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ASCENSION TECHNOLOGY CORPORATION

Motion Trackers for Computer Graphics Applications

laserBIRD™

Installation and Operation Guide

www.ascension-tech.com

laserBIRD

Installation and Operation Guide

REVISION NUMBER:
940020 Rev C
06/06/2002

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Introduction

Congratulations on your purchase of the Ascension Technology Corporation (ATC) laserBIRD motion tracking system. Our company is proud of the quality of all our motion tracking products.

The laserBIRD is an optical scanning system that tracks the position and orientation of a sensor in six degrees of freedom. Fan-shaped laser beams are scanned throughout a conical-like motion region, and are detected by photodiodes mounted in the laserBIRD sensor. Information from these detectors is used to compute sensor position and orientation, which is reported serially to a host computer through an RS232 interface.

This manual is designed to help you set up and install the laserBIRD hardware and software, and to assist you in configuring the system for optimal tracking. Please take the time to read this manual carefully. Properly setting up your system will maximize its performance for your application.

About This Manual

The laserBIRD *Installation and Operation Guide* contains everything you'll need to install and run the laserBIRD tracker. It provides simple steps to operate and test the system quickly, and it details the methods for communicating with the laserBIRD directly. In addition, it explains the tools available for configuring your system and how to find support.

How this manual is organized

This manual contains six chapters.

Chapter 1: Preparing for Setup

- Lists system software and hardware requirements
- Outlines the components of your system
- Details handling precautions

Chapter 2: Quick Start: Setup and Checkout

- Describes how to connect your system components
- Guides you through a quick checkout, using the demo software

Chapter 3: Configuration and Basic Operation

- Outlines configurable features, through use of the *LaserBIRD Utility*
- Provides diagrams to assist mounting
- Details the basic principles of tracker operation

Chapter 4: Software -Tools for Successful Tracking

- Outlines the methods for communicating with the laserBIRD directly.
- Details the RS232 interface protocol and command set.
- Describes a sample program for demonstrating basic communication structure

Chapter 5: Troubleshooting, Maintenance, and Repair

- Offers user maintenance suggestions
- Lists common setup problems and solutions.
- Explains how to contact Ascension Technology Corporation if you need assistance.
- Lists replacement part numbers

Chapter 6: Regulatory Information and Product Specifications

- Lists applicable standards, specifications, and certifications for this system.

Manual Conventions

This manual uses a number of conventions to explain procedures, and present information clearly.

Notes Throughout the manual, notes describe hardware or software features you should be aware of.

Tips Tips provide valuable suggestions for getting the most out of your laserBIRD

Names of files, directories and programs The names of files, directories and programs are italicized (for example, *winBIRD.exe*)

Note: This call-out explains important information about the features of your system

Tips: This call-out provides advice for maximizing the performance of your system

⊗ **CAUTION!**
This call-out points out steps that should be avoided to prevent damage to your system.

Caution! Caution! Messages alert you to important operating instructions. If you are ever unsure about an action you are about to take, contact Technical Support.

Getting Assistance

If you are experiencing a problem with the installation, set up, or operation of your laserBIRD tracking system, please consult the troubleshooting table in Chapter 5 of this manual. It provides many common setup problems and their solutions. If you continue to experience problems after following the recommended actions, contact Ascension Technology Corporation for technical support.

World Wide Web:

http://www.ascension-tech.com/support/troubleshoot/

E-mail:

techsupport@ascension-tech.com

Telephone:

Call (802) 893-6657 between 9 a.m. and 5 p.m. U.S. Eastern Standard Time, Monday through Friday.

Fax:

(802) 893-6659

Chapter 1

Preparing for Setup

This chapter describes everything you will need to setup your laserBIRD system.

System Requirements

Software Requirements

Two Windows® based utilities are included on the laserBIRD CD-ROM :

1. *winBIRD™* - a demonstration utility
2. laserBIRD Utility - A utility for changing the default configuration of your system.

These utilities require:

Windows98®, 2000®, or NT®

Note: A Windows® OS is only required for using the utilities. Communicate directly with the laserBIRD using the ATC Flock of Birds protocol. *See Chapter 4.*

Hardware Requirements

COM port(s): The laserBIRD reports data serially to a host computer, via an RS232 cable. An unused COM port is required per laserBIRD system.

Power: The laserBIRD power supply will operate from 100 to 240V, at frequencies of 50-60Hz.

CD-ROM drive: Only required for accessing the utilities, shipped on a CD-ROM. You may also download these utilities from the Internet by visiting Ascension's web site.

Note: The data format you select may require a baud rate of 115.2K to report all 240 records/sec. See the RS232 Commands section for details

Unpacking the System

Package Checklist

> **Tip:** If your laserBIRD shipping case is cold, open it and allow the components to stabilize to your ambient temperature. The scanner utilizes highly polished mirrors which if contaminated with condensation, may degrade accuracy.

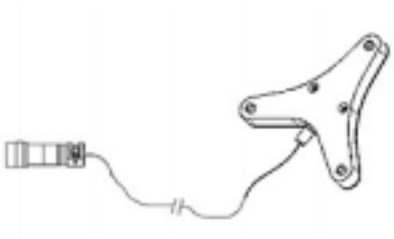
Your laserBIRD system is packaged in an extremely durable shipping case. Inside it you will find the following items. Please make sure that you have everything listed before proceeding to the setup and checkout section.

NOTE: If you have purchased a second system, this will be packaged in a separate case. (Please be sure to read the section in Chapter 3 regarding Dual Scanner Operation).

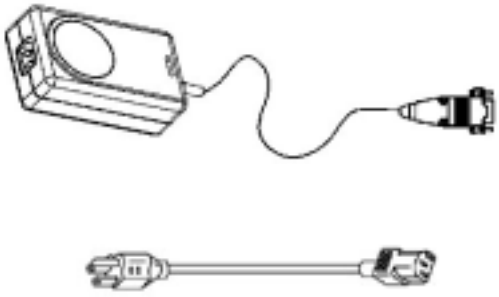
laserBIRD Scanner :



laserBIRD Sensor with cable :



1-External DC power supply w/AC cord



1-RS232 cable



- laserBIRD CD-ROM :



Installation and Operation Guide (this manual)



Additional Items You'll Need

- Small regular screwdriver: used for tightening the power connection

Optional:

- Mounting Hardware - The laserBIRD scanner has four mounting holes for 3mm screws. The two mounting holes in the sensor housing are countersunk for 3mm flat head socket screws.

Handling Precautions

⊗ CAUTION!
The laserBIRD is a Class I (eye-safe) laser device. However, attempts to adjust/alter the internal Scanner components, may jeopardize this status and cause injury.

The laserBIRD scanner and sensor, along with their attached cables and connectors are sensitive electronic components. To obtain consistent and reliable performance and maintain your warranty, treat them carefully.

Never attempt to open the Scanner unit. The Scanner contains no user serviceable parts, and opening it may jeopardize system performance or user safety.

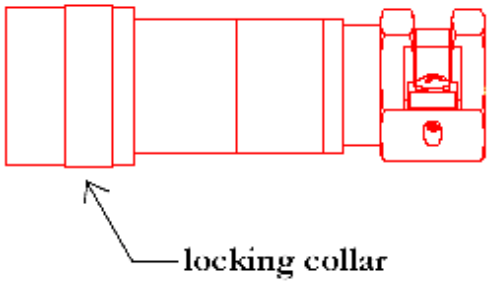
- Avoid contact with the round windows in the Scanner and the small detectors in the sensor. These are optical components, and surface contamination or scratching may lead to degraded performance.

- Never carry, throw or swing the sensor or scanner by the cables.
- Never over-bend the cable at the sensor or scanner housing. Repeated over-bending may lead to sensor failure.
- Never add your own sensor cable extensions or connectors. Our sensor cable is precisely shielded and calibrated to minimize noise and ensure accurate performance. If you add an extension cable, you compromise performance, regulatory approvals, and void your warranty.
- To clean your equipment, wipe it with a cloth dampened with cleaning solution according to your organization's standards. Do not immerse the Scanner, sensor, or cables in liquids.
- Keep the Scanner, sensor, and cables away from sources of heat.
- To minimize excessive wear to the Scanner's internal mechanical components and extend tracker life, shut down the Scanner when not in use. This can be done by disconnecting power, holding the system in reset using the CTS Reset feature (if enabled), sending the SLEEP command, or enabling the Sleep on Reset setting with the laserBIRD Utility.

SENSOR CONNECTOR

The sensor connector has coaxial pins which carry data from the detectors. Treat the connections carefully.

1. When installing the connector, rotate the body until the keys mate with those of the receptacle in the Scanner. Then turn the locking collar, until it clicks.
2. When removing the sensor from the Scanner, push the locking collar of the connector toward the Scanner, before turning to unlock it.



Sensor Connector

Chapter

2

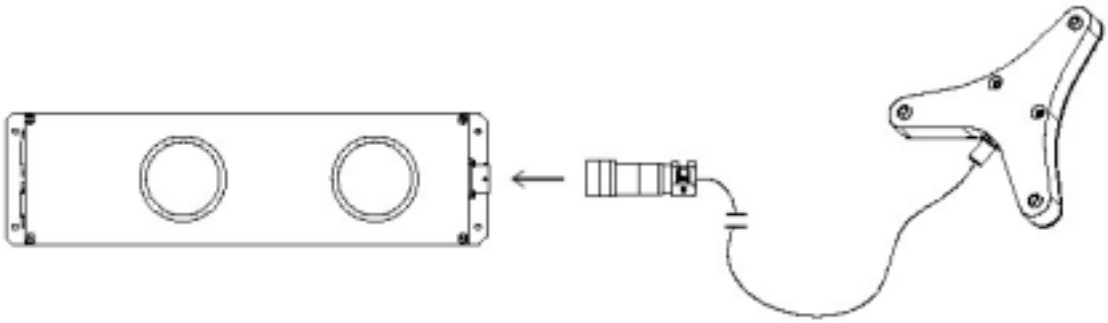
Quick Start: Setup and Checkout

This chapter demonstrates how to connect your components, and install the demonstration utility, so that you can quickly checkout your system and begin tracking.

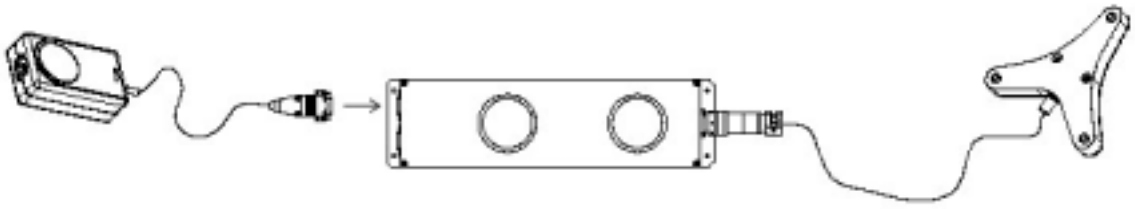
Cable Connections

The laserBIRD hardware can be setup and ready to run in four easy steps:

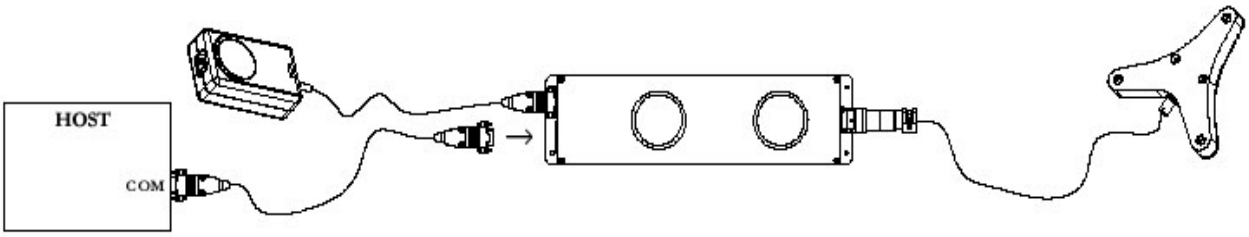
1. **Connect the Sensor :**



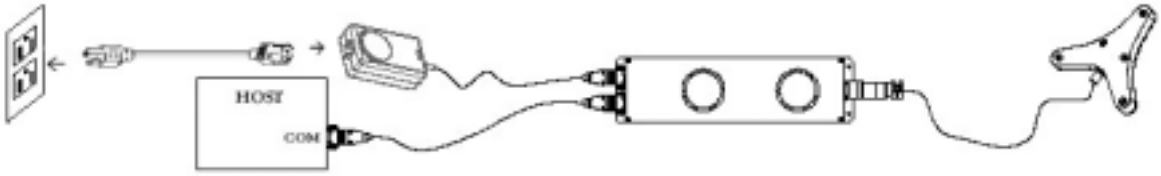
2. **Connect the DC Power Cable :**



3. **Connect the RS232 cable to the laserBIRD and the COM port on the Host PC :**



4. **Connect the AC Power cord to the laserBIRD power supply and the AC source (wall outlet)**



Note: When you plug in your AC Power cord, there will be a slight pause, ~3 seconds, while the system initializes and the speed of the rotating shaft is set. This is normal operation.

What you'll notice:

- After a short delay (see call-out at left), an audible noise will be heard from the Scanner. This is the internal mirror shaft, rotating at 3600RPM.

Installing the Utilities

1. Insert the laserBIRD CD into your PC's CD-ROM drive.

2. Click on the *Install laserBIRD Utility* option, and follow the prompts in the *Setup Wizard.*

3. Click on the Install *winBIRD*™ option, and follow the prompts in the *Setup Wizard.*

Note: *winBIRD*™ is a Windows® utility that will allow you to check out your setup. It is not required for normal operation.

Note: A DOS based demo utility, *CBIRD.exe*, is also available in the *\Direct* sub-directory of the CD-ROM.

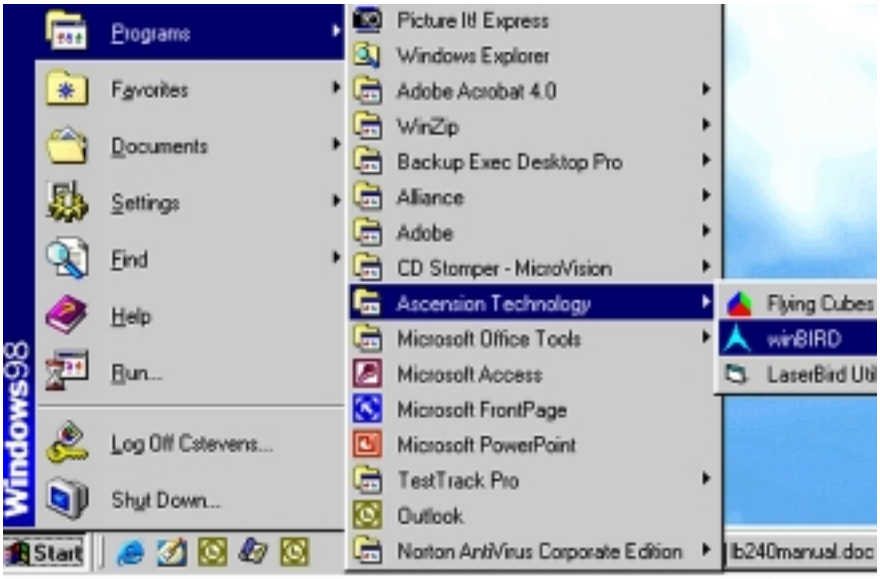
System Checkout: Running the Demo

With the utilities installed and the system running, you are ready to run the demo software and checkout your system.

Note: If you have purchased a second system that will be running in the same general region, you **must** change the Scanners' default configurations. See the Dual Scanner Operation section of Chapter 3.

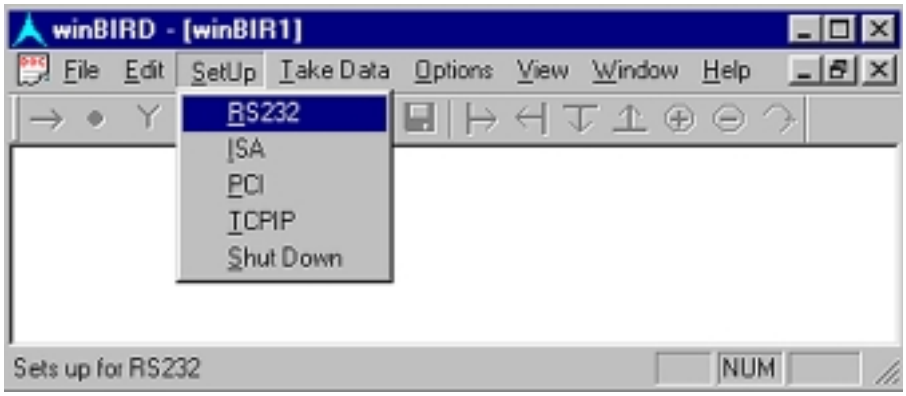
Dual Scanner Operation: See the call-out on the left. You may choose to skip to Chapter 3 now and return after you've configured your systems.

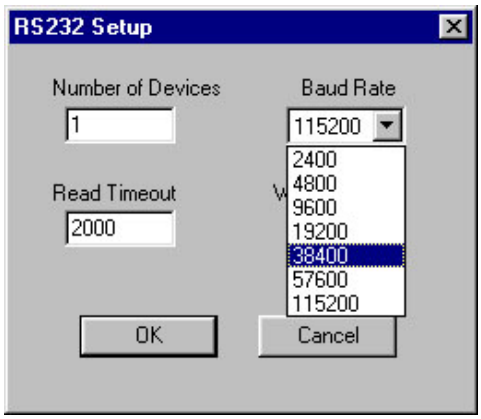
1. Start the demo utility by selecting *winBIRD* from the Ascension Technology program group in the Windows® Start menu.



This will open the *winBIRD* window. The top of the screen contains the menu bar and toolbars, providing links to main *winBIRD* functions. At the beginning of a session most of these will be disabled, each becoming available as procedures are fulfilled.

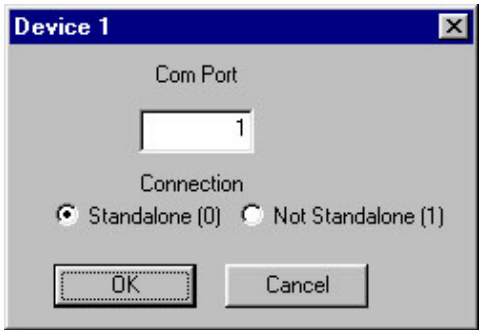
2. Click **Setup** on the menu bar, and select **RS232**.





3. Change the **'Baud Rate'** to setup your COM port for the laserBIRD's default setting: **38400**

4. and enter the correct Com Port for the laserBIRD:

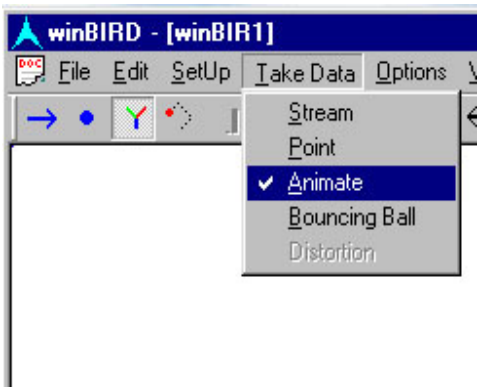


Note: The laserBIRD always runs in *Standalone* mode. 'Not Standalone' or 'Group' mode' is used with other ATC trackers.

When you click **OK**, the main screen will indicate that the utility is establishing communication with the system: **'Waking up bird…'**

After a brief pause, the text will change to indicate '**Setup complete'**, and several of the icons on the toolbar will be enabled.

5. Select **'Take Data'** from the menu bar and choose the option you would like for displaying the data..



What you'll see:

If you've selected **'Animate'**, the screen will display a tri-color axis. This axis graphically represents the sensor's translations and rotations in the motion region.

If you've selected **'Stream'** mode**,** the screen will continuously update two rows of data. The three values in the first row represent sensor position, in inches, relative to the Scanner. The three values in the second row give sensor orientation in degrees.

'Point' mode is a snap-shot form of the 'Stream' mode.

6. Use the demo utility to become familiar with the sensor's motion region, and the tracker's capabilities. If the utility does not run, or the laserBIRD does not operate as described, please consult the troubleshooting table in Chapter 5 of this manual for assistance.

