3D Navigator ™

POSITION AND ORIENTATION MEASUREMENT SYSTEM

INSTALLATION AND OPERATION GUIDE

910015-A Rev 1.0
March 31, 2004

PO Box 527
Burlington, Vermont 05402 USA
(802) 893-6657
http://www.ascension-tech.com

3D Navigator ™

POSITION AND ORIENTATION MEASUREMENT SYSTEM

INSTALLATION AND OPERATION GUIDE

910015-A Rev 1.0
March 31, 2004

PO Box 527
Burlington, Vermont 05402 USA
(802) 893-6657
http://www.ascension-tech.com

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 the user=s 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.

EC Declaration of Conformity
Issued by

Ascension Technology Corporation
PO Box 527
Burlington, VT 05402 USA
802-893-6657

Equipment Description: 3D Navigator
Tracking System
Chassis: 90 – 132 / 180 - 264 V
47 - 63 Hz
7 / 4 A
ERC: 100 – 120 / 200 - 240 V
47 - 63 Hz
3.6 / 1.8 A

Year of Manufacture: 2004

Applicable Directives: 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 Use, General Requirements

EN 61326-1: 1998
Electrical Equipment for Measurement, Control, and Laboratory Use – EMC Requirements 1998 Class A Emission and Immunity Levels from Table 1, “Minimum Immunity Test Requirements”

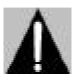
Authorized by:__________________ **Date:** _________
Ernie Blood
President
Ascension Technology Corporation

CE Specifications

There are no fuse or user serviceable parts inside the 3D Navigator chassis or the Extended Range Controller.

Modification or use of the equipment in any way that is not specified by Ascension Technology Corporation may impair the protection and accuracy provided by the equipment.

The lightning flash with arrowhead symbol within an equilateral triangle is intended to alert the user to the presence of uninsulated Adangerous voltage@ within the product=s enclosure that may be sufficient to constitute a risk of electric shock to persons.



The exclamation point within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance (servicing) instructions in the appliance literature.

Equipment Maintenance

1. Do not block the ventilation holes on the ERC or 3D Navigator chassis.

2. Do not expose the ERC or 3D Navigator chassis to rain or condensing moisture.

3. Keep the equipment away from extreme sources of heat.

Table of Contents

USER MANUAL REVISIONS

Manual Date	Rev	Changes
03/31/2004	1.0	Initial release of the 3D Navigator manual.

1.0 INTRODUCTION

The 3D Navigator is a six degree-of-freedom measurement system based on the MotionStar Wireless system that uses pulsed DC magnetic fields to simultaneously track the position and orientation of two sensors located on single person within ten feet of a transmitter. The system consists of the Wanda, body mounted sensors, body mounted electronics, and a base station (see Figure 1). There are no wires from the user's body to the base station. The user is completely free to move about without a trailing cable.

The Wanda is a navigating device that consists an integral magnetic sensor, a joystick and 3 buttons. The position and orientation of the Wanda is tracked by its magnetic sensor. The joystick can be used for 2D cursor control and the 3 buttons can be used to provide discrete control signals to the host application.

Each sensor measures the position and orientation of the specific object to which it is attached. Each sensor consists of a one-inch cube attached via a wire to the Electronics Unit that is mounted in a cloth pouch attached to the user's waist.

The Electronics Unit takes inputs from the 2 sensors and the Wanda and transmits this data through the air to the base station for processing. A battery powers the Electronics Unit. Both the Electronics Unit and the battery are mounted in a cloth pouch supplied with the system.

The base station consists of the 3D Navigator chassis, an Extended Range Controller (ERC), an Extended Range Transmitter (ERT), and a Remote Antenna Unit (RAU). The purpose of the base station is to: (a) Generate a pulsed magnetic field using the ERC and ERT that is measured by the body mounted sensors, (b) Receive sensor signals through the RAU from the backpack mounted Electronics Unit and (c) Provide an Ethernet interface to the user's host computer for passing the sensors' position and orientation along with the Wanda's data.

In addition to this manual, the user can now receive online support and assistance at Ascension's web site:

http://www.ascension-tech.com/support/troubleshooting.php

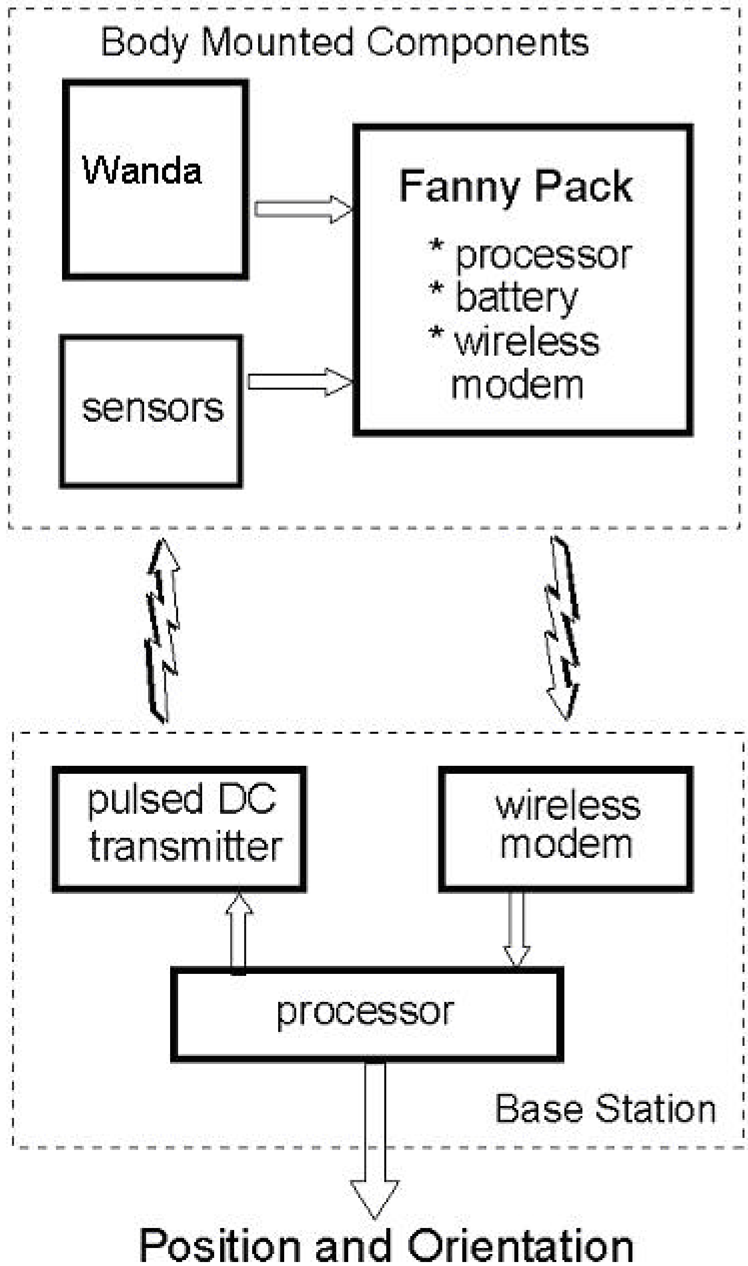


Figure 1. 3D Navigator System Block Diagram

1.1 PRODUCT ADVISORY

Ascension sensors and transmitters – along with their attached cables/connectors – are sensitive electronic components. To obtain good tracking performance and maintain your warranty, treat them carefully.

Most failures in the field occur because the cables attached to the sensors and transmitters are mishandled. Always remember that these components are not designed to withstand severe jolting, contortions, or high-impact shocks. When handling your cables, please observe the following:

- **Never flex, pull or twist cables.** This is the most common cause of tracker failure. Note that there is a strain relief where the sensor head attaches to its cable. Its job is to protect the delicate connection between the cable conductors and the sensor assembly head. It is also the area in which sensors are attached to the object being tracked. When attaching the sensor to the object to be tracked, be sure you do not pull, twist or repeatedly bend the cable here. Consider adding a secondary strain relief if the cable is prone to contortions.

- **Never yank the sensor off its mounting bracket or holder by grabbing the cable and pulling.**

- **Never carry, throw or swing a sensor by its cable.**

- **Never let the sensor impact with a hard object.**

- **Never add your own extensions/connectors** to our sensor/transmitter cables without our pre-approval. Our cables are precisely bundled and shielded to minimize noise and ensure accurate performance within specification. If you add an extension without our knowledge or approval, you may compromise the performance and/or negate certain regulatory certifications. You will also void your warranty. If you need to extend your cable lengths, please contact our tech support team first:

Phone: 1-802-893-6657
Fax: 1-802-893-6659
Email: techsupport@ascension-tech.com

2.0 UNPACKING YOUR SYSTEM

The 3D Navigator system is shipped to you in two boxes. The first box contains:

- The 3D Navigator chassis with a 110 volt 60 cycle power cord.

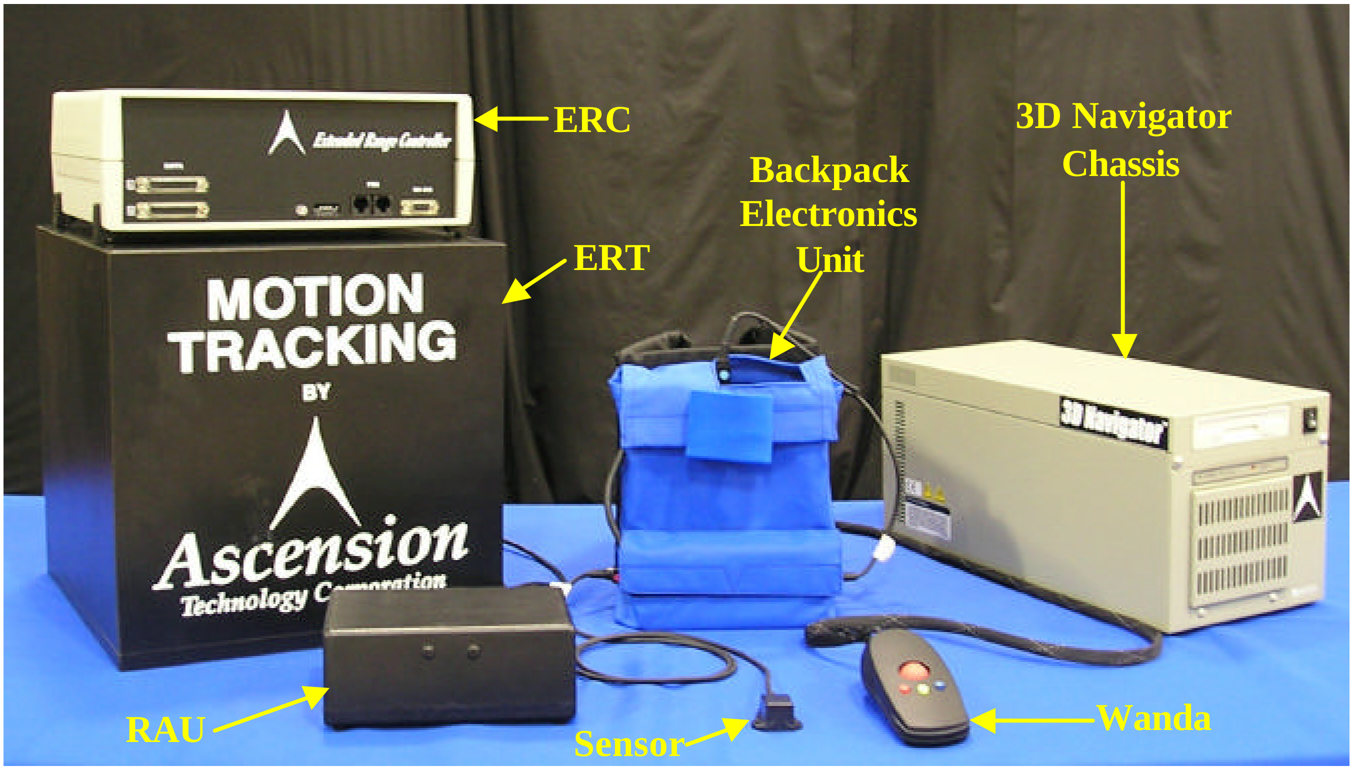
- The Extended Range Transmitter (ERT), a 12 x 12 inch black cube that generates the magnetic field measured by the sensors. Attached to the ERT is a 20 foot cable that connects to the Extended Range Controller.

- The Extended Range Controller (ERC), a computer controlled power amplifier that supplies the ERT with current. Included are:
  a. The ERC
  b. A 110 volt 60 cycle power cord
  c. A RS232 cable for attaching the ERC to the 3D Navigator chassis
  d. One Installation and Operation Guide (this manual)
  e. A package of spare jumper plugs for the circuit card in the ERC

- The backpack Electronics Unit. Included are:
  a. The sensor and the Wanda
  b. A cloth pouch for holding the backpack onto your body
  c. Four batteries and one battery charger
  d. A Remote Antenna Unit (RAU) and two cables for attaching it to the 3D Navigator chassis
  e. A 37 pin D connector
  f. A 30 foot patch cable

The second box contains:

- The 42” pedestal for the ERT.



If there are any discrepancies, or your shipment is damaged, call Ascension Technology at (802) 893-6657 between the hours of 9 AM and 5 PM Eastern Standard Time or fax us at (802) 893-6659.

2.1 INSTALLATION

2.1.1 EXTENDED RANGE TRANSMITTER LOCATION . The most critical part of installing an ERT is selecting a location for placement of the transmitter. A poor location will result in degraded measurement accuracy by the 3D Navigator system.

When large metal objects are near the transmitter and sensor(s), they will affect the accuracy of the position and angle measurements. A large metal object is considered to be near when the distance from the transmitter to sensor is the same as the distance from the transmitter or sensor to the large metal object. Large metal objects include metal desks, bookcases, files, and the floor, ceiling, and walls. In non-wood commercial buildings, the floor and possibly the ceiling are constructed of concrete that contains a mesh of reinforcing steel bars. Walls might be constructed of cinder blocks or plasterboard. Plasterboard walls, however, usually have internal steel supports spaced every sixteen inches. Even if the wall has no metal in it, there may be a large metal object directly on the other side, such as someone's desk. Usually the largest source of error is due to the floor. If you are going to use the sensors at a distance of eight feet from the ERT, the ERT and sensors should be at least eight feet away from the floor, ceiling, walls, or other large metal objects.

The only way to evaluate the building effects is to install the ERT and determine if the accuracy is satisfactory for your application. You can evaluate the accuracy degradation simply by taping one sensor to a cardboard box or yardstick or some other method of holding the sensor at a fixed distance above the floor. As you move the sensor farther away from the ERT in the X direction, record the sensor's Z position output. If the floor is not causing a large error the Z position output will remain relatively constant as you move away from the transmitter.

The ideal location for the ERT is in an all wood building or in a large room with a stage above the floor for mounting the transmitter and using the sensors.

Because the ERT generates magnetic fields, it may interfere with your computer's display, causing image bending, jitter or color distortion. With an unshielded commercial CRT-type display, the ERT usually must be located at least four feet away.

2.1.2 TRANSMITTER INSTALLATION . The ERT can be placed on the supplied 42" pedestal or alternatively, the ERT can be mounted on a 3 or 4 foot high wood pedestal in the center of the motion capture space or mounted overhead or under the floor of a wood stage. Because the transmitter is very heavy (50 lbs), fragile, and subject to performance degradation by nearby metal, the means you use to support the transmitter must be strong and non-metallic. Small amounts of metal in the mount, such as steel bolts, are acceptable. Supporting the transmitter on a steel or aluminum framework is not acceptable. We recommend wood, structural fiberglass, or laminated phenolic for mounting materials. Two bolt holes in the bottom of the transmitter have been provided for maintaining the alignment of the transmitter to your support. **These bolts holes are not strong enough to support the weight of the transmitter** and therefore must not be used to support or 'tie down' the transmitter to your mount. The alignment bolt threads inside the bottom of the transmitter are 10-24. Thread engagement will occur 1 ¾ inches into the base. You should screw the bolt in an additional ½ inch for full engagement but no more.

The cable from the transmitter to the ERC contains high voltages and currents and therefore must be protected so the cable will not be stepped on. Run the cable through the ceiling or under the floor. If the cable is on the floor, use a rigid cable protector that can be walked on such as 'Cordgard- Electrical Cord Ducting' available through Arrow Electronics and other electrical and electronic distributors. Putting the cable under a piece of rug will not provide protection; it will only create a fire hazard.

2.1.3 3D NAVIGATOR CHASSIS LOCATION . The chassis can be located on a table or in an equipment rack at least six feet away from the ERT. Since the chassis must have access to clean, circulating air for cooling, it is not recommended that the chassis be put on the floor or in a closed box or cabinet.

2.1.4 ERC LOCATION . The ERC sits near the 3D Navigator chassis.

2.1.5 ANTENNA LOCATION . The antenna box should be placed about 8 to 10 feet above the stage. The front face of the antenna box should be directed towards the stage. The antenna box should not be placed near any large amounts of metal as this may interfere with communication. The antenna box placement is very critical for good communication between the backpack and the base station. If you are having trouble with data packet loss try moving the location of your antenna box to directly above the center of your stage with the antenna box pointing downwards.

2.1.6 SENSOR LOCATION . The sensors should be mounted on a non-metallic surface such as wood or plastic, using non-metallic bolts or 300 series stainless steel bolts. When mounted on a person they are typically glued, sewn, or attached with velcro to a stretchable band that goes around the head, leg, or arm. Sensors should not be located near power cords, power supplies, or other low-frequency, current-generating devices. Their emanations will be picked up by the sensor and converted into noise on the output position and orientation measurements. The sensor will also pick up noise when it is operated near a CRT-type display.

2.2 QUICK SET-UP PROCEDURE

This quick set-up procedure describes setting up the 3D Navigator using an Ethernet interface to your host computer.

2.2.1 CABLING THE BASE STATION COMPONENTS TOGETHER

The names of the various connectors and switches are shown in Figures 2, 3 and 4 for the 3D Navigator chassis and the ERC.

1. Place the ERC beside the 3D Navigator chassis.

2. Following Figure 4, connect the following items:

   a. The ERT cable, labeled 1. Screw this connector into the top 25 pin D connector on the ERC.

   b. The INTERLOCK plug, labeled 2. Screw this connector into the lower 25 pin D connector on the ERC.

   c. The COM1 ERC INTERCONNECT CABLE, labeled 3. Screw one end of this 9 pin D connector cable into the 3D Navigator chassis COM1 port and the other end into the ERC's RS232 connector. The 3D Navigator does not use the FBB connectors on the ERC (RJ45 ports).

   d. The Timer Card Terminator. This is the 37 pin D connector. Screw the 37 pin D connector into the Timer Card, labeled 5, on the 3D Navigator chassis.

   e. Two antenna cables labeled 6. Screw the two antenna cables from the antenna box to the antenna card in the 3D Navigator chassis.

   f. The Ethernet cable, labeled 4. The Ethernet cable is NOT supplied by Ascension since it must be the same type and manufacturer as the cable you are currently using for your existing network (10Base2, 10Base-T, 100Base-T or AUI). Plug this cable into the appropriate Ethernet type connector shown in Figure 4 and supply an Ethernet terminator if the 3D Navigator base station is at the end of the network.

g. The monitor and keyboard are not included with the system. If you are supplying your own monitor and/or keyboard, attach the video cable to the connector labeled 8 in figure 4. Attach the keyboard to the connector labeled 9 in figure 4.

3. Screw in all connectors, just don't push them on. Unless they are screwed, in you may get erratic operational behavior.

