for the tag type you selected.
3. Complete these fields and click **OK**.
4. (Optional) To remove a tag, select it from the list and click **Delete**.
5. When you have finished adding and editing the SROM tags, click **OK**.
6. Click **Finish**. NDI 6D Architect will ask you if you wish to add these tags to the tool definition file.
7. Click **OK**.

13.4 Programming the SROM Device (Active Tools Only)

Note This section only applies to active tools that are physically connected to a Polaris System.

Use the characterization wizard to program the tool definition file onto the SROM device, so that the tool can carry its own information. Whenever the tool connects to a Polaris System, the tool definition file is automatically retrieved from the SROM device for interpretation.

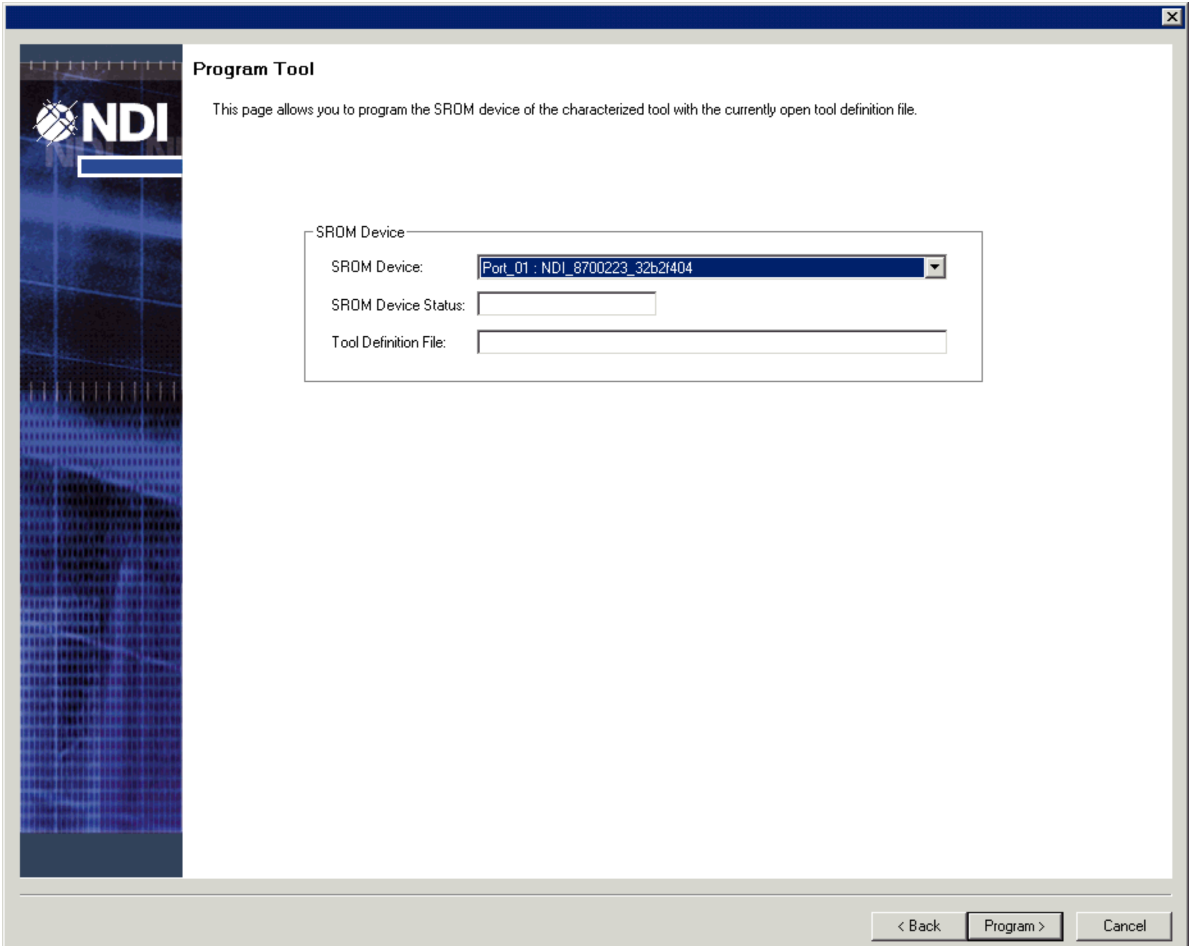


Figure 13-6 Program Tool

Warning! Do not program the tool or use it in an actual application until you have tested its tool definition file and verified that, when applied to the tool, it returns appropriate data. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.

Warning! Do not program a tool that has been dropped or damaged in any way during the characterization process, as the relative positions of its markers may have changed, and are no longer accurately described by the tool definition file. You must perform another characterization using newly collected data. Programming a damaged tool without recollecting tool data will produce an incorrectly characterized tool, inaccurate transformations, and possible personal injury.

Warning! Do not program a tool until you have verified that you are applying the correct, corresponding tool definition file. If the tool definition file does not match the tool the tool may still be tracked but will report incorrect data. This will produce inaccurate transformations and possible personal injury.

Warning!

Do not program a tool without first testing its tool definition file and reviewing its user-specified tags to ensure that the tool is properly characterized, and that its SROM device is not corrupted in any way. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.

Warning!

Make sure that markers are correctly identified in the tool definition file. Transformations for tools that are tracked using incorrect camera parameters will contain systematic errors and indicate incorrect positions for the tool. Incorrect tool positions may result in harm to a patient.

1. Ensure that the tool is connected to the Polaris System.
2. From the drop-down list provided, select the tool's **SROM Device**. This list is automatically populated by the software and read from all tools currently connected to the system.

   The SROM Device Status field will tell you if the SROM device you have selected has already been programmed with previous information.
3. (Optional) If the currently selected tool definition file is not the file you wish to program onto the SROM device, enter the correct **Definition File** location.
4. Click **Next** to write the tool definition file to the tool's SROM device. The Programming Tool dialog opens asking if you are sure you want to program the tool in the selected port.

Warning!

Do not interrupt the programming of an SROM device once it has started. A partially programmed SROM device will produce inaccurate transformations and possible personal injury.

5. Click **OK**.
   - If your tool already contains a tool definition file, a warning dialog appears stating that your tool is already programmed and that continuing the action may corrupt the tool. If you wish to continue programming the SROM, click **Yes**. If not, click **No**.
   - If your tool does not contain a tool definition file, a dialog appears stating that programming the SROM device was successful.

13.5 Auto-Characterization

NDI 6D Architect supports *auto-characterization*. Auto-characterization files contain all of a tool's characterization settings — the only task you need to perform is to collect the tool's data. Auto-characterization is particularly useful where multiple tools of the same design are being characterized.

Creating an Auto-Characterization File

After you have characterized a tool, the final characterization wizard screen offers you the opportunity to save your settings before testing the tool definition file and programming the tool's SROM device. By saving all your work, you are creating an auto-characterization file that can be used to characterize similar tools.

This step is offered as an option at the end of the characterization wizard. If you select this option, the wizard will provide you with a dialog to select a location and assign a name for the saved file:

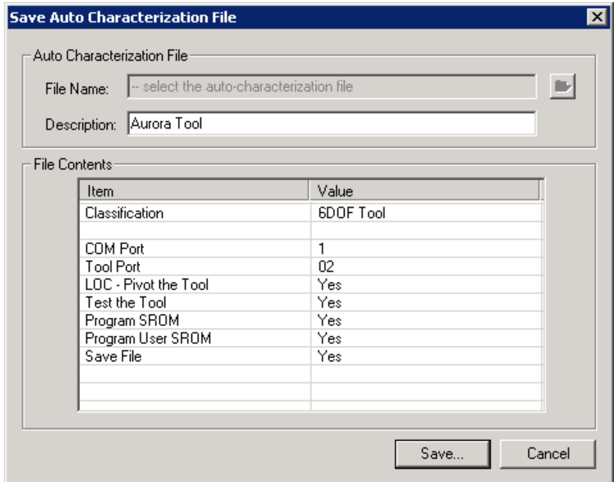


Figure 13-7 Save Auto-Characterization File Dialog

Using an Auto-Characterization File

1. From the main window, select **Build** > **Run Auto-characterization File**. The following dialog appears:

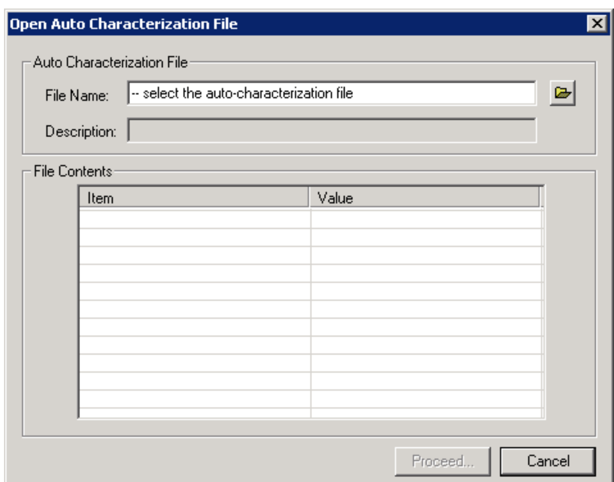


Figure 13-8 Auto-characterization File Dialog

2. Browse and select the **File Name**, indicating which auto-characterization file (with all its pre-programmed wizard settings) you wish to use. The software loads the selected auto-characterization file into the File Contents window, for you to review:

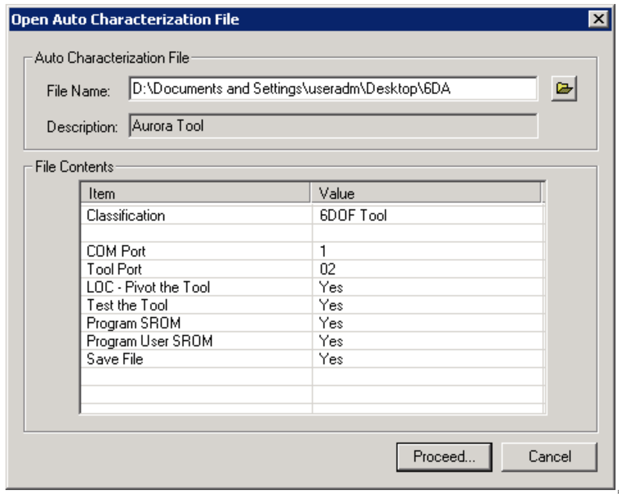


Figure 13-9 File Content Window with Values Displayed

3. Some of the entries in the File Content window can been altered for this particular run. Notice the one blank line amongst the entries: any entry listed below this line can be edited by simply clicking on the value and manually entering a new one.

Note Any changes you make are not permanently saved to the auto-characterization file; they are applied to this run only, and will be lost once you finish the process.

4. Click **Proceed**. The following dialog appears, to confirm the serial number for the first tool in the characterization run:

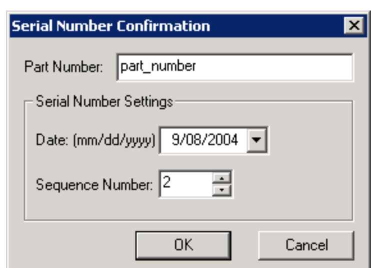


Figure 13-10 Serial Number Confirmation

5. Increase the **Sequence Number** by a set value (for example, an increment of 1), to ensure that the tool is labelled with a unique identifier.

6. Click **OK**. The system will run through the characterization procedure defined in the auto-characterization file, stopping at specified points for any user input required (such as data collection, user-specific SROM tag entries, or programming the SROM device).

14 Using the Pivot Wizard

Warning! Do not perform a pivot until you have read and understood how best to complete a pivot procedure. Refer to the "Polaris Tool Design Guide" for detailed instructions and guidance. Failure to perform a pivot correctly may lead to an incorrectly defined tool tip offset, which may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.

Use the pivot alignment wizard to calculate the location of a tool's end-tip. You can use this information to do the following:

- use the vector to transform a local coordinate system so that its origin is located at the end-tip
- permanently program the vector as a user-specified tag in a tool's SROM device
- use the vector to test a tool definition file

NDI does not recommend permanently transforming a tool's local coordinate system to its end-tip if your tool design is such that the location of the end-tip can be altered as a result of damage (such as a probe bending as a result of being dropped).

It is better to calculate the offset vector (such as performing a pivot procedure) and re-align a local coordinate system as a part of your application procedure, every time you are about to track the tool. Contact NDI for more information about incorporating this step into your application.

14.1 Adjusting Pivot Parameters

Note You cannot adjust pivot parameters during the characterization process. Perform this step before characterizing a tool if you plan on selecting "Pivot the tool to locate tool's tip" in the last screen of the characterization wizard.

Pivot wizard results are created by applying specific parameters to collected pivot data. Set these parameters from the main window:

1. From the main menu, select **Local Coordinate System > Pivot the Tool**. The pivot alignment wizard opens.
2. Click **Pivot Parameters**. The following dialog appears:

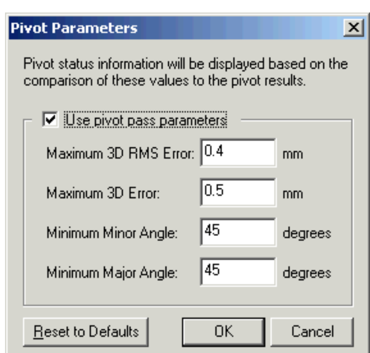


Figure 14-1 Pivot Parameters Dialog

3. Adjust the values in this dialog using the following table as a guide:

Table 14-1 Pivot Parameters

Pivot Parameter	Description
Maximum 3D RMS Error	This field defines the acceptable threshold for 3D RMS Error values produced by a pivot. The 3D RMS Error is produced by applying the result of the pivot procedure to each frame of the pivot procedure, and calculating an overall RMS error for the collection.
Maximum 3D Error	This field defines the acceptable threshold for 3D error values produced by a pivot. The 3D Error is produced by applying the result of the pivot procedure to each frame of the pivot procedure, and calculating an error for that frame.
Minimum Major Angle	This field defines the acceptable threshold for a major angle produced during a pivot. The major angle is the greatest angle the tool was moved during the pivot procedure.
Minimum Minor Angle	This field defines the acceptable threshold for a minor angle produced during a pivot. The minor angle is defined as being orthogonal to the plane of the major angle.

4. Enable **Use pivot pass parameters** to apply your adjustments to the pass/fail pivot thresholds.
5. Click **OK**.

14.2 Completing Pivot Setup

Note If you are using the pivot alignment wizard directly from the characterization wizard, you do not need to perform this step. All settings in this dialog are adjusted throughout the characterization process. Go directly to "Collecting Pivot Data" on page 66.

1. From the main menu, select **Local Coordinate System** > **Pivot the Tool**. The pivot alignment wizard opens:

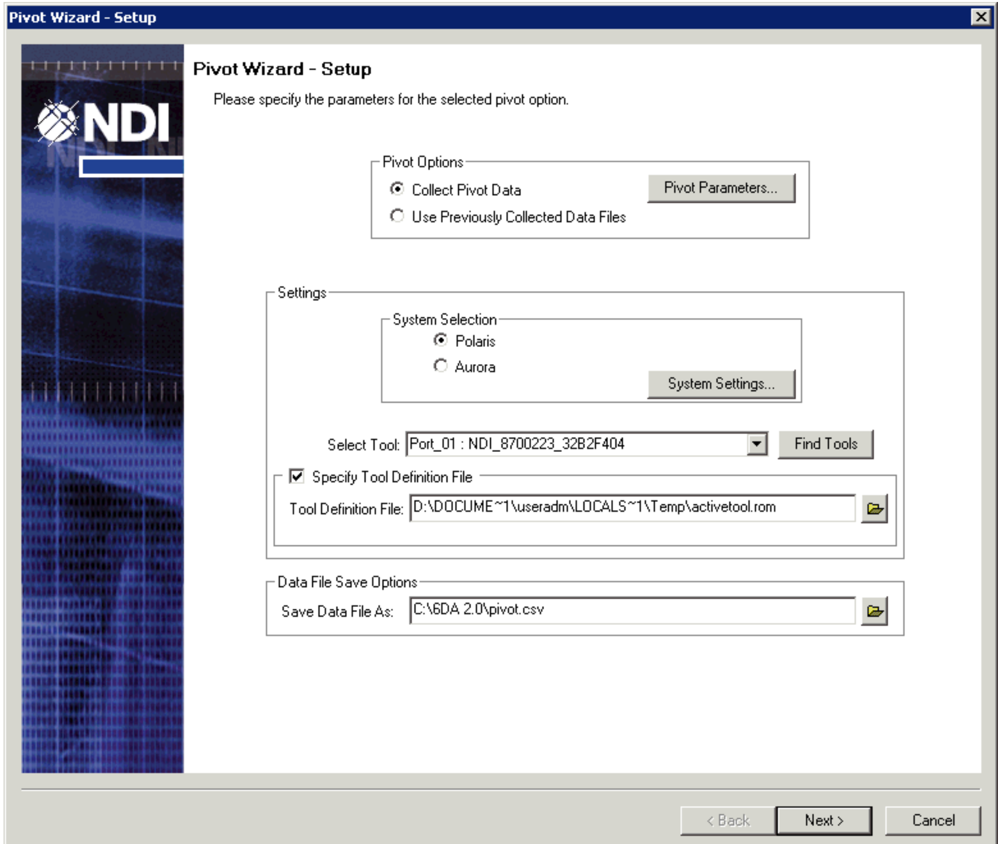


Figure 14-2 Pivot Wizard - Setup

2. From the **Pivot Options** provided, select **Collect Pivot Data**.

Note: As an alternative to collecting pivot data, you can load previously collected pivot data from a saved file. Select Use Previously Collected Data Files, and a dialog will open that allows you to search for and select the desired file. The pivot alignment wizard will load its information directly into the Pivot Wizard - Results page.

3. (Optional) Click **Pivot Parameters** and make any necessary changes. For instructions, see "Adjusting Pivot Parameters" on page 63.
4. Select **Polaris System**. You can also adjust your **System Settings**, should you choose. For instructions on how to change these settings, see "Opening the Characterization Wizard" on page 15.
5. Select your tool from the automatically-populated **Select Tool** drop-down list. You can also open a tool definition file in the **Specify Tool Definition File** section, if your tool does not have a tool definition file already loaded onto its SROM device.
6. In the S**ave Data File As** field, indicate a folder and location for saving the pivot data that you will be collecting.
7. Click **Next**. The Collection page appears.

14.3 Collecting Pivot Data

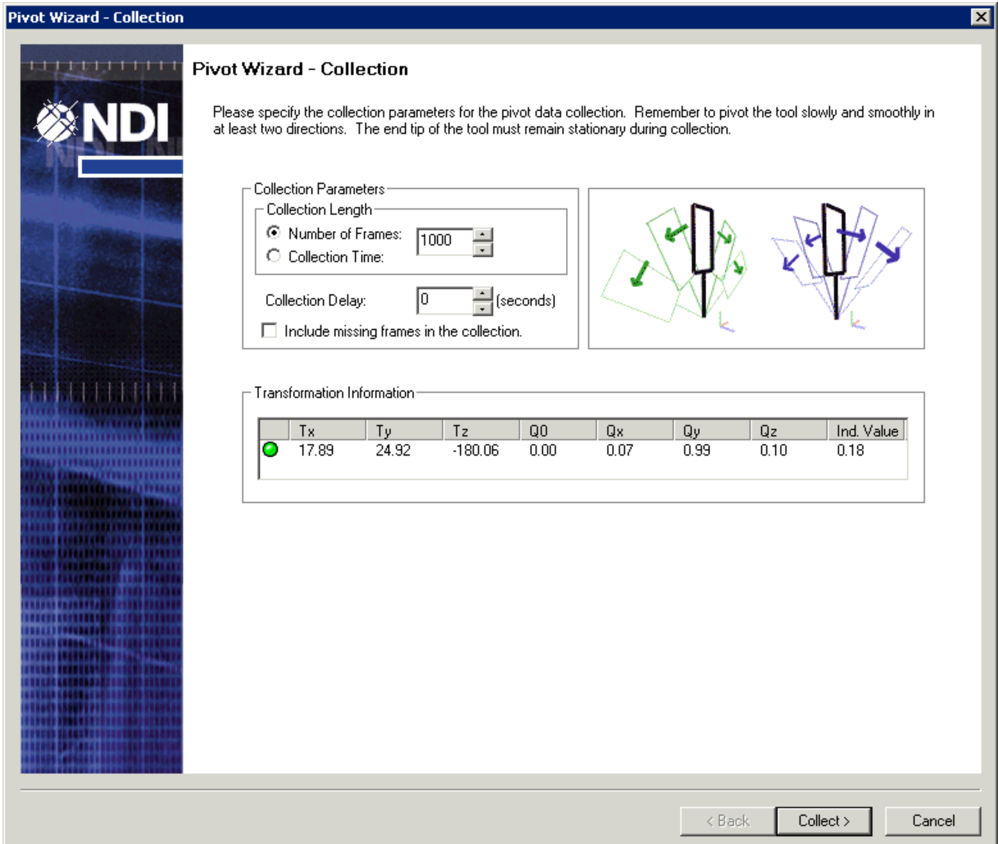


Figure 14-3 Pivot Wizard - Collection

1. Set the **Collection Length** in either frames or seconds.

   If you set the collection length by indicating a number of frames, you can enable an option called “Include missing frames in the collection”. The system will allow frames containing missing data if this option is enabled.