7. Proceed to Chapter 3 for tips on configuring the laserBIRD for your installation.

Chapter 3

Configuration and Basic Operation

A method for configuring the laserBIRD is presented in this chapter, along with a description of the basic operating characteristics.

When the laserBIRD is configured at the factory, settings are optimized to meet the needs of most applications. However, users may find that it is helpful to customize the power-up behavior of the laserBIRD to better meet specific application requirements.

Follow these steps to customize your system:

1. Review the list of configurable default settings.
2. Determine which (if any) of the settings you would like to change.

   NOTE: When two laserBIRD systems are sharing the same operating region, you must reconfigure their default settings. *See below*
3. Follow the steps in the 'Changing Your Settings' section to run the laserBIRD Utility.

Default Configuration

The following settings are installed as power-up defaults. The *laserBIRD Utility* may be used to alter this default power-up configuration. Those settings not accessible with the Utility may be changed during normal operation, through the appropriate direct software command.

		Utility	Direct SW command
BAUD RATE:	**38400**	✓	
SCALE:	**36 inches**	✓	✓
laserBIRD ID:	**A**	✓	

		Utility	Direct SW command
Sensor Offsets	Offsets of **zero**	✓	✓
ANGLE ALIGN:	Angles of **zero**	✓	✓
REFERENCE FRAME:	Angles of **zero**	✓	✓
Flip Sensor Axes:	Enabled	✓	
Reset on CTS:	Disabled	✓	
Sleep on Reset:	Disabled	✓	
Filter On/Off Status:			
AVG Filter (AC NARROW notch, moving average of 4)	**ON**	✓	✓
ADAPTIVE Filter (DC)	**ON**	✓	✓
ALPHA_MIN Table values	**.02**		✓
ALPHA_MAX Table values	**.9**		✓
Prediction:			
X,Y,Z,Az,El,Rl	All Disabled	✓	✓
Prediction Interval	0 ms	✓	✓
Data Request Mode:	**POINT**		✓
Data Record Type:	**POSITION/ANGLE**		✓
Report Rate:	**maximum -240**		✓

Configurable Power-up Settings:

The following may be re-configured using the *laserBIRD Utility*.

Note: When two laserBIRDs have operating regions that overlap, you must re-configure the 'laserBIRD ID'. See ***Dual Scanner Operation*** below.

Baud Rate Establishes the default RS232 communication rate for power-up.

Scale Sets the scale factor used by the laserBIRD to report the position of the sensor with respect to the scanner. Valid values of 36 and 72, represent the full scale position output in inches.

laserBIRD ID This setting indicates to the laserBIRD electronics, which of three frequencies to use for modulating the laser beams. Adjusting this setting is only advised for Dual Scanner Configurations.

Sensor Offsets Default position outputs from the laserBIRD represent the X, Y, Z position of the centroid of the sensor (located on front face -see Figures 3.1a,b) with respect to the Scanner origin. The Sensor Offsets allow you to configure the position outputs such that the Bird is reporting the position of a location that is offset from the centroid of the sensor. See the OFFSET command for details.

Tip: An easy alternative to re-configuring the 'Angle Align' is to issue the 'BORESIGHT' command. See the RS232 Command Reference for details.

Angle Align The Angle Align settings allow you to mathematically align the sensor's coordinate frame to the coordinate frame of the object being tracked. This is beneficial if you find that, when mounted to the object you are tracking, the angle outputs are not zero when in the normal 'resting' position.

Tip: For assistance with determining the Angle Align and Reference Frame settings for your installation, see the section titled ***laserBIRD Alignment Procedure***.

Reference Frame The default laserBIRD reference frame is defined by the Scanner's X,Y, and Z axes (see Figure 3.1). This Reference Frame setting allows you to enter the angles required to mathematically align the axes of the Scanner to those of a new reference frame.

Prediction Enables predicted outputs for those coordinates and angles selected by the user. Prediction interval is also configurable from 0-50 milliseconds. This may be beneficial for applications attempting to minimize lag (simulator, image generation, etc) See the CHANGE/EXAMINE PREDICTION command for details and suggestions.

Note: When disabled, the 'Flip Sensor Axes' setting permits compatibility with older definitions of the Sensor coordinate axes.

Flip Sensor Axes If enabled, this setting configures the default sensor coordinate axes such that the +X axis exits out the back of the sensor housing (surface opposite detectors). The +Y axis is also flipped 180 degrees from its historical setting. See *Default Reference Frame* below for details.

Reset on CTS If enabled, this setting allows the user to reset the laserBIRD by holding the CTS line (RTS on HOST side) high. See the *RS232 Signal Description* for details.

Sleep on Reset When enabled, this setting will cause the laserBIRD to enter SLEEP mode after completing a reset or following power-up. Issue the RUN command to resume normal operation. See the *SLEEP* command description in the RS232 Command Reference section for details.

AVG Filter When setting is configured to ON, a 4 element averaging filter is applied to the laserBIRD sensor data. Generally, this filter is always required in the system unless your application can work with noisy outputs.

Adaptive Filter When set to ON, an adaptive lowpass filter is applied to the sensor data to eliminate high frequency noise. Always enable the AVG filter if you plan to use this Adaptive filter. Generally, this filter is always required in the system unless your application can work with noisy outputs. When the filter is ON, you can modify its noise/lag characteristics by changing ALPHA_MIN, and Vm. *See the RS232 Command Reference for details.*

Default Reference Frame

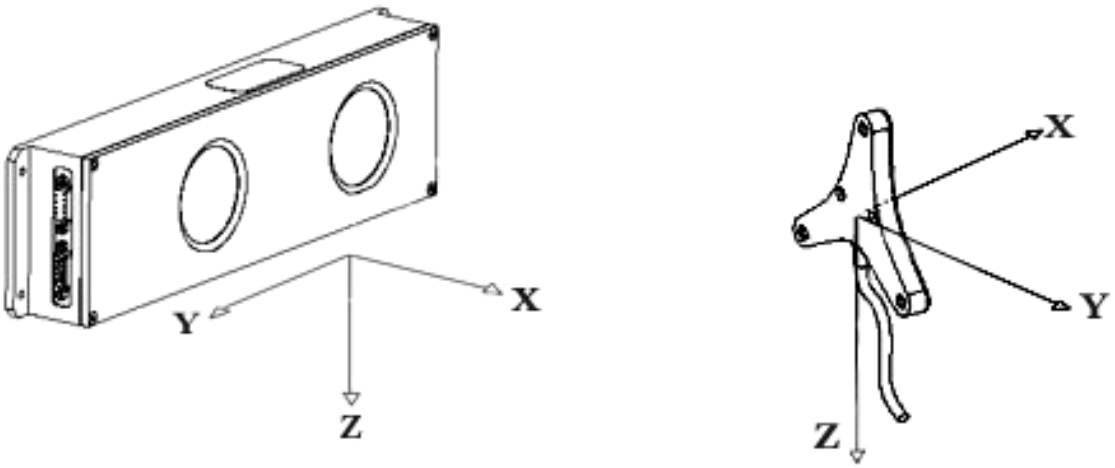


Figure 3.1a: Default Scanner/Sensor Coordinate Frames (*Flip Sensor Axes* setting enabled)

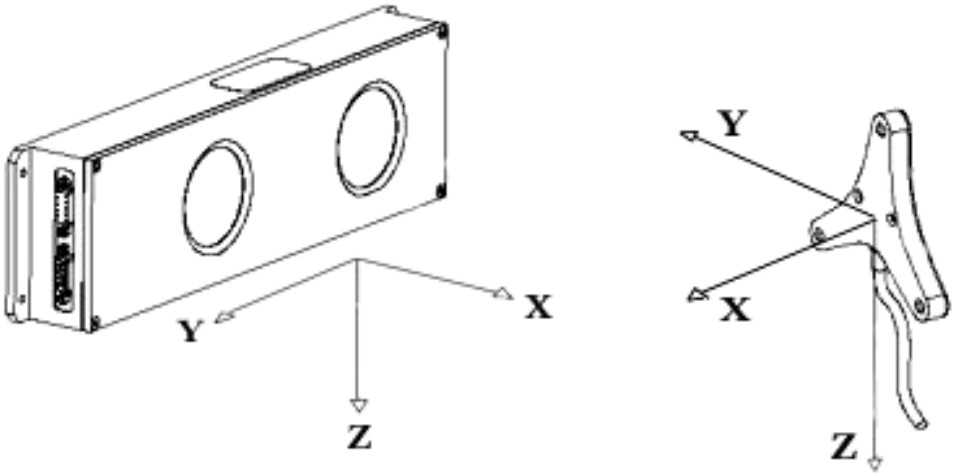


Figure 3.1b: Alternate Scanner/Sensor Coordinate Frames (*Flip Sensor Axes* setting NOT enabled)

NOTE: The origin of the scanner's default Reference Frame is defined as the location inside the Scanner which is:

- At the midpoint of a line which connects the centers of the two windows.

and

- Is one inch (1") from the bottom of the Scanner

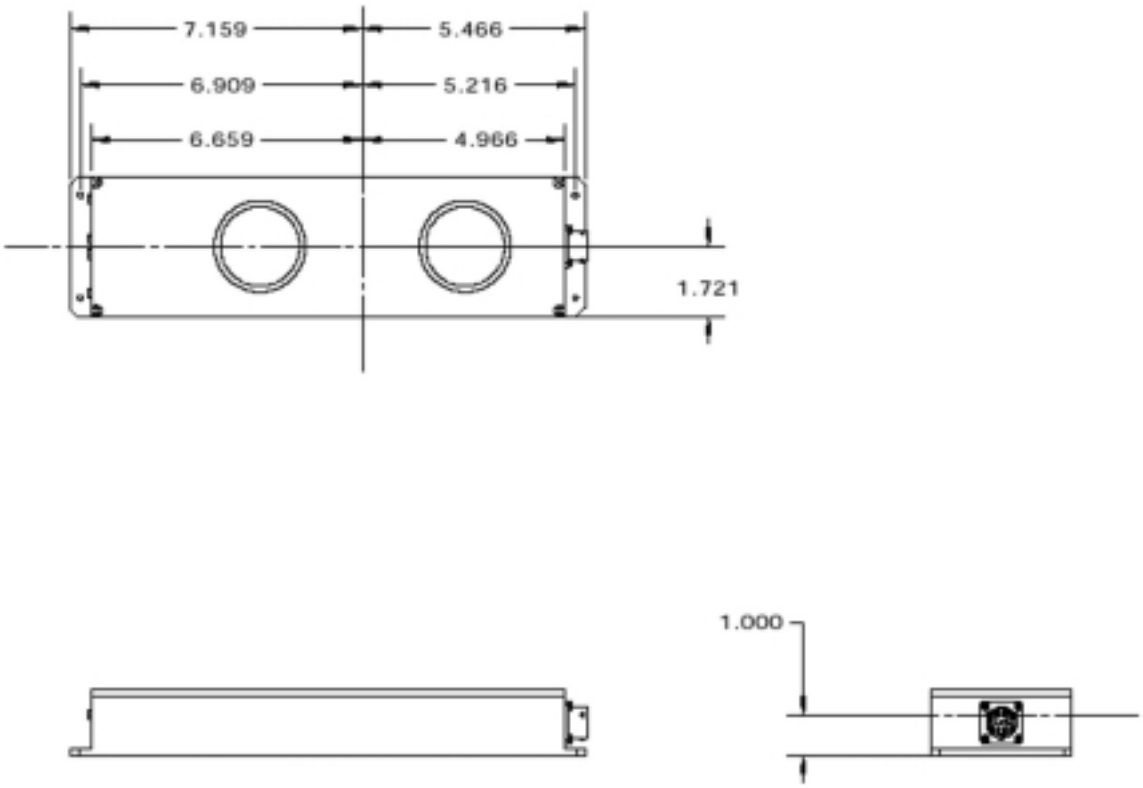


Figure 3.2: Default Reference Frame Origin

Dual Scanner Operation

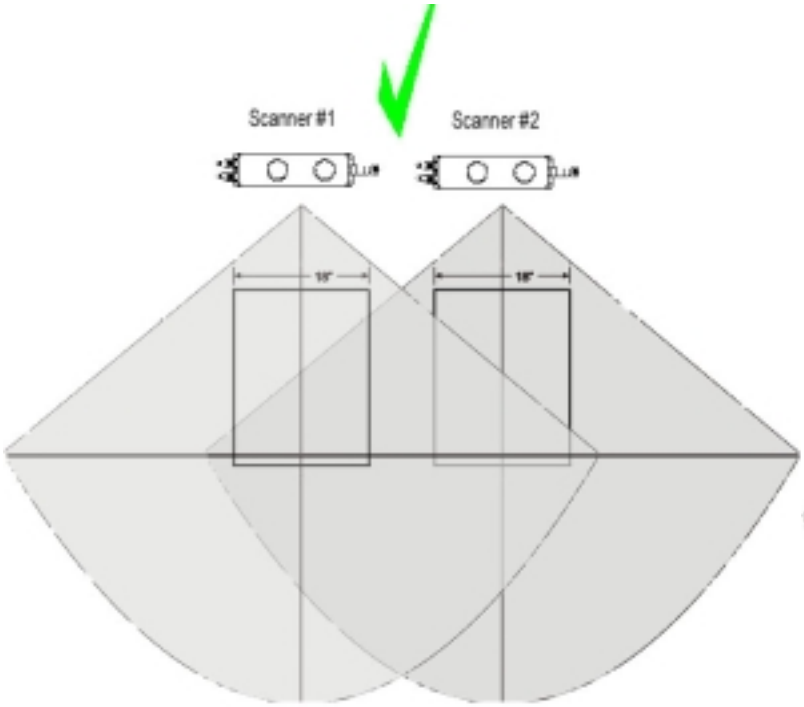
An important characteristic of the laserBIRD scanner is that its laser beams are modulated at a high frequency. This makes the system less sensitive to interfering light sources, thereby improving performance. When two scanners are installed such that their operating regions overlap, this modulation frequency must be changed for both units. This reduces the likelihood of the Scanners interfering with one another.

NOTE: Even with two modulation frequencies adjusted accordingly, it is still possible to introduce some Scanner interference between two systems. To avoid this, install dual scanner configurations such that:

1. Sensor motion is predominantly in the Performance Motion Box of its respective Scanner.

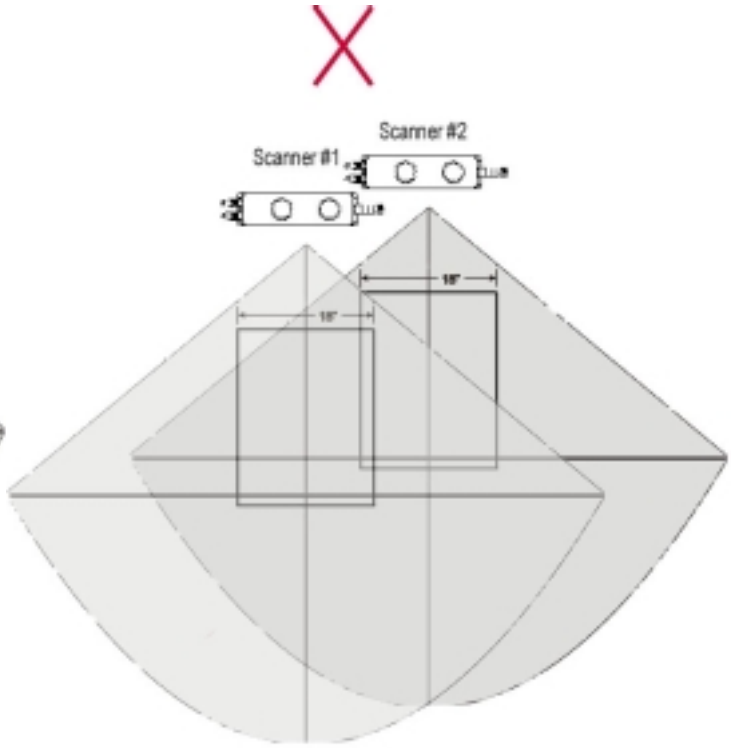
2. The sensor from one scanner, never enters the Performance Motion Box of the opposite Scanner.

Note: For a description of the 'Performance Motion Box', see the section entitled *'Operating Region'* below.



Correct:

Sensor motion predominantly in Performance Motion Box



Incorrect:
Sensor from one Scanner enters Performance Motion Box of opposite Scanner

The **laserBIRD ID** setting indicates to the system which modulation frequency to use as the power-up default. Valid settings include:

laserBIRD ID	Mod. Frequency
A	9.25 MHz -Default -Single configuration
B	12.3 MHz -Scanner #1 - Dual Configuration
C	6.2 MHz -Scanner #2 -Dual configuration

If you plan to operate two systems in the same general region, be sure to set the default ID values as indicated.

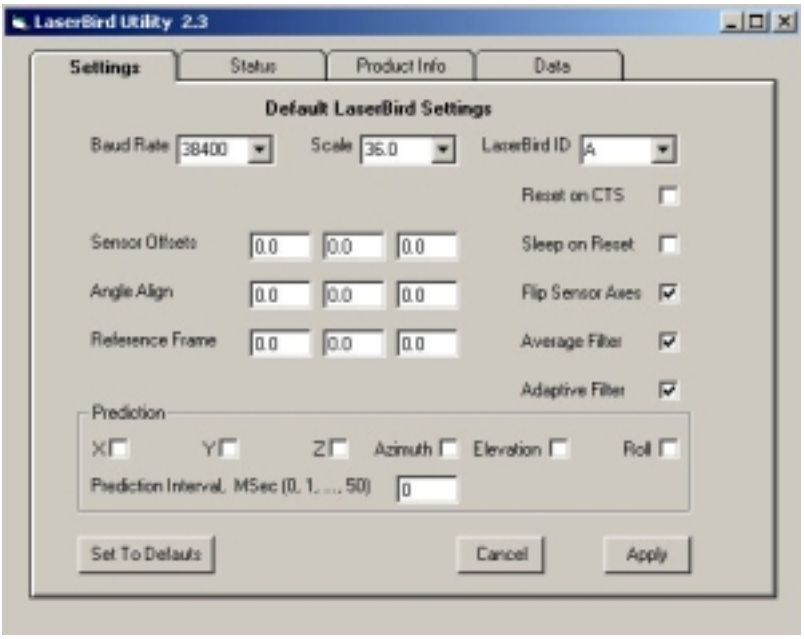
Proceed to the next section, 'Changing your settings' for instruction.

Changing Your Settings

The power-up settings are easily configured through use of the *laserBIRD Utility*.

> **Tip:** you can also download the Utility by visiting Ascension's web site.

1. Make sure the laserBIRD is running, and connected to the host PC where the utility has been installed.
2. Start the utility by selecting **laserBIRD Utility** from the Ascension Technology program group in the Windows® Start menu.
3. When the utility establishes communication with the laserBIRD it will open the main screen.



> **Note:** For Dual Scanner operation, remember to check the laserBIRD ID settings in both units. See ***Dual Scanner Operation*** **above**.

> **Tip:** Follow the steps in the *laserBIRD Alignment Procedure* for assistance with the Angle Align and Reference Frame settings.

4. Use the pull down menus and check boxes to select your desired Baud Rate, Scale, laserBIRD ID, Flip Sensor Axes, Sleep on Reset, Reset on CTS, Prediction, and Filter Status settings.
5. If you've determined the Angle Align and Reference Frame settings for your application and want to include them as defaults, enter them here in Degrees.
6. If required, enter default Sensor Offsets for X, Y, and Z in Inches.
7. Click **'Apply'** to download the new settings to your system's flash memory.

   NOTE: Selecting the 'Set to Defaults' option (and clicking 'Apply') will restore the factory installed settings.