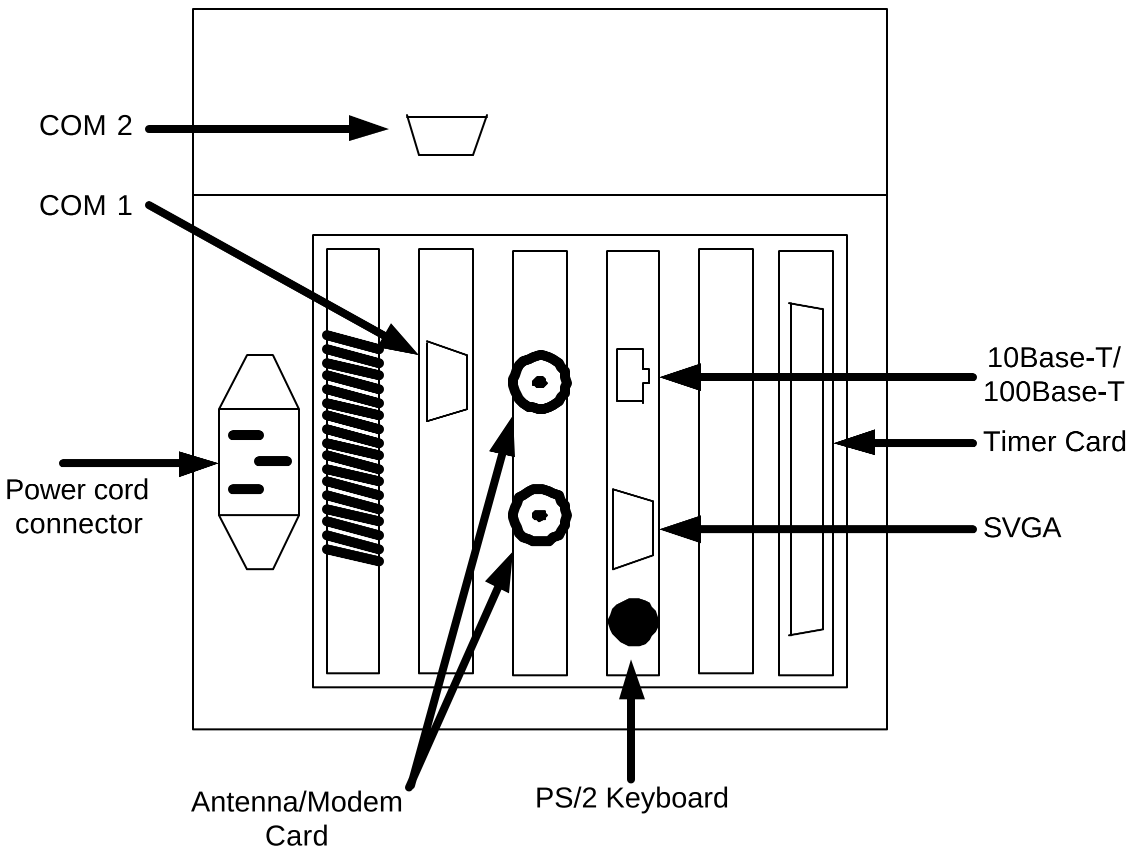


Figure 2. 3D Navigator Base Station Component Location

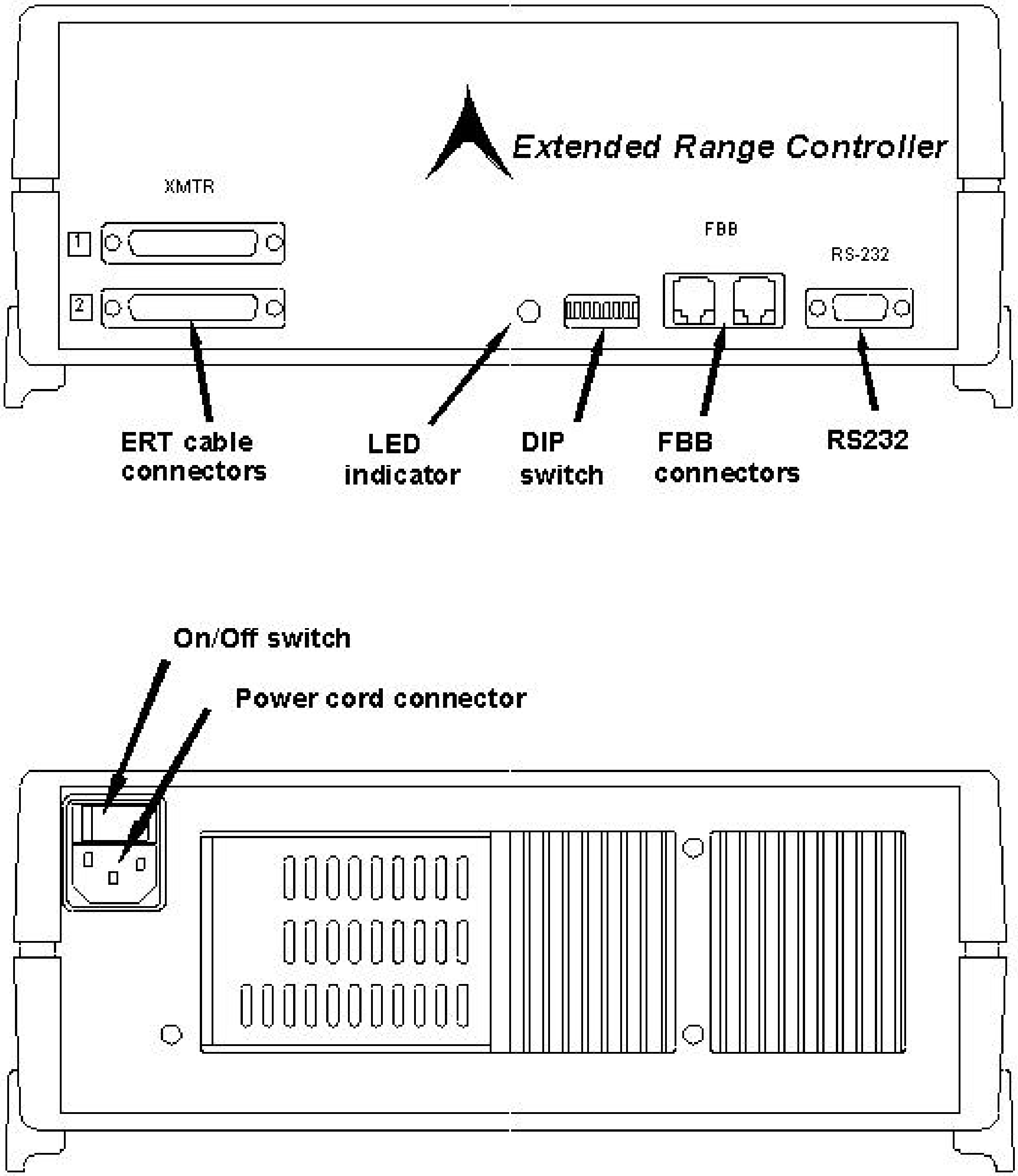


Figure 3. ERC Component Location On the Front and Rear Panels

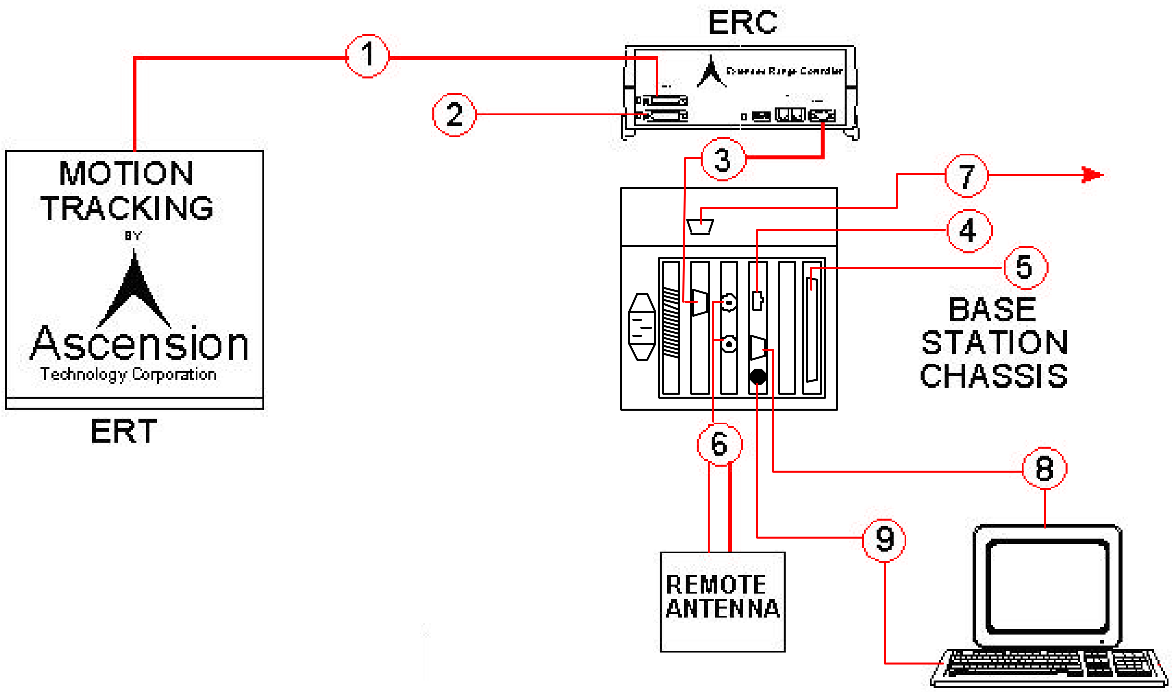


Figure 4. 3D Navigator Cabling

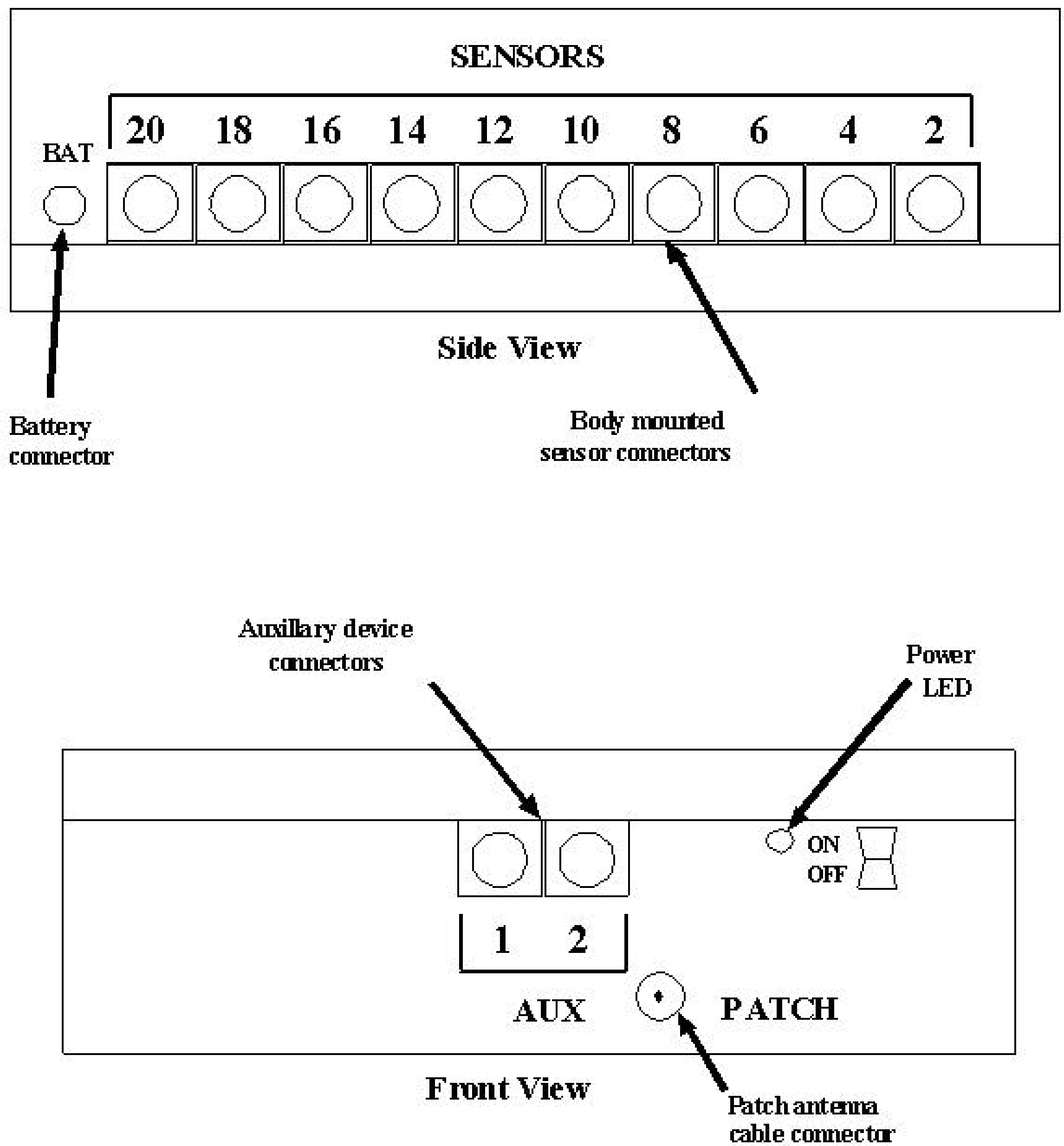


Figure 5. Backpack Electronics Unit Connectors

2.2.2 ETHERNET INTERFACE

1. The 3D Navigator's Ethernet IP address is set to the factory default of 192.168.0.249.

2. To change the IP address of the 3D Navigator chassis:

   a. Connect a VGA color monitor and keyboard per 8 and 9 shown in Figure 4.

   b. Apply power to the base station chassis following the **POWER-UP PROCEDURE** below and then...

   c. Anytime after the 3D Navigator base station application starts, press any key to exit the application.

   d. At the DOS prompt, edit the Base.ini file by typing **EDIT BASE.INI**. This starts the standard DOS editor.

   e. The IP address field is in the section [ETHERNET]. Find the line that looks like:

      IPaddr = 192.168.0.249

      and modify it to match the IP address required for your network.

   f. Save the modified file by typing **<Alt> F** then **<Alt> S**. Where **<Alt>** is the Alt key.

   g. Exit the DOS editor by typing **<Alt> F** then **<Alt> X**.

   h. At the DOS prompt, reboot the system by cycling the power for the changes to take effect.

2.2.3 MULTIPLE CHASSIS CONFIGURATION

Multiple 3D Navigator Base Stations can be connected in a serial daisy chain. Each Base Station operates in a standalone fashion, operating in the same manner whether it is directly connected to the ERC or is the last unit in the daisy chain. Each Base Station communicates with its backpack, and the data is made available at the Base Station IP Address. Up to 6 Base Stations can be linked together in a single daisy chain. The limitation of 6 Base Stations is due to backpack channels.

Each Base Station is cabled normally with the following exception. The first Base Station in the daisy chain connects COM1 directly to the ERC (Extended Range Controller). Each subsequent Base Station connects from COM1 to COM2 of the Base Station above it (closer to the ERC).

Each Base Station should be configured with a different channel and a unique IP Address. Both of these parameters are set by editing the BASE.INI file. Use the supplied DOS editor by typing **EDIT BASE.INI** at the command line. To save your work and exit the file type **<Alt> S** (save) followed by **<Alt> X** (exit).

To alter the IP Address edit the parameter **IPaddr** to match the desired IP Address.

To alter the backpack Channel edit, the parameter **Channel**. Valid channel numbers are 1 through 11 depending on the country.

If two 3D Navigator systems have the same backpack Channel, data will be multiplexed on that channel.

Note: If this 3D Navigator was purchased as an add on to an existing 3D Navigator or MotionStar Wireless system you should read Appendix VI.

2.2.4 CABLING THE BACKPACK COMPONENTS TOGETHER

The cloth pouch, as shipped to you, contains an electronics unit, a fully charged battery, and a battery cable. To get it running, you'll need to plug in the battery, sensors, and the Wanda, then turn the unit on. The names of the various connectors on the backpack are shown in Figure 5. This figure shows the connectors on the left side of the unit; the right side is similar except there is no battery connector. See also the photographs that follow this section.

1. Plug the battery cable into the electronics unit and attach it to the battery.

    a. Lay the backpack on a table or the floor to minimize damage if you drop the unit.

    b. Connect the battery cable to the battery and slide the battery into the side pocket.

    c. Firmly push in the battery connector into the electronics unit receptacle. There are no screws to tighten or connector rotations to be made.

    d. Close the battery pocket by pressing the Velcro surfaces together.

    e. If the status LED on the top of the electronics unit is blinking, turn the power switch located next to the LED to OFF.

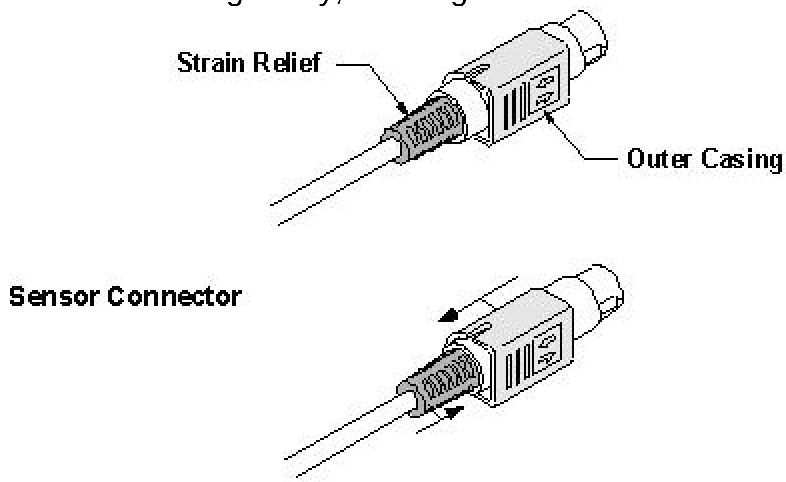
2. Plug the Wanda's serial data cable into the port labeled AUX 1 of the backpack electronics unit. The Wanda serial data cable's connector can be distinguished from the sensor's connector by counting the pins in the connector. The Wanda's connector has 6 pins and the sensor's connector has 8 pins.

3. Plug the sensors into the backpack electronics unit.

    One of the two sensors supplied with the 3D Navigator system is inside the Wanda unit. This sensor should be plugged into socket number 1 of the backpack electronics unit. Socket number 1 is on the opposite side of the backpack electronics unit as the battery connector. The other sensor plugs in to socket number 2. Socket number 2 is on the same side of the backpack electronics unit as the battery connector.

4. Sensor Insertion

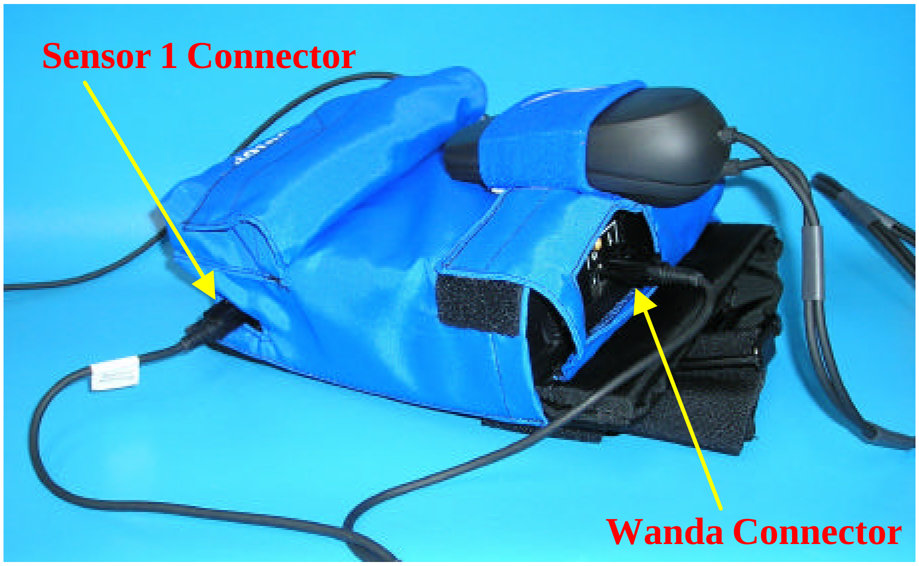
    Care must be taken when inserting or removing the sensor Mini-Din connector from the board. If the sensor connector is inserted or removed improperly, permanent damage can occur to the mating board connector. The result is premature wear and failure of the locking ability, allowing the sensors to fall out.