2. (Optional) Set a **Collection Delay** if you want the system to pause for several seconds before collecting a trial.

3. Position your tool in the measurement volume with its tool-tip placed on a fixed point (such as a divot in a pivot block). Ensure that the markers are visible and that the tracking light is green.

4. Click **Collect** to begin the data collection trial.

5. As the measurement system collects the data, continuously pivot the tool back and forth and side to side, with its tool-tip remaining stationary at the fixed point. Ideally, the angles of your pivot movements should fall between 30° and 60°.

Note It is very important that the tool-tip remains stationary while the tool is being pivoted. The design of the pivot block should take into account the shape of the tool’s end-tip. For more information about designing a pivot block, refer to the “***Polaris Tool Design Guide***” or contact NDI.

6. Once the collection has finished, click **Next**. The Results dialog opens, displaying the calculated results of the tool-tip data:

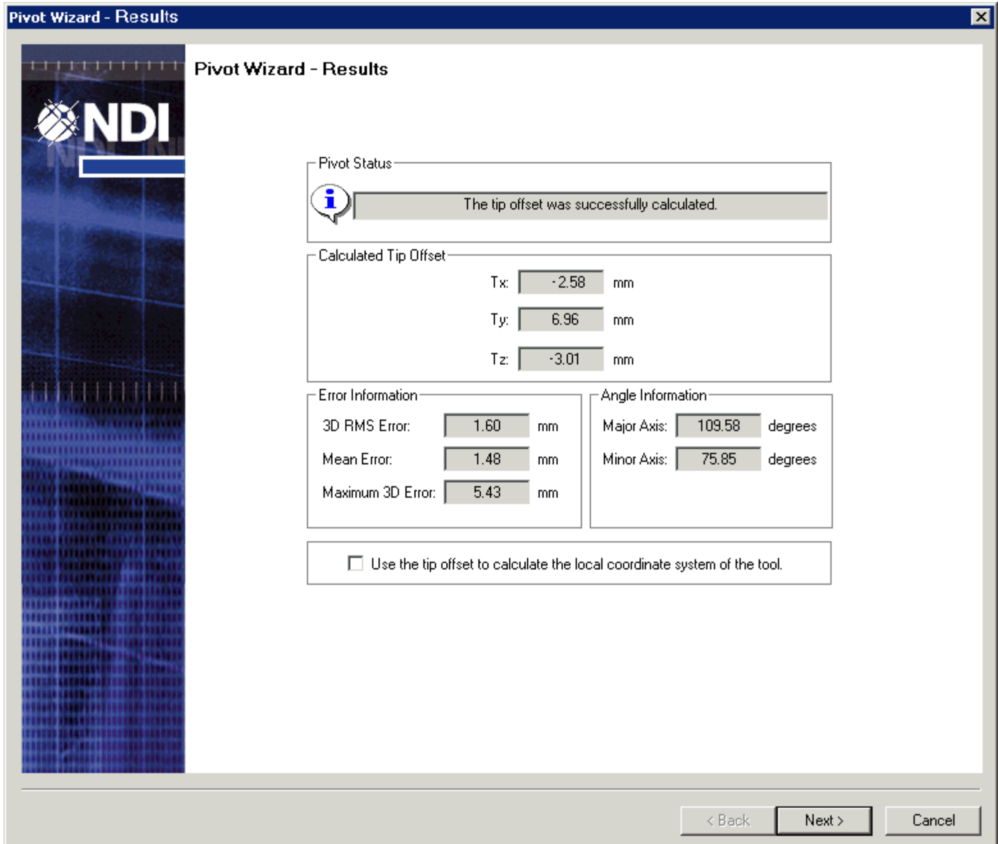


Figure 14-4 Pivot Wizard - Results

The Pivot Wizard Results page provides the following information:

Table 14-2 Pivot Results

Results	Description
Calculated Tip Offset	This section displays the Tx, Ty, and Tz position of the tool-tip, relative to the origin of the tool’s local coordinate system.
Error Information	This section displays the 3D RMS, Mean, and Maximum 3D Errors of the collection, in millimetres.
Angle Information	This section displays the maximum and minimum angles of the pivot you performed. The maximum angle is the greatest angle created by your pivot movements; the minimum angle is defined as being orthogonal to the plane of the maximum angle.

7. (Optional) If you want to transform the origin of the tool’s local coordinate system so that it is located at the tool-tip, enable **Use the tip offset to calculate the local coordinate system of the tool.**
8. Click **Finish**.

15 About .CSV files

A .csv file is a text-based data file storing collected data. You can create a .csv file using NDI 6D Architect by performing a standard data collection and then saving the results using a .csv file extension. For more information on this, see "Producing a Rigid Body Definition With Collection" on page 30.

You can also manually write a .csv file, without using NDI 6D Architect, by entering tool data into a text file using the following format:

###											
# NDI 6D ARCHITECT COLLECTED MARKER DATA (CSV FORMAT)											
#											
# Collection Date (M/D/Y): 11/19/2003											
# Collection Markers: 4											
# Collection Frames: 30											
#											
# Part Number: 436											
# Manufacturer: LALA											
# Revision: 1											
# Serial Number: 869599233I											
#											
###											
Marker1-X	Marker1-Y	Marker1-Z	Marker2-X	Marker2-Y	Marker2-Z	Marker3-X	Marker3-Y	Marker3-Z	Marker4-X	Marker4-Y	Marker4-Z
318.8974	-388.481	-2075.815	268.7373	-388.945	-2072.87	269.1944	-439.086	-2071.02	319.4174	-438.891	-2074.37
318.8983	-388.484	-2075.824	268.7395	-388.945	-2072.87	269.1987	-439.083	-2071.02	319.4209	-438.894	-2074.38
318.9042	-388.485	-2075.834	268.743	-388.942	-2072.88	269.2006	-439.083	-2071.02	319.4236	-438.892	-2074.37
318.9036	-388.492	-2075.838	268.7403	-388.942	-2072.87	269.1978	-439.085	-2071.02	319.4214	-438.89	-2074.37
318.9032	-388.488	-2075.841	268.7385	-388.937	-2072.86	269.1958	-439.083	-2071.02	319.4176	-438.881	-2074.36
318.909	-388.492	-2075.855	268.7419	-388.938	-2072.87	269.2023	-439.085	-2071.02	319.4203	-438.88	-2074.36
318.9039	-388.493	-2075.854	268.737	-388.94	-2072.87	269.1982	-439.09	-2071.03	319.416	-438.885	-2074.37
318.8987	-388.494	-2075.858	268.7343	-388.941	-2072.87	269.1969	-439.092	-2071.04	319.4183	-438.891	-2074.38
318.8943	-388.49	-2075.853	268.7312	-388.942	-2072.87	269.1956	-439.093	-2071.04	319.4178	-438.891	-2074.38
318.8916	-388.486	-2075.846	268.7269	-388.942	-2072.86	269.1932	-439.098	-2071.04	319.4138	-438.891	-2074.39
318.8841	-388.486	-2075.842	268.7172	-388.942	-2072.86	269.1869	-439.105	-2071.05	319.407	-438.889	-2074.39
318.8802	-388.48	-2075.83	268.7185	-388.944	-2072.85	269.1934	-439.11	-2071.06	319.4114	-438.887	-2074.38
318.8831	-388.48	-2075.825	268.7156	-388.941	-2072.83	269.1922	-439.112	-2071.05	319.4108	-438.888	-2074.38
318.8757	-388.48	-2075.814	268.7129	-388.94	-2072.83	269.1902	-439.114	-2071.05	319.4093	-438.893	-2074.39
318.8772	-388.481	-2075.824	268.714	-388.937	-2072.83	269.194	-439.117	-2071.06	319.415	-438.898	-2074.4
318.8844	-388.48	-2075.824	268.7166	-388.935	-2072.83	269.1939	-439.115	-2071.06	319.4148	-438.898	-2074.4
318.8842	-388.479	-2075.818	268.7189	-388.932	-2072.83	269.1939	-439.113	-2071.07	319.4131	-438.899	-2074.4

Figure 15-1 Standard Format of a Polaris Tool's .CSV File

Characterizing Aurora Tools

This section explains the following topics and procedures:

16 Exploring the Aurora Main Window

When working with Aurora tools, NDI 6D Architect's main window displays the following functionality:

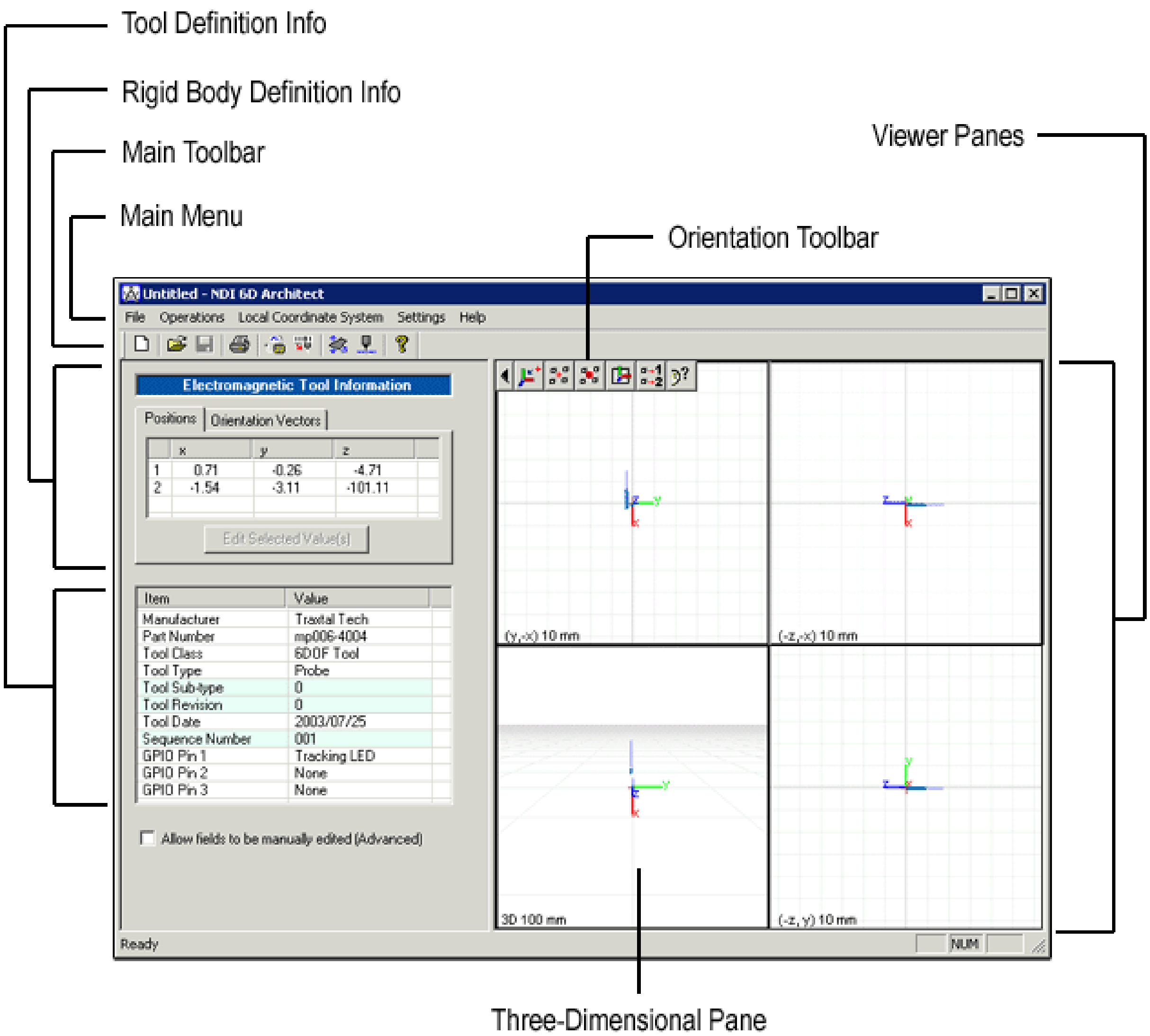


Figure 16-1 Aurora Main Window

Note: In the Tool Definition Information section, values that are marked in green can be seen in both hex and decimal formats. Double-click the entry to switch between formats.

16.1 Using the Viewer Panes

The *Viewer Panes* show a graphical representation of the tool's sensor coil(s) relative to its local coordinate system. When the tool is being tracked, these panes show, in real-time, the tool relative to the global coordinate system.

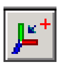
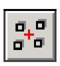
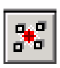
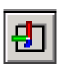
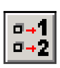
The default view of the Viewer Panes displays four separate panes. Three of the four panes provide a two-dimensional representation; the remaining pane provides a three-dimensional representation of the same information.

Note If you experience any problems with the Viewer Panes, review the Windows settings related to your graphics card. Changing these settings may be the solution.

Manipulating Views

The following table describes the command icons provided to manipulate the Viewer Panes.

Table 16-1 Explaining the Orientation Toolbar

Command Icon	Description
	Toggles the menu display
	Resets the view back to the default position
	Moves the view to the geometric centre of the sensor coil(s)
	Locks or unlocks the view to the geometric centre of the sensor coil(s)
	Toggles the view by 90° about the z-axis
	Toggles between different sensor coil display types
	Launches the navigation help

The following tables describe keyboard and mouse shortcuts you can use to manipulate the Viewer Panes:

Table 16-2 Two-Dimensional Pane Functionality

Change to Viewer Pane	Action
Move view	Hold left mouse button + drag
Zoom in	Hold right mouse button + drag up
Zoom out	Hold right mouse button + drag down

Table 16-3 Three-Dimensional Pane Functionality

Change to Viewer Pane	Action
Zoom in	Hold ‘Z’ + left mouse button + drag up
Zoom out	Hold ‘Z’ + left mouse button + drag down
Rotate view	Hold right mouse button + drag
Rotate view around the x-axis	Hold ‘Y’ + left mouse button + drag
Rotate view around the y-axis	Hold ‘P’ + left mouse button + drag
Rotate view around the z-axis	Hold ‘R’ + left mouse button + drag

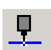
Table 16-4 Common Functionality

Change to Viewer Pane	Action
Reset view to the tool origin	Press ‘O’
Reset view to geometric centre of sensor coil(s)	Press ‘C’
Lock/unlock the view to geometric centre of sensor coil(s)	Press ‘L’
Change measurement volume display style (full, full without border-lines, mesh, and hidden)	Press ‘V’
Maximize/minimize a pane	Double-click the pane

16.2 Using the Main Toolbar

The following table describes the command icons on the main toolbar:

Table 16-5 Explaining the Main Toolbar

Command Icon	Description
	Loads a new blank tool definition file into the software and launches the characterization wizard. For more information, see "Step One: Select Tool Type and Method" on page 80.
	Opens an existing tool definition file
	Saves the tool definition file
	Prints the contents of the main window
	Tests the tracking of a tool within the measurement volume
	Programs the tool definition file to an SROM device. For more information, see "Programming the SROM Device" on page 103.
	Defines a local coordinate system. For more information, see "Step Four: Align the Local Coordinate System" on page 95.
	Launches the pivot alignment wizard used to calculate a tool-tip offset. For more information, see "Using the Pivot Wizard" on page 108.
	Provides information about the software version.

16.3 Using Menu Items

The following table describes the main window's menu item:

Table 16-6 Description of Main Window Menu Items

Menu Item	Submenu Items	Description
File	New	Closes currently open file and opens the characterization wizard
	Modify	Allows you to modify the current tool definition file by opening the characterization wizard and populating its screens with the current tool definition file's data.
	Open	Opens an existing tool definition file
	Save	Saves current changes to a tool definition file
	Save As	Saves a copy of the current tool definition file
	Close	Closes current tool definition file and opens a new blank tool definition file
	Print	Prints the current tool definition file's values
	Print Setup	Opens a standard print setup page
	Load Tool Definition File From Device	Allows you to open a tool definition file stored on a tool currently connected to the system.
	Recent File List	Lists up to four of the latest tool definition files used
	Exit	Closes NDI 6D Architect
Operations	Run Auto-Characterization File	This option allows to you open, review, edit and apply an auto-characterization file. For more information, see "Auto-Characterization" on page 105.
	Test Tool Definition File	Tests the current tool definition file against a connected tool. For more information, see "Testing the Tool Definition File" on page 100.
	Program SROM Device	Writes the current tool definition file to a connected tool's blank SROM device. For more information, see "Programming the SROM Device" on page 103.
	Add User-Specified SROM Tags	Allows you to add additional user-specified SROM tags to a tool definition file. For more information, see "Programming User-Specified Tags" on page 102.
Local Coordinate System	Define Local Coordinate System	Opens the Define Local Coordinate System dialog. For more information, see "Step Four: Align the Local Coordinate System" on page 95.
	Pivot the Tool	Opens the pivot alignment wizard. For more information, see "Using the Pivot Wizard" on page 108.

Table 16-6 Description of Main Window Menu Items

Menu Item	Submenu Items	Description
Settings	Polaris	This option is not available for Aurora Systems.
	Aurora	Opens the Aurora System Settings dialog. For more information, see "Before You Start: Adjust System Settings" on page 79.
	Pivot Parameters	Allows you to review the constraints applied to each pivot collection used to calculate the tool tip offset. For more information, see "Adjusting Pivot Parameters" on page 108.
Help	Contents	Opens NDI 6D Architect Online Help.
	About NDI 6D Architect	Opens the software description page.

17 Before You Start: Adjust System Settings

Use the following instructions to set up your system settings and start the characterization wizard:

17.1 Adjust Aurora Communication Settings

To achieve the best results for collection trials, tool testing, and programming SROM devices, review and adjust the communication settings for your system:

1. From the main menu, select **Settings** > **Aurora**. The Aurora System Settings dialog appears:

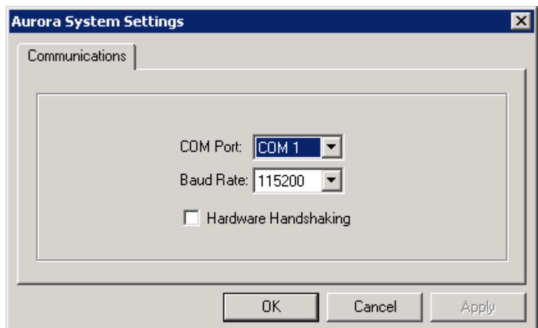


Figure 17-1 Aurora System Settings Dialog

2. From the drop-down list provided, specify the **COM Port** that the Aurora System uses to communicate with the host computer.
3. From the drop-down list provided, specify the **Baud Rate** for the communication between the host computer and the Aurora System.
4. (Recommended) Enable **Hardware Handshaking**. Hardware handshaking is a predetermined software activity designed to establish or maintain two machines or programs in synchronization. Handshaking is the exchange of messages or packets of data between two systems with limited buffers.
5. Click **Apply**.
6. Click **OK** to close the window.

