POLHEMUS
INNOVATION IN MOTION™

PATRIOT™ WIRELESS

PATRIOT™ WIRELESS USER MANUAL

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FCC Statement

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 designated to provide reasonable protection against 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 interference to radio communications. Operation of this equipment in a residential area is likely to cause interference in which case the user will be required to correct the interference at the user's own expense.

Medical Device Use

Polhemus is a Good Manufacturing Practices (GMP) Contract Manufacturer under U.S. FDA Regulations. We are not a manufacturer of Medical Devices. Polhemus systems are not certified for medical or bio-medical use. Any references to medical or bio-medical use are examples of what medical companies have done with the Products after they have obtained all necessary or appropriate medical certifications. The end user/OEM/VAR/ Distributor must comply with all pertinent FDA/CE regulations pertaining to the development and sale of medical devices and all other regulatory requirements.

EC – Declaration of Incorporation

This Product Complies with the following European Community Directives:

89/336/EEC as amended by 92/31/EEC
73/23/EEC Low Voltage as amended by 93/68/EEC

The following standards were used to verify compliance with the directives:

EMC: IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998
CCISPR 11:1990 / EN 55011:1991-Group 1 Class A
IEC 6100-4-2:1995+A1:1998 / EN 61000-4-2:1995 (ESD 4kV CD, 8kV AD)
IEC 6100-4-3:1995 / EN 61000-4-3:1995 (3V/m 80% AM)
IEC 6100-4-4:1995 / EN 61000-4-4:1995 (0.5kV line-line, 1kV line-earth)
IEC 6100-4-6:1995 / EN 61000-4-6:1995 (3V 80% AM, power line)
Australia/New Zealand: AS/NZS 2064.1

Safety: IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995

Safety Notices

Warnings

- Before turning on the instrument, be aware that the mains plug shall only be inserted in a socket outlet provided with a protective ground contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- This instrument contains no user serviceable parts. Do not attempt to service the unit. Return it to Polhemus for repair.
- Do not perform any unauthorized modification to the instrument.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not use the instrument in a manner not specified by the manufacturer.

To Clean the Instrument

If the instrument requires cleaning:

1. Remove power from the instrument.
2. Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water.

Make sure that the instrument is completely dry before reconnecting it to a power source.

HANDLING RECOMMENDATIONS
FOR LITHIUM ION OR LITHIUM POLYMER BATTERIES

In order to obtain optimum performance, please follow the warnings and safety instructions listed in the handling precautions below.

- **Keep Lithium ion/Lithium polymer batteries away from children. If a battery is swallowed promptly call your doctor.**
- **Do not allow any Lithium ion/Lithium polymer battery to come into contact with water or liquid of any kind. Do not leave the battery near flames, heaters, (microwave) ovens, stoves, fireplaces or other high-temperature locations. Excessive heat could cause the battery to deteriorate. Do not heat the battery or throw it into a fire. This can damage the safety vent and cause the electrolyte to catch fire.**
- **Do not leave the battery in a hot condition like strong direct sunlight, inside automobiles behind the windscreen, etc. This can overheat the cell and will reduce the battery's performance.**
- **Do not damage the battery in any way by nailing, hammering, crushing, etc. This can cause the cell to leak and/or to short circuit internally.**
- **Do not combine batteries of different capacities, types or brands.**
- **If a battery leaks or emits a strange odor during use or storage, stop using the cell immediately. Leaking electrolytes are flammable.**
- **If any fluid that has leaked from the battery comes into contact with skin or clothing, rinse with tap water or other clean water immediately. Contact with skin can cause irritation or burns.**
- **If fluid from a battery gets into a person's eye, rinse the eye immediately with clean water and seek medical attention promptly. Do not rub the eye.**

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DUE TO SOFTWARE AND HARDWARE MODIFICATIONS SCREEN OR PRODUCT EXAMPLES APPEARING IN THIS MANUAL MAY VARY SLIGHTLY FROM THE ACTUAL SCREENS OR PRODUCTS THE USER ACCESSES.

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1. Getting Started

Congratulations on your purchase of Polhemus' most innovative motion tracking system to date: The PATRIOT WIRELESS.

This section of the manual is provided to help get your tracking system up and running quickly. It covers the basics of understanding and setting up the system to demonstrate its principles. However, this is meant only as a starting point to show that the system is operating properly before delving into more detailed setup. The remaining sections of this manual serve as a complete reference resource for PATRIOT WIRELESS operation.

1.1 *PATRIOT WIRELESS Models*

The PATRIOT WIRELESS is designed to track Position and Orientation (P&O) of mobile wireless Markers relative to a user-defined coordinate system referenced to a fixed array of special sensing units called Receptors. Receptors are cabled to the SEU (System Electronics Unit) and are arrayed over the motion tracking environment. They track the magnetic field signals emanating from the wireless battery-powered markers. The position and orientation of each marker is calculated and communicated from the SEU to a host computer via RS-232 or USB. Marker P&O is automatically aligned to a user-defined reference point relative to the receptor array.

This user manual covers all PATRIOT WIRELESS models and configurations:

- The PATRIOT WIRELESS base system supports two receptors and up to four wireless markers.

Figure 1-1: PATRIOT WIRELESS

1.2 *Setting Up PATRIOT WIRELESS*

The basic system consists of a System Electronics Unit (SEU), which requires at least one receptor, at least one marker with rechargeable Lithium ion/Lithium polymer battery, and a charger for the battery.

The SEU can operate up to two receptors. Up to four unique markers can be operated simultaneously. The battery charger can charge up to four batteries simultaneously.

NOTE: For the purpose of Getting Started, the following assumptions are made:

- **There is one receptor.**
- **There is one marker plus a spare marker battery.**
- **The marker batteries have been charged.**
  See Charging and Using PATRIOT WIRELESS Marker Batteries **on page 7.**
- **The host computer is running Windows XP or later, and has an available USB or COM port.**
- **The Polhemus PiMgr GUI should be installed on the host computer. See** Installing PATRIOT WIRELESS Host Software **on page 15 for instructions.**

1. Unpack the PATRIOT WIRELESS SEU, receptor(s), marker(s), USB and RS-232 cables, PATRIOT WIRELESS Host Software CD, marker battery charger, two power supplies, and two power cords. See Figure 1-1.

2. Set up the PATRIOT WIRELESS close to your host computer but within reach of the receptor cable length to the test area.

3. Examine the front and rear panels of the PATRIOT WIRELESS and review the locations of the receptor (sensor), power, RS-232, and USB. The layout of the front and rear panels is the same for all PATRIOT WIRELESS configurations. See Figure 1-2.

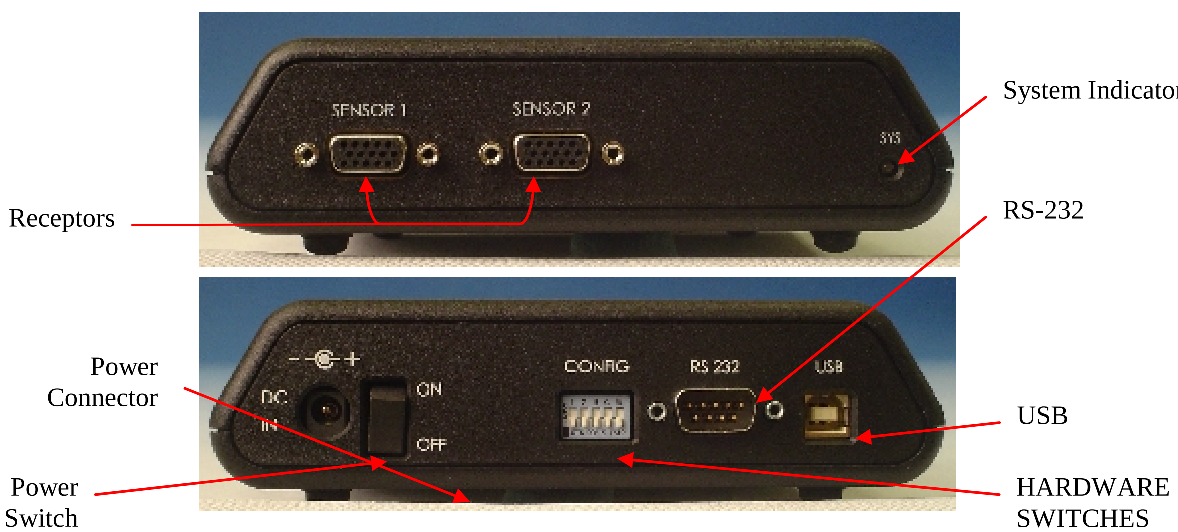


Figure 1-2: PATRIOT WIRELESS Front/Rear Panels

4. Connect the receptor. Uncoil a small length of the receptor cable and attach it to the "Sensor 1" connector on the SEU. Firmly engage and lock the receptor connector into place (See Figure 1-3 and Figure 1-4). Tighten the two retaining screws to secure.

Figure 1-3: Receptor and Receptor Connector Cord

Figure 1-4: Receptor Connection

5. Place the receptor head on a non-metallic surface. Dress the cable safely over to the SEU where it will not become entangled in a walkway. Place the *charged** marker on the surface, to the rear of the receptor and about 10-12 inches away from the receptor. Make sure that the marker is oriented so that the +X direction is *forward, toward the rear of the receptor*. Refer to Figure 1-5.

* **NOTE:** To charge a marker battery, refer to Charging and Using PATRIOT WIRELESS Marker Batteries on page 7.

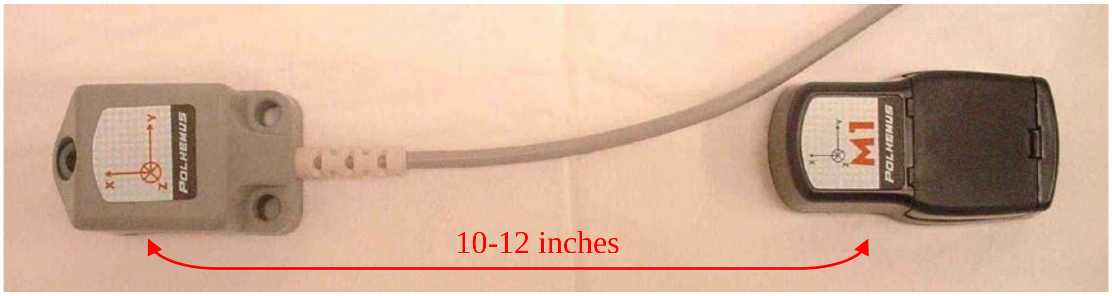


Figure 1-5: Receptor/Marker Test Setup

Make note of the marker number in your test setup. The marker number label is located on the top of the marker as shown in Figure 1-6.

Figure 1-6: Marker Number Label

6. Ensure that the power switch is in the OFF position (logic “0”, DOWN). With the separate power supply UNPLUGGED from the wall, connect the power input cable to the PATRIOT WIRELESS. The power supply can now be plugged into a 110/220 VAC outlet. See Figure 1-7.

Figure 1-7: Power Connector

USB or RS-232 Communications

- For USB, continue with Step 7.
- For RS-232, skip to Step 11.

NOTE: Only one I/O mode (USB or RS-232) can be active at a time. If at any time the USB is connected between the powered tracking system and the host computer, USB will become operational automatically and any RS-232 connection will be disabled. To re-enable the RS-232 connection, the SEU must be reset or powered down and up with the USB cable disconnected.

For USB Communications:

7. Identify the USB cable and insert it into the receptacle as shown in Figure 1-8. Connect the other end of the USB cable to the host computer.

Figure 1-8: USB Cable Connection

8. Turn on the PATRIOT WIRELESS using the power switch located on the back panel of the SEU. A system status indicator located on the front panel of the electronics unit should flash red for 5 to 10 seconds indicating self-test and setup. When these routines are completed, the indicator will display system status as described in Table 1.

Table 1 System Status Indicators

• **Steady green**	**System operational**	**Detected receptor is ready for marker detection.**
• **Solid red**	**System operational**	**Detected receptor is not ready (needs alignment).**
• **Flashing red**	**Failed self-test and set-up.**	

9. The host should detect the USB connection and respond with a “Found New Hardware” message. For step-by-step instructions for installing the USB drivers from the Host Software CD, refer to USB Driver Installation on page 15.

10. You are now ready to exercise the system. With the USB connection, you must use the Polhemus PiMgr GUI to do this. Continue to Using the Polhemus PiMgr GUI on page 16 to begin.

For RS-232 Communications:

11. Locate the RS-232 cable and insert it into the receptacle as shown in Figure 1-9.

Most PC hosts have a 9 pin, male "D" type connector for COM1. If you are using COM1, plug the remaining end of the cable into the COM1 port of the host PC, engage, and secure in place by tightening the two retaining screws.

If your host computer has a 25 pin "D" connector for the RS-232 port, you will need a 9 to 25 pin "D" connector adapter with the proper genders. Note that this adapter must not compromise the NULL MODEM sense of your cable.