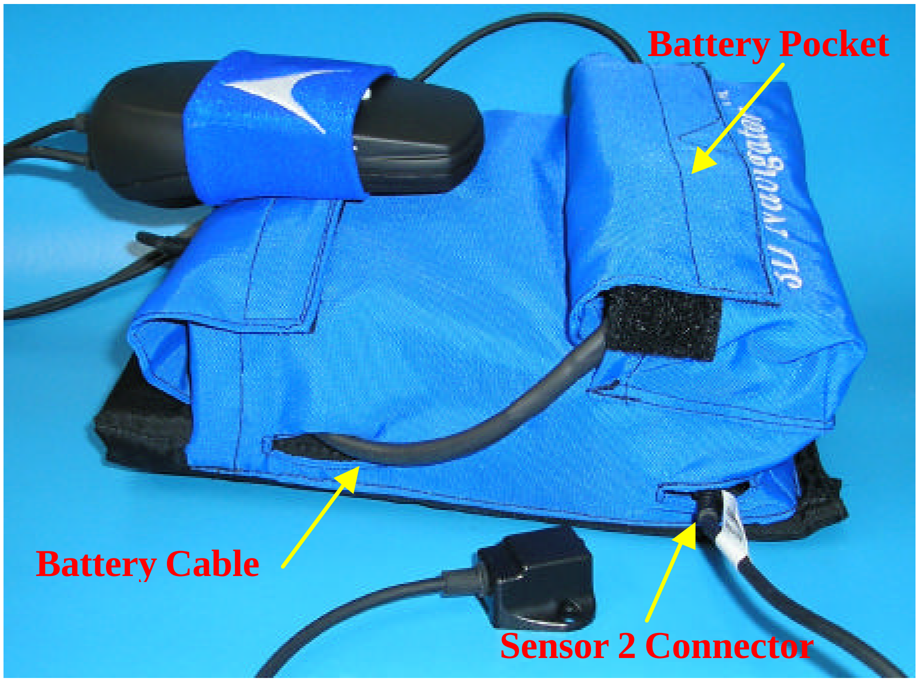


When inserting the sensor Mini-Din connector, you must first pull back on the Outer Casing while holding on to the Strain Relief. Then push the sensor connector into the mating board connector. The sensor should easily slide into the board connector. If an audible click is heard when pushing the sensor in, you did not pull back far enough on the Outer Casing.

When removing the sensor from the board, you must pull back firmly on the Outer Casing. Then the sensor should easily slide out of the board connector.

5. Attach the second sensor to its required location for tracking. Attachment can be done using the optional sensor holders you may have ordered from Ascension. Be sure there is enough slack in the sensor cables so that however the body moves there will not be too much pull at the sensor head or connector.


Sensor 1 Connector
Wanda Connector


Battery Pocket
Battery Cable
Sensor 2 Connector

2.2.5 STARTING THE 3D NAVIGATOR SYSTEM

1. Power-up the base station following the procedure defined in the section of this document called POWER-UP PROCEDURE FOR THE BASE STATION. The 3D Navigator is a turnkey system; it will start running by itself once power is applied.

2. Power-up the backpack by pushing its on/off switch to ON.

3. Once power up and initialization has completed, the base station will beep once every 5 seconds to let you know that no communications have been established yet between the host computer and the base station.

4. From the host computer, if using the Ethernet interface, send the wake up message (MSG_WAKE_UP) to establish communications with the base station. When communications is established the base station will stop beeping, indicating the base station is ready to accept any other commands for running the tracker.

5. From the host computer, if using the COM2 RS-232C interface, send any command to the base station to stop the base station beeping.

   Note: The audible status indicators can be disabled the BASE.INI configuration file.

2.2.6 BLINKING LIGHTS ON THE BACKPACK

There is a single indicator light on the top of the backpack. This light takes on different colors and blink patterns to indicate the occurrence of different events in the 3D Navigator system. What you will see during a normal power up is:

1. If the base station is already turned on and you turn on the backpack, the backpack's light will go from a red/orange blink to a solid green in 3 to 5 seconds. The solid green tells you the backpack and base station are now operational and talking to each other.

2. If the backpack is turned on before the base station, the backpack will blink red then orange at a rate of 2 blinks per second until the base station is turned on, at which time the backpack light will turn solid green.

3. When the backpack's battery needs to be recharged the light will start blinking red at a rate of 5 blinks per second.

4. If the host computer stops requesting data from the base station for more than 10 minutes, the backpack will automatically turn off to save its battery. You only have to cycle the backpack's on/off switch to start it up again.

5. If the backpack detects an error in the backpack electronics when it is turned on, its light will blink red at a rate of 2 blinks per second.

6. At any time during start-up or in the middle of operation, if the backpack blinks its light green at a rate of 2 blinks per second, then the backpack has lost its synchronization with the base stations Extended Range Transmitter. This may be due to a base station problem, an antenna problem, or a lot of ambient noise.

2.2.7 BATTERIES

1. Use only the batteries shipped with the system. Other batteries may damage the system.

2. A fully charged battery will run the backpack for approximately 1.5 hours continuously with the Wanda, the Wanda’s sensor, and the second sensor plugged into the backpack.

3. Switching the backpack power switch to OFF between "takes" will greatly extend the clock time between battery changes.

4. When you change the battery:

    a. Turn the backpack to OFF

    b. The base station or your application software do NOT have to be turned OFF.

    c. Open the battery compartment and remove the battery clip from the battery.

5. Charging the battery:

    a. Use only the supplied battery charger.

    b. Slide the battery into the charger and then plug the battery charger into the wall power.

    c. Proper care dictates that the batteries are charged immediately after each use. Even if only partially discharged, a battery should be fully charged as soon as possible. Even though the charger is designed to reduce the charge rate once the batteries are full, **batteries should not be left on the charger overnight or for periods exceeding six hours**. While a few episodes of moderate overcharging, such as overnight, won't damage the battery, prolonged periodic overcharging will shorten the service life of the battery. Ideally the battery should be removed within 1 hour of reaching full charge, which the charger will indicate by turning off the charge status LED.

2.2.8 POWER-UP PROCEDURE FOR THE BASE STATION

1. Attach power cords to both the ERC and the base station's chassis.

2. Preferably plug both power cords into a single power strip to simplify the process of turning the system power on/off.

3. Turn the ERC's power switch to ON. The front panel LED should blink either 1 or 2 times and then go out.

4. Turn the 3D Navigator chassis's power switch to ON.

5. After the system boots and initializes, the base station will give out a series of "happy sounding" beeps to indicate everything is initialized and working in the base station.

6. The 3D Navigator is now ready to operate with your application's software. The base station will beep once every 10 seconds until it receives its first command through either the Ethernet or COM2 RS-232C interface.

2.3 CHANGING THE DEFAULT SYSTEM CONFIGURATION

The following subsections tell you how to change the default hardware configuration of the system.

2.3.1 LINE VOLTAGE SELECTION .

The ERC contains a universal AC power supply that will work in either North America by selecting 110 volts or in most of Europe by selecting 220 volts. If you are not sure what the correct voltage is in your country, ask someone who knows. The system will be damaged and the warranty voided if you do not select the correct voltage.

The ERC's voltage selector is located below the power switch/power cord on the back panel. Insert a screwdriver into the selector and rotate until the appropriate voltage is aligned with the arrow. Some of the newer ERC models don't have a voltage selector.

The 3D Navigator chassis voltage selection is performed automatically by its power supply. No user action is required.

3.0 ETHERNET COMMANDS

This section describes the protocol used to communicate between one or more 3D Navigator chassis and a user host connected by an Ethernet cable using TCP/IP protocols. The protocol used is called the BIRDNET protocol.

The 3D Navigator chassis are considered to be “servers”, and the user’s host machine is considered to be a “client”.

The protocol described here may be communicated between the client and server using either UDP or TCP protocols. The determination of which protocol is being used is made through the port selection in the server. Port 5000 at the server’s IP address has been assigned as the UDP port and Port 6000 has been assigned to be the TCP port. The 3D Navigator chassis’s IP address may be re-configured by the user (see the Application Note on the Base.ini file). The systems are shipped with default IP addresses of 192.168.0.249 for the first chassis, 192.168.0.250 for the second chassis, etc.

All communication between a server and the client is initiated by the client. The client communicates with a server by sending commands. Every message (command) received by a server will cause it to generate a response. Sometimes the response is simply acknowledgment of receipt of the command, and sometimes the response will contain information as in a response to a request for status. For every message sent by the client to a server a message will be returned.

Once the server enters into continuous data transmission mode, the server will send data packets to the client when they become available. The format of every “packet” sent between the client and the servers and the servers and the client is the same. It consists of a fixed 16-byte header field and a variable length data field, the contents of which will depend on the nature of the command or the response. The data field can vary from 0 to MAXDATA bytes in length. The header field contains an item whose value is the number of bytes in the data field. Therefore it is possible to determine the position and size of every record in the data stream regardless of the protocol used.

Note: When using UDP, put each command/response in its own packet.

In a typical 3D Navigator system there will be one or more transmitters, two sensors, and the Wanda. The transmitter(s) (ERT) and its electronic unit (ERC) are located externally from the Master 3D Navigator chassis and connected to it by an RS232 cable. The two sensors and the Wanda are connected to the 3D Navigator Backpack with one of the sensors mounted inside the Wanda.

Each device in the 3D Navigator is assigned a unique address ranging from 1 to 3. The addresses are used to specify a particular device when sending commands to the 3D Navigator. This allows a sensor to be turned off or to have its operating parameters such as data format or filter coefficients changed

The 3D Navigator system has the following address assignments and corresponding backpack sensor numbers:

Address	Device	Backpack Sensor Number
1	Extended Range Transmitter	
2	Sensor	1
3	Sensor	2

When the 3D Navigator system is powered up, the Server applications are loaded and run automatically. They perform a number of tests on the system and initialize it. This process can take several minutes. When the Servers have finished their initialization, the system will be running with all sensors collecting data in the default mode (position and angle) at the default measurement rate (86.1 measurements/second).

The servers obtain initial system configuration information from an initialization file called Base.ini stored on the hard disk. This file is created at the factory. Damage to this file will cause the system to fail.

If the BEEP option has been enabled in the Base.ini file, when the system has completed its initialization and is ready for use it will alert the user by “beeping” six times rapidly. Thereafter, while in the “idle” state, the system will emit a single “beep” every five seconds. When the client successfully “connects” to the server(s), the “beeping” will cease for the duration of the connection. After the client “disconnects”, the “idle beep” will recommence.

When sending and receiving packets from the client to the server, the client may use either the UDP (USER DATAGRAM PROTOCOL) or the TCP (TRANSMISSION CONTROL PROTOCOL) mode of operation.

Note: Once the server has been accessed through a port using a particular protocol, the alternate services become disabled and are unavailable for access until the client disconnects from the current port. Even though the data formats are identical, there are certain differences and restrictions between the TCP and UDP modes of operation to which special attention must be paid.

The packets sent and received should have the formats described in the following pages. Each message should be treated as a discrete event while using UDP.

Messages may not be concatenated into larger packets while using UDP protocol. The general format of the packet is shown in Figure 8.

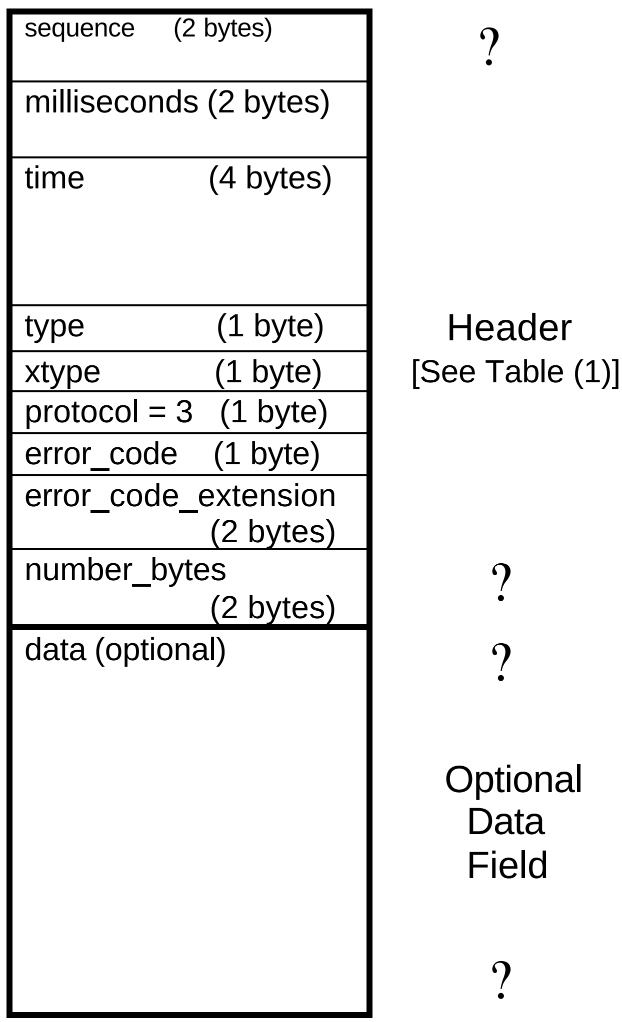


Figure 8. BirdNet Packet Format

Table 1. BIRDNET PACKET HEADER

FIELD#	FIELD SIZE (bytes)	FIELD NAME	DESCRIPTION
(1)	2	sequence	This field contains a 16-bit sequence number. This is needed to detect out of order and missing packets.
(2)	2	milliseconds	This is a 16-bit integer with a value between 0 and 999 where 1 bit equals 1 millisecond. It is required to resolve time increments below the 1 second granularity provided by field #3. It is useful for showing time intervals between data packets
(3)	4	time	This field contains a 32-bit long word value that represents the number of seconds that have elapsed since 00:00:00 January 1, 1970 (GMT). It is an integer and deals only in whole seconds. This is an industry standard way of recording time
(4)	1	type	This 1 character field contains the command/response code (see Table 2)
(5)	1	xtype	This 1 character field contains an extension if required to the command/response codes (see Table 2)
(6)	1	protocol	This 1 byte field will contain a code which indicates which protocol is being used in this packet. It is intended for future compatibility purposes. For the BIRDNET protocol this code will have a value of 3.
(7)	1	error_code	Error code describing unusual event concerning the previous packet received from the Client
(8)	2	error_code_extension	Additional Error code information if required. This usually contains the sequence number of the packet in error.
(9)	2	number_bytes	This 16-bit integer contains the size in bytes of the following data field
TOTAL	16 bytes		

Table 2. COMMAND/RESPONSE CODES

NAME	XTYPE	VALUE	Data Field	DESCRIPTION
MSG_WAKE_UP	Ignored	10	N	This is the first command that a client sends to the server. This command is used to synchronize communication between client and server.
RSP_WAKE_UP	0	20	N	This is the response to the Wake Up call.
MSG_SHUT_DOWN	Ignored	11	N	This message will terminate communication between the client and server.
RSP_SHUT_DOWN	0	21	N	This is the response to the Shut Down command
MSG_GET_STATUS	0 = general system status. Device address = that device's status.	101	N	This command instructs the server to return a status packet to the client. Typically this would be the first communication between client and server after MSG_WAKE_UP.
MSG_SEND_SETUP	0 = general system status. Device address = that device's status.	102	Y	This command instructs the server to take the contents of the attached data field and apply the contained setup information to the sensors and transmitters under its control
MSG_SINGLE_SHOT	Ignored	103	N	This command instructs the server to send a single data packet to the client
MSG_RUN_CONTINUOUS	Ignored	104	N	This command instructs the server to start sending data packets to the client until further notice.
MSG_STOP_DATA	Ignored	105	N	This command instructs the server to stop its continuous transmission of data packets
RSP_GET_STATUS	Same as XTYPE from MSG_ GET_ STATUS that this message is a response to.	201	Y	This is the server's response to MSG_GET_STATUS. It contains a data field with status information
RSP_SEND_SETUP	0	202	N	This is the server's response to the receipt of the setup information in MSG_SEND_SETUP.

NAME	XTYPE	VALUE	Data Field	DESCRIPTION
RSP_RUN_CONTINUOUS	0	204	N	This is the server's response to MSG_RUN_CONTINUOUS prior to sending the first data packet.
RSP_STOP_DATA	0	205	N	This is the server's response to MSG_STOP_DATA
DATA_PACKET_MULTI	Ignored	210	Y	This is a server originated data packet. Used for both the run continuous and single shot data.
RSP_ILLEGAL	0	40	N	This is the server's response to a packet received at an inappropriate time. For example: If the server receives any message before a wake-up call.
RSP_UNKNOWN	0	50	Y	This is the server's response to any packet with an invalid command/response code. The contents of the unknown packet including its header will be appended in the data field. This would usually indicate that the client and server data streams are out of sync. Disconnect and restart.
MSG_SYNC_SEQUENCE	0	30	N	Resets the server sequence numbers to a user-selectable value
RSP_SYNC_SEQUENCE	0	31	N	Acknowledge of MSG_SYNC_SEQUENCE command

3.1 BIRDNET MESSAGE PACKETS DESCRIPTIONS

For the following descriptions, Figure 9 is an example of what the command response header that is used for each command should look like.

MSG_WAKE_UP (See Figure 9)

This is the first message that the client sends to the server. It is used to synchronize the communication between the two devices. The **type** field contains the command/response value **10** and the **xtype** field is ignored. Receiving this message puts the server into a state of waiting for commands. If the server has already "woken up", it will respond with an error code in the message response. The client should then "ShutDown" the server and restart it. This message must be sent to every server in the "network".

Notes:

1. Whatever **SEQUENCE NUMBER** is used in this command will "prime" the servers. That is, they will respond with responses containing this sequence number. Every sequence number will proceed sequentially from this point on.

2. It is recommended that an equal number of commands be sent to each server in the system such that when the time comes to issue the MSG_RUN_CONTINUOUS command each server will issue a data packet from the same measurement cycle with the same sequence number. The MSG_SYNC_SEQUENCE command is also available to artificially force a server to proceed with a new sequence number. If this is sent to all the chassis prior to "streaming", all the packets associated with a particular sample period will all have the same sequence number.

RSP_WAKE_UP (See Figure 9)

This is the required response from a server to the initial "wake-up" message.

MSG_SHUT_DOWN (See Figure 9)

This message may be issued at any time by the client. It will cause the server to cease communication and revert to an idle state. The **type** field contains the command/response value **11** and the **xtype** field is ignored. In the idle state, it can only be re-started with a “Wake-Up” message. All pending packets are lost and the system will be restored to its default state.

Note: The Wake-Up/ShutDown message pair is useful for restarting and re-initializing the server in the event of a system hang or serious but non-fatal error condition. This message needs to be sent to all servers.

RSP_SHUT_DOWN (See Figure 9)

This message is issued by the server in response to the “ShutDown” request. It simply indicates that the server has successfully ShutDown and is now in the idle state. Failure to receive this message within a reasonable time should cause the client to re-issue the “ShutDown” message.

sequence (2 bytes)	?
milliseconds (2 bytes) (CONTENTS IGNORED)	
time (4 bytes) (CONTENTS IGNORED)	
type (1 byte)	Header
xtype (1 byte)	[See Table (1)]
protocol = 3 (1 byte)	
error_code (1 byte) (CONTENTS IGNORED)	
error_code_extension (2 bytes) (CONTENTS IGNORED)	
number_bytes = 0 (2 bytes)	?

Figure 9. BirdNet Simple Command/Response Format

MSG_SINGLE_SHOT (See Figure 9)

This message is issued by the client when a single asynchronous packet of data is required. It is a simple message comprised of only a header. The **type** field contains the command/response value **103** and the **xtype** field is ignored. A data packet will be issued whenever one is available. These events will occur almost immediately, but the age of the data can vary depending on which part of the acquisition cycle was executing when the command was issued.

Note: This message may be sent to Master or Slave chassis and will cause the generation of a packet from that chassis only.

MSG_RUN_CONTINUOUS (See Figure 9)

This is a simple message issued by the client comprised of only a header. This message initiates continuous data transfer mode. The **type** field of the header is set to **104** and the **xtype** field is ignored. The server will issue a response message to acknowledge receipt of the command and thereafter will issue data packets when they become available. After the first data packet is issued, which will be almost immediately, the consecutive packets are issued as soon as possible upon completion of the acquisition cycle. From this point on, the data transfer will be synchronized to the acquisition cycle.

MSG_STOP_DATA (See Figure 9)

This is a simple message issued by the client to inform the Master server to stop the continuous data transfer mode. The message contains only a header with the **type** field set to **105** and the **xtype** field is ignored. The Master server will acknowledge the receipt of the message and terminate the continuous data transfer from all servers including itself.

MSG_GET_STATUS (See Figure 9)

This is a simple message issued by the client and is comprised of only a header. The **type** field contains the command/response value **101** and the **xtype** field contains a special qualifying code. The qualifying code contains the address of the device within the 3D Navigator chassis whose status we want to check.

Note: It will create an error if the address used does not belong to a device residing on the server that the message is sent to.

Devices within the 3D Navigator system can be either transmitters or sensors. Each has a unique address ranging from 1 to 3. If the xtype field is set to 0, then the status returned is a general system status for the particular server addressed. This general system status will inform the user how many devices are in the system, what they are, what their addresses are and what is their current functionality. [See RSP_GET_STATUS]

It is advised that the client should first send a “get status” message with the xtype field set to 0 to each server in the system starting with the first server. This will return the system status for each server. The MASTER SERVER will also provide information about the entire system that the SLAVE SERVERS do not (i.e. Number of chassis in the system, Transmitter Address). The client may then inquire in detail as to the status of the individual 3D Navigator devices.