17.2 Open the Characterization Wizard

Note At the back of this guide are several pull-out reference cards designed to help you as you proceed with the characterization procedure. Be sure to remove them for quick reference as you work.

To start the characterization process, open the NDI 6D Architect characterization wizard. From the main menu, select **File** > **New** and proceed to the first step, "Step One: Select Tool Type and Method" on page 80.

18 Step One: Select Tool Type and Method

When you start the characterization wizard, the following dialog appears. This first screen not only welcomes you to the characterization wizard, but acts as a portal to the rest of the wizard's functionality. Tasks and procedures that the wizard will guide you through are customized according to the kind of tool you are characterizing, and the method you select:

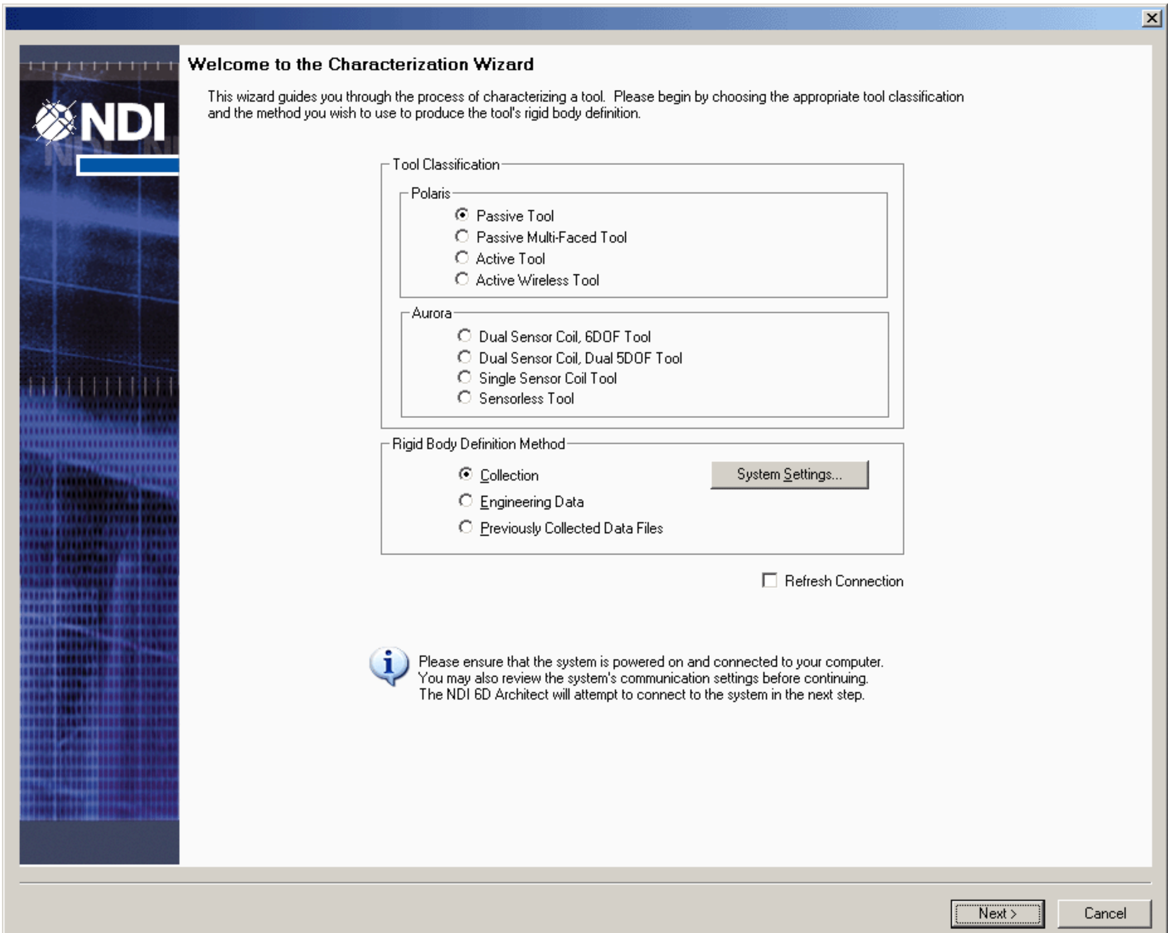


Figure 18-1 Welcome to the Characterization Wizard

1. In the **Tool Classification** section, select the type of **Aurora** tool that you are characterizing.

Note For information about tool types, refer to the ***"Aurora Tool Design Guide".***

2. If you are characterizing a 6DOF tool, you will need to produce a rigid body definition using a selected **Rigid Body Definition Method**:

Table 18-1 Rigid Body Definition Methods

Method	Description
Collection	Gather information about the tool's sensor coil locations by measuring them with an Aurora System.

Table 18-1 Rigid Body Definition Methods

Method	Description
Engineering Data	Using the engineering specifications used to manufacture the tool, manually enter the tool’s sensor coil locations.
Previously Collected Data Files	Skip the collection process and use data from saved collection trials instead.

Note If you are characterizing any other Aurora tool type, you do not need a rigid body definition and these selections are automatically disabled.

3. If you change the system that you are using to characterise tools with, check the **Refresh Connection** checkbox.
4. Click **Next**.

18.1 Additional Collection Settings

If you selected **Collection** as your method of producing a rigid body definition, NDI 6D Architect connects to your measurement system and the Tool Collection Settings page appears:

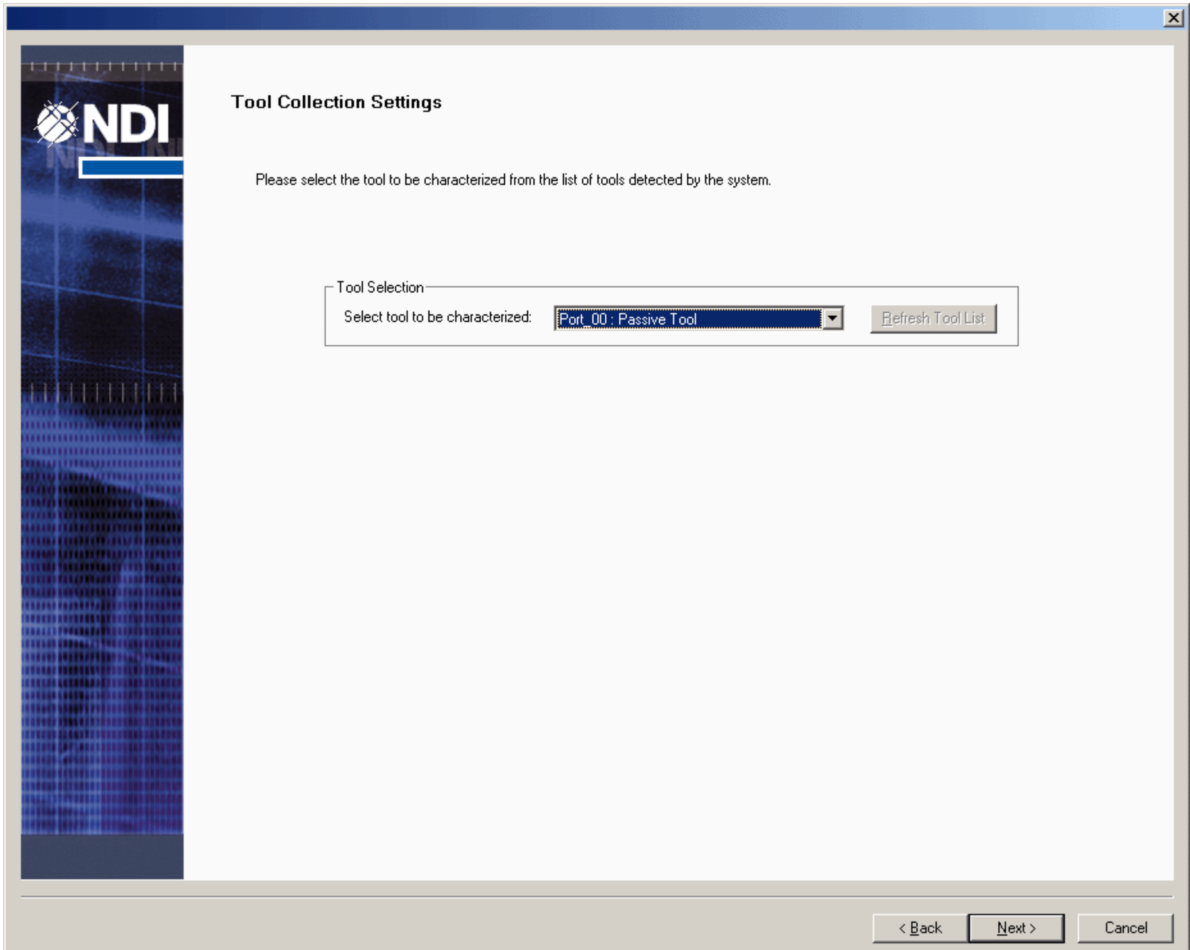


Figure 18-2 Tool Collection Settings

5. From the **Tool Selection** drop-down list provided, select the tool you are characterizing from the list of tools detected by the system.

Note: Click Refresh Tool List if you change tool ports or tool connections at any time during this procedure.

6. Click **Next**.

19 Step Two: Enter Tool Parameters

Once you have chosen the kind of tool you are characterizing, the characterization wizard will ask you to define basic tool parameters. These include a part number, a manufacturer name, and serial number settings. These parameters become part of the tool definition file when it is produced at the end of the characterization procedure.

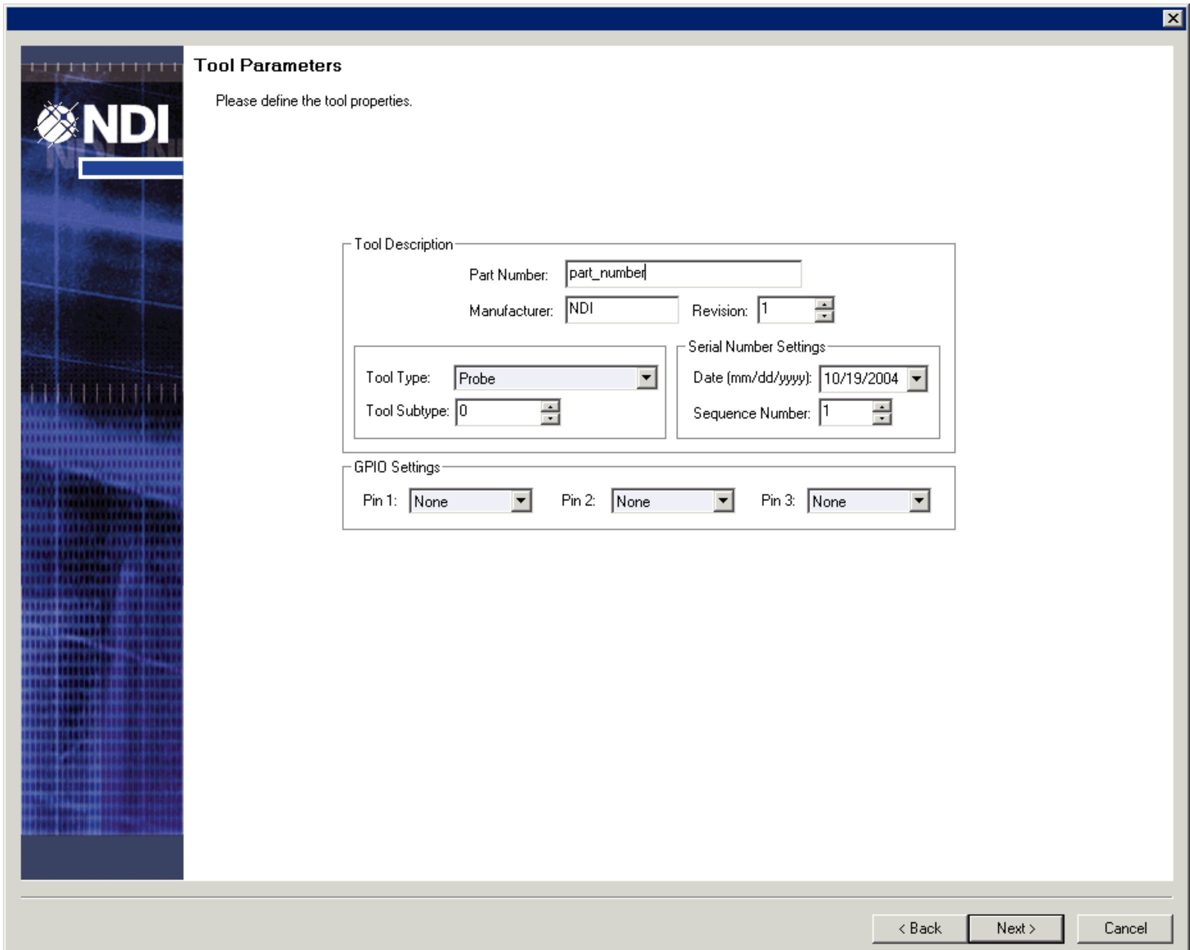


Figure 19-1 Aurora Tool Parameters

All tool parameters are retained for subsequent builds, so you do not need to enter them for each tool. The only exception is the sequence number, which is used to produce a unique serial number for each tool being characterized.

1. Enter the user-specified **Part Number** for your tool. This field will accept any character up to a maximum of 20.
2. Enter the **Manufacturer** name for your tool. This field will accept any character up to a maximum of 12.
3. Enter the user-specified **Revision** number of your tool. This field will accept any integer between 0 and 999.

4. From the drop-down list provided, select the appropriate **Tool Type**:

Table 19-1 Selecting Tool Types

Tool Type	Description
Reference	A tool meant to be used as a reference
Probe	A tool with a tip, meant to be used as a pointer
Button Box/Foot Switch	A tool meant to be used as an input device, such as a switch or foot pedal. This option is only available for sensorless tools.
Software Defined	Select this option if you want your software to identify and acknowledge the tool type instead of storing this information on the tool's SROM device
Calibration Device	A special type of reference tool used to verify the calibration of an instrument's tip location, and possibly the instrument's diameter and vector
Catheter	A special tool with a specific medical purpose

5. Enter a user-specified value to identify a **Tool Subtype**. This field will accept any integer between 0 and 255.

6. Specify the different **Serial Number Settings** provided:

   - Enter the **Date** that the tool was characterized (today). This field will accept any date as its value.

   - In the **Sequence Number** field, enter the number of the tool in the sequence of tools created on the same date, and of the same part number. This field will accept any integer between 0 and 1023.

   The software will use these settings to automatically produce a unique serial number for your tool.

7. Assign a status to the three **GPIO Settings** lines available for the tool:

Table 19-2 GPIO Settings

GPIO Setting	Description
None	Indicates that the GPIO pin for this tool has no I/O feature
Input	Indicates a triggered device. There are two states for this device: open and closed.
Output	Indicates the pin can supply up to 5 V with a maximum current draw of 10 mA
Visible LED	Used to control an LED (other than a Tracking LED)
Always High	Indicates the pin will always supply 5 V with a maximum current draw of 10 mA.
Tracking LED	Can be set to turn on when the system can calculate, but does not return, a valid transformation, for example, when the tool is out of volume.

8. Click **Next**.

Note

If you are characterizing anything other than a 6DOF tool, you will proceed directly to the end of the wizard, as no other steps are required. See "Step Five: Complete the Characterization" on page 98 for the instructions on completing the process.

20 Step Three: Produce a Rigid Body Definition

Now that you have defined the tool's parameters, you are ready to produce the tool's rigid body definition. This task is performed using the method you selected in the first screen of the characterization wizard: collection, previously collected data, or engineering data.

20.1 Producing a Rigid Body Definition With Collection

Build a rigid body definition by measuring the tool's sensor coil locations with an Aurora System. This method involves the following steps:

1. Set the save parameters.
2. Collect the data.
3. Set the Build Parameters.
4. Perform the rigid body build.

1. Set the save parameters

Each collection trial will be saved to separate files in a specified directory. You must indicate where it will be saved and what to call it.

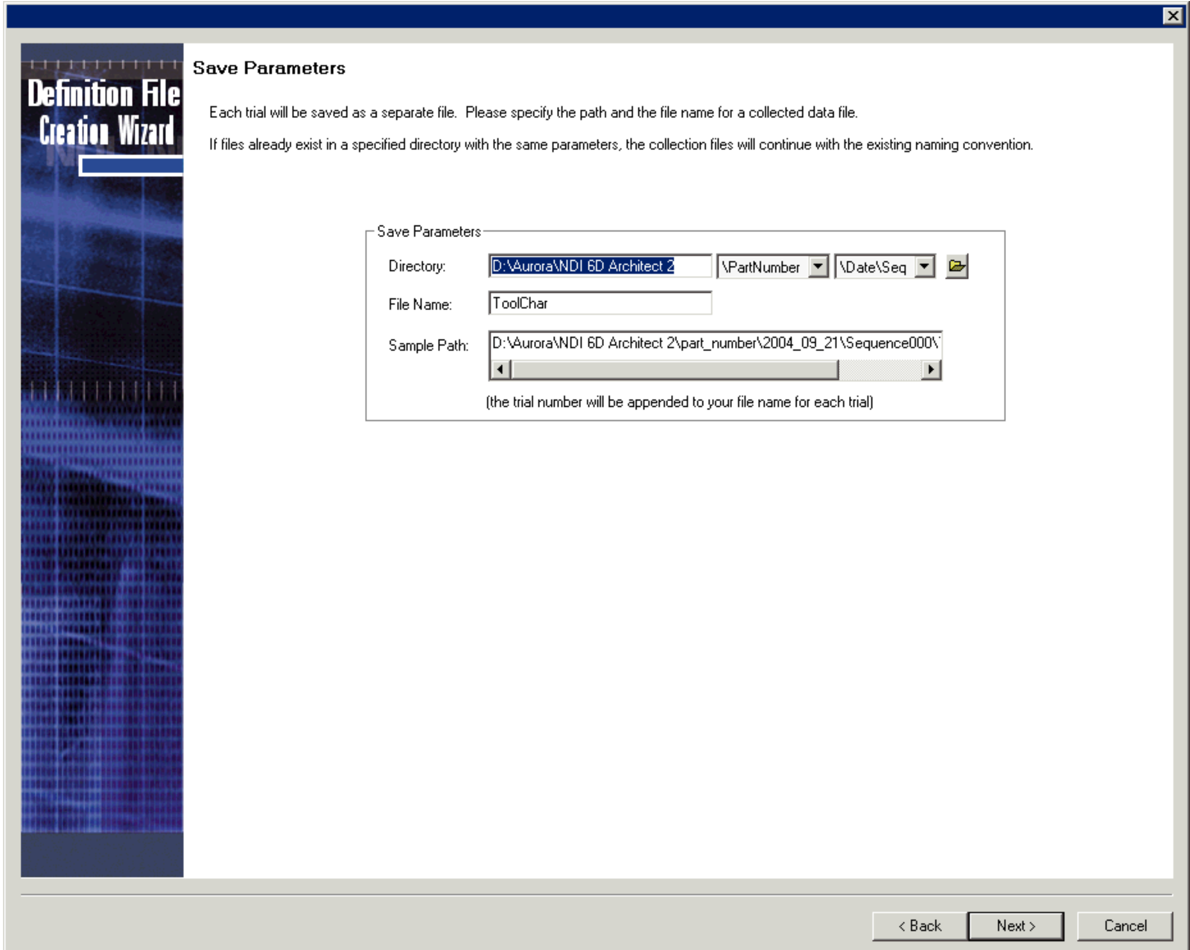


Figure 20-1 Save Parameters

1. Using the browse button, specify the **Directory** where each collection trial will be saved.
2. NDI 6D Architect automatically produces a file for each collection trial that you perform. You can add variables such as **/Pathname** or **/Date/Seq** to this process, so that the file produced includes this information. Use the two additional drop-down lists provided to select these variables. This information will be appended to the directory's name when the file is saved.
3. Enter a **File Name**. Notice that the **Sample Path** field now displays the pathname that would be created by the software.
4. Once you are satisfied with the settings and their results, click **Next**.

