Polaris Vega Application Program Interface Guide

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About This Guide

This guide describes revision G.003.001 and later of the Polaris API, introduced with Polaris Vega.

To determine the API revision number programmed into your system, use the APIREV (page 46) command.

Note

For information on previous revisions of the API, refer to the *Polaris Application Program Interface Guide* (IL-1070101) available on the NDI support site at https://support.ndigital.com.

Warnings and Cautions

Warnings

Warning!

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

1. When using reply option 0800 with the BX (page 49) or TX (page 138) commands, you must take appropriate action to detect the following events: the tool or marker is out of volume, the bump sensor has been tripped, or the system is outside of the optimal operating temperature range. You must determine whether these events are detrimental to your application. If one or more of the events listed occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.
2. No options exist for filtering data returned from the BX2 (page 60) command on the basis of system or tool status or location in the volume. Complete system and tool status information is always included in the reply and it is the application’s responsibility to interpret this data and ignore those measurements that fall outside of application requirements and constraints. Failure to do so may lead to inaccurate conclusions that may cause personal injury.

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1 List of Commands

Table 1-1 lists all the API commands, and whether they are supported by each revision of the API. Compatibility is indicated as follows:

X indicates that the command is supported.

* indicates that the command is deprecated. Deprecated commands will no longer be enhanced to support new hardware devices or new API features. Support for deprecated commands may be discontinued in future releases.

Table 1-1 Alphabetical List of Commands

Command	Page	Description	G.003.002
3D	41	Returns the latest 3D position of either a single marker or multiple markers.	*
APIREV	46	Returns the API revision number that functions with your system.	X
BEEP	47	Sounds the system beeper.	X
BX	49	Returns the latest tool transformations, individual marker positions, and system status in binary format.	X
BX2	60	Returns various levels of data on the latest tool transformations, individual marker positions, and system status in binary format.	X
COMM	70	Sets the serial communication settings of the system. (Serial communication only.) Not used in the Polaris Vega System.	X
DFLT	73	Restores the user parameters to factory default values.	X
DSTART	74	Starts Diagnostic mode.	X
DSTOP	75	Stops Diagnostic mode.	X
ECHO	76	Returns exactly what is sent with the command.	X
GET	77	Returns the user parameter values.	X
GETINFO	79	Returns descriptive information about the user parameters.	X
GETLOG	81	Returns the contents of a system log file.	X
INIT	83	Initializes the system.	X
IRATE	84	Sets the illuminator rate.	X
IRED	86	Turns the markers on a wired tool on or off.	X
LED	88	Changes the state of visible LEDs on a wired tool.	X
PDIS	90	Disables the reporting of transformations for a particular port handle.	X
PENA	91	Enables reporting of transformations for a particular port handle.	X
PFSEL	93	Sets which tool faces to use to track a multi-faced tool.	X
PHF	95	Releases system resources from an unused port handle.	X
PHINF	96	Returns port handle status, and information about the tool associated with the port handle, including physical port location.	X

Table 1-1 Alphabetical List of Commands (Continued)

Command	Page	Description	G.003.002
PHRQ	102	Assigns a port handle to a tool.	X
PHSR	104	Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool.	X
PINIT	107	Initializes a port handle.	*
PPRD	109	Reads data from the SROM device in a wired tool. (Polaris Vega - only applicable to the SCU.)	X
PPWR	110	Writes data to the SROM device in a wired tool. (Polaris Vega - only applicable to the SCU.)	X
PURD	112	Reads data from the user section of the SROM device in a wired tool. (Polaris Vega - only applicable to the SCU.)	X
PUWR	114	Writes data to the user section of a tool SROM device in a wired tool. (Polaris Vega - only applicable to the SCU.)	X
PVWR	116	Assigns a tool definition file to a wireless tool, overrides a tool definition file in a wired tool, and can be used to test a tool definition file before permanently recording the tool definition file onto the SROM device.	X
RESET	118	Resets the system (can specify either a hard reset or a soft reset).	X
SAVE	119	Saves all non-volatile user parameters that have been changed.	X
SET	120	Sets user parameter values.	X
SFLIST	121	Returns information about the supported features of the system.	*
STREAM	129	Initiates a streaming response to a specified command.	X
SYSLOG	131	Writes data to the Position Sensor or System Control Unit log file.	X
TCTST	133	Returns diagnostics on the active markers of a wired tool.	X
TSTART	133	Starts Tracking mode.	X
TSTOP	136	Stops Tracking mode.	X
TTCFG	137	Sets up a configuration for a wired tool so that you can test the tool without using a tool definition file.	X
TX	138	Returns the latest tool transformations, individual marker positions, and system status in text format.	X
USTREAM	150	Stops streaming of the indicated command	X
VCAP	151	Captures IR image data from the sensors.	X
VER	154	Returns the firmware revision number of critical processors installed in the system.	X
VSEL	156	Selects a characterized measurement volume.	*

2 Changes in Implementation

This chapter describes the changes in implementation introduced by API revision G.003.001and G.003.002. For details on previous revisions of the API, refer to the *Polaris Application Program Interface Guide*, available on the NDI support site at https://support.ndigital.com.

2.1 Deprecated Commands

The following commands are deprecated in this version of the API. Deprecated commands will no longer be enhanced to support new hardware devices or new API features. Support for deprecated commands may be discontinued in future releases.

Command	Replacement
3D	BX2 command
IRATE	User parameter Param.Tracking.Track Frequency
PINIT	PENA command calls PINIT
SFLIST	User parameters: Features.Tools.Active Ports, Features.Tools.Passive Ports, Features.Volumes *, Features.Tools.Wireless Ports
VSEL	User parameter Param.Tracking.Selected Volume

2.2 Deleted Commands

Deleted Commands are as follows:

Deleted Command	Description
GETIO	Deleted
HCWDOG	Deleted
PSEL	Deleted
PSOUT	Deleted
PSRCH	Deleted
SENSEL	Replaced by User Parameter Param.Tracking.Sensitivity (Table 4-8 on page 30)
SETIO	Deleted
SSTAT	Deleted
VGET	Replaced with VCAP
VSNAP	Replaced with VCAP

2.3 New Commands

New commands in API revision G.003.001 are as follows:

New Command	Description
BX2 (page 60)	Returns various levels of data on the latest tool transformations, individual marker positions, and system status in binary format.
STREAM (page 129)	Initiates a streaming response to a specified command.
USTREAM (page 150)	Stops streaming of the specified command.
VCAP (page 151)	Captures IR image data from the sensors.(Replaces the VGET and VSNAP commands.)

BX2

The BX2 command provides a flexible way of providing measurement data at various levels of detail. The reply can contain a single or multiple frames. Each frame can contain various levels of measurement data detail such as 6D, 3D or 2D data.

- It does not repeat already reported information.
- It works with the STREAM command to keep latency to a minimum and avoid missing or repeating information.
- Addresses the problem of providing system wide failures and warnings in the multi-connection environment.

STREAM

STREAM initiates a streaming response to a command. For details on data streaming, see “Data Streaming” on page 8.

USTREAM

USTREAM terminates the streaming response to a command. For details on data streaming, see “Data Streaming” on page 8.

VCAP

The VSNAP and VGET commands are removed and replaced with a single VCAP command. The VCAP command contains options to specify and control the image data returned. The reply contains the image data for a single frame from all sensors with embedded “metadata” that includes sensor number, frame number, timestamp, exposure and other relevant information about the frames. Readable parameters provide additional information that will assist in interpreting the image data, such as the makeup of the frame sequence and the number and names of the image sensors.

2.4 Changed Commands

“PHRQ” on page 102: New option in PHRQ allows you to add the specified type of measurement frame in the sequence and automatically add a “dummy” tool at the same time. This simplifies the process of setting up tracking of stray 3D targets.

The change involves the redefinition of the previously Reserved 2 characters of the request. In case of the wireless tool request, new use for those characters is to specify Active Wireless or Passive Dummy Tool.

```
PHRQ<SPACE><Hardware Device><System Type><1><Port Number>
<DummyTool><CR>
```

DummyTool	2 characters In case of Tool Type = Wireless 01 adds passive dummy tool 02 adds active wireless dummy tool

2.5 Change in Concepts

General Binary Format

The General Binary Format (GBF) is used consistently in all new commands returning tracking or video data. Its advantage is that the host does not need to keep the context of the request to be able to parse it correctly. It can also contain various levels of detail corresponding to the reported tracking frame. It is structured as a list of individual, well-defined components. Each component holds the information on its unique type and its options that define the process of parsing its content. It uses little endian byte order as the existing binary command and all size byte values are interpreted as unsigned values. The general structure of the format is illustrated in Figure 2-1.

All numeric values are 4 bytes (32 bits) unless otherwise specified. The first field in the payload is a 2 byte integer that indicates the number of components contained in the payload.

Each component starts with a unique 2 byte value defining its type, followed by 4 bytes specifying the size of the component, including the 12 bytes for the header. If the parsing software cannot parse this component, it can use the size information to skip to the beginning of the next component.

Item Format Option (2 bytes) is specific to the component type. Each type will have its own set of options that provide all the information needed to parse the content of the component. The Item Format Option implies the Item’s size.

Item Count (4 bytes) describes the number of following items to parse. After parsing all the specified items, a new component starts with its definition of the component type and the parsing process repeats.

Component ID’s are as follows:

01 – Frame Component

02 – 6D Data Component

03 – 3D Data Component

04 – 1D Data Component – buttons

05 – 2D Data Component

06 – reserved

07 – reserved

08 – reserved

09 – reserved

10 – Image Data Component

11 to 16 – reserved

17 – Sensor U,V Component

18 – System Alert Component

An example of the GBF structure, with an example of the BX2 command is shown in Figure 2-1.

Refer to page 67 for examples that contain the raw reply response converted to hex characters.

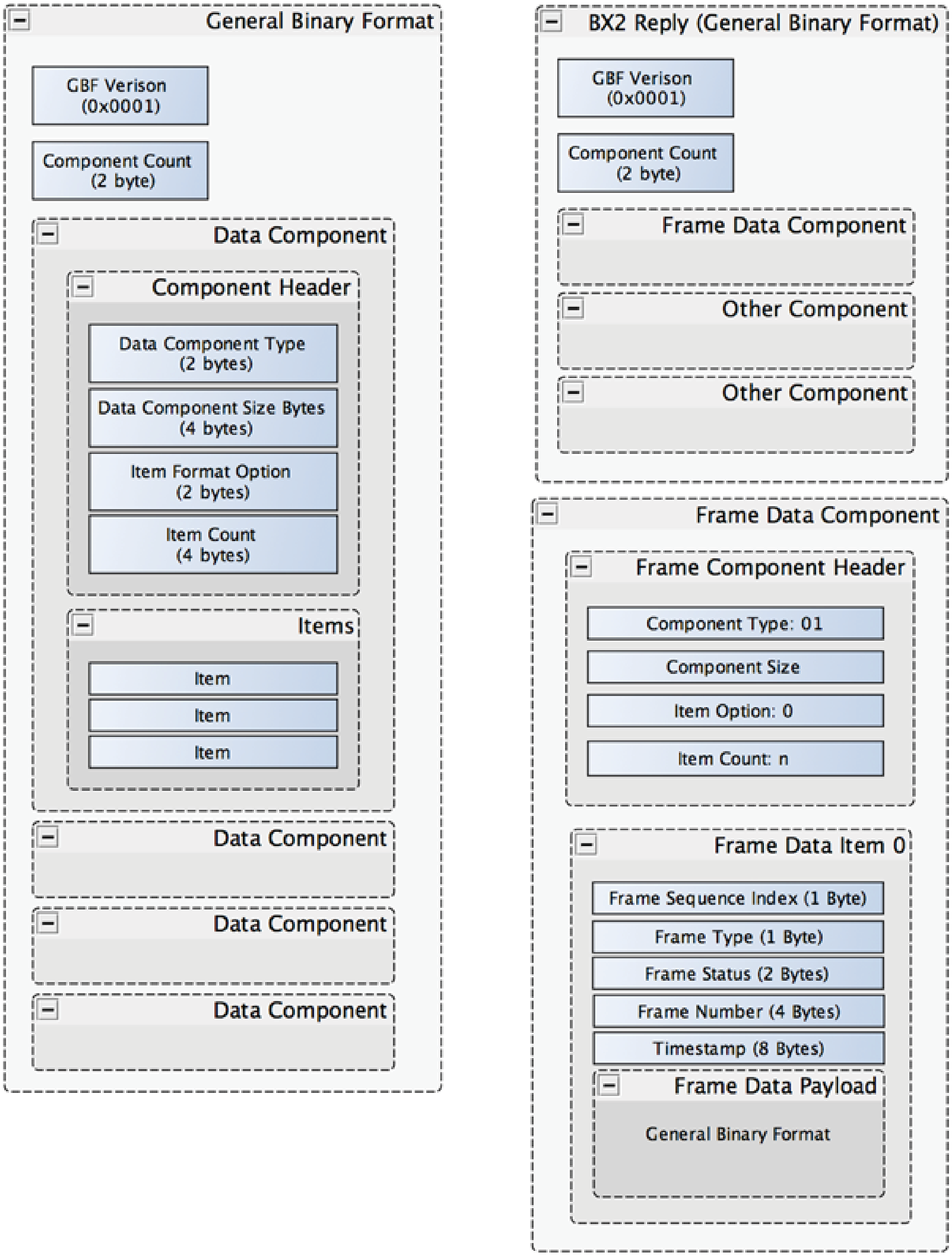


Figure 2-1 General Binary Format structure and BX2 example

Introduction of operating roles for host connections

With the introduction of the multi-host option, there is a need to ensure only one connection to the Vega device has the capability of changing configuration options and the mode of the device. That connection will hold the Master role and other connections will be in a Monitor role. The Master connection will have full control of the system. If a connection in a Monitor role issues a command that would change the operation of the system then error code 0x39 (Permission Denied) will be returned.

Initially a connection will be granted the Monitor role. When it issues a command that would require it to become the Master, the system assigns it the Master role, if the host is in the list of allowed Masters and there is not already another Master.

There is a Master Time Out setting that tracks the activity on the Master connection. If the period of inactivity on the Master connection exceeds the threshold set in the Master Time Out parameter, then the Monitor can become the Master.

Extended Binary Header

To facilitate binary replies that have a binary payload greater than 65535 bytes long, a new binary header type is introduced. This header has a 32 bit length field and allows for reply lengths up to 2^32-1 bytes long. Either binary header may be used in response to any of the “new” binary commands, currently BX2 and VCAP.

This extended binary reply header is intended for use with very large replies. If the reply length is less than 65535 bytes long, then the original binary header is used. Since TCP packets already include data checksums and to reduce processing time and allow for more efficient memory-to-memory transfer techniques, no CRC will be included in the header or at the end of the data. Thus, the extended header is the same length as the original header.

The format of an extended binary header reply is as follows:

```
A5C8<4 byte Reply Length><command reply>
```

Data Streaming

In previous versions of the API, the host and the system communicated in a strict Request-Response pattern. This version of the API introduces an option to continuously stream command responses for each new frame of data. For an application to make use of streaming, its communication drivers will have to be modified because most legacy applications expect the response to come after the request. Once streaming is enabled on the communication channel, the host can no longer assume that a given response received from the system belongs to the last request. The host addresses this in its parsing by always investigating the kind of reported data. Each streaming response will be clearly identified in its header then host processing routes each response to its corresponding process. See Figure 2-2 on page 9.

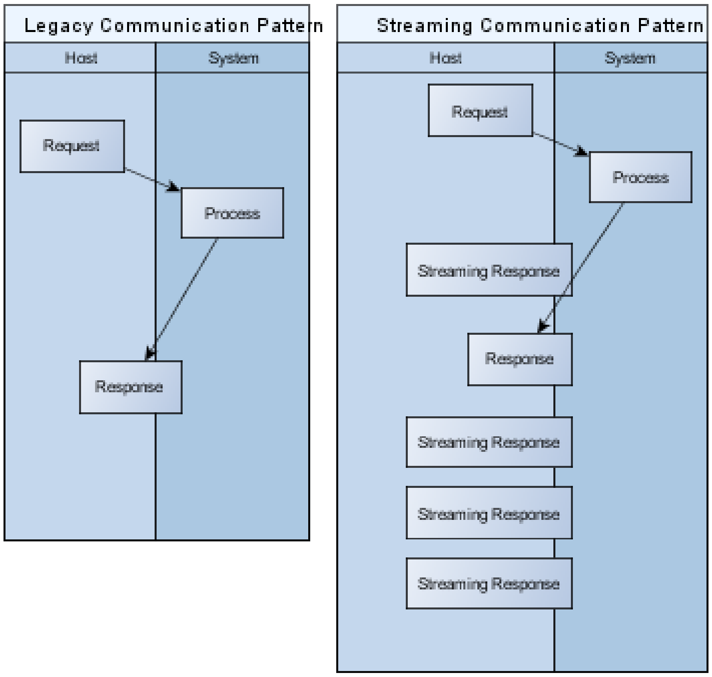


Figure 2-2 Streaming Response Pattern

This version of the API introduces two new streaming commands: STREAM (initiates a streaming response to a command) and USTREAM (terminates a stream).

Newly introduced streamed replies will be wrapped in the Streaming Reply Format in a similar way to how the BX binary data is currently wrapped in the Binary Data Format. Both are shown in Figure 2-3 on page 10.

Structures of both formats are similar. Both start with the header, followed by the binary data content and both are concluded by the CRC, ensuring correct content. Streaming reply starts with a new 2 byte identification sequence. The new parsing process checks for this sequence at the start of each reply. The header of the streaming message contains a unique string of bytes “Stream ID” which the host will use to identify which stream the response belongs to (in the case where more than one stream is initiated). If the reply is not a streaming reply, it belongs to the last pending non-streaming request. All of the tracking data is delivered in the new General Binary Format, see “General Binary Format” on page 5.

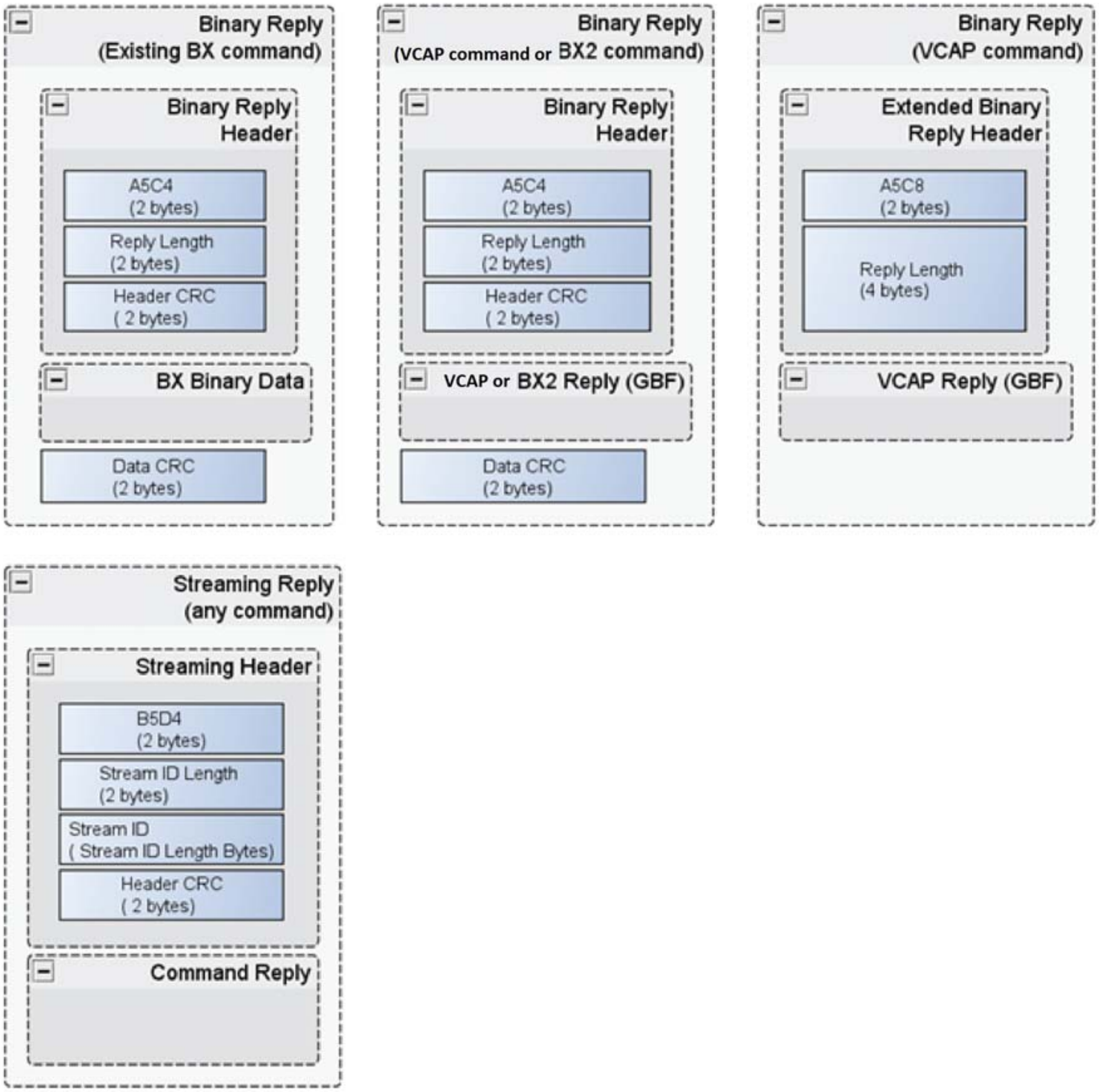


Figure 2-3   Binary and Streaming Reply Format

3 Communicating with an NDI System

3.1 Connection Requirements

The system must communicate with a host computer to pass measurement information to another application running on the host computer. Connection requirements are detailed below.

The ethernet connection must handle the bandwidth of data being sent. The bandwidth is dependent on the amount of data being requested from the Vega System.

The ethernet connection must be compliant with IEEE 802.3at and secure from any unauthorized connections.

The severity of all connection-related hazardous situations is the responsibility of the system integrator because there is no essential performance of the Vega System.

Note Operation on an open or uncontrolled network could limit communication bandwidth, increase latency or otherwise interfere with the normal operation of the Vega System and introduce risks which should be analyzed. Changes to the network including connection, disconnection or updates to any equipment may also affect operation of the system.

3.2 Communication Overview

There are two methods of communication with the Polaris systems; request-response and streaming. Both methods are described below.

Request-Response Communication

In request-response communication, from the application perspective, the Polaris Vega System is a serial device, which is listening for incoming commands. Upon receiving a command, the system performs some action and returns the status of this action. The system never initiates communication with the application.

Immediately after sending a command, the application can begin to poll the serial buffer for a reply. Most commands reply almost instantly. After reaching the end of the reply, the application can send another command. There may be some delay in the response of the INIT command, and the commands used to read from and write to an SROM device in a wired tool.

Streaming Communication

The Polaris Vega System introduces an option to continuously stream command responses for each new frame of data. The STREAM command initiates streaming response and the USTREAM command terminates the streaming response. For details, see "Data Streaming" on page 8.

3.3 Operating Modes

The system has three modes of operation: Setup, Tracking, and Diagnostic. Some commands will only work if they are sent while the system is in a specific mode of operation. If a command is sent when the system is in a mode not valid for that command, the system returns `ERROR0C`.

Setup

Setup mode allows you to configure the system and tools. Tasks done while the system is in Setup mode may include initializing the system, writing to the SROM on a tool, or checking the system revision.

A wireless tool must have a port handle assigned to it (PHRQ) before the application can load a tool definition file (PVWR) Both conditions must be satisfied before the tool can be enabled (PENA).

The system enters the Setup mode either on successful power up, on sending a reset, or on exiting from Tracking or Diagnostic modes.

Tracking

In Tracking mode, the system measures the positions and orientations of tools in real time and returns the information to the host computer when requested. The BX2 and BX commands are the most commonly used commands in Tracking mode.

The system enters Tracking mode on successful TSTART command and exits Tracking mode on TSTOP command.

Diagnostic

Diagnostic mode allows you to control and observe active tools, but not track them.

The system enters Diagnostic mode on successful DSTART command and exits Diagnostic mode on DSTOP command.

3.4 General Syntax

Commands must be sent from the host computer to the system in one of the two following formats. To ensure the integrity of data transmission, NDI recommends using format 1, as well as verifying the returned CRC on the host computer.

Format 1

```
<Command><:><Parameter1><Parameter2>...<ParameterN><CRC16><CR>
```

A `<:>` must be sent with every command even if no parameters are required. There are no characters or spaces separating the parameters or the individual parts of the commands, except in user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands. Commands and parameters are not case-sensitive, except for user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands and in POSIX-style parameters (which must be separated from each other by one or more spaces).

This format requires a 16-bit CRC (Cyclic Redundancy Check) value and therefore may be more useful in application software. The application software can incorporate a CRC calculation and add it to the command each time a command is sent to the system. Including a CRC provides a communications check to ensure that there are no communication problems between the system and the host computer. The CRC is used in both the commands and replies. It is based on all the characters in the command, up to the CRC itself. It is calculated using the polynomial $x^{16} + x^{15} + x^2 + 1$. See "Sample C Routines" on page 164 for sample code to calculate the CRC.

Format 2

```
<Command><SPACE><Parameter1><Parameter2>...<ParameterN><CR>
```

A `<SPACE>` may be sent with every command; it need not be sent if no parameters are required. There are no characters or spaces separating the parameters or the individual parts of the commands, except in user parameter names and string values used with the SET, GET, GETINFO, DFLT, SYSLOG commands and in POSIX-style parameters (which must be separated from each other by one or more spaces). Commands and parameters are not case-sensitive, except for user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands.

It is not necessary to calculate a CRC value when using this format, so this format is useful for sending commands to the system in an application such as a terminal program.

3.5 Receiving System Replies

Binary Replies

Commands BX, BX2, GETLOG, and VCAP return binary replies. All other commands return ASCII replies.

If a complete command is received by the system, replies are sent back in the format:

```
<Reply><CRC16>
```

The system always returns `<CRC16>` in the reply regardless of whether the command was sent in format 1 or format 2 unless the reply is an Extended Binary Reply. The `<Reply>` will be either the requested data, or `ERROR<error code>`. The `<error code>` is a two-digit hexadecimal error number. See "Error Code Definitions" on page 157 for a listing of all the error messages associated with error numbers.