RSP_GET_STATUS (See Figures 10 and 11)

This message is issued in response to the request for status command MSG_GET_STATUS. The data field of the packet returned will contain the system status (Figure 10) if the request contained an **xtype** code of **0**. Otherwise, the data field will contain an individual device’s status (Figure 11) and filter and angle table where the xtype code was set to the address of a specific device. The xtype field of the message response will be same as the value placed in the original request message.

sequence (2 bytes)	?
milliseconds (2 bytes) (CONTENTS IGNORED)	
time (4 bytes) (CONTENTS IGNORED)	
type (1 byte)	Header
xtype = 0 (1 byte)	[See Table (1)]
protocol = 3 (1 byte)	
error_code (1 byte) (CONTENTS IGNORED)	
error_code_extension (2 bytes) (CONTENTS IGNORED)	
number_bytes = number of bytes in following data field (2 bytes)	?
General System Status 16 bytes	?
System Status Number of bytes = number of devices in the system as defined in the General System Status. (MASTER ONLY)	Data Field ?

Figure 10. BirdNet System Status Record Format

This record format is only used when xtype = 0 (Get System Status). Otherwise Figure 11 is used for the individual device status.

sequence (2 bytes)	?
milliseconds (2 bytes) (CONTENTS IGNORED)	
time (4 bytes) (CONTENTS IGNORED)	
type = 102 or 201 (1 byte)	Header
xtype = address (1 byte)	[See Table (1)]
protocol = 3 (1 byte)	
error_code (1 byte)	
error_code_extension (2 bytes)	
number_bytes = 70 (2 bytes)	?
Single Device Status (16 bytes)	?
Alpha_Min Table (14 bytes)	
Alpha_Max Table (14 bytes)	Data Field
Vm Table (14 bytes)	
XYZ Reference Frame (6 bytes)	
Angle Align Table (6 bytes)	?

Figure 11. BirdNet Individual Device Status Packet Formats

System Status Record Data field formats:

(1) System Status (See Figure 10)

The system status returned in response to a request for status with xtype = 0 contains the following structures:

(a) General System Status :

This is a 16-byte data structure containing information about the entire system.
Its format is as follows:

Field	**Size**	**Description**
all	1 byte	A single byte general system status (see table below)
error	1 byte	Reserved for future use
deviceNumber	1 byte	This is a 8-bit integer whose value is equal to the number of devices on the entire system bus. (1 - 3)
serverNumber	1 byte	Number of servers in system
transmitterNumber	1 byte	This is an 8-bit integer whose value is the address of the currently active transmitter
measurementRate[6]	6 bytes	These 6 bytes contain the ASCII representation of the measurement rate multiplied by 1000. For example 120 samples/sec would be the ASCII string - '1', '2', '0', '0', '0', '0'
chassisNumber	1 byte	number identifying chassis
chassisDevices	1 byte	number of devices within this chassis
firstAddress	1 byte	address of first device in chassis
softwareRevision	2 bytes	Software Revision of Server application

Notes on the system status record:

The fields labeled **all, error, deviceNumber, serverNumber, transmitterNumber** and **measurementRate[6]** are known only to the Master server. These fields will be blank when returned from a Slave server. The Slave will only provide information on its own **chassisNumber, chassisDevices, firstAddress** and **softwareRevision.**

These are the descriptions of the bit positions in the **all** status byte:

Bit	Name	Description
7	SYSTEM_RUNNING	Set if the system has been initialized and is up and running.
6	SYSTEM_ERROR	If there is an error in the system this bit will be set
5	Undefined	Not Applicable
4	SYSTEM_LOCAL_ERROR	Set if there is an error local to this chassis.
3	SYSTEM_LOCAL_POWER	Set if there is a power status error to report for this chassis
2	SYSTEM_MASTER	Set if this chassis is the Master, cleared if a Slave
1	SYSTEM_CRTSYNC_TYPE	Defines type of CRT sync being used
0	SYSTEM_CRTSYNC	CRT Sync mode enabled and active

This is a description of the format of the **transmitterNumber** byte:

The transmitters (ERC) may have addresses within the range 1 - 14. An individual ERC may potentially control up to 2 ERTs. The **transmitterNumber** address byte contains the address and transmitter number as follows: The 4 MS Bits of the byte contain the ERC's address (1 - 14) and the 2 LS Bits of the byte contain the transmitter number within the ERC.

transmitterNumber byte bit positions							
7	6	5	4	3	2	1	0
Address				0	0	xmtr #	

(b) System Status

This structure contains a list of the Status for all possible devices in the system. The interpretation of each byte is as follows:

BIT	Meaning if set
7	Device is accessible
6	Device is running. The Configuration was performed correctly.
5	Device has a sensor
4	Device is an ERC (Extended Range Controller)
3	If Device is an ERC then ERT #3 is present (Extended Range Transmitter)
2	If Device is an ERC then ERT #2 is present
1	If Device is an ERC then ERT #1 is present
0	If Device is an ERC then ERT #0 is present, else the Device is an SRT (Standard Range Transmitter)

The length of the list is equal to the maximum number of devices possible. The system supports a maximum of 120 devices. More or less devices may be reported in this list than were expected in the system. Devices not present will be reported with a zero byte. For example, in a system with 10 devices, the bytes at offset 0 through 9 will contain valid status information while byte positions 10 through 119 will contain zeroes.

Note: This structure contains the status information for the entire system and is available from the **Master chassis only**. This structure will not be present when status is requested from a Slave chassis.

(2) Individual Device Status (See Figure 11)

The Individual Device Status is returned in the following data structures in response to the status request message with xtype = address of the device required.

Note: The address must be valid for the chassis that the message is sent to. Otherwise, a response will be returned with a zero length data field.

The following list of structures are contained in the data field of a single packet:

Name	**Structure type**
singleDeviceStatus	SINGLE_DEVICE_STATUS
alphaMin	FILTER_TABLE
alphaMax	FILTER_TABLE
Vm	FILTER_TABLE
xyzReferenceFrame	XYZREF_TABLE
xyzAngleAlign	XYZREF_TABLE

The structure SINGLE_DEVICE_STATUS contains 16 bytes of status information.
The structure FILTER_TABLE contains 7 single-word entries.
The structure XYZREF_TABLE contains 3 single-word entries where each entry is an angle.

singleDeviceStatus

A 16-byte data structure is included in the data field for the selected device within the addressed chassis. This structure will contain the complete status for that device. An individual status is known as a singleDeviceStatus. Its format is as follows:

singleDeviceStatus field definitions:

Field	Size	Description
status	1 byte	Individual device status (see table below)
id	1 byte	Individual device type (see table below)
softwareRevision	2 bytes	S/W rev level of firmware on individual device
errorCode	1 byte	Reserved for future use
setup	1 byte	Individual device setup parameters (see table below)
dataFormat	1 byte	Data Format Code and Data Size in words (see table)
reportRate	1 byte	rate at which data is generated relative to sample rate
scaling	2 bytes	Full scale output
hemisphere	1 byte	Individual device's hemisphere of operation (see table)
address	1 byte	Address of this device
transmitterType	1 byte	Transmitter Information (see table)
spare1	1 byte	<Reserved>
spare2	2 bytes	<Reserved>

The **status** byte contains information regarding the individual 3D Navigator device with the address given in field **address**.

status byte - bit definitions:

Bit	Name	Description
7	DEVICE_ERROR	Bit set if the device has an error
6	DEVICE_RUNNING	Bit set if the device successfully initializes and auto-configures
5	RESERVED1	Reserved for future use
4	RESERVED2	Reserved for future use
3	RESERVED3	Reserved for future use
2	SENSORPRESENT	Bit set if the device has a sensor
1	TRANSMITTERPRESENT	Bit set if the device has a transmitter
0	TRANSMITTERRUNNING	Bit set if the device has a transmitter and it is running

The device **id** is a code which indicates which of the device description strings was found when the device was interrogated.

Device id Code	Device Description String	Device
1	“6DFOB “	Stand alone (SRT)
2	“6DERC “	Extended Range Controller
3	“6DBOF “	MotionStar (old name)
4	“PCBIRD “	pcBIRD
5	“SPACEPAD “	SpacePad
6	"MOTIONSTAR"	MotionStar (new name)
7	“WIRELESS ”	MotionStar Wireless / 3D Navigator
255	<unable to recognize interrogated string from device>	

The **softwareRevision** is the s/w rev level read from 3D Navigator during interrogation. The first byte will contain a number specific to a family of devices, the second byte will contain the release number. For example, first byte = 24, second byte = 01. This would mean it is release 01 of the software belonging to 3D Navigator devices (24).

The **errorCode** is reserved for future use.

The **setup** byte contains bit definitions which could not be grouped with other status byte definitions. Their description is in the table below

setup byte - bit definitions:

Bit	Name	Description
(7 - 6)	unused	
5	SUDDENOUTPUTCHANGE	Sudden large data change will not update output data.
4	XYZREFERENCE	Position is derived from XYZ reference frame angle table.
3	APPENDBUTTONDATA	Not applicable to 3D Navigator.
2	ACNARROWNOTCHFILTER	Bit set if filter is used
1	ACWIDENOTCHFILTER	Bit set if filter is used
0	DCFILTER	Bit set if filter is used

The **dataFormat** byte contains two 4-bit codes which describe both the format and the size of the data which is currently being provided by the 3D Navigator device.

dataFormat byte - bit definitions

Bit	Name	Description
(7 - 4)	(data format size)	4 - bit code representing the size of the data record in words.
(3 - 0)	(data format code)	4 - bit code describing the data format (see table below)

dataFormat Record Sizes (Words):

Data Format	Record Size
NODATA	0 words
POSITION	3 words
ANGLES	3 words
MATRIX	9 words
POSITIONANGLES	6 words
POSITIONMATRIX	12 words
QUATERNION	4 words
POSITIONQUATERNION	7 words
FEEDTHROUGH_DATA	Variable Size
<invalid>	0 words

dataFormat Codes:

dataFormat	Format Code
NODATA	0
POSITION	1
ANGLES	2
MATRIX	3
POSITIONANGLES	4
POSITIONMATRIX	5
<invalid>	6
QUATERNION	7
POSITIONQUATERNION	8
<invalid>	9 – 13
FEEDTHROUGH_DATA	14
<invalid>	15

The **reportRate** is the rate at which data records are sent from the server to the host relative to the measurement rate. The **reportRate** can have any value between 0 and

255. A value of 0 results in no data being sent. A value of 1 will result in a data record being generated every measurement cycle. A value of 2 would result in a data record being generated every second measurement cycle etc. Each individual device can have its own report rate.

The **scaling** word contains a value which represents the full-scale measurement. The most significant 4 bits of the word contain a code which indicates which measurement system is being used.

scaling word bit positions															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
System code				Full-scale measurement											

A system code of 0 indicates that the Full-scale measurement is in inches. Other codes are currently undefined. Only certain values are currently valid and only with specific types of equipment. The value 144 must be used exclusively with the single ERC/ERT. The value 288 must be used exclusively with the dual ERC/ERTs.

The **hemisphere** byte contains a code which indicates within which hemisphere the sensor will be operating.

Hemisphere Codes:

hemisphere	**Code**
FRONT_HEMISPHERE	0
REAR_HEMISPHERE	1
UPPER_HEMISPHERE	2
LOWER_HEMISPHERE	3
LEFT_HEMISPHERE	4
RIGHT_HEMISPHERE	5

The shape of the magnetic field transmitted by the ERT is symmetrical about each of the axes of the transmitter. This symmetry leads to an ambiguity in determining the sensor's X, Y, Z position. The amplitudes will always be correct, but the signs (±) may all be wrong, depending upon the hemisphere of operation. In many applications, this will not be relevant, but if you desire an unambiguous measure of position, operation must be either confined to a defined hemisphere or your host computer must 'track' the location of the sensor.

There is no ambiguity in the sensor's orientation angles as output by the ANGLES command, or in the rotation matrix as output by the MATRIX command.

The HEMISPHERE command is used to tell the 3D Navigator in which hemisphere, centered about the transmitter, the sensor will be operating. There are six hemispheres from which you may choose: the front, rear, upper, lower, left, and the right. If no HEMISPHERE command is issued, the forward will be used by default.

The ambiguity in position determination can be eliminated if your host computer's software continuously 'tracks' the sensor location. In order to implement tracking, you must understand the behavior of the signs (±) of the X, Y, and Z position outputs when the sensor crosses a hemisphere boundary. When you select a given hemisphere of operation, the sign on the position axes that defines the hemisphere direction is forced to positive, even when the sensor moves into another hemisphere. For example, the power-up default hemisphere is the forward hemisphere. This forces X position outputs to always be positive. The signs on Y and Z will vary between plus and minus depending on where you are within this hemisphere. If you had selected the lower hemisphere, the sign of Z would always be positive, and the signs on X and Y will vary between plus and minus. If you had selected the left hemisphere, the sign of Y would always be negative, etc.

Returning to the default forward hemisphere, if the sensor moved into the rear hemisphere, the signs on Y and Z would instantaneously change to opposite polarities while the sign on X remained positive. To 'track' the sensor, your host software, on detecting this sign change, would reverse the signs on 3D Navigator's X, Y, and Z outputs. In order to 'track' correctly: You must start 'tracking' in the selected hemisphere so that the signs on the outputs are initially correct, and you must guard against the case where the sensor legally crossed the Y = 0, Z = 0 axes simultaneously without having crossed the X = 0 axes into the other hemisphere.

The **address** is the actual physical address of this 3D Navigator device on the bus. This should match the value that was placed in the **xtype** field of the Get Status command that was originally issued.

The **transmitterType** byte contains specific information on the type of transmitter located at this device. This byte is only valid if it was indicated that a transmitter was present in the **status** byte.

<u>transmitterType byte - bit definitions</u>:

Bit	Name	Description
7	XMTR_ERT	Bit set if the ERT (Extended Range Transmitter) is present. Implies that the 3D Navigator device is an ERC (Extended Range Controller)
6	XMTR_SRT	Not Applicable
5	XMTR_PCBIRD	Not Applicable
4	XMTR_ACTIVE	Bit set if the transmitter is currently running.
2 - 3	XMTR_SELECTED0, 1	2-bit number which indicates which of the 4 (maximum) possible transmitters has been selected for operation (Only valid if transmitter is an ERT and is currently running)
0 - 1	XMTR_NUMBER0, 1	2-bit number which indicates the number of transmitters attached to the ERC

The final entries in the **Single Device Status** structure: **spare1** and **spare2** are reserved for future enhancements.

The following descriptions cover the **alphaMax, alphaMin, Vm, xyzReferenceFrame** and **xyzAngleAlign** structures in the **Individual Device Status.** Two sets of tables are given for the filters because their values will depend on the type of transmitter being used. Note the different ranges covered by the filter values for the different transmitters types.

The total number of bytes in an individual device's status is 70.

ALPHA_MAX

The format of the FILTER_TABLE structure for an ERC/ERT is as follows:

Word	Range of values	Default	Range (Inches)
1	0000 ? 7FFF (hex)	7333 (hex)	0 to 55
2	" "	"	55 to 70
3	" "	"	70 to 90
4	" "	"	90 to 110
5	" "	"	110 to 138
6	" "	"	138 to 170
7	" "	"	170+

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 filter will provide no filtering of the data during fast movements.

During change, you may want to decrease ALPHA_MAX to increase the amount of filtering if 3D Navigator's outputs are too noisy during rapid sensor movement. ALPHA_MAX must always be greater than ALPHA_MIN.

ALPHA_MIN

The format of the FILTER_TABLE structure for an ERC/ERT (Extended Range Controller/ Extended Range Transmitter) is as follows:

Word	Range of values	Default	Range (Inches)
1	0000 ? 7FFF (hex)	028F (hex)	0 to 55
2	" "	"	55 to 70
3	" "	"	70 to 90
4	" "	"	90 to 110
5	" "	"	110 to 138
6	" "	"	138 to 170
7	" "	"	170+

When ALPHA_MIN = 0 Hex, the 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.

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). If you decrease the value below 0.008, the output noise will actually increase due to loss of mathematical precision. ALPHA_MIN must always be less than ALPHA_MAX.

Vm

The format of the FILTER_TABLE structure for an ERC/ERT is as follows:

Word	Range of values	Default	Range (Inches)
1	0000 ? 7FFF (hex)	0002 (hex)	0 to 55
2	“ “	0004 (hex)	55 to 70
3	“ “	0008 (hex)	70 to 90
4	“ “	0020 (hex)	90 to 110
5	“ “	0040 (hex)	110 to 138
6	“ “	0100 (hex)	138 to 170
7	“ “	0200 (hex)	170+

The DC filter is adaptive in that it tries to reduce the amount of low pass filtering in 3D Navigator as it detects translation or rotation rates in 3D Navigator's sensor. Reducing the amount of filtering results in less filter lag. Unfortunately, electrical noise in the environment, when measured by the sensor, also makes it look like the sensor is undergoing a translation and rotation. As the sensor moves farther and farther away from the transmitter, the amount of noise measured by the sensor appears to increase because the measured transmitted signal level is decreasing and the sensor amplifier gain is increasing. In order to decide if the amount of filtering should be reduced, 3D Navigator has to know if the measured rate is a real sensor rate due to movement or a false rate due to noise. The 3D Navigator gets this knowledge by the user specifying what the expected noise levels are in the operating environment as a function of distance from the transmitter. 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.

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 3D Navigator 's output is too large for your application.

The format of the XYZREF_TABLE structures is as follows:

ANGLE_ALIGN/REFERENCE_FRAME

Word	Range of values	Default	Description
1	8000 ? 7FFF (hex) [-180.00 ? +179.99]	0000 (hex) [0.00000]	Azimuth
2	4000 ? 3FFF (hex) [-90.00 ? +89.99]	0000 (hex) [0.00000]	Elevation
3	8000 ? 7FFF (hex) [-180.00 ? +179.99]	0000 (hex) [0.00000]	Roll

The ANGLE ALIGN command allows you to change the sensor's X, Y and Z axes to an orientation which differs from that of the actual sensor. By default, the angle outputs from the 3D Navigator are measured in the coordinate frame defined by the transmitter's X, Y and Z axes and are measured with respect to rotations about the physical X, Y and Z axes of the 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 Azimuth = 5 deg, Elevation = 10 and Roll = 15 when it is in its normal "resting" position. To compensate, use the ANGLE ALIGN command, passing as Data the 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 SINGLE SHOT or RUN CONTINUOUS mode data request, you may not see the effect of the ALIGN command in the data returned. It will take at least one measurement period (i.e. 10 milliseconds if the 3D Navigator is running at 100 measurements/sec) before you see the effect of the command.

The REFERENCE FRAME command permits you to define a new reference frame by inputting the angles required to align the physical axes of the transmitter to the X, Y, and Z axes of the new reference frame. By default, the 3D Navigator 's reference frame is defined by the transmitter's physical X, Y, and Z axes. In some applications, it may be desirable to have the orientation measured with respect to another reference frame. The alignment angles are defined as rotations about the Z, Y, and X axes of the transmitter. These angles are called the, Azimuth, Elevation, and Roll angles.

The REFERENCE FRAME command will cause the 3D Navigator 's output angles to change. It has no effect on the position outputs.

If you immediately follow the REFERENCE FRAME command with a SINGLE SHOT or RUN CONTINUOUS mode data request, you may not see the effect of this command in the data returned. It will take at least one measurement period (i.e. 10 milliseconds if running the 3D Navigator at 100 measurements/sec) before you see the effect of the command.

If the command is sent to the Master, then all accessible sensors in the 3D Navigator are updated. If the command is sent to the Slave, then only the Slave is updated.

MSG_SEND_SETUP (See Figures 10 and 11)

The process of setting up the system to perform in a manner other than the power-up default is very simple. To change the measurement rate or the data format or switch from one transmitter to another, all that is required is to: (a) execute a request for system status, (b) edit the entries in the system status that you wish to change, (c) execute a command to setup the system status using the currently acquired data with the changes added. It is, of course, possible to construct a system setup packet without first reading it from the server.

Sending a new system setup to a server involves sending a command with the **type** field containing the command/response value **102** and **xtype = 0**. The data field following the header contains the new system information. The format of the data field is identical to the format of the data field that was received when a request for status was issued (Figure 10). Simply edit the entries in the original field to reflect the new setup that is required.

Note: Some fields in the System Status structure cannot be altered. For example, you cannot force the system into an error state by setting the error bit. The Status entries should also be deleted from the packet.

The following System Status fields are valid fields for editing:

System Status:

(a) transmitterNumber (selects transmitter)
(b) measurementRate[0..5] (selects measurement rate)

Individual parameters cannot be changed by editing the System status packet (Figure 10).