Figure 1-9: RS-232 Cable Connection

12. You are now ready to exercise the system.

- To use the Polhemus PiMgr GUI, continue to Using the Polhemus PiMgr GUI on page 16.
- To use PATRIOT WIRELESS' ASCII interface through the Windows HyperTerminal program, refer to Using the PATRIOT WIRELESS ASCII Interface on page 20.

1.3 *Charging and Using PATRIOT WIRELESS Marker Batteries*

1.3.1 Charging the Extended Marker Battery

Figure 1-10 Extended Marker Battery

1. Locate the batteries and the charger of extended marker; see Figure 1-11.

Figure 1-11 Extended Marker Battery Charging Components

2. Slip the batteries into the receptacles atop the charger; see Figure 1-12.

Figure 1-12: Placing Extended Marker Batteries into Charger

3. To install the battery into the marker, orient the battery so that the two slots of battery contact is toward the marker pins (see Figure 1-13.

Figure 1-13: Extended Marker Battery Tab Orientation

Tip the battery at an angle and insert tabs in marker slots (see Figure 1-14.)

Figure 1-14: Extended Marker Battery Insertion

Figure 1-15: Extended Marker: Successful Battery Installation

1.3.2 Charging the Standard Marker Battery (discontinued)

Figure 1-16: Standard Marker Battery

1. Locate the batteries, the charger, and the charger's power supply and power cord; see Figure 1-17.

Figure 1-17: Standard Marker Battery Charging Components

2. Slip the two batteries into any two of the receptacles atop the charger; see Figure 1-18.

Figure 1-18: Standard Marker: Placing Batteries into Charger

3. Plug the power supply into the rear of the charger and then into the power mains as depicted in Figure 1-19.

Figure 1-19: Standard Marker Battery Charger Power ON

4. Turn on the power switch on the rear of the charger. The green power ON indicator will illuminate. The two red "charging" LED's where the batteries are inserted will also illuminate (see Figure 1-20**Error! Reference source not found.**). The other two "charging" LED's will flash on and off and can be disregarded.

Total charging time of up to 2.5 hours may be required, depending on the initial charge status. Each charging LED will extinguish when the battery is fully charged**.**

Figure 1-20 Standard Marker Batteries Charging

5. To remove the battery, place your middle finger on one side and thumb on the other of the battery charger (see Figure 1-21).

Figure 1-21: Standard Marker: Preparing to remove the battery

Then pull the retaining clip back using the nail of your index finger, and remove the battery from the charger (see Figure 1-22**Error! Reference source not found.**).

Figure 1-22: Standard Marker: Lifting the battery

6. To install the battery into the marker, orient the battery so that the two tabs are toward the two corresponding slots in the marker (see Figure 1-23).

Figure 1-23: Standard marker battery tab orientation

Tip the battery at an angle and insert tabs in marker slots (see Figure 1-24).

Figure 1-24: Standard marker battery insertion

Be certain that the spring tab on the battery pack seats fully into the marker base. A slight push down and forward on the spring tab with your forefinger will ensure that good battery contact will result (see Figure 1-25 and Figure 1-26).

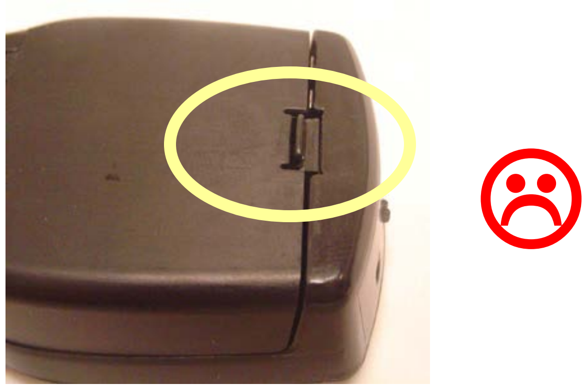


Figure 1-25: Spring clip improperly seated

Figure 1-26: Proper seating of spring clip

Be sure the retaining clip “clicks” into place so that the battery will not disengage during use (see Figure 1-27). This same procedure should be employed when installing the battery into either a marker or the battery charger.

Figure 1-27: Successful standard marker battery installation

1.3.3 Using Wireless Markers

Find the small power switch on one end of the marker (Figure 1-28). Slide it ON (away from the LED) and observe that the LED power indicator next to the switch illuminates briefly, indicating that the marker is live. The LED illuminates only briefly to conserve power. A fully charged standard battery should operate for up to 2 continuous hours. A fully charged extended marker battery should operate for 6 hours or more.

Note: As will all batteries: capacity (run-time) will diminish over time due to battery age and charging cycles.

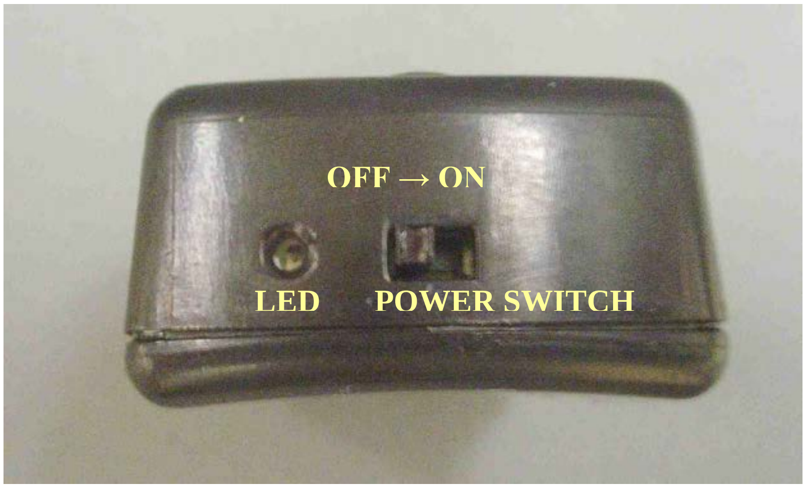


Figure 1-28: Marker Power Switch and LED

When the battery is nearing complete discharge, the marker's LED power indicator will illuminate continuously; the battery should be replaced or recharged immediately.

1.4 *Installing PATRIOT WIRELESS Host Software*

NOTE: PATRIOT WIRELESS Host Software is intended to be installed on a computer running Windows® XP or later.

1. Insert the PATRIOT WIRELESS Host Software CD-ROM into your computer's CD-ROM drive.

2. If the PATRIOT WIRELESS Host Software Installation Panel does not run automatically, then navigate to the CD-ROM drive using Windows Explorer. Select "Setup.exe". The Host Software Installation Panel will appear. Select "Install Host Software". The installation wizard will walk you through the installation.

3. For simplicity, it is recommended that you use the default installation settings suggested by the installation wizard.

1.4.1 USB Driver Installation

1. If you used the default installation settings when installing the Host Software (above), the PATRIOT USB Driver Package was installed.

2. On a Windows 7 or Windows 8 host, when PATRIOT WIRELESS is connected via USB for the first time, the PATRIOT USB drivers will be loaded automatically.

3. On a Windows XP host, the first time PATRIOT WIRELSS is connected, the host will display a "Found New Hardware" message. The host will then launch the "Found New Hardware Wizard" to locate and install the USB drivers for PATRIOT WIRELESS.

4. When the "Found New Hardware Wizard" displays, select the "Install software automatically" option and select "Next."

5. The wizard will install the PATRIOT Loader. When it has completed, select "Finish".

6. The same process will be launched again automatically to install the Polhemus PATRIOT USB runtime driver. Repeat the same selections and the process will be complete.

1.5 *Using the Polhemus PiMgr GUI*

NOTE: If you have not yet installed the Host Software, follow the instructions in Installing PATRIOT WIRELESS Host Software on page 15 before proceeding.

By following the instructions in this section, you will use the Polhemus PiMgr Graphical User Interface connect to configure the PATRIOT WIRELESS in the test scenario created for Getting Started. Detailed instruction on the use of these and other PiMgr features can be found in PiMgr's online help program, accessed through the PiMgr Help menu, Help buttons, or the ***What's This*** toolbar help button.

If you selected the default settings when you installed the PATRIOT WIRELESS Host Software on your computer, you will find a shortcut to the PiMgr application on your Windows® desktop. The icon looks like this:

Otherwise, navigate to the program through the windows Start menu:

Start⇨All Programs⇨Polhemus PiMgr

1. The initial PiMgr screen will appear as in Figure 1-29. With no PATRIOT WIRELESS system connected, notice that the icon appears in the lower right corner. Once connected, the icon will change to .

2. **I**f the PATRIOT WIRELESS is already connected to the computer, the PiMgr will discover the connection immediately upon startup. If PiMgr has a PATRIOT WIRELESS connection now, skip to Step 6. If not, you will need to manually create the connection once you have powered up the PATRIOT WIRELESS. To do this, first you must select the type of connection you wish to create.

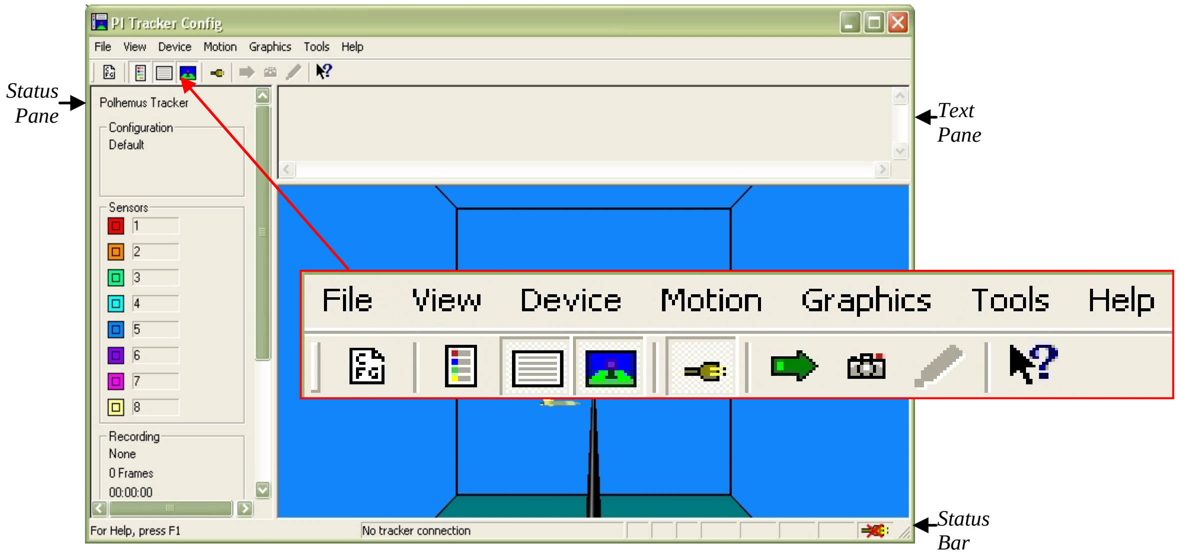


Figure 1-29: PiMgr Screen Display, No Connection

3. If you want to create a USB connection, skip to Step 5. PiMgr defaults to a USB connection.

4. If you want to create an RS-232 connection, first configure the serial port settings by opening the ***Tracker Configuration*** dialog. Open this dialog via the ***Device*** menu: Device⇨Tracker Configuration…(see Figure 1-30), or use the '^Z' – Read Operational Configuration shortcut (see page 97).

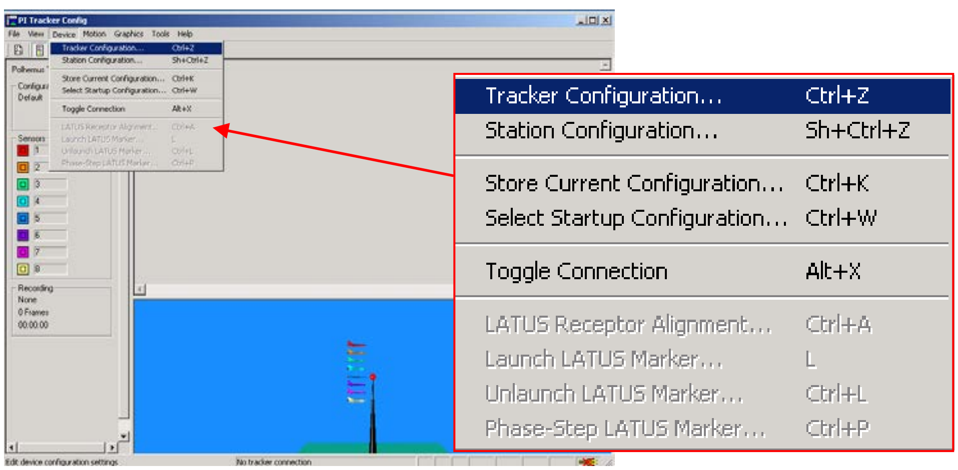


Figure 1-30: PiMgr Device Menu--Tracker Configuration

With the dialog displayed, select the ***Connection*** tab as shown in Figure 1-31. Select the **RS-232** Connection Type on the left, and the appropriate **RS-232 Properties** on the right. Select **OK**

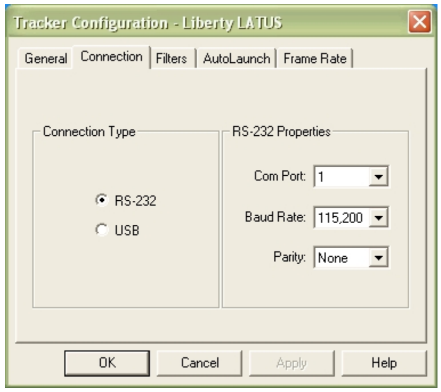


Figure 1-31: RS-232 Display

5. To create a connection, select the *Connect* button on the PiMgr toolbar: (see Figure 1-29). When the connection has been established, the connection icon at the lower right will change to .