Binary replies are returned in little endian format. For example, a 32-bit reply is returned in the format:

Bits	7 - 0	15 - 8	23 - 16	31 - 24
Reply byte	n	n + 1	n + 2	n + 3

Extended Binary Header

In order to facilitate binary replies that have a binary payload greater than 65535 bytes long, a new binary header type is introduced. This header has a 32 bit length field and allows for reply lengths up to 2^32-1 bytes long. Either binary header may be used in response to any of the "new" binary commands, currently BX2 and VCAP.

This extended binary reply header is intended for use with very large replies. If the reply length is less than 65535 bytes long, then the original binary header is used. Since TCP packets already include data checksums and to reduce processing time and allow for more efficient memory-to-memory transfer techniques, no CRC will be included in the header or at the end of the data. Thus, the extended header is the same length as the original header.

The format of an extended binary header reply is as follows:

```
A5C8<4 byte Reply Length><command reply>
```

ASCII Replies

All commands return ASCII replies except BX, BX2, GETLOG, and VCAP, which return binary replies.

If a complete command is received by the system, replies are sent back in the format:

```
<Reply><CRC16><CR>
```

The system always returns `<CRC16>` in the reply regardless of whether the command was sent in format 1 or format 2. The `<Reply>` will be either the requested data, `OKAY`, `WARNING`, `WARNING<warning code>`, or `ERROR<error code>.`

- `WARNING` is returned only with the PINIT command. See PINIT (page 107) or "Warning Code Definitions" on page 160 for details.
- `WARNING<warning code>` is returned only with the PENA command. See "Warning Code Definitions" on page 160 for a listing of the warning messages.
- The `<error code>` is a two-digit hexadecimal error number. See "Error Code Definitions" on page 157 for a listing of all the error messages associated with error numbers.

3.6 Best Practices

This section provides guidelines on how to write an application in order to minimize updates required when there are changes to the API. If your application is written correctly, it will still work when additions are made to the API; you will only need to update your application if you wish to take advantage of the new features.

- Ignore the value of any returned field that is listed as "reserved" in the API guide. The values of reserved fields may change in future API releases.
- Program the application to allow all possible values of a returned field, not only the values that are currently defined. This allows for future expansion. For example, if a field returns one character, but currently only characters 0 and 1 are defined, do not write your application such that 0 and 1 are the only acceptable values; more values may be defined in the future.
- Use the frame number, and not the host computer clock, to identify when data was collected. The frame number is incremented by 1 at a constant rate of 60 Hz. Associating a time from the host computer clock to replies from the system assumes that the duration of time between raw data collection and when the reply is received by the host computer is constant. This is not necessarily the case. The frame number is returned with the command BX (page 49), TX (page 138), BX2 (page 60), and VCAP (page 151).
- Use both the shape type and the shape parameters to represent the characterized measurement volume graphically. There may be multiple volumes with the same shape type. All volumes of the same shape type use the shape parameters the same way. The shape type and shape parameters are returned with the command SFLIST (page 121). See also 2.1.
- When checking the firmware revision, check only the combined firmware revision, not the firmware revision of the individual components. The combined firmware revision ensures that all components in a system have compatible firmware. To check the combined firmware revision, read the value of the user parameter **Config.Combined Firmware Revision** or use the command VER 5 (page 154). See "User Parameters" on page 20 for information on reading user parameters.
- When checking for protocol compatibility, check for the API revision instead of the combined firmware revision. An application written for a particular API revision will function with any system that supports that API revision. See the command APIREV (page 46) for details.
- Use **GET Device.*** to determine which devices are in the system configuration, instead of programming device names directly into the application. This will allow the addition or removal of devices without breaking the application. When setting or reading a user parameter value for every hardware device in the system, create a loop to repeat the action for every device name determined using **GET Device.***. See "Device Names" on page 21 for instructions on how to determine the device names of the hardware devices in your system and how to access user parameters using device names.
- Read the timeout values of the API commands from the user parameter **Info.Timeout.<command name>**; do not program the timeout values directly into the application. See "User Parameters" on page 20 for information on user parameters.
- Do not use the system log to record minor system events. The system log is intended for major milestones only, and may not have enough space to accommodate numerous minor

entries. For minor entries, use the user parameters **Param.User.String0** to **Param.User.String4** as required. These parameters can be used for any purpose; the system does not make use of them. For example, an incoming inspection result might be a major milestone to be saved in the system log; a cleaning schedule might be a minor entry to be saved in a user parameter. See “User-Defined User Parameters” on page 29 for information on these user parameters.

3.7 Port Handles

About Port Handles

The system assigns each tool a port handle. Using the commands below, port handles are two characters in hexadecimal format, 0x01 to 0xFF. (BX2, for example, returns port handles as 4 characters.)

Port handles can be assigned to tools only while the system is in Setup mode.

Port Handle Commands

The following commands are used for port handles:

Command	Description
PHSR (page 104)	Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool.
PHRQ (page 102)	Assigns a port handle to a tool. PHRQ is followed by PVWR.
PVWR (page 116)	Assigns a tool definition file to a tool, overrides a tool definition file in a wired tool, and can be used to test a tool definition file before permanently recording the tool definition file onto the SROM device of a wired tool.
PINIT (page 107)	Initializes a port handle. PENA calls PINIT.
PHINF (page 96)	Returns port handle status, and information about the tool associated with the port handle, including physical port location.
PHF (page 95)	Releases system resources from an unused port handle. This is required if a tool is disconnected. If a tool is disconnected and then reconnected, the system assigns it a new port handle. The old handle is reported as disabled and should be freed using PHF.
PENA (page 91)	Enables reporting of transformations for a particular port handle.
PDIS (page 90)	Disables the reporting of transformations for a particular port handle.

The order in which these commands are used is detailed in Figure 3-1 on page 18 (for wired tools) and Figure 3-2 on page 19 (for wireless tools).

Disabled Transformations

A transformation may be reported as DISABLED if:

- the port handle was not enabled with PENA (page 91),

- the port handle has been disabled with PDIS (page 90), or
- a wired tool has been disconnected and the port handle has not been freed.

Unoccupied Port Handle

A port handle may be reported as UNOCCUPIED if:

- the tool has been disconnected and port handle information is requested using PHINF (page 96), or
- you have requested a port handle with PHRQ (page 102) but you have not yet used PVWR (page 116) to associate a tool definition file with the port handle.

Flow Charts for Port Handle Usage

Figure 3-1 details the logic for using port handles with wired tools.

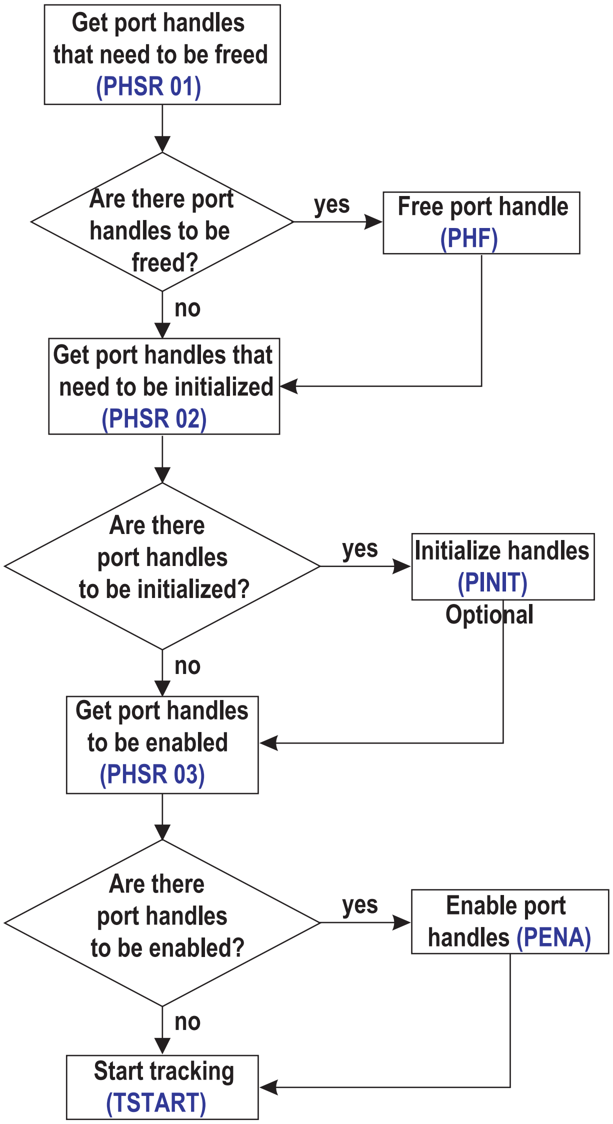

Get port handles that need to be freed (PHSR 01)
Are there port handles to be freed?
yes
Free port handle (PHF)
no
Get port handles that need to be initialized (PHSR 02)
Are there port handles to be initialized?
yes
Initialize handles (PINIT)
Optional
no
Get port handles to be enabled (PHSR 03)
Are there port handles to be enabled?
yes
Enable port handles (PENA)
no
Start tracking (TSTART)

Figure 3-1   Flow Chart for Port Handle Usage - Wired Tools

Figure 3-2 details the logic for using port handles with wireless tools.

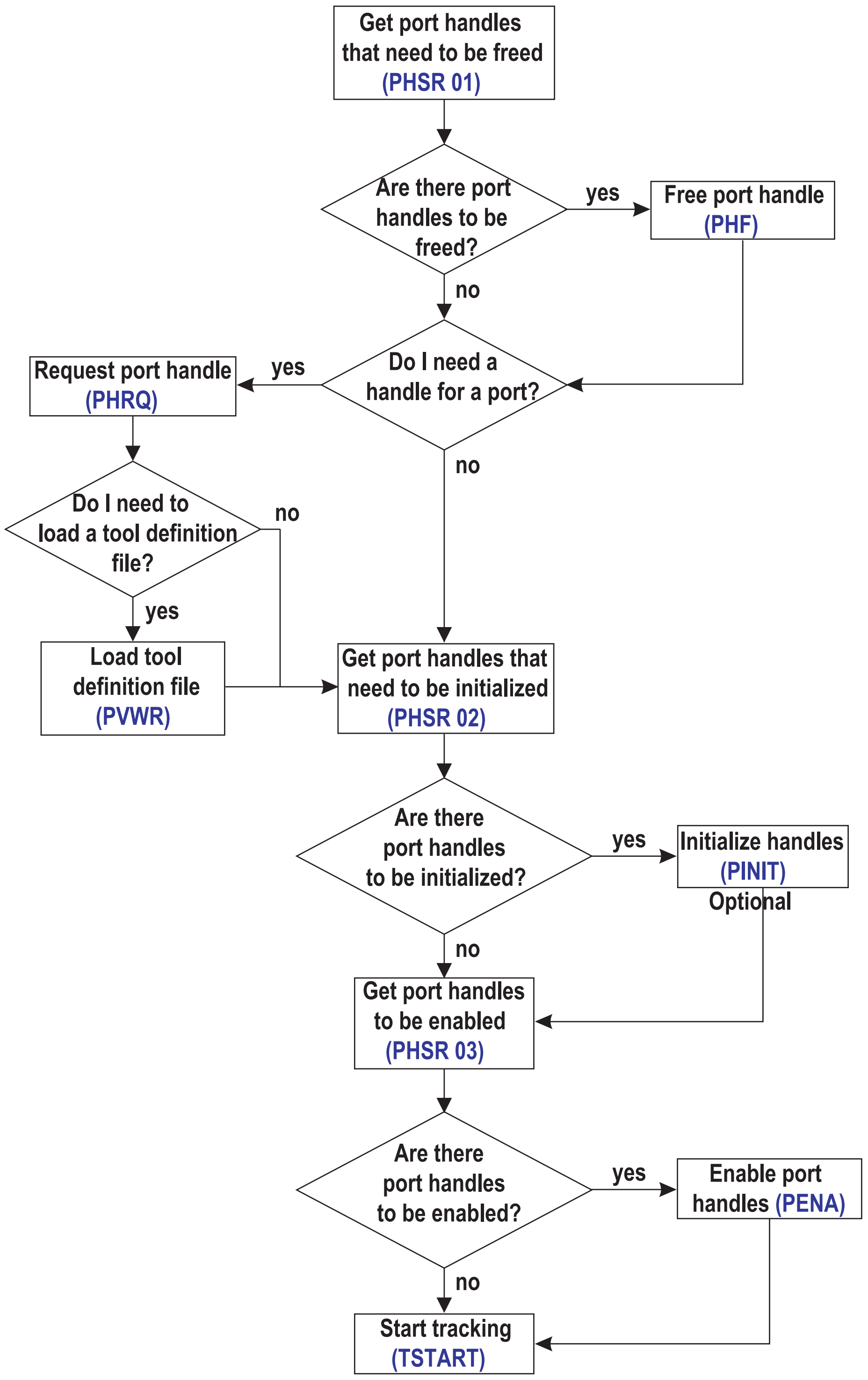

Get port handles that need to be freed (PHSR 01)
Are there port handles to be freed?
yes
Free port handle (PHF)
no
Do I need a handle for a port?
yes
Request port handle (PHRQ)
no
Do I need to load a tool definition file?
no
yes
Load tool definition file (PVWR)
Get port handles that need to be initialized (PHSR 02)
Are there port handles to be initialized?
yes
Initialize handles (PINIT) Optional
no
Get port handles to be enabled (PHSR 03)
Are there port handles to be enabled?
yes
Enable port handles (PENA)
no
Start tracking (TSTART)

Figure 3-2 Flow Chart for Port Handle Usage - Wireless Tools

4 User Parameters

4.1 About User Parameters

User parameters store values for different aspects of the Polaris Vega System. Some user parameters store values for the full system configuration; others store values pertaining to a particular hardware device in the system. Some user parameters are read-only parameters that store useful information about the system; some user parameter values can be changed to allow you to configure the system.

User parameters fall under the following categories:

- Image Capture User Parameters: These user parameters are used in conjunction with the VCAP command to store settings and values related to image capture. For example background or illuminated frame.
- Settings User Parameters: These user parameters store settings for each hardware device in the system. For example, the illuminator rate and the available characterized measurement volumes are stored in the settings user parameters.
- Information User Parameters: These user parameters store status information for each hardware device in the system and command timeout values.
- Features User Parameters: These user parameters store information about the features of each hardware device in the system.
- System Configuration User Parameters: These user parameters store information about the configuration of the system. These user parameters describe the configuration of the entire system, not a particular device.
- Hardware Device Information User Parameters: These user parameters store information about which hardware devices are part of the system.
- Network User Parameters: These user parameters store information about the network settings of the system.
- Clock User Parameters: These parameters store information about the system clock, including the day, month, year, hour, minutes and seconds.
- Volume User Parameters: These parameters store information about the Vega volume, including the volume shapes and supported wavelengths.

- Video Camera User Parameters: These parameters store information about the optional video camera.

For a full list of user parameters, see page 30.

4.2 User Parameter Commands

The following commands are used with the user parameters:

Command	Description
DFLT (page 73)	Restores the user parameters to factory default values.
GET (page 77)	Returns user parameter values.
GETINFO (page 79)	Returns user parameter values and descriptive information about the user parameters, including use details, possible values and access rules.
SET (page 120)	Sets user parameter values.
SAVE (page 119)	Saves all non-volatile user parameters that have been changed.

See the individual commands for more details.

4.3 Device Names

Each hardware device in the system configuration has a unique device name. For passive systems, the Position Sensor and Video Camera Unit are the only hardware devices. For hybrid systems, the Position Sensor, System Control Unit and Video Camera Unit each have a device name.

Each hardware device has its own set of user parameters and its own log file.

Note For information on the log files, see GETLOG (page 81) and SYSLOG (page 131).

Determining the Devices in the System Configuration

Use the GET command to determine which hardware devices are in your system. To ensure future compatibility if more devices are integrated into your system, your application should read the list of devices every time you connect to a system, or whenever a component is connected or disconnected.

Note The list of devices does not update while the system is in tracking mode. The list of devices will not show changes until the system exits tracking mode.

The most general method of reading the list of devices to ensure consistent behaviour in the future is as follows:

Command:

```
GET Device.*
```

Reply:

```
Device.Type.0=PS
Device.Type.1=SCU
Device.Type.2=VCU
Device.Instance.0=0
Device.Instance.1=0
Device.Instance.2=0
Device.Address.0=local
Device.Address.1=192.168.1.11
Device.Address.2=
Device.Port.0=8765
Device.Port.1=8765
Device.Port.2=0
```

The reply gives information about every device in the system configuration. For each device, there are four parameters as shown in the reply example above.

- **Device.Type.X** describes the type of connected device:

Device.Type Parameter	Hardware Device
PS	Position Sensor
SCU	System Control Unit
VCU	Video Camera Unit

- **Device.Instance.X** describes the instance of that type of device in the configuration.

Parameters with the same X index value (for example, Device.Type.0 and Device.Instance.0) describe the same device. For more information, refer to table Table 4-12.

4.4 Alerts User Parameters

The alerts user parameters describe the status of a particular hardware device in the system.

Alerts User Parameters

Table 4-1 describes the alerts user parameters.

Table 4-1 Alerts User Parameters

User Parameter	Description
Info.Status. Alerts	This user parameter describes the current state of the hardware device. See the alerts listed in Table 4-2 for the Position Sensor. For System Control Unit alerts, see Table 4-3. The bit corresponding to a particular alert is set when the system first detects the condition. This is accompanied by system response in Table 4-2 or Table 4-3. The bit is cleared when the condition no longer exists. Note: the “bump detected” bit will be cleared only when you set the **“Param.Bump Detector.Clear”** Position Sensor user parameter to “1”.

Table 4-1 Alerts User Parameters (Continued)

User Parameter	Description
Info.Status. New Alerts	Read this user parameter when the diagnostic pending bit is set (bit 8 in the BX or TX System Status component). This user parameter lists the current alerts status whenever an alert is set or cleared. The act of reading this parameter clears both this parameter and the diagnostic pending bit. The bit corresponding to a particular alert is set when the system first detects the condition, and is cleared when the system first detects that the condition has been resolved. This is accompanied by system response in Table 4-2 or Table 4-3. The act of reading this user parameter clears it.
Param.Simulated Alerts	Simulates the **Info.Status.Alerts** parameter, for the hardware device specified, for testing purposes. To test the response of a particular alert, set the value of this parameter to the value of the alert. See Table 4-2 or Table 4-3.

Position Sensor Alerts

Table 4-2 describes the Position Sensor alerts that are returned by the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together:

Table 4-2 Position Sensor Alerts

Hexadecimal Value	Alert	System Response	Log to File	Position Sensor LED Indication	BX2 Code
0x00000001	Non-recoverable parameter fault The system parameter file or some other critical file is missing or has been corrupted (CRC check failed).	INIT returns `ERROR15` See page 157.	yes	Error LED: on Power LED: off	Fault 1
0x00000002	Sensor parameter fault The sensor parameters were not programmed properly, or cannot be read by the system. Not in use.	INIT returns `ERROR15` See page 157.	yes	Error LED: on Power LED: off	Fault 2
0x00000004	Not in use.				
0x00000008	Not in use.				
0x00000010	Illuminator voltage fault The illuminator voltage is outside of operating range. This may be caused by a hardware failure.	Sets diagnostic pending bit (bit 8) in TX or BX system status. See page 157.	yes	Error LED: on Power LED: off	Fault 5
0x00000020	Illuminator current fault The illuminator current is outside of operating range. This may be caused by a hardware failure.	Sets diagnostic pending bit (bit 8) in TX or BX system status. See page 157.	yes	Error LED: on Power LED: off	Fault 6

Table 4-2 Position Sensor Alerts (Continued)

Hexadecimal Value	Alert	System Response	Log to File	Position Sensor LED Indication	BX2 Code
0x00000040	Left sensor temperature fault The left sensor temperature cannot be read.	INIT returns `ERROR15` Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. See page 157.	yes	Error LED: on Power LED: off	Fault 7
0x00000080	Right sensor temperature fault The right sensor temperature cannot be read.	INIT returns `ERROR15` Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. See page 157.	yes	Error LED: on Power LED: off	Fault 8
0x00000100	Main temperature fault The main board temperature cannot be read.	INIT returns `ERROR15` Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. See page 157.	yes	Error LED: on Power LED: off	Fault 9
0x00000200	One of the image sensors on the PSU is not functioning. This may be caused by an internal hardware failure.	INIT returns `ERROR15` Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. See page 157.	yes	Error LED: on Power LED: off	Fault 10
0x00000400 0x00020000	Reserved				
0x00040000	A Type 1 low power PSE is detected and there is insufficient power for tracking. A Type 2 PSE compliant with the 802.3at standard that outputs up to 30W must be used.	INIT returns `ERROR15` See page 157.	no	Error LED: on Power LED: on	N/A
0x00080000	SCU configured but not present This may mean that the SCU is not functioning, has not powered up yet, or has been disconnected. It can also mean that the system is misconfigured.	Active tools will not be available for tracking.	no	Error LED: on Power LED: on	Alert 10

Table 4-2 Position Sensor Alerts (Continued)

Hexadecimal Value	Alert	System Response	Log to File	Position Sensor LED Indication	BX2 Code
0x00100000	System battery fault The system battery power is too low. This may be caused by a depleted or disconnected battery. This battery powers the bump sensor and the system clock.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data. See page 157.	yes	Error LED: on Power LED: on	Alert 1
0x00200000	Bump detected The bump sensor has detected a bump.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data. See page 157.	yes	Error LED: on Power LED: on	Alert 2
0x00400000	Video camera not functioning	Video output is not available. The VCU signals a fault or fails to respond to the PSU.	yes	Error LED: on Power LED: on	Alert 15
0x00800000	Incompatible firmware The combination of firmware on the Position Sensor is not compatible. This may be caused by a failed attempt to update the firmware.	INIT returns `ERROR2E` See page 157.	yes	Error LED: flashing Power LED: on	Alert 3
0x01000000	Recoverable parameter fault The user parameter file has been corrupted (CRC check failed) or is missing. To correct this problem, check that the settings of the user parameters are set correctly, and save them (use SAVE (page 119)).	INIT returns `ERROR15` See page 157.	yes	Error LED: on Power LED: on	Alert 4
0x02000000	Not in use.				
0x08000000	PTP clock is not synced PSU's PTP clock is not synced with other devices on the same network.	See page 157.	no	Error LED: on Power LED: on	Alert 14
0x20000000	Temperature characterized high The Position Sensor temperature is above the optimal operating range (see the user guide for details).	Sets temperature bit (bit 9) in TX or BX system status. Need reply option 0800 in TX or BX to return data. See page 157.	no	Error LED: on Power LED: on	Alert 8
0x40000000	Temperature characterized low The Position Sensor temperature is below the optimal operating range (see the user guide for details).	Sets temperature bit (bit 9) in TX or BX system status. Need reply option 0800 in TX or BX to return data. See page 157.	no	Power LED: flashes during warm-up when system is first powered on. Error LED: on	Alert 9

Table 4-2 Position Sensor Alerts (Continued)

Hexadecimal Value	Alert	System Response	Log to File	Position Sensor LED Indication	BX2 Code
0x80000000	Reserved				

System Control Unit Alerts

Table 4-3 describes the SCU alerts that are returned by the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together:

Note The Polaris Vega SCU only incorporates one (Status) LED located on the rear of the SCU.

Table 4-3 System Control Unit Alerts

Hexadecimal Value	Alert	System Response	Log to File	SCU LED Indication
0x00000001	Non-recoverable parameter fault The system parameter file or some other critical file is missing or has been corrupted (CRC check failed).	INIT returns `ERROR15`	yes	Rear LED: amber
0x00000002 to 0x00000008	Reserved			
0x00000010	Internal strober communication fault The SCU can detect the internal strober, but cannot communicate with it.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	yes	Rear LED: amber
0x00000020 to 0x00000040	Reserved			
0x00000080	Not in use.			
0x00000100	Strober fault raised The SCU has detected a fault raised by the strober. There could be a voltage monitor fault or an active marker current monitor fault.		yes	Rear LED: amber
0x00000200 to 0x00400000	Reserved			

Table 4-3 System Control Unit Alerts (Continued)

Hexadecimal Value	Alert	System Response	Log to File	SCU LED Indication
0x00800000	Incompatible firmware The combination of firmware on the SCU is not compatible. This may be caused by a failed attempt to update the firmware.	INIT returns `ERROR2E`	yes	Rear LED: amber flash
0x01000000	Recoverable parameter fault The user parameter file has been corrupted (CRC check failed) or is missing. To correct this problem, check that the settings of the user parameters are set correctly, and save them (use SAVE (page 119)).	INIT returns `ERROR15` See page 157.	yes	Rear LED: amber flash
0x02000000	Not in use.			
0x04000000	Reserved			
0x08000000	PTP clock not synced SCU's PTP clock is not synced with other devices on the same network.		no	Rear LED: amber flash
0x10000000	SCU fan not functioning as expected		no	Rear LED: amber flash
0x20000000	SCU battery voltage low. This may be caused by a depleted or disconnected battery.		yes	Rear LED: amber flash
0x40000000	Strober alert raised A strober parameter is missing.		yes	Rear LED: amber flash
0x80000000	Not in use			

Video Camera Alerts

Table 4-4 describes the VCU alerts that are returned by the **VCU-0.Info.Status.Alerts** and **VCU-0.Info.Status.Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together::

Table 4-4 Video Camera Alerts

Hexadecimal Value	Alert	System Response	Log to File	PSU LED Indication
0x00000001 0x00000002	Internal video camera error	If this condition persists for more than 17 seconds, the system will reboot the video camera.	no	None

4.5 Bump Sensor User Parameters

Table 4-5 lists the user parameters that relate to the bump sensor. For details on the bump sensor, see the user guide that accompanied your system.

Table 4-5 Bump Sensor User Parameters

User Parameter	Description
Info.Status.Bump Detected	This user parameter indicates when the system has detected a bump. The system sets this user parameter to “1” upon detecting a bump. The system resets this user parameter to “0” once you have set the **Param.Bump Detector.Clear** user parameter to “1”.
Param.Bump Detector.Clear	Set this user parameter to clear all bumps detected up to that point. This clears the “bump detected” bit in the **Info.Status.Alerts** user parameter, and sets the **Info.Status.Bump Detected** user parameter and the **Param.Bump Detector.Bumped** user parameter to “0”. Values: “1” clears all detected bumps. The system will automatically reset this user parameter to “0”.
Param.Bump Detector.Bumped	This user parameter indicates when the system has detected a bump. The system sets this user parameter to “1” upon detecting a bump. The system resets this user parameter to “0” once you have set the **Param.Bump Detector.Clear** user parameter to “1.”
Param.Bump Detector. Bump Detection	This user parameter enables the bump detector. Values: “1” bump detector enabled (default). “0” bump detector disabled.