A single device setup is performed by sending an Individual device Status packet (Figure 11). The parameters affected are those in the SINGLE DEVICE STATUS and the FILTER, XYZ_REFERENCE, and ANGLE_ALIGN Tables.

To change the setup and tables for an individual device send a command packet to the server with **type = 102** and **xtype** set to the address of the target device whose tables you wish to change. The data field of the packet contains the status and tables to be changed. They are sent using the same format as the status and tables that were received for an individual device using the Get Status command.

Single Device Status:

(a) setup (selects xyz reference, filters)
(b) dataFormat
(c) scaling
(d) hemisphere
(e) reportRate

RSP_SEND_SETUP (See Figure 9)

This is the required response to the MSG_SEND_SETUP command. The **xtype** field of the message response will always be set to 0.

3.2 DATA_PACKET (See Figure 12)

The data packets are transferred from the servers to the client in the standard packet format (Figure 12). The **type** field of the header contains the value **210**. The **xtype** field can be ignored. The packet header contains enhanced timing information.

There will be one "packet" or data record from each server in the system.

The milliseconds field enables the client to resolve the seconds provided in the time field down to milliseconds.

The data packet contains a data field. The size of this field is determined by the number of sensors whose data is being returned to the client, and it is also determined by the format of the data from these sensors.

Any combination of sensors may be enabled and any combination of data formats may be used with them.

<u>For example</u>: Sensor #1 may be turned on and sending Position and Angle data while Sensor #2 is sending Matrix data.

In the previous example, the first byte of the data record for Sensor #1 would be "01" hex which is its address. The second byte would be "46" hex because in Position and Angle mode, six data words are generated. The format code for position and angles is 4. There would follow 12 bytes of data containing the 6 words. The format of an individual data word is such that the valid data is stored in bits 15 through 0. The first byte of the data record for Sensor #2 would be "02" hex which is its address. The second byte would be "39" hex because in Matrix mode, nine data words are generated. The format code for matrix is 3. There would follow 18 bytes of data containing the 9 words. The format of an individual data word is such that the valid data is stored in bits 15 through 0.

Selecting which sensors to use and their formats for a particular server is performed in one operation using the MSG_SEND_SETUP command. The **singleDeviceStatus** (Figure 11) contains a field called **setup** which contains a 4-bit field where the data format code is placed. A data format code of 0 indicates No Data. This effectively turns off the sensor.

The total size of the data field can be determined from the **number_bytes** field in the header. The data field is comprised of a number of records. There is one record per sensor. The first byte of the record contains the address of the sensor in the least significant 7 bits. The MS bit of the first byte of the record is unused. The second byte contains a value in the least significant 4 bits corresponding to the number of words of formatted data in the data record.

Note: Data is always generated in whole words and is stored in the data packet MS Byte first followed by the LS Byte (Network byte order). The most significant 4 bits of the second byte contain the data format code.

There is a special code of 15 which is used to indicate that an error occurred during acquisition of the data from the 3D Navigator device. The data record will be complete but contain invalid data.

There is also a code of 14 used to indicate "feed through data". This is data from the Wanda attached to the backpack using the backpack communication system to convey the data. When the format code is 14, we have Wanda data. The data size field value can vary from 0 to 15 indicating as before that there are from 0 to 15 words of Wanda data. The address field in the first byte now no longer refers to a device address but specifies which of the two serial ports on the backpack the data came from. The breakdown of the Wanda data packet is as follows:

The Wanda data is output from the 3D Navigator System via the data packet of the BIRDNET Ethernet protocol. The data packet consists of a header record and data record. The first byte of the data record contains the port address and flag data. The second byte contains the data size in words and the data format. These bytes are decoded as follows:

Byte 1	0x81	bit 15	Extra Data Flag	Signifies 2 extra bytes at end of record.
		bits 14 - 0	Serial Port	Data is from serial port 1
Byte 2	0xE1	High nibble	Data Format	The value "E" (14) specifies serial data.
		Low nibble	Word count	The value 1 specifies a single data word in the record. Will be different if there are more data words in the record.
Byte3 – Word Count * 2	Varies		Serial data bytes	Data from the serial device connected to the 3D Navigator Backpack.
Byte n-1	0x00		First "extra" byte	Reserved.
Byte n	0x01		Second "extra" byte	Contains the actual byte count of the serial data in the data record.

Following the first 2 bytes are the serial data bytes.

It's important to note that the word count can only specify an even number of bytes (word count = byte count * 2). If an odd number of bytes are in the data record, then the word count will indicate one byte more than is really present. For example, if the data consists of 3 bytes, then the word count will indicate 2 words (which would equal 4 bytes). The fourth byte does not contain valid data and is only there so the data record ends on a word boundary. The actual byte count can be found in the second byte of the two extras bytes appended to the end of the data record. This byte count field can be located by multiplying the word count by 2 to get the byte count and then adding 3 (to skip the 2 header bytes and the first "extra" byte appended to the end of the data record). This value (word count * 2 + 3) can then be used as an offset from the start of the data record to locate the serial data byte count field.

The Wanda transmits its data to the 3D Navigator Backpack at 1200 baud. At this transmission rate it takes about 8.33 milliseconds per character. The Wanda transmits 3 characters whenever the left button, the right button, or the joystick states change. The Wanda sends 4 characters if the middle button state changes. The 3 character transmission takes about 25 milliseconds and the 4 characters take about 33.33 milliseconds. When the 3D Navigator System is running at the default measurement rate of 86.1 samples per second, a single cycle takes 11.614 milliseconds. The result is the Wanda data gets broken up across multiple measurement cycles of the 3D Navigator. At most only 2 characters of Wanda data will arrive during a single 3D Navigator measurement cycle. This causes the data bytes to be transmitted in consecutive data records. The host application receiving data from the 3D Navigator system will have to collect and buffer the Wanda data bytes and reassemble them into the 3 or 4 character data records. The Wanda's data is formatted within the data bytes as follows:

Byte 1		
Bit 0	X6	X Data Bit
Bit 1	X7	MSB of X Data
Bit 2	Y6	Y Data Bit
Bit 3	Y7	MSB of Y Data
Bit 4	Right Button Status	1 = Depressed
Bit 5	Left Button Status	1 = Depressed
Bit 6	Phase bit	Always =1
Byte 2		
Bit 0	X0	LSB of X Data
Bit 1	X1	X Data Bit
Bit 2	X2	X Data Bit
Bit 3	X3	X Data Bit
Bit 4	X4	X Data Bit
Bit 5	X5	X Data Bit
Bit 6	N/A	Always = 0
Byte 3		
Bit 0	Y0	LSB of Y Data

Bit 1	Y1	Y Data Bit
Bit 2	Y2	Y Data Bit
Bit 3	Y3	Y Data Bit
Bit 4	Y4	Y Data Bit
Bit 5	Y5	Y Data Bit
Bit 6	N/A	Always = 0
Byte 4 *		
Bit 0	N/A	Always = 0
Bit 1	N/A	Always = 0
Bit 2	N/A	Always = 0
Bit 3	N/A	Always = 0
Bit 4	N/A	Always = 0
Bit 5	Middle Button Status	1 = Depressed
Bit 6	N/A	Always = 0

* - Byte 4 is only transmitted when there is a middle button state change.

The serial data format for the Wanda is reproduced from the following data sheet:

http://www.semtech.com/pdf/doc7-dmp-ds.pdf

A sample program (bnSample) is available to demonstrate how to receive the 3D Navigator data, both position/orientation data as well as the serial data, on a host computer interfacing with the 3D Navigator via TCP/IP. It can be downloaded from our FTP site at:

ftp://ftp.ascension-tech.com/Ethernet_Motionstar/BNSAMPLE/

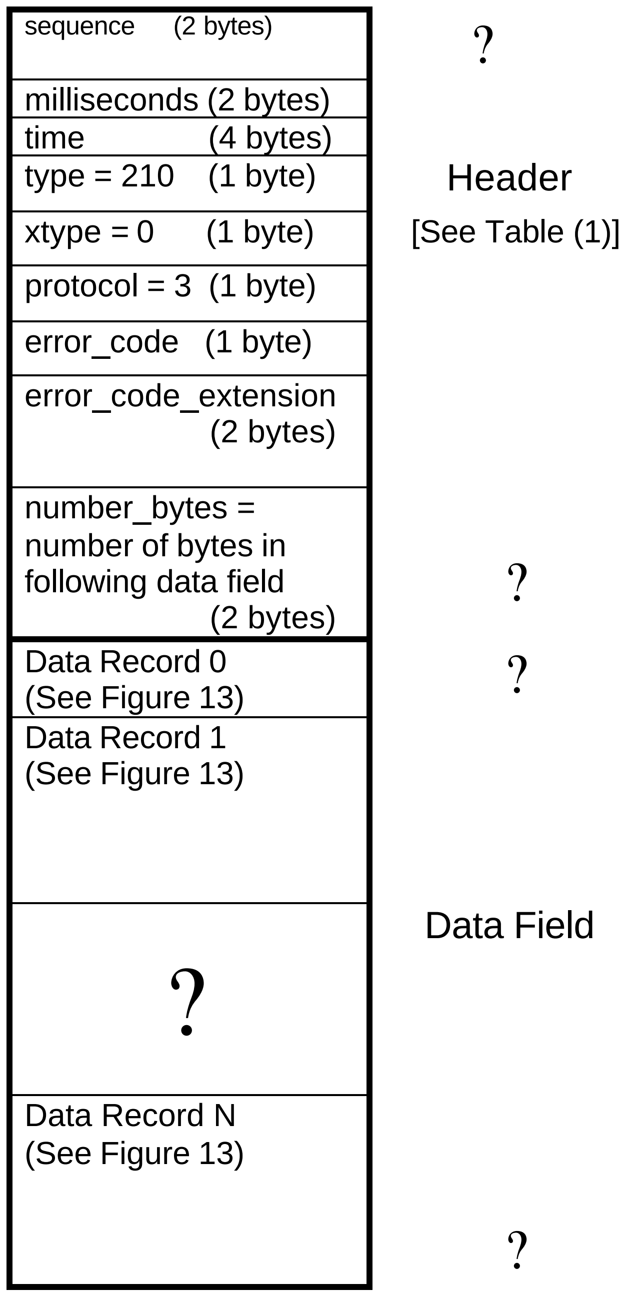
See Section 6.0 SERIAL DEVICE INTERFACE for more info on other types of serial devices that can be connected to the backpack serial ports and how to configure them.

The following tables list the data sizes to be expected for the different data formats.

Data Format Size:

Data Format Type	Data Format Code	Size (words)
NODATA	0	0 (No Record)
POSITION	1	3
ANGLES	2	3
MATRIX	3	9
POSITIONANGLES	4	6
POSITIONMATRIX	5	12
<unused>	6	0 (No Record)
QUATERNION	7	4
POSITIONQUATERNION	8	7
<unused>	9	0 (No Record)
<unused>	10	0 (No Record)
<unused>	11	0 (No Record)
<unused>	12	0 (No Record)
<unused>	13	0 (No Record)
FEEDTHROUGH_DATA	14	<variable size>
<error code>	15	Corresponds to size of requested format.

Note: Feed through data is unsolicited and may occur at any time. It will be appended to the next available packet leaving a system.



Data is always generated in whole words and is stored in the data packet MS Byte first followed by the LS Byte (Network byte order). The most significant 4 bits of the second byte contain the data format code.

Figure 12. BirdNet Data Packet Format

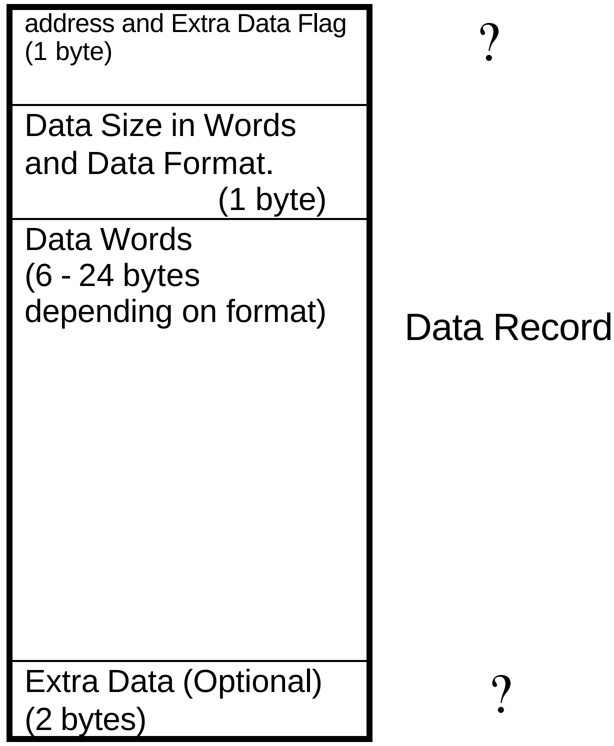


Figure 13. BirdNet Individual Data Record Format

The following is advice on how to handle bad or missing packets and whether to use the TCP or UDP protocol.

Retransmission of Data Packets

This could cause unacceptable lags and gaps in data transfer when used in a real time system. It is preferable to drop “bad” or “missing” packets.

Handling Missing Packets

The re-transmission of bad or missing packets is handled automatically within the TCP protocol therefore no attempt has been made to include this process in the BIRDNET protocol. If the UDP protocol is being used, the user may expect to occasionally lose a packet. If this happens, there is no recovery and the packet is lost forever. If this situation is unacceptable, it is recommended that TCP be used. The UDP protocol will produce the fastest response with the least network “lag”. This is because the packets are sent as soon as the data is ready, and there is less of an overhead attached to the packet by the protocol itself.

3.3 PACKET HEADER ERROR CODES

Error Code	**Error Description**
0	No Error. All commands and responses are correct up to this point.
1	Out of sequence packet error. A single packet is missing in the data stream. A packet was received with a sequence number 1 greater than the sequence number expected.
2	Out of sequence packet error. Two or more packets are missing in the data stream. Sequence number is 2 or more greater than expected.
3	Out of sequence packet error. A very large number of packets are missing in the data stream. Sequence number is very much greater than expected. Re-syncing is required.
4	Out of sequence packet error. This sequence number has already been used very recently. Repeat of a sequence number. This would not occur normally unless approximately 64k packets went missing.
6	Unexpected packet received. A packet of this type was not expected at this time. For example: An ACK packet issued by the client when no data packet has been sent would result in this error. The **errorCodeExtension** field of the header contains the sequence number of the illegal packet. May require re-syncing
7	Bad Packet error. The contents of the packet could not be determined
8	Illegal request for status. The status was requested for a device that does not exist within this chassis. The data field returned will have zero length
9	Illegal setup. The status packet sent for setup contained illegal values or the setup was intended for a device that doesn't reside within this chassis. The entire setup data field will be ignored.
100	System Not Ready Error. This error code may be contained in a response to a "Wake-Up" message or a command to start Run Continuous. It may indicate a serious problem or simply be that the system has not been initialized.

3.4 ETHERNET COMMAND UTILIZATION

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

This first example is the bare minimum commands that must be sent to the system in order to receive data.

COMMAND	ACTION
MSG_WAKE_UP	Synchronize the communication between the Client and the Server.
RSP_WAKE_UP	The Server's response to the MSG_WAKE_UP command.
MSG_GET_STATUS with xtype = 0	To get the number of devices in the system, what they are, their address, and their current functionality.
RSP_GET_STATUS	The Server's response to the MSG_GET_STATUS command. It contains a data field with status information.
MSG_RUN_CONTINUOUS	Start sending data packets until further notice.
RSP_RUN_CONTINUOUS	The Server's response to the MSG_RUN_CONTINUOUS command prior to sending the first data packet.

This next example shows how to setup sensors to send back different kinds of data information.

COMMAND	ACTION
MSG_SEND_SETUP with xtype = 2 and dataFormat = C5 (Hex)	Sensor at addr = 2 changed to return Position/Matrix data (twelve words = C and Position/Matrix = 5).
RSP_SEND_SETUP	The Server's response to the MSG_SEND_SETUP command.
MSG_SEND_SETUP with xtype = 3 and dataFormat = 31 (Hex)	Sensor at addr = 3 changed to return Position only (three words = 3 and Position = 1).
RSP_SEND_SETUP	The Server's response to the MSG_SEND_SETUP command.
MSG_RUN_CONTINUOUS	Start sending data packets until further notice.
RSP_RUN_CONTINUOUS	The Server's response to the MSG_RUN_CONTINUOUS command prior to sending the first data packet.

4.0 DUAL TRANSMITTER SETUP

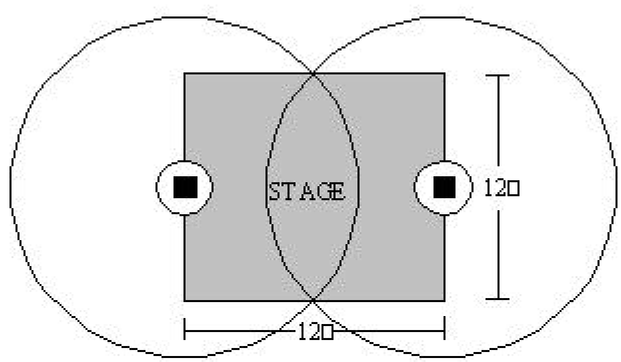
For increased range, the 3D Navigator can be configured to run with two transmitters. When running with two transmitters, the transmitters are time multiplexed and the position and orientation of the sensor relative to each transmitter is recorded. This data, along with information about the relative position and orientation of the second transmitter, allows the position and orientation of the sensor relative to the first transmitter to be determined. The position and orientation of the second transmitter is determined by running a stand alone application, Xmtrs.exe, and having the results placed in the Xmtr.ini file to be used in normal operations.

4.1 HARDWARE INSTALLATION

To connect the second transmitter, remove the interlock on the lower ERT cable connector on the ERC. Plug the second transmitter ERT cable into this connector. The 3D Navigator Base Station software automatically detects that two ERTs are connected.

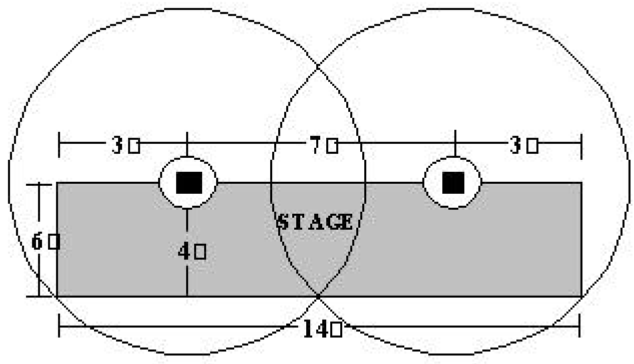
4.2 PLACEMENT OF TRANSMITTERS

The two transmitters can be placed anywhere in the environment with the following restrictions. Transmitters must both operate in the forward hemisphere. The transmitters can be a maximum of 16 feet apart from each other. The two standard configurations are side by side or facing each other. With the transmitters facing each other, a square motion capture space is created:



Transmitters Facing Each Other

With the transmitters side by side a long rectangular motion capture space is created:



Transmitters Side by Side

Note: These dimensions are considered to be the optimal setups for receiving useable data. Useable data is defined as data that has a noise level that is at or below our static accuracy specifications. These dimensions can be affected by variables in your environment (i.e. Metal, Noise, etc.) and you may not be able to get the same size motion capture area that is shown in the above diagrams.

4.3 AUTOMATIC CALIBRATION

In order for the Base Station to correctly determine the position and orientation of the sensors, the position and orientation of the second transmitter must be determined. This is done by running the application Xmtrs.exe on the Master Base Station. The transmitter calibration application, Xmtrs.exe, locates the position and orientation of the second transmitter by using the position and orientation data reported by sensor number 1 for both transmitters. Xmtrs.exe first determines that there are multiple transmitters available and then prompts the user to place sensor number 1 equidistant between the two transmitters (i.e. In the center of the operating environment). The position and orientation of the sensor is sampled for each transmitter and displayed on the screen. Using this information, the position and orientation of the second transmitter is determined and the results are displayed on the screen and saved to the file Xmtr.ini that is used by the Base Station software. Below is a sample screen:

```
                 Ascension Technology
       Multiple Transmitters Calibration Program

               Backpack Status:  Running
   XMTR     X       Y       Z       A       E      R   STDDEV
       0:  +52.1    -7.2   +13.1   -87.4    -0.5   -0.4 +0.0
       1:  +51.1    -8.5   +20.2   +98.2    -2.0   -2.2 +0.0
    Result: +124.3    -9.3    -5.5  +174.4    +1.5   -1.7

                Calibration Successful
```

4.4 MANUAL CALIBRATION

In a metal free environment, the Xmtrs.exe program gives good results, but in a metal distorted environment, the Xmtrs.exe program uses distorted data to calculate the positions of each transmitter. To correct for this, it may be necessary to calculate the Xmtr.ini file by hand. To edit the Xmtr.ini file:

- Start up the 3D Navigator.
- When the Base.exe program starts, press the Esc key to exit to a DOS prompt.
- Type **edit xmtr.ini** and press Enter.