Mounting the Hardware

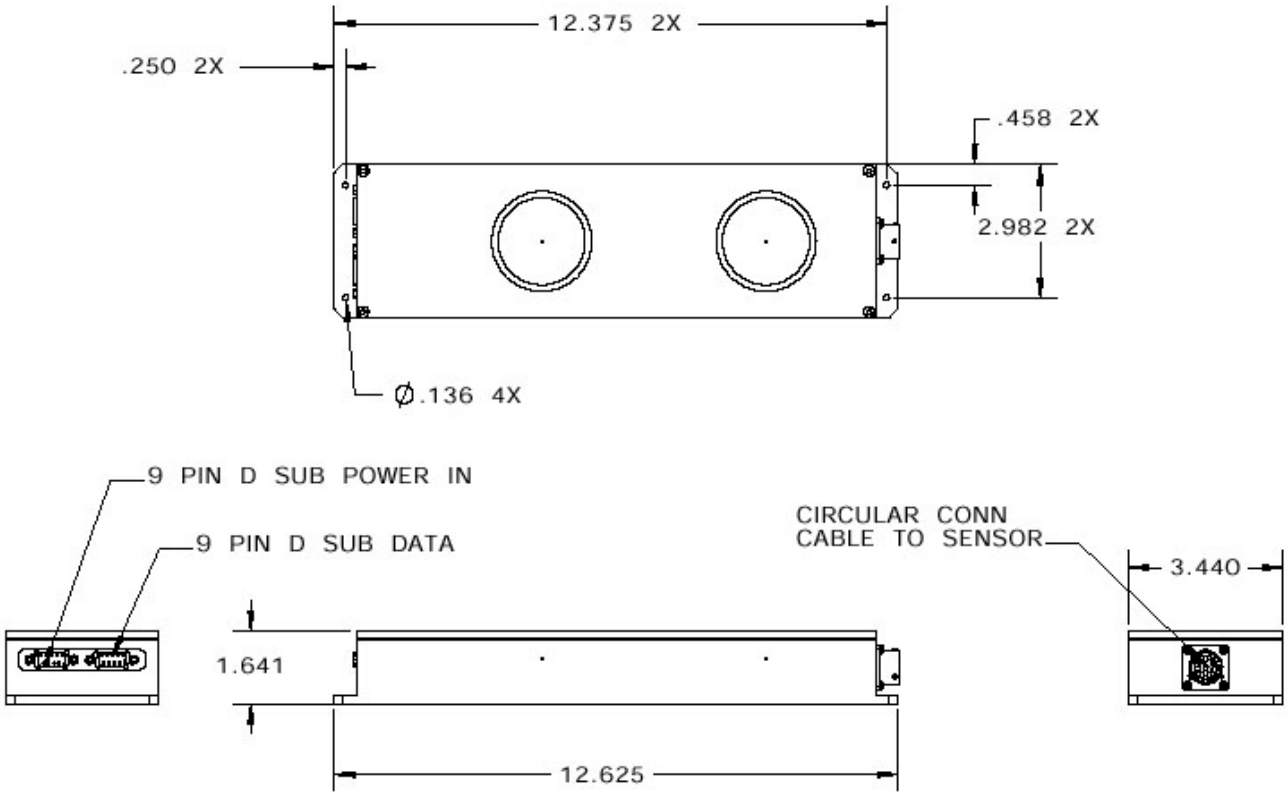


Figure 3.2

Scanner Mounting Dimensions (inches)

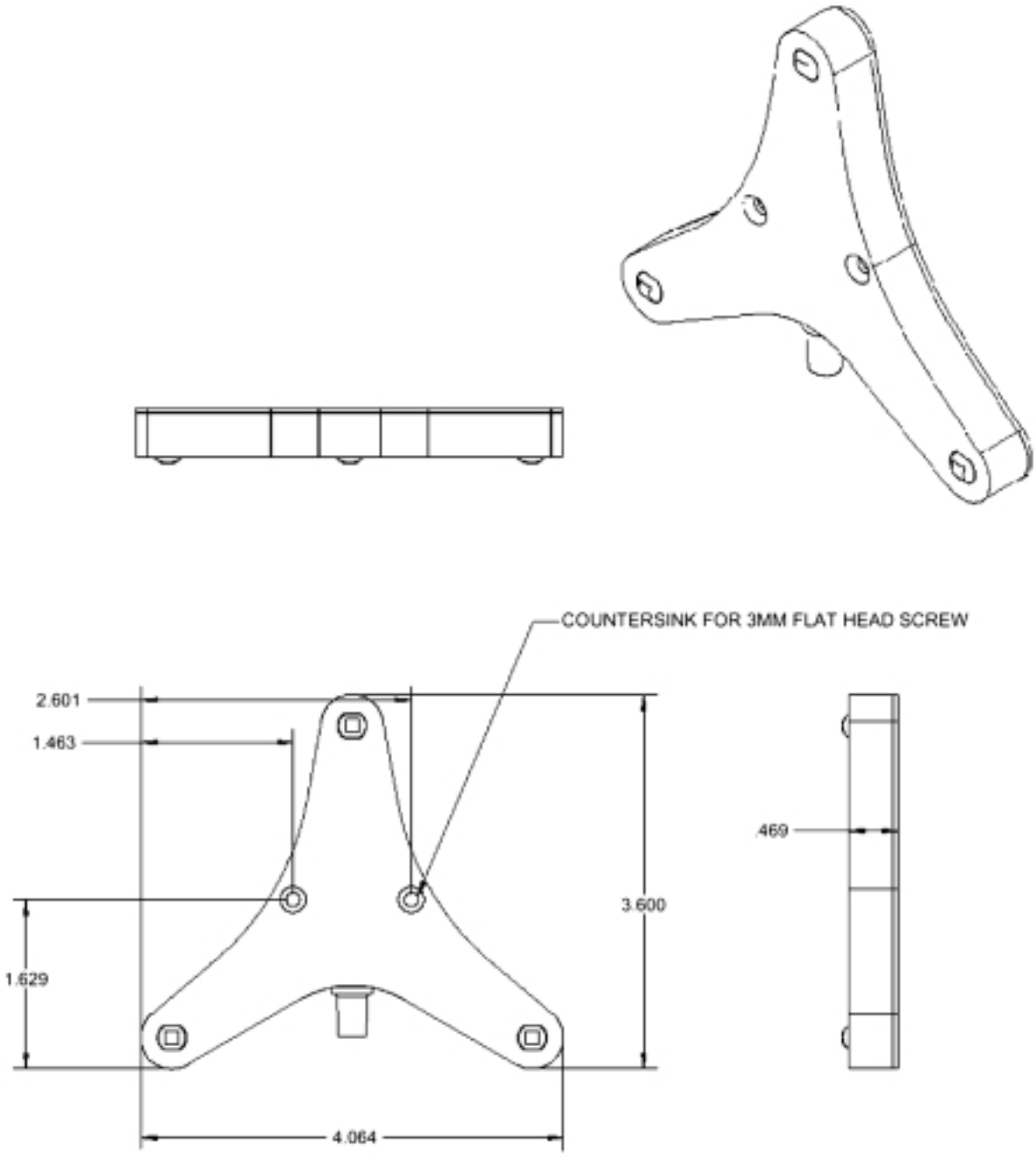


Figure 3.3

Sensor Mounting Dimensions (inches)

laserBIRD Alignment Procedure

By default, most trackers return position and orientation of a sensor relative to a measurement source (transmitter, Scanner, etc). In many instances however, it is useful to have the tracker return the position and orientation of an object relative to a chosen reference frame. The **Reference Frame** and **Angle Align** settings allow you to customize the laserBIRD for your specific tracking requirements. If you're familiar with a procedure for determining these values, enter them as shown in the Changing Your Settings section above. This procedure provides a simple way to determine the correct values for your installation, without the use of additional equipment.

Begin this procedure with the Scanner mounted at your desired position and orientation, and not moving.

1. Make sure the laserBIRD is running and connected to the host PC where the *laserBIRD Utility* has been installed.

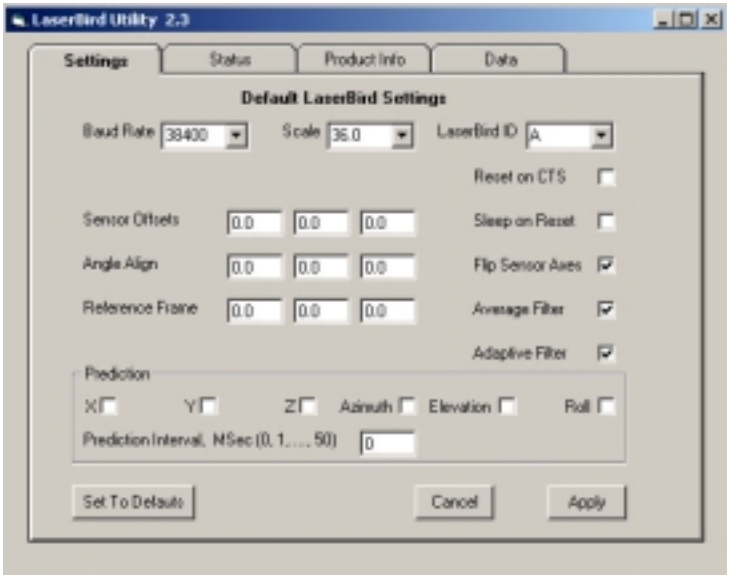
2. Start the utility by selecting **laserBIRD Utility** from the Ascension Technology program group in the Windows® Start menu.

> **Note:** You can also download the utility by visiting Ascension's web site.

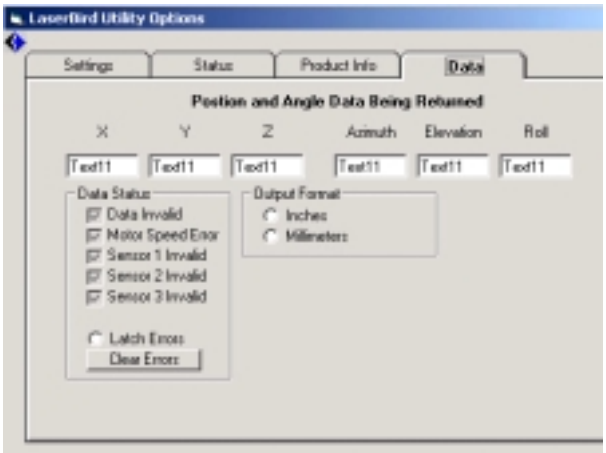
3. Go to the **Settings** tab and check that the **Angle Align** and **Reference Frame** settings are '0.0', and the **Flip Sensor Axes** setting is enabled.

Set the **Scale** to '72.0'

If you had to alter any setting, click 'Apply' to send the laserBIRD the updated value.



4. Click on the **Data** tab and look for streaming sensor data.



Setting the Reference Frame

This section of the procedure begins by establishing how your laserBIRD Scanner is mounted, relative to a six-sided cube representing your desired Reference Frame.

Note: This procedure assumes that the 'Flip Sensor Axes' setting is enabled. (default)

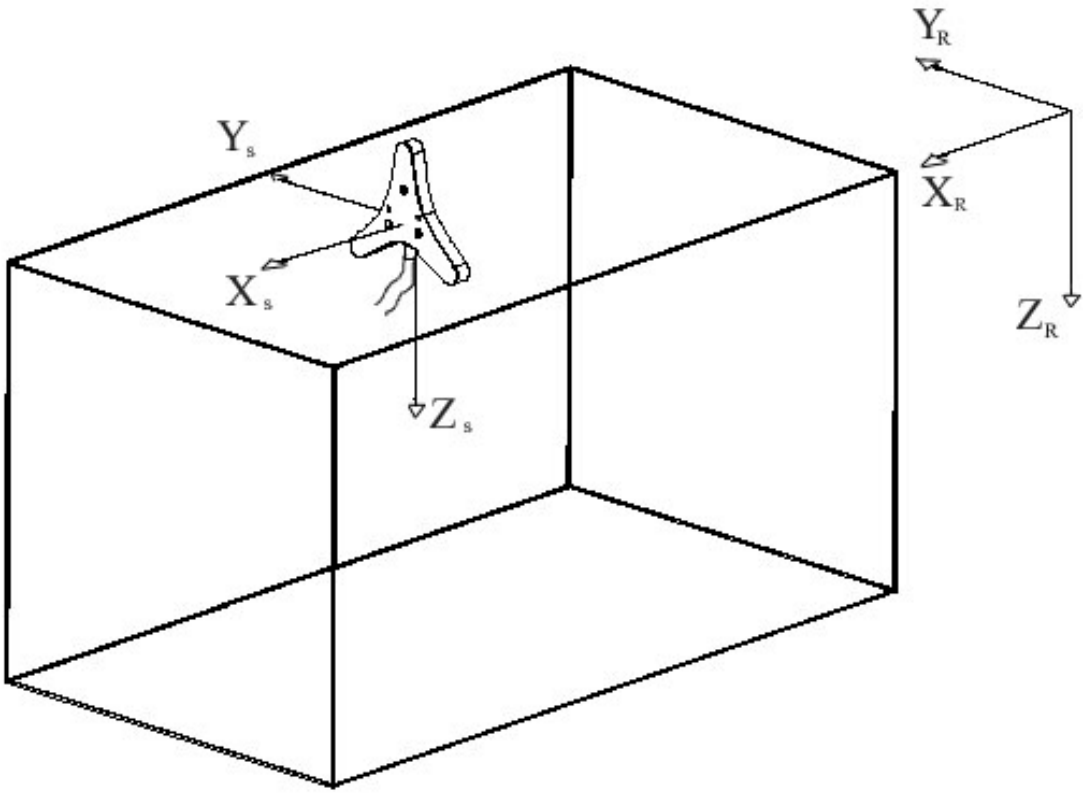
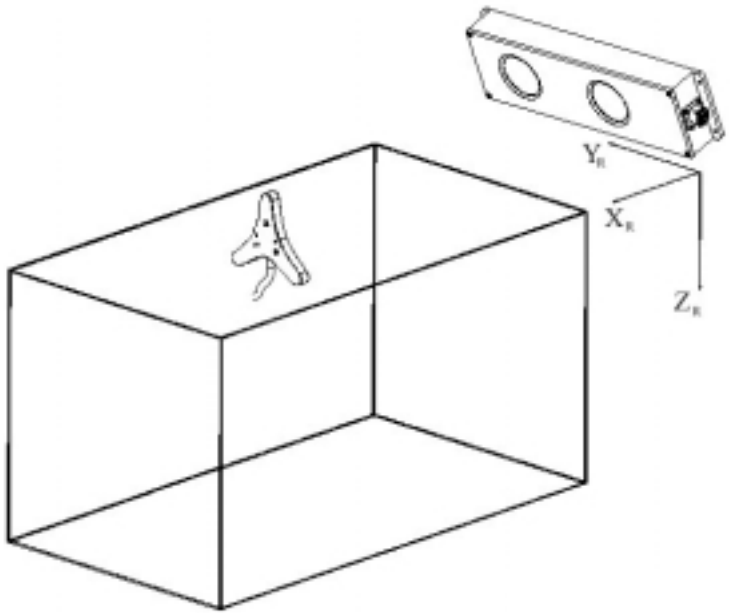


Figure 3.4 : Setting the Reference Frame

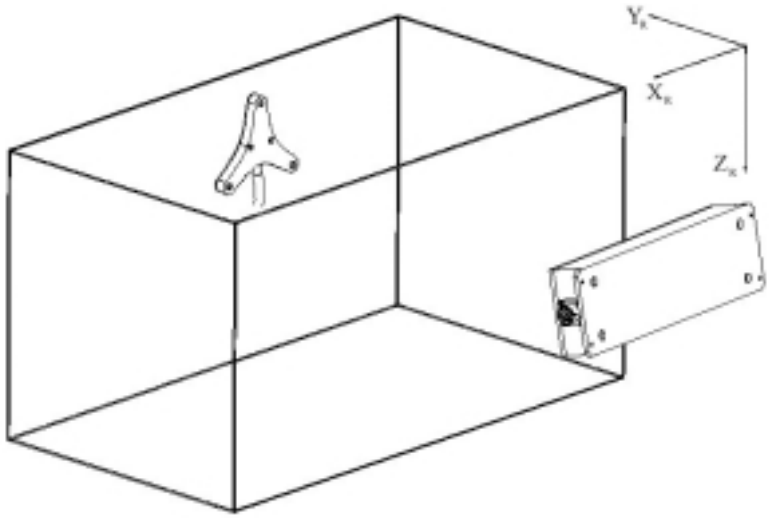
5. Choose from the following diagrams, the one that best represents the mounting of your Scanner relative to the cube that defines your desired Reference Frame.

Notice that in each diagram the Sensor has been placed such that the detectors face the same side of the cube as the Scanner. The angles (Azimuth, Elevation ,Roll) required for this rotation are indicated for each configuration.



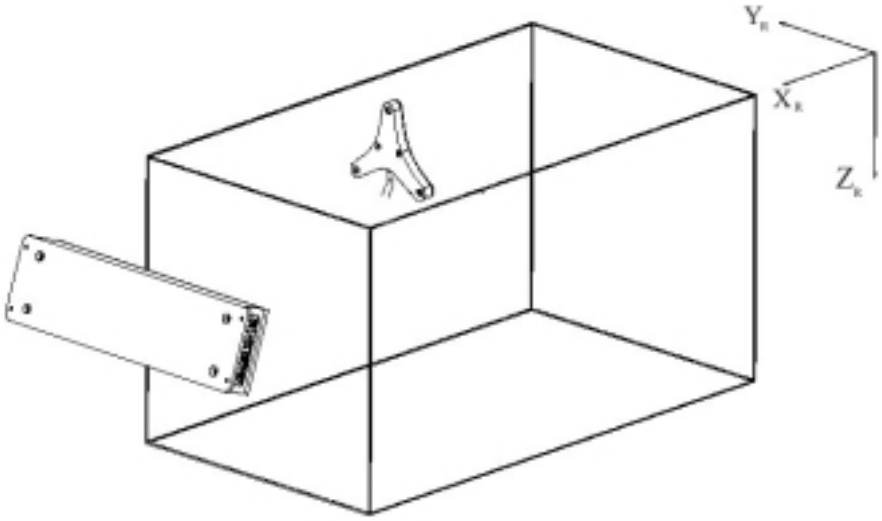
Back:

Angles: 0.0, 0.0, 0.0



Left

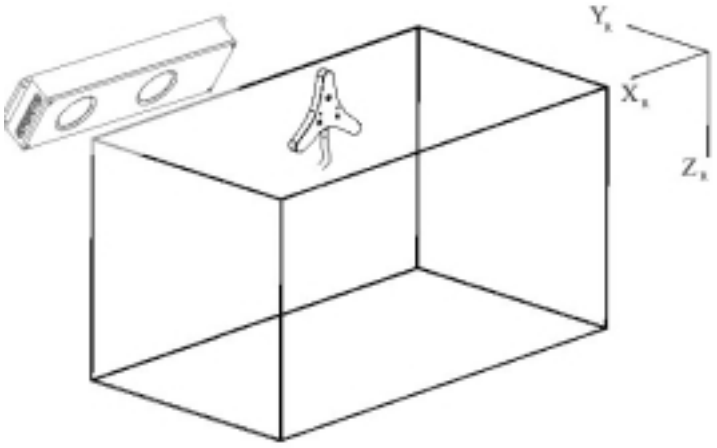
Angles: 90.0, 0.0, 0.0



Front

Angles:

180.0, 0.0, 0.0

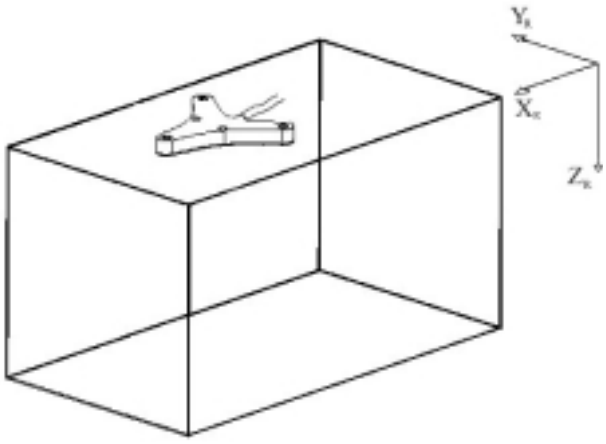


Right

Angles:

-90.0, 0.0, 0.0

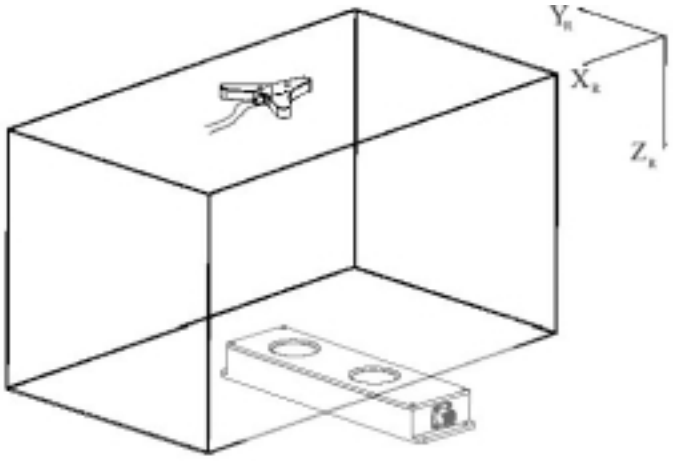




Top

Angles:

0.0, -90.0, 0.0



Bottom

Angles:

0.0, 90.0, 0.0

6. Rotate your sensor to the position shown in the diagram you selected in Step 5. Click on the **'Settings'** tab and enter the corresponding angles as 'Angle Align' values:

For example: for "Top"

Angle Align: 0.0 -90.0 0.0
(select 'Apply' to send to the Scanner)

7. Now go back to the **'Data'** tab. Read and record the sensor orientation angles **Azimuth (AZ1), Elevation (EL1), and Roll (RL1)** being returned from the laserBIRD. These angles describe the orientation of the Scanner relative to your desired reference frame.