4.6 Video Camera User Parameters

Table 4-6 lists the information user parameters that relate to the optional video camera. For details on the video camera, see the user guide that accompanied your system.

Table 4-6 Video Camera User Parameters

User Parameter	Description
VCU-0.Info.Status.Alerts	This user parameter describes the current state of the hardware device. See the alerts listed in Table 4-4 for the VCU. The bit corresponding to a particular alert is set when the system first detects the condition. The bit is cleared when the condition no longer exists.
VCU-0.Info.Status.New Alerts	This user parameter lists the current alerts status whenever an alert is set or cleared. The act of reading this parameter clears this parameter.

4.7 User-Defined User Parameters

There are five user parameters, **Param.User.String0** to **Param.User.String4**, that can be used to store user-defined information. For example, these parameters could be used to keep track of the system maintenance or cleaning schedule. These parameters can be used for any purpose; the system does not make use of them.

4.8 Complete List of User Parameters

The following tables list the user parameters for the Polaris Vega System. To view a complete list of user parameters for your system, use the command GET * (for parameter names and values) or GETINFO * (for parameter names, values, and usage details).

Image Capture User Parameters

The following user parameters are used in conjunction with the VCAP command. These user parameters apply only to the Position Sensor.

Table 4-7 Image Capture User Parameters

User Parameter Name	Description	Access Rules
Cmd.VGet.Sensor.Color Depth	Number of bits per pixel on the video sensor.	Read
Cmd.VGet.Sensor.Width	Number of horizontal pixels on the video sensor.	Read
Cmd.VGet.Sensor.Height	Number of vertical pixels on the video sensor.	Read
Cmd.VGet.Sensor.Number	Number of image sensors in system.	Read

Settings User Parameters

The following user parameters store settings for the hardware devices indicated in the Hardware Device column.

Table 4-8 System Settings User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Param.Laser.Laser Status	Starts/stops firing the positioning laser. Use this parameter when the Positioning Laser keyed feature is enabled. See “Positioning Laser” on page 163 for details. The laser will turn off automatically after 35 s.	Read, write	Position Sensor
Param.User.String0	User-defined string (up to 63 chars).	Read, write, save	Position Sensor, SCU
Param.User.String1	User-defined string (up to 63 chars).	Read, write, save	Position Sensor, SCU
Param.User.String2	User-defined string (up to 63 chars).	Read, write, save	Position Sensor, SCU
Param.User.String3	User-defined string (up to 63 chars).	Read, write, save	Position Sensor, SCU
Param.User.String4	User-defined string (up to 63 chars).	Read, write, save	Position Sensor, SCU
Param.Tracking. Available Volumes	Available characterized measurement volumes.	Read	Position Sensor

Table 4-8 System Settings User Parameters (Continued)

Param.Tracking.Selected Volume	Selects a characterized measurement volume. Can only be set in Setup mode.	Read, write	Position Sensor
Param.Tracking.Sensitivity.Active	Background IR sensitivity level (1-lowest, 7-highest) for wired active tools.	Read, write, save	Position Sensor
Param.Tracking.Sensitivity.Active Wireless	Background IR sensitivity level (1-lowest, 7-highest) for active wireless tools.	Read, write, save	Position Sensor
Param.Tracking.Sensitivity.Passive	Background IR sensitivity level (1-lowest, 7-highest) for wireless passive tools. Valid only for **API revision G.003.001** and later.	Read, write, save	Position Sensor
Param.Tracking.Track Frequency	Tool tracking frequency [Hz] Can only be set in Setup mode. Valid only for **API revision G.003.001** and later.	Read, write	Position Sensor
Param.Tracking.Frame Sequence	Sequence of frame types currently being tracked.	Read	Position Sensor
Param.Default Wavelength.Return Warning	Enables/disables returning a warning on PINIT if the default wavelength was selected for the tool corresponding to the port handle.	Read, write	Position Sensor
Param.Bump Detector.Bump Detection	Enables/disables the bump sensor.	Read, write, save	Position Sensor
Param.Bump Detector.Bumped	Indicates when the system has detected a bump.	Read	Position Sensor
Param.Bump Detector.Clear	Set to 'Clear' (1) to acknowledge reported bumps.	Read, write	Position Sensor
Param.Simulated Alerts	Simulates the 'Info.Status.Alerts' parameter, for testing purposes.	Read, write, save	Position Sensor, SCU
Param.System Beeper	Enables/disables the beeper sequence on system reset.	Read, write, save	Position Sensor, SCU
Param.Connect.SCU Port	TCP port for SCU connections Valid only for **API revision G.003.001** and later.	Read, write, save	SCU
Param.Connect.SCU Hostname	Host name or address for SCU connection Valid only for **API revision G.003.001** and later.	Read, write, save	Position Sensor

Table 4-8 System Settings User Parameters (Continued)

Param.Tracking.Illuminated Frame	Forces the collection of a frame with illuminators on. Takes effect on next DSTART or TSTART. Valid only for **API revision G.003.001** and later.	Read, write	Position Sensor
Param.Tracking.Background Frame	Forces the collection of a background frame with illuminators off. **T**akes effect on next DSTART or TSTART. Valid only for **API revision G.003.001** and later.	Read, write	Position Sensor
Param.Exposure.Time Slot.Passive	Time slot within the frame, to coordinate multiple position sensors. Valid only for **API revision G.003.001** and later.	Read, write	Position Sensor
Param.Exposure.Shutter Time.Other	Exposure time for illuminated and background frames [us]. Valid only for **API revision G.003.001** and later.	Read, write	Position Sensor

Information User Parameters

The following user parameters store status information for the hardware devices indicated in the Hardware Device column, and command time out values.

Table 4-9 Information User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Info.Timeout.<command>	Time out for the specified command (sec). For the SCU, only the following commands have timeout values: APIREV, COMM, DFLT, ECHO, GET, GETINFO, GETLOG, INIT, SYSLOG, RESET, SAVE, SET, VER.	Read	Position Sensor, SCU
Info.Status.System Mode	System operating mode.	Read	Position Sensor
Info.Status.Alerts	System hardware and operating status flags; see “Alerts User Parameters” on page 22 for details.	Read	Position Sensor, SCU
Info.Status.New Alerts	System hardware and operating status flags; see “Alerts User Parameters” on page 22 for details.	Read	Position Sensor, SCU
Info.Status.Bump Detected	Indicates if the system has detected a bump.	Read	Position Sensor
Info.Status.PTP.Clock State	PTP Clock Master/Slave state.	Read	Position Sensor

Table 4-9 Information User Parameters (Continued)

Info.Status.PTP.Sync State	PTP Clock sync state.	Read	Position Sensor
Info.Status.PTP.Master Offset	PTP Clock master offset in µs.	Read	Position Sensor
Info.Status.New Log Entry	Indicates a new system log entry has been made; set to 'False' (0) to clear.	Read, write	Position Sensor, SCU
Info.Status.Gravity Vector	Gravity directional vector reported in Position Sensor coordinate space. Valid only for **API revision G.003.001** and later.	Read	Position Sensor

Features User Parameters

The following user parameters store information about the features for the hardware devices indicated in the Hardware Device column.

Table 4-10 Features User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Features.Keys.Installed Keys	'Value' is the name of the installed feature.	Read	Position Sensor, SCU
Features.Keys.Active Keys	List of active feature keys; See page 161 for details.	Read	Position Sensor, SCU
Features.Keys.Disabled Keys	List of disabled keys; change takes effect on next reset. See page 161 for details.	Read, write, save	Position Sensor, SCU
Features.Tools.Enabled Tools	Maximum number of tools that can be enabled simultaneously.	Read	Position Sensor
Features.Tools.Active Ports	Maximum number of wired active tools that can be enabled simultaneously.	Read	Position Sensor
Features.Tools.Passive Ports	Maximum number of passive tools that can be enabled simultaneously.	Read	Position Sensor
Features.Tools.Wireless Ports	Maximum number wireless active tools that can be enabled simultaneously.	Read	Position Sensor
Features.Firmware.Bootloader.Version	Current bootloader revision number.	Read	Position Sensor
Features.Firmware.Version	Current firmware revision number.	Read	Position Sensor, SCU
Features.Firmware.Major Version	Current firmware major revision number.	Read	Position Sensor, SCU
Features.Firmware.Minor Version	Current firmware minor revision number.	Read	Position Sensor, SCU
Features.Firmware.Build Number	Current firmware build revision number.	Read	Position Sensor, SCU

Table 4-10 Features User Parameters (Continued)

Features.Firmware.Available Versions	List of firmware revisions loaded in the device.	Read	Position Sensor, SCU
Features.Firmware. Maximum Versions	Number of firmware revisions that may be stored in the device simultaneously.	Read	Position Sensor, SCU
Features.Firmware. Configuration Check	System configuration checksum (for NDI use only).	Read	Position Sensor, SCU
Features.Firmware.Package Number	Current firmware package number.	Read	Position Sensor, SCU
Features.Hardware. Serial Number	Hardware device serial number.	Read	Position Sensor, SCU
Features.Hardware.Part Number	Product part number.	Read	Position Sensor, SCU
Features.Hardware. OEM Number	Hardware device customer number.	Read	Position Sensor, SCU
Features.Hardware.Model	Hardware device model name.	Read	Position Sensor, SCU
Features.Firmware. Safeloader Version	Current safeloader firmware revision number.	Read	Position Sensor, SCU
Features.Firmware. Available Combined Firmware Revisions	List of combined firmware revisions loaded in the device.	Read	Position Sensor, SCU
Features.Firmware. Combined Firmware Revision	Current combined firmware revision of the device.	Read	Position Sensor, SCU
Features.Volumes.*	Volume information from camera parameter files.	Read	Position Sensor
Features.Video Camera	Video camera is installed or not installed.	Read	Position Sensor

System Configuration User Parameters

The following user parameters store information about the configuration of the system. These user parameters describe the configuration of the entire system, not a particular device.

Table 4-11 System Configuration User Parameters

User Parameter Name	Description	Access Rules
Config.Multi Firmware. Load Combined Firmware Revision	Combined firmware revision to load on next reset (selection automatically saves when set). Use this parameter when the Multi Firmware keyed feature is enabled. See “Multi Firmware Feature” on page 162 for details.	Read, write
Config.Multi Firmware. Update Combined Firmware Revision	Combined firmware revision to replace on next upgrade or downgrade. Use this parameter when the Multi Firmware keyed feature is enabled. See “Multi Firmware Feature” on page 162 for details.	Read, write, save
Config.Multi Firmware. Available Combined Firmware Revisions	List of combined firmware revisions loaded in the system.	Read
Config.Combined Firmware Revision	Current combined firmware revision of the system.	Read

Hardware Device Information User Parameters

The following user parameters store information about the hardware devices in the system. See “Device Names” on page 21 for information on how to use the hardware device user parameters.

Table 4-12 Hardware Device User Parameters

User Parameter Name	Description	Access Rules
Device.Type	Type of device in the system configuration.	Read
Device.Instance	Instance of this type of device in the system configuration.	Read
Device.Address	The network address of the device (or “local” if that is the device you are talking to).	Read
Device.Port	The network port to connect to the device.	Read

Network User Parameters

The following user parameters store information about the system network settings.

Table 4-13 Network User Parameters

User Parameter Name	Description	Access Rules
Param.Network.IP Method	Method of receiving IP address.	Read, Write, Save
Param.Network.Static.IP Address	Requested ethernet interface IPv4 address.	Read, Write, Save
Param.Network.Static.Subnet Mask	Requested ethernet interface IPv4 subnet mask.	Read, Write, Save
Param.Network.Static.Gateway	Requested interface IPv4 gateway.	Read, Write, Save
Param.Network.DNS Servers	DNS Server list. Space separated.	Read, Write, Save
Param.Network.Host Name	Ethernet interface hostname, blank for default.	Read, Write, Save
Param.Network.MAC Address	Ethernet interface MAC address.	Read, Write, Save
Param.Network.Service Name	Service name advertised in DNS-SD. m=model h=host name, n=serial number, t=tracking group.	Read, Write, Save
Param.Network.Tracking Group	Tracking group name. Enables discovery of group members.	Read, Write, Save
Param.Connect.Master Hosts	List of hosts allowed to become configuration masters, blank=unrestricted.	Read, Write, Save
Param.Connect.Monitor Hosts	List of hosts allowed to connect, blank=unrestricted, none=no monitor hosts.	Read, Write, Save
Param.Connect.Host Port	TCP port to listen for host connections.	Read, Write, Save
Info.Connections. Address	Remote IP address.	Read
Info.Connections.Port	Remote IP port.	Read
Info.Connections.Rx Bytes	Received byte count.	Read
Info.Connections.Tx Bytes	Transmitted byte count.	Read
Info.Connections.Requests	Number of API requests.	Read
Info.Connections.Replies	Number of API replies.	Read
Info.Connections.Streams	Number of active streams.	Read
Info.Connect.isMaster	True if this connection is master.	Read
Info.Connect.isAuth	True if this connection is authenticated.	Read
Param.Connect.Master Timeout	Seconds of inactivity before another connection is allowed to become master (0=never)	Read, Write, Save

Param.Connect.SCU Port	TCP port for SCU connections	Read, Write, Save
Param.Connect.SCU Hostname	Host name or address for SCU connection	Read, Write, Save

Clock User Parameters

The following user parameters store information about the system clock.

Table 4-14 Clock User Parameters

User Parameter Name	Description	Access Rules
Param.Clock.Date	Numerical value for the day of the month.	Read, Write, Save
Param.Clock.Day Of Week	Numerical value for the day of the week. 0= Monday, 1= Tuesday, etc.	Read, Write, Save
Param.Clock.Hours	Numerical value for the current hour using the 24 hour clock.	Read, Write, Save
Param.Clock.Minutes	Numerical value for the current minute.	Read, Write, Save
Param.Clock.Seconds	Numerical value for the current second.	Read, Write, Save
Param.Clock.Year	Numerical value for the current year, using the last two digits of the year. For example, 2016 would be set as 16.	Read, Write, Save
Param.Clock.Month	Numerical value for the current month.	Read, Write, Save

Volume User Parameters

The following user parameters describe the volume shapes and supported wavelengths for the measurement volumes.

Table 4-15 Volume User Parameters

User Parameter Name	Description	Access Rules
Features.Volumes.Index	Indicates the volume that is being referred to.	Read
Features.Volumes.Name	The volume name.	Read
Features.Volumes.Shape	The shape type.	Read
Features.Volumes.Wavelengths	Which wavelengths are supported in the volume.	Read
Features.Volumes.Param*n*	Shape parameters as described in SFLIST.	Read

Video Camera User Parameters

The following parameters store information about the video camera.

Table 4-16 Video Camera User Parameters

User Parameter Name	Description	Access Rules
Param.Video Camera.Allow Streaming	Enables or disables video output.Video output is disabled by default. Note: INIT does not disable video streaming if it has been enabled.	Read/Write
VCU-0.Features.Firmware.Version	Current firmware revision number for the video camera.	Read
VCU-0.Param.White Balance.[Red|Green|Blue]	Selected white balance configuration. Values: 0 to 128	Read/Write/Save
VCU-0.Param.White Balance.Name	Lighting presets to control the R|G|B colour gains.	Read/Write/Save
VCU-0.Param.White Balance. Gains.[Name|Red|Green|Blue]	Gain values that are set when the VCU-0.White Balance.Name is changed.	Read/Write
VCU-0.Param.System Gain	A multiplier applied to the colour gains to increase or decrease overall brightness. Values: 0-15.998	Read/Write/Save
VCU-0.Param.Brightness	Brightness offset added to all pixels equally, not based on colour. Values: 0 to 255	Read/Write/Save
VCU-0.Param.Contrast	The contrast gain parameter applied to all colours. Value: 0-15.94	Read/Write/Save
VCU-0.Param.Exposure Time	Exposure time in microseconds.	Read/Write/Save
VCU-0.Param.Frame Rate	The frame rate streaming out of the video camera in frames per second.	Read
VCU-0.Param.Resolution	Selects the resolution of the video stream.	Read/Write/Save
VCU-0.Param.Stream Preset	Video stream parameters, prioritizing quality, latency, or compression.	Read/Write/Save
VCU-0.Param.Vertical Flip	Vertically flips the image generated by the video camera.	Read/Write/Save
VCU-0.Param.Clients	IP address of the client connected to the video stream.	Read
VCU-0.Param.Disconnect Clients	Set this parameter to disconnect the connected client. Values: “1” disconnects the client. The system will automatically reset this parameter to “0”.	Write
VCU-0.Param.Lens. Distortion.[k1|k2|k3|p1|p2]	Lens distortion parameters for Zhang's method for the currently selected resolution parameters. Values come from factory characterization of the video camera.	Read
VCU-0.Param.Lens. Pinhole.[U0,V0,fx,fy]	Lens pinhole parameters for the currently selected resolution. Values come from factory characterization of the video camera.	Read

VCU-0.Param.Lens.6D.[q0|qx|qy|qz|x|y|z]	The orientation and location of the video camera in the Vega measurement coordinate space. Initial values come from factory characterization of the video camera.	Read/Write/Save
VCU-0.Param.Lens.6D.reset	Use this parameter to reset the 6D values to factory defaults. Values: “1” resets the 6D parameters. The system will automatically reset this parameter to “0”.	Write

5 Command Details

Before sending any commands to the system, read the user guide that accompanied your system to ensure that you have a full understanding of the system functionality.

3D

Returns the latest three-dimensional marker position of a single marker or multiple markers.

Deprecated

Operating Mode

Diagnostic, Tracking

Prerequisite Command

IRED (page 86), only for active markers in Diagnostic mode

Syntax

```
3D<SPACE><Port Handle><Reply Option><CR>
```

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td><code>Port Handle</code></td><td colspan="2">2 hexadecimal characters.
Specifies for which type of marker the system will report data (see “Usage Notes” on page 45 for details). The specified port handle must be initialized (PINIT) and enabled (PENA).</td></tr>
<tr><td rowspan="6"><code>Reply Option</code></td><td colspan="2">Specifies which information will be returned.
The reply options cannot be OR’d.
<b>Valid Values:</b></td></tr>
<tr><td>1</td><td>Single marker 3D data, with error value</td></tr>
<tr><td>2</td><td>Single marker 3D data, with error value and out-of-volume information</td></tr>
<tr><td>3</td><td>Single marker 3D data, with line separation value</td></tr>
<tr><td>4</td><td>Single marker 3D data, with line separation value and out-of-volume information</td></tr>
<tr><td>5</td><td>3D data for up to 50 markers, with line separation and out-of-volume information</td></tr>
</table>

Replies

Upon Success:

```
<Number of Visible Markers><LF>
<Reply Option n Data><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`Number of Visible Markers`	3 characters (a sign and 2 decimal digits) The number of markers detected by the system. For reply options 1 to 4, only one marker can be in view. If more than one marker is in view, the system will return 00 for the number of markers.
`Reply Option n Data`	The data specific to the requested reply option. See the reply option information below for details: Reply option 1 (3D data for a single marker, with error value) Reply option 2 (3D data for a single marker, with error value and out-of-volume information) Reply option 3 (3D data for a single marker, with line separation value) Reply option 4 (3D data for a single marker, with line separation value and out-of-volume information) Reply option 5 (3D data for up to 50 markers, with line separation and out-of-volume information)

Reply Option 1 - 3D data for a single marker, with error value

```
<Reply Option 1 Data> = <Tx><Ty><Tz><Error Value>
```

Reply Component	Description
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.
`Error Value`	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The normalized error number associated with the calculation for this marker position. **Possible Values:** +000 (best case) to +100 (worst case)

Reply Option 2 - 3D data for a single marker, with error value and out-of-volume information

```
<Reply Option 2 Data> = <Tx><Ty><Tz><Error Value><Out of Volume>
```

Reply Component	Description
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.

Reply Component	Description	
`Error Value`	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The normalized error number associated with the calculation for this marker position. **Possible Values:** +000 (best case) to +100 (worst case)	
`Out of Volume`	1 hexadecimal character Indicates whether the marker is outside the characterized measurement volume. **Possible Values:**	
	0	The marker is inside the characterized measurement volume.
	1	The marker is out of volume.

Reply Option 3 - 3D data for a single marker, with line separation value

```
<Reply Option 3 Data> = <Tx><Ty><Tz><Line Separation>
```

Reply Component	Description
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.
`Line Separation`	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)

Reply Option 4 - 3D data for a single marker, with line separation value and out-of-volume information

<Reply Option 4 Data> = <T_x><T_y><T_z><Line Separation><Out of Volume>

Reply Component	Description
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.

Reply Component	Description
Line Separation	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)
Out of Volume	1 hexadecimal character Indicates whether the marker is outside the characterized measurement volume. **Possible Values:** 0 The marker is inside the characterized measurement volume. 1 The marker is out of volume.

Reply Option 5 - 3D data for up to 50 markers, with line separation value and out-of-volume information

<Reply Option 5 Data> =
<T_{x1}><T_{y1}><T_{z1}><Line Separation 1><Out of Volume 1><LF>
<T_{x50}><T_{y50}><T_{z50}><Line Separation 50><Out of Volume 50><LF>

Reply Component	Description
Txn, Tyn, Tzn	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the nth marker, in the coordinate system of the Position Sensor. The system will report up to 50 3D positions, including phantom markers. If the system detects more than 50 IR sources, it will only report the first 50. The IR sources are not reported in any particular order.
Line Separation n	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) Line separation of the nth marker. The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)
Out of Volume n	1 hexadecimal character Indicates whether the nth marker is outside the characterized measurement volume. **Possible Values:** 0 The marker is inside the characterized measurement volume. 1 The marker is out of volume.

Usage Notes

1. The specified port handle must be enabled using PENA (page 91).
2. You may need to use the 3D command about ten times if it is sent immediately after using IRED (page 86). This allows time for the system to implement the activation signature and optimize the signal by adjusting the range control.
3. **Reply Options 1 to 4**: You cannot have more than one marker in view. Any other IR sources in view will prevent the system from returning marker data.
4. **Reply Option 5**: The system does not distinguish between real markers, phantom markers, or other IR sources. You must determine whether the reported marker positions are valid. See the user guide that accompanied the system for more information on phantom markers.
5. The 3D command returns data regardless of the bump status, temperature status, and other system status conditions. Before trusting the marker positions returned by the 3D command, you should check these conditions by reading the **Info.Status.Alerts** user parameter. (Use the GET (page 77) command to check the value of user parameters.) You can use the BX (page 49) or TX (page 138) command to request 3D data that is filtered when the bump status, temperature status, or other system conditions are not ideal.

Compatibility Notes

Reply Option 1 and **Reply Option 2**: The system will not calculate an error, and will return an error value of +000.

Example

Command:

```
3D 011
```

Reply:

```
+01-12345678+12345678-12345678+0954B7B
```

In this case, one marker is in view.

APIREV

Returns the API revision number that functions with your system.

Operating Mode

All modes

Syntax

```
APIREV<SPACE><CR>
```

Replies

Upon Success:

```
<Family>.<Major revision number>.<Minor revision number><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`Family`	1 ASCII character. This character is always G. (Other types of NDI measurement systems use other characters.)
`Major revision number`	3 ASCII characters The major revision number is incremented whenever there is an incompatible change in the API. (Whenever a command is deprecated or when its response is changed in a way that may break an application.)
`Minor revision number`	3 ASCII characters The minor number is incremented whenever there is an addition to the API that is compatible with all existing applications and usage. (Compatible changes are additions to the API command or option set that will not affect any existing applications.)

Example

Command:

```
APIREV
```

Reply:

```
G.003.0016379
```

BEEP

Sounds the system beeper.