6. To track a wireless marker, PATRIOT WIRELESS receptors must be *aligned*. By default, PATRIOT WIRELESS receptor 1 is automatically aligned as the *anchor receptor* at (0,0,0), so for this Getting Started example, it is not necessary to align any receptors. To learn more about receptor alignment, refer to Section 3.3 Receptor Setup.

7. Further, to track a wireless marker the marker must be *launched*. Display the Launch Marker dialog (see Figure 1-33). Open this dialog via the ***Device*** menu: Device⇨ Wireless Operations ⇨ Launch Marker (see Figure 1-32) or type the ‘L’ – Launch Marker keyboard shortcut (page 83) in the PiMgr window.

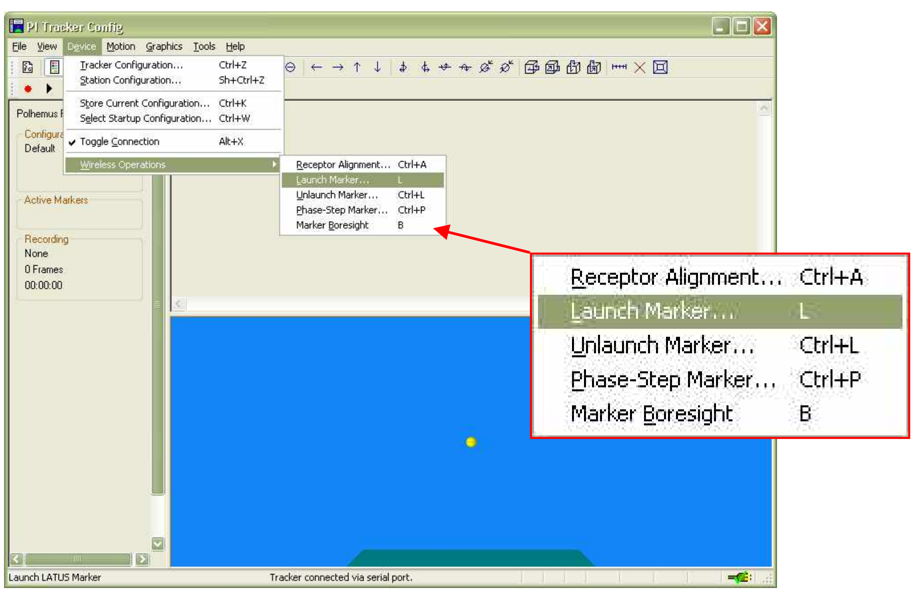


Figure 1-32: PiMgr Wireless Options Submenu

Figure 1-33: Launch Marker Dialog

Receptor 1 appears as detected and aligned . Receptor 1 is designated as the "anchor receptor" because it is located at the Origin in Cartesian space (0,0,0). For Getting Started, Receptor 2 appears as undetected .

8. To manually launch the marker, make sure that the receptor and powered-on marker are positioned in the test setup as described in Step 5 on page 3. Make sure that Receptor 1 is selected as the Launching Receptor in the Marker Launch Dialog as shown in Figure 1-33 and select *Launch*.

   The PiMgr Status Pane displays the launched marker and its ID as shown below in Figure 1-34

Figure 1-34: Marker in PiMgr Status Pane

9. PATRIOT WIRELESS is now ready to collect motion data from the marker. To collect a single frame of motion data from the PATRIOT WIRELESS, select the Single button on the toolbar or type the 'P' – Single Data Record Output keyboard shortcut (see page 86). This will cause PiMgr to request a single data frame from the PATRIOT WIRELESS.

   To collect continuous motion data, select the **Continuous** button on the toolbar or type the 'C' – Continuous Print Output keyboard shortcut (see page 80). (To stop continuous data collection, un-select the button or type 'C' or 'P'.)

The contents of the motion data frames will be displayed in the **Text Pane** at the top of the PiMgr display. The airplane image in the **Graphics Pane** of the screen will move to the retrieved position and orientation. See Figure 1-35.

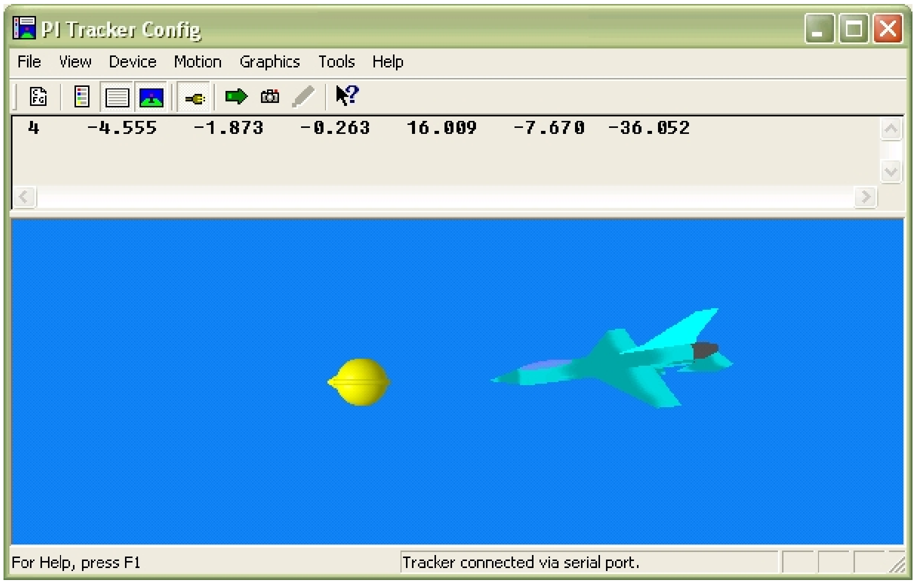


Figure 1-35: PiMgr Data Record Display (Using Marker 4)

The **Text Pane** will display the marker number and the retrieved XYZAER position and orientation.

	Position in inches			**Euler Orientation in degrees**		
Marker Number	**X**	**Y**	**Z**	**Azimuth**	**Elevation**	**Roll**
4	**-4.555**	**-1.873**	**-0.263**	**16.009**	**-7.670**	**-36.052**

1.6 *Using the PATRIOT WIRELESS ASCII Interface*

1. Navigate to HyperTerminal from the Windows XP Start Menu: Start ⇨ All Programs ⇨ Accessories ⇨ Communications ⇨ HyperTerminal.

NOTE: Windows Vista and later does not bundle the HyperTerminal serial communications utility. To use the PATRIOT WIRELESS ASCII interface on Vista, you will need to install a third party application to perform COM port serial communication.

2. Configure HyperTerminal and open a serial port:

- In HyperTerminal, enter a session name, choose an icon, and select OK
- In the “Connect using” field, select the desired COM port (COM1) and select OK.
- In the “Bits per second” field, select 115200.
- In the “Data bits” field, select 8 (default).
- In the “Parity” field, select None (default).
- In the “Stop bits” field, select 1 (default).
- In the “Flow control” field, select None and select OK

3. You ould now have a serial connection opened to PATRIOT WIRELESS. Turn the system on. In 5 to 10 seconds, you will see the startup message in the HyperTerminal Screen:

`PATRIOT WIRELESS Ready!`

Refer also to Table 1 on page 5.

4. To track a wireless marker, PATRIOT WIRELESS receptors must be *aligned*. By default, PATRIOT WIRELESS receptor 1 is automatically aligned as the *anchor receptor* at (0,0,0), so for this Getting Started example, it is not necessary to align any receptors. To learn more about receptor alignment, refer to Section 3.3, Receptor Setup.

5. Further, to track a wireless marker the marker must be *launched*. To manually launch the marker, make sure that the receptor and powered-on marker are positioned in the test setup as described in Figure 1-5 in Section 1.2, Step 5. Use the 'L' – Launch Marker command (see page 83) in the HyperTerminal screen by typing the following ("<>" denotes the Enter key):

`l1<>`

With this command, the PATRIOT WIRELESS will attempt to launch a marker located directly behind Receptor 1.

6. To verify that the marker was launched, use the '^U' – Active Marker Map command (see page 71):

`^u0<>`

The PATRIOT WIRELESS will respond with a hexadecimal bitmap identifying the known markers. In our Getting Started example, marker 1 is being used, so the bitmap will have bit 1 set and the PATRIOT WIRELESS response will be:

`00u 000000000001`

If no markers were active, the bitmap would be all zeros. See the '^U' – Active Marker Map command reference on page 71 for a detailed explanation of this command.

7. PATRIOT WIRELESS is now ready to collect motion data from the marker. Collect a single data record from PATRIOT WIRELESS by typing the 'P' – Single Data Record Output command on page 86, noting that there is no '<>' required with this command:

`P`

PATRIOT WIRELESS will respond with a single frame of position and orientation data for marker 1:

```
01    -4.608   -1.488    0.345    6.706    2.283   -24.355
```

This frame of data is comprised of the ASCII header (“**`01`**”) that echoes the marker number (“01”), followed by six floating-point numbers for the XYZAER position and orientation of the marker.

NOTE: The values displayed in the sample output above are not the actual values; they represent an arbitrary placement of the marker and anchor receptor.

8. Continue experimenting with the position and orientation data. See Experiment with PATRIOT WIRELESS Data below.

1.7 *Experiment with PATRIOT WIRELESS Data*

1. With one or more launched markers in a stationary position, take some initial samples of data using the ‘P’ – Single Data Record Output command (see page 86) or the ‘C’ – Continuous Print Output on page 80.

2. Move the launched marker six inches toward the reference point or anchor receptor and place it in a stationary position. The value of the X position data will decrease by approximately six inches. The Y and Z values will remain roughly the same as the original data. If you left the attitude of the marker approximately the same as it was when you started, then the attitude data also will be approximately the same.

3. Change the orientation of one or more of the launched markers without changing position. Try twisting it in azimuth (in the same plane as the floor) by approximately 45 degrees and fix it in place. Now collect another data frame. The first four columns will be approximately as they were in Step 1, but the Azimuth data in column 5 will have changed by approximately 45 degrees.

4. Continue to experiment with the system as described in Steps 2 and 3 to demonstrate that it measures the position and orientation (6 Degrees Of Freedom) of the marker(s) with respect to the reference point (or anchor receptor).

2. Component Description

2.1 *System Electronics Unit (SEU)*

The SEU is a stand-alone unit that may be located anywhere that is convenient to the work area, AC power and the host computer. It contains the required input and output connectors and controls to support up to 2 receptors, the USB port, and the RS-232 port. See Figure 1-1 on page 1 for a picture of the SEU. The PATRIOT WIRELESS supports up to 4 wireless markers.

2.1.1 Receptor Ports (2)

The receptor ports are 15-pin high density receptacle "D" type connectors located on the front of the SEU as shown in Figure 1-2 on page 2. The PATRIOT WIRELESS SEU supports up to 2 receptors.

2.1.2 LED Indicator

An LED "power on" indicator is located on the front of the SEU. Upon power up, the indicator will blink red for 5-10 seconds while the system performs its initialization and self-test routines. When these routines are completed, the indicator changes from blink mode to steady-on mode, indicating that the system is ready for operation. At this point the LED color gives the status of the receptor alignment. If the LED continues to flash red, the self-test and startup has failed, The following table summarizes the LED condition.

Table 2 LED Indicators

• **Steady green**	**System operational**	**Detected receptor is ready for marker detection.**
• **Solid red**	**System operational**	**Detected receptor is not ready (needs alignment).**
• **Flashing red**	**Failed self-test and set-up.**	

2.1.3 RS-232 I/O

The RS-232 I/O serial connector is a standard 9 pin plug "D" type connector located on the rear panel of the SEU as shown in Figure 1-2 on page 2. The pinout identification for this connector is shown in Table 3, below.