8. Click on the **'Settings'** tab and enter as 'Reference Frame' settings the values you just recorded in Step 7.

Reference Frame: AZ1 EL1 RL1
(values from Step 7)
Select 'Apply' to send these settings to the Scanner.

9. Click on the **'Data'** tab and read the new sensor orientation angles. If the sensor has not moved, all angles should be close to '0'.

Setting the Angle Align

Note: Prior to setting the 'Angle Align', make sure you have configured the Reference Frame setting. (Steps 1-9)

Note: If you prefer to have the 'Flip Sensor Axes' setting disabled, and you enabled it to follow Steps 1-9, return to the '**Settings**' tab and disable it before beginning this section of the procedure.

10. Attach the sensor to the object that you would like to track. Align that object's coordinate frame to your new reference frame, such that the object axes, $\mathbf{X}_{obj}$, $\mathbf{Y}_{obj}$ and $\mathbf{Z}_{obj}$, are parallel to $\mathbf{X}_{R}$, $\mathbf{Y}_{R}$ and $\mathbf{Z}_{R}$.

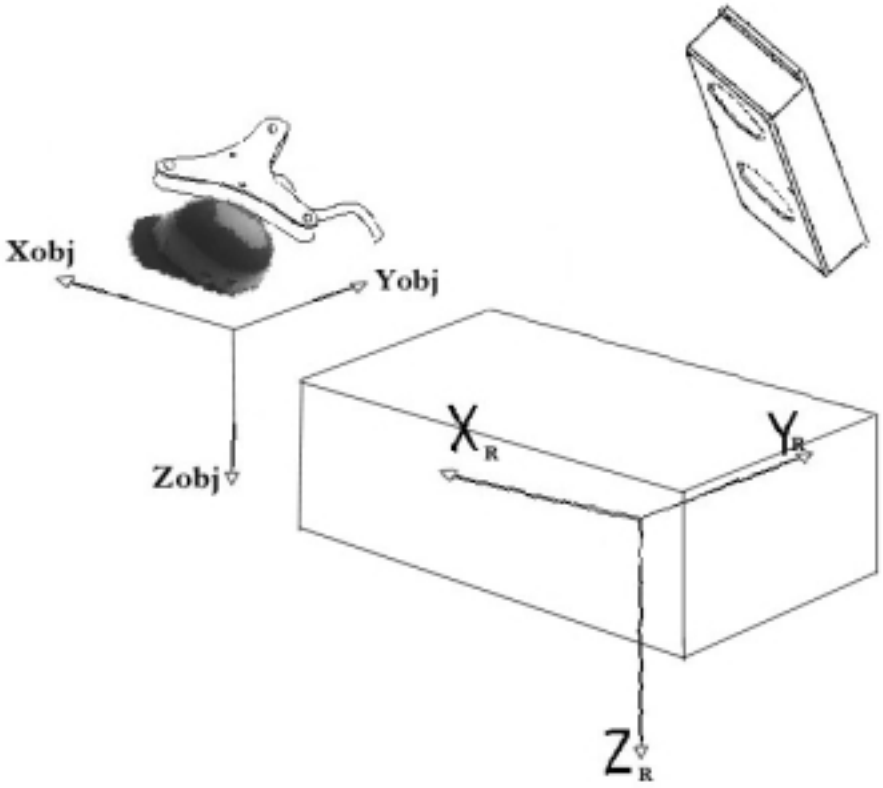


Figure 3.5: Setting the Angle Align

11. With the object stationary, click on the **'Settings'** tab, and enter the following 'Angle Align' values:

Angle Align: 0.0 0.0 0.0
(select 'Apply' to send to the Scanner)

> **Note:** If the value of ***EL2*** is below -80° or above +80°, then you cannot use the values in step 13. Contact Ascension for an alternative procedure.

12. Now go back to the **'Data'** tab. Read and record the new sensor orientation angles. **Azimuth (AZ2), Elevation (EL2), and Roll (RL2).** These angles describe the current orientation of the sensor (mounted on your object) relative to your reference frame.

13. To complete the configuration, click on the **'Settings'** tab, and enter as 'Angle Align' settings the values you just recorded in Step12:

Angle Align: AZ2 EL2 RL2
(values from Step 12)
(select 'Apply' to send to the Scanner)

14. If the alignment procedure was successful, here's what you'll notice:

a. The orientation angles now displayed in the **'Data'** tab describe the orientation of your object relative to your desired reference frame.

b. If the object has not moved (from position in step 11), these angles will be close to '0.0'.

Basic Operation

The laserBIRD tracks position and orientation of its sensor through an optical scanning technique. Fan-shaped laser beams are scanned throughout a pyramid-like motion region, and are detected by photodiodes mounted in the laserBIRD sensor. Information from these detectors is used to compute the sensor position and orientation. This is reported serially to the host computer through an RS232 interface.

Scanner

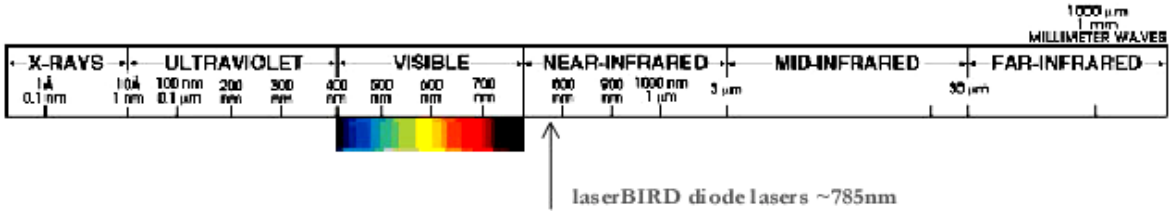
The laserBIRD Scanner is the main electronics unit for the system. It utilizes digital signal processors (DSPs) to process data events returning from the sensor and to calculate position and orientation. In addition it contains the opto-mechanical sub-assembly that generates the required laser beams and scans them across the operating region.

The beams are scanned across the motion region by reflecting them off a rotating shaft. This single shaft is designed with polished mirrored facets that reflect all four beams during a single rotation. A small DC motor spins the shaft at 3600 RPM (60Hz), thus providing the required data for a 240Hz measurement rate.

Lasers

The four beams generated by the Scanner electronics for tracking are produced using laser diodes with a typical operating wavelength of 785 nm. This places the light in the near infrared region, and eliminates the possibility of visual distractions.

⊗ CAUTION!
Attempts to adjust/alter the internal Scanner components, may cause hazardous levels of laser radiation. Never attempt to open the Scanner unit.



In addition, each beam is modulated at a high frequency. This ensures that the sensor event data, demodulated using the same high frequency, has decreased sensitivity to interfering light sources.

Because each tracking laser is diverged into a fan-like beam and then scanned, the energy radiated outside the windows (apertures) of the Scanner is well below the Class I limit. (EN 60825-1 and CFR-1040.10-11) This means that the unit cannot emit laser radiation at known hazard levels and is eye safe when used as designed.

An interlock is designed into the laserBIRD Scanner which disables the lasers if the scanner shaft is not rotating appropriately. This is a safety feature, and cannot be disabled.

Sensor

The laserBIRD sensor incorporates three detectors. These detectors are custom photodiodes that produce an event pulse when energized by the scanning laser beam. The detectors also contain a color glass filter over the active optical area of the diode. Embedded in the epoxy of the detector package, this filter mitigates the effects of extremely high ambient conditions.

The event waveforms produced from each detector, are amplified and sent to the Scanner for processing. The calculated positions of the three detectors help to define a plane that is used to determine sensor orientation. For this reason the sensor must maintain a clear line of sight between all detectors and the scanner, and the detectors must not exceed an orientation range of ±85° with respect to the Scanner.

Operating Region

Note: Due to decreasing laser beam intensity as the Sensor moves off Scanner center (default X axis) , angular range will fall off (up to ~40%) as the sensor approaches the edges of the operating region.

The effective operating region (valid sensor tracking) for the laserBIRD is shown below. Note that the field of view diagrams depict a conical-like motion region, which begins ~6 inches in the +X direction from the Scanner origin. Therefore, sensor motion closer to the Scanner than 6 inches, will not be detected.

Angular range is best defined as a range of angular motion in the horizontal and vertical directions, beginning along an axis that connects the Scanner to the Sensor. This range of motion is ±85 degrees in both vertical and horizontal directions, when the Sensor is directly in front of the Scanner in the center of the Performance Motion Box (see below). Due to decreasing laser beam intensity as the Sensor moves off Scanner center (default X axis) , angular range will fall off (up to ~40%) as the sensor approaches the edges of the operating region. Users requiring maximum angular range should restrict motion to the center of the Performance Motion Box.

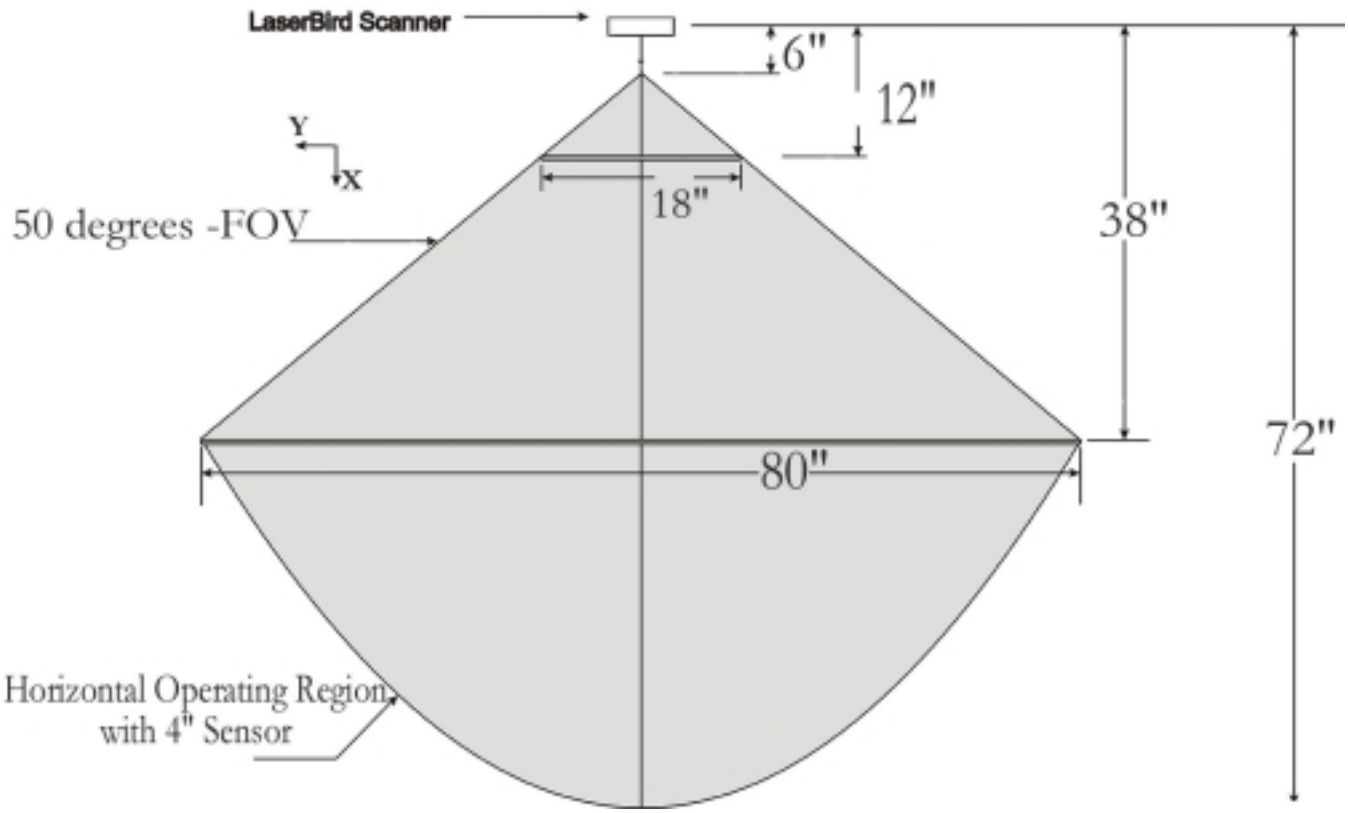


Figure 3.6: Horizontal Field of View

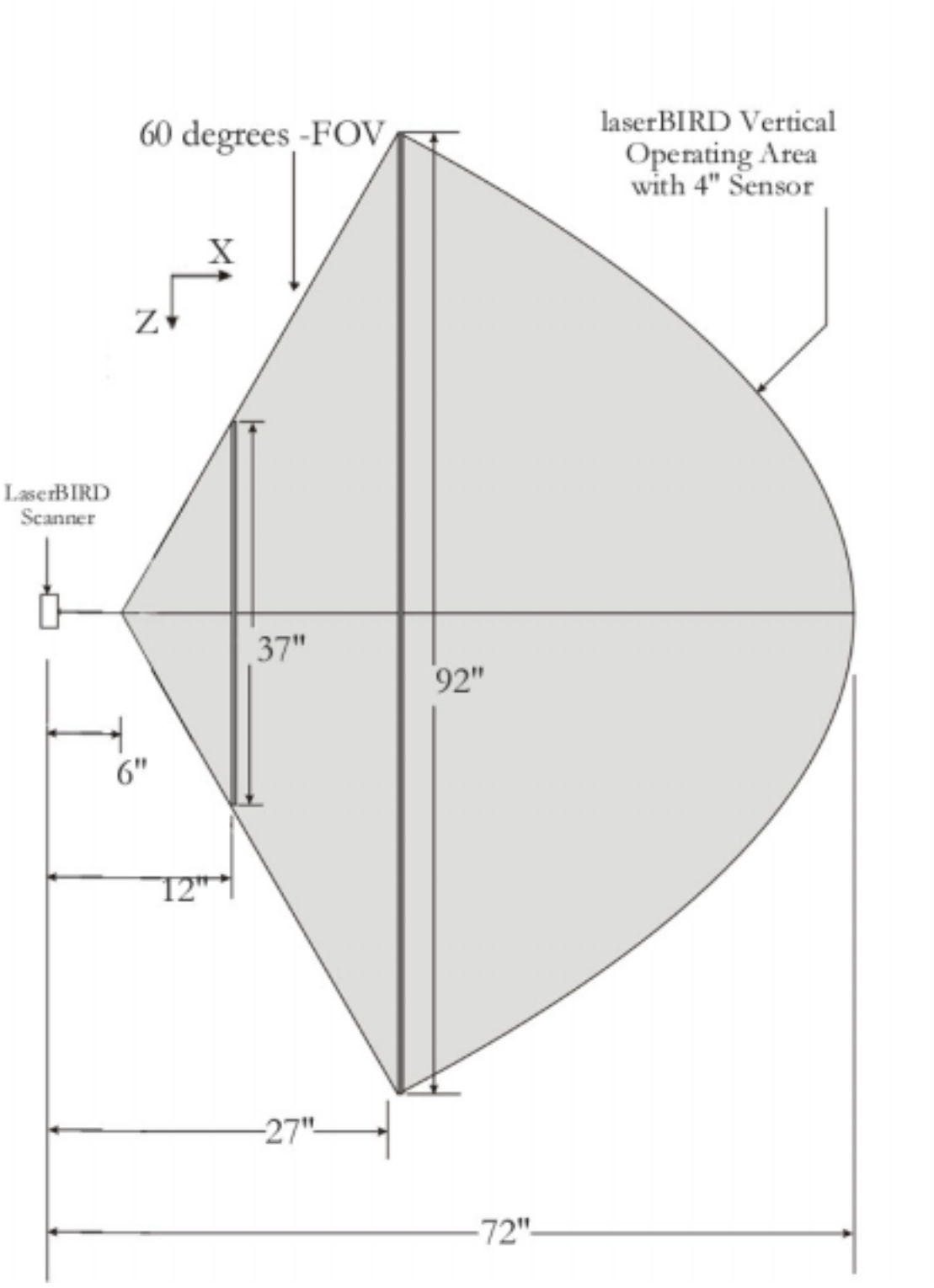


Figure 3.7: Vertical Field of View

Performance Motion Box

While each component of the laserBIRD is manufactured within very tight tolerances, it is almost impossible to construct a system that matches the theoretical model perfectly. For this reason, all systems are subjected to a calibration procedure that optimizes performance over a given region. This region is referred to as the Performance Motion Box.

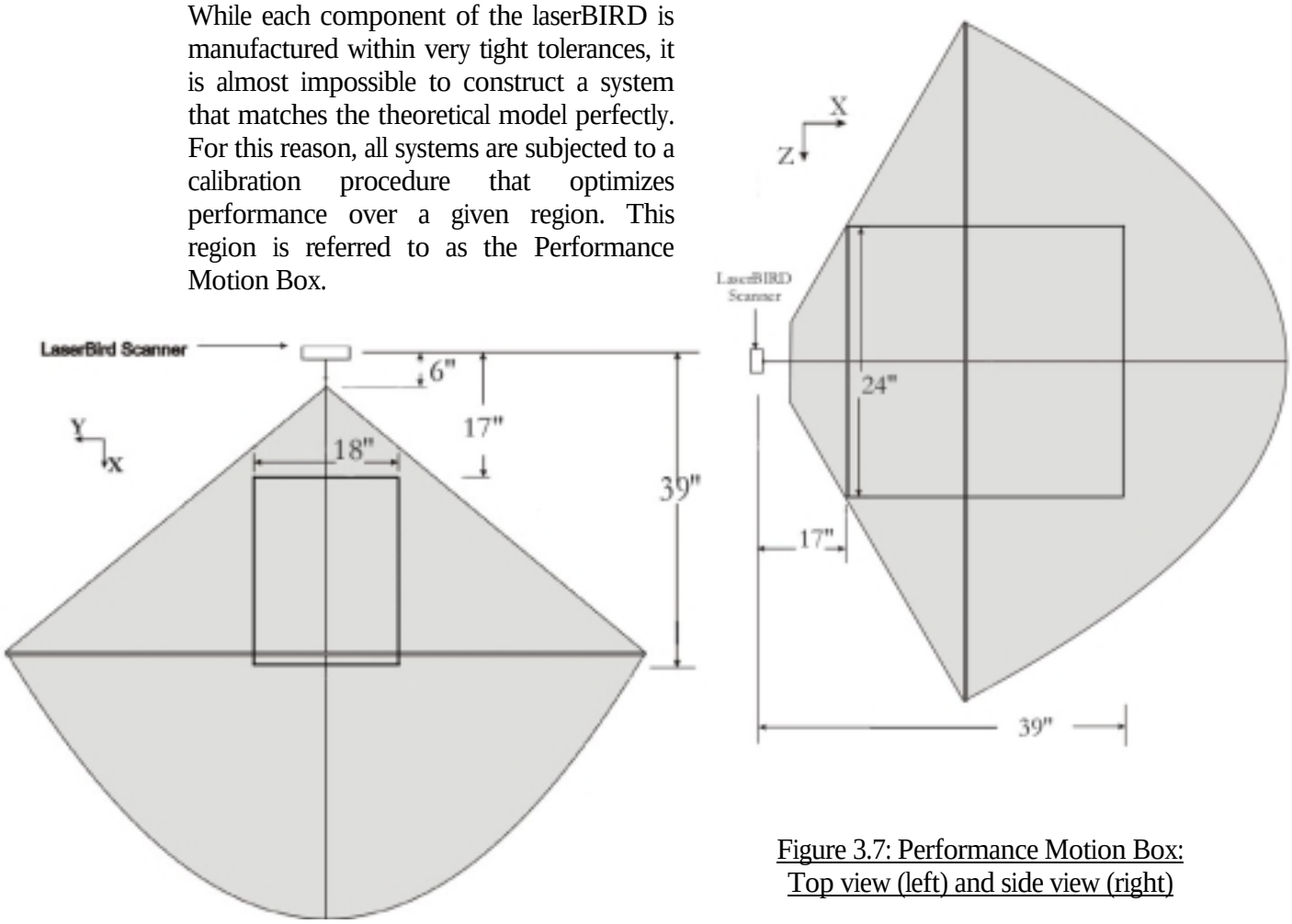


Figure 3.7: Performance Motion Box: Top view (left) and side view (right)

Dimensions in each axis are:

X: +17" to +39" (+43 cm to +99 cm)

Y: -9" to +9" (-23 cm to +23)

Z: -12" to +12" (-30cm to +30cm)

Applications requiring high accuracy should restrict sensor motion to locations within the Performance Motion Box. Tracking outside this box may not yield results with equivalent accuracy.