Operating Mode

All modes

Syntax

```
BEEP<SPACE><Number of Beeps><CR>
```

Parameter	Description
`Number of Beeps`	**Valid Values:** 1 to 9

Replies

Upon Success:

```
<Beep Status><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description		G.003.002
`Beep Status`	**Possible Values:**		
	0	The system is busy beeping.	
	1	Beeping has started.	X

Usage Notes

1. The beep duration is shorter than the beep used for reset and fatal error conditions.
2. Disabling the system beeper (by setting the value of the user parameter **Param.System Beeper**) does not affect the BEEP command.

Compatibility Notes

The system will never return a beep status of 0. If you send the BEEP command while the system is busy beeping, the system will return a beep status of 1, but will not initiate the second sequence of beeps.

Example

Command:

```
BEEP 1
```

Reply:

```
1D4C1
```

BX

Returns the latest tool transformations, individual marker positions, and system status in binary format.

Operating Mode

Tracking

Note For information on previous revisions of the API, refer to the *Polaris Application Program Interface Guide* (IL-1070101) available on the NDI support site at https://support.ndigital.com.

Syntax

```
BX<SPACE><Reply Option><CR>
```

Parameter	Description		G.003.002
`Reply Option`	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned for each port handle in order of increasing option value, with the following exceptions: Reply option 0800 is not reported separately from the other options; it simply enables the system to return certain information in the other options. Reply option 1000 is reported after all handle-specific options but before the <system status> and <CRC16>. **Valid Values:**		
	0001	Transformation data (default)	X
	0002	Tool and marker information	X
	0004	3D position of a single stray active marker	X
	0008	3D positions of markers on tools	X
	0800	Transformations not normally reported	X
	1000	3D positions of stray passive markers	X

Replies

Upon Success:

```
<Start Sequence><Reply Length><Header CRC><01(Number of Handles)>
<Handle 1><Handle 1 Status><Reply Opt 0001 Data>...<Reply Opt 0008 Data>
...
<Handle n><Handle n Status><Reply Opt 0001 Data>...<Reply Opt 0008 Data>
```

```
<Reply Option 1000 Data>
<System Status><CRC16>
```

Note The reply for the BX command is binary data.

Note If a handle status is “disabled,” the system will not return any of <Reply Option 0001 Data>... <Reply Option 0008> for that port handle.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description		G.003.002
`Start Sequence`	2 bytes: A5C4 Indicates the start of the BX reply.		X
`Reply Length`	2 bytes Indicates the number of bytes in the reply body between the <Header CRC> and the <CRC16>, exclusive.		X
`Header CRC`	2 bytes CRC16 of <Start Sequence> and <Reply Length>		X
`Number of Handles`	1 byte The number of port handles for which information is returned.		X
`Handle n`	1 byte The port handle whose information follows.		X
`Handle Status`	1 byte **Possible Values:**		
	01	Valid	X
	02	Missing	X
	04	Disabled	X

Reply Component	Description		G.003.002
`Reply Option m Data`	The data specific to the requested reply option. See the reply option information below for details:		
	Reply option 0001 (transformation data) (default)		X
	Reply option 0002 (tool and marker information)		X
	Reply option 0004 (latest 3D position of single stray active marker)		X
	Reply option 0008 (3D position of markers on tools)		X
	Reply option 0800 (reporting all transformations)		X
	Reply option 1000 (3D position of stray passive markers)		X
`System Status`	2 bytes The status of the system. **Bit field:**		
	bit 0	System communication synchronization error	X
	bits 1 and 2	Reserved	
	bit 3	Recoverable system processing exception.	X
	bit 4-5	Reserved	
	bit 6	Some port handle has become occupied	X
	bit 7	Some port handle has become unoccupied	X
	bit 8	Diagnostic pending	X
	bit 9	Temperature (system is not within operating temperature range)	X
	bit 10	Hardware configuration changed (e.g. VCU or SCU has connected or disconnected)	X
	bits 11 to 15	Reserved	

Note The “diagnostic pending” bit is set whenever an alert is detected or cleared. To view the alerts status and clear the diagnostic pending bit, use GET (page 77) to check the Info.Status.New Alerts user parameter for every hardware device in the system. See “Usage Notes” on page 58 for more details. (For API revision G.001.003 and earlier, the diagnostic pending bit did not indicate when an alert was cleared.)

Reply Option 0001 - Transformation Data

<Reply Option 0001 Data> = <Q_0><Q_x><Q_y><Q_z><T_x><T_y><T_z><Error><Port Status><Frame Number>
or
<Reply Option 0001 Data> = <Port Status><Frame Number>

Reply Component	Description	G.003.002
`Q0, Qx, Qy, Qz`	4 bytes each Rotational components of the transformation, quaternion, unitless, reported as IEEE 32-bit, single precision, floating point numbers. The value for Q0 is always non-negative.	X
`Tx, Ty, Tz`	4 bytes each Translational components of the transformation, in mm, reported as IEEE 32-bit, single precision, floating point numbers.	X
`Error`	4 bytes The error is an RMS value, given in mm. It is the result of the least squares minimization between the marker geometry in the tool definition file and the data from the tool’s markers measured by the system. Reported as IEEE 32-bit, single precision, floating point number.	X

Reply Component	Description		G.003.002
`Port Status`	4 bytes **Bit field:**		
	bit 0	Occupied	X
	bit 1	Switch 1 closed	X
	bit 2	Switch 2 closed	X
	bit 3	Switch 3 closed	X
	bits 4	Initialized	X
	bit 5	Enabled	X
	bit 6	Out of volume	X
	bit 7	Partially out of volume	X
	bit 8	Algorithm limitation (processing requires more buffer than is available)	X
	bit 9	IR interference (a large bright IR object)	X
	bits 10 and 11	Reserved	
	bit 12	Processing exception (same as tool information bit 7 in reply option 0002)	X
	bit 13	Reserved	
	bit 14	Fell behind while processing (same as tool information bit 3 in reply option 0002)	X
	bit 15	Data buffer limitation (too much data; for example, too many markers)	X
	bits 16 to 31	Reserved	
`Frame Number`	4 byte unsigned number The frame number is an internal counter related to data acquisition, which is derived from the PTP time. The frame rate is 60 Hz. The frame number corresponds to the frame in which the raw data, used to calculate the accompanying transformation, was collected.		X

Note If the handle status is “missing,” the system returns only the port status and the frame number.
- Tools are reported as missing if a transformation cannot be determined.
- In the event of a system error that prevents tracking, all tools are reported as missing.

Reply Option 0002 - Tool and Marker Information

```
<Reply Option 0002 Data> = <Tool Information><Marker Information>
```

Reply Component	Description		G.003.002
`Tool Information`	1 byte **Bit field:**		
	bit 0	Bad transformation fit	X
	bit 1	Not enough acceptable markers for transformation	X
	bit 2	IR interference—environmental IR is interfering with the system (combination of port status bits 9 and 15 in reply option 0001)	X
	bit 3	Fell behind while processing (same as port status bit 14 in reply option 0001)	X
	bits 4 to 6	Tool face used	X
	bit 7	Processing exception (same as port status bit 12 in reply option 0001)	X
`Marker Information`	10 bytes (4 bits per marker) See below for an example. **Possible Values:**		
	0000	Not used because it was missing	X
	0001	Not used because it exceeded the maximum marker angle	X
	0010	Not used because it exceeded the maximum 3D error for the tool	X
	0011	Used to calculate the transformation	X
	0100	Used to calculate the transformation, but it is out of volume	X
	0101	Not used because it was outside the characterized measurement and was not needed to calculate a transformation.	X

Example - Marker Information: A tool with markers located at T, R, C, and A, where all four markers were used to determine the calculation, would have the following reply:

Marker	T	S	R	Q	...	D	C	B	A
Reply	0011	0000	0011	0000	...	0000	0011	0000	0011

Reply Option 0004 - 3D Position of Single Stray Active Marker

<Reply Option 0004 Data> = <Status><T_x><T_y><T_z>

```
or
<Reply Option 0004 Data> = <Status>
```

Reply Component	Description		G.003.002
`Status`	1 byte The status of the stray active marker. A stray marker on an active tool is not fixed with respect to the other markers that make up the tool. **Bit field:**		
	bit 0	Valid stray active marker	X
	bit 1	Marker is missing	X
	bit 2	Reserved	
	bit 3	Marker is out of volume	X
	bits 4 to 7	Reserved	
`Tx, Ty, Tz`	4 bytes each Position of the marker in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers. The marker position is reported only if the marker status is “valid,” or “out of volume” and reply option 0800 is used.		X

Note If no stray active marker is defined (for example, for wireless port handles, or wired tools with no stray marker defined in the tool definition file), the status is 00, and no position information is returned. If the marker is missing, or if the marker is out of volume and reply option 0800 is not used, the system returns only the status.

Reply Option 0008 - 3D Position of Markers On Tools

<Reply Option 0008 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.003.002
Number of Markers	1 byte Number of markers used in tool transformations.	X
Out of Volume	1 byte/8 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/8, rounded up to the nearest integer.	X
Txn, Tyn, and Tzn	4 bytes each Position of the nth marker, reported in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers. The system will report the positions of markers used in tool transformations, as well as markers that exceeded the maximum marker angle or maximum 3D error specified in the tool definition file. See “Usage Notes” on page 58 for more information.	X

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number								9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Reply	0				1				F				F			
Reply Byte	n								n + 1							

Reply Option 0800 - Reporting All Transformations

This option enables the reporting of transformations or translations in situations where translations or transformations are calculated, but by default are not reported by the system. Such situations include:

- The tool or marker is outside of the characterized measurement volume.
- The bump sensor has been tripped.
- The system is outside of the optimal operating temperature range.

- Other system conditions are not ideal; see “Alerts User Parameters” on page 22 for a full list of these conditions.

This reply option must be OR’d with reply option 0001 to obtain transformations for tools in the situations listed above. It must be OR’d with reply options 0004, 0008, or 1000 to obtain position information for markers in the situations listed above.

Warning!

When using reply option 0800 with the BX command, you must take appropriate action to detect the events listed above, and determine whether they are detrimental to your application. If one or more of the events listed above occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Appropriate action to detect the events listed above includes:

- reading the out-of-volume flag in reply options 0001 and 0002 when tracking tools
- reading the out-of-volume information in reply options 0004, 0008, and 1000 when tracking stray markers
- reading the temperature flag in the system status
- reading the diagnostic pending bit in the system status
- reading the **Info.Status.New Alerts** user parameter for every hardware device in the system when the diagnostic pending bit is set. See “Usage Notes” on page 58 for details.

Reply Option 1000 - 3D Position of Stray Passive Markers

<Reply Option 1000 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.003.002
Number of Markers	1 byte Number of stray markers.	X
Out of Volume	1 byte/8 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/8, rounded up to the nearest integer.	X
Txn, Tyn, Tzn	4 bytes each Position of the nth marker in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers.	X

Note At least one passive port handle must be enabled, to activate the illuminators on the Position Sensor. If no passive port handles are enabled, <Number of Markers> will return 00 and no other data will be returned.

Stray passive markers are defined as markers which are not used to calculate any of the transformations for any enabled, passive tools. Stray active wireless tool markers are not reported.

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number								9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Reply	0				1				F				F			
Reply Byte	n								n + 1							

Usage Notes

1. The BX reply format requires fewer characters than the text format; this allows transformations to be reported more quickly. For replies in text format, use TX (page 138).
2. Replies are returned in little endian format.
3. By default, transformations will not be reported if the tool is either partially or wholly out of the characterized measurement volume, if the bump sensor has been tripped, if the system is outside of the optimal operating temperature range, or if certain other alerts have occurred (see “Alerts User Parameters” on page 22 for details). To report these transformations, you must use reply option 0800 OR’d with the desired reply option(s). The accuracy of these transformations is unknown.
4. **Reply Option 0001**:
    - When the “diagnostic pending” bit is set in the system status, use GET (page 77) to read the **Info.Status.New Alerts** user parameter for every hardware device in the system. The act of reading these parameters clears the parameters and the “diagnostic pending” bit. For more information on alerts and their associated user parameters, see “Alerts User Parameters” on page 22.
    - For wired tools, bits 1, 2, and 3 in the port status report switch status.
5. **Reply Option 0008**: Markers are returned in alphabetical order according to how they are labelled in the tool definition file. For example, for a tool with markers labelled A, G, M and S, the system will return the marker positions in the order A G M S. Reply option 0008 only returns data for markers that the system detects. To identify which marker is which, compare the reply option 0008 data to the data returned with reply option 0002. The marker order is the same for both replies; each marker that does not have a <marker information> status of 0000 (“missing”) in reply option 0002 corresponds to a marker in reply option 0008.

Compatibility Notes

1. **System Status**:
    - The external IR bit (bit 1) and system CRC error bit (bit 2) are not used by the system.

- In API revision G.001.004 and later, the diagnostic pending bit (bit 8) is set whenever an alert is detected or cleared. In API revision G.001.003 and earlier, the diagnostic pending bit is set only when an alert is detected.

2. **Reply Option 0002**:

    - Reply 0010 means that the marker was not used because it exceeded the maximum 3D error for the tool.

Example

Command:

```
BX 0801
```

Reply:

```
A5C4005723130201013F3AF3CABE5B7209BF1C07713E635592C39E831F43332973C500511
33DA5BD9F00000031000002CC02013EA1B5D03D137D21BD787C673F72394A4286B6CB4360
6EF4C50468C13ED4E74100000031000002CD000059C9
```

This is the hexadecimal representation of the binary data being returned. This example returns data for two tools.

BX2

Returns the latest tool transformations, individual marker positions, and system status in the General Binary Format.

The BX2 command provides a flexible way of providing measurement data at various levels of detail. The reply can contain a single or multiple frames. Each frame can contain various levels of measurement data details such as 6D, 3D or 2D data.

- It does not repeat already reported information.
- It works with the STREAM command to keep latency to a minimum and avoid missing or repeating information.
- Addresses the problem of providing system wide failures and warning in the multi-connection environment.

Operating Mode

Tracking

Syntax

```
BX2<SPACE><Reply Options><CR>
```

Reply Option	Description
--6d= tools|none	specifies whether 6D information for tools are returned or not. Default is “tools”
--3d= none|tools|strays|all	specifies which 3D information is returned, none, tool 3D’s, stray 3D’s or all 3D’s. The default is none. (If selected, 3D’s will be returned for all frame types, not just passive frames.)
--2d= none|tools|strays|all	specifies which 2D (line of sight) information will be returned. The default is none.
--sensor=none|tools|strays|all	--sensor specifies which scaled sensor UV information is returned. Scaled UV can be used to visualize the images on the sensors and also provide diagnostic information related to UV brightness. The default is none.
--1d=buttons|none	--1d specifies whether buttons are reported or not. The default is buttons.

Replies

Upon Success:

```
<Start Sequence><2 byte Reply Length><Header CRC><GBF Version>
<Component Count><Frame Component 1>...<Frame Component N><Data CRC>
```

or

```
<Extended Binary Start Sequence><4 byte Reply Length><GBF
Version><Component Count><Frame Component 1>...<Frame Component N>
```

On Error:

```
ERROR<error code>
```

See page 157 for error code definitions.

Frame Component: 0x0001

The Frame status field contains error status information related to the frame. In all cases, a value of zero indicates no errors or fault conditions.

All other measurement data details are included as part of the frame data payload. The payload itself follows the General Binary Format.

Frame Data Item		
Frame Type	1 byte	See below
Frame Sequence Index	1 byte	
Frame Status	2 bytes	See below
Frame Number	4 bytes	
Frame Timestamp	8 bytes	struct timespec (bytes 0-3=seconds since start of epoch, bytes 4-7=nanoseconds)
Frame Data Payload	Variable	General Binary Format

Frame Types will be as follows:

DUMMY =	0
ACTIVE_WIRELESS =	1
PASSIVE =	2
ACTIVE =	3
LASER =	4
ILLUMINATED =	5
BACKGROUND =	6
MAGNETIC =	7

Frame Status is as follows:

Bit 0-15	This field uses the same codes as the 6D Port/ Tool Status, but only the ones which are applicable to the frame as a whole.

6D Data Component: 0x0002

The payload consists of a variable number of 6D data items. Each item has a tool handle (2 bytes in the interest of data alignment) followed by a 2 byte bit-field of port/tool status. If the tool is not missing, this will be followed by a transformation in the same format as the BX command (q0, qx, qy, qz, tx, ty, tz, error)

6D Tool Data Item		
Tool Handle	2 bytes	
Status	2 bytes	See below
Q0, Qx, Qy, Qz, Tx, Ty, Tz, Error	4 bytes each	

Port/Tool Status is as follows:

Bit 0-7	Error codes as described in Port/Tool Status Error Codes (page 62) and Port/Tool Status Error Codes (Tool Missing) (page 62)
Bit 8	Transform missing
Bit 9-12	Reserved
Bit 13-15	Which face of a multi-face tool is being tracked

Table 5-1 Port/Tool Status Error Codes

Error Code	Description
0	Enabled
3	Tool is partially out of the characterized measurement volume
9	Tool is out of the characterized measurement volume

Note The following error codes will only be reported if the tool is missing

Table 5-2 Port/Tool Status Error Codes (Tool Missing)

Error Code	Description
13	Too few markers detected
14	IR interference (a large bright IR object)
17	Bad transformation fit
18	Data buffer limitation (too much data; for example, too many markers)
19	Algorithm limitation (processing requires more buffer than is available)
20	Fell behind while processing

Table 5-2 Port/Tool Status Error Codes (Tool Missing)

Error Code	Description
21	Position sensors out of synch
22	Processing exception
31	Tool is missing
32	Tracking is not enabled for this tool
33	Tool has been unplugged from the System Control Unit

3D Data Component: 0x0003

The 3D component payload consists of a variable number of 3D items. Each item has a 4 byte handle reference to the port handle of the tool to which the 3D’s belong. If the 3D is “stray”, the handle reference will be -1. Location information will be equivalent to the 3D information in the BX command. If the marker is missing its 3D item then information will not be present.

Note To provide additional diagnostic information for active and passive tools, all defined markers are reported with appropriate status and index (whether they are visible or not) for tools defined with up to 20 markers. For tools with more than 20 defined markers, only visible markers will be reported.

3D Tool Data Item		
Tool Handle Reference	2 bytes	0xffff for “stray” 3D
Number of 3Ds	2 bytes	
3D Data Item		
Status	1 byte	See below
-reserved-	1 byte	
Marker Index	2 bytes	index of marker on tool, sequential # for strays
X, Y, Z	4 bytes each	

For data alignment, the marker status field is 4 bytes as follows:

0x00	OK
0x01	Missing (missing markers may not be reported in component at all)
0x02	Not used: exceeded max marker angle
0x03	Not used: exceeded max 3D error for tool
0x04	Not used: Out of Volume
0x05	Out of Volume – used in 6D
0x06	Possible phantom marker (in volume, applies to stray markers only
0x07	Saturated (in or out of volume, not used in 6D)

0x08	Saturated and out of volume (not used in 6D)
0x09-0xFF	reserved

1D Button Component: 0x0004

The 1D button component consists of a variable number of button state items. Each item contains a port handle (tool) reference or, in the case of non-tool buttons, a dummy tool reference corresponding to the frame in which the button was sampled. Button states are 1 byte each. Use 0 for open and 1 for closed.

Note Currently the only supported states are CLOSED and OPEN. In future, button processing on the firmware may be enhanced to support additional states, such as PRESSED, RELEASED, CLICKED, DOUBLE-CLICKED, HOLD, etc.

1D Button Data Item		
Tool Handle Reference	2 bytes	0xffff for “stray” (non-tool) buttons
Number of buttons	2 bytes	
Button Data Item		
Button data	4 bytes	1 byte for each 4 buttons (little endian)

2D Data Component: 0x0005

The 2D data component is as follows:

Tool Line of Sight (LOS) Item		
Tool Handle Reference	2 bytes	0xffff for “stray” LOS
Number of Sensors	2 bytes	
LOS Sensor Item		
Sensor Reference	2 bytes	Index number of the sensor
Number of LOS Items	2 bytes	
LOS Item		
Base X,Y,Z	4 bytes each	vector from origin to sensor
LOS X,Y,Z	4 bytes each	LOS vector from sensor
Number Marker References (N)	2 bytes	0-65535
Marker References	2 bytes each	Index of 3D item reported for tool handle
LOS Item padding	((N+1)*2)%4 bytes	0 or 2 bytes of padding to ensure each item ends in a 4 byte boundary

Sensor UV Component: 0x0011

This component is returned if the –sensor option is used. It returns simplified uv data that can be used for diagnostics.

Component Item		
Tool Handle Reference	2 bytes	0xffff for “stray” LOS

Number of Sensors	2 bytes	
UV Sensor Item		
Sensor Reference	2 bytes	Index number of the sensor
Number of UV Items	2 bytes	
Scaled UV Item		
Scaled U, scaled V	1 byte each	0-255 upper left of view is 0,0
Width U, Height V	1 bytes each	
Energy	4 bytes	Sum intensity of all centroid pixels
Peak Intensity	2 bytes	0-65535
Number Marker References (N)	2 bytes	
Marker References	2 bytes each	Refers to 3D index for tool in 3D item
UV Item padding	((N+1)*2)%4 bytes	0 or 2 bytes of padding to ensure each item ends in a 4 byte boundary

System Alert Component 0x0012

The System Alert Component returns all current system faults, alerts and events. The component header indicates the number of items. An item consists of a 2 byte type followed by a 2 byte code.

Faults are conditions that indicate the system is unable to function correctly. In general the unit must be returned to NDI for repair. Alerts are conditions that may impact measurement performance but can be resolved on their own or without physical repair. Events may also impact performance or system behaviour but they are a normal part of operations and do not indicate a system malfunction.

Component Item		
Condition Type	1 byte	0=fault, 1=alert 2=event
- reserved -	1 bytes	
Condition Code	2 bytes each	

Faults

The following faults are returned as part of the BX2 component 0x0012:

Error Code	Description
1	Non-recoverable parameter fault
2	Sensor parameter fault
3	Main voltage fault
4	Sensor voltage fault
5	Illuminator voltage fault
6	Illuminator current fault
7	Sensor 0 temperature fault (left)
8	Sensor 1 temperature fault (right)
9	Main temperature fault
10	Sensor fault

Alerts

The following alerts are returned as part of the BX2 component 0x0012:

Error Code	Description
1	Battery fault
2	Bump detected
3	Firmware incompatible
4	Non fatal parameter fault
5	Not used
6	Not used
7	Not used
8	Temperature high
9	Temperature low
10	SCU disconnected
11	Not used
12	Not used
13	Not used
14	PTP synchronization fault
15	Video camera not functioning

For detailed information on system faults and alerts, refer to "Position Sensor Alerts" on page 23.

Events

The following events are returned as part of the BX2 component 0x0012:

Event Code	Description	How the event is cleared
1	Active tool connected	PHSR by the master connection
2	Active tool disconnected	PHSR by the master connection
5	Hardware configuration changed (e.g. VCU or SCU has connected or disconnected)	PHSR by the master connection

Usage Notes

The `<Reply>` will be either Requested Data or `ERROR<error code>`. The BX2 command can be used alone to generate one reply for each BX2 request, or it can be used with the STREAM command to generate a continuous, non-repeating stream of tracking data.

Data returned by the BX2 command is reported in a new binary format, see "General Binary Format" on page 5. The content is wrapped in the same Binary Reply Format as the BX command. When streamed, the entire response will be preceded by the Streaming Reply Format header, see "Data Streaming" on page 8.

Warning!

No options exist for filtering data returned from the BX2 (page 60) command on the basis of system or tool status or location in the volume. Complete system and tool status information is always included in the reply and it is the application's responsibility to interpret this data and ignore those measurements that fall outside of application requirements and constraints. Failure to do so may lead to inaccurate conclusions that may cause personal injury.

BX2 Binary Data structured in General Binary Format contains one or more tracking frames, similar to the BX command. It contains up to one full frame sequence of previously unreported data. Each frame will be contained in the Frame Data Component, see “General Binary Format” on page 5.

Frame data component will contain various level of tracking data according to the specified BX2 commands. Each type of the tracking data such as 6D, 3D or 2D will be reported again in the General Binary Data Format as separate components.

The content of the single frame of data contains various levels of tracking detail. Each lower level of information references the higher-level information, see Figure 5-1.

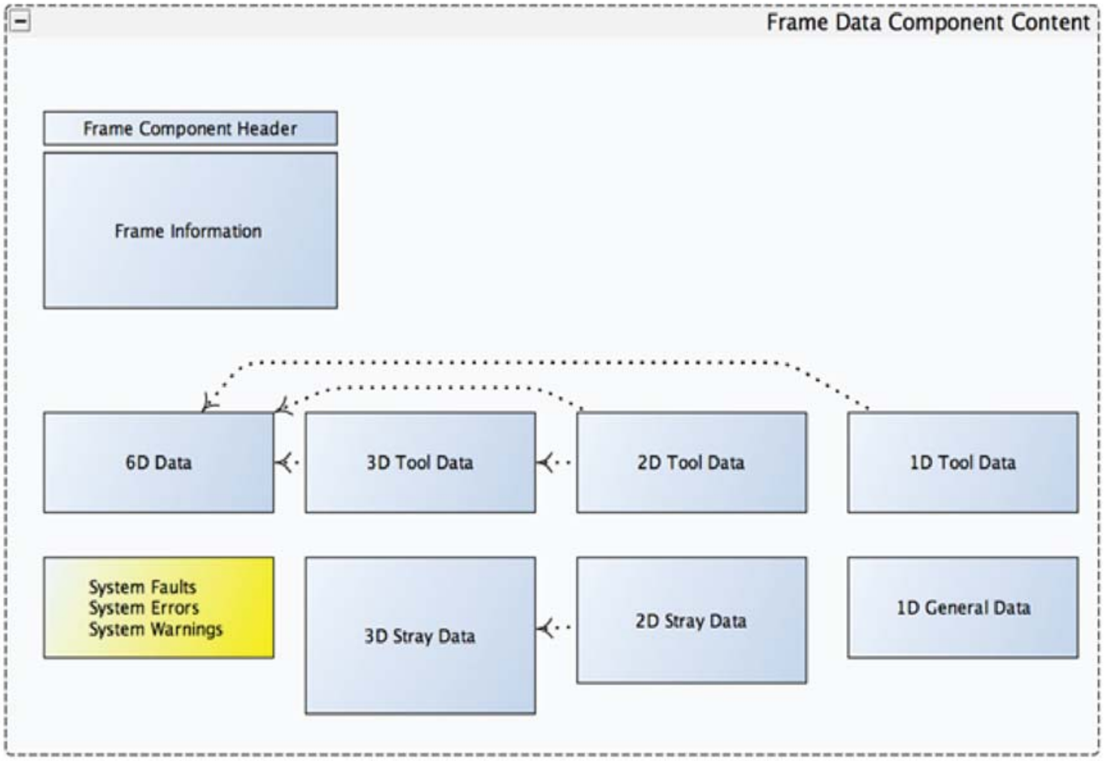


Figure 5-1 Frame Component Overview

Example

Command:

6D tools (2 passive tools loaded and tracking)

```
Command: BX2 --6d=tools --1d=none
```

Reply:

```
C4 A5 64 00 07 D3 01 00 01 00 01 00 60 00 00 00 00 00 01 00 00 00 02 00 00
00 BF 05 2E 38 CB 74 75 57 12 A2 D9 2A 01 00 02 00 12 00 0C 00 00 00 00 00
00 00 00 00 02 00 34 00 00 00 00 00 02 00 00 00 03 00 00 20 79 3A 7E 3F 76
F0 37 BD DE 39 DE BD 83 3A B2 BA 10 95 6A 42 C0 05 F6 C2 BD CA 8C C4 6F 7B
```

```
CE 3C 04 00 0D 01 F3 7D
```

This string decodes as:

```
Start sequence          2 Bytes     Unitless    0xA5C4
Reply length            2 Bytes     Bytes       0x0064      100 Bytes
Header CRC              2 Bytes     Unitless    0xD307

GBF version             2 Bytes     Unitless    0x0001      Version 1
Component count         2 Bytes     Unitless    0x0001      1 Component

  Component 1

  Component type        2 Bytes     Unitless    0x0001      Frame Component
  Component size        4 Bytes     Bytes       0x00000060  96 Bytes
  Item Format Option    2 Bytes     Unitless    0x0000
  Item count            4 Bytes     Count       0x00000001  1 Item to parse

    Frame Item 1

    Frame Type          1 Byte      Type        0x02        Passive
    Sequence Index      1 Byte                  0x00
    Frame Status        2 Bytes                 0x0000      OK
    Frame Number        4 Bytes     Count       0x382E05BF  942540223 decimal
    Timestamp           8 Bytes     Seconds     0x577574CB  Jun 30 2016 15:36:43
                                    Nanoseconds 0x2AD9A212

    GBF version         2 Bytes     Unitless    0x0001      Version 1
    Component count     2 Bytes     Unitless    0x0002      2 Data Components

      Data Component 1

      Component type     2 Bytes    Unitless    0x0012      System Alerts
      Component size     4 Bytes    Count       0x0000000C  12 Bytes
      Item Format Option 2 Bytes    Unitless    0x0000
      Item count         4 Bytes    Count       0x00000000  No System Alert Items