Table 3 RS-232 Pin-Outs

Pin	PATRIOT WIRELESS		Host
1	**Not used**		**Not used**
2	**RxD**	←	**TxD**
3	**TxD**	→	**RxD**
4	**Not used**		**Not used**
5	**GND**	—	**GND**
6	**Not used**		**Not used**
7	**Not used**		**Not used**
8	**Not used**		**Not used**
9	**Not used**		**Not used**

The PATRIOT WIRELESS is set to 115.2K baud as the default speed. This setting can be changed with the '^O' – RS-232 command on page 68.

Hardware Switches

NOTE: UP switch position is a logic ‘1’ and DOWN is logic ‘0’.

The hardware switches are located on the rear panel of the SEU to the left of the RS-232 serial port connector as depicted in Figure 1-8 on page 5. PATRIOT WIRELESS reads baud rate and parity RS-232 connection settings from these switches only on power up. If you change the switches to obtain a different setting, you must restart PATRIOT WIRELESS either by using the ‘^Y’ – Initialize System command (page 96) or by cycling the power.

Alternatively, the ‘^O’ – RS-232 Port Configuration command (page 68) may be used to configure the RS-232 connection during operation. However, after using this command and saving the new settings to the startup configuration (‘^W’ – Set Operational Configuration, page 95), the saved settings will be ignored during the next power up or system initialize (‘^Y’ – Initialize System) in deference to the hardware switch settings.

The hardware switches are numbered 1 to 5 from left to right. Switch setting definitions are provided in Table 4, below.

Table 4 Switch Settings

Baud Rate Switches

1	2	3	
⇩	⇩	⇩	**115,200**
⇩	⇩	⇧	**57600**
⇩	⇧	⇩	**38400**
⇩	⇧	⇧	**19200**
⇧	⇩	⇩	**9600**
⇧	⇩	⇧	**4800**
⇧	⇧	⇩	**2400**
⇧	⇧	⇧	**reserved**

Parity Switches

4	5	
⇩	⇩	**None**
⇩	⇧	**Odd**
⇧	⇩	**Even**
⇧	⇧	**reserved**

2.1.4 USB I/O

The USB connection is made with a standard Series A receptacle connector.

2.1.5 RS-422 I/O

The PATRIOT WIRELESS does not come with an RS-422 option. If RS-422 is needed, standard conversion modules are available from several sources. Contact Polhemus Customer Service (see APPENDIX E) if help is needed.

2.2 *Receptor*

The receptor is a cabled device that tracks electro-magnetic fields produced by the wireless markers. Arrays of receptors usually are fixed to positions on non-metallic surfaces in the desired motion tracking environment. The standard receptor measures approximately 1.5 inches H x 1.5 inches W x 2.5 inches L and has a cable length of up to 60 feet. The dimensions for the standard receptor are shown in Figure 2-1 including the position of the electrical center. The receptor package provides three mounting holes for the ¼ inch nylon screws supplied.

NOTE: Nylon hardware is provided to install the receptor. Lightweight fasteners such as wall mount adhesive or double-sided tape can be used to affix each receptor to its temporary location. Metallic hardware such as screws, nuts and bolts in moderate proximity to the receptor have little to no effect on the accuracy of the PATRIOT WIRELESS operation.

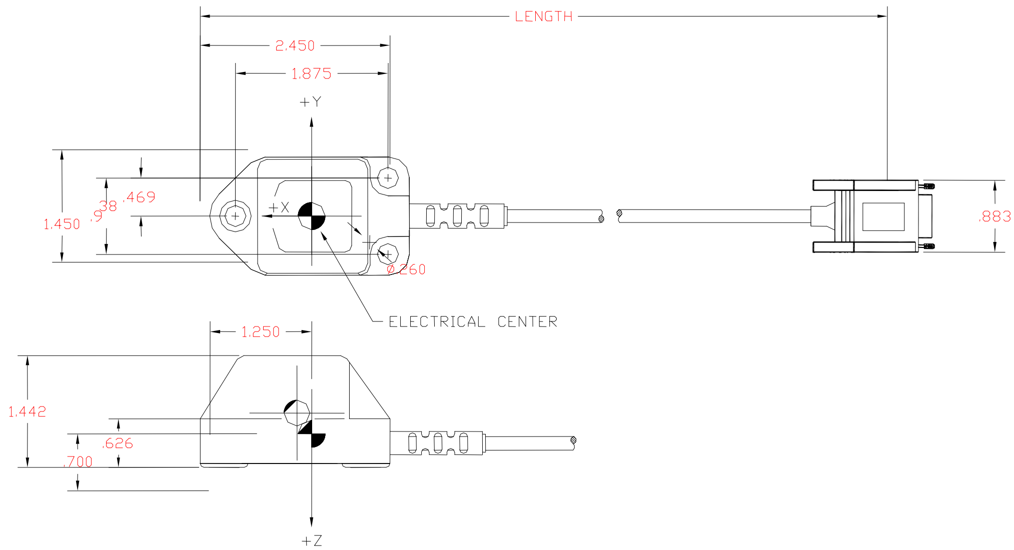


Figure 2-1: Receptor

2.3 *Extended Marker*

The extended marker uses quick-charging lithium-ion technology, ensuring maximum battery life and maximum power. The position and orientation of the marker is measured relative to a pre-defined coordinate reference frame in the motion tracking environment. By default, this reference frame is defined by one of the receptors, which is designated as the “anchor” Receptor.

The dimensions of the extended marker are shown in Figure x-x.

The marker incorporates a removable, rechargeable battery pack assembly, a power switch and an LED power indicator. Markers are available in 4 different frequencies for use with the PATRIOT WIRELESS system, allowing for simultaneous operation in the motion tracking environment.

When the power switch is moved to the ON position, the LED will flash red for less than a second and then go off. The LED goes solid red when there is about 10 minutes life left in the battery. If the LED does not flash when the power switch is moved to the ON position, then the battery needs to be recharged. A fully charged extended marker battery should operate for 6 hours or more.

NOTE: As with all batteries, capacity (run-time) will diminish over time due to battery age and charging cycles.

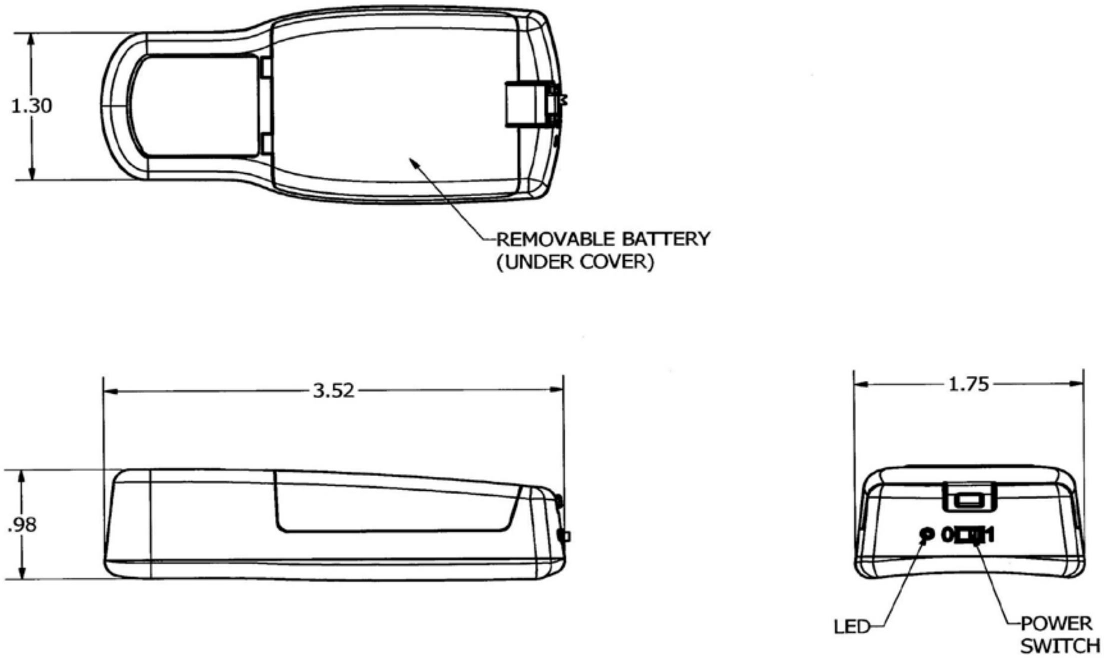


Figure 2-2: Extended Marker Dimensions (inches)

The extended marker battery can be recharged with a standard off-the-shelf plug-in battery charger such as the one pictured below in Figure 2-3. This charger is included in a complete PATRIOT WIRELESS system.

Figure 2-3: Extended Marker Battery Charger

2.4 *Standard Marker (Discontinued)*

The standard wireless marker uses a lithium-ion/lithium polymer battery. The operation of the extended marker is the same as the extended marker. A fully charged standard battery should operate for up to 2 continuous hours.

Note: The standard marker has been discontinued. The PATRIOT WIRELESS now ships with the extended marker.

The dimensions if the standard marker are shown in Figure 2-4.

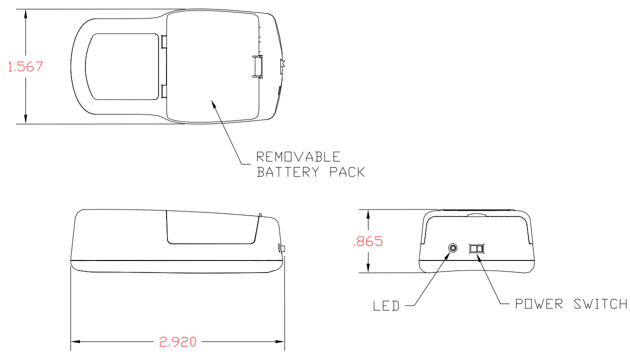


Figure 2-4: Standard Marker Dimensions (inches)

2.5 *Quad Charger (Discontinued)*

A charger is provided for maintaining the charge on up to four of the standard marker Lithium ion/Lithium polymer batteries at a single time. Recharging time to maximum capacity is approximately 2.5 hours regardless of the number of batteries being recharged.

The standard marker charger consists of three components: the charger chassis, a power cord, and an external power supply. Figure 2-5 shows the charger. It has receptacles across its top that are identical in size and shape to the actual PATRIOT WIRELESS marker so that the battery pack is inserted and extracted in exactly the same fashion as in the marker. The easiest way to insert the battery is shown in Figure 1-24. The most successful way to extract the battery is to use the grip and fingernail placement shown in **Error! Reference source not found.**.

Figure 2-5: Standard Marker Battery Charger, Front View

Figure 2-6 shows the rear view of the charger, including the power supply connected to it, the ON/OFF switch and the green Power ON indicator LED that is just over the top corner of the chassis between the DC receptacle and the switch.

Figure 2-6: Standard Marker Battery Charger and Power Supply, Rear View

3. SYSTEM OPERATION

NOTE: Several of the processes for system operation are described in this section using the Polhemus PiMgr GUI. For detailed instructions on getting started with PiMgr, see Using the Polhemus PiMgr GUI on page 16. Where applicable, steps in these procedures also include reference to the ASCII command or commands needed to perform them. Finally, if you are using the Polhemus SDK to program your own interface to the PATRIOT WIRELESS, the steps detailed here will be of interest, but for programming guidelines please refer to the **Polhemus SDK Online HELP** program. Navigate to this help program via the Windows **START** menu:

Start ⇨ All Programs ⇨ Polhemus ⇨ PDI.

3.1 *I/O Considerations*

There are two possible interface configuration options available on the PATRIOT WIRELESS: USB or RS-232. Each configuration supports either Binary or ASCII formats.

Upon power up or system initialization, if the USB cable is not plugged into the SEU, the PATRIOT WIRELESS will automatically send data to the RS-232 interface. The USB cable can be plugged in at any time and the PATRIOT WIRELESS will shift to USB operation. If the USB is unplugged, the PATRIOT WIRELESS' power must be recycled to shift back to RS-232 operation.

3.2 *Powering Up PATRIOT WIRELESS*

To power-up the PATRIOT WIRELESS, first ensure that the power switch on the back panel is in the OFF (DOWN) position.

- Connect the power cord to the power supply, then connect the power supply to the SEU and plug the power cord into the AC wall outlet.
- Plug in the desired number of receptors and secure them with the connector screws.
- Plug in the desired I/O cable (USB or RS-232).
- Turn the power switch to the ON (UP) position.

Upon power up, the front-panel LED indicator will blink red for 5 to 10 seconds to indicate the system is performing initialization and self test. During this time, system operation is not possible. At the completion of the power-up sequence, the LED will change from a flashing red state to a steady state. The LED will remain solid red if any connected receptors have not been aligned. This is not a system failure, but a warning that the receptors must be aligned prior to tracking markers. See Table 2, LED Indicators, on page 23 for a description of the LED status.

If connected via RS-232, a "PATRIOT WIRELESS Ready!" text message will be sent to the RS-232 port when initialization is complete. This message will be seen if the port is connected to a host system and a terminal emulation program is running.