2. Collect the data

Once you have set the save parameters, the characterization wizard opens the Data Collection page:

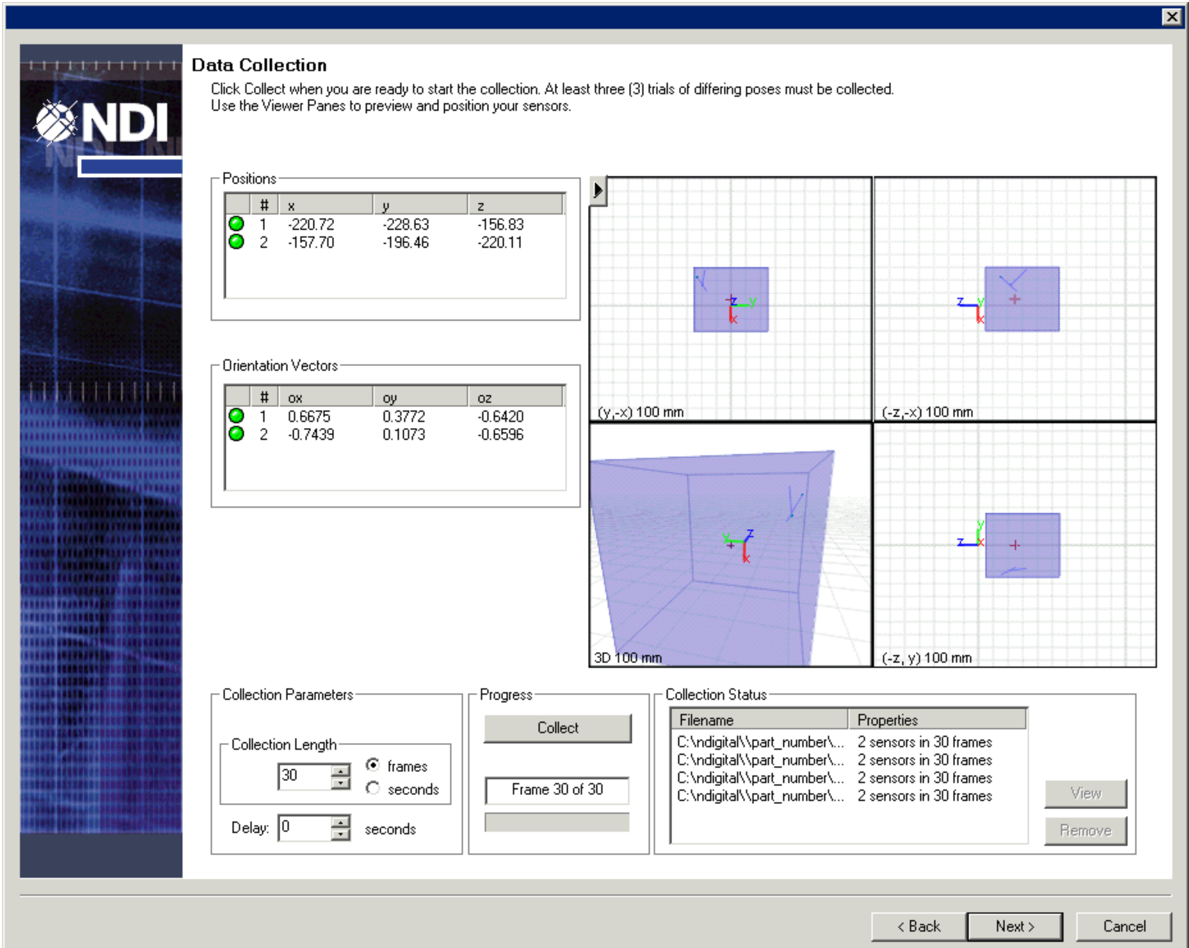


Figure 20-2 Data Collection

1. Set the **Collection Length** for each trial in either **Frames** or **Seconds**.
2. (Optional) Specify a **Delay** if you want the software to wait before beginning the collection trial.
3. Position the tool in the measurement volume. Notice the following changes:
   - The **Positions** section is populated with the identifying name, tracking status light, and position data for both sensor coils.

- The **Orientation Vectors** section is populated with the identifying name, tracking status light, and orientation data for both sensor coils. A sensor coil's three orientation coordinates combine to create a vector running the length of the sensor coil, indicating the direction that it is pointing. This information is reported in real-time and can help you place the tool correctly in the measurement volume.

4. Click **Collect**. The collection trial begins and the **Collect** button becomes a **Stop** button during collection. Note that you can stop a trial at any time by clicking this button; however, any data collected for that trial will be erased.

   Once the collection trial is finished, the software will check the data to make sure that the tool did not move. Once the data has been confirmed, the system saves the file and adds it to the **Collection Status** list.

5. Continue performing collections for each position of the tool that you need to measure.

Note: You must collect at least THREE trials, with the tool in a different pose for each.

6. (Optional) Select a collection trial from the **Collection Status** list, and click **View** to open a playback window:

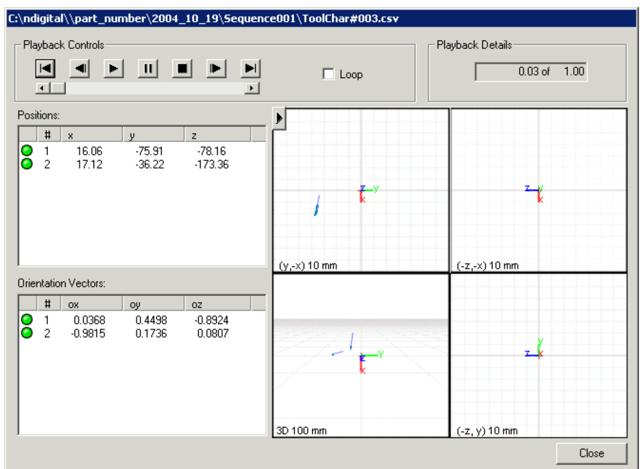


Figure 20-3 Playback Window

   Use the controls provided to play back the collection trial in real-time, then click **Close** to return to the Data Collection dialog.

7. Click **Next** when you are satisfied with the results.

3. Set the Build Parameters

Now that you have collected the tool data, you need to specify how this data will be processed to produce the rigid body definition.

Note: These parameters are used to create the rigid body definition, and are not used when tracking a tool in an actual application. These settings are not stored anywhere in the tool definition file.

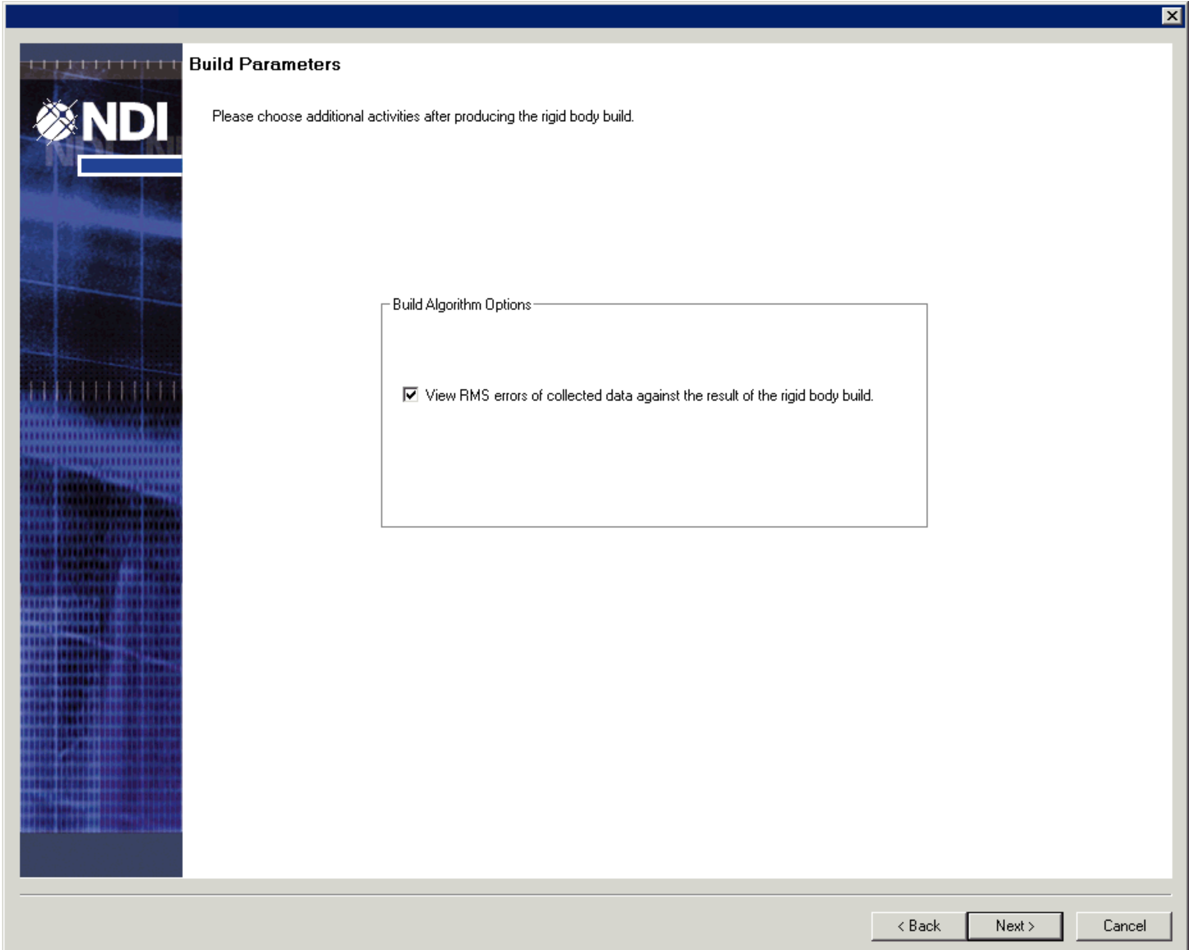


Figure 20-4 Build Parameters

1. If you want to see the results of the build in greater detail once it is complete, enable **View RMS errors of collected data against the result of the rigid body build.**
2. Click **Next**.

4. Perform the rigid body build

Now that you have finished adjusting the build parameters, the characterization wizard initiates a build and displays a window showing the time, iteration number, and status:

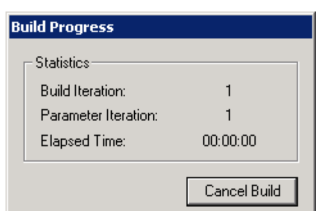


Figure 20-5 Build Progress

Note If, after performing collections, the rigid body definition build fails, return to the Data Collection page by pressing the Back button. Use the View button and play back each collection you made. If there are significantly different results for one of the collections, delete that one collection using the Remove button, then perform a new collection to replace it.

20.2 Producing a Rigid Body Definition With Previously Collected Data

Produce a rigid body definition with previously collected tool data. This method involves the following steps:

1. Select the file.

2. Set the build parameters.

3. Perform the rigid body build.

1. Select the file

Select three previously-collected data trials using the Data File Selection page:

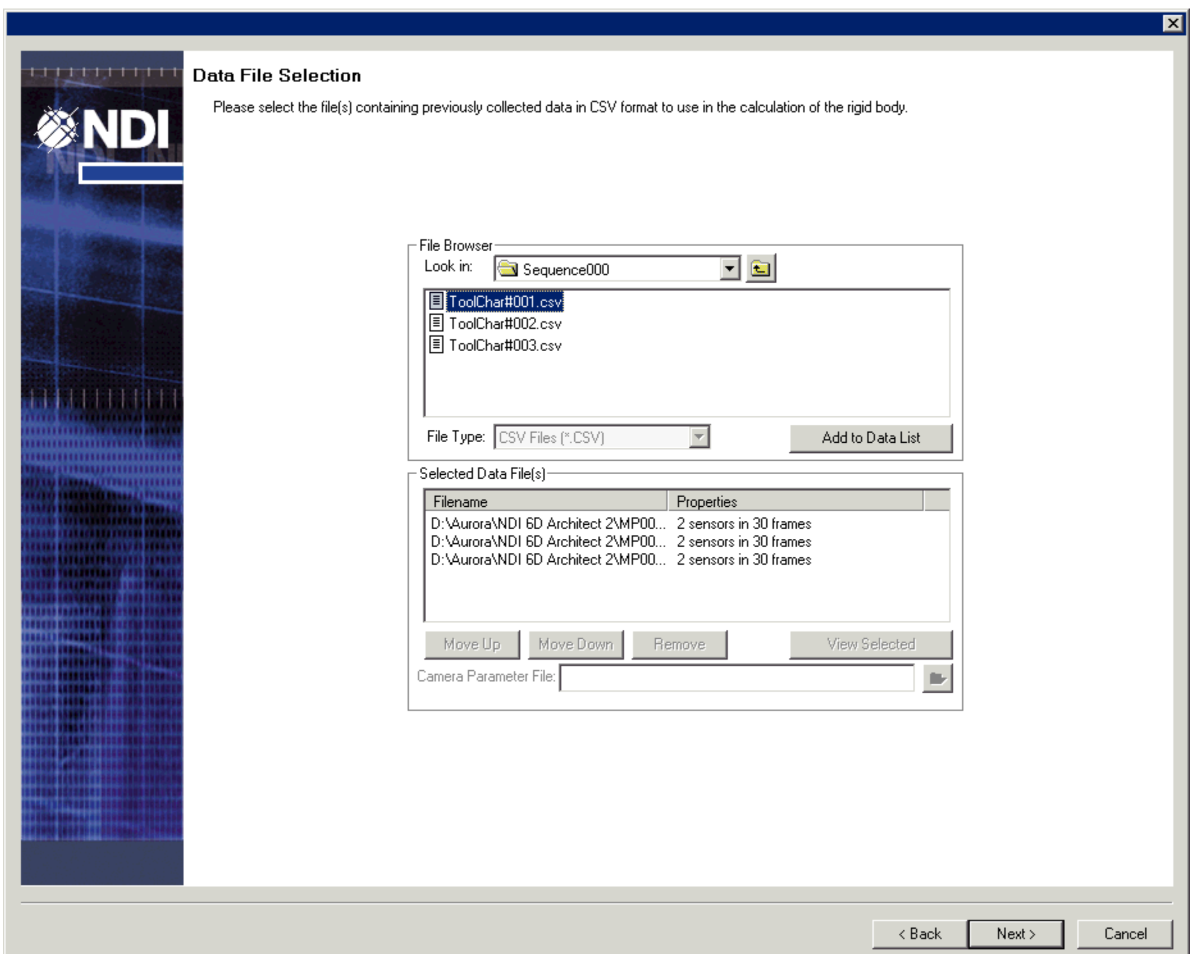


Figure 20-6 Data File Selection

1. Using the **File Browser** window, browse to and open the file containing the required data collection trials.
2. Click **Add to Data List** to move the contents of the file to the **Selected Data File(s)** list.
3. (Optional) In the **Selected Data File(s)** list, click **Remove** to delete any data trials from consideration.
4. Click **Next** once you are satisfied with the files selected.

2. Set the build parameters

Now that you have selected tool data, you need to specify how this data will be processed, to produce the rigid body definition.

Note These parameters are used to create the rigid body definition, and are not used when tracking a tool in an actual application. These settings are not stored anywhere in the tool definition file.

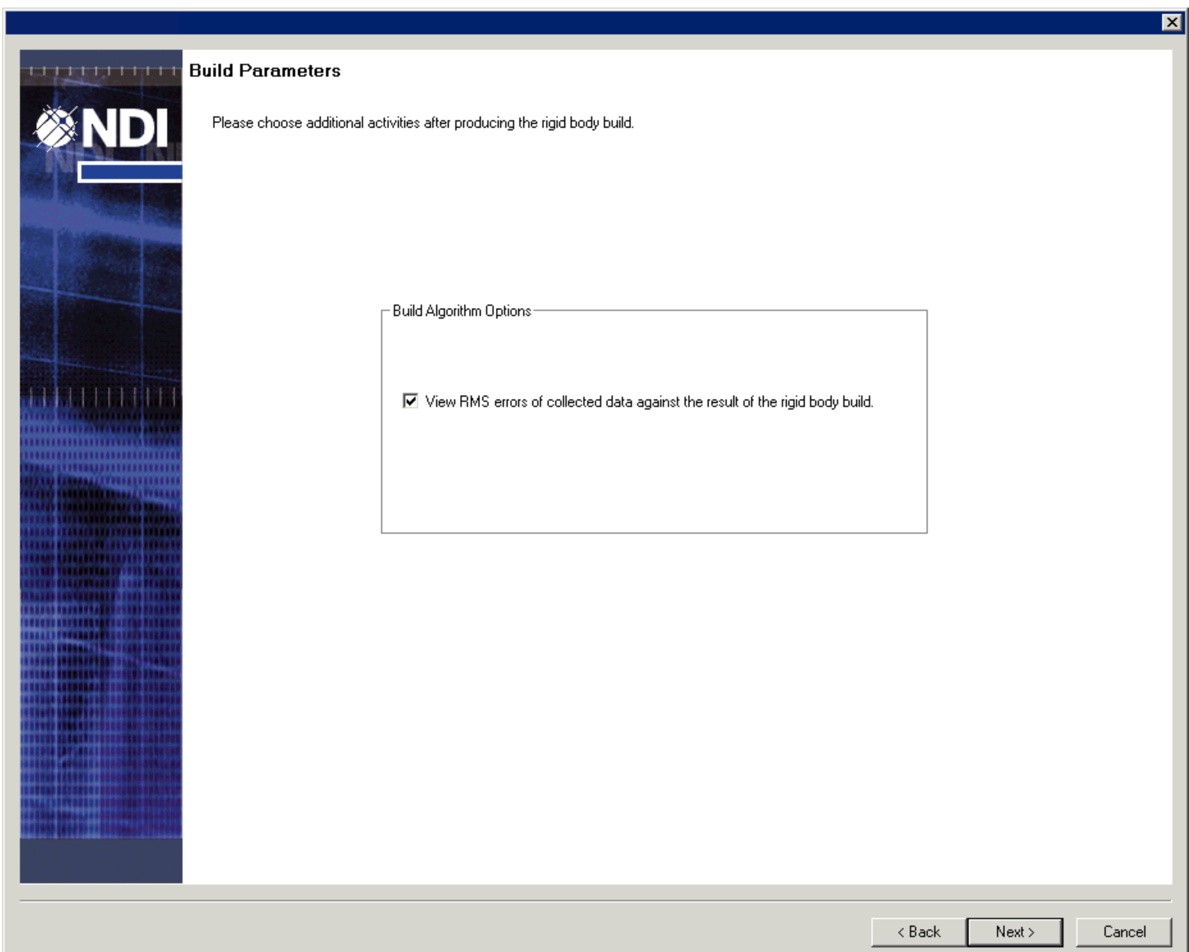


Figure 20-7 Build Parameters

1. If you want to see the results of the build in greater detail once it is complete, enable **View RMS errors of collected data against the result of the rigid body build.**

2. Click **Next**.

3. Perform the rigid body build

Now that you have finished adjusting the build parameters, the characterization wizard initiates a build and displays a window showing the time, iteration number, and status:

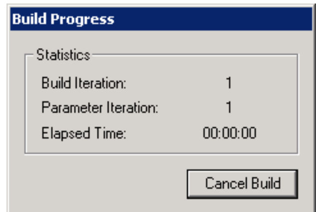


Figure 20-8 Build Progress

20.3 Producing a Rigid Body Definition With Engineering Data

You can skip the build process altogether if you enter the contents of the final rigid body definition using the tool's engineering data:

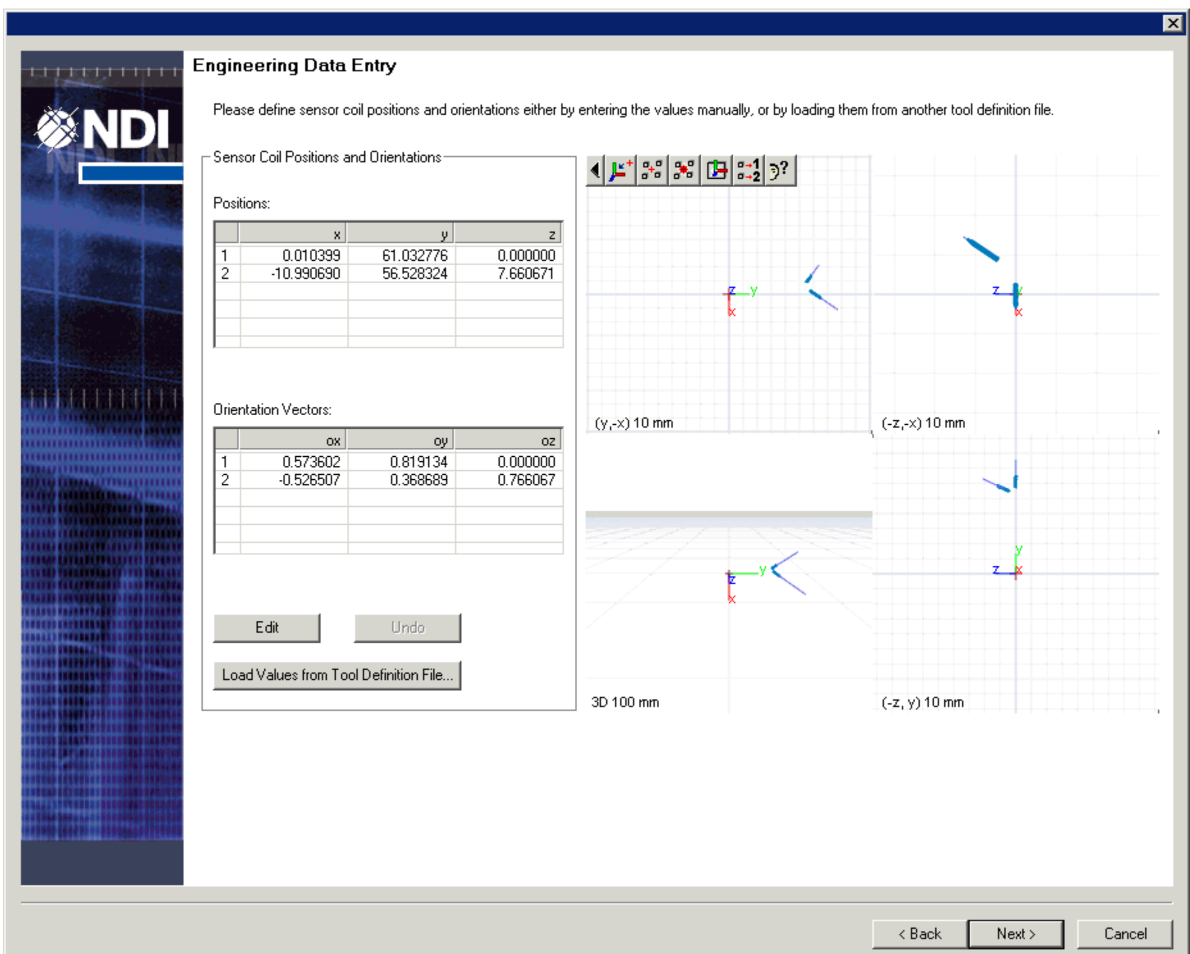


Figure 20-9 Engineering Data Entry

1. Select an individual sensor coil in the list, and click **Edit** to enter its position and/or orientation vector values, respectively.

Note A sensor coil's three orientation coordinates combine to create a vector running the length of the sensor coil, indicating the direction that it is pointing. This information is reported in real-time and can help you place the tool correctly in the measurement volume.

2. (Optional) Click **Load Values from Tool Definition File** and select the desired tool definition file from its home directory. The software will read its stored information and enter sensor coil values into the Sensor Coil list.
3. Click **Next**.

21 Step Four: Align the Local Coordinate System

The next step in the characterization process is to ensure that the tool's local coordinate system is correctly aligned. You can perform this step by allowing the software to calculate coordinates based on specific constraints. You can also simply enter the coordinate values manually.

The characterization wizard also provides you with a graphic representation of each axis and origin value that you enter, to help you review your adjustments.

Note For more information about local coordinate systems and where best to align them, refer to the "***Aurora Tool Design Guide***".

21.1 Aligning a Local Coordinate System Using Alignment Constraints

You can set specific constraints and then ask the software to calculate a local coordinate system that best fits these requirements.

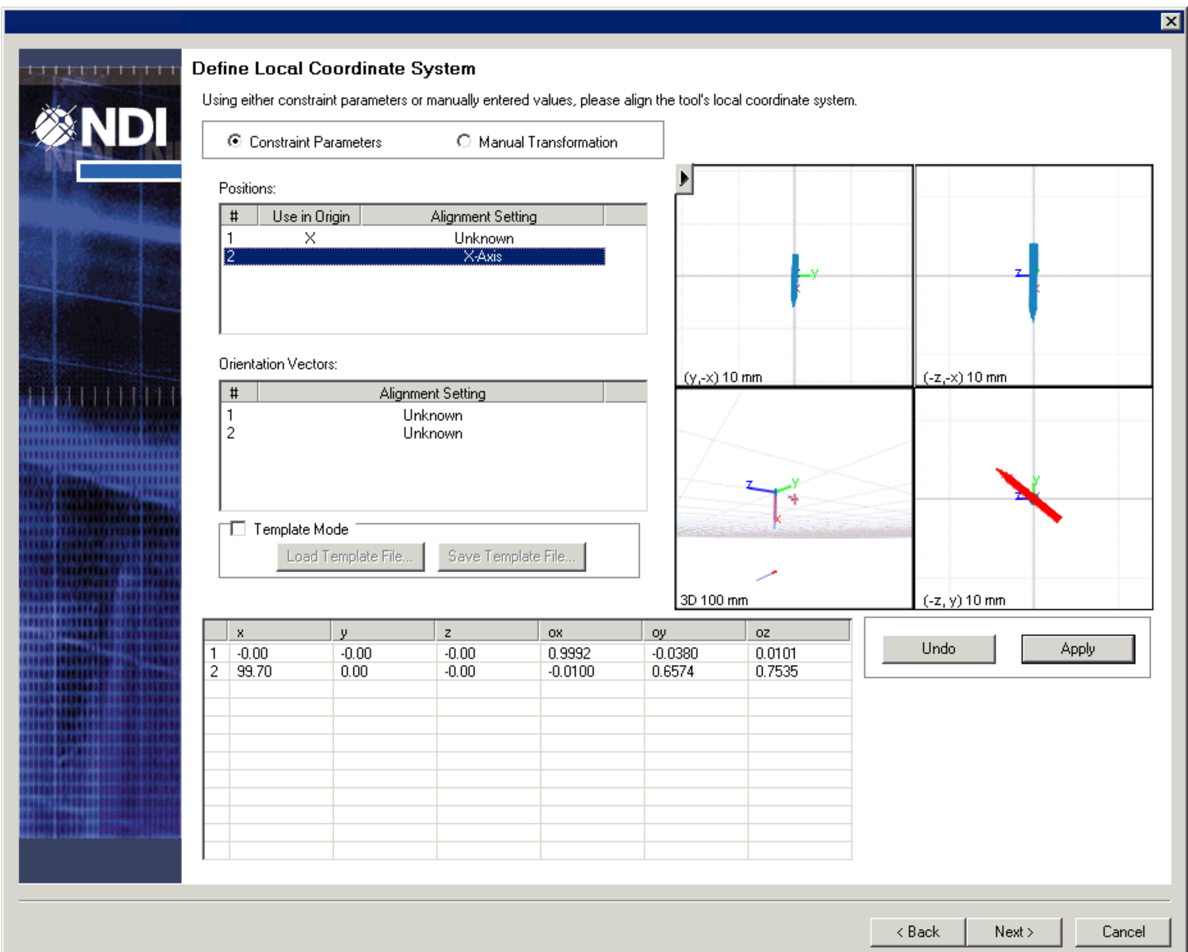


Figure 21-1 Defining a Local Coordinate System Using Constraints

1. Select **Constraint Parameters**.

2. In the Positions table:
   - If you wish to assign a sensor coil as the origin of the local coordinate system, double-click that sensor coil's entry in the **Use In Origin** column. If you select more than one sensor coil as the origin of your tool, the software will place the origin at the geometric centre the sensor coil(s).
   - Right-click a sensor coil's entry under **Alignment Setting**. Use the list that appears to constrain any positive or negative x, y, or z-axis to be on the sensor coil.
   - Right-click a sensor coil's entry under **Alignment Setting**. Use the list that appears to constrain any quadrant of any plane to the sensor coil.
3. In the Orientation Vectors table:
   - Right-click a sensor coil's entry under **Alignment Setting**. Use the list that appears to constrain the sensor coil's orientation to be on any positive or negative x, y, or z-axis.
   - Right-click that sensor coil's entry under **Alignment Setting**. Use the list that appears to constrain the sensor coil's orientation to any quadrant of any plane.
4. Click **Apply** to calculate a local coordinate system that best matches the parameters that you have set. The system will display this coordinate system in the Viewer Panes, and update the coordinates of each sensor coil in the table at the bottom of the dialog.
5. (Optional) If you want to either save these alignment settings to a template or open an existing alignment template and apply it to your tool, enable **Template Mode** and use the **Save Template File** and the **Load Template File** buttons, respectively.

Note Notice that when you enable Template Mode, more specific values are represented in the Positions and Orientations tables. These allow you to specify constraints to a greater degree.

6. Repeat this procedure to adjust your entries as required.
7. Click **Next**.

21.2 Aligning a Local Coordinate System Manually

Instead of assigning constraints and then allowing the software to calculate a local coordinate system, you can directly enter the coordinates yourself.

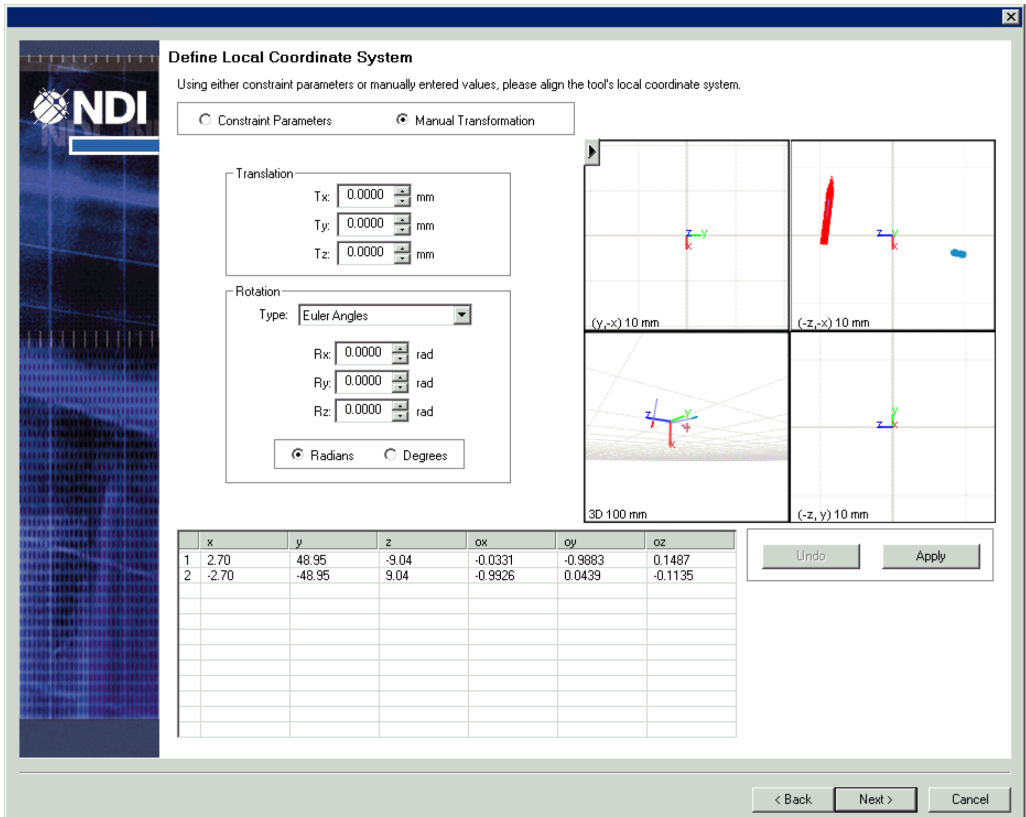


Figure 21-2 Defining a Local Coordinate System Manually

1. Click **Manual Transformation**.
2. In the **Translation** section, use the coordinate fields provided to translate the origin of the local coordinate system.
3. In the **Rotation** section, use the fields provided to rotate the local coordinate system.

Note Use the Type drop-down list to select the format of the rotation values. The Rotation Matrix and Quaternion selections are advanced options. The easiest and most intuitive way to rotate coordinate systems is to use Euler Angles.

4. Click **Apply** to display the local coordinate system that you have described in the graphic window. The software will also update each sensor coil coordinate in the window at the bottom of the dialog, to reflect the new local coordinate system.
5. Repeat this procedure to adjust your entries as required.
6. Click **Next**.

22 Step Five: Complete the Characterization

Before you can complete the characterization process, the wizard offers you several selections for final tasks. If nothing is selected, the wizard closes and the software populates the main window with the tool definition file that you have created.

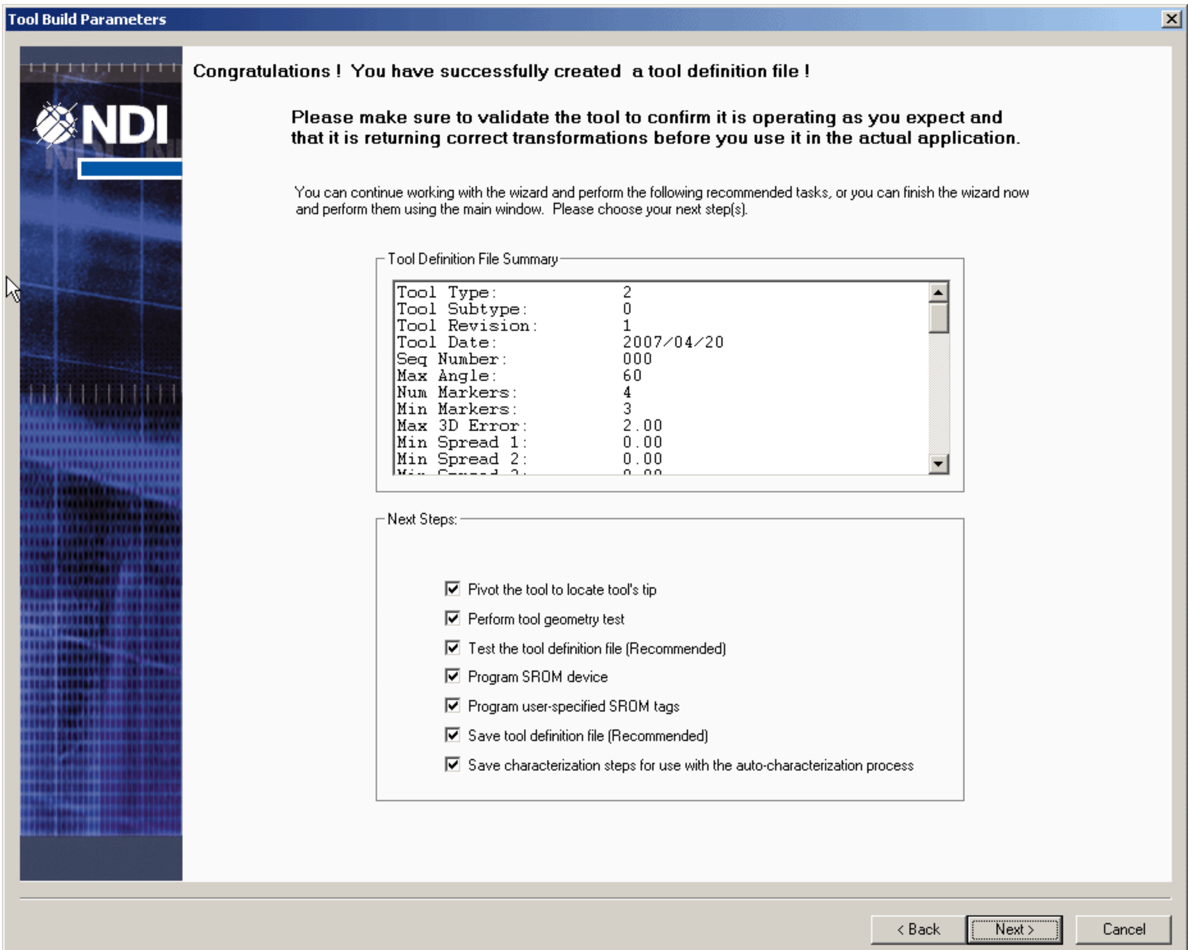


Figure 22-1 Complete Characterization

1. Review the **Tool Definition Summary** table to make sure that all the tool definition file data that you have just created is as you expect. If there are any obvious errors or omissions, simply use the **Back** button to return to the appropriate characterization wizard step and edit its contents.
2. From the **Next Steps** list, select the additional tasks that you wish to perform. NDI 6D Architect will tailor any further characterization wizard screens to match these selections.

Table 22-1 Next Steps

Option	Description
Pivot the tool to locate tool’s tip	Perform a pivot to calculate tool tip offset. For instructions, see "Using the Pivot Wizard" on page 108.
Test the tool definition file (Recommended)	**NDI recommends that you perform this task. It is selected by default.** Test the tool definition file against the actual tool to ensure that you have performed the characterization properly. For instructions, see "Testing the Tool Definition File" on page 100.
Program SROM Device	Program the tool definition file onto the SROM device, so that the tool can carry its own information. For instructions, see "Programming the SROM Device" on page 103.
Program user-specified SROM tags	Append additional tags of information to the tool definition file. For instructions, see "Programming User-Specified Tags" on page 102.
Save tool definition file (Recommended)	**NDI recommends that you perform this task. It is selected by default.** Use the save dialog provided to save your tool definition file to a directory.
Save characterization steps for use with the auto-characterization process	For more information about this selection, see "Auto-Characterization" on page 105.

3. Click **Next**.

22.1 Testing the Tool Definition File

Note NDI recommends that you perform this task; it is selected by default.

Test the tool definition file by using it to track its associated tool in the measurement volume. You can review the results in real-time using the Tool Definition Test dialog, to help you evaluate the accuracy of the tool definition file.