      Data Component 2

      Component type     2 Bytes    Unitless    0x0002      6D Data Component
      Component size     4 Bytes    Bytes       0x00000034  52 Bytes
      Item Format Option 2 Bytes    Unitless    0x0000
      Item count         4 Bytes    Count       0x00000002  Two 6D Data Items

        6D Data Item 1

        Tool Handle      2 Bytes                0x0003      Handle 3
        Handle status    2 Bytes                0x2000      OK, Face 1
                                                            Transform not missing
        Q0               4 Bytes    Unitless    0x3F7E3A79  +0.993079722
        Qx               4 Bytes    Unitless    0xBD37F076  -0.044907056
        Qy               4 Bytes    Unitless    0xBDDE39DE  -0.108508810
        Qz               4 Bytes    Unitless    0xBAB23A83  -0.001359776
        Tx               4 Bytes    mm          0x426A9510  58.645568848 mm
        Ty               4 Bytes    mm          0xC2F605C0  -123.0112305 mm
        Tz               4 Bytes    mm          0xC48CCABD  -1126.335571 mm
        Error            4 Bytes    mm          0x3CCE7B6F  0.0252053421 mm RMS

        6D Data Item 2
        Tool Handle      2 Bytes                0x0004      Handle 4
        Handle status    2 Bytes                0x010D      Too Few Markers
                                                            Transform missing

CRC16                    2 Bytes    Unitless    0x7DF3
```

COMM

Sets the serial communication settings for the system.

Operating Mode

All modes

Compatibility

Not currently used in the Polaris Vega System

Note

For information of previous revisions of the API, refer to the *Polaris Application Program Interface Guide* (IL-1070101) available on the NDI support site at https://support.ndigital.com.

Syntax

```
COMM<SPACE><Baud Rate><Data Bits><Parity><Stop Bits><Hardware
Handshaking><CR>
```

Parameter	Description		G.003.002
`Baud Rate`	The data transmission rate between the system and the host computer, in bits per second. The default baud rate is 9600 bps. **Valid Values:**		
	0	9600 bps	X
	1	14 400 bps	X
	2	19 200 bps	X
	3	38 400 bps	X
	4	57 600 bps	X
	5	115 200 bps	X
	6	921 600 bps	X
	7	1 228 739 bps	X
`Data Bits`	The data bits must be set to 8 bits in order to use any command that returns binary data (BX, GETLOG, or VCAP). The default is 8 data bits. **Valid Values:**		
	0	8 bits	X
	1	7 bits	X

Parameter	Description		G.003.002
Parity	The default is no parity. **Valid Values:**		
	0	None	X
	1	Odd	X
	2	Even	X
Stop Bits	The default is one stop bit. **Valid Values:**		
	0	1 bit	X
	1	2 bits	X
Hardware Handshaking	The default is no hardware handshaking. **Valid Values:**		
	0	Off	X
	1	On	X

Replies

Upon Success:
OKAY<CRC16><CR>

On Error:
ERROR<Error Code><CRC16><CR>

See page 157 for error code definitions.

Usage Notes

1. The system serial communication parameters have a default setting of 00000 (i.e. 9600 baud, 8 data bits, no parity, 1 stop bit, hardware handshaking off).
2. To use any command that returns binary data (BX, GETLOG, or VCAP), you must set the data bits to 0 (8 bits).
3. If you change the baud rate using the COMM command, you must also change your host computer baud rate; otherwise, a system reset or other unexpected communication behaviour will occur. The host application should wait approximately 100 ms after receiving the OKAY reply from the system before changing its own communication parameters.
4. NDI strongly recommends using hardware handshaking when using the higher baud rates.
5. Most Windows applications do not allow you to choose 1.2 Mbaud. To allow you to communicate at this speed, NDI has aliased 19 200 baud to 1.2 Mbaud when using a USB connection. Thus, to communicate at 1.2 MB:

a) Connect the system using a USB connection (this is the only option for passive systems).

b) Set the system to 1.2 Mbaud (<baud rate> parameter value 7).

c) Set the application on the host computer to 19 200 baud. The virtual COM driver maps the communications speed to 1.2 Mbaud, so the application will actually communicate with the system at 1.2 Mbaud.

Do not set the System to 19 200 baud when using a USB connection; if the system is set to 19 200 baud, it will be unable to communicate with the host computer, because setting the host application to 19 200 baud will result in the aliased rate of 1.2 Mbaud.

Example

Command:

```
COMM 30001
```

Reply:

```
OKAYA896
```

This changes the serial communication parameters to 38400 baud, 8 data bits, no parity, 1 stop bit, hardware handshaking on.

DFLT

Restores the user parameters to factory default values.

Operating Mode

All modes

Syntax

```
DFLT<SPACE><User Parameter Name><CR>
```

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*) Use **DLFT *** to restore all user parameters to default values. User parameter names are case-sensitive.

Replies

Upon Success:
```
OKAY<CRC16><CR>
```

On Error:
```
ERROR<Error Code><CRC16><CR>
```
See page 157 for error code definitions.

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **DFLT *** to return all user parameters to their default values.
3. The user parameter values set using the DFLT command persist until the system is reset or initialized. To save the user parameters at their factory default values, use SAVE (page 119) after using the DFLT command.
4. To view a list of user parameters and their current values, use **GET ***.
5. User parameter names are case-sensitive.
6. For more information on user parameters, see “User Parameters” on page 20.

Example

Command:
```
DFLT *
```

Reply:
```
OKAYA896
```

DSTART

Starts Diagnostic mode.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
DSTART<SPACE><Reply Option><CR>
```

Parameter	Description
`Reply Option`	80 (Optional)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

The frame number is reported in reply option 0001 of the TX (page 138) and BX (page 49) commands. In the Polaris Vega System, the frame number is derived from the PTP time, and reply option 80 is ignored.

In order to facilitate active tool setup from a monitor connection, DSTART will return OKAY when in diagnostic mode.

Example

Command:

```
DSTART
```

Reply:

```
OKAYA896
```

DSTOP

Stops Diagnostic mode.

Operating Mode

Diagnostic

Prerequisite Command

DSTART (page 74)

Syntax

```
DSTOP<SPACE><CR>
```

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

If executed from setup mode, it will return OKAY.

Example

Command:

```
DSTOP
```

Reply:

```
OKAYA896
```

ECHO

Returns exactly what is sent with the command.

Operating Mode

All modes

Syntax

```
ECHO<SPACE><Any ASCII characters><CR>
```

Replies

Upon Success:

Exactly what is sent with the command, with `<CRC16><CR>`.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

The ECHO command can handle a maximum of ~50,000 characters. Exceeding this number will cause the system to return error 02.

Example

Command:

```
ECHO Testing!
```

Reply:

```
Testing!A81C
```

GET

Returns the user parameter values.

Operating Mode

All modes

Syntax

```
GET<SPACE><User Parameter Name><CR>
```

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*). Use **GET *** to return all user parameter values. User parameter names are case-sensitive.

Replies

Upon Success:

```
<User Parameter Name>=<value><LF> (repeated for each user parameter name,
but no line feed after the last parameter)
<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`User Parameter Name`	Variable size Full name of the user parameter
`Value`	Value of the user parameter

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **GET *** to return the names and values of all user parameters.
3. Numeric user parameter values are returned as decimal strings.
4. User parameter names are case-sensitive.
5. For descriptive information about each user parameter, including type, attributes, and possible values, use the GETINFO command.

For more information on user parameters, see “User Parameters” on page 20.

Example

Command:

```
GET Info.Status.New Alerts
```

Reply:

```
Info.Status.New Alerts=08B32
```

GETINFO

Returns descriptive information about the user parameters.

Operating Mode

All modes

Syntax

```
GETINFO<SPACE><User Parameter Name><CR>
```

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*). Use **GETINFO *** to return information for all user parameters. User parameter names are case-sensitive.

Replies

Upon Success:

```
<User Parameter Name>=<Value>;<Type>;<Attribute>;<Minimum>;<Maximum>;
<Enumeration>;<Description><LF> (repeated for each user parameter, but no
line feed after last parameter)
<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

<table>
<tr><th>Reply Component</th><th colspan="2">Description</th></tr>
<tr><td><code>User Parameter Name</code></td><td colspan="2">Variable size
Full name of the user parameter</td></tr>
<tr><td><code>Value</code></td><td colspan="2">Variable size
Value of the user parameter</td></tr>
<tr><td rowspan="5"><code>Type</code></td><td colspan="2">1 hexadecimal character
Describes the data type.
<b>Possible Values:</b></td></tr>
<tr><td>0</td><td>Boolean</td></tr>
<tr><td>1</td><td>Integer</td></tr>
<tr><td>2</td><td>Float</td></tr>
<tr><td>3</td><td>String</td></tr>
</table>

<table>
<tr><th>Reply Component</th><th colspan="2">Description</th></tr>
<tr><td rowspan="10"><code>Attribute</code></td><td colspan="2">1 to 4 hexadecimal characters
Describes the access rules.
<b>Bit field:</b></td></tr>
<tr><td>bit 0</td><td>Read</td></tr>
<tr><td>bit 1</td><td>Write</td></tr>
<tr><td>bit 2</td><td>Save</td></tr>
<tr><td>bit 3</td><td>Volatile (may change frequently)</td></tr>
<tr><td>bit 4</td><td>Keyed (cannot be changed unless key is supplied) - Not used in Vega</td></tr>
<tr><td>bit 5</td><td>Enabled keyed parameter - Not used in Vega</td></tr>
<tr><td>bits 6 to 7</td><td>Reserved (may not all be set to 0)</td></tr>
<tr><td>bit 8</td><td>Table parameter</td></tr>
<tr><td>bit 9-15</td><td>Reserved (may not all be set to 0)</td></tr>
<tr><td><code>Minimum</code></td><td colspan="2">Minimum allowed value of the user parameter. For a string, the minimum number of characters allowed.
If minimum = maximum = 0, no range check is performed.</td></tr>
<tr><td><code>Maximum</code></td><td colspan="2">Maximum allowed value of the user parameter. For a string, the maximum number of characters allowed.
If minimum = maximum = 0, no range check is performed.</td></tr>
<tr><td><code>Enumeration</code></td><td colspan="2">Comma-separated enumeration list. This is a list of possible values that the user parameter can take, and corresponds to the values in the <code><Value></code> field (the first item in the list corresponds to value 0, the second item corresponds to value 1, etc.).</td></tr>
<tr><td><code>Description</code></td><td colspan="2">Describes the user parameter’s function.</td></tr>
</table>

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **GETINFO *** to return information for all user parameters.
3. Numeric user parameter values are returned as decimal strings.
4. User parameter names are case-sensitive.
5. For a list of user parameters and values without descriptive information, use the GET command.

For more information on user parameters, see “User Parameters” on page 20

Example 1

Command:

```
GETINFO Info.Status.Bump Detected
```

Reply:

```
Info.Status.Bump Detected=0;1;800D;0;1;False,True;Indicates if the system
has detected a bump49CB
```

The system returns descriptive information for the specified parameter.

GETLOG

Returns the contents of the Position Sensor or System Control Unit log file.

Operating Mode

All modes

Syntax

```
GETLOG<SPACE><Offset><Length><Logname><CR>
```

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td><code>Offset</code></td><td colspan="2">8 hexadecimal character string
Specifies the offset of the data requested within the file.</td></tr>
<tr><td><code>Length</code></td><td colspan="2">4 hexadecimal character string
Specifies the requested amount of data, in bytes. Up to 50 kilobytes can be requested at one time.</td></tr>
<tr><td rowspan="4"><code>Logname</code></td><td colspan="2">String identifying the name of the log. Log names are case-sensitive.</td></tr>
<tr><td><b>API revision</b></td><td><b>Name of log file</b></td></tr>
<tr><td>API revision G.001.003 and earlier, and G.003.001 and later</td><td>sysinfo</td></tr>
<tr><td>API revision G.001.004 up to but not including G.003.001</td><td>\<Device Name>\sysinfo
(See “Device Names” on page 21 for device name details.)</td></tr>
</table>

Replies

Upon Success:

```
<Header><Length><Header CRC><Data><Data CRC>
```

Note The reply for the GETLOG command is binary data.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`Header`	2 bytes: A5C4 Indicates the start of the GETLOG reply.

Reply Component	Description
`Length`	2 bytes The number of bytes of data being returned.
`Header CRC`	2 bytes CRC16 for header.
`Data`	Up to 50 kilobytes of binary data
`Data CRC`	2 hexadecimal characters CRC16 of the <Data> section.

Usage Notes

1. To read the entire log file:
   a) Start with an offset of 0, and request 50 kilobytes of data.
   b) Increment the offset by 50 kilobytes, and request another 50 kilobytes of data.
   c) Repeat step b) until the reply length of the data is less than the amount you requested. This indicates that you have reached the end of the log file.
2. Replies are returned in little endian format.
3. To write to a log, use SYSLOG (page 131).

Compatibility Notes

The log name is **sysinfo**.

Example

Command:

```
GETLOG 000000000800sysinfo
```

INIT

Initializes the system.

Operating Mode

All modes

Syntax

```
INIT<SPACE><CR>
```

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. During power up or system reset, the system configuration is determined. The configuration includes firmware revisions and the characterized measurement volumes for which the Position Sensor has been calibrated. The INIT command ensures that the system configuration was determined successfully.
2. The system will automatically return to Setup mode after using the INIT command.
3. The INIT command sets any modified user parameters back to the saved values. To prevent modified values from being reset, send the SAVE command before sending INIT.
4. If ERROR2E or ERROR15 is returned, there may be a system fault that is indicated by the alerts in the **Info.Status. New Alerts** or **Info.Status.Alerts** user parameter on one or more devices. Use GET to read these user parameters. See “Alerts User Parameters” on page 22 for details.
5. In the case where a Monitor mode connection issues the INIT command

   a) if the system is already in the Setup mode with no tools loaded the system, the response is OKAY.

   a) if the system is already initialized but is in Tracking or Diagnostics mode, or if there are tools loaded, the response is WARNING.

   a) if the system is not initialized, the response is ERROR39 (Permission denied).

Example

Command:

```
INIT
```

Reply:

```
OKAYA896
```

IRATE

Sets the illuminator rate.

Deprecated

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
IRATE<SPACE><Illuminator Rate><CR>
```

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td rowspan="4"><code>Illuminator Rate</code></td><td colspan="2">Sets the number of times per second that the illuminators emit IR.

Valid values:</td></tr>
<tr><td>0</td><td>20 Hz</td></tr>
<tr><td>1</td><td>30 Hz</td></tr>
<tr><td>2</td><td>60 Hz</td></tr>
</table>

Replies

Upon Success:
`OKAY<CRC16><CR>`

On Error:
`ERROR<Error Code><CRC16><CR>`
See page 157 for error code definitions.

Usage and Compatibility Notes

Usage Notes

The circuitry in the NDI active wireless tool kit limits its activation rate to 20 Hz.

Compatibility Notes

1. The IRATE command has been deprecated for the Vega system. To set the illuminator rate for Vega, use the command SET (page 120) to set the user parameter **Param.Tracking.Illuminator Rate**.

Example

Command:

```
IRATE 0
```

Reply:

```
OKAYA896
```

IRED

Turns the markers on a wired tool on or off.

Operating Mode

Diagnostic

Prerequisite Command

PENA (page 91)

Syntax

```
IRED<SPACE><Port Handle><Marker Activation Signature><CR>
```

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Port Handle</td><td colspan="2">2 hexadecimal characters</td></tr>
<tr><td rowspan="7">Marker Activation Signature</td><td colspan="2">8 hexadecimal characters (32 bits)
One bit for each marker. Set the bits corresponding to the markers you wish to activate. See example in Usage Notes.
<b>Bit field:</b></td></tr>
<tr><td>bit 0</td><td>Marker A</td></tr>
<tr><td>bit 1</td><td>Marker B</td></tr>
<tr><td>bit 2</td><td>Marker C</td></tr>
<tr><td>...</td><td>...</td></tr>
<tr><td>bit 19</td><td>Marker T</td></tr>
<tr><td>bits 20 to 31</td><td>Reserved</td></tr>
</table>

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

There are 20 marker positions, labelled “A” to “T.” To specify that a marker should be turned on, set the bit corresponding to that marker to 1. For example, you will need to set the bit field as follows if you wanted to activate markers B, G, M and T:

Marker Location		T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
Bit	31- 20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit Value	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0
Activation Signature Parameter Value	0 0 0	8				1				0				4				2			

Example

Command:

```
IRED 0A00081042
```

Reply:

```
OKAYA896
```

LED

Changes the state of visible LEDs on a wired tool.

Operating Mode

All modes

Prerequisite Command

INIT (page 83)

Syntax

```
LED<SPACE><Port Handle><LED Number><State><CR>
```

Parameter	Description	
`Port Handle`	2 hexadecimal characters	
`LED Number`	Specifies the LED. **Valid values:** 1 to 3	
`State`	Sets the state of the specified LED.	
	B	Blank (not on)
	F	Flash
	S	Solid on

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

The visible LEDs are only activated while the system is in Tracking and Diagnostic modes.

Example

Command:

```
LED 0A1S
```

Reply:

```
OKAYA896
```

PDIS

Disables the reporting of transformations for a particular port handle.

Operating Mode

All modes

Prerequisite Command

PENA (page 91)

Syntax

```
PDIS<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Example

Command:

```
PDIS 01
```

Reply:

```
OKAYA896
```

PENA

Enables the reporting of transformations for a particular port handle.

Operating Mode

Setup

Syntax

```
PENA<SPACE><Port Handle><Tool Tracking Priority><CR>
```

Parameter	Description	
`Port Handle`	2 hexadecimal characters	
`Tool Tracking Priority`	Describes the type of tool. **Valid Values:**	
	S	Static: a static tool is considered to be relatively immobile, e.g. a reference tool.
	D	Dynamic: a dynamic tool is considered to be in motion, e.g. a probe.
	B	Button box: a button box can have and LEDs, but no markers. No transformations are returned for a button box tool, but switch status is returned.

Replies

Upon Success:
`OKAY<CRC16><CR>`

or

`WARNING02<CRC16><CR>` (Indicates that the tool you are trying to enable is a unique geometry tool that doesn’t meet the unique geometry requirements.)

`WARNING03<CRC16><CR>` (Indicates that the tool you are trying to enable is a unique geometry tool that conflicts with another unique geometry tool already loaded and enabled.)

`WARNING04<CRC16><CR>` (Indicates that the tool you are trying to enable is a unique geometry tool that doesn’t meet the unique geometry requirements, and conflicts with another unique geometry tool already loaded and enabled.)

`WARNING05<CRC16><CR>` (Returned when the system selects a default marker wavelength to track a tool if the tool’s definition file did not specify a marker wavelength.)

On Error:
`ERROR<Error Code><CRC16><CR>`

See page 157 for error code definitions.

Usage Notes

1. The system does not make use of the tool tracking priority. You must still specify a value, but it does not matter which tool tracking priority you choose.
2. When the PENA command is issued, the system compares the tool being enabled with currently enabled tools for conflicting unique geometry constraints. This process is almost instantaneous. If the tool doesn't meet the unique geometry constraints, or conflicts with a tool that is already enabled, the system will issue a `WARNING02`, `WARNING03`, or `WARNING04`.
3. The system will still enable the tool when the system returns `WARNING02`, `WARNING03` or `WARNING04`; however, the tool may not track properly since the unique geometry is compromised.
4. For more information on unique geometry tools and unique geometry constraints, see the *Polaris Tool Design Guide*.

Example

Command:

```
PENA 01D
```

Reply:

```
OKAYA896
```

PFSEL

Sets which tool faces to use to track a multi-faced tool.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PINIT (page 107)

Syntax

```
PFSEL<SPACE><Port Handle><Face Selection Mask><CR>
```

Reply

```
OKAY<CRC16><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`Face Selection`	2 hexadecimal characters (8 bits) Set the bits corresponding to the faces you wish to track.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

Usage Notes

1. When a tool is initialized, the face selection defaults to a value of 0xFF, so all faces are tracked by default.
2. To include a tool face to be tracked, set the corresponding bit. For example, if you wish to track faces 0 and 5, the face selection value is 0x21, as shown in the following table:

Tool Face Number	7	6	5	4	3	2	1	0
Bit Value	0	0	1	0	0	0	0	1

Face Selection Hexadecimal Value	2	1

3. If the system returns error code 23, the face selection did not include any of the valid faces of the selected tool.

Example

Command:

```
PFSEL 0121
```

Reply:

```
OKAYA896
```

PHF

Releases system resources from an unused port handle.

Operating Mode

Setup

Prerequisite Command

PHRQ (page 102)

Syntax

```
PHF<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. The PHF command should be used whenever a tool is disconnected. This optimizes the use of system resources. If PHF is not used, the system will be unable to assign a port handle after the maximum number of port handles has been reached.
2. If a tool is disconnected then reconnected, it is a assigned a new port handle. The old port handle is no longer in use and should be freed using PHF.

Example

Command:

```
PHF 01
```

Reply:

```
OKAYA896
```

This frees port handle 01, so it is no longer assigned.

PHINF

Returns port handle status, information about the tool associated with the port handle, and the physical location of a port handle.

Operating Mode

All modes

Prerequisite Command

PHSR (page 104) or PHRQ (page 102)

Syntax

```
PHINF<SPACE><Port Handle><Reply Option><CR>
```

Parameter	Description		G.003.002
Port Handle	2 hexadecimal characters		
Reply Option	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned in order of increasing option value. **Valid Values:**		
	0001	Tool information (default)	X
	0002	Wired tool electrical information	X
	0004	Tool part number	X
	0008	Switch and visible LED information	X
	0010	Tool marker type and wavelength	X
	0020	Physical port location	X

Replies

Upon Success:

If there is a tool assigned tool definition file to the port handle:

```
<Reply Option 0001 Data><Reply Option 0002 Data>...<Reply Option 0020
Data><CRC16><CR>
```

Note The physical location of a port handle is the only information available unless PHINF has been preceded by PINIT (page 107).

If no tool definition file is assigned to the port handle:

```
UNOCCUPIED<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Option 0001 - Tool Information

```
<Reply Option 0001 Data> = <Tool Type><Manufacturer’s ID><Tool
Revision><Serial Number><Port Status>
```

Reply Component	Description		
`Tool Type`	8 characters `<Tool Type> = <Main Type><Number of Switches><Number of Visible LEDs><Reserved><Subtype>`		
	`Main Type`	2 hexadecimal characters **Possible Values:**	
		`01`	Reference
		`02`	Probe
		`03`	Button box or foot switch
		`04`	Software-defined
		`05`	Microscope tracker
		`06`	Reserved
		`07`	Calibration device
		`08`	Tool Docking Station
		`09`	Isolation box
		`0A`	C-arm tracker
		`0B`	Catheter
		0D to FF	Reserved
	`Number of Switches`	1 character	
	`Number of Visible LEDs`	1 character	
	`Reserved`	2 characters	
	`Subtype`	2 characters	
`Manufacturer’s ID`	12 characters		
`Tool Revision`	3 characters		

Reply Component	Description	
`Serial Number`	8 hexadecimal characters (32 bits) **Bit field:**	
	bits 0 to 9	Sequence number (one-based)
	bits 10 to 18	Day of year (zero-based, e.g. Jan 1 is day 0 and Dec 31 is day 364)
	bits 19 to 22	Month (zero-based)
	bits 23 to 31	Year (year is <current year> - 1900, e.g. the year 2009 is 109)
`Port Status`	2 hexadecimal characters (8 bits) **Bit field:**	
	bit 0	Tool-in-port
	bit 1	Switch 1 closed
	bit 2	Switch 2 closed
	bit 3	Switch 3 closed
	bit 4	Port initialized
	bit 5	Port enabled
	bit 6	Reserved
	bit 7	Tool-in-port from current sensing

Reply Option 0002 - Wired Tool Electrical Information

Reply Component	Description	
`Reply Option 0002 Data`	8 hexadecimal characters Wired tool electrical information. The electrical current is tested for two conditions: over and under. An “over” current condition indicates that there is a short circuit in either the cable or the marker. An “under” current condition indicates that there is either a break in the cable or the marker has burnt out. **Bit field:**	
	bits 0 to 19	Marker failed. Bit 0 = marker A, ..., bit 19 = marker T
	bits 20 to 29	Reserved
	bit 30	Under
	bit 31	Over

You can test the electrical current of all the markers on a tool using TCTST (page 133).

Reply Option 0004 - Tool Part Number

Reply Component	Description
`Reply Option 0004 Data`	20 characters The part number of the tool.

Reply Option 0008 - Switch and Visible LED Information

<table>
<tr><th>Reply Component</th><th colspan="2">Description</th></tr>
<tr><td rowspan="9"><code>Reply Option 0008 Data</code></td><td colspan="2">2 hexadecimal characters (8 bits)
This option reports the information found in the tool description. It is not information sensed by the hardware.
<b>Bit field:</b></td></tr>
<tr><td>bit 0</td><td>Tool-in-port switch supported</td></tr>
<tr><td>bit 1</td><td>Switch 1 supported</td></tr>
<tr><td>bit 2</td><td>Switch 2 supported</td></tr>
<tr><td>bit 3</td><td>Switch 3 supported</td></tr>
<tr><td>bit 4</td><td>Tool tracking LED supported</td></tr>
<tr><td>bit 5</td><td>LED 1 line 1 supported</td></tr>
<tr><td>bit 6</td><td>LED 2 line 2 supported</td></tr>
<tr><td>bit 7</td><td>LED 3 line 3 supported</td></tr>
</table>

Reply Option 0010 - Tool Marker Type and Wavelength

Reply Component	Description		G.003.002
`Reply Option 0010 Data`	2 hexadecimal characters (8 bits) **Bits 0 to 2 give information on the marker wavelength:**		
	000	9*x*0 nm (See “Compatibility Notes” on page 101.)	X
	001	880 nm	X
	010	930 nm	X
	100	870 nm	X
	111	850 nm	
	Bits 3 to 7 give information on the marker type:		
	00000	Reserved	
	00001	NDI active	X
	00010	NDI ceramic	X
	00011	Unknown active	X
	00100	Unknown passive	X
	00101	Passive sphere	X
	00110	Passive disc	X
	00111	NDI Radix	X
	01000 to 11111	Reserved	

Reply Option 0020 - Physical Port Location