If connected via USB, no message appears after initialization. After the front panel light indicates initialization is complete, the host computer must initiate communication with the PATRIOT WIRELESS before any message will appear.

3.3 *Receptor Setup*

Before PATRIOT WIRELESS can generate position and orientation coordinates for wireless markers, the position and orientation of the receptors must be known and a common frame of reference must be defined for the coordinates of the tracked markers. The process of setting up the PATRIOT WIRELESS with this information is called *Receptor Alignment*. Receptor alignment data can then be stored in PATRIOT WIRELESS non-volatile memory so that the process does not need to be repeated unless the receptor positions are changed.

3.3.1 Receptor Positioning and Setup

When arranging receptors in the motion capture area, there are a few things to keep in mind:

- PATRIOT WIRELESS accuracy is best when markers are within approximately 2 to 2.5 feet (0.6-0.75m) of a receptor. Therefore, receptors should be arranged and mounted no more than 4 to 5 feet (1.2-1.5m) apart.
- To minimize magnetic distortion, secure receptors to non-metallic surfaces with nylon, fiberglass, or stainless steel 302 screws.
- Route the receptor cables to the SEU in a manner that avoids hazards in the traffic pattern.

3.3.2 Setting Receptor Alignment

When configuring PATRIOT WIRELESS receptor alignments, you choose an alignment reference location. Then the position and orientation relative to the reference location is measured by hand for each receptor in the array. Each receptor's alignment P&O data is then input to the PATRIOT WIRELESS.

To perform this alignment process, you will need:

- All receptors mounted and connected to the PATRIOT WIRELESS;
- PATRIOT WIRELESS powered ON.

If you are using the Polhemus PiMgr GUI to perform the alignment:

- PiMgr should be running and have a connection to the PATRIOT WIRELESS established;

  and

- **Receptor Alignment** dialog should be open. Open this dialog via the ***Device*** menu: **Device⇨ Wireless Operations ⇨ Receptor Alignment** (see Figure 3-1, page 31) or type the keyboard shortcut '^A' – Receptor Alignments (page 88) in the PiMgr window. Refer to the Help button on this dialog if needed.

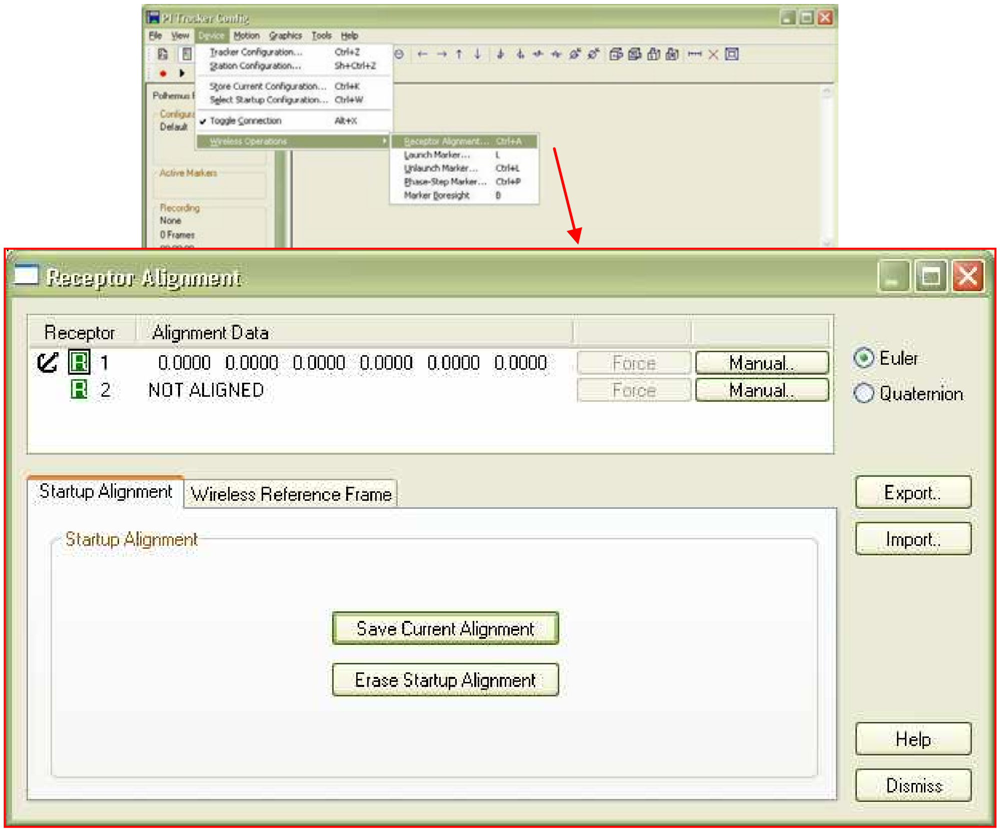


Figure 3-1: Receptor Alignment Dialog

1. Choose a Reference Location

First, determine the *alignment reference location*, a location from which you will measure the position and rotation of each of your receptors. This point may be inside or outside of your motion environment. It does not matter where it is, but it is important that the position and orientation of each receptor be measured from this location.

NOTE: By default, Receptor 1 is automatically aligned at the origin. This alignment may be edited using the steps below.

2. Measure Receptor Position and Orientation Relative to the Origin

Next, carefully measure the position and orientation of each receptor relative to the reference location. To specify a receptor's measured P&O, find the entry of the receptor in the receptor list at the top of the dialog and select the Manual.. button next to that entry; see Figure 3-2.

The **Set Receptor Alignment** dialog will appear. Enter the measured P&O into the fields in this dialog and select OK as shown in Figure 3-2.

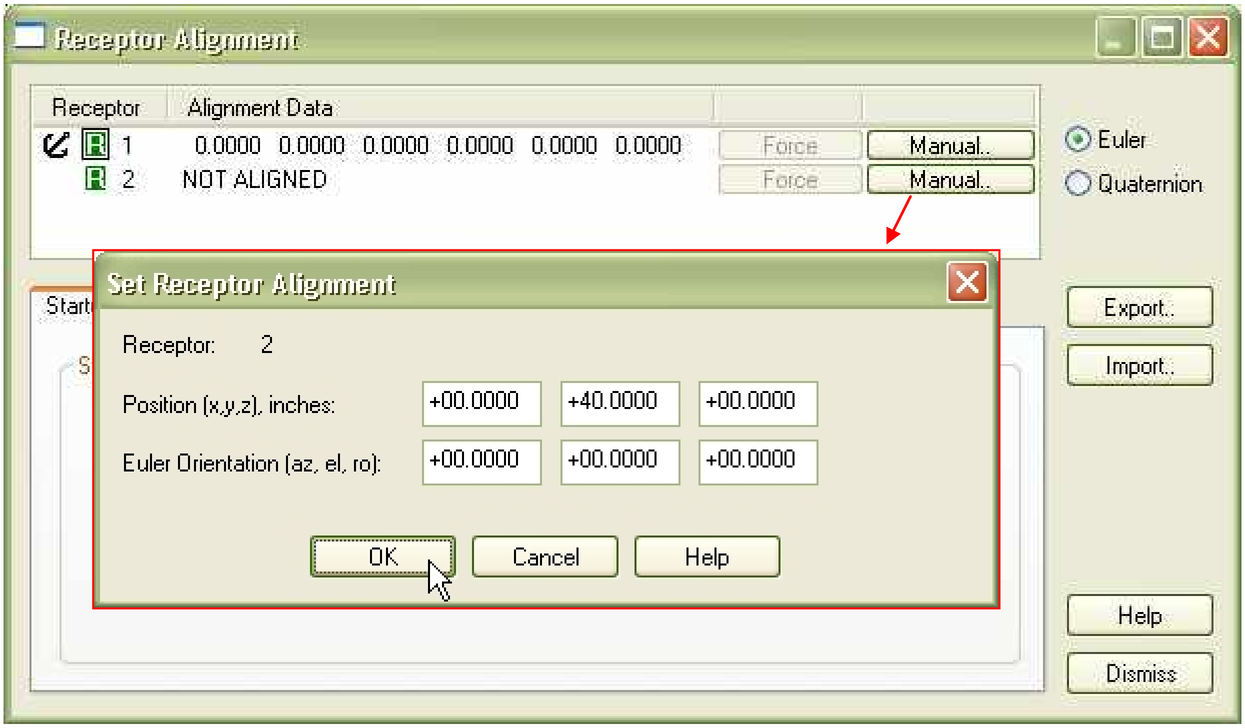


Figure 3-2: Set Receptor Alignment

The receptor will now be indicated in the receptor list with a R. The alignment data column associated with that receptor will also show the XYZAER coordinates that you have measured and input.

Repeat this process for each receptor in the array.

To perform this process through the ASCII interface, refer to ASCII Command '^A' – Receptor Alignments on page 88.

NOTE: Receptor alignments may be reconfigured at any time.

3.3.3 Saving Alignment Data

To avoid the need to realign the receptors each time the PATRIOT WIRELESS is restarted, the receptor alignments can be saved as the "Startup Alignment." When a Startup Alignment has been saved, the PATRIOT WIRELESS receptors will already be aligned and ready to go each time the PATRIOT WIRELESS is restarted.

Regardless of the existence of a Startup Alignment in PATRIOT WIRELESS memory, the receptors ***can*** be aligned and realigned at any time.

To manage the saved Startup Alignment data, open the **PATRIOT WIRELESS Receptor Alignment** dialog in the PiMgr GUI and select the ***Startup Alignment*** tab.

From this control, you can:

- **Save the current receptor alignment data** as the Startup Alignment. The next time the PATRIOT WIRELESS is restarted, the receptors will be automatically aligned with the current alignment data.

- **Erase the saved startup alignment data.** The next time the PATRIOT WIRELESS is restarted, it will require receptor alignment before it can track markers. This should be done each time a setup is modified.

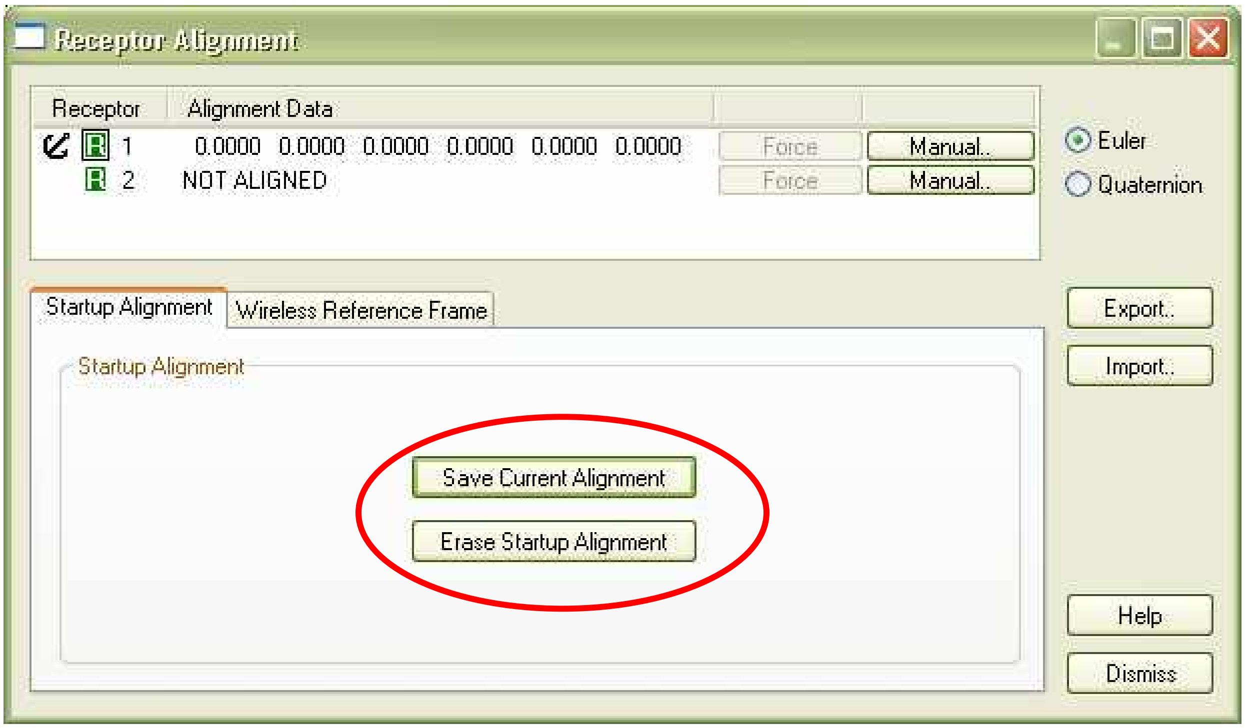


Figure 3-3: Save or Erase Startup Alignment Data

NOTE: This does not erase the *current* alignment data. It only erases the *startup* alignment data. If the PATRIOT WIRELESS is currently aligned, it will remain aligned until it is restarted.