A text editor will appear with two rows of three numbers.

Xmtr.ini file description

The first row is the X, Y, and Z position of the second transmitter relative to the first transmitter (center to center in inches). The second row is the Azimuth, Elevation, and Roll of the second transmitter relative to the first (in Radians).

Transmitter 2
<X> <Y> <Z>
<Azimuth> <Elevation> <Roll>

Example 1: Transmitters facing each other 12 feet apart

Both transmitters are at the same height, so the Z position is zero. The second transmitter is rotated 180 degrees relative to the first transmitter so the Azimuth value is 1?= 3.141593.

Transmitter 2
144.000000 0.000000 0.000000
3.141593 0.000000 0.000000

Example 2: Transmitters side by side 12 feet apart

Both transmitters are at the same height, but the Y position now shows the distance between the transmitters. The Azimuth is now zero because both transmitters are now facing in the same direction.

Transmitter 2
0.000000 144.000000 0.000000
0.000000 0.000000 0.000000

4.5 APPLICATION SUPPORT

There are no changes required at the application level to run dual transmitters. Position data is reported as normal, but with a scaling factor of 288 inches instead of 144 inches. Applications which do not reference this scaling factor in the 3D Navigator interface may report positions as half their correct value.

5.0 MOTION PREVIEWER

The Motion Previewer program is located on the 3D Navigator chassis in the C:\Base directory. To start the Motion Previewer program:

1. Turn on the 3D Navigator and wait until the Base.exe program is fully running.

2. When the Base.exe program is fully running, hit any key on the keyboard to exit to the DOS command prompt.

3. Type **Mp.exe** at the DOS command prompt followed by the Enter key. The program should now be running.

5.1 PURPOSE

1. **Verify operation of 3D Navigator system**

   Demonstrate that the 3D Navigator system is operating correctly. Help with technical support issues. Identify any bad sensors.

2. **Demonstrate speed of 3D Navigator system**

   Show which lag effects are caused by the 3D Navigator versus rendering on the host computer.

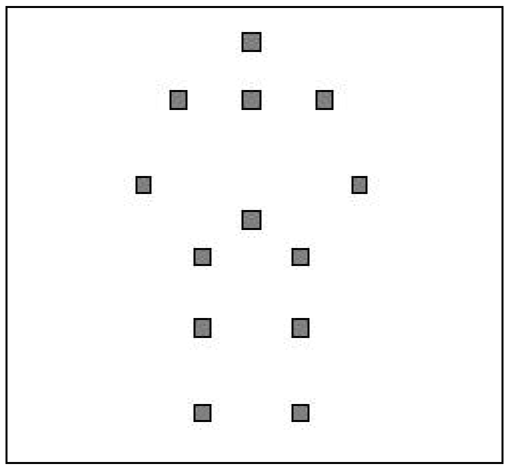
3. **Capture data for later processing/playback**

   Allow the 3D Navigator system to become a fully functional front end for the host computer. Capture data at data frame rates.

5.2 FUNCTIONALITY

1. **Cubes**

A cube is displayed for every sensor. Each cube is drawn as a series of 12 vectors. Each vector is drawn in white except the 3 primary axis which are drawn in red (X), green (Y), and blue (Z). Cubes are displayed in 640 x 480 resolution with 256 colors and double buffered.



2. **Data capture independent of drawing**

Capture of the motion data is independent of the speed of the drawing on the display. All of the motion data is captured and saved to memory.

3. **Status info**

1. Memory Available
2. Application State (Recording/Idle/Playback)

4. **Command Interface**

Command interface is via single character keystrokes. No provision is made for a mouse interface.

5. **Data Collection/Playback**

Motion Data can be stored in expanded memory (4 or 8 Mbytes in standard configurations) using the Record feature. This data can then be played back (using Playback) or sent to a file (using the File command).

Previously saved data can be brought back into memory and viewed using the Load command.

5.3 COMMANDS

1. **Translate (arrow keys)**: Move the image up, down, left or right.

2. **Zoom (+/-)**: Zoom the image in or out.

3. **Record (R)**: Save the motion data to memory. Saving of data continues until a Stop command is issued or memory is exhausted.

4. **Play (P)**: The Play command plays back any motion data saved in memory. The playback displays all the motion data recorded, but it is slower than the actual motion since every data instance is displayed.

5. **File (F)**: Store the motion data saved in memory to a file for later processing or playback.

6. **Stop (S)**: Stop Recording or Playback.

7. **Load (L)**: Load a previously stored motion data file into memory for Playback.

8. **Help (F1)**: In response to the Help command (F1), the help screen is displayed with the correspondence between keys and commands.

5.4 CONVERSION OF MOTION DATA

Motion data saved by the Motion Previewer program can be converted to an ASCII format by running the program Decode.exe found on our FTP site:

ftp://ftp.ascension-tech.com/WIRELESS/DECODE/

The following is a sample output from Decode.exe:

```
File: xxx.dat
File Created: Fri Apr 17 12:06:15 1999

Capture Model ID: WIRELESS
Base Software Version: 14.29
Number of Receivers: 5
*===========================*

Record: 0
TimeStamp: 12:6:10:941:0
Receiver: 0
Position Matrix Data
33.657715 -24.020508 -57.045410
-0.973846 0.033051 0.224609
0.059937 0.991638 0.113861
-0.218994 0.124359 -0.967712
Receiver: 1
Position Matrix Data
34.532227 -38.096191 -53.187012
-0.969086 0.098633 0.225983
-0.093842 -0.995026 0.031830
0.227997 0.009644 0.973572
```

6.0 SERIAL DEVICE INTERFACE

The 3D Navigator backpack incorporates two serial ports. These serial ports are intended for **external devices such as gloves, face trackers, and the Wanda**. The system is designed primarily to act as a data conduit, accepting data from the serial device and presenting that data at a TCP/IP socket address. Due to the current nature of wireless communications, it is difficult or impossible to maintain a 2-way link while transmitting a large quantity of real-time data. As a result, a device driver structure has been created in which all the interactive 2 way serial communications are performed by the backpack.

6.1 HARDWARE INTERFACE

6.1.1 PHYSICAL CONNECTOR SPECIFICATIONS

The serial port connector is a 6 pin mini-din locking connector. The recommended mating plug is a **Kycon # KMDLA-6P**. The Pin out is per Figure 14 below.

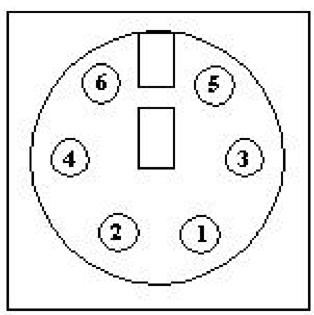


Figure 14. Connector Pin out facing PCB connector

Pin Descriptions

Pin	Signal	Description
1	VBAT	Signal and fused Battery. 8.0 to 14.4V, 200mA maximum current per, 220uF maximum input capacitance per device
2	RX	Receive Data input, fully RS232 compliant
3	TX	Transmit Data output, fully RS232 compliant
4	VCC	+5V ±5%, switched, 100mA maximum current per port, 10uF maximum input capacitance per device
5	PRES	Presence detect input. Pulled to ground by an external device when the device is connected. CMOS TTL level input, internally pulled up to VCC with 10k resistor, tolerates ±20V
6	GND	Ground
Shield	GND	Ground

6.1.2 POWER

The system is battery powered and has been designed for maximum battery life. For this reason, the output current on the ports is somewhat limited compared to a system powered from the AC mains.

Unregulated battery voltages are available on pin 1. These voltages have been passed through a series FET and a PTC fuse having a combined resistance of 1 Ohm nominal at 25? C. This circuit is common to both ports, so a fuse open due to an overload on one port will affect the other port. The port is slew rate limited at turn on, and the maximum permissible capacitance is 220uF on each port. This pin switches off during power conservation modes. The voltage output range for the port will depend on the battery technology being used and the total current draw out of the ports. For Lead-Acid batteries, this voltage is 13.6V for a fresh battery and an unloaded port, down to 10.5V for a nearly dead battery and a heavily loaded pair of ports. Nickel Cadmium, metal hydride, and some lithium chemistries will range between 10.8V on full charge down to 8.0V at cutoff. A 4 cell lithium metal pack will deliver 14.4V when fresh and unloaded, and this is the nominal design maximum input voltage for the system. Initially, the system is shipped with Panasonic PV-BP50 batteries, which are 12V 2AH lead acid packs. They are found at most video/photography stores.

Pins 2 and 3 use standard RS-232 signals provided by a maxim MAX242 interface IC. These pins are disabled during power conservation mode, as the MAX242/SHDN pin is driven low.

Pin 4 is a regulated +5V, derived from the system VCC. It is passed through a FET switch, a 1 amp PTC fuse, and a Scottky diode. The nominal output impedance is 1.1 Ohms. This output can range from 5.25V down to 4.75V (±5%) depending on output loading and initial switching supply tolerances. This pin is slew rate limited at turn on, and maximum capacitive loading is 10uF per port if hot plugging (plugging in a serial device with system power on) is allowed. It can tolerate a continuous short from ground up to +20V maximum without damage. This pin switches off during power conservation modes. The +5V is derived through a high efficiency switching regulator, and is supplied as a convenience for those desiring +5V with minimal battery loading, but cannot tolerate the EMI and other noises associated with an on board switching supply.

Pin 5 (presence detect) is a general purpose digital input with a 10K pull-up to VCC. It can tolerate ±30V maximum. It is normally HIGH, but when an external device is plugged into the system and pulls this pin to ground, the system responds by initializing and communicating with the device.

Pin 6 and the shield are connected to ground.

6.1.2.1 EXTERNAL POWER SOURCES

When the external device is powered from its own power source, the two power pins on the 3D Navigator system must not be used for power, as the two sources may differ in voltage level resulting in a high current condition and/or possible "back feeding" of power into one of the devices. The Vcc (Vbat) line may be monitored by using a 1K pull down. When the line goes to Vcc (Vbat), the system should power up, make sure presence detect is LOW, and respond to the serial port. When the VCC line is floating, the system has been put in power conserve mode and appropriate action, if any, can be taken by the external device.

6.1.3 DIGITAL SIGNAL THRESHOLDS

Pins 2 and 3 are RS-232 level signals provided by a Maxim MAX242 and are fully RS-232 compliant. Pin 5 has a logic LOW threshold of 0.8V and a logic HIGH threshold of 4.0V.

6.1.4 ERROR HANDLING

6.1.4.1 DRAWING EXCESSIVE CURRENT

If the external device draws excessive current, this will cause decreased battery life and will cause the voltage levels on the ports to fall out of spec. If the combined current on the two Vcc outputs exceeds 200mA, this may hang the 3D Navigator backpack with unpredictable results, most likely requiring the backpack power switch to be cycled.

The resettable fuse on Vbat may open if the combined current on both Vbat ports exceeds 0.5A. This is designed to protect the system from damage. The backpack will operate normally in this condition and will try to communicate with the devices on the ports. Note that both port devices are simultaneously affected by this condition, as the power supplies are common to both.

6.1.4.2 HOT PLUGGING THE EXTERNAL DEVICE

The external device can be “Hot Plugged” into the system, if the maximum capacitive loads are not exceeded. The system will continue to function and the Backpack will detect a LOW on the presence detect pin 5. This will cause the Backpack to initialize and communicate with the device normally. If the maximum capacitance is exceeded, the system may hang and require a manual reset from the user. Also, repeated hot plugs with large input capacitance may degrade connector reliability by burning the plating from the contacts and pitting the metal.

6.2 SERIAL DEVICE DRIVER OVERFLOW

The Serial Device Driver is downloaded into the Backpack when the backpack is initialized after power is applied. The backpack kernel calls the device driver once every measurement cycle. The device driver uses software interrupts to interrogate system state, perform serial I/O and append serial data/status onto the backpack data messages. **All interactive aspects of communication with the serial device are done by the device driver**. The driver is loaded after the kernel in the same download command. The device drivers and their associated parameter blocks are downloaded to specific memory locations. Ascension Technology supplies a generic driver that is sufficient for most applications. The generic driver (GENERIC.DRV) is a simple ‘call and response’ driver, which sends an (optional) pacing character string to request data from the device and waits for data of a specified length. Configuration of the driver parameter is done via an editable configuration file.

6.3 USING THE GENERIC DRIVER

The generic Serial Device Driver is intended to handle most record and stream oriented serial devices. The generic Serial Device Driver file name is GENERIC.DRV and the corresponding format file is GENERIC.FMT. In order to use the generic driver, a configuration file must be created. This file contains information about the steps needed to properly initialize the device and how to get data from the device. Included in this document is a sample configuration file WANDA.CFG for the Murray Consulting Wanda.

After the driver configuration file is complete, edit the file BASE.INI to connect the driver with a given port on the backpack. For instance, to connect the Wanda to port 1 of the backpack, make the following entry in the [BACKPACK] section of BASE.INI.

Port1 = WANDA

This will cause the Base Station to look for the file WANDA.CFG which will in turn download the file GENERIC.DRV to the backpack along with the configuration information in WANDA.CFG.

6.3.1 DRIVER CONFIGURATION FILE

The Driver Configuration file for a device using the generic driver must have the following line:

Driver: GENERIC

The Driver parameter is used to find the appropriate driver file and driver format file. In this case, those files would be named GENERIC.DRV and GENERIC.FMT. The driver file, GENERIC.DRV is a compressed version of a standard Intel Hex file. The format file, GENERIC.FMT tells the base how to interpret the rest of the fields in the configuration file. The other parameters in the file are:

Parameter	**Range**	**Default**
ResetDelay	0.1 - 25.6 Seconds	0.5 Seconds
BaudRate	9600, 19200, 38400, 115200	115200
InitReadyString	0 - 32 Bytes	NULL
InitCommandString	0 - 256 Bytes	NULL
InitResponseLength	0 - 256	0
PacingString	0 - 32 Bytes	NULL
ByteCount	1 - 32	1
StatusN	0 - 24 Bytes	
StateN	0 - 24 Bytes	

When the backpack is initialized, power is applied to the configured external serial devices. If the ReadyString is blank, the Device Driver will delay at least Reset Delay seconds. If the ReadyString is not blank, the backpack will wait for the ReadyString to be issued by the serial device indicating a device ready condition. The Device Driver then sends the CommandString to the serial device and waits for Response bytes to be returned.

The PacingString is issued at the beginning of each 3D Navigator system cycle. The system waits until RecordCount bytes have been received (if RecordCount = 0, then driver always sends whatever bytes have been received). If this occurs before the end of the cycle, data will be transferred at the end of that cycle. If not, the data will be transferred at the end of the system cycle that it was received in. In either case, the PacingString will be re-issued at the beginning of the cycle following that in which the last data character in the string was received. Thus, if a device is fast enough, data will be sent to the base on every cycle.

The strings supplied in Status0 through Status34 allow for customization of output messages displayed on the 3D Navigator Base. The generic driver has the following Status return values defined:

Status	Description
0	No Error. All commands and responses are correct up to this point.
1	Unable to find Serial Device Driver
2	Serial Device Not Present
3	
4	Serial Device Not Responding
5	Serial Framing Error (Usually Baud Rate mismatch)
6	Serial OverRun
32	Timeout Waiting for Ready String
33	Timeout Waiting Command Response
34	Timeout Waiting Record Packet

The generic driver also returns a state variable that indicates the state of the external serial device. Message strings can be associated with these states for display on the 3D Navigator Base Station.

State	Description
0	Initialization
1	Reset
2	Waiting for Command Response
3	Receiving Data

6.3.2 SERIAL STATUS DISPLAY

For each serial device, both the serial device driver state and status will be displayed on the Base Station VGA screen.

6.4 CLIENT INTERFACE

6.4.1 TCP/IP PROTOCOL

The TCP/IP protocol used is an extension of the BirdNet protocol outlined in the document by the same name. The 3D Navigator Base Station is a "server" and the user's host machine is considered to be a "client". All communication between a server and the client is initiated by the client. The client communicates with a server by sending commands. Every message (command) received by a server will cause it to generate a response. The format of every "packet" sent between client and server has an identical 16 byte header and a variable length data field. The serial data from each port is added to the Sensor data passed to the client.

The BirdNet protocol as been extended by using the data packets with format 14(FEEDTHROUGH_DATA) to pass the serial data. The serial data is contained in one or more data packets of format 14 (FEEDTHROUGH_DATA) with the serial status information contained in the first of the two extra bytes appended to the end of the data record.

6.4.1.1 SERIAL DATA RECORD

The serial data records follow Sensor data in a BirdNet data packet (DATA_PACKET_MULTI). No serial data records are sent until the receipt of a valid Serial Configuration Command for a given port. Serial Data Records are recognized by having a Data Format of 14. The Serial Data Record format is:

Byte Address	Format	Length	Description
0	Byte	1	Port Address and Extension Bit
1	Byte	1	Data Size and Format Upper Nibble = E
2	Byte	n	Serial Data (up to 15 words)
n * 2 + 3	Byte	1	If Extension Bit set, Serial Status Byte returned from device driver
n * 2 + 4	Byte	1	If Extension Bit set, total number of bytes in serial packet for this port

The Extension Bit (the MS bit) is always set for the first Serial Data Record for a given port. There may be one or more Serial Data Records from a given port if there were more than 30 bytes of data sent by the driver to the base. In other words, Serial Packets may be broken into several Serial Data Records if the Serial Packet is greater than 30 bytes. In all cases the first Serial Data Record for a given port will have the Extension Bit set and the total number of bytes in the Serial Packet and status for the packet recorded. The Serial Status Byte returned by the Serial Device Driver is driver specific although the first 32 entries are identical for all drivers. Device Driver specific entries start at 32 and continue to 255.

Status	**Description**
0	No Error. All commands and responses are correct up to this point.
1	Unable to find Serial Device Driver
2	Serial Device Not Present
3	
4	Serial Device Not Responding
5	Serial Framing Error (Usually Baud Rate mismatch)
6	Serial OverRun
32	Timeout Waiting for Ready String
33	Timeout Waiting Command Response
34	Timeout Waiting Record Packet

6.5 SAMPLE FILES

6.5.1 BASE.INI

```
[SYSTEM]
; Measurement rate may be set to a value between 30.0 and 100.0
; ideal values are one of the following
;
;  For 60 Hz Powerline freq.:
;      68.3, 76.2, 86.1, 93, 97.9
;  For 50 Hz Powerline freq.:
;      61.6, 63.5, 68.3, 71.7, 86.1, 93.4, 94.1, 94.7
MeasurementRate=86.1

; turn status beep on or off
; system gives five quick beeps when it is ready for use
; system beeps once every five seconds when disconnected from client
; system silent when connected to client
Beep = Yes
;Beep = No

; Linefrequency is used in Algorithm for filtering. Set to either 50 or 60 (Hz)
;LineFrequency = 50
LineFrequency = 60

Country=North America          ;Channels 1 2 3 4 5 6 7 8 9 10 11
;Country=E.T.S.I.              ;Channels 1 2 3 4 5 6 7 8 9 10 11
;Country=France                ;Channels 10 11
;Country=Spain                 ;Channels 10 11

;SlapFilter = 500
;Vm = 2,4,8,32,64,256,512

TransmitterMode = PULSE
;TransmitterMode = STANDARD

; For systems attached to an ERC this is the address of the ERC
; For 2nd and 3rd chassis in a system this is the address of the first sensor
;FirstFlockAddress = 1


[ETHERNET]
```

```
; IP address and host name are not required to be given in the setup file
IPaddr = 192.168.0.249

;BroadcastAddr = 192.9.200.255
;BroadcastPort = 7000


[BACKPACK]
; backpacks which are assigned the same channel
;               will be multiplexed on that channel
Channel = 6

SerialNumber = 330

Port1 = WANDA
;Port2 = 5DT


[MULTICHASSIS]
BaudRate = 115200
```

6.5.2 WANDA.CFG

```
//
//  Configuration file for 5DT glove
//
Driver:             GENERIC
Reset Delay:        10
Baud Rate:          1200
Record Count:       0
Response Length:    0
Reset String:       ""
Ready String:               ""
Command String:     ""
Pace String:        ""
//
//      Status code strings
//
Status0:                    ""
Status1:                    "No Device Driver"
Status2:                    "WANDA Not Present"
Status4:                    "WANDA Not Responding"
Status5:                    "Serial Framing Error"
Status6:                    "Serial Overrun Error"
Status32:                   "Timeout - Ready String"
Status33:                   "Timeout - Command Response"
Status34:                   "Timeout - Record Packet"
//
//      State code strings
//
State0:                 "Init"
State1:                 "Reset"
State2:                 "Waiting Command Response"
State3:                 "Receiving Data"
```

6.5.3 GENERIC.FMT

```
//
//  Configuration format for generic driver
//
//  specify configuration record format
//      integer - 16 bit word
//      baud - will be divided by 100 to 16 bit word
//      string - will load at 16 bit word length followed by byte stream
//

Reset Delay:        integer
Baud Rate:          baud
Record Count:       integer
Response Length:    integer
Reset String:       string
Ready String:               string
Command String:     string
Pace String:        string
```

7.0 ERROR MESSAGES

The ERC keeps track of the ERC specific errors it encounters. These errors are reported via the panel light on the front of the ERC. When an error occurs, the ERC will temporarily or permanently stop and the panel light blink the error code as 10 short blinks followed by the N long blinks, where N is the error code. If the error is temporary, the ERC will resume running when the panel light has finished blinking the error code. Permanent errors (where the panel light does not stop blinking) will require you to cycle the power switch.