1. Before you can test the tool definition file, you must indicate which tool to track. The following dialog appears:

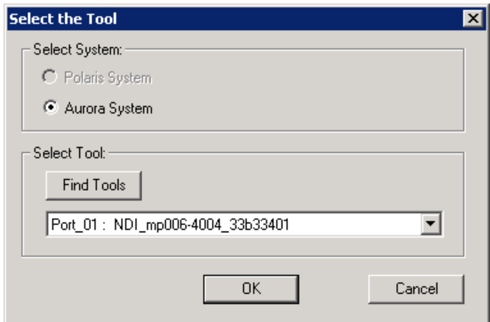


Figure 22-2 Select the Tool Dialog

2. Select **Aurora System**.
3. Click **Find Tools** to automatically populate the drop-down list with all tools connected to the system.
4. Select the tool that is associated with your tool definition file.
5. Click **OK**. The Tool Definition Test Page appears:

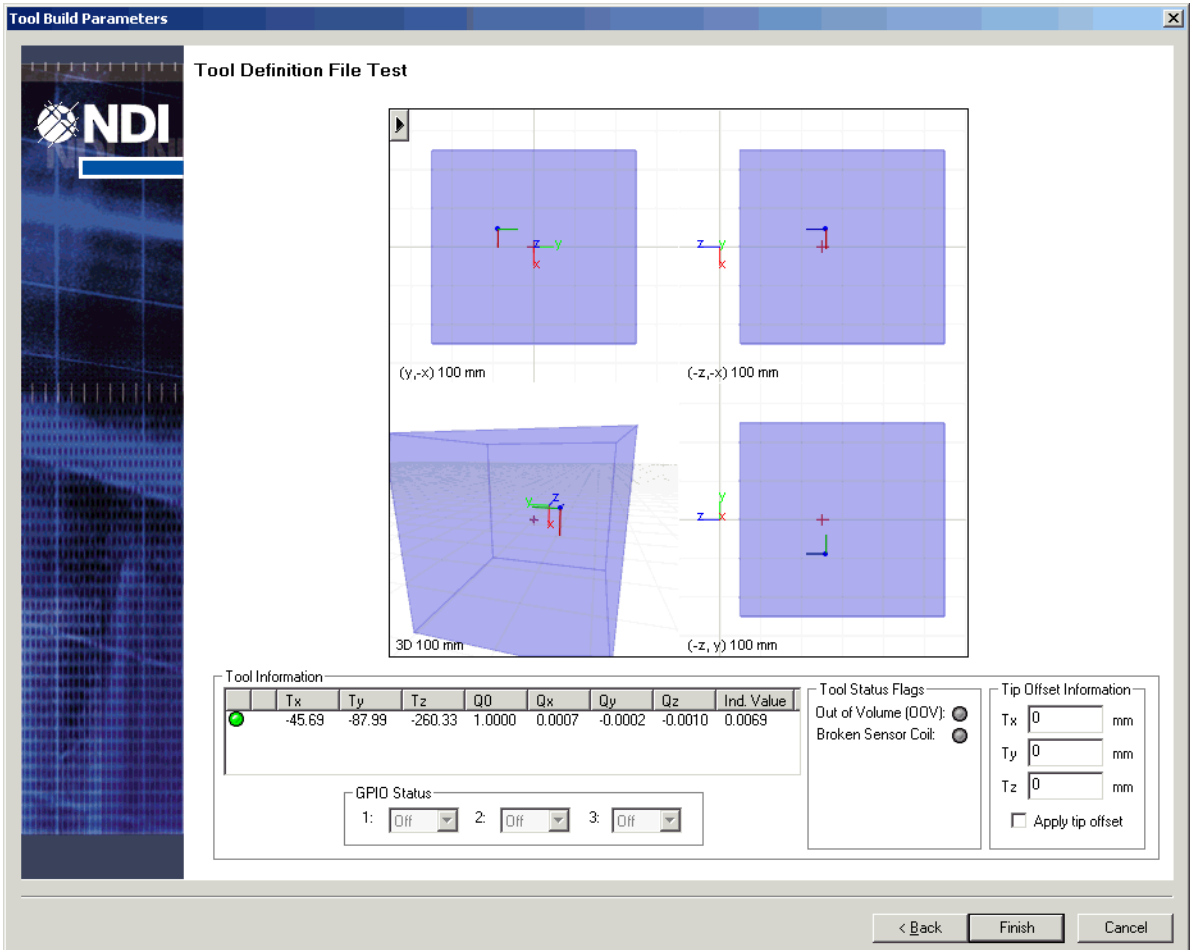


Figure 22-3 Tool Definition File Test

6. Position the tool in the measurement volume. The system tracks the tool using the tool definition file, and NDI 6D Architect populates the dialog fields with the resulting information:

Table 22-2 Tool Definition Test Results

Section	Description
Tool Information	This table displays the transformations and indicator values
Tool Status Flags	This section displays whether or not the tool passes out of volume and whether or not a sensor coil is broken.
GPIO Status	If the GPIO is an input, the status is shown as an “LED”. If it is an output, it is configurable via the drop-down list. Notice that only the GPIOs recorded in the tool definition file are enabled
Tip Offset Information	Use this section to test tip offset vectors. Manually enter offset values in the coordinate fields provided, then enable **Apply Tip Offset**. You can prepare a set of values to test by first pivoting the tool. For more information about pivoting, see "Using the Pivot Wizard" on page 108.

7. Click **Next**.

22.2 Programming User-Specified Tags

You can append additional tags to a tool's definition file, to further identify the parameters of your tool.

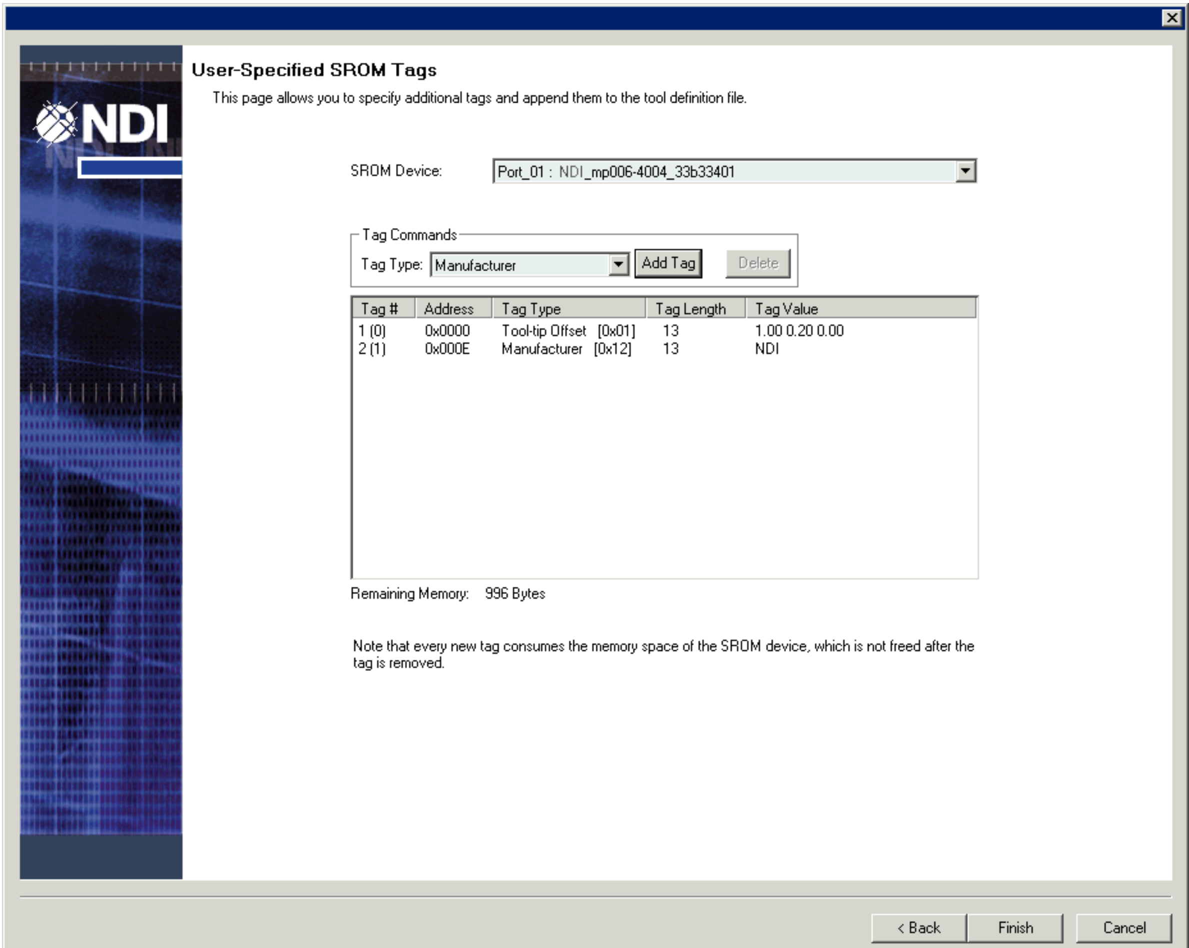


Figure 22-4 User-Specified SROM Tags

The User-specified SROM Tags page provides the following details about each SROM tag:

Table 22-3 SROM Tag Information

Column	Description
Tag #	The first number lists the currently existing tags. The bracketed number is a zero-based index of all tags on the SROM device (including any previously deleted tags).
Address	The tag address in memory
Tag Type	The tag description with corresponding tag identification
Tag Length	The tag length in bytes
Tag Value	The tag contents

Note If pre-existing tags exist with your tool definition file, that information will appear in the table.

1. Choose a **Tag Type** from the drop-down list provided:

Table 22-4 Tag Types

Tag Type	Description
Tool-tip Offset	If your tool has an end-tip, this tag stores its location using x, y, and z coordinates.
Trajectory	This tag sets the tool's trajectory, and consists of quaternion coordinates. **Note: Make sure that quaternions are normalized. Failure to do so may result in the unwanted scaling of tool transformations.**
Tool Type	This tag assigns a tool type number to the tool, with a maximum value of 65,535.
Manufacturer	This tag assigns a manufacturing name to the tool, with a maximum of 12 characters.
Binary Data	This tag allows you to store user-defined binary data on the tool's SROM device.
Icon	This tag allows you to store an icon on the tool's SROM device.

2. Click **Add Tag**. A brief dialog will appear with the appropriate data fields for the tag type you selected.
3. Complete these fields and click **OK**.
4. (Optional) To remove a tag, select it from the list and click **Delete**.
5. When you have finished adding and editing the SROM tags, click **OK**.
6. Click **Finish**. NDI 6D Architect will ask you if you wish to add these tags to the SROM device. Click **OK**.

22.3 Programming the SROM Device

Use the characterization wizard to program the tool definition file onto the SROM device, so that the tool can carry its own information. Whenever the tool connects to an Aurora system, the tool definition file is automatically retrieved from the SROM device for interpretation.

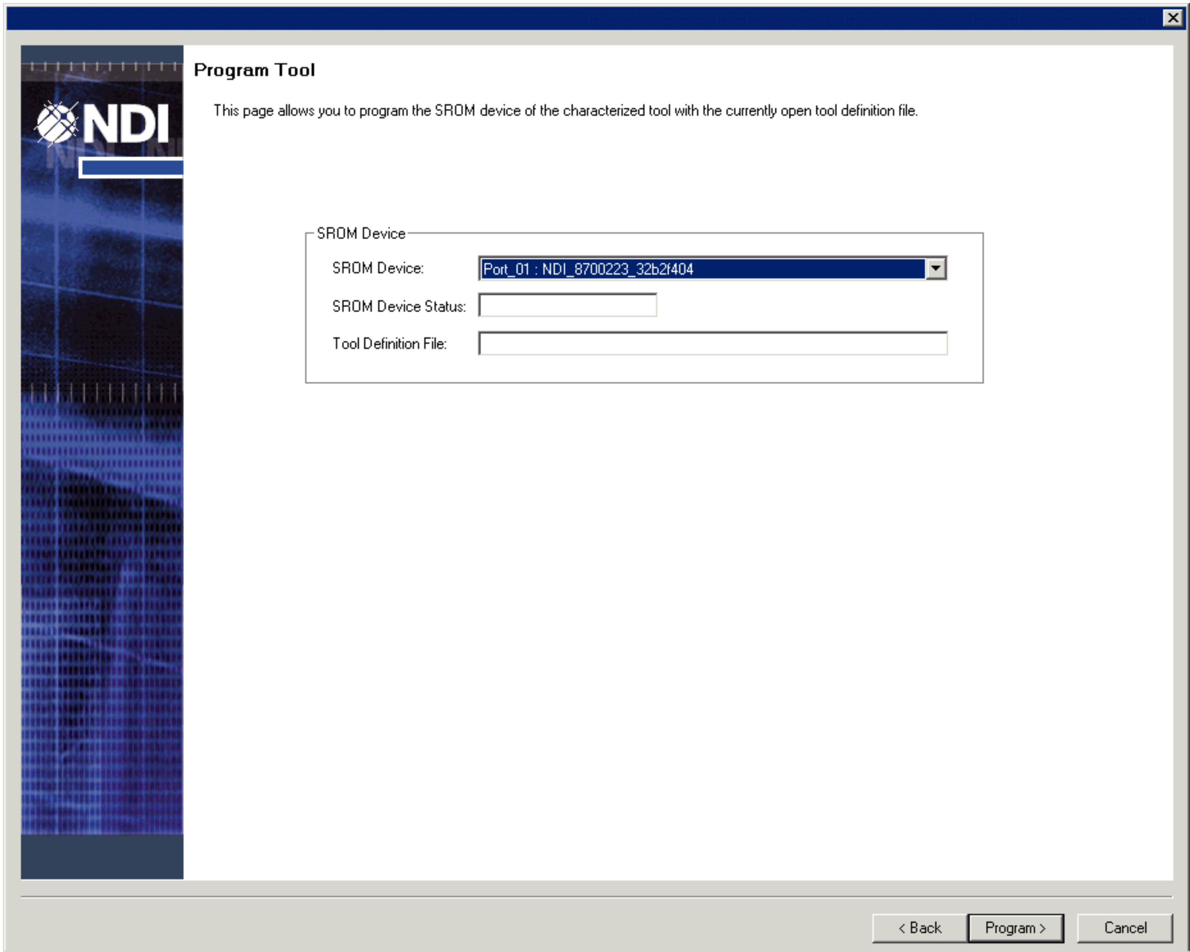


Figure 22-5 Program Tool

Warning!

Do not program the tool or use it in an actual application until you have tested its tool definition file and verified that, when applied to the tool, it returns appropriate data. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.

Warning!

Do not program a tool that has been dropped or damaged in any way during the characterization process, as the relative positions of its sensor coils may have changed, and are no longer accurately described by the tool definition file. You must perform another characterization using newly collected data. Programming a damaged tool without recollecting tool data will produce an incorrectly characterized tool, inaccurate transformations, and possible personal injury.

Warning!

Do not program a tool until you have verified that you are applying the correct, corresponding tool definition file. If the tool definition file does not match the tool the tool may still be tracked but will report incorrect data. This will produce inaccurate transformations and possible personal injury.

Warning!

Do not program a tool without first testing its tool definition file and reviewing its user-specified tags to ensure that the tool is properly characterized, and that its SROM device is not corrupted in any way. Failure to do so may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions may increase the possibility of personal injury.

Warning!

Make sure that markers are correctly identified in the tool definition file. Transformations for tools that are tracked using incorrect camera parameters will contain systematic errors and indicate incorrect positions for the tool. Incorrect tool positions may result in harm to a patient.

1. Ensure that the tool is connected to the Aurora System.
2. From the drop-down list provided, select the tool's **SROM Device**. This list is automatically populated by the software and read from all tools currently connected to the system.

Note

The SROM Device Status field will tell you if the SROM device you have selected has already been programmed with previous information.

3. (Optional) If the current tool definition file is not the file you wish to program onto the SROM device, enter the correct **Tool Definition File** location.
4. Click **Next** to write the tool definition file to the tool's SROM device. The Programming Tool dialog opens asking if you are sure you want to program the tool in the selected port.

Warning!

Do not interrupt the programming of an SROM device once it has started. A partially programmed SROM device will produce inaccurate transformations and possible personal injury.

5. Click **OK**.
   - If your tool already contains a tool definition file, a warning dialog appears stating that your tool is already programmed and that continuing the action may corrupt the tool. If you wish to continue programming the SROM, click **Yes**. If not, click **No**.
   - If your tool does not contain a tool definition file, a dialog appears stating that programming the SROM device was successful.

22.4 Auto-Characterization

NDI 6D Architect supports *auto-characterization*. Auto-characterization files contain all of a tool's characterization settings — the only task you need to perform is to collect the tool's data. Auto-characterization is particularly useful where multiple tools of the same design are being characterized.

Creating an Auto-Characterization File

After you have characterized a tool, the final characterization wizard screen offers you the opportunity to save your settings before testing the tool definition file and programming the tool's

SROM device. By saving all your work, you are creating an auto-characterization file that can be used to characterize similar tools.

This step is offered as an option at the end of the characterization wizard. If you select this option, the wizard will provide you with a dialog to select a location and assign a name for the saved file:

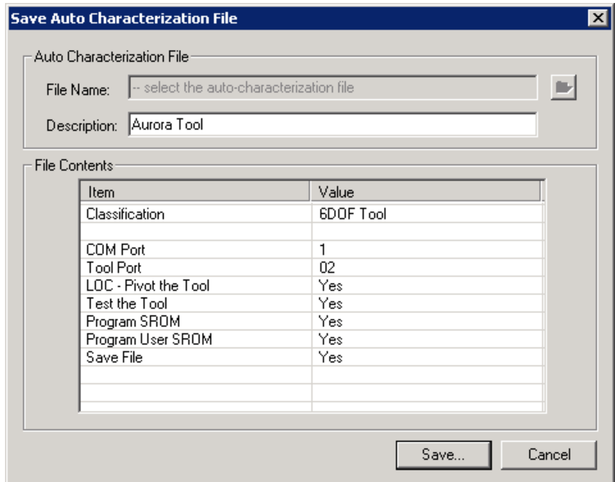


Figure 22-6   Save Auto-Characterization File Dialog

Using an Auto-Characterization File

1. From the main window, select **Build** > **Run Auto-characterization File**. The following dialog appears:

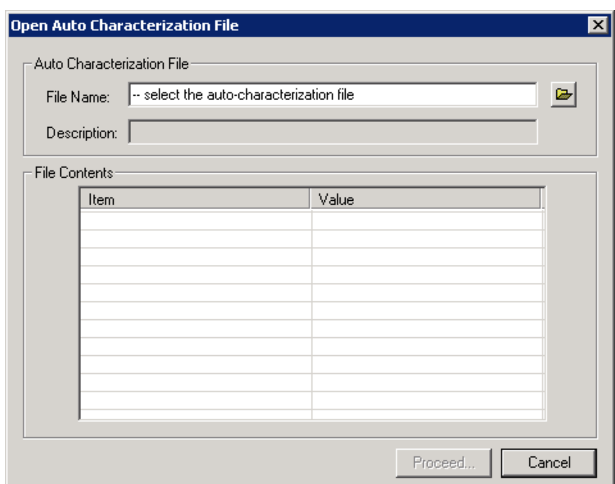


Figure 22-7   Auto-characterization File Dialog

2. Browse and select the **File Name**, indicating which auto-characterization file (with all its pre-programmed wizard settings) you wish to use. The software loads the selected auto-characterization file into the File Contents window, for you to review:

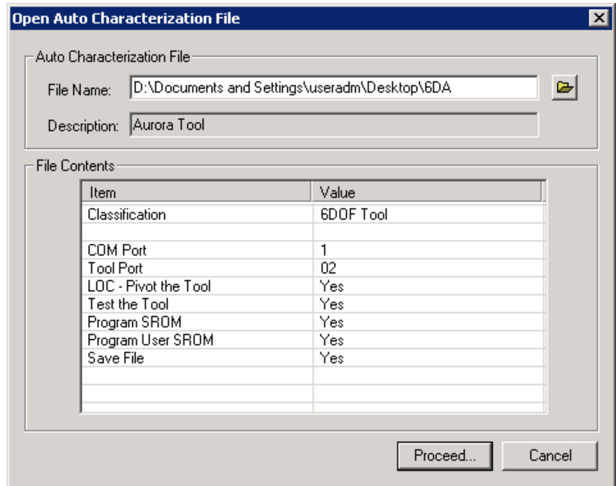


Figure 22-8 File Content Window with Values Displayed

3. Some of the entries in the File Content window can been altered for this particular run. Notice the one blank line amongst the entries: any entry listed below this line can be edited by simply clicking on the value and manually entering a new one.

Note Any changes you make are not permanently saved to the auto-characterization file; they are applied to this run only, and will be lost once you finish the process.

4. Click **Proceed**. The following dialog appears, to confirm the serial number for the first tool in the characterization run:

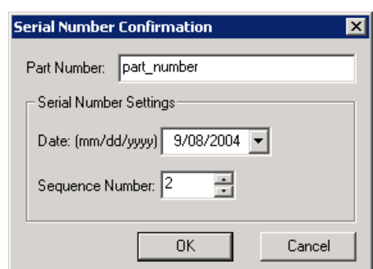


Figure 22-9 Serial Number Confirmation

5. Increase the **Sequence Number** by a set value (for example, an increment of 1), to ensure that the tool is labelled with a unique identifier.