See the PiMgr Online help for details.

NOTE: It is not necessary to erase the saved startup alignment before saving a new receptor alignment.

See also '^S' – Startup Receptor Alignment Configuration on page 70.

3.3.4 Reference Frame Setup

By default, all marker P&O is referenced to the *alignment reference location* used during alignment. In some circumstances it may be necessary to select another frame of reference for position and/or orientation for the tracked markers.

For example, if the *receptors* must be mounted upside down (rolled 180°) or in some other orientation relative to the alignment reference location, the frame of reference can be set so that marker orientations will also be rolled 180°.

The frame of reference could also be set in a more dynamic fashion (if the exact P&O of the desired frame of reference is not known), by placing a marker at the desired location and attitude and instructing the PATRIOT WIRELESS to use the marker's current P&O as the reference frame instead of the anchor's P&O. It is also possible to use only the marker's orientation as a rotation reference, and leave the origin as it is.

To configure the PATRIOT WIRELESS frame of reference, open the **Receptor Alignment** dialog in the PiMgr GUI and select the ***Wireless Reference Frame*** tab.

From this control, you can:

- Reset the frame of reference to (0,0,0,0,0,0) and restore it to the alignment reference location: the anchor receptor or the reference location from which manual alignments were measured
- Set the frame of reference explicitly to XYZAER coordinates
- Set the frame of reference rotation to the current orientation of a marker
- Set the frame of reference translation and rotation to the current P&O of a marker

See the PiMgr Online help for details.

NOTE: When using a marker to set the frame of reference, the lowest-index marker that is currently active is used. The PiMgr control indicates which marker should be used. See also ASCII Command 'G' – Marker Reference Frame on page 54.

3.3.5 Receptor Close Range Mode

PATRIOT WIRELESS can support up to four markers with a single receptor. It is for this reason that the PATRIOT WIRELESS receptor signal processing does not employ Automatic Gain Control (AGC): If one marker is far from a receptor and forces a gain increase, a second marker that is close to the receptor can cause saturation in the receptor's preamplifier. Once a receptor saturates, the tracking information is lost and the marker must be launched again.

For this reason, the PATRIOT WIRELESS system defaults all receptors to Close Range Mode, or a minimum receptor gain setting. This allows markers to be tracked up to 5 feet (1.5 m) away from a receptor and also operate within inches of a receptor.

If a longer range (5-8 feet) is desired, the Receptor Close Range can be disabled with the '@R' – Receptor Close-Range Mode ASCII command (see page 78). With Close Range Mode disabled, marker operation is possible up to 8 feet (2.5 m) from the receptor, but the closest a marker can operate to the receptor without causing preamp saturation is 12-18 inches (30-45 cm).

If two receptors are being used, the Receptor Close Range Mode can be disabled as long as the receptor saturation is less than 5 feet (1.5 m). This is because in this configuration, if one receptor is saturated, the other receptor is able to retain the tracking information.

3.4 *Marker Operation*

When PATRIOT WIRELESS is ready (already running and receptors are aligned), it is capable of tracking up to 4 wireless markers. Before this can happen, however, markers must be **installed** and **launched**.

Each physical marker has a unique ID and data set. Marker data records are stored (or *installed*) in PATRIOT WIRELESS memory. When a marker is *launched* or introduced into the tracking environment, the PATRIOT WIRELESS detects the frequency of the new marker signal. If marker data associated with that frequency has been installed, PATRIOT WIRELESS will begin tracking the marker using the installed data set.

Some Notes about Marker Frequency:

- Only one marker of a given frequency can be launched at any given time. There are four (4) possible marker frequencies.
- If more than one marker data record for a frequency is installed, PATRIOT WIRELESS will try each data record for that frequency and select the record that produces the best result.
- If no records are found for a frequency, the marker will be tracked with default marker data values but the accuracy will be impaired.

Each newly shipped PATRIOT WIRELESS has marker data records pre-installed for any markers that are shipped with the PATRIOT WIRELESS. Markers shipped individually must be installed to the PATRIOT WIRELESS before they can be tracked effectively. A CD containing this data will be shipped with the new marker(s), ready to install on the system. See Marker Installation on page 40.

3.4.1 Marker Launch and Unlaunch

Markers can be launched and unlaunched manually or automatically. To autolaunch a marker, two receptors must be installed and aligned (see 3.3.2 Setting Receptor Alignment on page 30). There are tradeoffs involved with each approach. Launching a marker manually takes more time; the marker must be deliberately placed and oriented before instructing the PATRIOT WIRELESS to detect it. Similarly, unlaunching a marker requires an explicit instruction to the PATRIOT WIRELESS.

When a marker is launched automatically, it can be introduced into the environment at any place or orientation and the PATRIOT WIRELESS will detect it and begin tracking it without any specific instruction to do so. In this mode, markers will also be automatically unlaunched when they leave the environment.

The tradeoff with automatic marker launch is that the PATRIOT WIRELESS cannot guarantee that it will report the orientation of the newly detected marker correctly. (Position will always be correct.) The reason for this is that the marker can enter the environment at any location and it can be at any orientation. If the orientation is unknown initially, the calculated orientation has only a one in four chance of being correct.

The orientation can be corrected with the ‘^P’ – Phase Step command (see page 93) after the marker has been launched automatically; however, the feasibility of this approach varies with the application.

3.4.2 Manual Marker Launch

When launching markers manually, indicate the receptor at which the marker will be launched, place the marker near that receptor in a known position and orientation, and then instruct the PATRIOT WIRELESS to detect and launch the marker.

To perform the manual marker launch process, you will need:

- The PATRIOT WIRELESS powered ON;
- All receptors aligned (refer to ‘^A’ – Receptor Alignments on page 88);
- A powered ON wireless marker to launch.

If you are using the Polhemus PiMgr GUI to perform the manual marker launch:

- PiMgr should be running and have a connection to the PATRIOT WIRELESS established; and
- Launch PATRIOT WIRELESS Marker dialog is open. Refer to the Help button on this dialog if needed. Refer to PiMgr Online Help for instructions on opening this dialog.

1. Select Launch Receptor

First determine and specify at which receptor the marker will be launched. Select the entry in the receptor list in the dialog. Be sure that the receptor you have selected is detected and aligned and identified with .

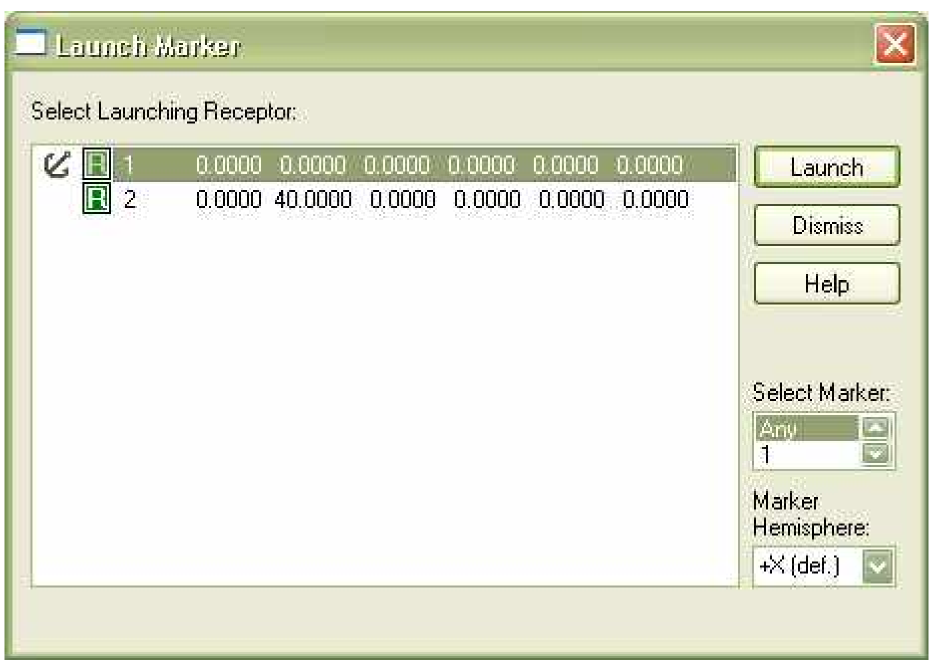


Figure 3-4: Select Launch Receptor

2. **Place Marker**
   Place the marker to the rear of the selected launch receptor and about 10-12 away from it. Make sure that the marker is oriented so that the +X *forward* direction of the marker is toward the rear of the receptor. The receptor and marker should be aligned head to tail; see Figure 3-5.

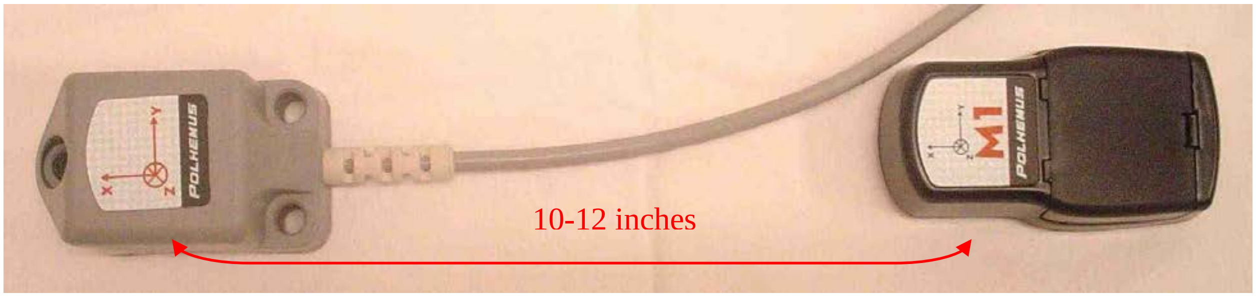


Figure 3-5: Marker Launch Orientation

3. **Launch Marker**
   With the marker positioned, select the Launch button.

   To launch additional markers, repeat steps 1 through 3. Select the Dismiss button to close the dialog. See also ASCII Command 'L' – Launch Marker on page 83.

   NOTE: It is possible to specify the marker you wish to launch, and the hemisphere from which the marker is launching. Refer to the PiMgr Online help for details, or to the ASCII command reference 'L' – Launch Marker on page 83.

3.4.2.1 *Manual Marker Unlaunch*

Markers are manually unlaunched simply by sending the '^L' – Unlaunch Marker command on page 92.

To manually unlaunch a marker:

1. Open the Unlaunch PATRIOT WIRELESS Marker dialog in the PiMgr GUI.

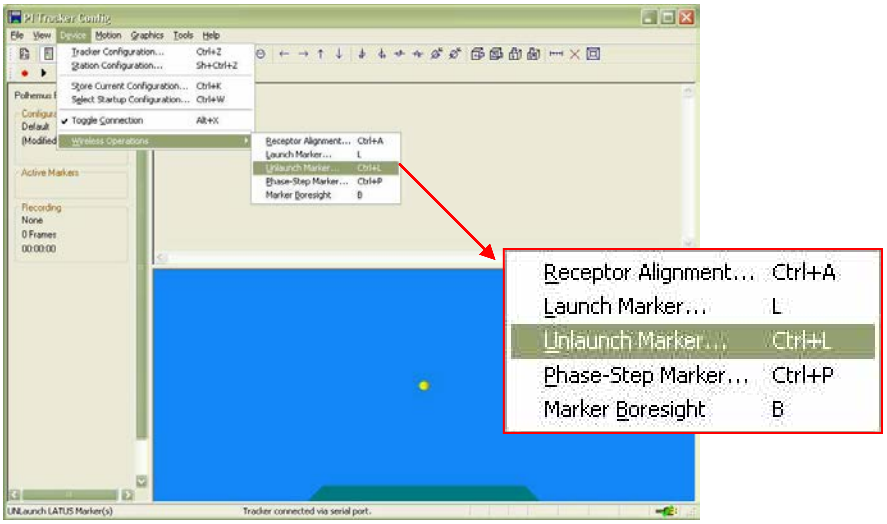


Figure 3-6: Unlaunching a marker

2. Select an individual launched marker from the list (identified by  or select all markers by selecting on Select All (see).

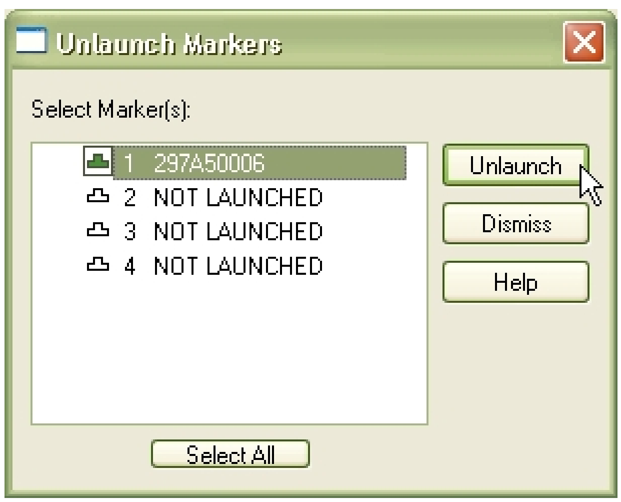


Figure 3-7: Select marker to unlaunch

3. Select the Unlaunch button to unlaunch the selected marker(s).

Refer also to the ASCII Command ‘^L’ – Unlaunch Marker on page 92.