```
<Reply Option 0020 Data> = <Hardware Device><System Type><Tool Type>
<Port Number><Reserved>
```

Reply Component	Description
`Hardware Device`	8 characters For passive or active wireless tools this is the Position Sensor serial number. For Polaris Vega active tools, this is STB-0.
`System Type`	1 character **Possible values:** Reserved

Reply Component	Description	
`Tool Type`	1 character **Possible values:**	
	0	Wired
	1	Wireless
`Port Number`	2 ASCII characters **Possible values:**	
	01 to 03	Used for Polaris Vega wired tools
	00	Used for Polaris Vega wireless tools
`Reserved`	2 characters	

Usage Notes

1. The physical location of a port handle is the only information available unless PHINF has been preceded by PINIT (page 107) or PENA (page 91).
2. Port handles for tools that have been disconnected will be reported as UNOCCUPIED and no additional information will be returned.
3. **Reply option 0001**: For wired tools, bits 1, 2, and 3 in the port status report status.
4. **Reply option 0008**: For wired tools, bits 1, 2, and 3 report status, and bits 5, 6, and 7 report LED status.

Compatibility Notes

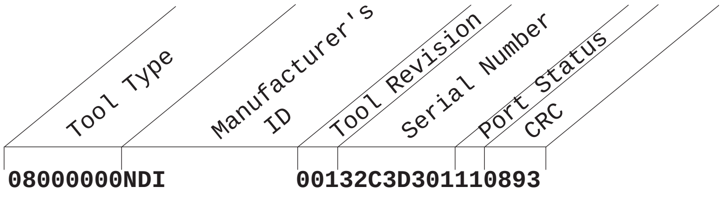
1. **Reply option 0010**: A value of 010 for marker wavelength can be returned only for tools characterized using NDI 6D Architect version 2.02 or later. Tools characterized with earlier versions of NDI 6D Architect will have a value of 000 for a marker wavelength of 930 nm.
2. **Reply option 0040**: This option is not supported by the hybrid Polaris Vega System.

Example

Command:

```
PHINF 040001
```

Reply:



```
08000000NDI         00132C3D301110893
```

PHRQ

Assigns a port handle to a tool.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
PHRQ<SPACE><Hardware Device><System Type><Tool Type><Port Number><Dummy
Tool><CR>
```

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td><code>Hardware Device</code></td><td colspan="2">8 characters
The hardware device must match the one returned by PHINF (page 96) reply option 0020, or use wild card characters (*). For active tools connected to the system, specifying all wildcards will default to hardware device STB-0 (the tool ports on the System Control Unit).</td></tr>
<tr><td><code>System Type</code></td><td colspan="2">1 character
<b>Valid Values:</b>
Use a wild card character (*).</td></tr>
<tr><td rowspan="3"><code>Tool Type</code></td><td colspan="2">1 character
This must be specified for wireless tools.
<b>Valid Values:</b></td></tr>
<tr><td>0 or *</td><td>Wired</td></tr>
<tr><td>1</td><td>Wireless (passive or active wireless)</td></tr>
<tr><td rowspan="3"><code>Port Number</code></td><td colspan="2">2 characters
The physical port number where a wired tool is plugged in. This must be specified for wired tools.
<b>Valid Values:</b></td></tr>
<tr><td>01 to 03</td><td>Used for hybrid Polaris Vega wired tools</td></tr>
<tr><td>00 or **</td><td>Used for wireless tools</td></tr>
</table>

Parameter	Description	
`Dummy Tool`	2 characters If specified, will auto-generate a non-trackable dummy tool. Useful for 3D stray-marker tracking. In the case of Tool Type = Wired, either 01 or 02 adds an active wired dummy tool. Otherwise, In case of Tool Type = Wireless: **Valid Values:**	
	**	Do not load a dummy tool. Requires tool definition to be loaded with subsequent PVWR (page 116) commands.
	01	adds passive dummy tool
	02	adds active wireless dummy tool

Replies

Upon Success:

```
<Port Handle><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. Use PHRQ to assign a port handle to a wireless tool or to a wired tool that has neither a tool-in-port diode or a marker in position A of the tool wiring matrix. If a wired tool has a tool-in-port diode or a marker in position A of the tool wiring matrix, use PHSR (page 104) to detect the tool and assign it a port handle.
2. **Wireless tools**: You must specify the tool type. All other parameters may be left as wild card characters (*).
3. **Wired tools**: You must specify the port number. All other parameters may be left as wild card characters (*).
4. After using PHRQ, you must use PVWR (page 116) to assign a tool definition file to the tool. If you do not assign a tool definition file to the tool, the port handle will be reported as unoccupied when it is initialized with PINIT (page 107) or PENA (page 91).

Example

Command:

```
PHRQ *********1****
```

Reply:

```
04D715
```

This requests a port handle for a wireless tool.

PHSR

Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool.

Operating Mode

All modes

Prerequisite Command

INIT (page 83)

Syntax

```
PHSR<SPACE><Reply Option><CR>
```

Parameter	Description	
Reply Option	Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 00. The reply options cannot be OR'd. **Valid Values:**	
	00	Reports all allocated port handles (default)
	01	Reports port handles that need to be freed
	02	Reports port handles that are occupied, but not initialized or enabled
	03	Reports port handles that are occupied and initialized, but not enabled
	04	Reports enabled port handles

Replies

Upon Success:

```
<Number of Port Handles>
<1st Port Handle><1st Port Handle Status>
<2nd Port Handle><2nd Port Handle Status>
...
<nth Port Handle><nth Port Handle Status>
<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions

Reply Component	Description	
`Number of Port Handles`	2 hexadecimal characters The number of allocated port handles of the type specified in the reply option. If no reply option is specified, the number returned is the total number of allocated port handles.	
`nth Port Handle`	2 hexadecimal characters Specifies the port handle whose status follows.	
`nth Port Handle Status`	3 hexadecimal characters (12 bits) **Bit field:**	
	bit 0	Occupied
	bit 1	Switch 1 closed
	bit 2	Switch 2 closed
	bit 3	Switch 3 closed
	bit 4	Initialized
	bit 5	Enabled
	bit 6	Reserved
	bit 7	Tool detected from current sensing
	bit 8 to 11	Reserved

Usage Notes

1. When you send the PHSR command, the system will detect and assign port handles to any wired tools that do not already have a port handle assigned (i.e. any wired tools that were plugged in after the last PHSR call). It will then return the requested port handle information.
2. The system will detect a wired tool if the tool has a tool-in-port diode, or a marker in position A of the tool wiring matrix. If you are using a wired tool that does not meet this criteria, you will need to request a port handle for the tool using PHRQ.
3. If you unplug a wired tool while the system is in tracking mode, the port handle will be reported as “disabled” in the replies to the BX and TX commands. If you reconnect the tool, it will need a new port handle.
4. If you connect a wired tool to the system while the system is in tracking mode, you will have to take the following steps before the system will report the tool:

   a) Exit tracking mode (TSTOP).

   b) Assign, initialize, and enable a port handle for the tool as outlined in Figure 3-1 on page 18.

   c) Re-enter tracking mode (TSTART).

5. PHSR will report wireless tool ports as unoccupied if you have requested a port handle using PHRQ (page 102) but have not yet associated a tool definition file for the port handle (using PVWR (page 116)).
6. To obtain a port handle for a wireless tool, use PHRQ.
7. PHSR will only return the number of assigned port handles and their status when executed in tracking or diagnostic mode from a master connection, or when executed in any mode from a monitor connection.

Examples

Command:

```
PHSR
```

Reply:

```
001414
```

In this case, there are no occupied port handles.

Command:

```
PHSR
```

Reply:

```
0101031F1AF
```

In this case, there is one occupied port handle, which is initialized and enabled.

PINIT

Initializes a port handle.

Deprecated

Operating Mode

Setup

Prerequisite Command

PVWR (page 116) or PHSR (page 104)

Syntax

```
PINIT<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:
`OKAY<CRC16><CR>`

or

`WARNING` (Indicates that a non-fatal tool error has been encountered, e.g. a burnt out marker.)

or

WARNING05 is returned when the system selects a default marker wavelength to track a tool (if the tool’s tool definition file did not specify a marker wavelength).

On Error:
`ERROR<Error Code><CRC16><CR>`

See page 157 for error code definitions.

Usage Notes

1. PENA now initializes tools that have not been initialized with PINIT. Therefore, it is no longer necessary to use PINIT.
2. If the tool description is drawn from a tool definition file that has been loaded using PVWR (page 116), initialization involves unpacking and verifying the tool definition file. This process is almost instantaneous.
3. If the tool description is drawn from an SROM device, initialization involves reading, unpacking, and verifying the tool definition file contents, and testing electrical current through all the markers to detect burnt out markers. This process takes approximately two seconds if successful, or several seconds longer if a problem is encountered and retries are attempted by the system.

4. The port handle will still initialize when the system returns WARNING. or WARNING05.
5. The SCU will load and parse active tool info when a tool is plugged in. PENA will load and parse passive tool info if not done so yet.

Example

Command:

```
PINIT 01
```

Reply:

```
OKAYA896
```

This initializes port handle 01.

PPRD

Reads data from the SROM device in a wired tool.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
PPRD<SPACE><Port Handle><SROM Device Address><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`SROM Device Address`	4 hexadecimal characters **Valid Values:** 0x0000 to 0x07C0

Replies

Upon Success:

```
<SROM Device Data><CRC16><CR>
```

The SROM device data is 64 bytes (128 hexadecimal characters) of data.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. The SROM device is a 2-KB write-once device that must be read in 64-byte chunks. An SROM device is considered blank if its contents are all 0xFFs.
2. PPRD reads 64 bytes of data from the SROM device starting at a specified SROM device address.

Example

Command:

```
PPRD 010000
```

Reply:

```
0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF012345678
9ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF66A5
```

PPWR

Writes data to the SROM device in a wired tool.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
PPWR<SPACE><Port Handle><SROM Device Address><SROM Device Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`SROM Device Address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x07C0
`SROM Device Data`	64 bytes (128 hexadecimal characters) of data

Replies

Command:
```
OKAY<CRC16><CR>
```

On Error:
```
ERROR<Error Code><CRC16><CR>
```
See page 157 for error code definitions.

Usage Notes

1. PPWR writes 64 bytes of data to the SROM device starting at a specified SROM device address.
2. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character).
3. The tool description section of tool SROM device is a 1-Kbyte, write-once area that must be written in 64-byte chunks. If the information being written to the system is less than 64 bytes in size, then the remainder of the chunk must be padded out with ones to maintain the 64-byte size before being written to the system. To write to the second 1-Kbyte section, use the PUWR command.
4. An SROM device is considered blank if its contents are all 0xFFs.
5. The recommended procedure to follow for updating an SROM device is:

a) Read the contents of the SROM device using PPRD (page 109).

b) Modify the data.

c) Write the modified data back to the SROM device using PPWR (page 110).

Example

Command:

```
PPWR 0100C000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000009731
```

Reply:

```
OKAYA896
```

PURD

Reads data from the user section of the SROM device in a wired tool.

Operating Mode

All modes

Prerequisite Command

INIT (page 83)

Syntax

```
PURD<SPACE><Port Handle><User SROM Device Address><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`User SROM Device Address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x03C0

Replies

Upon Success:

```
<SROM Device Data><CRC16><CR>
```

The SROM device data is 64 bytes (128 hexadecimal characters) of data.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. The SROM device is automatically selected as the reading target when this command is issued, so you do not need to find and specify the SROM device ID. The SROM device address has an implied offset in the command which places the user information at the correct SROM device address.
2. The PURD command returns 64 bytes of data at a time.

Example

Command:

```
PURD:010000
```

Reply:

```
0022446688AACCEE0022446688AACCEE0022446688AACCEE0022446688AACCEE002244668
8AACCEE0022446688AACCEE0022446688AACCEE0022446688AACCEE3CC0
```

PUWR

Writes data to the user section of the SROM device in a wired tool.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
PUWR<SPACE><Port Handle><User SROM device address><User SROM device
Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`User SROM device address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x03C0
`User SROM device data`	64 bytes of data to write (128 hexadecimal characters)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. The SROM device is automatically selected as the reading target when this command is issued, so you do not need to find and specify the SROM device ID. The SROM device address has an implied offset in the command which places the user information at the correct SROM device address.
2. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character).
3. The user section of SROM devices is a 1-Kbyte, write-once area that must be written in 64-byte chunks. If the information being written to the system is less than 64 bytes in size, then the remainder of the chunk must be padded out with ones to maintain the 64-byte size before being written to the system.

4. The recommended procedure to follow for updating an SROM device is outlined below:
    a) Read the contents of the SROM device using PURD (page 112).
    b) Modify the data read.
    c) Write the modified data back to the SROM device using PUWR.

Example

Command:

```
PUWR 0100800000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000A927
```

Reply:

```
OKAYA896
```

PVWR

Assigns a tool definition file to a wireless tool, or overrides the SROM device in a wired tool.

Operating Mode

Setup

Prerequisite Command

PHRQ (page 102) or PHSR (page 104)

Syntax

```
PVWR<SPACE><Port Handle><Start Address><Tool Definition File Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`Start Address`	4 hexadecimal characters Increment the start address by 64 bytes with each chunk of data sent for a particular port handle. **Valid values:** 0x0000 to 0x3FC0
`Tool Definition Data`	64 bytes (128 hexadecimal characters) of data

Replies

Upon Success:
`OKAY<CRC16><CR>`

On Error:
`ERROR<Error Code><CRC16><CR>`

See page 157 for error code definitions.

Usage Notes

1. Use PVWR
   - To assign a tool definition file to a wireless tool after using PHRQ.
   - To assign a tool definition file to a wired tool, to override the SROM device in the tool.
   - To assign a tool definition file to a wired tool, to test the tool definition file before permanently recording the tool definition file onto the SROM device.
2. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character.

3. Data is sent to the system in 64-byte chunks (128 hexadecimal characters). The last chunk must be padded out with zeroes to maintain the 64-byte size before being written to the system.
4. If a wireless tool port is the target of this command, the port becomes occupied when the first 64 bytes of information is written. Any previous initialization for the port is lost.
5. Use PVWR to assign a tool definition file to a wireless tool after using PHRQ (page 102).
6. After using PVWR, enable (PENA) the port handle in order to track the tool.
7. To permanently write a tool definition file to an SROM device, use PPWR (page 110).

Example

Command:

```
PVWR 0200004E444900551C000001000000000000010100000001A419335A000000030000
000300000000000040000000000000000000000000000000000000000000000000
```

Reply:

```
OKAYA896
```

RESET

Resets the system.

Operating Mode

All modes

Syntax

```
RESET<SPACE><Reset Option><CR>
```

Parameter	Description	
`Reset Option`	Optional. Specifies the type of reset. If no reset option is specified, the system performs a RESET 0. The reset options cannot be OR’d. **Valid Values:**	
	0	Generates a soft reset. Does not power cycle the Position Sensor.
	1	Performs a board-level reset of all hardware devices.

Replies

Upon Success:

```
RESET<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Example

Command:

```
RESET 0
```

Reply:

```
RESETBE6F
```

SAVE

Saves all non-volatile user parameters that have been changed.

Operating Mode

All modes

Syntax

```
SAVE<SPACE><CR>
```

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. To restore the user parameters to factory default values, use the DFLT (page 73) command. To save the user parameters at their factory default values, use the SAVE command after using the DFLT command.
2. On systems that have the Password Protect keyed feature enabled, user parameters can only be saved after the correct password is entered. To enter the password, use **SET Config.Password= <password>**, where <password> is the correct password. For more information on the Password Protect keyed feature, see the user guide that accompanied the system.
3. To set user parameter values, use the SET (page 120) command.
4. For more information on user parameters, see “User Parameters” on page 20.

Example

Command:

```
SAVE
```

Reply:

```
OKAYA896
```

SET

Sets user parameter values.

Operating Mode

All modes

Syntax

```
SET<SPACE><User Parameter Name>=<Value><CR>
```

Parameter	Description
`User Parameter Name`	A case-sensitive string, identifying the name of the user parameter.
`Value`	The value to set. Numerical values are decimal unless preceded by 0x. For boolean values, 1 is true and 0 is false.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. To view a list of user parameters and their current values, use **GET ***. For a description of the user parameters, use **GETINFO ***.
2. The user parameter values set using the SET command persist until the system is reset or initialized. To save the user parameter values, use SAVE (page 119). To reset user parameters to their default values, use DFLT (page 73).
3. User parameter names are case-sensitive.
4. For more information on user parameters, see “User Parameters” on page 20

Example

Command:

```
SET Param.Tracking.Sensitivity=1
```

Reply:

```
OKAYA896
```

This sets the infrared light sensitivity level to level 1 on the first Position Sensor in the configuration.

SFLIST

Returns information about the supported features of the system.

Deprecated

Operating Mode

Setup, diagnostics or tracking

Syntax

```
SFLIST<SPACE><Reply Option><CR>
```

Parameter	Description		G.003.002
`Reply Option`	Specifies which information will be returned. The reply options cannot be OR'd. **Valid values:**		X
	00	Summary of supported features	X
	01	Number of active tool ports	X
	02	Number of wireless tool ports	X
	03	Number of measurement volumes and wavelengths; volume shapes and supported wavelengths	X
	04	The number of wired tool ports available which support tool-in-port detection from current sensing	X
	05	Number of active wireless tools	X

The reply options cannot be OR’d.

Replies

Upon Success:

```
<Reply Option n Data><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`Reply Option n Data`	The data specific to the requested reply option. See the reply option information below for details: Reply option 00 (Summary of supported features) Reply option 01 (Number of active tool ports) Reply option 02 (Number of wireless tool ports) Reply option 03 (Number of characterized measurement volumes and wavelengths; volume shapes and supported wavelength) Reply option 04 (The number of wired tool ports available which support tool-in-port detection from current sensing) Reply option 05 (Number of active wireless tools)

Reply Option 00 - Supported Features Summary

Reply Component	Description	
`Reply Option 00 Data`	8 hexadecimal characters (32 bits) **Bit field:**	
	bit 0	Active tool ports available
	bit 1	Passive tool ports available
	bit 2	Multiple volume characterization parameters supported
	bit 3	Tool-in-port from current sensing available
	bit 4	Active wireless tool ports available
	bit 5	Reserved
	bits 7 to 31	Reserved

Reply Option 01 - Number of Active Tool Ports

Reply Component	Description
`Reply Option 01 Data`	1 hexadecimal character The number of wired tool ports.

Reply Option 02 - Number of Wireless Tool Ports

Reply Component	Description
`Reply Option 02 Data`	1 hexadecimal character The number of wireless tool ports, up to a maximum of 15 (the highest number that can be represented in one hexadecimal digit). To find out the actual number of wireless tool ports, read the parameters **Features.Tools.Passive Ports** (for passive wireless) and **Features.Tools.Wireless Ports** (for active wireless).

Reply Option 03 - Volumes

Note Because SFLIST is deprecated, the Volume User Parameters on page 37 should be used instead.

```
<Reply Option 03 Data> =
<Number of Volumes>
<1st Shape Type><1st Shape Parameter><1st Number of Wavelengths
Supported><1st Supported Wavelengths><LF>
...
<nth Shape Type><nth Shape Parameter><nth Number of Wavelengths
Supported><nth Supported Wavelengths><LF>
```

Reply Component	Description	
Number of Volumes	1 hexadecimal character	
nth Shape Type	1 hexadecimal character **Possible values:**	
	5	Extended Pyramid Shape The volumes are named “Pyramid”, “Extended Pyramid”
	7	Arc Shape The volume name is “Vicra”
nth Shape Parameter	10 parameters, 7 characters each (a sign, and six digits with an implied decimal in the position XXXX . XX)	
nth Number of Wavelengths Supported	1 hexadecimal character	
nth Supported Wavelengths	1 character per wavelength supported **Possible values:**	
	0	930 nm (see “Usage Notes” on page 127)
	1	880 nm
	4	870 nm
	7	850 nm

Reply Option 04 - Number of Active Tool Ports Supporting Tool-in-Port Detection From Current Sensing

Reply Component	Description
Reply Option 04 Data	1 hexadecimal character

Reply Option 05 - Number of Active Wireless Ports

Reply Component	Description
Reply Option 05 Data	1 hexadecimal character

Polaris Vega System - Shape Parameters

Note Because SFLIST is deprecated, the Volume User Parameters on page 37 should be used instead.

For the pyramid measurement volume, <Shape Parameter> in reply option 03 returns the following values (illustrated in Figure 5-2):

Shape Parameter	Value	Description
D1	-2400 mm	*z*-coordinate of back of volume
D2	-1532 mm	*z*-coordinate where sides of volume change slope
D3	-950 mm	*z*-coordinate of front of volume
D4	572 mm	Half width of volume at *z* = D2
D5	398 mm	Half height of volume *z* = D2
D6	0569.46	Slope of front part of volume sides in the *yz*-plane (scaled by 1000)
D7	0243.03	Slope of back part of volume sides in the *yz*-plane (scaled by 1000)
D8	0297.73	Slope of volume top and bottom in the *xz*-plane (scaled by 1000)
D9	9999.99 mm	Maximum half width of volume (unrestricted)
D10	9999.99 mm	Maximum half height of volume (unrestricted)

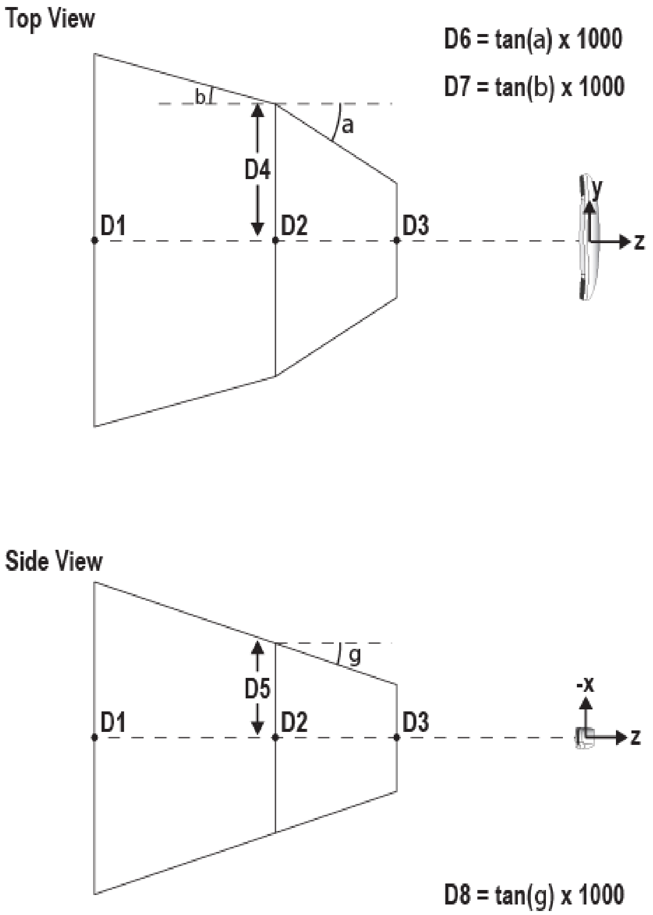


Figure 5-2 Pyramid Volume Parameters (Polaris Vega)

For the extended pyramid measurement volume, <Shape Parameter> in reply option 03 returns the following values (illustrated in Figure 5-2 and Figure 5-3):

Shape Parameter	Value	Description
D1	-3000 mm	*z*-coordinate of back of volume
D2	-1532 mm	*z*-coordinate where sides of volume change slope
D3	-950 mm	*z*-coordinate of front of volume
D4	572 mm	Half width of volume at *z* = D2
D5	398 mm	Half height of volume *z* = D2
D6	0569.46	Slope of front part of volume sides in the *yz*-plane (scaled by 1000)
D7	0243.03	Slope of back part of volume sides in the *yz*-plane (scaled by 1000)
D8	0297.73	Slope of volume top and bottom in the *xz*-plane (scaled by 1000)
D9	9999.99 mm	Maximum half width of volume (unrestricted)
D10	735 mm	Maximum half height of volume

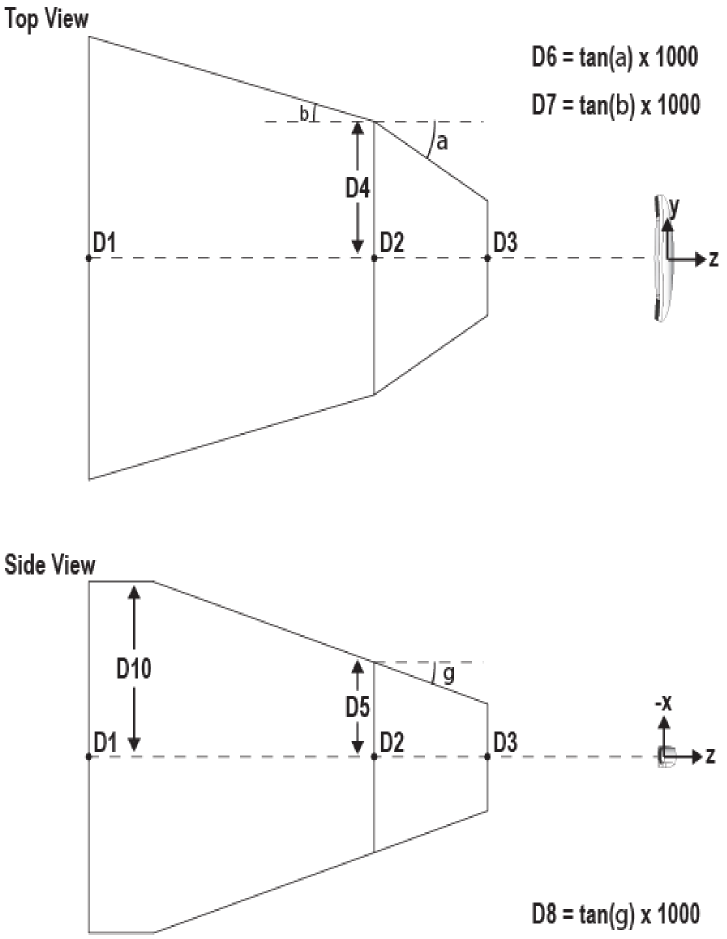


Figure 5-3 Extended Pyramid Volume Parameters (Polaris Vega)

Usage Notes

1. Use both the shape type and the shape parameters to represent the characterized measurement volume graphically. There may be multiple volumes with the same shape type. All volumes of the same shape type use the shape parameters the same way.
2. **Reply option 03**: A characterized measurement volume that supports wavelength value 0 (930 nm) supports the wavelength values of 000 (9*x*0 nm) and 010 (930 nm) returned with PHINF (page 96).

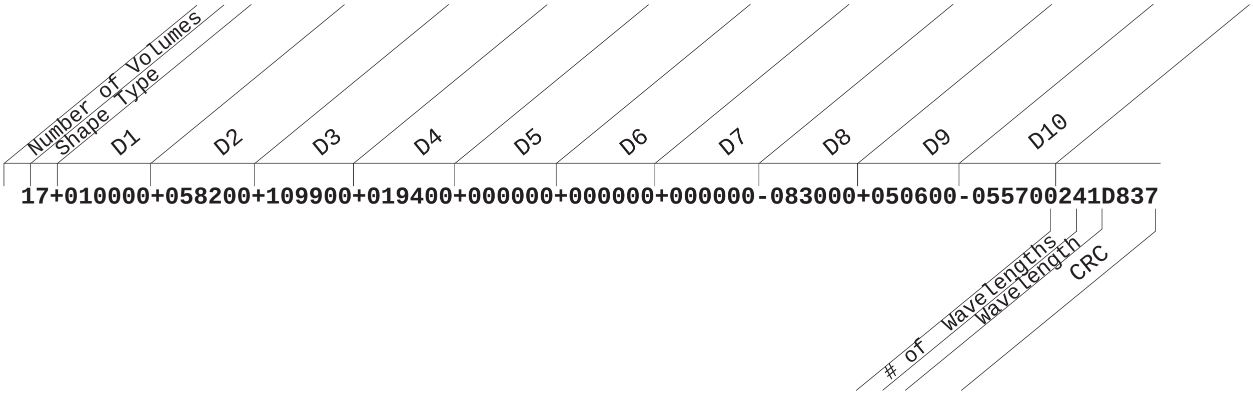
Examples

Command:
```
SFLIST
```

Reply:
```
0000003FEEEC
```

Command:
```
SFLIST 03
```

Reply:



```
17+010000+058200+109900+019400+000000+000000+000000-083000+050600-055700241D837
```

STREAM

Initiates a streaming response to a command

Operating Mode

All modes

Syntax

```
STREAM<SPACE><Parameter><CR>
```

Parameter	Description
[**--id**=`<id string>`]	--id=`<id string>` is an optional id string that will be returned in the stream response header. If it contains spaces it must be quoted. If it is omitted the command string will be used as the id. ids must be unique to the given connection.
[**--interval**=`<frame count>`]	--interval=`<frame count>` is an integer frame count interval that will be used to limit the response rate.
[**--diff=true**]	--diff=true when present indicates that only the differences between the current response and the last streamed response will be sent. At present this option is valid for ascii responses to commands such as GET and GETINFO.
[--cmd=]`<command to stream>`	`<command to stream>` is the command string exactly as it would be if issued separately. For consistency and flexibility it is also possible to specify the command using option **--cmd**=`<command to stream>`

Replies

Upon Success:

OKAY`<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 157 for error code definitions.

Note

The response is binary and is similar to the BX binary response with a different header signature. In order to maintain compatibility with the serial protocol, all binary replies are in little endian format rather than network byte order. The header signature is a 2 byte little endian code. The first byte is 0xD4 the second byte is 0xB5.

B5D4`<Stream ID Length(2 bytes)><Stream ID><Header CRC16><command reply>`

`<command reply>` is the unmodified reply for the command that is being streamed exactly as it would appear if the command were given separately without streaming.

Usage Notes

For details on data streaming format see “Data Streaming” on page 8.

Example

Command:

```
STREAM BX 0803
```

Reply:

```
OKAYA896
```

The following would continue with updated data replies until USTREAM is issued

B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
B5D40700BX 08031234**A5C4**....
...

SYSLOG

Writes data to the Position Sensor or System Control Unit log file.

Operating Mode

All modes

Syntax

```
SYSLOG<SPACE>\<Device Name>\<Category>=<Message><CR>
```

or

```
SYSLOG<SPACE><Category>=<Message><CR>
```

Parameter	Description
`Device Name`	Selects a hardware device to write to. See “Device Names” on page 21 for information on device names. The device name is ignored if it is specified.
`Category`	A string, up to 12 characters Specifies the log entry category or source. If you enter more than 12 characters, the system will truncate the category to 12 characters.
`Message`	A string, up to 256 characters. Contains the log message. If you enter more than 256 characters, the system will truncate the message to 256 characters.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. The system log in each hardware device is intended to record events central to the life of the device. The system automatically records events such as updates, bump sensor events, and hardware faults in the log.
2. To read the log, use GETLOG (page 81).

Compatibility Notes

For passive systems, only the Position Sensor log file is available.

Example

Command:

```
SYSLOG Test=This is a SYSLOG test!
```

Reply:

```
OKAYA896
```

TCTST

Returns diagnostics on the active markers of a wired tool.

Operating Mode

Setup

Prerequisite Command

PINIT (page 107)

Syntax

```
TCTST<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon success:

```
<Marker A Current><Marker B Current>...<Marker T Current><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description
`Marker n Current`	2 hexadecimal characters The electrical current of the markers.

Usage Notes

1. If the result is less than 0x0A either there is no marker, or there is a problem with the diode that has caused an open circuit.
2. If the result is greater than 0x0A the marker is either okay or it has short-circuited. The exact value cannot be predicted as it depends upon the System Control Unit and the tool design (cable length, number of markers, and marker configuration). This value should be determined on a historical basis for each particular tool design.
3. You cannot test a visible LED, since the System Control Unit cannot reliably test the low current of an LED because the LED current result may be corrupted from electrical noise.

Example

Command:

```
TCTST 01
```

Reply:

```
9400000000940100000092000000009400000000DF24
```

TSTART

Starts Tracking mode.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
TSTART<SPACE><Reply Option><CR>
```

Parameter	Description
`Reply Option`	80 (Optional)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

The frame number is reported in reply option 0001 of the TX (page 138) and BX (page 49) commands. In the Polaris Vega System, the frame number is derived from the PTP time, and reply option 80 is ignored.

In order to facilitate the retrieval of tracking data in a monitor connection, TSTART will return OKAY when in tracking mode.

Example

Command:

```
TSTART
```

Reply:

```
OKAYA896
```

TSTOP

Stops tracking mode.

Operating Mode

Tracking

Prerequisite Command

TSTART (page 135)

Syntax

```
TSTOP<SPACE><CR>
```

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

If executed from the Setup mode, it will return OKAY.

Example

Command:

```
TSTOP
```

Reply:

```
OKAYA896
```

TTCFG

Sets up a configuration for a wired tool, so that you can test the tool without using a tool definition file.

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
TTCFG<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. TTCFG internally sets up a test configuration for a wired tool, so that it can be tested without having a tool definition file. This is useful for testing the wiring in the tool before characterizing the tool. For example, after sending TTCFG, you can:
   - use TCTST to test the current
   - in diagnostic mode, use IRED to individually activate the markers.
2. After sending the TTCFG command, you will need to enable (PENA) the port handle before using any other commands that list these as prerequisites.
3. With the test configuration, the tool cannot be tracked.

Example

Command:

```
TTCFG 0A
```

Reply:

```
OKAYA896
```

TX

Returns the latest tool transformations, individual marker positions, and system status in text format.

Operating Mode

Tracking

Syntax

```
TX<SPACE><Reply Option><CR>
```

Parameter	Description		G.003.002
Reply Option	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned for each port handle in order of increasing option value, with the following exceptions: Reply option 0800 is not reported separately from the other options; it simply enables the system to return certain information in the other options. Reply option 1000 is reported after all handle-specific options but before the <system status> and <CRC16>. **Valid Values:**		
	0001	Transformation data (default)	X
	0002	Tool and marker information	X
	0004	3D position of a single stray active marker	X
	0008	3D positions of markers on tools	X
	0800	Transformations not normally reported	X
	1000	3D positions of stray passive markers	X

Replies

Upon Success:

```
<# of Handles><Handle 1><Reply Opt 0001 Data>...<Reply Opt 0008 Data><LF>
...
<Handle n><Reply Option 0001 Data>...<Reply Option 0008 Data><LF>
<Reply Option 1000 Data><System Status><CRC16><CR>
```

Note If the port handle is disabled, the system returns the string DISABLED instead of <Reply Option 0001 Data>...<Reply Option 0008 Data>.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Reply Component	Description		G.003.002
Number of Handles	2 hexadecimal characters The number of port handles for which information is returned.		X
Handle n	2 hexadecimal characters The port handle whose information follows.		X
Reply Option m Data	The data specific to the requested reply option. See the reply option information below for details:		
	Reply option 0001 (transformation data) (default)		X
	Reply option 0002 (tool and marker information)		X
	Reply option 0004 (latest 3D position of single, stray, active marker)		X
	Reply option 0008 (3D position of markers on tools)		X
	Reply option 0800 (reporting all transformations)		X
	Reply option 1000 (3D position of stray passive markers)		X
System Status	4 hexadecimal characters (16 bits) The status of the system. **Bit field:**		
	bit 0	System communication synchronization error	X
	bits 1 and 2	Reserved	
	bit 3	Recoverable system processing exception.	X
	bit 4-5	Reserved	
	bit 6	Some port handle has become occupied	X
	bit 7	Some port handle has become unoccupied	X
	bit 8	Diagnostic pending	X
	bit 9	Temperature (system is not within operating temperature range)	X
	bit 10	Hardware configuration changed (e.g. VCU or SCU has connected or disconnected)	X
	bits 11 to 15	Reserved	

Note The “diagnostic pending” bit is set whenever an alert is detected or cleared. To view the alerts status and clear the diagnostic pending bit, use GET (page 77) to check the Info.Status.New Alerts user parameter for every hardware device in the system. See “Usage Notes” on page 58 for more details. (Note: For API revision G.001.003 and earlier, the diagnostic pending bit did not indicate when an alert was cleared.)

Reply Option 0001 - Transformation Data

```
<Reply Option 0001 Data> = <Q0><Qx><Qy><Qz><Tx><Ty><Tz><Error><Port Status>
<Frame Number>
or
<Reply Option 0001 Data> = MISSING<Port Status><Frame Number>
```

Reply Component	Description	G.003.002
`Q0, Qx, Qy, Qz`	6 characters each (a sign, and 5 decimal digits with an implied decimal in the position X . XXXX) Rotational component of the transformation, quaternion, unitless. The value for Q0 is always non-negative.	X
`Tx, Ty, Tz`	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Translational components of the transformation, in mm.	X
`Error`	6 characters (a sign, and 5 decimal digits with an implied decimal in the position X . XXXX) The error is an RMS value, given in mm. It is the result of the least squares minimization between the marker geometry in the tool definition file and the data from the tool’s markers measured by the system.	X

Reply Component	Description		G.003.002
`Port Status`	8 hexadecimal characters (32 bits) **Bit field:**		
	bit 0	Occupied	X
	bit 1	Switch 1 closed	X
	bit 2	Switch 2 closed	X
	bit 3	Switch 3 closed	X
	bit 4	Initialized	X
	bit 5	Enabled	X
	bit 6	Out of volume	X
	bit 7	Partially out of volume	X
	bit 8	Algorithm limitation (processing requires more buffer than is available)	X
	bit 9	IR interference (a large bright IR object)	X
	bits 10 and 11	Reserved	
	bit 12	Processing exception (same as tool information bit 7 in reply option 0002)	X
	bit 13	Reserved	
	bit 14	Fell behind while processing (same as tool information bit 3 in reply option 0002)	X
	bit 15	Data buffer limitation (too much data; for example, too many markers)	X
	bits 16 to 31	Reserved	
`Frame Number`	8 hexadecimal characters The frame number is an internal counter related to data acquisition, which is derived from the PTP time. The frame number corresponds to the frame in which the raw data, used to calculate the accompanying transformation, was collected.		X

Note The system returns the string MISSING, followed by the port status and frame number, in the following situation:
- Tools are reported as missing if a transformation cannot be determined.

Reply Option 0002 - Tool and Marker Information

```
<Reply Option 0002 Data> = <Tool Information><Marker Information>
```

Reply Component	Description		G.003.002
`Tool Information`	2 hexadecimal characters (8 bits) **Bit field:**		
	bit 0	Bad transformation fit	X
	bit 1	Not enough acceptable markers for transformation	X
	bit 2	IR interference—environmental IR is interfering with the system (combination of port status bits 9 and 15 in reply option 0001)	X
	bit 3	Fell behind while processing (same as port status bit 14 in reply option 0001)	X
	bits 4 to 6	Tool face used	X
	bit 7	Processing exception (same as port status bit 12 in reply option 0001)	X
`Marker Information`	20 hexadecimal characters (1 per marker) See below for an example. **Possible Values:**		
	0	Not used because it was missing	X
	1	Not used because it exceeded the maximum marker angle	X
	2	Not used because it exceeded the maximum 3D error for the tool	X
	3	Used to calculate the transformation	X
	4	Used to calculate the transformation, but it is out of volume	X
	5	Not used because it was outside the characterized measurement volume and was not needed to calculate a transformation.	X

Example - Marker Information: A tool with markers located at T, R, C, and A, where all four markers were used to determine the calculation, would have the reply 30300000000000000303, as illustrated:

Marker Letter	T	S	R	Q	...	D	C	B	A
Reply Char (Hex)	3	0	3	0	...	0	3	0	3

Reply Option 0004 - 3D Position of Single Stray Active Marker

<Reply Option 0004 Data> = <Status><T_x><T_y><T_z>
or
<Reply Option 0004 Data> = <Status>

Reply Component	Description		G.003.002
Status	2 hexadecimal characters (8 bits) The status of the stray active marker. A stray marker on an active tool is not fixed with respect to the other markers that make up the tool. **Bit field:**		
	bit 0	Valid stray active marker	X
	bit 1	Marker is missing	X
	bit 2	Reserved	
	bit 3	Marker is out of volume	X
	bits 4 to 7	Reserved	
Tx, Ty, Tz	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the marker, reported in the coordinate system of the Position Sensor. The marker position is reported only if the marker status is “valid,” or if the status is “out of volume” and reply option 0800 is used.		X

Note If no stray active marker is defined (for example, for wireless port handles or wired tools with no stray marker defined in the tool definition file), the status is 00, and no position information is returned. If the marker is missing, or if the marker is out of volume and reply option 0800 is not used, the system returns only the status.

Reply Option 0008 - 3D Position of Markers on Tools

<Reply Option 0008 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.003.002
Number of Markers	2 hexadecimal characters Number of markers used in tool transformations.	X
Out of Volume	1 hexadecimal character per 4 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/4, rounded up to the nearest integer.	X
Txn, Tyn, and Tzn	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the nth marker, reported in the coordinate system of the Position Sensor. The system will report the positions of markers used in tool transformations, as well as markers that exceeded the maximum marker angle or maximum 3D error specified in the tool definition file. See "Usage Notes" on page 147 for more information. **Reply size:** If reply option 0800 is not used, reply size = (21 characters) x (number of markers inside the characterized measurement volume). If reply option 0800 is used, reply size = (21 characters) x (total number of markers).	X

Example - Out of Volume: The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number				9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	1	1	1	1	1	1	1	1	1
Reply	1				F				F			

Reply Option 0800 - Reporting All Transformations

This option enables the reporting of transformations or translations in situations where translations or transformations are calculated, but by default are not reported by the system. Such situations include:

- The tool or marker is outside of the characterized measurement volume.
- The bump sensor has been tripped.
- The system is outside of the optimal operating temperature range.
- Other system conditions are not ideal; see "Alerts User Parameters" on page 22 for a full list of these conditions.

This reply option must be OR'd with reply option 0001 to obtain transformations for tools in the situations listed above. It must be OR'd with reply options 0004, 0008, or 1000 to obtain position information for markers in the situations listed above.

Warning!

When using reply option 0800 with the TX command, you must take appropriate action to detect the events listed above, and determine whether they are detrimental to your application. If one or more of the events listed above occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Appropriate action to detect the events listed above includes:

- reading the out-of-volume flag in reply options 0001 and 0002 when tracking tools
- reading the out-of-volume information in reply options 0004, 0008, and 1000 when tracking stray markers
- reading the temperature flag in the system status
- reading the diagnostic pending bit in the system status
- reading the **Info.Status.New Alerts** user parameter for every hardware device in the system when the diagnostic pending bit is set. See "Usage Notes" on page 147 for details.

Reply Option 1000 - 3D Position of up to 50 Stray Passive Markers

```
<Reply Option 1000 Data> = <Number of Markers><Out of Volume><Txn><Tyn><Tzn>
```

Reply Component	Description	G.003.002
`Number of Markers`	2 hexadecimal characters Number of stray markers.	X
`Out of Volume`	1 hexadecimal character per 4 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/4, rounded up to the nearest integer.	X
`Txn, Tyn, Tzn`	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the nth marker, reported in the coordinate system of the Position Sensor. **Reply size:** If reply option 0800 is not used, reply size = (21 characters) x (number of markers inside the characterized measurement volume). If reply option 0800 is used, reply size = (21 characters) x (total number of markers).	X

Note At least one passive port handle must be enabled, to activate the illuminators on the Position Sensor. If no passive port handles are enabled, <Number of Markers> will return 00 and no other data will be returned.

Stray passive markers are defined as markers which are not used to calculate any of the transformations for any enabled, passive tools. Stray active wireless tool markers are not reported.

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number				9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	1	1	1	1	1	1	1	1	1
Reply	1				F				F			

Usage Notes

1. The TX format is easier to parse than the binary format; it is useful when troubleshooting, or observing data as it is collected. For replies in binary format, use BX2 (page 60).
2. By default, transformations will not be reported if the tool is either partially or wholly out of the characterized measurement volume, if the bump sensor has been tripped, or if the system is outside of the optimal operating temperature range. To report these transformations, you must use reply option 0800 OR'd with the desired reply option(s). The accuracy of these transformations is unknown.
3. **Reply Option 0001**:
    - When the "diagnostic pending" bit is set in the system status, use GET (page 77) to read the **Info.Status.New Alerts** user parameter for every hardware device in the system. The act of reading these parameters clears the parameters and the "diagnostic pending" bit. For more information on alerts and their associated user parameters, see "Alerts User Parameters" on page 22.
    - For wired tools, bits 1, 2, and 3 in the port status report switch status.
4. **Reply Option 0008**: Markers are returned in alphabetical order according to how they are labelled in the tool definition file. For example, for a tool with markers labelled A, G, M and S, the system will return the marker positions in the order A G M S. Reply option 0008 only returns data for markers that the system detects. To identify which marker is which, compare the reply option 0008 data to the data returned with reply option 0002. The marker order is the same for both replies; each marker that does not have a <marker information> status of 0 ("missing") in reply option 0002 corresponds to a marker in reply option 0008
5. **Reply Option 1000**: At least one passive tool definition file must be initialized and enabled in order for the system to return stray passive marker data. If no passive tool definition files are enabled, this reply option will return 00.

Compatibility Notes

1. **System Status**:
    - In API revision G.001.004 and later, the diagnostic pending bit (bit 8) is set whenever an alert is detected or cleared. In API revision G.001.003 and earlier, the diagnostic pending bit is set only when an alert is detected.
2. **Reply Option 0002**:
    - Marker information value 2 means that the marker was not used because it exceeded the maximum 3D error for the tool.

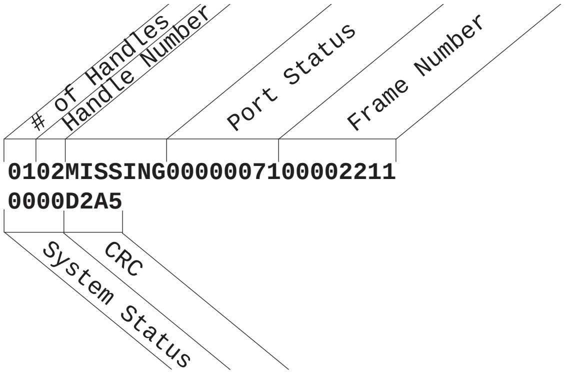
Examples

Example 1

Command:

```
TX 0001
```

Reply:



```
0102MISSING0000007100002211
0000D2A5
```

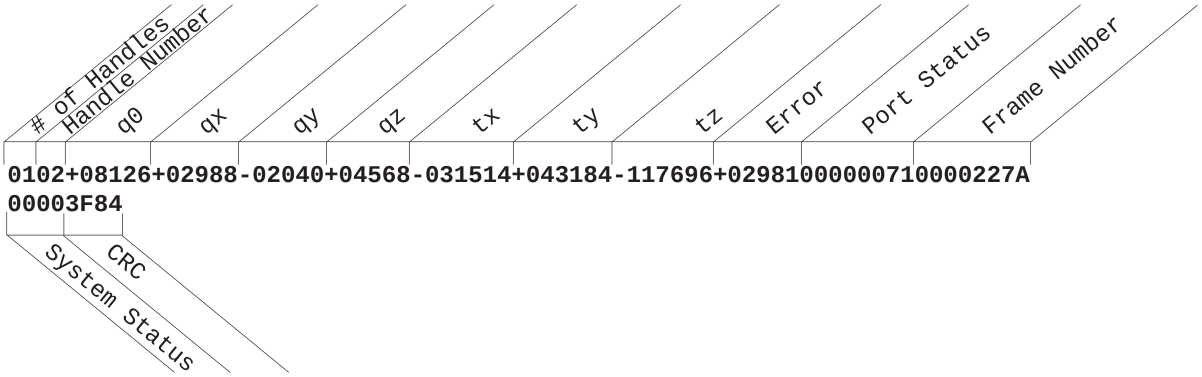
The system reports that there is one tool, which is missing. Notice the port status, which indicates that the tool is occupied, initialized, enabled, and out of volume.

Example 2

Command:

```
TX 0801
```

Reply:



```
0102+08126+02988-02040+04568-031514+043184-117696+02981000000710000227A
00003F84
```

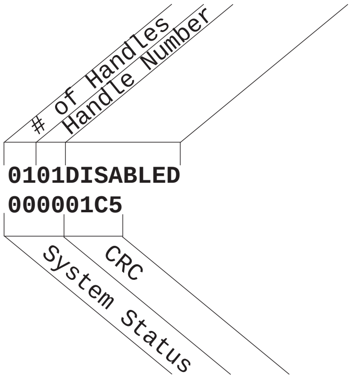
With the 0800 reply option applied, the system reports the missing tool. Notice the port status, which indicates that the tool is occupied, initialized, enabled, and out of volume.

Example 3

Command:

```
TX 0001
```

Reply:



```
0101DISABLED
000001C5
```

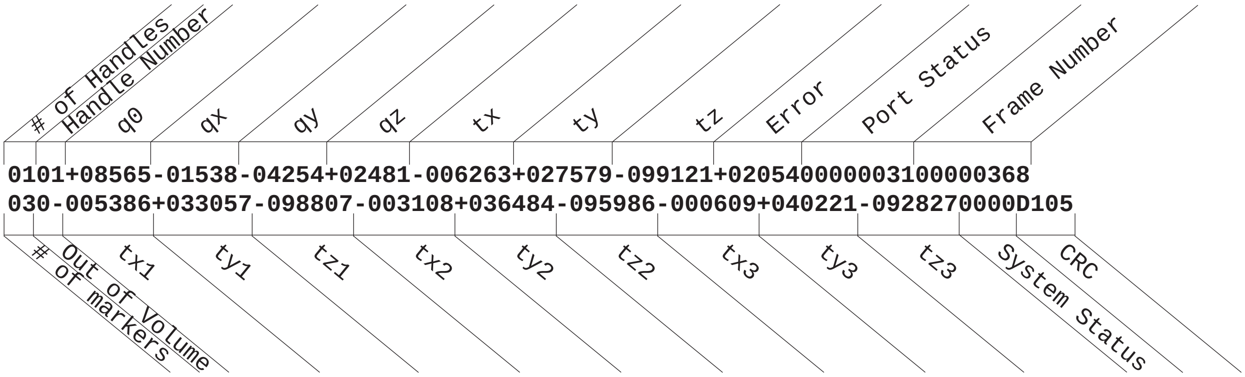
The system reports that there is one tool, whose port handle is disabled. It also reports the system status.

Example 4

Command:

```
TX 1001
```

Reply:



```
0101+08565-01538-04254+02481-006263+027579-099121+020540000003100000368
030-005386+033057-098807-003108+036484-095986-000609+040221-0928270000D105
```

The system reports the transformation for one tool (first line of the reply), and the positions of three stray passive markers (second line of the reply).

USTREAM

Terminates a streaming response to a command.

Operating Mode

All modes

Syntax

```
USTREAM --id=<id string><CR>
```

`--id=` is optional

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Example

Command:

```
USTREAM BX 0803
```

Reply:

```
OKAYA896
```

The stream of "B5D40700BX 08031234A5C4...." messages stops.

VCAP

Captures and returns IR image data from the sensors.

Operating Mode

Tracking

Syntax

```
VCAP<SPACE><Parameters><CR>
```

Parameter	Description
`--frame=passive|active|activewireless|background|illuminated`	Specifies what type of frame to return. When VCAP is sent with no parameters, the next available frame type is returned. The Param.Tracking.Illuminated (Background) Frame parameters must be set to 1 before frames will be returned.
`--frameindex=<frame index>`	Specifies which frame in the frame sequence to return. This is useful when the system is configured with more than one frame of a particular type (e.g. two active frames) and only one of them needs to be returned. When VCAP is sent with no frame index, the next available frame type is returned.
`--sensor=<sensor number>`	Specifies which sensor to capture an image from. By default both sensors are used. The left sensor (sensor 0) is returned first, followed by the right sensor (sensor 1).
`--format=RAW|TIFF|PGM`	Specifies the image format. By default, RAW is used.
`--depth=<bits-per-pixel>`	Specifies the number of bits to use per pixel. Valid values are 1, 2, 4, 8 and 16. The default is 16.
`--stride=<number of pixels>`	Specifies the pixel-read step size. For example, a stride of 4 means that every fourth pixel is returned. The default is 1 (i.e. return every pixel).
`--sample=pixel|average|peak`	If stride is greater than 1, this specifies how to sample the intermediate pixels. The default is pixel (i.e. intermediate pixels are ignored).
`--area=<x, y, width, height>`	Specifies the area of the image to be returned. The maximum size of the image is 1920 x 1200. The default is to return the whole image. If the `stride` parameter is defined, the area returned will be a subset of the area that is defined.

Replies

Upon Success:

`A5C8<4 byte Reply Length><command reply>` or
`A5C4<2 byte Reply Length><2 byte Header CRC><command reply><2 byte Data CRC>`

Note The `<command reply>` payload is in the General Binary Format, which is documented in the section General Binary Format on page 5.

On Error:
`ERROR<Error Code><CRC16><CR>`

See page 157 for error code definitions.