6. Click **OK**. The system will run through the characterization procedure defined in the auto-characterization file, stopping at specified points for any user input required (such as data collection, user-specific SROM tag entries, or programming the SROM device).

23 Using the Pivot Wizard

Warning! Do not perform a pivot until you have read and understood how best to complete a pivot procedure. Refer to the "Aurora Tool Design Guide" for detailed instructions and guidance. Failure to perform a pivot correctly may lead to an incorrectly defined tool tip offset, which may lead to inaccurate conclusions. If your application involves personal safety, inaccurate conclusions increase the possibility of personal injury.

Use the pivot alignment wizard to calculate the location of a tool's end-tip. You can use this information to do the following:

- for 6DOF tool, use the vector to transform a local coordinate system so that its origin is located at the end-tip
- permanently program the vector as a user-specified tag in a tool's SROM device
- use the vector to test a tool definition file

NDI does not recommend permanently transforming a tool's local coordinate system to its end-tip if your tool design is such that the location of the end-tip can be altered as a result of damage (such as a probe bending as a result of being dropped).

It is better to calculate the offset vector (such as performing a pivot procedure) and re-align a local coordinate system as a part of your application procedure, every time you are about to track the tool. Contact NDI for more information about incorporating this step into your application.

23.1 Adjusting Pivot Parameters

Note You cannot adjust pivot parameters during the characterization process. Perform this step before characterizing a tool if you plan on selecting "Pivot the tool to locate tool's tip" in the last screen of the characterization wizard.

Pivot wizard results are created by applying specific parameters to collected pivot data. Set these parameters from the main window:

1. From the main menu, select **Local Coordinate System** > **Pivot the Tool**. The pivot alignment wizard opens.
2. Click **Pivot Parameters**. The following dialog appears:

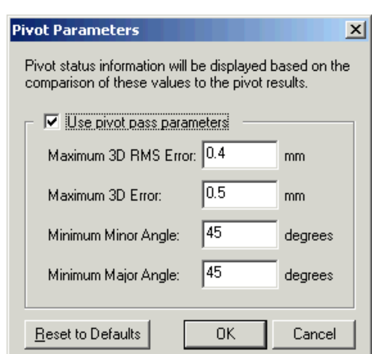


Figure 23-1 Pivot Parameters Dialog

3. Adjust the values in this dialog using the following table as a guide:

Table 23-1 Pivot Parameters

Pivot Parameter	Description
Maximum 3D RMS Error	This field defines the acceptable threshold for 3D RMS Error values produced by a pivot. The 3D RMS Error is produced by applying the result of the pivot procedure to each frame of the pivot procedure, and calculating an overall RMS error for the collection.
Maximum 3D Error	This field defines the acceptable threshold for 3D error values produced by a pivot. The 3D Error is produced by applying the result of the pivot procedure to each frame of the pivot procedure, and calculating an error for that frame.
Minimum Major Angle	This field defines the acceptable threshold for a major angle produced during a pivot. The major angle is the greatest angle the tool was moved during the pivot procedure.
Minimum Minor Angle	This field defines the acceptable threshold for a minor angle produced during a pivot. The minor angle is defined as being orthogonal to the plane of the major angle.

4. Enable **Use pivot pass parameters** to apply your adjustments to the pass/fail pivot thresholds.
5. Click **OK**.

23.2 Completing Pivot Setup

Note: If you are using the pivot alignment wizard directly from the characterization wizard, you do not need to perform this step. All settings in this dialog are adjusted throughout the characterization process. Go directly to "Collecting Pivot Data" on page 111.

1. From the main menu, select **Local Coordinate System > Pivot the Tool**. The pivot alignment wizard opens:

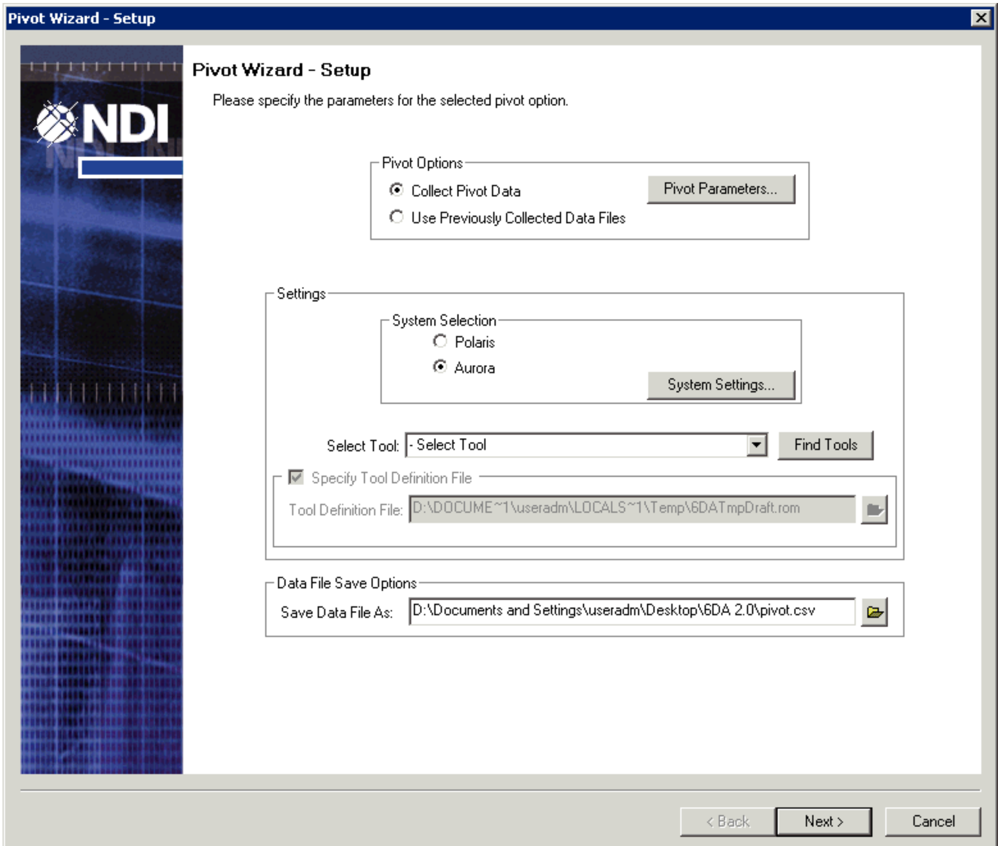


Figure 23-2 Pivot Wizard - Setup

2. From the **Pivot Options** provided, select **Collect Pivot Data**.

Note: As an alternative to collecting pivot data, you can load previously collected pivot data from a saved file. Select Use Previously Collected Data Files, and a dialog will open that allows you to search for and select the desired file. The pivot alignment wizard will load its information directly into the Pivot Wizard - Results dialog.

---

3. (Optional) Click **Adjust Pivot Parameters** and make any necessary changes. For instructions, see "Adjusting Pivot Parameters" on page 108.
4. Select **Aurora System**. You can also adjust your **System Settings**, should you choose. For instructions on how to change these settings, see "Adjust Aurora Communication Settings" on page 79.
5. Select your tool from the automatically-populated **Select Tool** drop-down list. You can also open a tool definition file in the **Specify Tool Definition File** section, if your tool does not have a tool definition file already loaded onto its SROM device.
6. In the S**ave Data File As** field, indicate a folder and location for saving the pivot data that you will be collecting.
7. Click **Next**. The Pivot Wizard - Collection dialog appears.

23.3 Collecting Pivot Data

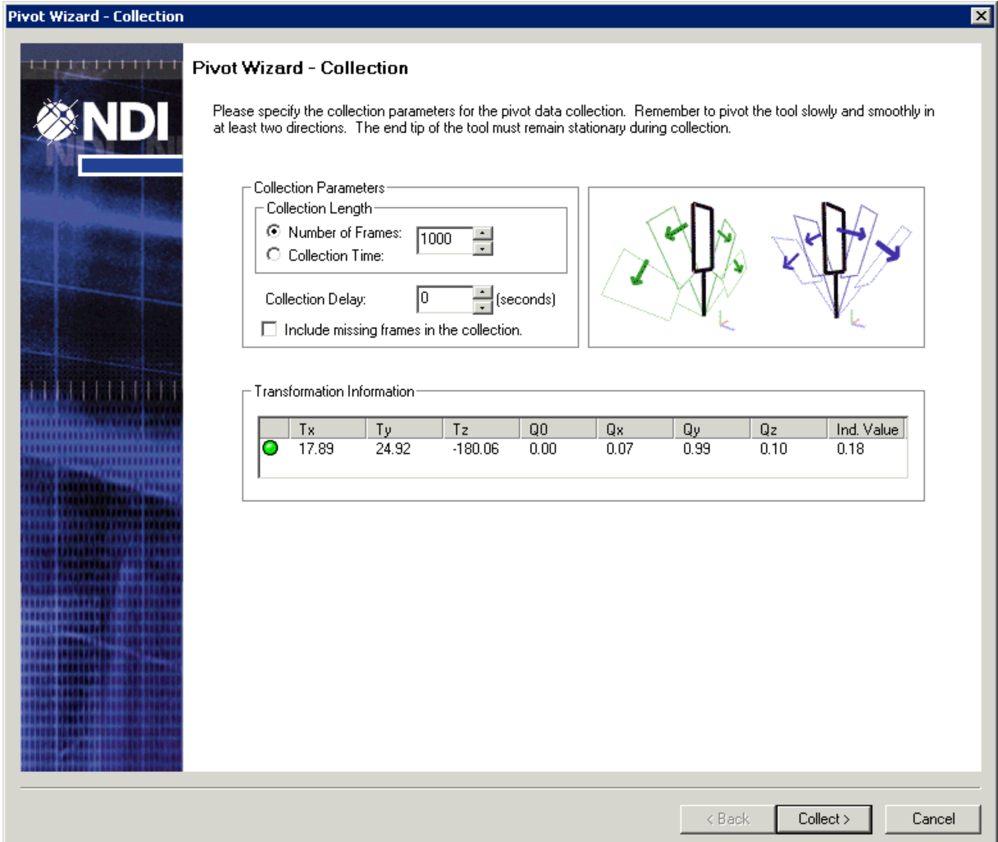


Figure 23-3 Pivot Wizard - Collection

1. Set the **Collection Length** in either frames or seconds.

   If you set the collection length by indicating a number of frames, you can enable an option called “Include missing frames in the collection”. The system will disregard any frames containing missing data if this option is enabled.

2. (Optional) Set a **Collection Delay** if you want the system to pause for several seconds before collecting a trial.

3. Position your tool in the measurement volume with its tool-tip placed on a fixed point (such as a divot in a pivot block). Ensure that the sensor coil(s) are visible and that the tracking light is green.

4. Click **Collect** to begin the data collection trial.

5. As the measurement system collects the data, continuously pivot the tool back and forth and side to side, with its tool-tip remaining stationary at the fixed point. Ideally, the angles of your pivot movements should fall between 30° and 60°.

Note: It is very important that the tool-tip remains stationary while the tool is being pivoted. The design of the pivot block should take into account the shape of the tool’s end-tip. For more information about designing a pivot block, contact NDI.

6. Once the collection has finished, click **Next**. The Pivot Wizard - Results dialog opens, displaying the calculated results of the tool-tip data:

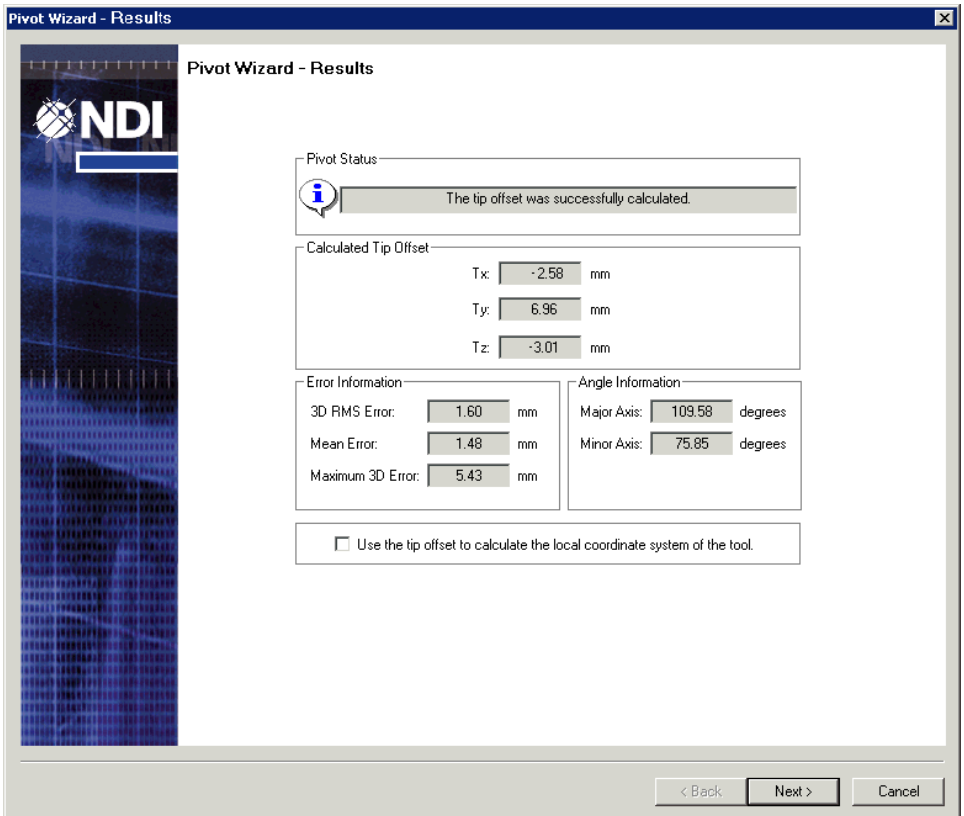


Figure 23-4 Pivot Wizard - Results

The Pivot Wizard Results dialog provides the following information:

Table 23-2 Pivot Results

Results	Description
Calculated Tip Offset	This section displays the Tx, Ty, and Tz position of the tool-tip, relative to the origin of the tool's local coordinate system.
Error Information	This section displays the 3D RMS, Mean, and Maximum 3D Errors of the collection, in millimetres.
Angle Information	This section displays the maximum and minimum angles of the pivot you performed. The maximum angle is the greatest angle created by your pivot movements; the minimum angle is defined as being orthogonal to the plane of the maximum angle.

7. (Optional) If you want to transform the origin of the tool's local coordinate system so that it is located at the tool-tip, enable **Use the tip offset to calculate the local coordinate system of the tool.**

8. Click **Finish**.

24 About .CSV files

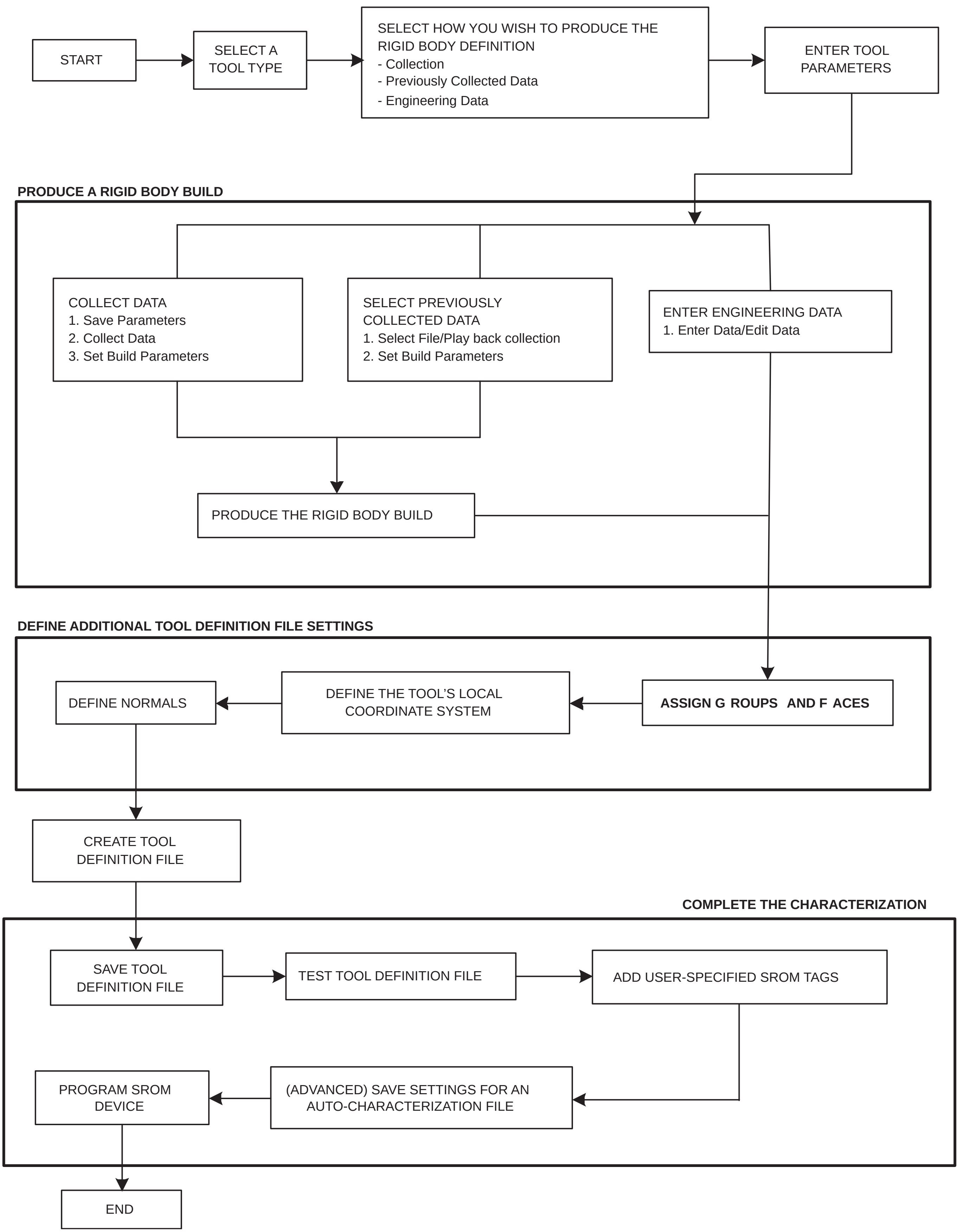
A .csv file is a text-based data file storing collected data. You can create a .csv file using NDI 6D Architect by performing a standard data collection and then saving the results using a .csv file extension. For more information on this, see "Producing a Rigid Body Definition With Collection" on page 86.