The error codes are summarized on the next page. A detailed description of each is presented later.

CODE	ERROR DESCRIPTION	TYPE
1	System RAM Failure	FATAL
2	Non-Volatile Storage Write Failure	FATAL
3	PCB Configuration Data Corrupt	WARNING1
4	Transmitter Calibration Data Corrupt or Not Connected	WARNING1
6	Invalid RS232 Command	WARNING2
9	Not Initialized	WARNING2
11	RS232 Serial Port Receive Error	WARNING1
16	Invalid CPU Speed	FATAL
18	Illegal Baud Rate	WARNING1
20-27	Intel 80186 CPU Errors	FATAL
29	Transmitter Not accessible	WARNING1
30	Extended Range Transmitter Not Attached	WARNING1
31	CPU Time Overflow	WARNING2
34	Watch Dog Timer	WARNING1
35	Over Temperature	WARNING1

MESSAGE TYPE	DESCRIPTION
FATAL	Error is posted in system status, panel light continuously blinks the error code, the ERC stops running.
WARNING1	Error is posted in system status, panel light blinks the error code once, the ERC resumes operation after the blinking stops.
WARNING2	Error is posted in the system status, no light blinking, the ERC continues to run.

7.1 ERROR MESSAGE DETAILS

The error messages below pertain only to the ERC. For each of the ERC error codes a possible cause and corrective action are listed. Corrective actions with an * indicate that you should not attempt this fix. Ascension Technology should be contacted by phone **802-893-6657**, fax **802-893-6659** or email **techsupport@ascension-tech.com**.

CODE	ERROR DESCRIPTION	TYPE
1	RAM Failure Cause: System RAM Test has did not PASS. Action: *Check for shorts or opens to the RAM chips and if OK, replace system RAM.	FATAL
2	Non-Volatile Storage Write Failure Cause: Occurs when trying to write a transmitter, sensor, or PCB EEPROM but the device does not acknowledge either because it is not there or there is a circuit failure. Action: *Check the target EEPROM via a read command to verify that it is present prior to writing the device.	FATAL
3	PCB Configuration Data Corrupt Cause: The system was not able to read the PCB EEPROM 'Initialized Code'. Action: *Verify that the error persists after removing the transmitter and the sensor.	WARNING1
4	Transmitter Configuration Data Corrupt Cause: The system was not able to read the Transmitter EEPROM 'Initialized Code' or the Transmitter is not plugged in. Action: *Insure that the Transmitter is present, calibrate the transmitter and set the 'Initialized Code' in the EEPROM.	WARNING1
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 make sense (i.e., change value commands with an unknown parameter number). Action: Only send valid RS232 commands to ERC.	WARNING2
9	ERC is Not Initialized Cause: The ERC is sent the FBB ARM command, but it has not been initialized via the FBB Configuration command. Action: Send the FBB Configuration command prior to sending the FBB ARM or the WAKE UP command.	WARNING2

CODE	ERROR DESCRIPTION	TYPE
11	RS232 Receive Overrun or Framing Error Cause: An overrun or framing error has been detected by the serial channel 1 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 ERC differ. This may be due to incorrect baud selection, inaccuracy of the baud rate generator, or the RS232 cable being 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.	WARNING1
16	Invalid CPU Speed Cause: If the system reads an invalid CPU speed from the system EEPROM and the EEPROM is initialized, the error will occur. Action: *Initialize the system EEPROM.	FATAL
18	Illegal Baud Rate Error Cause: If the dip switch is in an 'invalid' baud rate setting, this error will occur. Action: Set dip switch to a valid baud rate setting.	WARNING1
20	Unused_INT4 Cause: CPU overflow. Action: *Check code for INTO instruction.	FATAL
21	Unused_INT5 Cause: Array Bounds. Action: *Check code for BOUND Instruction.	FATAL
22	Unused_INT6 Cause: Unused Opcode. Action: *CPU has executed an invalid opcode. Possibly bad (or going bad) EPROM. Also, check the power supply to assure that the +5VD is not dropping below 4.75 volts even when the transmitter is running.	FATAL
23	Unused_INT7 Cause: ESC Opcode. Action: *Check code for the ESC Instruction.	FATAL
24	Unused_INT9 Cause: Reserved. Action: *Should never occur.	FATAL
25	Unused_INT10 Cause: Reserved. Action: *Should never occur.	FATAL
26	Unused_INT11 Cause: Reserved. Action: *Should never occur.	FATAL

CODE	ERROR DESCRIPTION	TYPE
27	Unused_INT16 Cause: Numeric coprocessor exception. Action: *Numeric CPU does not exists, so this should never occur. Check to make sure the ERROR/signal on the CPU is tied to +5VD.	FATAL
29	Transmitter Not accessible Error Cause: This error occurs when the host starts the system FLYing via the Auto-Configuration command, and the ERC which should have a transmitter does not have a transmitter. Action: Assure that the specified ERC has a transmitter.	WARNING1
30	Extended Range Transmitter Not Attached Error Cause: If the Extended Range Controller does not have an Extended Range Transmitter attached, this error will occur. Action: Assure that the Extended Range Controller has a Extended Range Transmitter attached.	WARNING1
31	CPU Time Overflow Error Cause: This error occurs if the CPU in Extended Range Controller runs out of CPU time. This can occur if the host overburdens the ERC with multiple commands in a measurement cycle. Action: The host can either slow down the measurement rate or decrease the number of commands sent to the ERC.	WARNING2
34	Watch Dog Error Cause: This error occurs on an Extended Range Controller if the CPU does not update the Watch Dog Timer within a 100 mS period. This will only occur if the CPU or ROMs fail during operation. Action: *Should never occur.	WARNING1
35	Over Temperature Error Cause: This error occurs on an Extended Range Controller if the transmitter driver overheats. This can occur if the fan in the controller fails or if the ambient temperature of the controller exceeds operating specifications. Action: Verify that the fan is operating.	WARNING1

*Do not attempt to fix this error. Contact Ascension Technology at 802-893-6657.

8.0 TROUBLESHOOTING

A. Sound

Sound	Probable Cause
5 note trill	System Running Normally.
Single note every 3 seconds	No Connection Active. The system is running normally but no interface is active. This sound stops when either an Ethernet connection is made or connection via the MultiChassis RS232 is detected. If no Ethernet connection can be made, check the Ethernet Connection troubleshooting section. This sound can be disabled in the file Base.ini.
3 note trill every 5 seconds	Error message. System was unable to properly initialize. If possible, attach a VGA monitor to the system to view the error messages. If no monitor is available, check all the probable causes listed in the Base Station Trouble Shooting section.

B. Backpack Trouble Shooting

Light	Probable Cause
None	No power. Battery could be completely drained or not connected. Power switch is off or backpack timed out and shut itself off.
Blinking Red/Orange 2 blinks per second	Normal start up. Backpack has successfully passed Power On Self Test and is waiting for download from the Base Station.
Blinking Orange 1 blink per second	Backpack reset sequence. During a normal startup, the backpack resets the internal modem.
Blinking Orange 2 blinks per second	Backpack download. Info is being downloaded from the Base Station into the backpack. The download to the backpack happens very fast, so you might miss seeing this state.
Solid Green light	Backpack data. Backpack is functioning normally and sending data to the Base Station.
Blinking Green 2 blinks per second	Backpack lost its sync. Backpack cannot detect ERT. Backpack must be within 18 feet of the ERT.
Slow blinking Red 2 blinks per second	POST Failure. Backpack failed Power On Self Test.
Fast blinking Red 5 blinks per second	Low battery. Change battery.

C. Base Station Trouble Shooting

Messages are ordered roughly according to likeliness.

Base Station Message	Probable Cause
Running	Normal Operation. The 3D Navigator has successfully started and is receiving data from the backpack.
RCV DATA	Normal Operation. Data is being sent from the backpack and being processed by the Base Station.
WAITING FOR BACKPACK	Base Station is waiting for the backpack. System has successfully initialized. Cannot find backpack. Check backpack (see backpack Trouble Shooting). Verify Serial Number displayed matches Serial Number of backpack. Check **both** antenna connections. Modem card should have upper light green, lower light blinking.
Not Present	The backpack has been found, but is not currently present. Check to make sure that the backpack is turned on.
DOWNLOAD	Backpack download. Backpack firmware is being downloaded from the Base Station.
Init ERC	ERC Initialization. The 3D Navigator is initializing the ERC.
Download ERC	ERC download. ERC firmware is being downloaded.
READ EEPROM	Read backpack EEPROM. Calibration data is being read from backpack.
Exiting	A key on the keyboard has been hit and the program is 'Exiting' to DOS.
SYNCING	Backpack syncing. Backpack is attempting to 'sync' with the ERT. If the backpack cannot sync, check the measurement rate (must be lower than 100Hz), make sure that the sensors are not directly on metal or within 2 feet of the ERT.
Check ERC	ERC error. Unable to initialize ERC. Check the ERC power and the RS232 cable. If ERC resets (audible click) when Base Station starts, then cabling is OK. Cycle ERC power (off for 6 seconds). You should get either 1 blink (Super-Expanded addressing mode) or 2 blinks (Expanded addressing mode). If not, change the addressing mode. Check dip switch settings. For Super-Expanded addressing, all dip switches should be up except number 1. For Expanded addressing, dip switches 1, 2, and 7 should be down. Repeated blinking indicates the ERC detected an error. Check ERT cabling.
Check MultiChassis - or - Check MultiChassis Port	MultiChassis Error. Secondary Base Station has lost communication. Check RS232 cabling and functionality of the connected Base Station.
Check Antenna	Communication errors. Data packets from the backpack are being lost. Check antenna connection. Check for RF noise (microwave oven).
Check for Metal	Bad Sync Error. Unable to cleanly detect ERT waveform. Check for metal in the environment. Backpack must be within 18 feet of the ERT. Check for sensors close to strong electrical or magnetic fields (computer monitors, high voltage electric lines, etc.).
Could not find ERC.FRM	Missing Firmware. The ERC firmware file is missing.
ERC Download Error	ERC Error. The 3D Navigator cannot download the firmware file to the ERC. Cycle ERC power (off for 6 seconds).
ERC Memory Error	ERC Error. The ERC does not have enough memory to accept the firmware download.

Base Station Message	Probable Cause
ERC PROMs Incorrect	ERC EPROMs. ERC EPROMs must be upgraded to be used with this system.
ERC not in super or extended address mode	ERC addressing mode. Change addressing mode to either Expanded or Super-Expanded. See Section 4.0.
XMTR.INI not found	XMTR Error. There are two transmitters attached to the ERC, but the XMTR.EXE program has not been run. Scaling may be different than the host computer expects. Run the XMTR.EXE program to create the file XMTR.INI.
XMTR.INI corrupt	XMTR Error. The XMTR.INI file has become damaged. Scaling may be different than the host computer expects. Run the XMTR.EXE program to correct the problem.
Unable to open WIRELESS.FRM	Missing firmware. Backpack firmware file is missing.
Invalid RS232 Data	Data received from RS232 port is invalid. This often happens when power is removed from whatever the RS232 is connected to.
RS232 Receive Overrun Error	RS232 overrun. Data was sent to the Base Station faster than it could accept it.
Memory Allocation Error - or - Malloc Error	Memory allocation. Unable to allocate memory.
Timer Board Not Found	Timer board missing. Reset timer board.
Unable to open XXX.CFG	Missing Config File. The serial port configuration file is missing.
Unable to open XXX.DRV	Missing Driver File. The serial port driver file is missing.
Unable to open XXX.FMT	Missing Format File. The serial port format file is missing.
Config file missing value for XXX	The serial port configuration file is missing a needed value.
Illegal value in CFG file XXX	The value in the CFG file in not valid.
Illegal format XXX	The value in the CFG file is not a valid format.

8.1 PATCH CABLE

If communications problems result because of interference from other devices, the backup patch cable may be used. This device gives customers who have extremely important demos (such as at a trade show) a backup procedure which allows them to function in a non-wireless mode.

The patch cable is a separate cable that came with your system. To attach the patch cable simply disconnect one of the antenna box cables from the Base Station. Connect the patch cable to the back of the Base Station and the other end to the top of the backpack near where it says '**PATCH**'. All other items and use of the backpack/Base Station are as normal.

APPENDIX I - NOMENCLATURE

MASTER	The Master 3D Navigator controls and coordinates the operation of all other 3D Navigators (the Slaves) when they are connected in a daisy chain. The Master controls the sequencing and synchronizing of the transmitters and tells the slaves when to measure the transmitted magnetic fields. There can only be one Master running at a time.
SLAVE	One or more 3D Navigators that receive operating instructions from the Master 3D Navigator.
NOISE	Noise is when you place a sensor in a stable location and the sensor still looks like it is moving. Noise can come from many places in your environment including, but not limited to: power lines, monitors, transformers, overhead lights, fuse boxes, etc.
CRT	The CRT (Cathode Ray Tube) is the monitor that connects to the host computer.
EULER ANGLE	These are the rotations about the axes. The Azimuth is the rotation about the Z axis, the Elevation is the rotation about the Y axis, and the Roll is the rotation about the X axis.

APPENDIX II - 3D Navigator SPECIFICATIONS

Physical:

Transmitter:	12" x 12" x 12" cube (mounted inside enclosure or external) with 20' cable.
Sensor:	1.0" x 1.0" x 0.8" cube with 2.5', 3.5', or 5' cable lengths.
Chassis Enclosure:	6.5" x 6.7" x 15.5" rack mountable chassis]
ERC Enclosure:	4½" x 11¾" x 10"
Backpack Enclosure:	5½" x 2" x 8"

Technical:

Positional range:	± 8' in any direction
Angular range:	± 180° Azimuth & Roll ± 90° Elevation
Static positional accuracy:	0.3" RMS @ 5' range
Positional resolution:	0.03" RMS @ 5' range
Static angular accuracy:	0.5° RMS @ 5' range
Angular resolution:	0.1° RMS @ 5' range
Update rate:	30-120 measurements/sec
Outputs:	X, Y, Z positional coordinates and orientation angles: rotation, matrix, or quaternions
Interface:	RS232: 9,600 to 115,200 baud Ethernet: 10 Base2, 10 Base-T, 100 Base-T, AUI
Format:	Binary
Modes:	Point or Stream

Electrical:

Chassis Power Requirements:	115/230V	Voltage
	47-63Hz	Frequency Range
	7A/4A	Amperage
ERC Power Requirements:	100-120/200-240V	Voltage
	47-63Hz	Frequency Range
	3.6A/1.8A	Amperage
Backpack Power Requirements:	11-14.4V	Regulated DC Volts
	1.5A	Amperage

Environment: All specifications are valid at 30 deg C ± 10 deg in an environment void of large metal objects and electromagnetic frequencies, other than the power line.

APPENDIX III - OPENING AND CLOSING THE ERC AND CHASSIS

D A N G E R

THERE ARE STATIC SENSITIVE CIRCUIT COMPONENTS ON THE PCB. GROUND YOURSELF BEFORE TOUCHING THE PCB TO DISSIPATE ANY STATIC CHARGE THAT MAY HAVE BUILT UP ON YOUR CLOTHING.

1. OPEN THE ERC ELECTRONICS ENCLOSURE:

    1. Unplug all cables attached to the unit.
    2. Turn the unit upside down.
    3. Loosen, but do not remove, the four screws found in each of the black support legs. These screws secure the top half of the enclosure.
    4. Turn the unit over so it is standing on its legs and lift the top cover off vertically. Do not try to remove the front and rear back panels.

2. REPLACE THE TOP OF THE ERC ENCLOSURE:

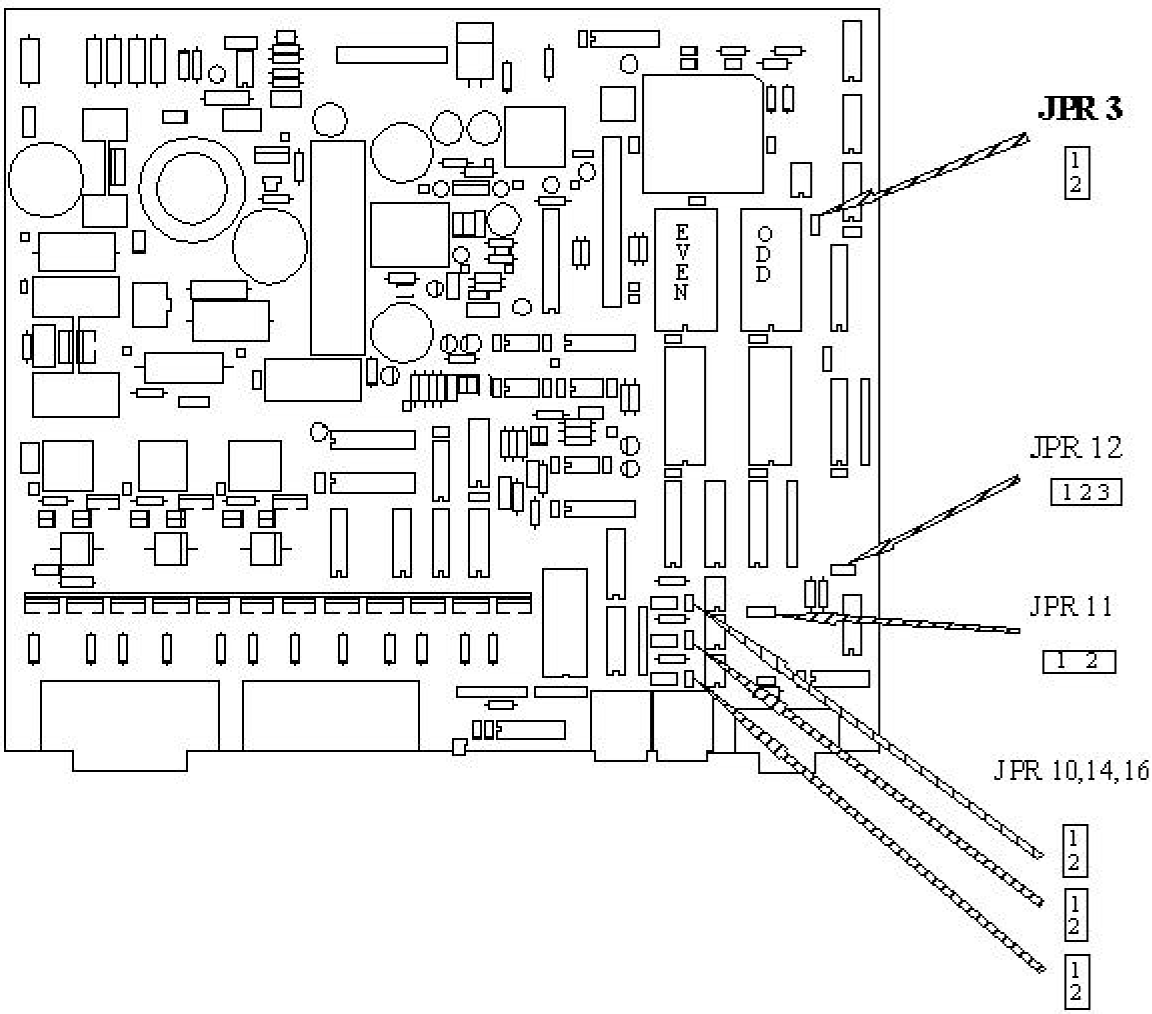
a. Slide the top over the front and rear panels. There is a left and right side to the top. One side has male grooves, the other female.
b. Invert the electronics unit.
c. Tighten the four hold-down screws. Do not over tighten.
d. You are done.