Image Data Component: 0x000A

Image Component Header		
Item Type	1 byte	0=RAW, 1=PGM, 2=TIFF
Sensor	1 byte	Sensor number
Frame Type	1 byte	Frame type (see BX2)
Frame Index	1 byte	Frame sequence index
Frame Number	4 bytes	Frame number
Trigger Threshold	4 bytes	Trigger threshold, percentage of full scale (float)
Background Threshold	4 bytes	Background threshold, percentage of full scale (float)
Exposure	2 bytes	Exposure in microseconds
Stride	1 byte	Pixel stride count
Image Depth	1 byte	Bits per pixel
Image Area	8 bytes	X, Y, Width, Height (2 bytes each)
Meta data length (M)	4 bytes	Length of optional meta data. Must be multiple of 4
Meta data	M bytes	Optional meta data
Image Item		The image data

PGM format images have the following meta data embedded as comments:

# **frame_type** = `<frame type>`

# **frame_number** = `<frame number>`

# **sensor** = `<sensor number>`

# **exposure** = `<exposure time>`

# **trigger_threshold** = `<% of full scale>`

# **background_threshold** = `<% of full scale>`

# **stride** = `<stride pixel count>`

# **depth** = `<bits per pixel>`

# **area** = <x,y,width,height>

Examples

Command:
VCAP

Reply:

9.2 MB of data in GBF format, consisting of two image components (one for each sensor), each showing the entire image (1920 x 1200 pixels x 16 bits of gray scale) in RAW format.

Command:

```
vcap --sensor=0 --stride=2 --format=tiff --depth=8
```

Reply:

576,326 bytes of data in GBF format, consisting of one image component (for the left sensor), showing 960 x 600 pixels (sampling every second pixel in every second row of the entire image), in 8-bit gray scale, in TIFF format.

VER

Returns the firmware revision number of critical processors installed in the system.

Operating Mode

Setup

Syntax

```
VER<SPACE><Reply Option><CR>
```

Parameter	Description		G.003.002
Reply Option	Specifies which information will be returned. The reply options cannot be OR'd. **Valid Values:**		
	0	System Control Processor (Position Sensor)	X
	1	Reserved	
	2	Reserved	
	3	System Control Unit Processor	X
	4	System Control Processor (Position Sensor), with enhanced revision numbering. The revision numbering is XXX.YYY, where XXX = major revision and YYY = minor revision. The major revision number is always the same as the revision number for parameter value 0.	X
	5	Combined firmware revision number. The revision numbering format is XXX. Only the number is reported; there is no information about the type of system.	*
	6	Reserved	

Replies

Upon Success:

Reply Options 0 to 4 and 6:

```
<Type of Firmware><LF>
<NDI Serial Number><LF>
<Characterization Date><LF> (included only for Reply Option 0 and 4)
<Freeze Tag><LF>
<Freeze Date><LF>
<Copyright Information><LF>
<CRC16><CR>
```

Reply Option 5:

```
<Combined Firmware Revision><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

1. If you send the command VER 5 after the INIT command has replied with `ERROR2E`, the reply will be ???, because component versions are incompatible.

Compatibility Notes

1. You can also obtain the combined firmware revision of the system by using the command GET (page 77) to read the value of the user parameter **Config.Combined Firmware Revision**. See “User Parameters” on page 20 for more information on user parameters.
2. **Reply Option 3**: Is not supported by passive systems.

Examples

Command:

```
VER 4
```

Reply:

```
Polaris Vega Control Firmware
NDI S/N: P9-B0058
Characterization Date: 06/09/16
Freeze Tag: Polaris Vega Beta 008.002
Freeze Date: June 20 2016
(c) Northern Digital Inc.
AEBC
```

Command:

```
VER 5
```

Reply:

```
001BDB5
```

VSEL

Selects a characterised measurement volume.

Deprecated

Operating Mode

Setup

Prerequisite Command

INIT (page 83)

Syntax

```
VSEL<SPACE><Volume Number><CR>
```

Parameter	Description
`Volume Number`	1 hexadecimal character Possible Values: 1 to the maximum returned by SFLIST (page 121)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 157 for error code definitions.

Usage Notes

Use SFLIST (page 121) to determine which measurement volumes are available.

Compatibility Notes

The VSEL command has been deprecated for the Polaris Vega System. To select a measurement volume for the Polaris Vega System, use the command SET (page 120) to set the user parameter **Param.Tracking.Selected Volume**.

Example

Command:

```
VSEL 1
```

Reply:

```
OKAYA896
```

6 Error and Warning Code Definitions

6.1 Error Code Definitions

If the system receives an invalid command, it responds to the host with the message `ERROR<Error Code>`. Table 6-1 identifies the error codes and their definitions.

Table 6-1 Error Code Definitions

Error Code	Definition
01	Invalid command.
02	Command too long.
03	Command too short.
04	Invalid CRC calculated for command; calculated CRC does not match the one sent.
05	Time-out on command execution.
06	Unable to set up new communication parameters. This occurs if one of the communication parameters is out of range.
07	Incorrect number of parameters.
08	Invalid port handle selected.
09	Invalid mode selected. Either the tracking priority is out of range, or an incorrect priority was selected (e.g. the tool has markers defined and “button box” was selected).
0A	Invalid LED selected. The LED selected is out of range.
0B	Invalid LED state selected. The LED state selected is out of range.
0C	Command is invalid while in the current mode.
0D	No tool is assigned to the selected port handle.
0E	Selected port handle not initialized. The port handle needs to be initialized before the command is sent.
0F	Selected port handle not enabled. The port handle needs to be enabled before the command is sent.
10	System not initialized. The system must be initialized before the command is sent.
11	Unable to stop tracking. This occurs if there are hardware problems. Please contact NDI.
12	Unable to start tracking. This occurs if there are hardware problems. Please contact NDI.
13	Hardware error: unable to read the SROM device.
14	Invalid Position Sensor characterization parameters.
15	Unable to initialize the system. This occurs if: • the system could not return to Setup mode • there are internal hardware problems. Please contact NDI. • there are internal parameter errors. Use GET to read the **Info.Status.Alerts** parameter for more details.

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
16	Unable to start Diagnostic mode. This occurs if there are hardware problems. Please contact NDI.
17	Unable to stop Diagnostic mode. This occurs if there are hardware problems. Please contact NDI.
18	Reserved
19	Unable to read device's version information. This occurs if: • the processor selected is out of range • the system is unable to inquire firmware version information from a processor
1A	Internal system error. This occurs when the system is unable to recover after: • too much IR • a system processing exception
1B	Reserved
1C	Unable to set marker activation signature.
1D	Reserved
1E	Unable to read SROM device data. This occurs if the system is: • unable to auto-select the first SROM device on the given port handle as a target to read from • unable to read a page of SROM device data successfully
1F	Unable to write SROM device data. This can occur if: • the system is unable to auto-select the first SROM device on the given port handle as a target for writing to the SROM device • the system is unable to write a page of SROM device data successfully
20	Reserved
21	Unable to test electrical current on tool.
22	Enabled tools are not supported by selected volume parameters. For example, a Position Sensor cannot track a tool if the volume parameter set does not include the marker wavelength of an enabled tool.
23	Command parameter is out of range.
24	Unable to select measurement volume. This occurs if: • the selected volume is not available • there are internal hardware errors. Please contact NDI.
25	Unable to determine the system’s supported features list. This occurs if the system is unable to read all the hardware information.
26-27	Reserved
28	Too many tools are enabled, or the configuration of tools loaded requires too many frames.
29	Reserved
2A	No memory is available for dynamic allocation (heap is full).

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
2B	The requested port handle has not been allocated.
2C	The requested port handle has become unoccupied.
2D	All handles have been allocated.
2E	Incompatible firmware versions. This can occur if: • a firmware update failed • components with incompatible firmware are connected To correct the problem, update the firmware. If the Multi Firmware feature is installed, select a valid combined firmware revision.
2F	Invalid port description.
30	Requested port is already assigned a port handle.
31	Reserved
32	Invalid operation for the device associated with the specified port handle.
33	Feature not available.
34	User parameter does not exist.
35	Invalid value type (e.g. string instead of integer).
36	User parameter value set is out of valid range.
37	User parameter array index is out of valid range.
38	User parameter size is incorrect.
39	Permission denied; file or user parameter is read-only, or a command which requires master mode is attempted from a monitor mode connection.
3A	Reserved
3B	File not found.
3C	Error writing to file.
3D	Error reading from file.
3E-3F	Reserved
40	Tool Definition File Error. This occurs if: • the CRC failed • the file format is invalid
41	Tool characteristics not supported. This occurs when one of the following fields in the tool definition file is outside of the range supported by the system: • number of markers • number of faces • number of groups • number of markers per face (unique geometry tools only)
42	Device not present. This occurs when the command is specific to a device that is not connected to the system.
43	Reserved

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
F0	Reserved
F1-FF	Reserved

6.2 Warning Code Definitions

Table 6-2 Warning Code Definitions

Warning	Definition
`WARNING01`	A non-fatal tool error has been encountered, e.g. a burnt out marker.
`WARNING02`	The tool you are trying to enable is a unique geometry tool that doesn’t meet the unique geometry requirements.
`WARNING03`	The tool you are trying to enable is a unique geometry tool that conflicts with another unique geometry tool already loaded and enabled.
`WARNING04`	The tool you are trying to enable is a unique geometry tool that doesn’t meet the unique geometry requirements, and conflicts with another unique geometry tool already loaded and enabled.
`WARNING05`	The system has selected a default marker wavelength to track a tool (if the tool’s tool definition file did not specify a marker wavelength).

`WARNING01 and WARNING05` are returned with the PINIT or the PENA command.

`WARNING02`, `WARNING03` and `WARNING04` are returned with the PENA command.

Appendix A Keyed Features

This section describes how to use the API commands and user parameters with the keyed features. For more information on keyed features, see the user guide that accompanied your system. For more information on user parameters, see "User Parameters" on page 20.

A.1 Disabling and Enabling Keyed Features

Disabling a keyed feature makes that feature unavailable. Enabling a keyed feature makes the feature available. A keyed feature is enabled upon installation.

To disable or enable a keyed feature:

1. Use the API command SET to set the value of the user parameter **Features.Keys.Disabled Keys**.

   The value of this parameter is a comma-separated list. To disable a keyed feature, add its name to the comma-separated list. To re-enable a keyed feature, remove its name from the comma-separated list. For example:

   "SET Features.Keys.Disabled Keys=Multi Firmware" will disable the Multi Firmware feature.
   "SET Features.Keys.Disabled Keys=" will re-enable all the installed features keys.

2. Use the API command SAVE to save the settings.
3. Reset the system (use the API command RESET). The changed settings take effect upon system reset.

A.2 Multi Firmware Feature

The multi firmware feature allows the system to contain more than one combined firmware revision. When the multi firmware feature is enabled, you can specify which combined firmware revision the system will use on its next reset or power up.

Changing the Combined Firmware Revision Currently in Use

Procedure

Example

1. (Optional) Determine which combined firmware revision is currently in use: use the API command GET to read the user parameter **Config.Combined Firmware Revision**.

```
Command: GET Config.Combined Firmware
Revision
Reply: Config.Combined Firmware
Revision=002<CRC16>
```

2. Determine which combined firmware revisions are available:

   API revision G.001.004 and later: use the API command GET (page 77) to read the user parameter **Config.Multi Firmware.Available Combined Firmware Revisions**.

```
Command: GET Config.Multi Firmware.
Available Combined Firmware Revisions
Reply: 002,003<CRC16>
```

   The list of possible firmware revisions is given in the enumerated list. In this example, the firmware revisions are 002 and 003.

   API revision G.001.003 or earlier: use GETINFO (page 79) to read the user parameter **Config.Multi Firmware.Load Combined Firmware Revision**.)

```
Command: GETINFO Config.Multi
Firmware.Load Combined Firmware Revision
Reply: Config.Multi Firmware.Load
Combined Firmware
Revision=0;1;3;0;255;002,003; Combined
firmware revision to load on next reset
(selection automatically saves when
set)<CRC16>
```

   The list of possible firmware revisions is given in the enumerated list returned by GETINFO. In this example, the firmware revisions are 002 and 003.

   Select the desired combined firmware revision: use the API command SET to set the value of the user parameter **Config.Multi Firmware.Load Combined Firmware Revision**.The enumeration is zero-based. For example, to select the second item in the list (revision 003), set the value of the user parameter to 1.This parameter value is automatically saved when set. The selected combined firmware revision is loaded on the next reset.

```
Command: SET Config.Multi Firmware.Load
Combined Firmware Revision=1
Reply: OKAY<CRC16>
```

A.3 Positioning Laser

The positioning laser is located in the Polaris Vega System Position Sensor and indicates the centre of the characterized measurement volume. This feature allows you to properly position the Position Sensor, or position objects in the measurement volume. Unlike the other keyed features, the positioning laser feature cannot be purchased after you obtain the system; the laser hardware must be installed when the system is manufactured. For full details on the positioning laser, see the user guide that accompanied your system.

It is possible to activate (turn on) the laser by using an external laser switch connected to a laser switch port. The optional laser switch is not supplied by NDI.

Appendix B Sample C Routines

The following sample C routines are included for reference. For more information and sample code, refer to the Combined API Sample (CAPI).

Table 6-3 Sample C Routines

Routine	Description
CalcCRC16	Calculates a running CRC16 using the polynomial X^16 + X^15 + X^2 + 1.
EulerAngleTrig	Determines the sine and cosine of the Euler angles.
DetermineR	Calculates the 3x3 rotation matrix which corresponds to the given Euler angles.
CvtQuatToRotationMatrix	Determines the rotation matrix that corresponds to the given quaternion values.
DetermineEuler	Calculates the Euler angles given the 3x3 rotation matrix.
CvtQuatToEulerRotation	Determines the rotation in Euler angles (degrees) that corresponds to the given quaternion rotation.

The following defines are used by the sample C routines:

```
/*
 * Conversion factors.
 */
#define RAD_TO_DEGREES        (180 / 3.1415926)

/*
 * Defined data types.
 */
typedef float
    RotationMatrix[3][3];

typedef struct Rotation
{
    float
        fRoll,      /* rotation about the object's z-axis (Euler angle) */
        fPitch,     /* rotation about the object's y-axis (Euler angle) */
        fYaw;       /* rotation about the object's x-axis (Euler angle) */
} Rotation;

typedef struct QuatRotation
{
    float
        fQ0,
        fQX,
        fQY,
        fQZ;
} QuatRotation;
```

B.1 CalcCRC16

The following is a sample C routine, for calculating a running 16 bit CRC, as used in communications between the host computer and the Polaris System.

```
/*****************************************************************
Name:        CalcCRC16

Input Values:
    int
        data         :Data value to add to running CRC16.
    unsigned int
        *puCRC16     :Ptr. to running CRC16.

Output Values:
    None.

Returned Value:
    None.

Description:
    This routine calculates a running CRC16 using the polynomial
    X^16 + X^15 + X^2 + 1.

*****************************************************************/
void CalcCRC16( int data, unsigned int *puCRC16 )
{
    static int
        oddparity[16] = { 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0 };

    data = (data ^ (*puCRC16 & 0xff)) & 0xff;
    *puCRC16 >>= 8;

    if ( oddparity[data & 0x0f] ^ oddparity[data >> 4] )
    {
       *puCRC16 ^=0xc001

    } /* if */
    data <<= 6;
    *puCRC16 ^= data;
    data <<= 1;
    *puCRC16 ^= data;

} /* CalcCRC16 */
```

B.2 EulerAngleTrig

```
/********************************************************************
Name:        EulerAngleTrig

Input Values:
    Rotation
        *pdtRotationAngle :Ptr to struct containing the roll, pitch, yaw
                           Euler angles which define the required rotation.

Output Values:
    Rotation
        *pdtSinAngle :Ptr to struct containing the sine of the roll, pitch,
                      yaw Euler angles.
        *pdtCosAngle :Ptr to struct containing the cosine of the roll, pitch,
                      yaw Euler angles.

Returned Value:
    None.

Description:
    This routine determines the sine and cosine of the Euler angles.

*********************************************************************/
static void EulerAngleTrig( Rotation *pdtRotationAngle,
                Rotation *pdtSinAngle,
                Rotation *pdtCosAngle )
{
    pdtSinAngle->fRoll=    sin( pdtRotationAngle->fRoll );
    pdtSinAngle->fPitch=   sin( pdtRotationAngle->fPitch );
    pdtSinAngle->fYaw =    sin( pdtRotationAngle->fYaw );
    pdtCosAngle->fRoll=    cos( pdtRotationAngle->fRoll );
    pdtCosAngle->fPitch=   cos( pdtRotationAngle->fPitch );
    pdtCosAngle->fYaw=     cos( pdtRotationAngle->fYaw );

} /* EulerAngleTrig */
```

B.3 DetermineR

```
/*****************************************************************
Name:        DetermineR

Input Values:
    Rotation
        *pdtRotationAngle :Ptr to struct containing the roll, pitch, yaw
                            Euler angles which define the required rotation.

Output Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 rotation matrix to be determined.

Returned Value:
    None.

Description:
    This routine calculates the 3x3 rotation matrix which corresponds to the
    given Euler angles.

*****************************************************************/
void DetermineR( Rotation *pdtRotationAngle, RotationMatrix
         dtRotationMatrix )
{
    Rotation
        dtSinAngle, /* the sine of the roll, pitch, and yaw angles */
        dtCosAngle; /* the cosine of the roll, pitch, and yaw angles */

/*
* Might as well determine the sine and cosine of the given Euler
*angles right from the start
*/
EulerAngleTrig( pdtRotationAngle, &dtSinAngle, &dtCosAngle );

/*
* Fill in the rotation matrix.
*/
dtRotationMatrix[0][0] = dtCosAngle.fRoll * dtCosAngle.fPitch;
dtRotationMatrix[0][1] = dtCosAngle.fRoll * dtSinAngle.fPitch *
    dtSinAngle.fYaw - dtSinAngle.fRoll * dtCosAngle.fYaw;
dtRotationMatrix[0][2] = dtCosAngle.fRoll * dtSinAngle.fPitch *
    dtCosAngle.fYaw + dtSinAngle.fRoll * dtSinAngle.fYaw;
dtRotationMatrix[1][0] = dtSinAngle.fRoll * dtCosAngle.fPitch;
dtRotationMatrix[1][1] = dtSinAngle.fRoll * dtSinAngle.fPitch *
    dtSinAngle.fYaw + dtCosAngle.fRoll * dtCosAngle.fYaw;
dtRotationMatrix[1][2] = dtSinAngle.fRoll * dtSinAngle.fPitch *
    dtCosAngle.fYaw - dtCosAngle.fRoll * dtSinAngle.fYaw;
dtRotationMatrix[2][0] = - dtSinAngle.fPitch;
dtRotationMatrix[2][1] = dtCosAngle.fPitch * dtSinAngle.fYaw;
dtRotationMatrix[2][2] = dtCosAngle.fPitch * dtCosAngle.fYaw;

} /* DetermineR */
```

B.4 CvtQuatToRotationMatrix

```
/*****************************************************************
Name:        CvtQuatToRotationMatrix

Input Values:
    QuatRotation
        *pdtQuatRot :Ptr to the quaternion rotation.

Output Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 determined rotation matrix.

Returned Value:
    None.

Description:
    This routine determines the rotation matrix that corresponds
    to the given quaternion.

    Let the quaternion be represented by:

        | Q0 |
    Q = | Qx |
        | Qy |
        | Qz |

    and the rotation matrix by:

        | M00 M01 M02 |
    M = | M10 M11 M12 |
        | M20 M21 M22 |

    then assuming the quaternion, Q, has been normalized to convert
    Q to M we use the following equations:

    M00 = (Q0 * Q0) + (Qx * Qx) - (Qy * Qy) - (Qz * Qz)
    M01 = 2 * ((Qx * Qy) - (Q0 * Qz))
    M02 = 2 * ((Qx * Qz) + (Q0 * Qy))
    M10 = 2 * ((Qx * Qy) + (Q0 * Qz))
    M11 = (Q0 * Q0) - (Qx * Qx) + (Qy * Qy) - (Qz * Qz)
    M12 = 2 * ((Qy * Qz) - (Q0 * Qx))
    M20 = 2 * ((Qx * Qz) - (Q0 * Qy))
    M21 = 2 * ((Qy * Qz) + (Q0 * Qx))
    M22 = (Q0 * Q0) - (Qx * Qx) - (Qy * Qy) + (Qz * Qz)

*****************************************************************/
void CvtQuatToRotationMatrix( QuatRotation *pdtQuatRot,
                RotationMatrix dtRotMatrix )
{
    float
        fQ0Q0,
        fQxQx,
        fQyQy,
        fQzQz,
        fQ0Qx,
            fQ0Qy,
            fQ0Qz,
            fQxQy,
            fQxQz,
            fQyQz;

        /*
         * Determine some calculations done more than once.
         */
            fQ0Q0 = pdtQuatRot->fQ0 * pdtQuatRot->fQ0;
            fQxQx = pdtQuatRot->fQX * pdtQuatRot->fQX;
            fQyQy = pdtQuatRot->fQY * pdtQuatRot->fQY;
            fQzQz = pdtQuatRot->fQZ * pdtQuatRot->fQZ;
            fQ0Qx = pdtQuatRot->fQ0 * pdtQuatRot->fQX;
            fQ0Qy = pdtQuatRot->fQ0 * pdtQuatRot->fQY;
            fQ0Qz = pdtQuatRot->fQ0 * pdtQuatRot->fQZ;
            fQxQy = pdtQuatRot->fQX * pdtQuatRot->fQY;
            fQxQz = pdtQuatRot->fQX * pdtQuatRot->fQZ;
            fQyQz = pdtQuatRot->fQY * pdtQuatRot->fQZ;

        /*
         * Determine the rotation matrix elements.
         */
            dtRotMatrix[0][0] = fQ0Q0 + fQxQx - fQyQy - fQzQz;
            dtRotMatrix[0][1] = 2.0 * (-fQ0Qz + fQxQy);
            dtRotMatrix[0][2] = 2.0 * (fQ0Qy + fQxQz);
            dtRotMatrix[1][0] = 2.0 * (fQ0Qz + fQxQy);
            dtRotMatrix[1][1] = fQ0Q0 - fQxQx + fQyQy - fQzQz;
            dtRotMatrix[1][2] = 2.0 * (-fQ0Qx + fQyQz);
            dtRotMatrix[2][0] = 2.0 * (-fQ0Qy + fQxQz);
            dtRotMatrix[2][1] = 2.0 * (fQ0Qx + fQyQz);
            dtRotMatrix[2][2] = fQ0Q0 - fQxQx - fQyQy + fQzQz;

    } /* CvtQuatToRotationMatrix */
```

B.5 DetermineEuler

```
/*******************************************************************
Name:         DetermineEuler

Input Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 rotation matrix to convert.

Output Values:
    Rotation
        *pdtEulerRot :Rotation is Euler angle format.
            Roll, pitch, yaw Euler angles which define the required rotation.

Returned Value:
    None.

Description:
    This routine calculates the Euler angles given the 3x3 rotation matrix.

*******************************************************************/
void DetermineEuler( RotationMatrix dtRotMatrix, Rotation *pdtEulerRot )
{
       float
        fRoll,
        fCosRoll,
        fSinRoll;

       fRoll    = atan2( dtRotMatrix[1][0], dtRotMatrix[0][0] );
       fCosRoll = cos( fRoll );
       fSinRoll = sin( fRoll );

       pdtEulerRot->fRoll  = fRoll;
       pdtEulerRot->fPitch = atan2( -dtRotMatrix[2][0],
                             (fCosRoll * dtRotMatrix[0][0]) + (fSinRoll *
       dtRotMatrix[1][0]) );
       pdtEulerRot->fYaw   = atan2(
                             (fSinRoll * dtRotMatrix[0][2]) -
                             (fCosRoll * dtRotMatrix[1][2]),
                             (-fSinRoll * dtRotMatrix[0][1]) +
                             (fCosRoll * dtRotMatrix[1][1]) );

}      /* DetermineEuler */
```

B.6 CvtQuatToEulerRotation

```
/***************************************************************
Name:        CvtQuatToEulerRotation

Input Values:
    QuatRotation
        *pdtQuatRot :Ptr to the quaternion rotation.

Output Values:
    Rotation
        *pdtEulerRot :Ptr to the determined rotation Euler angles.

Returned Value:
    None.

Description:
    This routine determines the rotation in Euler angles (degrees)that
    corresponds to the given quaternion rotation.

*******************************************************************/
void CvtQuatToEulerRotation( QuatRotation *pdtQuatRot, Rotation *pdtEulerRot )
{
    RotationMatrix
        dtRotMatrix;

    CvtQuatToRotationMatrix( pdtQuatRot, dtRotMatrix );

    DetermineEuler( dtRotMatrix, pdtEulerRot );

    pdtEulerRot->fYaw   *= RAD_TO_DEGREES;
    pdtEulerRot->fPitch *= RAD_TO_DEGREES;
    pdtEulerRot->fRoll  *= RAD_TO_DEGREES;

} /* CvtQuatToEulerRotation */
```

Abbreviations and Acronyms

Abbreviation or Acronym	Definition
API	Application Program Interface
CRC	Cyclic Redundancy Check
IEEE	Institute of Electrical and Electronic Engineers
IRED	Infrared light Emitting Diode
LED	Light Emitting Diode
LOS	Line of Sight
OOV	Out of Volume
PSE‘	Power Sourcing Equipment
Rev xx	Combined firmware revision. For example, rev 24 refers to combined firmware revision 024.
RMS	Root Mean Square
SCU	System Control Unit
SROM	Serial Read Only Memory
TIP	Tool-In-Port
UV	Refers to the rows and columns on the Position Sensor. U is the column number and V is the row number
VCU	Video Camera Unit

Glossary

characterized measurement volume

The characterized measurement volume is the volume within the field of view where accuracy is within specified limits. NDI cannot guarantee measurement accuracy performed outside this region.

faces

Tool faces are separate rigid bodies that make up a tool. Up to eight faces can be defined for one tool.

firmware

Firmware is a computer program stored in Polaris hardware and controls the Polaris System.

maximum 3D error

Maximum 3D error applies to individual markers. It is a parameter in the tool definition file, that specifies the maximum allowable difference between the actual and expected location of a marker on a tool.

maximum marker angle

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

missing

If the system cannot detect a marker, that marker is considered missing. If the system cannot detect enough markers on a tool to determine a transformation, that tool is considered missing.

SCU

The System Control Unit (SCU) is a component of the hybrid Polaris Vega System.

stray marker

A stray marker is a marker that is not part of a tool.

SROM device

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.

switch

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

tool definition file

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

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