Chapter

4

Software Operation - Tools for Successful Tracking

This chapter outlines the methods for communicating with the laserBIRD directly and details the RS232 interface protocol and command set.

Software Overview

The laserBIRD communicates with the host via RS232, using the Ascension Technology Flock of Birds® protocol. Using the Flock of Birds protocol gives instant access to a wide range of motion capture, virtual reality and biomechanics applications.

For users wishing to access the laserBIRD directly, there are two options:

1. Use an existing driver for the laserBIRD (i.e. SGI, Win32)
2. Communicate directly via the **Flock of Birds®** protocol

Windows® Driver

The Windows driver provides an interface to the Ascension Technology birds for WIN32 applications. With the exception of the initialization routines, this interface is standardized across platforms and devices. The following Ascension Technology products are supported by this driver: Flock of Birds, pcBIRD, miniBIRD, MotionStar, MotionStar Wireless and laserBIRD. To use the driver, simply include the header file Bird.h in your source code, link with the library module Bird.lib, and put the dynamic-link library Bird.dll anywhere on the DLL search path. Definitions for the data structures and API calls documented here are in the file bird.h. Although this driver interface will change over time, all efforts will be made to keep it backward compatible. The Windows Driver User Manual is included in your laserBIRD documentation. The driver files are located in the WIN32/Driver directory on the laserBIRD CD-ROM.

Flock of Birds Interface

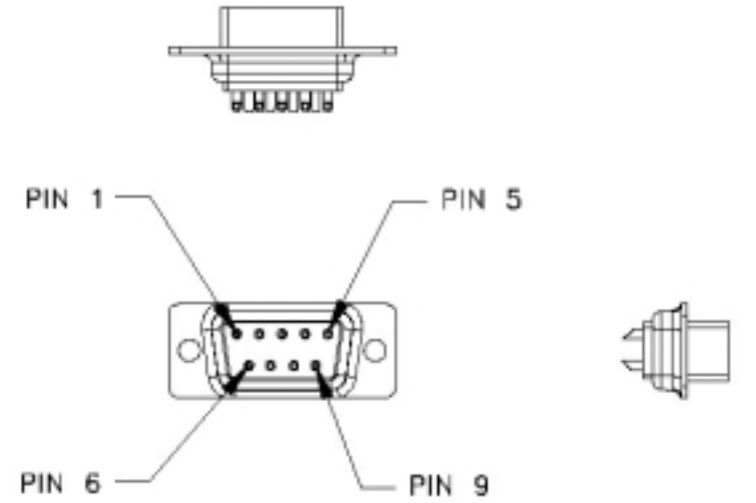
The Flock of Birds protocol involves interpreting RS232 commands sent directly to the laserBIRD. A short sample program utilizing many of these commands is described at the end of this chapter and can be found in the *Direct* subdirectory of the laserBIRD CD-ROM.

RS232 Signal Description

A pinout and signal description of the RS-232C interface is found below. Note that The Bird requires connections only to pins 2, 3 and 5 of the 9-pin interface connector.

The Bird's 9-pin RS-232C connector is arranged as follows:

PIN	RS232 SIGNAL[1]	DIRECTION	DESCRIPTION
2	Receive Data	Bird to host	Serial data output from The Bird to the host
3	Transmit Data	host to Bird	Serial data output from the host to The Bird
5	Signal Ground	Bird to host	Signal reference
7	Request to Send	host to Bird	Holds The Bird in RESET when high



REAR VIEW : 9 PIN D-SUBMINIATURE CONNECTOR

Notes:
1) These are the Electronic Industries Association (EIA) RS232 signals names. The Bird is configured as Data Communication equipment (DCE) and therefore Transmit Data is an input and Receive Data is an output.

Using the 'reset on CTS' feature

The laserBIRD can be configured to perform a system reset when pin 7, its CTS line (RTS on HOST side) is held high. This provides an alternative to issuing the RESET command, if the state of the firmware is unknown. To enable the feature, check the appropriate box in the Settings tab of the *laserBIRD Utility*.

NOTE: Users running applications in a Windows® environment who would like to enable this feature, should take steps to ensure that command of this line (and of the serial port) is clearly asserted.

RS232 Commands

Each RS232 command consists of a single **command byte** followed by **N command data bytes**, where N depends upon the command. A command is an 8-bit value which the host transmits to the Bird (laserBIRD).

The RS232 **command format** is as follows:

	MS BIT								LS BIT
	Stop	7	6	5	4	3	2	1	0	Start
RS232 Command	1	BC7	BC6	BC5	BC4	BC3	BC2	BC1	BC0	0

where BC7-BC0 is the 8-bit command value (see RS232 Command Reference) and the MS BIT (Stop = 1) and LS BIT (Start = 0) refers to the bit values that the UART in your computer's RS232 port automatically inserts into the serial data stream.

The RS232 **command data format** is as follows:

	MS BIT								LS BIT
	Stop	7	6	5	4	3	2	1	0	Start
RS232 Data	1	BD7	BD6	BD5	BD4	BD3	BD6	BD1	BD0	0

where BD7-BD0 is the 8-bit data value associated with a given command.

Command Summary

The following summarizes the action of each RS232 command. The details of command usage are presented later in this chapter in the section entitled 'RS232 Command Reference'.

Command Name	Description
ANGLES	Data record contains 3 rotation angles.
ANGLE ALIGN	Aligns Bird to reference direction.
BORESIGHT	Aligns sensor to the reference frame
BORESIGHT REMOVE	Remove the sensor BORESIGHT
CHANGE VALUE	Changes the value of a selected Bird system parameter.

Tip: For a listing of valid system parameters to use with the CHANGE or EXAMINE VALUE commands, see CHANGE VALUE in the ***'Command Reference'*** section.

EXAMINE VALUE	Reads and examines a selected Bird system parameter.
MATRIX	Data record contains 9-element rotation matrix.
OFFSET	Configures positional outputs from the Bird to specify a location that is offset from the centroid of the Sensor.
POINT	One data record is output for each B command from the selected laserBIRD unit.
POSITION	Data record contains X, Y, Z position of sensor.
POSITION/ANGLES	Data record contains POSITION and ANGLES.
POSITION/MATRIX	Data record contains POSITION and MATRIX.
POSITION/QUATERNION	Data record contains POSITION and QUATERNION.
QUATERNION	Data record contains QUATERNIONs.
REFERENCE FRAME	Defines new measurement reference frame.
REPORT RATE	Number of data records/second output in STREAM mode.
RESET	Performs a system reset
RUN	Turns Scanner ON and starts running after SLEEP.
SLEEP	Turns transmitter OFF and suspends system operation.
STREAM	Data records are transmitted continuously from the selected laserBIRD unit. If GROUP mode is enabled then data records are output continuously from all running laserBIRD units.
STREAM STOP	Stops any data output that was started with the STREAM.

Command Utilization

The host may tell The Bird what type of data to send when a data request is issued. The desired type of data is indicated by sending one of the following data record commands: ANGLES, MATRIX, POSITION, QUATERNION, POSITION/ANGLES, POSITION/MATRIX or POSITION/QUATERNION. These commands do not cause The Bird to transmit data to the host. For the host to receive data, it must issue a data request. Use the POINT data request each time you want one data record or use the STREAM data request to initiate a continuous flow of data records from The Bird. If you want to reduce the rate at which data STREAMs from The Bird, use the REPORT RATE command. All commands can be issued in any order and at any time to change The Bird's output characteristics.

Tip: Check out the sample program *'Terminal'* at the end of this Chapter (and on the CD-ROM) for further illustration of the command usage.

The following is a hypothetical command sequence, issued after power-up, which illustrates the use of some of the commands.

COMMAND	ACTION
ANGLES	Output records will contain angles only.
POINT	Bird outputs ANGLES data record.
STREAM	ANGLE data records start streaming from Bird and will not stop until the mode is changed to POINT or the STREAM STOP command is issued.
POINT	An ANGLE data record is output and the streaming is stopped.

Response Format

Two types of binary data are returned from The Bird:

1. **Position/Orientation** data
2. **CHANGE/EXAMINE VALUE** data

Position/orientation data are the data returned from The Bird in the ANGLES, POSITION, MATRIX, POSITION/ANGLES, POSITION/MATRIX, POSITION/QUATERNION and QUATERNION formats. This data is returned in one or more 8-bit data bytes, using a special format described below.

All other types of data that The Bird returns are in the **CHANGE/EXAMINE VALUE** data format. This data is also returned in one or more 8 bit data bytes, using the response format described with each Change/Examine value command. (see the 'Command Reference' section for details). The Change/Examine value data is not shifted and does not contain the 'phasing' bits found in the Position/Orientation data.

Position/Orientation Data Format.

The Position/Orientation information generated by The Bird is sent in a form called a data record. The number of bytes in each record is dependent on the output format selected by the user. Each 2-byte word is in a binary format dependent on the word type (i.e. Position, Angles, etc.). The binary formats consist of the 14 most significant bits (bits B15 - B2) of the sixteen bits (bits B15 - B0) which define each word. The two least significant bits (bits B1 and B0) are not used by The Bird. The first bit of the first byte transmitted is always a one (1) while the first bit of all other transmitted bytes in the record is always a zero (0). These "phasing" bits are required for the host computer to identify the start of a record when the data is streaming from The Bird without individual record requests. In general, the output data will appear as follows:

MS BIT							LS BIT	
7	6	5	4	3	2	1	0	WORD #
1	B8	B7	B6	B5	B4	B3	B2	#1 LSbyte
0	B15	B14	B13	B12	B11	B10	B9	#1 MSbyte
0	C8	C7	C6	C5	C4	C3	C2	#2 LSbyte
0	C15	C14	C13	C12	C11	C10	C9	#2 MSbyte
0	.	.	.	.	.	.	.	.
0	.	.	.	.	.	.	.	.
0	.	.	.	.	.	.	.	.
0	N8	N7	N6	N5	N4	N5	N2	#N LSbyte
0	N15	N14	N13	N12	N11	N10	N9	#N MSbyte

The MS (most significant) bits are the phasing bits, and are not part of the data.
For example, The Bird is about to send a data record consisting of these three data words:

Word#	Decimal	Hex	Binary (2 bytes) MSbyte	LSbyte
#1	4386	1122	00010001	00100010
#2	13124	3344	00110011	01000100
#3	21862	5566	01010101	01100110

The conversion to the binary data format by the Bird is as follows:

BIRD

1) Shifts each data word right one bit

MS	LS
00001000	10010001
00011001	10100010
00101010	10110011

2) Breaks each word into MSByte LSByte pairs

10010001	LS
00001000	MS
10100010	LS
00011001	MS
10110011	LS
00101010	MS

3) Shifts each LSByte right one more

4) Transmits all bytes in stream

bit (Marks with "1" if first byte)

MS BIT						LS BIT		
7	6	5	4	3	2	1	0	WORD #
1	1	0	0	1	0	0	0	#1 LSByte
0	0	0	0	1	0	0	0	#1 MSByte
0	1	0	1	0	0	0	1	#2 LSByte
0	0	0	1	1	0	0	1	#2 MSByte
0	1	0	1	1	0	0	1	#3 LSByte
0	0	1	0	1	0	1	0	#3 MSByte

The user's computer can identify the beginning of the data record by catching the leading "1", and converting subsequent data bytes back to their proper binary values.

HOST:

1) Receives data bytes in stream after catching first marked "1" (Changes that "1" back to a "0")

01001000	LS
00001000	MS
01010001	LS
00011001	MS
01011001	LS
00101010	MS

2) Shifts each LSByte left one bit

10010000	LS
00001000	MS
10100010	LS
00011001	MS
10110010	LS
00101010	MS

3) Combines each MSByte/LSByte pair into data words

MS	LS
00001000	10010000
00011001	10100010
00101010	10110010

4) Shifts each word left one more bit, giving the correct original binary value

MS	LS
00010001	00100000
00110011	01000100
01010101	01100100

You don't need to worry about the fact that the two least significant bits are different because the data words do not use these bits.

RS232 Command Reference

All commands are listed alphabetically in the following section. Each command description contains the command codes required to initiate the commands, as well as the format and scaling of the data records which The Bird will output to the host computer.

ANGLES

	ASCII	HEX	DECIMAL	BINARY
Command Byte	W	57	87	01010111

In the ANGLES mode, The Bird outputs the orientation angles of the sensor with respect to the transmitter. The orientation angles are defined as rotations about the Z, Y, and X axes of the sensor. These angles are called Zang, Yang, and Xang or, in Euler angle nomenclature, Azimuth, Elevation, and Roll. The output record is in the following format for the six transmitted bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#1 LSbyte Zang
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#2 MSbyte Zang
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#3 LSbyte Yang
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#4 MSbyte Yang
0	X8	X7	X6	X5	X4	X3	X2	#5 LSbyte Xang
0	X15	X14	X13	X12	X11	X10	X9	#6 MSbyte Xang

Zang (Azimuth) takes on values between the binary equivalent of +/- 180 degrees. Yang (Elevation) takes on values between +/- 90 degrees, and Xang (Roll) takes on values between +/- 180 degrees. As Yang (Elevation) approaches +/- 90 degrees, the Zang (Azimuth) and Xang (Roll) become very noisy and exhibit large errors. At 90 degrees the Zang (Azimuth) and Xang (Roll) become undefined. This behavior is not a limitation of The Bird - it is an inherent characteristic of these Euler angles. If you need a stable representation of the sensor orientation at high Elevation angles, use the MATRIX output mode.

The scaling of all angles is full scale = 180 degrees. That is, +179.99 deg = 7FFF Hex, 0 deg = 0 Hex, -180.00 deg = 8000 Hex.

To convert the numbers into angles (degrees) first cast it into a signed integer. This will give you a number from +/- 32767. Second multiply by 180 and finally divide the number by 32768 to get the angle. The equation should look something like this:

(signed int(Hex #) * 180) / 32768

ANGLE ALIGN

	ASCII	HEX	DECIMAL	BINARY
Command Byte	q	71	113	01110001

Command Data	A, E, R



Tip: For assistance with the 'Angle Align' settings, check out the ***'laserBIRD Alignment Procedure'*** in Chapter 3.

By default, the angle outputs from The Bird are measured in the coordinate frame defined by the Scanner's X, Y and Z axes, *as shown in Figure 3.1*, and are measured with respect to rotations about the physical X, Y and Z axes of the sensor. The ANGLE ALIGN1 command allows you to mathematically change the sensor's X, Y and Z axes to an orientation which differs from that of the actual sensor.

For example:

Suppose that during installation you find it necessary, due to physical requirements, to cock the sensor, resulting in its angle outputs reading Azim = 5 deg, Elev = 10 and Roll = 15 when it is in its normal "resting" position. To compensate, use the ANGLE ALIGN command, passing as Command Data the angles of 5, 10 and 15 degrees. After this sequence is sent, the sensor outputs will be zero, and orientations will be computed as if the sensor were not misaligned.

Note: the ANGLE ALIGN command only affects the computation of orientation - it has no effect on position.

If you immediately follow the ANGLE ALIGN command with a POINT or STREAM mode data request, you may not see the effect of the ALIGN command in the data returned. It may take one measurement period (~4.2 milliseconds) before you see the effect of the command.

The host computer must send the *Command Data* immediately following the *Command Byte*. Command data consists of the angles.

The Command Byte and Command Data must be transmitted to The Bird in the following seven-byte format:

```
MSB                                   LSB
 7    6    5    4    3    2   1    0      BYTE #

 0    1    1    1    0    0   1    0      #1 Command Byte
 B7   B6   B5   B4   B3   B2  B1   B0     #2  LSbyte A
 B15  B14  B13  B12  B11  B10 B9   B8     #3  MSbyte A
 B7   B6   B5   B4   B3   B2  B1   B0     #4  LSbyte E
 B15  B14  B13  B12  B11  B10 B9   B8     #5  MSbyte E
 B7   B6   B5   B4   B3   B2  B1   B0     #6  LSbyte R
 B15  B14  B13  B12  B11  B10 B9   B8     #7  MSbyte R
```

See the ANGLES command for the format and scaling of the angle values sent.

BORESIGHT

	ASCII	HEX	DECIMAL	BINARY
Command Byte	u	75	117	01110101

Sending the single byte BORESIGHT command to the laserBIRD causes the sensor to be aligned to the Bird's REFERENCE FRAME. In other words, when you send the command, the sensor's orientation outputs will go to zero, making it appear as if it was physically aligned with the Bird's REFERENCE FRAME. All orientation outputs thereafter are with respect to this BORESIGHTed orientation. This command is equivalent to taking the angle outputs from the Bird and using them in the ANGLE ALIGN commands but without the need to supply any angles with the command. This command does not change any angles you may have set using the ANGLE ALIGN command. However, if you use the ANGLE ALIGN command after you send the BORESIGHT command, these new ANGLE ALIGNs will remove the effect of the BORESIGHT command and replace them with the ANGLE ALIGN angles.

Use the BORESIGHT REMOVE command to revert to the sensor outputs as measured by the orientation of the sensor

BORESIGHT REMOVE

	ASCII	HEX	DECIMAL	BINARY
Command Byte	v	76	118	01110110

Sending the single byte BORESIGHT REMOVE command to the laserBIRD causes the sensor's orientation outputs to revert to their values before you sent the BORESIGHT command. That is, if there were no ANGLE ALIGN values preset, the sensor's orientation outputs will now be with respect to the sensor's physical orientation. If there were ANGLE ALIGN values present before the BORESIGHT command was given, then after the BORESIGHT REMOVE command is given, the sensor's orientation outputs will be with respect to this mathematically defined ANGLE ALIGNed sensor orientation.

CHANGE VALUE

	ASCII	HEX	DECIMAL	BINARY
CHANGE VALUE Command Byte	P	50	80	01010000

CHANGE VALUE Command Byte	PARAMETERnumber	PARAMETERvalue

The CHANGE VALUE command allows you to change the value of The Bird system parameter defined by the PARAMETERnumber byte and the PARAMETERvalue byte(s) sent with the command.

EXAMINE VALUE

	ASCII	HEX	DECIMAL	BINARY
EXAMINE VALUE Command Byte	O	4F	79	01001111

EXAMINE VALUE Command Byte	PARAMETERnumber

The EXAMINE VALUE command allows you to read the value of The Bird system parameter defined by the PARAMETERnumber sent with the command. Immediately after The Bird receives the command and command data, it will return the parameter value as a multi-byte response.

VALID PARAMETERS

Valid CHANGE VALUE and EXAMINE VALUE PARAMETERnumbers are listed in the table below.
Note: not all PARAMETERnumbers are CHANGEable, but ALL are EXAMINEable.