3.4.2.2 Automatic Marker Launch and Unlaunch

Before launching markers automatically, two receptors must be installed and properly aligned (see **3.3.2 Setting Receptor Alignment**, page 30), and a configuration setting must be applied to PATRIOT WIRELESS to put it into AutoLaunch mode. (Refer to ‘@A’ – Autolaunch Mode command on page 75 for a discussion on AutoLaunch orientation ambiguity.) This setting can be saved in the startup configuration so that PATRIOT WIRELESS will always be in this mode when it is started or reset (see Configuration Changes on page 41). When in this mode, PATRIOT WIRELESS will detect when a marker enters the motion tracking environment and will automatically launch the marker and begin tracking it. Similarly, PATRIOT WIRELESS will detect when the marker has left the environment and will automatically unlaunch it. The sensitivity of PATRIOT WIRELESS to marker signals entering and leaving the environment is configurable so that the feature can be "tuned" to the environment to prevent the Autolaunch from triggering in error.

To enable the PATRIOT WIRELESS AutoLaunch mode:

- Open the **Tracker Configuration** dialog in the PiMgr GUI;
- Select the **AutoLaunch** tab;
- Select the ***Enable AutoLaunch*** checkbox;
- To adjust the launch and unlaunch signal sensitivity, modify the ***Launch*** and/or ***Unlaunch*** range criteria.

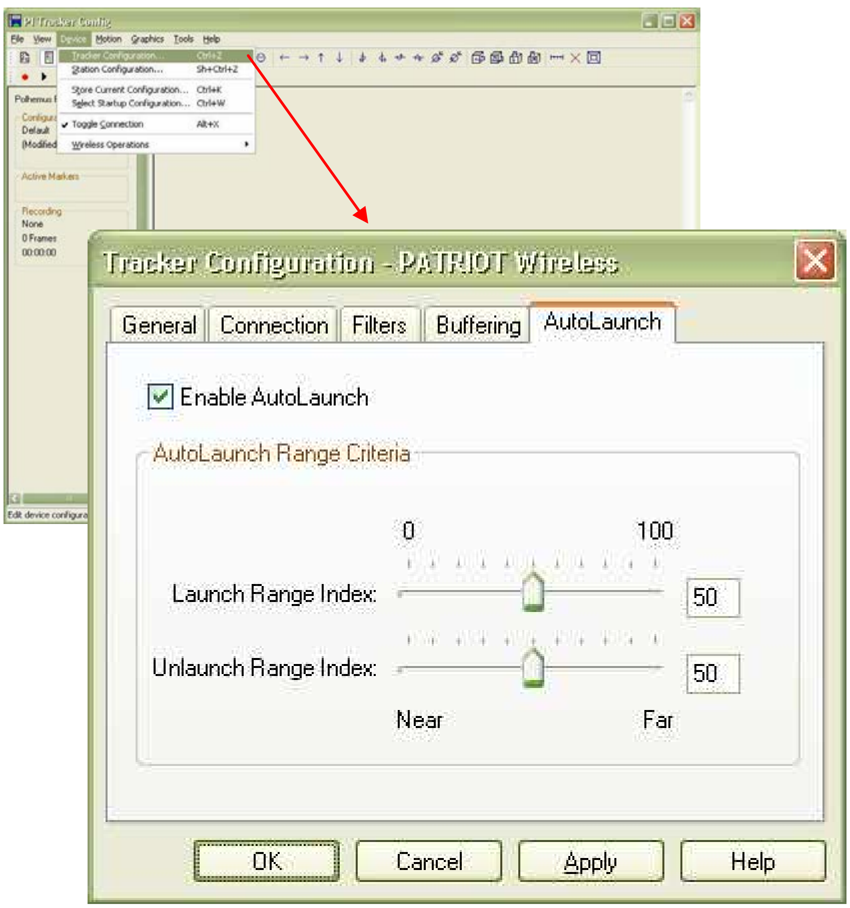


Figure 3-8: Autolaunch

NOTE: Higher values in these index criteria cause PATRIOT WIRELESS to be more sensitive to detected signal levels, and therefore allow new markers to be automatically launched or unlaunched when farther away from detecting receptors.

- Select the 

button to apply the new PATRIOT WIRELESS settings.

Refer to ASCII Commands ‘@A’ – Autolaunch Mode on page 75, and ‘^G’ – Set Autolaunch Criteria on page 65.

3.4.3 Marker Installation

Each newly shipped PATRIOT WIRELESS has marker data records pre-installed for any markers that are shipped with the PATRIOT WIRELESS. A CD-ROM containing the records is also supplied as backup.

To view marker data records installed in the PATRIOT WIRELESS, open the **Manage Wireless Markers** dialog from the PiMgr GUI ***Tools*** menu. This dialog displays serial numbers of all marker records installed in the PATRIOT WIRELESS, sorted by frequency index. From this dialog, marker records can be manually installed and un-installed, although this utility should be required only in rare circumstances. The ‘M’ – Installed Markers command (see page 56) may also be used to retrieve a list of installed markers from the PATRIOT WIRELESS directly.

Markers purchased individually must be installed to the PATRIOT WIRELESS before they can be tracked effectively. The marker records are supplied on a CD-ROM and the self-installing executable on the CD will automatically copy the marker records to the host computer and install them onto the PATRIOT WIRELESS through a guided step-by-step process. Once installed, the markers can be viewed in the **Manage Wireless Markers** dialog.

3.5 *Update Rate*

The data output update rate for the PATRIOT WIRELESS is 50 Hz.

3.6 *Output Considerations*

Many applications of the PATRIOT WIRELESS involve using its data output to manipulate some type of computer graphics in real time. In this circumstance, it is important to allow the data to be processed as quickly as possible and to optimize PATRIOT WIRELESS configurations so as to diminish latency or lag.

Factors affecting latency are:

- Output Record Length
- Data Format (binary is more efficient than ASCII)
- Filtering (data are produced at normal times but will show effects of filter lag)
- USB Buffering Mode (should be disabled to minimize latency; see ‘@B’ – USB Buffering Mode on page 76)

Factors affecting lag are:

- Competing processes running on the host computer
- Connection type: RS-232 vs. USB

In general the RS-232 will have the lowest lag but, any lag encountered using USB can be reduced or eliminated by disabling '@B' – USB Buffering Mode (see page 76).

3.6.1 Adaptive Filters

The PATRIOT WIRELESS contains an adaptive filter that is designed to control noise in the data output. The filter can be applied to position or orientation, or both. It should be noted that the effect that is seen in the data may have (or appear to have) a slower dynamic response with medium or heavy filtering selected. Although data transferred is at normal time, the filtering gives it the appearance of lag.

In the PiMgr GUI, change the adaptive filters in the **Tracker Configuration** dialog, ***Filters*** tab.

See the ASCII Commands 'Y' – Attitude Filter Parameters on page 62 and 'X' – Position Filter Parameters on page 60 for more information on setting the filters.

3.6.2 Increment

PATRIOT WIRELESS can be configured to only change output data when the new P&O of markers has changed by a specified amount, or *increment*.

In the PiMgr GUI, set the increment in the **Device ⇨ Station Configuration** dialog, ***Increment*** tab.

See the ASCII Command '^N' – Increment on page 67.

3.7 *Configuration Changes*

The PATRIOT WIRELESS will start up with a default configuration unless set to a different start-up configuration. Up to three user-defined configurations can be stored in the PATRIOT WIRELESS. Any one of these configurations can be set as the startup configuration.

In the PiMgr GUI, manage configurations in the **Device ⇨ Store Current Configuration or the Device ⇨ Select Startup Configuration** dialogs.

See also ASCII Commands '^K' – Save Operational Configuration on page 91 and '^W' – Set Operational Configuration on page 95 for instructions on how to set and store configurations.

3.8 *Charging Marker Batteries*

Operation of the charger is accomplished as follows:

1. Assure that the power switch is in the OFF position.
2. Plug in the power supply circular 5 VDC cord at the receptacle near the power switch.
3. Plug the power cord into the power supply. Plug the power cord into a power mains outlet (using any adapters, as appropriate, since it will operate under AC voltages of 100-240 volts and 47-63 Hz) prior to inserting any of the battery packs.

4. Actuate the power switch to the ON position and observe that the power indicator illuminates green.

5. Turn to the front of the unit to note the four red LED charge indicators. With no batteries inserted for charging, these indicators may (or may not) blink.

To charge one to four of the Lithium ion/Lithium polymer battery packs, perform the following:

1. The power switch can be in either the ON or OFF position when inserting batteries, but at the outset we recommend turning off the power or unplugging the power supply from the power mains.

2. Insert one or more battery packs into the receptacles. The charging circuits are independent of each other for each charging station so that the station chosen is totally arbitrary.

3. Move the power switch to ON (or plug in the power supply and observe that the power indicator illuminates. Observe that the indicator corresponding to the battery being charged in the receptacle above it will illuminate steadily without flickering ON and OFF.

4. While a battery is charging, the red LED indicator remains solid ON, and when the battery is totally charged the indicator will automatically extinguish. Any combination of the four indicators could be occurring at a given time; random ON/OFF, solid ON or solid OFF depending on the state of usage and state of battery charge(s).

5. After the indicator is extinguished, the fully charged battery may be removed and is ready for use in a marker.

6. After all batteries have been charged, the charger should be turned OFF and/or its power supply unplugged from the power mains.

7. Do not keep batteries plugged in charger with charger power OFF. The batteries will very slowly discharge back through the charger.

-CAUTION-

The Quad Charger is specifically designed to charge the batteries contained in the Polhemus wireless marker. Its voltage and charging current are adjusted for this particular Lithium ion/Lithium polymer battery. The charger should NOT be used to charge any other battery, Lithium ion/Lithium polymer or other type. Even among Lithium ion/Lithium polymer batteries, the characteristics vary such that charging is unique for any given design. To misuse the charger for charging any other battery, the user assumes all liability risks of damage to the battery, the charger, and to the operator or other equipment.

Please note that Lithium ion/Lithium polymer batteries have excellent self-discharge characteristics so that keeping extra batteries charged and waiting for use is the best strategy for quickly powering up a marker even after a month-long wait.

HANDLING RECOMMENDATIONS FOR LITHIUM ION OR LITHIUM POLYMER BATTERIES

In order to obtain optimum performance, please follow the warnings and safety instructions listed in the handling precautions below.

- **Keep Lithium ion/Lithium polymer batteries away from children. If a battery is swallowed promptly call your doctor.**
- **Do not allow any Lithium ion/Lithium polymer battery to come into contact with water or liquid of any kind. Do not leave the battery near flames, heaters, (microwave) ovens, stoves, fireplaces or other high-temperature locations. Excessive heat could cause the battery to deteriorate. Do not heat the battery or throw it into a fire. This can damage the safety vent and cause the electrolyte to catch fire.**
- **Do not leave the battery in a hot condition like strong direct sunlight, inside automobiles behind the windscreen, etc. This can overheat the cell and will reduce the battery's performance.**
- **Do not damage the battery in any way by nailing, hammering, crushing, etc. This can cause the cell to leak and/or to short circuit internally.**
- **Do not combine batteries of different capacities, types or brands.**
- **If a battery leaks or emits a strange odor during use or storage, stop using the cell immediately. Leaking electrolytes are flammable.**
- **If any fluid that has leaked from the battery comes into contact with skin or clothing, rinse with tap water or other clean water immediately. Contact with skin can cause irritation or burns.**
- **If fluid from a battery gets into a person's eye, rinse the eye immediately with clean water and seek medical attention promptly. Do not rub the eye.**

4. PATRIOT WIRELESS System Commands

4.1 *Overview*

This section of the document specifies the PATRIOT WIRELESS Command Interface. It provides the basis for Interface development. The Command Interface defines the structure and function of commands PATRIOT WIRELESS will respond to and the messages PATRIOT WIRELESS will provide to an external device or 'Host.'

The Command Interface is comprised of ASCII commands. The interface is designed to work in a 'dumb terminal' mode, thus keeping the communications protocol simple and easy to use. These commands provided the building blocks for the Polhemus PATRIOT WIRELESS SDK.

Additional information is provided in this document to give the reader some background in the terminology and general science behind the Polhemus tracking technology.

Key factors that influence the design of the interface are also discussed.

All commands are input on the RS-232 serial port or USB port. Additionally, format notations and conventions for commands and outputs are presented first.