You can also manually write a .csv file, without using NDI 6D Architect, by entering tool data into a text file using the following formats:

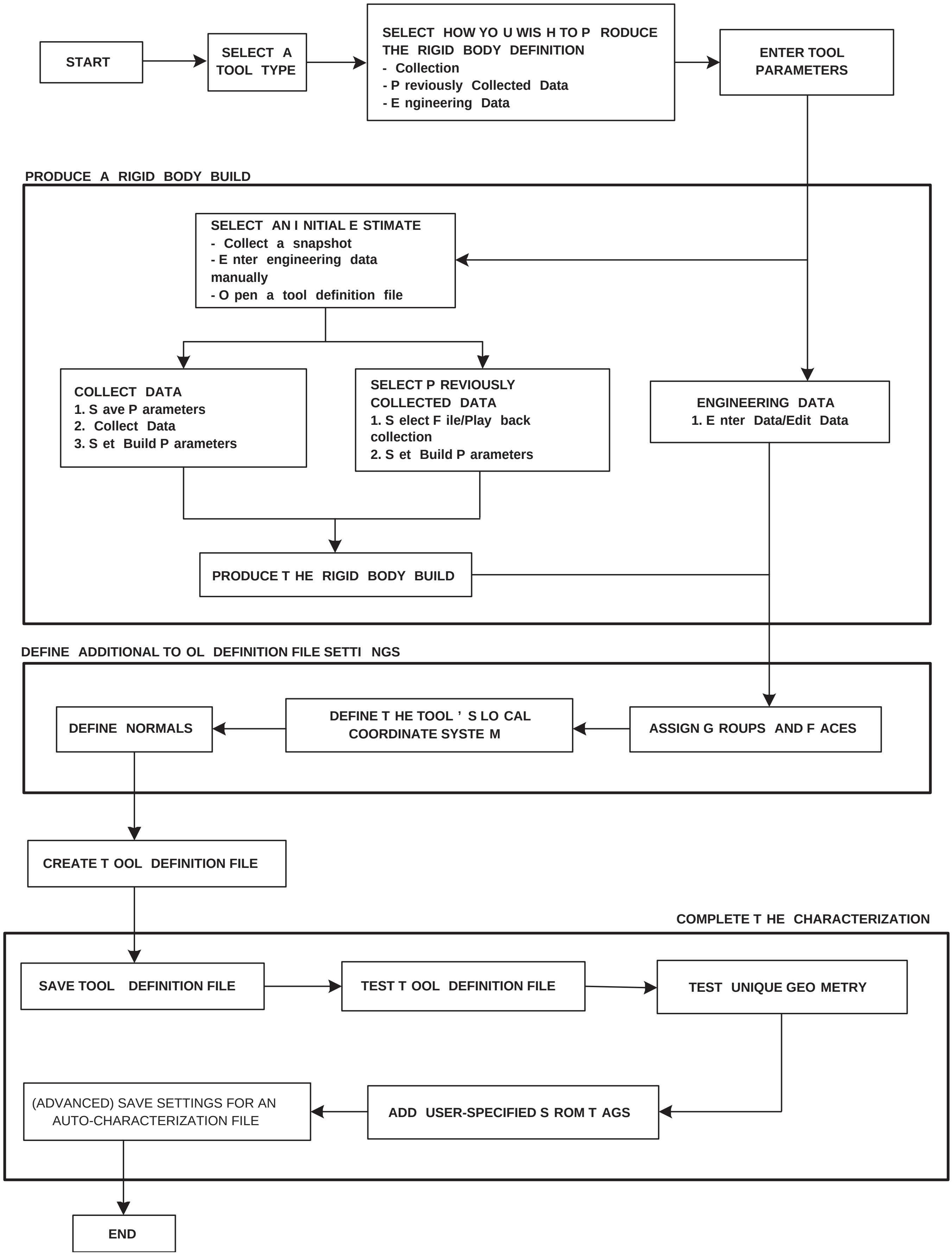
##													
# NDI 6D ARCHITECT COLLECTED COIL SENSOR DATA (CSV FORMAT)													
#													
# Collection Date (M/D/Y): 5/28/2004													
# Collection Sensor Coils: 2													
# Collection Frames: 200													
#													
# Part Number: dfa													
# Manufacturer: sdfa													
# Revision: 0													
# Date/Sequence Number: 2004-05-28-0000													
#													
##													
# x	y	z	Q0	Qx	Qy	Qz	x	y	z	Q0	Qx	Qy	Qz
##													
100.6	24.5	-337.1	0.8699	-0.3676	0.3287	0	-105.1	-31.8	-251.6	0.933	0.2748	-0.2321	0
68.2	33	-333	0.8514	-0.3529	0.3878	0	-104.2	-32.3	-250.9	0.9331	0.2769	-0.2293	0
62.2	37.4	-351.6	0.8484	-0.3311	0.4128	0	-101	-34.3	-246.4	0.9305	0.2968	-0.2143	0
101.5	23.9	-351.9	0.8668	-0.3567	0.3482	0	-100.5	-34	-245.8	0.9307	0.298	-0.212	0
73.1	35.2	-355.1	0.8538	-0.3258	0.4058	0	-99.8	-32.4	-245.4	0.9307	0.2975	-0.2127	0
72.7	35.5	-333.1	0.8565	-0.3224	0.4029	0	-100.2	-31.5	-245.5	0.9301	0.2988	-0.2135	0
78.8	37.3	-337.4	0.862	-0.3198	0.3931	0	-101.2	-31.9	-245.9	0.9301	0.3001	-0.2116	0
76.7	40.7	-336	0.8624	-0.3209	0.3913	0	-102.4	-32.3	-246.1	0.9295	0.302	-0.2113	0
76.1	41.8	-332.7	0.8626	-0.3198	0.3918	0	-102.4	-32.7	-246.2	0.9296	0.3013	-0.212	0
61.5	34.1	-327	0.847	-0.3387	0.4095	0	-102.5	-33.7	-246	0.9291	0.3035	-0.2111	0
63.5	35	-329.6	0.849	-0.3379	0.4061	0	-102.5	-34	-246.1	0.9292	0.3029	-0.2113	0
60.5	31.2	-331	0.8411	-0.3505	0.4118	0	-102.6	-34.2	-245.8	0.9291	0.3038	-0.2107	0
69.9	34	-342.6	0.8498	-0.336	0.4059	0	-102.9	-34.2	-245.7	0.9291	0.3043	-0.2101	0

Figure 24-1 Standard Format of an Aurora Tool’s .CSV File

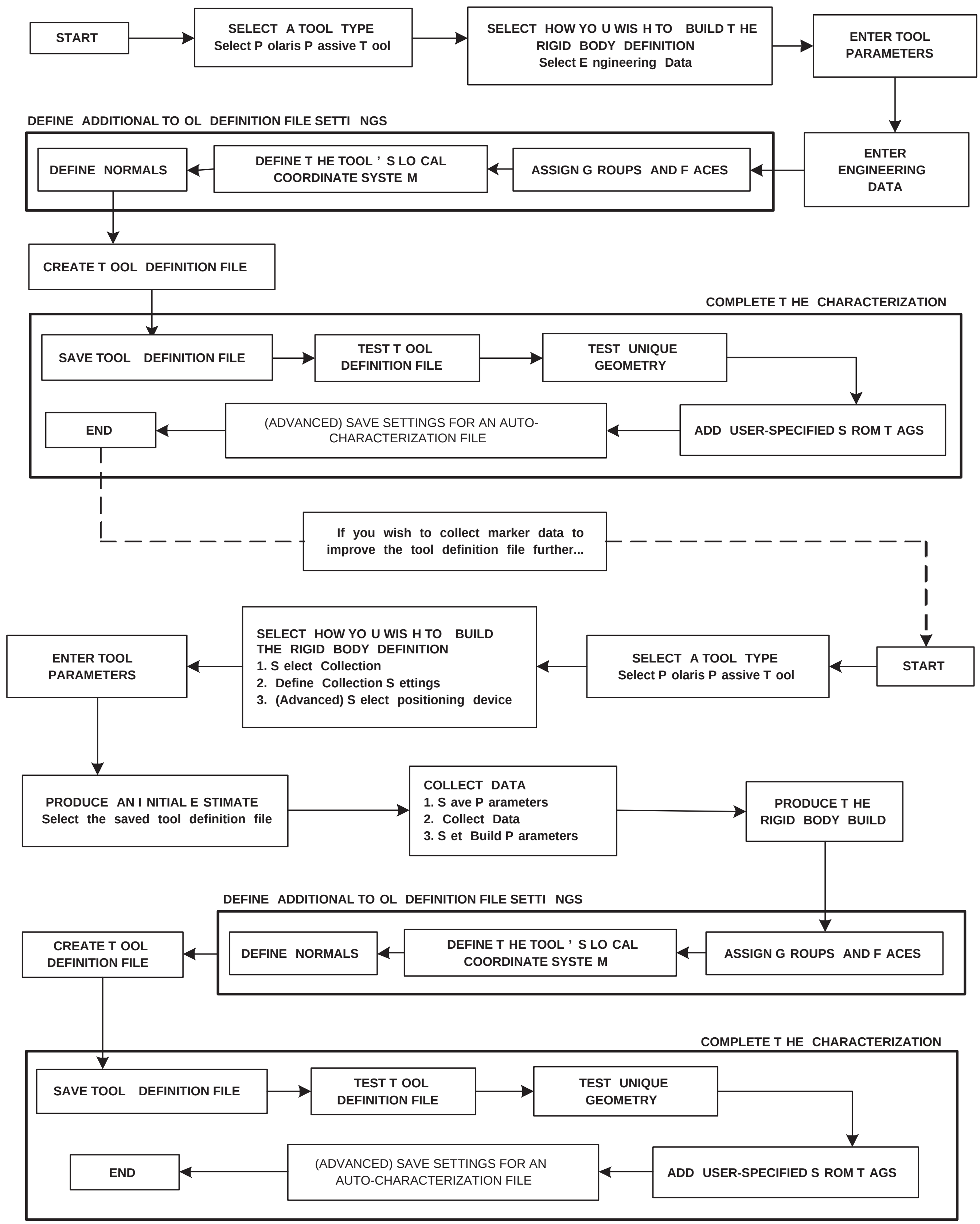
BASIC CHARACTERIZATION PROCEDURE: POLARIS ACTIVE TOOLS



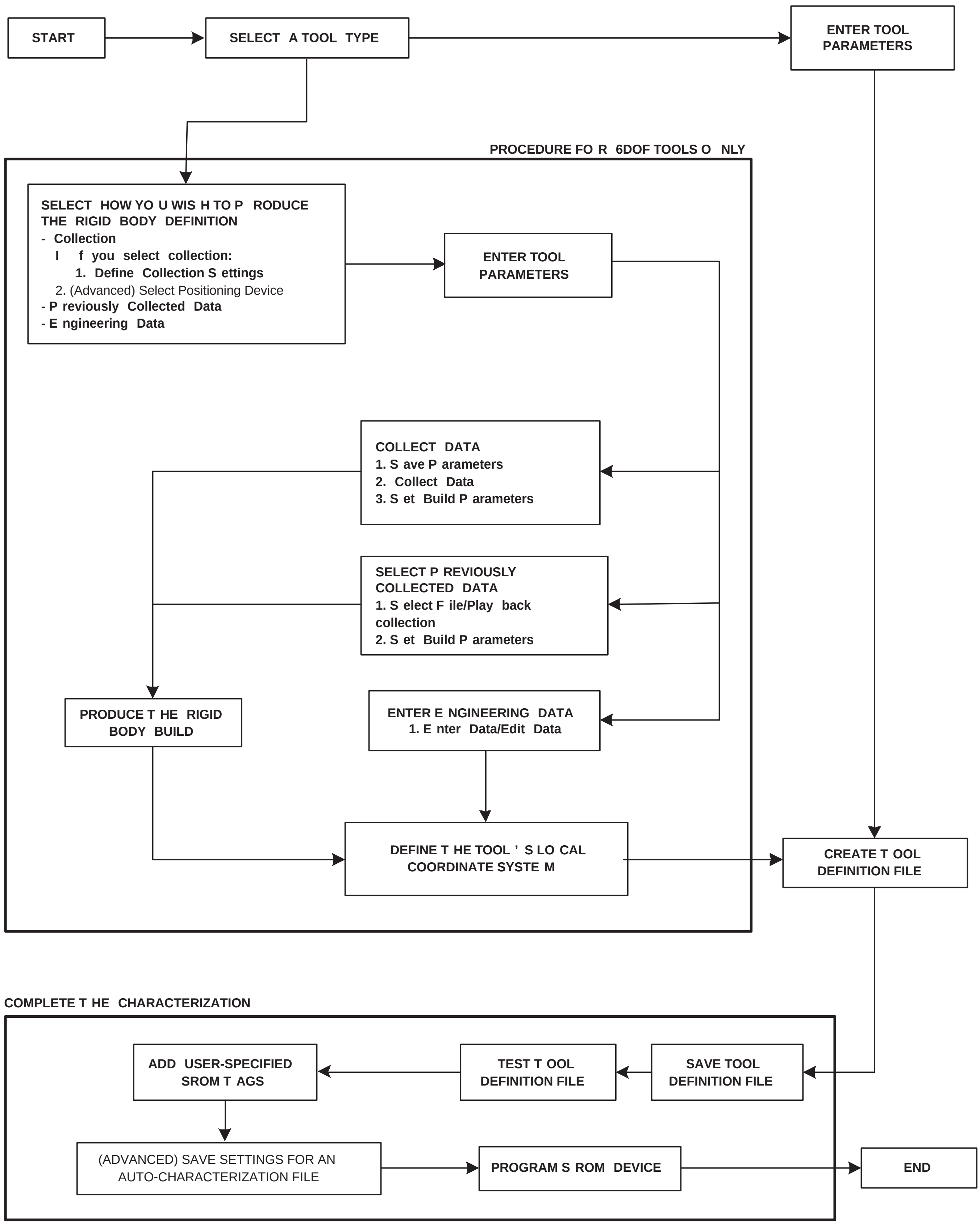
BASIC CHARACTERIZATION PROCEDURE: POLARIS PASSIVE TOOLS



BASIC CHARACTERIZATION PROCEDURE: POLARIS MULTI-FACED PASSIVE TOOLS



BASIC CHARACTERIZATION PROCEDURE: AURORA TOOLS



Glossary

.csv file

A .csv file is a Comma Separated Value file that stores characterization data in ASCII format.

.rig file

A .rig file is a rigid body’s tool definition file.

.rom file

A .rom file is a tool’s tool definition file.

.tem file

A .tem file is a template file that stores a tool’s local coordinate system information.

3D data

3D data refers to the x, y, and z positions of a marker.

3D RMS Error

3D RMS (Root Mean Square) Error is determined by calculating the difference between the measured locations of markers/sensor coils on a tool and the marker/sensor coil positions in the tool definition file.

5DOF

Five degrees of freedom. The three translation values of the x, y, and z-axes, and two of the three rotation value around each axes (Rx and Ry, but not Rz).

6DOF

Six degrees of freedom. The three translation values of the x, y, and z-axes, and the three rotation values around each axis (Rx, Ry, and Rz).

alignment

Alignment is the process of adjusting a tool or position sensor's local coordinate system.

auto-characterization file

An auto-characterization file stores all the settings and user-defined parameters required to characterize a specific tool design. Auto-characterization is particularly useful in assembly line environments, where multiple tools of the same design are being characterized.

axis of interest

An axis of interest represents an imaginary vector that is projected through a tool and represents an area where measurement values are required. For example, if the tool is a probe, an axis of interest might be an imaginary line travelling along the body of the probe and out its tip.

build parameters

Build parameters constrain how NDI 6D Architect uses collected tool data to build a rigid body definition of a tool.

centroid

A centroid is the centre point of an imagined three-dimensional volume created by the selected markers/sensor coils.

characterization

Characterizing a tool or rigid body is the process of creating its tool definition file (either .rom or .rig).

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 performed outside this region.

collection time

Collection time is the number of seconds or frames in which data will be recorded to a data file.

data trial

A data trial is a single collection of tool data with a collection time defined by the user.

default coordinate system

The default coordinate system is a global coordinate system assigned by the manufacturer, usually with the origin placed at the Position Sensor/Field Generator.

detection region

The detection region is the total volume in which an NDI measurement system can track a marker/ sensor coil, regardless of accuracy. Also known as "field of view".

dual sensor coil tool

A dual sensor coil tool contains two sensor coils. If the sensor coils are affixed relative to each other inside this tool, the system is able to measure the transformations of the tool in 6DOF.

Euler rotation

An Euler rotation is a mathematical method of describing a rotation in three dimensions: the rotation of the object around each axis (Rx, Ry, and Rz), applied in a specific order.

Euler transformation

An Euler transformation is a mathematical method of describing translations and rotations in three dimensions. Six values are reported for an Euler transformation: the three translational values in the x, y, and z-axes; and rotations around each of the axes, Rx, Ry, and Rz.

faces

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

face normal

See *normal*.

frame frequency

The frame frequency is the number of frames of data per second measured by an NDI measurement system.

frame

A frame contains the measured positions of the markers/sensor coils in the detection region at a particular point in time.

global coordinate system

The global coordinate system is an NDI measurement system's coordinate system. The global coordinate system is used by the measurement system as a frame of reference against which tools are measured. By default, the global coordinate system's origin is set at the Position Sensor/Field Generator.

groups

A group is a set of markers on a wired tool that are activated simultaneously. A tool face can be divided into a maximum of two groups.

indicator value

The indicator value is a unitless estimate of how well the system calculated a particular transformation.

local coordinate system

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

marker

A marker is an object that can be detected and tracked with a Polaris System.

marker normal

See *normal*.

markeless tools

Tools that have no markers, but still perform a function when connected to the Polaris System. For example, a foot switch.

matrix transformation

A matrix transformation is a mathematical method of describing rotations in three dimensions, using a 3x3 matrix called a rotation matrix.

maximum 3D error

Maximum 3D error applies to individual markers. It specifies the maximum allowable 3D residual error for each marker in the rigid body definition.

maximum marker angle

Maximum marker angle is used to determine if the Position Sensor can view a specific marker and if it should be included in the transformation calculated for the tool.

measurement rate

The rate at which the system calculates transformations, measured in Hz or frames/second.

normal

A normal is a vector assigned to each marker, tool face or rigid body face to define the direction they are facing.

offset vectors

An offset vector describes a location of the point of interest with respect to the tool origin.

pivoting

Pivoting is a procedure used to determine the tool tip offset.

point of interest

The point of interest is a point on or near the tool that represents a specific area where measurement values are required. For example, if the tool is a probe, the tip of the probe can be its point of interest.

pose

The pose is a static position and orientation of a rigid body or tool.

quaternion rotation

Quaternion rotation is a mathematical method of describing rotations in three-dimensional space, using four-dimensional objects that are represented as ordered quadruples [q0, qx, qy, qz].

quaternion transformation

A quaternion transformation is a mathematical method of describing a change in position and orientation in three dimensions. Seven values are reported for a quaternion transformation: the three translational values in the x, y, and z axes; qx, qy and qz form a vector and q0 indicates the amount of rotation about that vector.

q0, qx, qy, qz

The terms q0, qx, qy, qz represent the four elements of a single quaternion rotation.

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 tracked.

rigid body

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

rigid body definition

A rigid body definition is a description of the number and locations of markers/sensor coils on a tool.

RMS error

Root Mean Square (RMS) error is the square root of the mean of the squares of the individual distance errors along the x, y, and z-axes.

rotation matrix

A rotation matrix is a 3x3 matrix used to calculate a matrix transformation.

Rx, Ry, Rz

The terms Rx, Ry, and Rz refer to angles of rotation around the x, y and z-axes respectively.

sensor coil

A sensor coil is a small metal core wrapped with insulated metal wire and attached to two lead wires.

sensorless tools

Tools that have no sensor coils, but still perform a function when connected to the Aurora System. For example, a foot switch.

serial number

The serial number, calculated using the tool date and sequence number, identifies the unique tool.

single sensor coil tool

A single sensor coil tool contains one sensor coil. This tool can only provide 5DOF.

SROM device

An SROM device is a memory device located inside a wired tool. A tool definition file can be programmed into the SROM device so that the tool can carry its own information for automatic retrieval by an NDI measurement system.

SROM Image file

See *.rom file*.

switch

A switch, when activated, initiates certain actions in the associated software application. A tool may have switches incorporated into its design.

tip offset

See *tool tip offset*.

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 or sensor coils, the location of its end-tip, and its manufacturing data. A tool definition file can be formatted in two ways: .rig for rigid bodies, or .rom for tools.

tool origin

The tool origin is the origin of the tool's local coordinate system.

tool tip offset

The tool tip offset is the distance 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's position and orientation.

unique geometry

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

user-defined coordinate system

A user-defined coordinate system is a global coordinate system in which the user has changed the location of the default origin and/or the orientation of its axes.

user-specified SROM tags

A user-specified SROM tag is an additional tag appended to the tool definition file that further identifies the parameters of a tool. User-specified SROM tags fall outside standard tool definition file settings, and are designed to further customize the tool.

verification

Verification is the testing of a tool to ensure that it meets the needs of your intended application.

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