PARAMETER #		CHANGEable	CHANGE bytes send	EXAMINE bytes send	EXAMINE bytes received	PARAMETER DESCRIPTION
Dec	Hex					
0	0	No	0	2	2	Bird status
1	1	No	0	2	2	Software revision number
2	2	No	0	2	2	Bird computer crystal speed
3	3	Yes	4	2	2	Position scaling
4	4	Yes	4	2	2	Filter on/off status
5	5	Yes	16	2	14	DC Filter constant table ALPHA_MIN
8	8	Yes	3	2	1	Disable/Enable data ready output character
9	9	Yes	3	2	1	Changes data ready character
10	A	No	0	2	1	Bird outputs an error code
12	C	Yes	16	2	14	DC filter constant table Vm
13	D	Yes	16	2	14	DC filter constant table ALPHA_MAX

15	F	No	0	2	10	System Model Identification
23	17	Yes	8	2	6	Change/Examine Angle Align2
24	18	Yes	8	2	6	Change/Examine Reference Frame2
25	19	No	0	2	2	Bird (Scanner) Serial Number
128	80	Yes	3	2	1	Disable/Enable Run Time Status
132	84	Yes	4	2	2	Prediction

The **CHANGE VALUE** command must be issued to The Bird in the following N-byte sequence:

```
MSB                                   LSB
 7    6    5    4    3    2    1    0     BYTE #

 0    1    0    1    0    0    0    0     #1 Command Byte, 'P'
 N7   N6   N5   N4   N3   N2   N1   N0    #2 PARAMETERnumber
 B7   B6   B5   B4   B3   B2   B1   B0    #3 PARAMETERdata LSbyte
 B7   B6   B5   B4   B3   B2   B1   B0    #4 PARAMETERdata MSbyte
 B7   B6   B5   B4   B3   B2   B1   B0    #N PARAMETERdata
```

Where N7-N0 represent a PARAMETERnumber (i.e. 00000011 or 00000100), and B7-B0 represent N-bytes of PARAMETERdata. If the PARAMETERdata is a word then the Least Significant byte (LSbyte) is transmitted before the Most Significant byte (MSbyte). If the PARAMETERdata is numeric, it must be in 2's complement format. You do not shift and add 'phasing' bits to the data.

The **EXAMINE VALUE** command must be issued to The Bird in the following 2-byte sequence:

```
MSB                                   LSB
7    6    5    4    3    2    1    0     BYTE #

0    1    0    0    1    1    1    1     #1 Command Byte
N7   N6   N5   N4   N3   N2   N1   N0    #2 PARAMETERnumber
```

Where N7-N0 represent a PARAMETERnumber, i.e. 00000000 or 00000001, etc.

If the PARAMETERdata returned is a word then the Least Significant byte (LSbyte) is received before the Most Significant byte (MSbyte). If the PARAMETERdata is numeric, it is in 2's complement format. The PARAMETERdata received does not contain 'phasing' bits. The PARAMETERdata value, content and scaling depend on the particular parameter requested. See the following discussion of each parameter.

BIRD STATUS

When PARAMETERnumber = 0 during EXAMINE, The Bird returns a status word to tell the user in what mode the unit is operating. The bit assignments for the two byte response are:

B15	1 if Bird is a Master Bird -Only setting possible for laserBIRD 0 - Not used with laserBIRD
B14	1 if Bird has been initialized 0 if Bird has not been initialized
B13	1 if errors exist in the SYSTEM ERROR register (error(s) detected) 0 if no errors exist in the register (no errors detected)
B12	1 if Bird is RUNNING 0 if Bird is not RUNNING
B6-B11	Not used by laserBIRD
B5	1 if The Bird is in SLEEP mode. (Opposite of B12) 0 if The Bird is in RUN mode
B4, B3, B2, B1	0001 if POSITION outputs selected 0010 if ANGLE outputs selected 0011 if MATRIX outputs selected 0100 if POSITION/ANGLE outputs selected 0101 if POSITION/MATRIX outputs selected 0110 factory use only 0111 if QUATERNION outputs selected 1000 if POSITION/QUATERNION outputs selected
B0	0 if POINT mode selected 1 if STREAM mode selected (Note: in STREAM mode you can not examine status)

Tip: To retrieve the error code(s) indicated by this 'flag' (B13), send '10' as the parameter. See *Error Code below.*

SOFTWARE REVISION NUMBER

When PARAMETERnumber = 1 during EXAMINE, The Bird returns the two byte revision number of the software located in The Bird's PROM memory. The revision number in base 10 is expressed as INT.FRA where INT is the integer part of the revision number and FRA is the fractional part. For example, if the revision number is 2.13 then INT = 2 and FRA = 13. The value of the most significant byte returned is FRA. The value of the least significant byte returned is INT. Thus, in the above example the value returned in the most significant byte would have been 0D Hex and the value of the least significant byte would have been 02 Hex. If the revision number were 3.1 then the bytes would be 01 and 03 Hex.

BIRD COMPUTER CRYSTAL SPEED

When PARAMETERnumber = 2 during EXAMINE, The Bird returns the speed of its computer's crystal in megahertz (MHz). The most significant byte of the speed word is equal to zero, and the base 10 value of the least significant byte represents the speed of the crystal. For example, if the least significant byte = 19 Hex, the crystal speed is 25 MHz. The laserBIRD always reports 37MHz.

POSITION SCALING

When PARAMETERnumber = 3 during EXAMINE, The Bird returns a code that describes the scale factor used to compute the position of the sensor with respect to the transmitter. If the separation exceeds this scale factor, The Bird's position outputs will not change to reflect this increased distance, rendering the measurements useless. The most significant byte of the parameter word returned is always zero. If the least significant byte = 0, the scale factor is 36 inches for a full scale position output. If the least significant byte is = 1, the full scale output is 72 inches

To CHANGE the scale factor send The Bird two bytes of PARAMETERdata with the most significant byte set to zero and the least significant set to zero or one.

Note: Changing the scale factor from the default 36 inches to 72 inches reduces by half the resolution of the output X, Y, Z coordinates.

FILTER ON/OFF STATUS

When PARAMETERnumber = 4 during EXAMINE, The Bird returns a code that tells you what software filters are turned on or off in the unit. The average user of The Bird should not have to change the filters, but it is possible to do so. The most significant byte returned is always zero. The bits in the least significant byte are coded per the following:

BIT NUMBER	MEANING	
B7-B3	0	
B2	0	if the AVERAGE (AC NARROW notch) filter is ON (default)
	1	if the AVERAGE filter is OFF
B0	0	if the DC (Adaptive) filter is ON (default)
	1	if the DC filter is OFF

The AVERAGE filter refers to a four element averaging filter that is applied to The Bird's sensor data to eliminate a narrow band of noise with sinusoidal characteristics.

The DC filter refers to an adaptive, low pass filter applied to the sensor data to eliminate high frequency noise. When the DC filter is turned on, you can modify its noise/lag characteristics by changing ALPHA_MIN and Vm.
To CHANGE the FILTER ON/OFF STATUS send The Bird two bytes of PARAMETERdata with the most significant byte set to zero and the least significant set to the code in the table above.

DC FILTER CONSTANT TABLE ALPHA_MIN

When PARAMETERnumber = 5 during EXAMINE, The Bird returns 7 words (14 bytes) which define the lower end of the adaptive range that filter constant ALPHA_MIN can assume in the DC filter as a function of sensor to Scanner separation. When ALPHA_MIN = 0 Hex, the DC filter will provide an infinite amount of filtering (the outputs will never change even if you move the sensor). When ALPHA_MIN = 0.99996 = 7FFF Hex, the DC filter will provide no filtering of the data.

The default values as a function of Scanner to sensor separation range are:

Std. Range Range (inches)	ALPHA_MIN (decimal)
0 to 17	0.02 = 028F Hex.
17 to 22	0.02
22 to 27	0.02
27 to 34	0.02
34 to 42	0.02
42 to 54	0.02
54 +	0.02

To CHANGE ALPHA_MIN, send The Bird seven words of PARAMETERdata corresponding to the ALPHA_MIN table defined above. At the shorter ranges you may want to increase ALPHA_MIN to obtain less lag while at longer ranges you may want to decrease ALPHA_MIN to provide more filtering (less noise/more lag). ALPHA_MIN must always be less than ALPHA_MAX.

DISABLE/ENABLE DATA READY OUTPUT

Enabling the DATA READY character provides a method for notifying you as soon as the newest position and orientation data has been computed. Typically, you would issue a POINT data request as soon as you receive the DATA READY command. If you are running in STREAM mode you should not use the DATA READY character since the position and orientation is sent to you automatically as soon as it is ready.

When PARAMETERnumber = 8 during EXAMINE, The Bird outputs one byte of data, equal to 1 if Data Ready Output is enable or a 0 if disabled.

To CHANGE DATA READY, send The Bird one byte of PARAMETERdata = 1 if The Bird is to output the Data Ready Character every measurement cycle as soon as a new measurement is ready for output. The default Data Ready Character is a comma (2C Hex, 44 Dec).

SET DATA READY CHARACTER

When PARAMETERnumber = 9 during EXAMINE, The Bird returns one byte, the current ASCII value of the Data Ready Character.

To CHANGE the DATA READY CHARACTER, send The Bird one byte of PARAMETERdata equal to the character value that The Bird should use as the Data Ready Character.

ERROR CODE

When PARAMETERnumber = 10 during EXAMINE, The Bird will output a one byte Error code, indicating a particular system condition was detected. The byte returned represents the earliest error code sent to the SYSTEM ERROR register. See the ***Error Reporting*** section below, for details.

DC FILTER TABLE Vm

When PARAMETERnumber = 12 during EXAMINE, The Bird returns a 7 word (14 byte) table, or during CHANGE, the user sends to The Bird a 14 byte table representing the expected noise that the DC filter will measure. By changing the table values the user can increase or decrease the DC filter's lag as a function of sensor range from the Scanner.

The DC filter is adaptive in that it tries to reduce the amount of low pass filtering in The Bird as it detects translation or rotation rates in The Bird's sensor. Reducing the amount of filtering results in less filter lag. Unfortunately electrical noise in the environment, when measured by the sensor, may also make it look like the sensor is undergoing a translation and rotation. As the sensor moves farther and farther away from the Scanner, the amount of noise measured by the sensor appears to increase because the measured signal level is decreasing and the sensor amplifier gain is increasing. In order to decide if the amount of filtering should be reduced, The Bird has to know if the measured events are real due to movement or false due to noise. The Bird gets this knowledge by the user specifying what the expected noise levels are in the operating environment as a function of distance from the Scanner. These noise levels are the 7 words that form the Vm table. The Vm values can range from 1 for almost no noise to 32767 for a lot of noise.

The default values as a function of Scanner to sensor separation range are:

Std. Range Xmtr Range (inches)	Vm (integer)
0 to 17	2
17 to 22	4
22 to 27	8
27 to 34	16
34 to 42	64
42 to 54	128
54 +	512

As Vm increases with range so does the amount of filter lag. To reduce the amount of lag, reduce the larger Vm values until the noise in The Bird's output is too large for your application.

DC FILTER CONSTANT TABLE ALPHA_MAX

When PARAMETERnumber = 13 during EXAMINE, The Bird returns 7 words (14 bytes) which define the upper end of the adaptive range that filter constant ALPHA_MAX can assume in the DC filter as a function of sensor to Scanner separation. When there is a fast motion of the sensor, the

adaptive filter reduces the amount of filtering by increasing the ALPHA used in the filter. It will increase ALPHA only up to the limiting ALPHA_MAX value. By doing this, the lag in the filter is reduced during fast movements. When ALPHA_MAX = 0.99996 = 7FFF Hex, the DC filter will provide no filtering of the data during fast movements.

The default values as a function of Scanner to sensor separation range are:

Std. Range Xmtr Range (inches)	ALPHA_MAX (fractional)
0 to 17	0.9 = 07333 Hex.
17 to 22	0.9
22 to 27	0.9
27 to 34	0.9
34 to 42	0.9
42 to 54	0.9
54 +	0.9

To CHANGE ALPHA_MAX send The Bird seven words of PARAMETERdata corresponding to ALPHA_MAX. During CHANGE, you may want to decrease ALPHA_MAX to increase the amount of filtering if The Bird's outputs are too noisy during rapid sensor movement. ALPHA_MAX must always be greater than ALPHA_MIN.

SYSTEM MODEL IDENTIFICATION

When PARAMETERnumber = 15 during EXAMINE, The Bird returns 10 bytes which will represent the device that was found.

Device Description String	Device
“6DFOB “	Stand alone (SRT)
“6DERC “	Extended Range Controller
“6DBOF “	MotionStar (old name)
“PCBIRD “	pcBIRD
“SPACEPAD “	SpacePad
“MOTIONSTAR”	MotionStar (new name)
“WIRELESS “	MotionStar Wireless
“ LaserBird ”	laserBIRD

CHANGE/EXAMINE ANGLE ALIGN

When PARAMETERnumber = 23 during EXAMINE, The Bird will return 3 words (6 bytes) of data corresponding to the Azimuth, Elevation, and Roll angles used in the ANGLE ALIGN command. This command differs from the ANGLE ALIGN command only in that it allows both reading and writing of the angles. See ANGLE ALIGN for a full explanation of it use.

To CHANGE the angles send 6 bytes of PARAMETERdata after the 2 command bytes.

Note: The angles can only be read back with this command if they were previously written with this command, i.e. if the ANGLE ALIGN was used to set the angles, then those angles will not be accessible with the EXAMINE ANGLE ALIGN command.

CHANGE/EXAMINE REFERENCE FRAME

When PARAMETERnumber = 24 during EXAMINE, The Bird will return 3 words (6 bytes) of data corresponding to the Azimuth, Elevation and Roll angles used in the REFERENCE FRAME command.

See REFERENCE FRAME2 command for an explanation.

To CHANGE the angles send 6 bytes of PARAMETERdata after the 2 command bytes.

Note: These angles are only accessible with this command if they were previously written with this command.

BIRD SERIAL NUMBER

When PARAMETERnumber = 25 during EXAMINE, The Bird will return a 1 word (2 byte) value corresponding to the Serial Number of the Scanner.

Note: This number cannot be changed.

DISABLE/ENABLE RUN TIME STATUS

Enabling the RUN TIME STATUS byte provides a method for notifying you of specific error conditions encountered during operation. When the RUN TIME STATUS is enabled, all subsequent Bird data requests will have a RUN TIME STATUS byte added to the end of the data stream.
The bits in the RUN TIME STATUS byte are coded per the following:

BIT NUMBER	MEANING	
B7	0	
B6	0	if the Motor speed and Measurement Data are valid
	1	if the Motor speed or Measurement Data are invalid

B5	0	
B4	0	if the Motor speed is valid
	1	if the Motor speed is invalid
B3	0	
B2	0	if data from Detector #3 is valid
	1	if data from Detector #3 is invalid
B1	0	if data from Detector #2 is valid
	1	if data from Detector #2 is invalid
B0	0	if data from Detector #1 is valid
	1	if data from Detector #1 is invalid

When PARAMETERnumber = 128 during EXAMINE, The Bird outputs one byte of data, equal to 1 if RUN TIME STATUS is enabled or a 0 if disabled.

To CHANGE RUN TIME STATUS, send The Bird one byte of PARAMETERdata = 1 if The Bird is to append the RUN TIME STATUS byte to each data record.

NOTE: B6 and B4 will be set to '1' during power up and following a system RESET. This is to allow time for the system initialization and self-calibration.

PREDICTION

The laserBIRD can predict positional and angular motion from 0 to 50 mSec into the future. Kalman Filtering and linear extrapolation are combined in a technique that forecasts the selected coordinates and angles by the desired prediction interval.

Tracking algorithms implementing prediction are well known to have a tradeoff between longer prediction intervals on one side, and data degradation (noise and overshoot) on the other. The following suggestions are provided:

1. Customize the selection of predicted parameters such that the laserBIRD is only predicting motion along or about the axis of interest. This will reduce or remove noise and overshoot in the outputs of those coordinates and angles that do not depict motion.

2. Customize the prediction interval to balance the length of forecasting versus observed noise and overshoot.

When PARAMETERnumber = 132 during EXAMINE, The Bird returns a two byte code that describes the current Prediction settings. The bits in the PREDICTION bytes are coded per the following:

BYTE 0:

BIT NUMBER	MEANING
B7,B6	0 Not used
B5	0 if the prediction for X is OFF 1 if the prediction for X is ON
B4	0 if the prediction for Y is OFF 1 if the prediction for Y is ON
B3	0 if the prediction for Z is OFF 1 if the prediction for Z is ON
B2	0 if the prediction for AZIMUTH is OFF 1 if the prediction for AZIMUTH is ON
B1	0 if the prediction for ELEVATION is OFF 1 if the prediction for ELEVATION is ON
B0	0 if the prediction for ROLL is OFF 1 if the prediction for ROLL is ON

BYTE 1: Prediction Interval in milliseconds

i.e. :

19 Hex	Prediction interval for enabled parameters =25 mSec.

To CHANGE the Prediction settings send the laserBIRD two bytes of PARAMETERdata with the most significant byte set to the desired Prediction Interval, and the least significant set using the code in the table above.
Users who utilize the Angle Align settings should note that enabling parameters for prediction does so in the object versus reference frame, not the sensor versus reference frame.

MATRIX

	ASCII	HEX	DECIMAL	BINARY
Command Byte	X	58	88	01011000

The MATRIX mode outputs the 9 elements of the rotation matrix that define the orientation of the sensor's X, Y, and Z axes with respect to the Scanner's X, Y, and Z axes. If you want a three-dimensional image to follow the rotation of the sensor, you must multiply your image coordinates by this output matrix.

The nine elements of the output matrix are defined generically by:

```
        M(1,1)          M(1,2)          M(1,3)

        M(2,1)          M(2,2)          M(2,3)

        M(3,1)          M(3,2)          M(3,3)
```

Or in terms of the rotation angles about each axis
where Z = Zang, Y = Yang and X = Xang:

```
 COS(Y)*COS(Z)          COS(Y)*SIN(Z)         -SIN(Y)

-COS(X)*SIN(Z)          COS(X)*COS(Z)
+SIN(X)*SIN(Y)*COS(Z)  +SIN(X)*SIN(Y)*SIN(Z)   SIN(X)*COS(Y)

 SIN(X)*SIN(Z)         -SIN(X)*COS(Z)
+COS(X)*SIN(Y)*COS(Z)  +COS(X)*SIN(Y)*SIN(Z)   COS(X)*COS(Y)
```

Or in Euler angle notation, where R = Roll, E = Elevation, A = Azimuth:

```
 COS(E)*COS(A)            COS(E)*SIN(A)          -SIN(E)

-COS(R)*SIN(A)            COS(R)*COS(A)
+SIN(R)*SIN(E)*COS(A)    +SIN(R)*SIN(E)*SIN(A)    SIN(R)*COS(E)

 SIN(R)*SIN(A)           -SIN(R)*COS(A)
+COS(R)*SIN(E)*COS(A)    +COS(R)*SIN(E)*SIN(A)    COS(R)*COS(E)
```

The output record is in the following format for the eighteen transmitted bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	M8	M7	M6	M5	M4	M3	M2	#1 LSbyte M(1,1)
0	M15	M14	M13	M12	M11	M10	M9	#2 MSbyte M(1,1)
0	M8	M7	M6	M5	M4	M3	M2	#3 LSbyte M(2,1)
0	M15	M14	M13	M12	M11	M10	M9	#4 MSbyte M(2,1)
0	M8	M7	M6	M5	M4	M3	M2	#5 LSbyte M(3,1)
0	M15	M14	M13	M12	M11	M10	M9	#6 MSbyte M(3,1)
0	M8	M7	M6	M5	M4	M3	M2	#7 LSbyte M(1,2)
0	M15	M14	M13	M12	M11	M10	M9	#8 MSbyte M(1,2)
0	M8	M7	M6	M5	M4	M3	M2	#9 LSbyte M(2,2)
0	M15	M14	M13	M12	M11	M10	M9	#10 MSbyte M(2,2)
0	M8	M7	M6	M5	M4	M3	M2	#11 LSbyte M(3,2)
0	M15	M14	M13	M12	M11	M10	M9	#12 MSbyte M(3,2)
0	M8	M7	M6	M5	M4	M3	M2	#13 LSbyte M(1,3)
0	M15	M14	M13	M12	M11	M10	M9	#14 MSbyte M(1,3)
0	M8	M7	M6	M5	M4	M3	M2	#15 LSbyte M(2,3)
0	M15	M14	M13	M12	M11	M10	M9	#16 MSbyte M(2,3)
0	M8	M7	M6	M5	M4	M3	M2	#17 LSbyte M(3,3)
0	M15	M14	M13	M12	M11	M10	M9	#18 MSbyte M(3,3)

The matrix elements take values between the binary equivalents of +.99996 and -1.0. Element scaling is +.99996 = 7FFF Hex, 0 = 0 Hex, and -1.0 = 8000 Hex.