3. TOP COVER REMOVAL/INSTALLATION ON THE INTEGRATED CHASSIS

Remove the power cable. The seven screws on the top are captive, partial turn screws. To remove the top, turn each screw approximately ½ turn counter-clockwise. Do not force the screw - you may break it off. If the screws came off with some difficulty, to install the top, first, put a small amount of grease into the screw holders before putting on the top. When screwing in, apply some downward pressure on the screw driver and rotate clockwise approximately ½ turn until you hear a click.

APPENDIX IV - JUMPER LOCATIONS ON THE ERC CIRCUIT BOARD

The Extended Range Controller Circuit Card Jumper Location



APPENDIX V - JUMPER FUNCTIONS

Jumper assignments on the ERC circuit card

Jumper	Function
1,2	do not exist
3	1 - 2 connected when using RS485 host control 1 - 2 not connected when using RS232 host control *
4-9	do not exist
10	1 - 2 connected, FBB CTS terminated * 1 - 2 not connected, FBB CTS not terminated
11	1 - 2 connected, bus reset is enabled 1 - 2 not connected, bus reset is not enabled *
12	1 - 2 connected, RS485 host receive data enabled 2 - 3 connected, RS232 host receive data enabled *
13	does not exist
14	1 - 2 connected, FBB data terminated * 1 - 2 not connected, FBB data not terminated
15	does not exist
16	1 - 2 connected, RS485 HOST BUS data terminated * 1 - 2 not connected, RS485 HOST BUS data not terminated

Notes: * indicates factory default setting

APPENDIX VI - BACKPACK FREQUENCIES

When choosing backpack channels, be careful to choose channels that do not overlap. This is especially true when using a backpack with the old modem and a backpack with the new modem. The two modems do not necessarily use the same frequencies. The table below lists the center frequencies of each modem. Because the modems are spread spectrum each channel uses 10MHz on each side of the center frequency.

Country	Old Backpack Frequencies	New Backpack Frequencies
North America	2412, 2427, 2442, 2457, 2465	2412, 2417, 2422, 2427, 2432, 2437, 2442, 2447, 2452, 2457, 2462
E.T.S.I.	2412, 2427, 2442, 2457	2412, 2417, 2422, 2427, 2432, 2437, 2442, 2447, 2452, 2457, 2462
Japan	2484	2412, 2417, 2422, 2427, 2432, 2437, 2442, 2447, 2452, 2457, 2462
France	2457, 2465	2457, 2462
Australia	2412, 2427	2412, 2417, 2422, 2427, 2432, 2437, 2442, 2447, 2452, 2457, 2462
Germany	2427, 2442, 2457	2412, 2417, 2422, 2427, 2432, 2437, 2442, 2447, 2452, 2457, 2462
Spain	2457	2457, 2462

The easiest way to tell if a backpack has an old or new modem is to look at the wording on the top of the backpack. If the word '**PATCH**' is written on the top of the backpack, it has the new modem in it, otherwise the backpack has the old modem in it. The old backpacks will only work with the 14.XX software. The new backpacks will only work with the 23.XX, 24.XX or later software.

With the old backpack modem, adjacent channels overlap by about 5MHz, but every other channel does not overlap.

With the new backpack modem, adjacent channels overlap by about 15MHz, and channels 1, 6 and 11 don't overlap.

When mixing old and new backpacks we recommend using channel **1** with the old backpack and either channel **6** or **11** with the new backpack.

APPENDIX VII - APPLICATION NOTES

Application Note #1

BirdNet Sample Program

On our FTP site:

ftp://ftp.ascension-tech.com/Ethernet_Motionstar/BNSAMPLE/

there is the source code and executable for a sample application using sockets and the BIRDNET protocol to communicate with a 3D Navigator system. This application is a simple confidence check designed to verify that the 3D Navigator chassis is communicating with the Host and sending data.

For SGI computers, the first line of the source file contains a comment which contains the command line to be entered if it is required to compile and link the source file. This command is as follows:

```
cc bnsample.c -Xcpluscomm  -o bnsample
```

This will cause the source file **bnsample.c** to be compiled and linked into the executable **bnsample**.

For Windows 95/NT computers, double click on the file **bnsample.mak** to open up Microsoft Developer Studio. Then compile the program by going to **Build - Build bnsample.exe**.

The application **bnsample** can be executed from either a Unix Shell window or a MS-DOS Prompt window on a Windows 95/NT machine by typing **bnsample** with the appropriate command line options.

When executed, the application **bnsample** will “connect” with the 3D Navigator and send a **<Wake-Up>** message (This initializes the 3D Navigator internally and prepares it for further communication). The program then sends the command **<Get Status>** with a subcommand value of **<0>**. This causes the 3D Navigator to send the System Status back to the application. The application responds by altering the contents of the Status packet and returning it to the 3D Navigator as part of a **<Send Setup>** command. The Bnsample application then issues the command **<Get Status>** for each of the 3D Navigator devices in the chassis sequentially. The subcommand value corresponds to the **address** of the 3D Navigator device. Then finally the application issues either the **<Run Continuous>** or the **<Single Shot>** commands. Run Continuous will proceed until 100000 packets have been received then terminate the 3D Navigator with a **<Stop**

Data> and a **<ShutDown>** command before terminating the application. The Run Continuous mode corresponds to the Flock of Birds - **Stream** command.

The executable has a number of command line options available as follows:

Option Prefix	**Option**
-I	IP Address of the 3D Navigator Chassis (if omitted a default of 192.9.200.51 is used)
-p	Protocol (TCP or UDP)
-b	Broadcast Address
-B	Broadcast Address (Receive ONLY)
-v	Verbose Level
-m	Measurement Rate
-r	Report Rate
-f	Data Format: 0 = No Data 1 = Position 2 = Angles 3 = Matrix 4 = Position and Angles 5 = Position and Matrix 7 = Quaternions 8 = Position and Quaternions
-n	Number of sensors reporting data
-s	Number of Single Shot mode data samples to take. Default mode is Continuous Run mode

In the Single Shot mode, the application will terminate after it has received the number of packets determined by the command line(s) option. In Single Shot mode, the Client has to send a **<Single Shot>** command to the 3D Navigator to initiate each and every data packet transfer. This corresponds to the Flock of Birds - **Point** command.

Here is an example command line:

\> **bnsample -i192.9.200.66 -m100.3 -f3 -s20**

This command line would attempt to connect with a 3D Navigator at IP address 192.9.200.66 (-i192.9.200.66); and cause the 3D Navigator to run with a measurement rate of 100.3 samples per second (-m100.3); with the data format of all the 3D Navigator devices set to Matrix (-f3); and the data is generated in response to Single Shot commands of which there will be 20 (-s20).

When the program is executing properly, it will first display configuration information about the 3D Navigator that you are connected to. It will then get and set the status for each 3D Navigator sensor. Finally it will display the Position/Angle information for each sensor along with the time stamp for when the data was taken.

Trouble-shooting:

(1) After entering **bnsample** at the command line, nothing is displayed or eventually "Connection Timed Out" is displayed: Check physical connection between host and the 3D Navigator. Check that the 3D Navigator is powered up. Check that the 3D Navigator has the correct IP address.

(1) Message "Connection Refused" is displayed immediately: The 3D Navigator is powered up, but the server application is not running.

(1) Message "Permission Denied" is displayed immediately: Check that the IP address was entered correctly.

(1) Application successfully connects and exchanges initial command/response transactions with the 3D Navigator but does not proceed to send data: Check that the ERC/ERT are connected properly and/or powered up. Verify that all the 3D Navigator and ERC LEDs are illuminated and are not blinking.

Application Note #2

The Base.ini File

1. Overview

The BASE.INI file is used to configure the 3D Navigator Base Station. The file is read at initialization time by the Base Station software (BASE.EXE) to set such things as the IP address, default filter performance, etc. It is divided into several sections delineated by square bracketed keywords. The sections are [SYSTEM], [ETHERNET], and [MULTICHASSIS].

2. Parameters

The following table summarizes the various parameters configurable in the BASE.INI and the defaults. In some cases, newer versions of the command have superceded older versions. Both commands are supported, but the older command is presented with a gray background.

3. How Do I?

A. Change IP Address

Find and edit the BASE.INI parameter **IPAddr** in the section [ETHERNET]. IP addresses are specified as 4 numbers 0 to 255 separated by periods. This is the IP address used when the Base Station Software is running. If the default IP address needs to be changed, for instance to TFTP data from a remote system to the Base Station, the parameter **ip-address** in the file C:\Pctcp\Pctcp.ini must also be changed.

B. Alter Default Filter Performance

There are 3 standard filters that can be applied to the 3D Navigator position and orientation data. These are the Notch (or AC Wide Notch) Filter, Impulse (or DC) Filter and the Average (or AC Narrow Notch) Filter. Each of these filters can be turned on or off using the filter flags by the same name. The Impulse Filter performance can be altered by adjusting the Vm, AlphaMin and AlphaMax values.

C. Broadcast data to multiple clients

Creating a valid BroadcastAddr entry in the ETHERNET section allows the 3D Navigator to broadcast the motion capture data to the IP address specified. For broadcast data to be successful, all communication with the 3D Navigator must be via the UDP (or datagram) protocol. Then normal command sequence between the client and the 3D Navigator occurs normally with the 3D Navigator issuing **sendto** socket command to the client address. When motion capture data packets are sent, they are sent to the BroadcastAddr instead of the normal client address. On the client side, a broadcast socket must be opened (using socket option SO_BROADCAST) with the IP address matching the BroadcastAddr. Only motion capture data will be received via this socket. Receive-only clients will only open a broadcast socket, and will not issue any commands to the 3D Navigator.

Parameter	Section	Description	Values	Default
MeasurementRate	SYSTEM	Default measurement rate	30.0 to 120.0	86.1
Beep	SYSTEM	Audio connect flag	Yes No	Yes
LineFrequency	SYSTEM	Line frequency 50 or 60 Hz	50 or 60	60
Country	SYSTEM	Country code for selecting possible modem channels.	North America E.T.S.I. France Spain	North America
Hemisphere	SYSTEM	Default Hemisphere	FORWARD AFT UPPER LOWER LEFT RIGHT	FORWARD
NotchFilter	SYSTEM	Notch Filter flag	Yes No	Yes
ImpulseFilter	SYSTEM	Impulse Filter flag	Yes No	Yes
AverageFilter	SYSTEM	Average Filter flag	Yes No	No
SlapFilter	SYSTEM	Slap test detects large changes in the Earth's magnetic field - such as occurs when a sensor is slapped against a table. The Slap parameter sets the minimum value for ignoring data.	Integer 1 to 32767	500
SkewFilter	SYSTEM	Removes a large portion of time skew error resulting in better dynamic performance.	Yes No	Yes
AlphaMin	SYSTEM	Minimum allowed Alpha values allowed at various distances. Alpha is used in the Impulse Filter to determine the amount of filtering applied.	1 to 7 floating point numbers	.02,.02,.02,.02,.02,.005,.005

Parameter	Section	Description	Values	Default
AlphaMax	SYSTEM	Maximum allowed Alpha values allowed at various distances. Alpha is used in the Impulse Filter to determine the amount of filtering applied.	1 to 7 floating point numbers	.9,.9,.9,.9,.9,.9,.9
Vm	SYSTEM	Value is proportional to the expected sum of the variances of the noise	1 to 7 integer numbers	2,4,8,32,64,256,512
TransmitterMode	SYSTEM	Sets the transmitter waveform. STANDARD mode gives the best metal immunity. PULSE gives the best dynamic performance.	STANDARD PULSE	PULSE
AddressMode	SYSTEM	Sets the Addressing mode that will be used for RS232 communication. This is for backwards compatibility with older RS232 software.	Super Expanded Normal	Expanded
FirstFlockAddress	SYSTEM	Used for backwards compatibility. For systems attached to the ERC, this is the address of the ERC. For 2nd and 3rd chassis, this is the address of the first sensor in the chassis.	1 to 120	1
Transmitter	SYSTEM	Turns on only Transmitter number 1 or Transmitter number 2	1 or 2	Default is commented out
IPaddr	ETHERNET	IP address	quad Internet address	192.168.0.249
BroadcastAddr	ETHERNET	Broadcast IP address - If specified, data will be broadcast to this address.	quad Internet address - depending on the subnet mask this address is the IPaddr with 255 replacing the last value(s)	none
BroadcastPort	ETHERNET	Broadcast Port address	Integer	7000
SerialNumber	BACKPACK	The Serial Number of the backpack that communication is to be established with.	1 ->	
Channel	BACKPACK	Modem Channel	1, 2, 3, 4, 5	3
Port1	BACKPACK	Backpack external serial Port 1 driver		WANDA
Port2	BACKPACK	Backpack external serial Port 2 driver		none
BaudRate	HOST RS232	The Baud Rate used for the optional Rocketport multiple RS232 ports.	9600 19200 38400 57600 115200	38400
BaudRate	MULTICHASSIS	The Baud Rate used for Multichassis communication and/or the Baud Rate used when trying to talk to the chassis using the RS232 COM2 port.	9600 19200 38400 57600 115200	115200
BackPack1.NID	BACKPACK	Net address of backpack. Replaced by SerialNumber.		

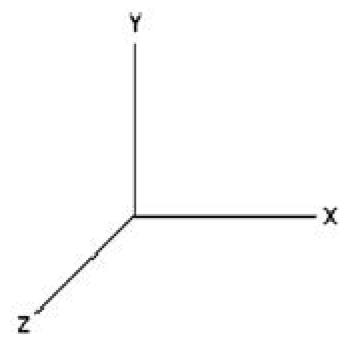
Parameter	Section	Description	Values	Default
Backpack1.Channel	BACKPACK	Modem Channel. Replaced by Channel.	1, 2, 3, 4, 5	3
Backpack1.Port1	BACKPACK	Backpack external serial Port 1 driver. Replaced by Port1.		none
Backpack1.Port2	BACKPACK	Backpack external serial Port 2 driver. Replaced by Port2.		none
Backpack1.FirstFlockAddress	BACKPACK	Used for backwards compatibility. For systems attached to the ERC, this is the address of the ERC. For 2nd and 3rd chassis this is the address of the first sensor in the chassis. Replaced by FirstFlockAddress.	1 to 120	2
PulseCode	SYSTEM	Set transmitter mode to PULSE. Replaced by TransmitterMode.	Yes No	Yes
AlternateXmit	SYSTEM	Set transmitter mode to ALTERNATE - used to solve time skewing errors. Replaced by Deskew.	Yes No	Yes
Deskew	SYSTEM	Removes a large portion of time skew error resulting in better dynamic performance. Replaced by SkewFilter.	Yes No	Yes

Application Note #3

Converting The 3D Navigator Outputs to a Graphics Modeling Matrix

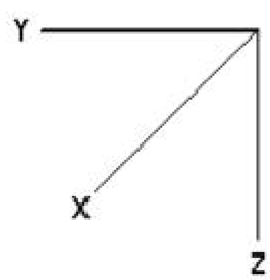
Purpose: Build the 12 elements of a standard computer graphics modeling matrix, MM(I, j), given the 9 matrix output elements from The 3D Navigator, MB(I, j), and The 3D Navigator 's X, Y, Z position outputs Xpos, Ypos, and Zpos.

The standard computer graphics XYZ coordinate system is: positive X axis points to the right, positive Y axis points up, and positive Z points towards you.



Standard Graphic Mode

The 3D Navigator XYZ coordinate system is, when the transmitter is between you and the graphics screen and the transmitter's power cord extends in the direction toward the screen: positive X axis points out of the screen, positive Y axis points to the left, positive Z axis points down.



Ascension's Magnetic Mode

To have the screen image follow the rotations and translations of The 3D Navigator 's sensor with movement of the sensor toward the screen causing the image to move toward the front of the graphics screen, the following transformations from 3D Navigator coordinates to modeling matrix elements are required:

MM(1,1) = MB(2,2)
MM(1,2) = MB(2,3)
MM(1,3) = - MB(2,1)
MM(1,4) = 0.
MM(2,1) = MB(3,2)
MM(2,2) = MB(3,3)
MM(2,3) = - MB(3,1)
MM(2,4) = 0.
MM(3,1) = - MB(1,2)
MM(3,2) = - MB(1,3)
MM(3,3) = MB(1,1)
MM(3,4) = 0.
MM(4,1) = - Ypos
MM(4,2) = - Zpos
MM(4,3) = Xpos
MM(4,4) = 1.0

Application Note #4

Computing the Coordinates of a Stylus Tip

Some applications need to measure the X, Y, Z coordinates that describe the physical shape of an object such as a plastic model or a person's face. This measurement can be accomplished by moving The 3D Navigator 's sensor over the object and recording the X, Y, Z positional outputs. Because of the sensor's size, it is sometimes more convenient to mount The 3D Navigator 's sensor onto a pencil or pen or some other type of device with a pointed tip (generically called a stylus) and then trace the object with the stylus tip to record its shape. Since the positional outputs of The 3D Navigator are with respect to the center of the sensor, one needs to find the corresponding X, Y, Z coordinates at the tip of the stylus. This translation of coordinates is easily accomplished with the application of some elementary trigonometry given the POSITION/MATRIX outputs and the X, Y, Z offset distances from The 3D Navigator 's sensor center to the tip of the attached stylus.

Notation: X_B, Y_B, Z_B are the X, Y, Z position outputs from The 3D Navigator, that is, the location of the sensor's center with respect to the transmitter's center.

X_O, Y_O, Z_O are the offset distances from the sensor's center to the tip of the stylus.

X_S, Y_S, Z_S are the coordinates of the stylus's tip with respect to the transmitter's center.

M(I, j) are the elements of the rotation matrix returned to the user when he requests POSITION/MATRIX outputs. Definition of the individual matrix elements can be found in the User's manual under the heading MATRIX.

Math: The stylus coordinates can be computed from the following:

$$X_S = X_B + X_O * M(1,1) + Y_O * M(2,1) + Z_O * M(3,1)$$

$$Y_S = Y_B + X_O * M(1,2) + Y_O * M(2,2) + Z_O * M(3,2)$$

$$Z_S = Z_B + X_O * M(1,3) + Y_O * M(2,3) + Z_O * M(3,3)$$

Application Note #5

Motion Capture Area Requirements

The single most important item that needs your pre-installation attention is the selection of a suitable area for installing the 3D Navigator system. If you don't have a "good" motion capture area, the 3D Navigator will not be able to deliver all the performance it is capable of delivering.

The main considerations in selecting a motion capture area are keeping the transmitter and sensors away from metal and low frequency electronic noise sources.

To provide accurate body tracking without the need for metal mapping, the 3D Navigator transmitter and sensors should ideally be at least eight feet away from any large metal items. In a typical office building, this metal is the steel reinforcement located in the walls, floor and ceiling, and the steel vertical beams going from the floor to the ceiling. This means that if an actor with the body mounted sensors is going to move ten feet from the transmitter toward a wall, the transmitter should be located eighteen feet from the wall. In addition, ideally, the transmitter should be at least eight feet above the floor and at least eight feet below the ceiling. This can be accomplished by having a four foot high wood stage on which the actors move and then mounting the transmitter on a pedestal four feet above the stage.

The stage should be constructed of wood. 300 series Stainless Steel nails and bolts for holding the pieces together are needed for minimum distortion. Do not use the steel hanger plates that are sometimes used to attach floor joists. If any of the bolts and nails used will be located at the stage floor level, you should use commercially available 18-8 stainless steel or aluminum bolts and nails which are non-magnetic. The stage floor should be supported on wood beams to the floor not steel or aluminum. The railing around the stage to prevent the actors from falling off should also be wood.

Try to minimize the amount of metal used in stage lighting that is directly overhead of the motion capture area. If it's not possible to keep large metal light supports or metal reflectors eight feet above the transmitter, offset them as much as possible so that they are not directly over the capture area.

Power cables with a lot of amperage should not run under the stage or above the stage area to minimize electronic low frequency noise. Computer displays should be located at least five feet away from the transmitter to avoid image distortion on the display. The computer displays should also be located at least five feet away from the 3D Navigator's sensors to avoid noise pickup by the sensors.

Since not all locations have enough space to construct the ideal motion capture area, you should at least locate the transmitter and sensors at maximum distances from any walls, floors, ceiling or steel vertical support beams.

Ascension Technology Corporation
PO Box 527
Burlington, VT 05402 USA
(802) 893-6657
http://www.ascension-tech.com