OFFSET

	ASCII	HEX	DECIMAL	BINARY
Command Byte	K	4B	75	01001011

Command Data	X, Y, Z OFFSET DISTANCES FROM SENSOR

Normally the position outputs from the laserBIRD represent the x, y, z position of the centroid of the sensor with respect to the origin of the Scanner. The OFFSET command allows the user to specify a location that is offset from the centroid of the sensor. Figure 4.1 shows an application of the offset command where the desired positional outputs from the Bird differ from the normal x, y, z sensor outputs.

Referring to Figure 4.1, the x, y, z offset distances you supply with this command are measured in the reference frame attached to the sensor and are measured from the sensor centroid to the desired position. After the command is executed, all subsequent positional outputs from the Bird will be x, y, z desired.

With the command you send to the Bird three words of data, the Xoffset, Yoffset, and Zoffset coordinates. The scaling of these coordinates is the same as the POSITION command coordinates. For example, assume you were using a Bird in its default maximum range mode of 36 inches full scale. Also assume the Xoffset, Yoffset, and Zoffset values where 5.4 inches, - 2.1 inches, and 1.3 inches. You would then output three integer or their hex equivalents to the Bird equal to:

Xoffset = 4915 = 5.4 * 32768 / 36.
Yoffset = 63625 = 65536 - 1911
Zoffset = 1183

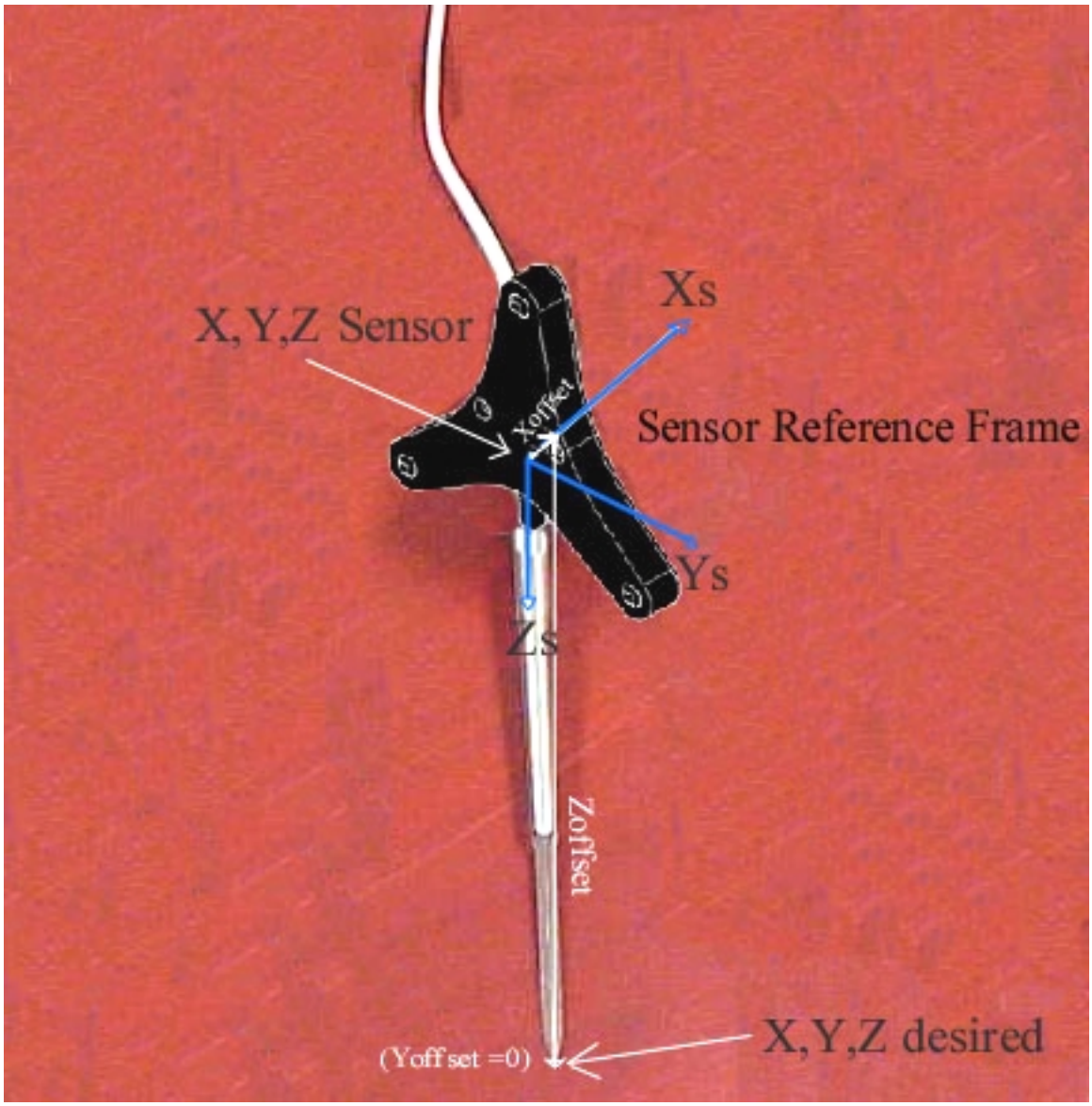


Figure 4.1: Using the OFFSET command

POINT

	ASCII	HEX	DECIMAL	BINARY
Command Byte	B	42	66	01000010

In the POINT mode, The Bird sends one data record each time it receives the B Command Byte.

POSITION

	ASCII	HEX	DECIMAL	BINARY
Command Byte	V	56	86	01010110

In the POSITION mode, The Bird outputs the X, Y, and Z positional coordinates of the sensor with respect to the Scanner. The output record is in the following format for the six transmitted bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	X8	X7	X6	X5	X4	X3	X2	#1 LSbyte X
0	X15	X14	X13	X12	X11	X10	X9	#2 MSbyte X
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#3 LSbyte Y
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#4 MSbyte Y
0	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#5 LSbyte Z
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#6 MSbyte Z

The X, Y, and Z values vary between the binary equivalent of ± MAX inches. Where MAX = 36" or 72". The default positive X, Y, and Z directions are shown in *Figure 3.1*

Scaling of each position coordinate is full scale = MAX inches. That is,
+MAX = 7FFF Hex, 0 = 0 Hex, -MAX = 8000 Hex. Since the maximum range (Range = square root(X**2+Y**2+Z**2)) from the Scanner to the sensor is limited to MAX inches, only one of the X, Y, or Z coordinates may reach its full scale value. Once a full scale value is reached, the positional coordinates no longer reflect the correct position of the sensor.

To convert the numbers into inches first cast it into a signed integer. This will give you a number from +/- 32767. Second multiply by 36 or 72. Finally divide the number by 32768 to get the position ***in inches.*** The equation should look something like this:

(signed int(Hex #) * 36) / 32768
Or: (signed int(Hex #) * 72) / 32768

POSITION/ANGLES

	ASCII	HEX	DECIMAL	BINARY
Command Byte	Y	59	89	01011001

In the POSITION/ANGLES mode, the outputs from the POSITION and ANGLES modes are combined into one record containing the following twelve bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #	
1	X8	X7	X6	X5	X4	X3	X2	#1	LSbyte X
0	X15	X14	X13	X12	X11	X10	X9	#2	MSbyte X
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#3	LSbyte Y
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#4	MSbyte Y
0	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#5	LSbyte Z
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#6	MSbyte Z
0	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#7	LSbyte Zang
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#8	MSbyte Zang
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#9	LSbyte Yang
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#10	MSbyte Yang
0	X8	X7	X6	X5	X4	X3	X2	#11	LSbyte Xang
0	X15	X14	X13	X12	X11	X10	X9	#12	MSbyte Xang

See POSITION mode and ANGLE mode for number ranges and scaling.

POSITION/MATRIX

	ASCII	HEX	DECIMAL	BINARY
Command Byte	Z	5A	90	01011010

In the POSITION/MATRIX mode, the outputs from the POSITION and MATRIX modes are combined into one record containing the following twenty four bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	X8	X7	X6	X5	X4	X3	X2	#1 LSbyte X
0	X15	X14	X13	X12	X11	X10	X9	#2 MSbyte X
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#3 LSbyte Y
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#4 MSbyte Y
0	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#5 LSbyte Z
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#6 MSbyte Z
0	M8	M7	M6	M5	M4	M3	M2	#7 LSbyte M(1,1)
0	M15	M14	M13	M12	M11	M10	M9	#8 MSbyte M(1,1)
0	M8	M7	M6	M5	M4	M3	M2	#9 LSbyte M(2,1)
0	M15	M14	M13	M12	M11	M10	M9	#10 MSbyte M(2,1)
0	M8	M7	M6	M5	M4	M3	M2	#11 LSbyte M(3,1)
0	M15	M14	M13	M12	M11	M10	M9	#12 MSbyte M(3,1)
0	M8	M7	M6	M5	M4	M3	M2	#13 LSbyte M(1,2)
0	M15	M14	M13	M12	M11	M10	M9	#14 MSbyte M(1,2)
0	M8	M7	M6	M5	M4	M3	M2	#15 LSbyte M(2,2)
0	M15	M14	M13	M12	M11	M10	M9	#16 MSbyte M(2,2)
0	M8	M7	M6	M5	M4	M3	M2	#17 LSbyte M(3,2)
0	M15	M14	M13	M12	M11	M10	M9	#18 MSbyte M(3,2)
0	M8	M7	M6	M5	M4	M3	M2	#19 LSbyte M(1,3)
0	M15	M14	M13	M12	M11	M10	M9	#20 MSbyte M(1,3)
0	M8	M7	M6	M5	M4	M3	M2	#21 LSbyte M(2,3)
0	M15	M14	M13	M12	M11	M10	M9	#22 MSbyte M(2,3)
0	M8	M7	M6	M5	M4	M3	M2	#23 LSbyte M(3,3)
0	M15	M14	M13	M12	M11	M10	M9	#24 MSbyte M(3,3)

See POSITION mode and MATRIX mode for number ranges and scaling.

POSITION/QUATERNION

	ASCII	HEX	DECIMAL	BINARY
Command Byte	]	5D	93	01011101

In the POSITION/QUATERNION mode, The Bird outputs the X, Y, and Z position and the four quaternion parameters, q_0, q_1, q_2, and q_3 which describe the orientation of the sensor with respect to the Scanner. The output record is in the following format for the fourteen transmitted bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	X8	X7	X6	X5	X4	X3	X2	#1 LSbyte X
0	X15	X14	X13	X12	X11	X10	X9	#2 MSbyte X
0	Y8	Y7	Y6	Y5	Y4	Y3	Y2	#3 LSbyte Y
0	Y15	Y14	Y13	Y12	Y11	Y10	Y9	#4 MSbyte Y
0	Z8	Z7	Z6	Z5	Z4	Z3	Z2	#5 LSbyte Z
0	Z15	Z14	Z13	Z12	Z11	Z10	Z9	#6 MSbyte Z
0	B8	B7	B6	B5	B4	B3	B2	#7 LSbyte q_0
0	B15	B14	B13	B12	B11	B10	B9	#8 MSbyte q_0
0	B8	B7	B6	B5	B4	B3	B2	#9 LSbyte q_1
0	B15	B14	B13	B12	B11	B10	B9	#10 MSbyte q_1
0	B8	B7	B6	B5	B4	B3	B2	#11 LSbyte q_2
0	B15	B14	B13	B12	B11	B10	B9	#12 MSbyte q_2
0	B8	B7	B6	B5	B4	B3	B2	#13 LSbyte q_3
0	B15	B14	B13	B12	B11	B10	B9	#14 MSbyte q_3

See POSITION mode and QUATERNION mode for number ranges and scaling.

QUATERNION

	ASCII	HEX	DECIMAL	BINARY
Command Byte	\	5C	92	01011100

In the QUATERNION mode, The Bird outputs the four quaternion parameters that describe the orientation of the sensor with respect to the Scanner. The quaternions, q_0, q_1, q_2, and q_3 where q_0 is the scaler component, have been extracted from the MATRIX output using the algorithm described in "Quaternion from Rotation Matrix" by Stanley W. Shepperd, Journal of Guidance and Control, Vol. 1, May-June 1978, pp. 223-4. The output record is in the following format for the eight transmitted bytes:

MSB 7	6	5	4	3	2	1	LSB 0	BYTE #
1	B8	B7	B6	B5	B4	B3	B2	#1 LSbyte q_0
0	B15	B14	B13	B12	B11	B10	B9	#2 MSbyte q_0
0	B8	B7	B6	B5	B4	B3	B2	#3 LSbyte q_1
0	B15	B14	B13	B12	B11	B10	B9	#4 MSbyte q_1
0	B8	B7	B6	B5	B4	B3	B2	#5 LSbyte q_2
0	B15	B14	B13	B12	B11	B10	B9	#6 MSbyte q_2
0	B8	B7	B6	B5	B4	B3	B2	#7 LSbyte q_3
0	B15	B14	B13	B12	B11	B10	B9	#8 MSbyte q_3

Scaling of the quaternions is full scale = +.99996 = 7FFF Hex, 0 = 0 Hex, and -1.0 = 8000 Hex.

REFERENCE FRAME

	ASCII	HEX	DECIMAL	BINARY
Command Byte	r	72	114	01110010

Command Data	A, E, R

Tip: For assistance with the 'Reference Frame' settings, check out the ***'laserBIRD Alignment Procedure'*** in Chapter 3.

By default, The Bird's reference frame is defined by the Scanner's physical X, Y, and Z axes.*(see Figure 3.1)* In some applications, it may be desirable to have the orientation measured with respect to another reference frame. The REFERENCE FRAME command permits you to define a new reference frame by inputting the angles required to align the physical axes of the Scanner to the X, Y, and Z axes of the new reference frame. The alignment angles are defined as rotations about the Z, Y, and X axes of the Scanner. These angles are called the, Azimuth, Elevation, and Roll angles.

The command sequence consists of a Command Byte and 6 Command Data bytes. The Command Data consists of the alignment angles Azimuth (A), Elevation (E), and Roll (R).

If you immediately follow the REFERENCE FRAME command with a POINT or STREAM mode data request you may not see the effect of this command in the data returned. It may take one measurement period before you see the effect of the command.

The Command Byte and Command Data must be transmitted to The Bird in the following seven-byte format:

```
MSB                                   LSB
 7    6    5    4    3    2    1    0      BYTE #

 0    1    1    1    0    0    1    0      #1 Command Byte
 B7   B6   B5   B4   B3   B2   B1   B0     #2  LSbyte A
 B15  B14  B13  B12  B11  B10  B9   B8     #3  MSbyte A
 B7   B6   B5   B4   B3   B2   B1   B0     #4  LSbyte E
 B15  B14  B13  B12  B11  B10  B9   B8     #5  MSbyte E
 B7   B6   B5   B4   B3   B2   B1   B0     #6  LSbyte R
 B15  B14  B13  B12  B11  B10  B9   B8     #7  MSbyte R
```

See the ANGLES command for the format and scaling of the angle values sent.

REPORT RATE

Measurement Rate Divisor Command	ASCII	HEX	DECIMAL	BINARY
1	Q	51	81	01010001
2	R	52	82	01010010
8	S	53	83	01010011
32	T	54	84	01010100

If you do not want a Bird data record output to your host computer every Bird measurement cycle when in STREAM mode then use the REPORT RATE command to change the output rate to every other cycle (R), every eight cycles (S) or every thirty-two cycles (T). If no REPORT RATE command is issued, transmission proceeds at the measurement rate by default.

RESET

	ASCII	HEX	DECIMAL	BINARY
Command Byte	b	62	98	01100010

The RESET command is issued to the standalone Bird to restart the entire system. RESET does reinitialize the system from the flash memory, so any configuration or alignment data entered before the system was reset, will revert back to power-up settings stored in the Flash.

RUN

	ASCII	HEX	DECIMAL	BINARY
Command Byte	F	46	70	01000110

The RUN command is issued to the standalone Bird to restart normal system operation after The Bird has been put to sleep with the SLEEP command. RUN does not reinitialize the system RAM memory, so any configuration or alignment data entered before the system went to SLEEP will be retained.

SLEEP

Tip: To help maximize the life of your system's lasers and other internal Scanner components, issue the SLEEP command when you are not using the tracker, or configure the Sleep on Reset setting in the laserBIRD Utility.

	ASCII	HEX	DECIMAL	BINARY
Command Byte	G	47	71	01000111

The SLEEP command turns the tracking lasers in the Scanner off, and halts the system. (Scanner shaft stops rotating). While asleep, The Bird will respond to data requests and mode changes but the data output will not change. To resume normal system operation, issue the RUN command.

STREAM

	ASCII	HEX	DECIMAL	BINARY
Command Byte	@	40	64	01000000

In the STREAM mode, The Bird starts sending continuous data records to the host computer as soon as new data is available -240 times per second. Data records will continue to be sent until the host sends the STREAM STOP command or the POINT command, or any format command such as POSITION to stop the stream.

Some computers and/or high level software languages may not be able to keep up with the constant STREAM of data in this mode. Bytes received by your RS232 port may overrun one another or your input buffer may overflow if Bird data is not retrieved fast enough. This condition will cause lost bytes, hence if your high level application software requests say 12 bytes from the RS232 input buffer, it may hang because one or more bytes were lost. To eliminate this possibility, read one byte at a time looking for the phasing bit that marks the first byte of the data record.

See REPORT RATE to change the rate at which records are transmitted during STREAM.

STREAM STOP

	ASCII	HEX	DECIMAL	BINARY
Command Byte	?	3F	63	00111111

STREAM STOP turns STREAM mode off, stopping any data that was STREAMing from the Bird. This is an alternative to stopping the stream using a POINT command. NOTE: The record in progress when the laserBIRD receives the command will still be output in its entirety to the host computer. To ensure that you have cleared your input port before executing any new commands, send STREAM STOP, delay and then discard any data in your serial port buffer.

Error Reporting

The laserBIRD is designed to continuously monitor system activities, and to report particular conditions to the user through error codes. These codes may be generated as a result of the power-up diagnostics, or from regular error detection during normal operation. All error codes are 1 byte in length, and are reported to the SYSTEM ERROR buffer. This buffer holds up to 16 bytes of error information (16 codes).

NOTE: Users may also choose to enable the RUN TIME STATUS byte for notification of specific conditions. See the DISABLE/ENABLE RUN TIME STATUS PARAMETERnumber=128 for details.

Notification

The user can choose to be notified that an error has been generated through any of the following methods:

Error Flag

Monitor the ERROR bit **(B13)** in the **two byte** BIRD STATUS register.

1. Send EXAMINE VALUE command with PARAMETERnumber = 0

When an error is detected this bit is set to a '1', and the generated error code is sent to the SYSTEM ERROR buffer.

To retrieve the code after the flag has been set:

2. Send the EXAMINE VALUE command with PARAMETERnumber = 10

   This returns the earliest Error sent to the buffer and clears it.

Note: If there is only one error in the buffer, reading the ERROR bit (B13) in the BIRD STATUS word, will reset the bit to '0' indicating all errors have been read and cleared from the buffer. If the bit remains a '1', then additional errors remain and should be read.

SYSTEM ERROR

Alternatively, the user can query the SYSTEM ERROR buffer directly.

1. Send the EXAMINE VALUE command with PARAMETERnumber = 10

   This returns the earliest Error sent to the buffer. and clears it.

2. Additional queries will return and clear the next Error code in the buffer, until the buffer. is empty. When the buffer is empty, the query will return '0'.

Note: If the query returns '45', then the 16-byte(16 error codes) buffer has overflowed, and the newest codes generated will be lost.

Error Code Listing

CODE ERROR DESCRIPTION

0 No Error
Cause: SYSTEM ERROR register empty

3 Scanner Configuration Data Corrupt
Cause: The system was not able to read the Scanner configuration data
Action: Reset the system

5 Sensor Configuration Data Corrupt
Cause: The system was not able to read the Sensor EEPROM configuration data, or the Sensor is not plugged in.
Action: Insure that the Sensor is present, calibrate the sensor

6 Invalid RS232 Command
Cause: The system has received an invalid RS232 command, which can occur if the user sends down a command character that is not defined or if the data for a command does not make sense (i.e., change value commands with an unknown parameter number).
Action: Only send valid RS232 commands to The Bird.

11 RS232 Receive Overrun or Framing Error
Cause: An overrun or framing error has been detected by the serial channel UART as it received characters from the user's host computer on the RS232 interface.
Action: If an overrun error, the baud rate of the user's host computer and The Bird differ. This may be due to incorrect baud selection, inaccuracy of the baud rate generator, or the RS232 cable is too long for the selected baud rate. If a framing error, the host software may be sending characters to its own UART before the UART finishes outputting the previous character.

18 Illegal Baud Rate Error
Cause: If the baud rate setting is in an 'invalid' baud rate setting then this error will occur.
Action: Set up baud rate with a valid setting.

36 Invalid Motor Speed
Cause: Scanner motor speed is out of range. May be caused by excessive movement or vibration of the Scanner unit
Action: Steady the Scanner or reset the system.

37 DSP POST error

Cause: Can't download code to the acquisition DSP(s).
Action: Contact Ascension

44 Algorithm Overflow
Cause: Computational error, possibly due to noise in the environment
Action: Check environment, and detector data using utility

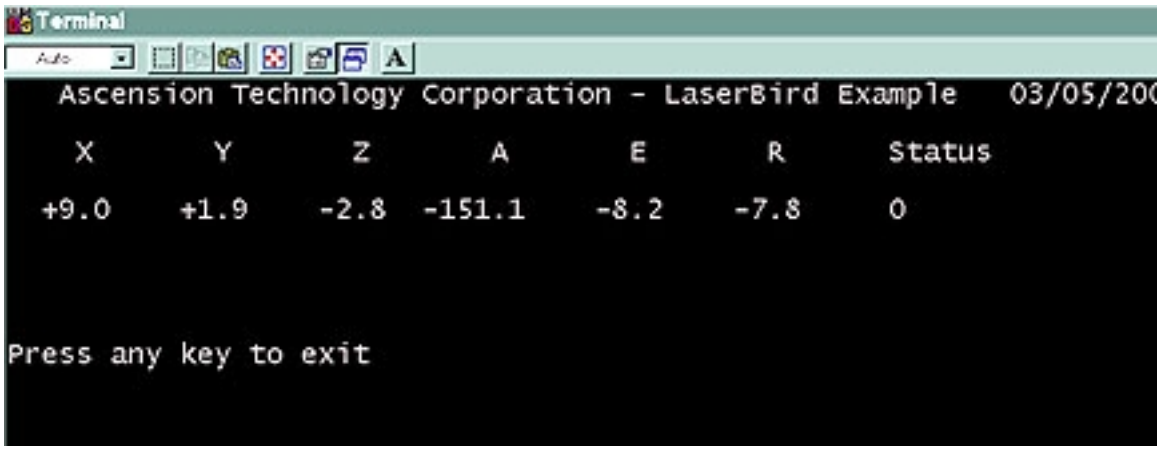
45 Error Buffer Overflow
Cause: Too many errors detected and sent to the SYSTEM ERROR register. Not all errors will be reported
Action: Read register to clear errors

46 Flash Checksum error
Cause: Section of the Scanners Flash memory corrupted.
Action: Reload the Flash using the utility, but not more than 5000 times.

Sample Program

An example of the basic structure that applications should follow to communicate with the laserBIRD can be found in the sample program *Terminal* . This program utilizes the basic elements (RS232 commands) required to establish communication, configure the data format, and output data to the HOST screen display. Users will find the source code and the executable file located in the *\Direct* subdirectory of the laserBIRD CD-ROM.

NOTE: Users should use this program as an example only. Follow the description included with each command in the Command Reference section of this chapter, for details of Command usage in your specific application.



Chapter 5

Troubleshooting, Maintenance, and Repair

User Maintenance

The laserBIRD system requires very little maintenance to obtain consistent and reliable performance. User efforts to maintain good performance should include the following:

1. Periodically check the Sensor cables for nicks and cuts in the insulation.
2. Keep the optical surfaces of the laserBIRD clean. Carefully wipe off dirt or contaminants with a clean, non-abrasive cloth.
3. Inspect both the Sensor connector and receptacle (on the Scanner) for bent or damaged pins.
4. Inspect power supply and serial port connections. Tighten as necessary to maintain positive contact.

Software Updates

As new features or updates become available for the laserBIRD system, you may find it necessary to update the firmware stored in the Scanner's memory. The *laserBIRD Utility* included on your CD-ROM allows you to do this without opening the Scanner, or returning it to Ascension. Instructions for this procedure are included with updates.

Troubleshooting

Most installation and tracking problems are easy to fix. Consult the troubleshooting table for common problems and their solutions. If you continue to experience problems, contact Ascension for technical support.

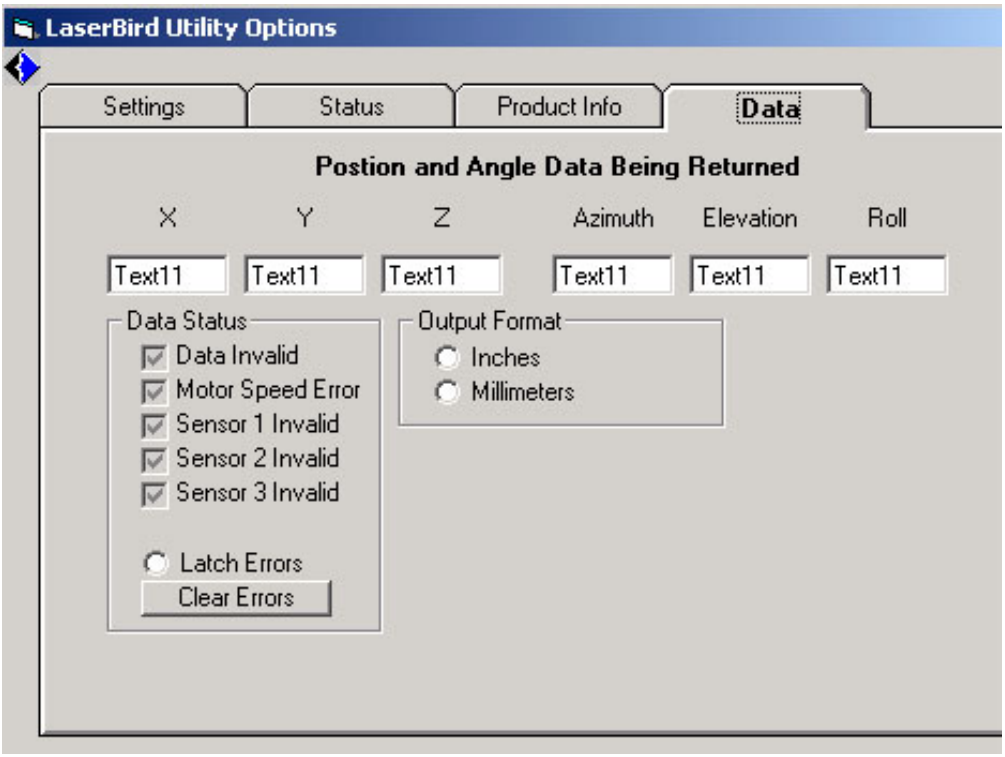
Symptom	Possible Causes	Solution
No audible sound when Scanner plugged in	No Power	-Check AC connections to power supply -Check that d-sub connector fully seated -Reset hardware by cycling AC power
	System in SLEEP mode	-Check BIRD STATUS for SLEEP mode; issue RUN command
	System in RESET	-Run the laserBIRD utility, and check for status of the 'reset on CTS' setting. If enabled, and you are running Windows, either disable it or ensure that your application takes control of the COM port.
Utility doesn't run	No serial communication	-Check the suggestions outlined in 'Not able to communicate' below
	Software Installation unsuccessful	-Re-initialize the HOST PC and run the installation again
Power-up defaults did not change after configuring with the utility	Configuration download interrupted	-Re-start the laserBIRD and the utility and set the defaults again. Be sure to click APPLY to send the settings to the Scanner
	LaserBIRD did not reset(restart) after burning the Flash settings	-Cycle power to the laserBIRD, and re-check the settings
Not able to communicate with the system	Baud rate incorrect	-Default Baud rate for the laserBIRD is 38400. Start the laserBIRD utility using this setting, and configure the default for your needs. See Chapter 3 for details
	COM port incorrect	-Specify to your HOST PC the COM port that the tracker is connected to.
	RS232 cable disconnected	-Check that the serial connections at both ends of the cable are fully seated.

Symptom	Possible Causes	Solution
Can communicate with the system, but data not changing	Detectors occluded	-Use the utility to check for valid data from each detector
	Detectors saturated	-Sensor may be too close to the Scanner; increase distance. Also check for presence of high intensity light sources in the operating region.
	Sensor connection faulty	-Check that Sensor connector is correctly installed and locked. Inspect coaxial pins for wear or damage. -Contact Ascension for assistance
Data is too noisy	Filters OFF	-Check FILTER STATUS for present state of filter configuration. Enable AVG and Adaptive filters as necessary
	DC Filter not optimized	-Check settings of VM and Alpha_ Min. Adjust until data acceptable. See Command Reference in Chapter 4 for details
	Reflective surfaces in the operating region	-Remove object or surface causing reflection, or adjust Scanner mounting to minimize effect.
	Interference from another laserBIRD	-If running dual Scanners, check the configuration of the 'laserBIRD ID' setting. Configure as detailed in the DUAL SCANNER OPERATION section in Chapter 3 -If configured correctly, adjust Scanner mounting such that the 'Performance Motion Boxes' do not overlap. See DUAL SCANNER OPERATION in Chapter 3.

Using the Utility for Troubleshooting

The laserBIRD Utility provides a fast and easy way to evaluate how each individual detector in your Sensor is performing throughout the operating region.

For example, if you were experiencing interruptions (static or noisy data) during your tracking application, you could run the utility and determine which of the detectors were returning invalid data. Invalid data is most often caused by an occluded detector or a saturated detector. The utility refers to the three detectors as *Sensor 1, Sensor 2, and Sensor 3.*



NOTE: The Scanner must receive valid data from **all 3** detectors to process and compute a data record (position and orientation).

Repair: Contacting Ascension Technology Corporation

There are no fuses or user serviceable parts in the laserBIRD Scanner, Sensor, or power supply.

In addition to this manual, Ascension Technology provides technical support via:

World Wide Web:

http://www.ascension-tech.com/support/troubleshoot/

E-mail:

techsupport@ascension-tech.com.

Telephone:

Call (802) 893-6657 between 9 a.m. and 5 p.m. U.S. Eastern Standard Time, Monday through Friday.

Fax:

(802) 893-6659.

Warranty

Ascension warrants that its products are free from defects in material and workmanship for a period of one (1) year from date of delivery, providing the products are not subject to misuse, neglect, accident, incorrect installation, or improper care. If any Ascension products fail due to no fault of the buyer, Ascension will (at its option) either repair the defective product and restore it to normal operation without charge for parts and labor or provide a replacement in exchange for the defective product. Repair work shall be warranted for the remainder of the unexpired warranty period or for a period of 60 days, whichever is longer. This warranty is the exclusive warranty given in lieu of any other express or implied warranty. Ascension disclaims any implied warranties of merchantability and fitness to a particular purpose. Warranties are voided if the buyer utilizes a power supply that does not strictly adhere to Ascension's electrical power requirements, changes the configuration of a tracker, (such as, adding extensions to cables or modifying boards), or mishandles Sensors or cables. To avoid warranty issues, customers should carefully adhere to all product advisories. Scanners, sensors, cables, and connectors are sensitive electronic components and should be treated with care. Do not drop, pull, twist, or mishandle cables. Do not open the Scanner housing.

Replacement Parts

Part Number	Description
600333	Assembly, laserBIRD Scanner
600326	Assembly, laserBIRD Sensor
106045	Power Supply, laserBIRD
940019	laserBIRD CD-ROM
940020	laserBIRD Installation and Operation Guide

Chapter

6

Regulatory Information and Product Specifications

FCC Regulations

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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

Canadian Regulations

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulation of the Canadian Department of Communications.

Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques de la class A prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

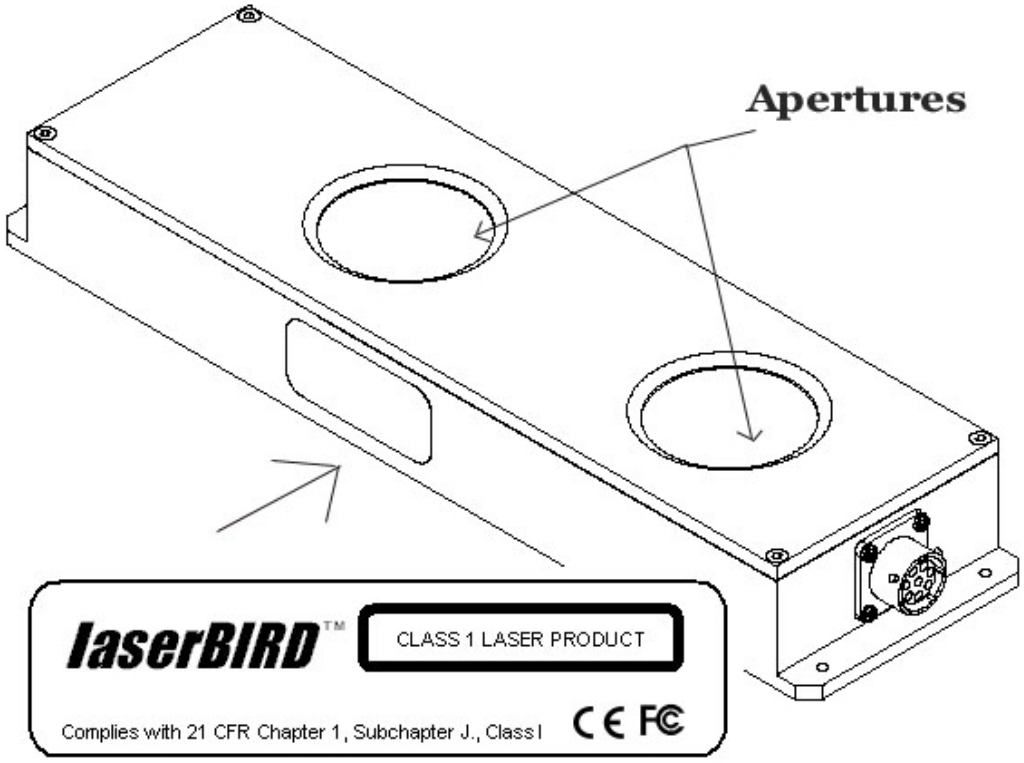
CE Specifications

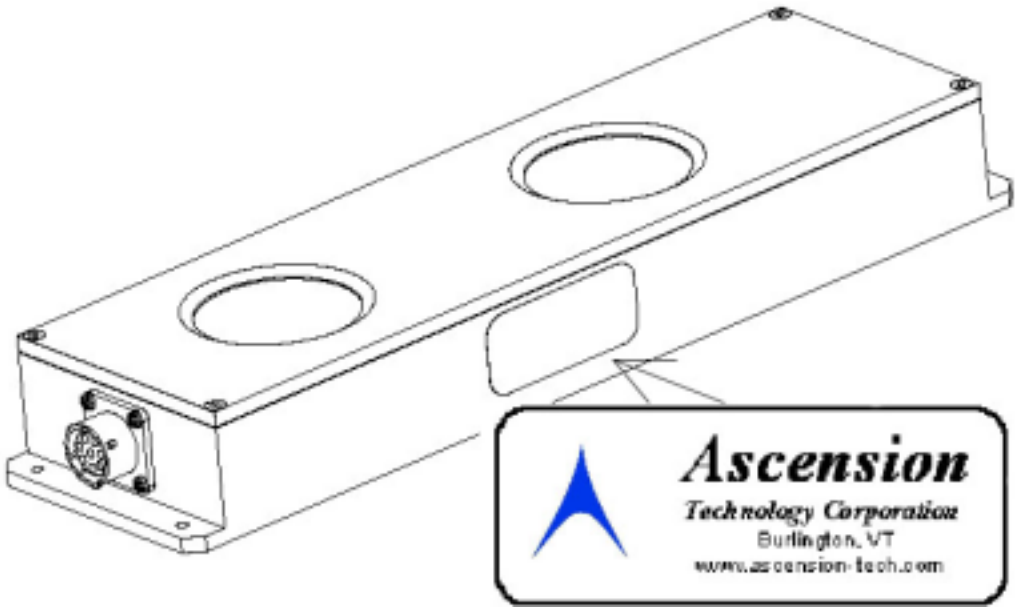
Equipment Classification

In Accordance with EN60825-1 (Safety of Laser Products), this equipment is classified as follows:

CLASS 1 LASER PRODUCT

A CLASS 1 laser product is defined as any laser product which does not permit human access to laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations.





Laser Radiation Fields

The four beams generated by the Scanner electronics for tracking, are produced using laser diodes with a typical operating wavelength of 785 nm. Each tracking laser is spread into a fan-like pattern, with a beam divergence of approximately 100 degrees in one direction. These fan beams are scanned vertically through the target area, by reflecting off a rotating mirrored shaft. This produces an angular coverage or field of view of ±60°deg vertical and ±50° horizontal. Fans are at 15 degrees from the axis of shaft rotation. The shaft rotates at 60Hz.

⊗ **CAUTION!**
Attempts to adjust/alter the internal Scanner components, may cause hazardous levels of laser radiation. Never attempt to open the Scanner unit.

Instantaneous laser energy failing into the measurement acceptance angle:
$\mathbf{E_{beam} = 7.9 \times 10^{-9} J}$

Steady-state power into the measurement acceptance angle:
$\mathbf{P_{beam} = 0.95 \mu W}$

An interlock is designed into the laserBIRD Scanner which disables the lasers if the scanner shaft is not rotating appropriately. This is a safety feature, and can not be disabled.

EC Declaration of Conformity

Issued by

ASCENSION TECHNOLOGY CORPORATION
PO Box 527
Burlington, VT 05402 USA
(802) 893-6657

Equipment description: laserBIRD Model
laserBIRD Tracking System
+12V @ 1.0 A , 5V @ 2.0 A

Tested with: The laserBIRD passed all CE standards when using a ThinkPad Type 9549 IBM Laptop PC S.N. 78-NA276.

Applicable directive: 73/23/EEC, Low Voltage Directive
89/336/EEC, EMC Directive

Applicable standards: EN 61010-1: 1995
Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory (MCL) Use-Part 1. General Requirements

EN 61326-1: 1998
Electrical Equipment for Measurement, Control and Laboratory Use -Electromagnetic Compatibility Requirements

EN 60825-1: 1994
Safety of Laser products - Part 1: Equipment Classification, Requirements and User's guide

Authorized by:  **Date:** 3-19-02

Jay Monahan,
Chief Operations Officer
Ascension Technology Corporation

Specifications

Performance

The performance of the laserBIRD is specified below. Performance is based on measurements taken from one scanner unit to one sensor. Position and angle accuracy assumes the sensor is within the angular range or field-of-view of the scanner laser beams (approximately ±60° vertical and ±50° horizontal) and that the sensor is between 43 cm (17") and 106 cm (41.8") from the scanner unit. The sensor unit must also maintain a clear line of sight between detectors and the scanner, and not exceed the detector orientation range of ±85° with respect to the scanner.

Degrees of Freedom:	6
Interface:	RS-232
Scanner Field-of-View:	±50° horizontal ±60° vertical to 30" (.75m) ±54° vertical to 47" (1.2m)
Measurement Rate:	240Hz
Lag:	Tracking response: 5.17ms; All filters off Step response: 9.34 ms
RS-232 Reporting Time	1.1ms ; 115.2 kBaud, Position and Euler Angles

Sensor Position:

Operating Distance:	10" to 72" (0.25m to 1.83m)
Static Accuracy @ 39"(1m):	0.040" (1.0mm) RMS ; AVG filter on
Static Resolution @ 39"(1m):	0.004" (0.1mm) ;

Sensor Angles:

Angle Range:	For Sensor motion in the center of the Performance Motion Box:: ±85° Azimuth, Elevation,±180° Roll; or ±180° Azimuth, ±85° Elevation, Roll Note: Angular Range decreases gradually as Sensor motion moves outside the box toward the edges of the Operating Region.
Static Accuracy @ 39"(1m):	1° RMS ; AVG filter on
Static Resolution @ 39"(1m):	0.05° Sensor Position ;

Physical:

Scanner Dimensions (L x W x H):	12.63" x 3.44"x 1.64" (32.1cm x 8.7cm x4.2cm)
Scanner Weight:	1.53Kg
Sensor Dimensions (Base x Alt x H):	4.06" x 3.60" x 0.47" (10.3cm x 9.1cm x 1.2cm)
Sensor Weight:	40g

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