4.2 *Command Syntax*

4.2.1 Notation

The following notations are used in this manual to describe PATRIOT WIRELESS command syntax:

[ ] Items shown inside square brackets are optional. To include optional items, type only the information inside the brackets. Do not type the brackets.

<> Represents an ASCII carriage return or "enter" ('^M', 0x0d). Whenever shown this value must be present to terminate the command sequence.

... An ellipsis indicates that you can repeat an item.

, A comma represents a delimiter in a list of optional parameters. The comma must be present for those parameters which are omitted except for the case of trailing commas. For example:

Qs,p1,,,p4<>

is the proper command format when omitting parameters p2 and p3. Commas following the parameter p4 are not required if parameters p5 and p6 are omitted.

| A vertical bar means either/or. Choose one of the separated items and type it as part of the command. For example, ON|OFF indicates that you should enter either ON or OFF, but not both. Do not enter the vertical bar.

^ A caret in front of a command letter indicates that the control key should be held down while typing the command letter. Control commands produce ASCII values between 0x00 and 0x1F.

@ An "at" symbol in front of a command letter designates a unique 2-character command, independent of the plain command letter or a control-key ('^') sequence.

4.2.2 Command Format Notes

- Commands and alphabetic parameters are NOT case sensitive.
- Commands that use optional parameters use current system retained values for parameters omitted from the command. See Station Wildcard, below.
- The term *"station"* in the command syntax descriptions is a generic term for marker(s) or receptor(s), whichever the command applies to.
- Unless otherwise noted, commands do not take any punctuation immediately following the command letter. However, if an optional first parameter is to be omitted, a comma is necessary between the command letter and the next argument.
- With the exception of the 'P' command and unless otherwise noted, all command strings are terminated with a '<>' (carriage return).
- A numeric floating point value will be accepted by the machine if any of the following formats are used: for example, 3.0 may be specified as: 3, 3., 3.0 or 3.0E+00.

Station Wildcard

When using a command that requires a receptor or marker number as the parameter, the user may wish to apply the command to all receptors or markers of the PATRIOT WIRELESS. In such situations a '*' character may be used in place of the station (receptor or marker) number to apply the settings to every receptor or marker in the PATRIOT WIRELESS.

e.g. ^N*,0.5,4.0 would change the P&O increments *for* ***every*** *launched marker* to 0.5 inches and 4.0 degrees.

e.g. ^N1,0.5,4.0 would change the P&O increments for *marker 1* ***only***.

Default Parameters

Commands that take multiple parameters can be used to change a subset of the parameters and leave the remaining parameter values unchanged.

For example:

- The command G2,*az,el,roll*<> changes the marker reference frame to (az, el, roll).
- The command G2,*0,180,0*<> changes the marker reference frame to (0,180,0).

- By omitting the *el* parameter from the command: G2,*0,,180*<> the marker reference frame would then change to (0,180,180). The el setting remains unchanged.
- Similarly, the *az* parameter can be defaulted by: G2,,*el,roll*<>,
- The *roll* parameter can be defaulted by G2,*az,el*<>. The trailing comma is not required when the last parameter(s) are omitted.

4.2.3 Response Format Notes

Depending on the ‘F’ – Output Format configuration setting (see page 53), frames received from PATRIOT WIRELESS in response to the commands detailed in this document will conform to one of the following format definitions.

ASCII

ASCII response frames are described in this document using the following notation:

A .... Is an ASCII character

B .... Is a blank or space

S .... Is the sign character (+,- or a space for (+))

x .... Is a decimal digit (0-9)

s .... Is an ASCII string

X........... Is a hex digit (0-F)

<> .... Carriage return + line feed “CRLF” (i.e. ^M^J, 0x0d 0x0a)

n() .... Repeat contents of parentheses n times

Example: A format 3(Sx.xxxxB), would be output as: -1.1111 2.2222 -3.3333

Except where noted, ASCII mode response includes a standard 5-character response header. The default ASCII response frame format is as follows:

Table 5 ASCII Response Format

	Byte Index	Format	Description
HEADER	0	A	First Digit of Receptor or Marker Number
	1	A	Second Digit of Receptor or Marker Number
	2	A	Command Letter or ‘@’ if a 2-character command
	3	A	Error Indicator
	4	B	ASCII Blank character
	5 thru n	A	Response Body
	n+1, n+2	<>	A P&O response frame may or may not contain a Carriage Return/Line Feed as specified by the user with the ‘O’ command

If the receptor or marker number is not applicable to the command, the first two fields will be ASCII zeros ‘0’.

Error codes presented in the Error Indicator field are detailed in PATRIOT WIRELESS Error Code Summary on page 50. “No Error” is represented by an ASCII blank character ‘ ’.

Binary

Binary response frames are described in this document using the following notation:

US .... unsigned short, 16 bits

SH .... signed short, 16 bits

UC .... unsigned char, 8 bits

CH .... char, 8 bits

I .... signed integer, 32 bits

DW .... unsigned double word, 32 bits

FL .... 32-bit single-precision floating-point in IEEE format consisting of sign bit, 8-bit exponent, and 23-bit mantissa:

`SXXX XXXX XMMM MMMM MMMM MMMM MMMM MMMM`

[n] .... Array of size n of type preceding square brackets (e.g. FL[3])

Binary response frames are composed of an 8 byte frame header followed by a variable-length frame body as follows:

Table 6 Binary Response Format

	Byte Index	TYPE	Description
HEADER	0,1	US	Frame Tag, always 'PL' or 0x4C50 for PATRIOT WIRELESS
	2	UC	Receptor or Marker Number
	3	UC	Initiating command or '@' if a 2-character command
	4	UC	Error Indicator
	5	UC	Reserved
	6,7	SH	Response size; number of bytes in the response body
	8 - n		Binary Response body

Error codes presented in the Error Indicator field are detailed in PATRIOT WIRELESS Error Code Summary on page 50. "No Error" is represented by NULL (0x00).

Error Responses

When in binary mode, error responses are always prepended by the binary frame header, followed by the ASCII error string. In ASCII mode, error responses have no header. See PATRIOT WIRELESS Error Code Summary on page 50 for a complete listing of error responses.

4.3 *PATRIOT WIRELESS User Command Set Summary*

Command	Description	Decimal	Hexadecimal	Notes	Page
B	Boresight	66	42	0.0=off, 1.0=on	52
C	Continuous Print Output	67	43		80
D	Marker Tip Offset	68	44		81
F	Output Format	70	46	0=asc 1=bin	53
G	Marker Reference Frame	71	47		54
L	Launch Marker	76	4C		83
M	Installed Markers	77	4D		56
N	Launched Marker ID	78	4E		85
O	Output Data List	79	4F		57
P	Single Data Record Output	80	50		86
Q	Reset Counters	81	51	0=both;1=FC,2=TS	87
U	Set Units	85	55	0=in, 1=cm	59
X	Position Filter Parameters	88	58		60
Y	Attitude Filter Parameters	89	59		62
^A	Receptor Alignments	1	01		88
^B	Aligned Receptors Map	2	02		90
^E	Set Echo Mode	5	05	0=off, 1=on	64
^G	Set Autolaunch Criteria	7	07		65
^K	Save Operational Configuration	11	0B		91
^L	Unlaunch Marker	12	0C		92
^N	Increment	14	0E		67
^O	RS-232 Port Configuration	15	0F		68
^P	Phase Step	16	10		93
^S	Startup Receptor Alignment Configuration	19	13		70
^U	Active Marker Map	21	15		71
^V	WhoAmI (Software versions)	22	16		94
^W	Set Operational Configuration	23	17		95
^X	Operational Configuration ID	24	18		73
^Y	Initialize System	25	19		96
^Z	Read Operational Configuration	26	1A		97
@A	Autolaunch Mode	00 65	00 41	0=off, 1=on	75
@B	USB Buffering Mode	00 66	00 42	0=off, 1=on	76
@R	Receptor Close-Range Mode	00 82	00 52	0=off, 1=on	78
@S	Signal Strength	00 83	00 53		100

4.4 *PATRIOT WIRELESS Error Code Summary*

These error codes may appear as binary values in binary mode frame headers. In ASCII mode, only the text/meaning appears.

Error	Hexadecimal	ASCII Text/Meaning
0	0x00	No Error
1	0x01	Invalid Command
2	0x02	Invalid Station
3	0x03	Invalid Parameter
4	0x04	Too Few Parameters
5	0x05	Too Many Parameters
6	0x06	Parameter Below Limit
7	0x07	Parameter Above Limit
8	0x08	Communication Failure with Sensor Processor Board
9	0x09	Error Initiating Sensor Processor 1
10	0x0a	Error Initiating Sensor Processor 2
11	0x0b	Error Initiating Sensor Processor 3
12	0x0c	Error Initiating Sensor Processor 4
13	0x0d	No Sensor Processors Detected
15	0x0f	Memory Allocation Error
16	0x10	Excessive Command Characters Entered
20	0x14	Non-fatal text message
22	0x16	Error Synchronizing Sensors
26	0x1a	Indicated Receptor Not Present
27	0x1b	Error aligning Receptor
28	0x1c	No Markers recognized by System
29	0x1d	Launch Error – Launch Receptor is not aligned
30	0x1e	Wildcard is not supported by this command
31	0x1f	No markers of this frequency have been installed on the system
32	0x20	Not used
33	0x21	No marker of this frequency has been launched
34	0x22	Error Installing Marker
35	0x23	Marker Serial Number not found for this frequency
36	0x24	Receptor PROM Error
70	0x46	Unsupported Receptor Detected

4.5 *Command Reference*

4.5.1 Configuration Commands

Configuration Commands are typically issued during system setup. They affect the overall operation of the PATRIOT WIRELESS. Once a configuration has been established, PATRIOT WIRELESS will operate in that configuration until power is removed, a reset is issued, or the configuration is changed again through a command. The current configuration may be saved and used at initialization time by commands discussed in this section.

Unless otherwise indicated, the default behavior of the configuration commands will be as follows:

- When no arguments (except marker or receptor number, where applicable) are supplied with the command, PATRIOT WIRELESS will respond with the current value of the setting in the response frame body.
- When arguments *are* supplied, the command modifies the setting, and the PATRIOT WIRELESS sends *no response* to the command. (If the '^E' – Set Echo Mode on page 64 is enabled, PATRIOT WIRELESS echoes back the command as verification that the command was received and executed.)
- Marker- and receptor-specific commands have an option to apply the setting to all markers or receptors. See Station Wildcard on page 46.

‘B’ – Marker Boresight

Description:
This command causes the marker to be electronically aligned in orientation with the user system coordinates, and establishes the boresight reference angles for the station. Azimuth, elevation and roll outputs will equal the boresight reference values at the current orientation. Any marker orientation can be designated as the zero orientation point.

A station may also be unboresighted with this command.

Syntax:
B*marker*, [*action*,*Azref*,*Elref*,*Rlref*]<>

Part	**Description**
marker	1 to 4, which specifies the relevant marker
action	1 to Boresight, 2 to Unboresight
Azref	The azimuth reference angle
Elref	The elevation reference angle
Rlref	The roll reference angle

Remarks:
The system default boresight reference values are: 0, 0, 0.

Issuing a command without the optional parameters will return whether a marker is boresighted or not. It will not return the boresight reference angles.

Output Record:

Table 7 ‘B’ ASCII Response

Byte Index	Format	Description
0	A	First Digit of marker number
1	A	Second Digit of marker number
2	A	‘B’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	1.0 = On, 0.0 = Off
8	AA	Carriage Return/Line Feed

Table 8 ‘B’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	F1	1.0 = On, 0.0 = Off

Examples:

B1, 1,10,20,30.5<>

Boresights marker 1 to 10 degrees in azimuth, 20 degrees in elevation, and 30.5 degrees in roll.

B1,0<>

Unboresights marker 1

B4,1<>

Boresights marker 4 to the default values of 0,0,0.

B3<>

Returns 0.0 to indicate that marker 3 is not presently boresighted, or 1.0 to indicate that it is.

‘F’ – Output Format

Description:

This command selects the Binary or ASCII output data format. ASCII format means that the data is generally human readable, while binary format is generally computer readable. Regardless of output data format selected, all input data (commands) to PATRIOT WIRELESS must be in ASCII format.

Syntax:

F[*fmt*] <>

Part	Description
fmt	Defines the type of output from PATRIOT WIRELESS. The choices are: 0 …. ASCII output 1 …. Binary output

Remarks:

The default output data format is ASCII. The Polhemus SDK uses binary output exclusively. As with other configuration commands, if no fmt argument is provided, the current value of the setting is returned in the default response frame.

If a software application is written to receive binary data from PATRIOT WIRELESS and there is a requirement to take it off line temporarily to do visual checks, the user would enable the ASCII output data format in order to be able to easily read PATRIOT WIRELESS data on the PC monitor.

The user may wish to write a software application for PATRIOT WIRELESS where a fast update rate is crucial. In order to reduce data throughput size, PATRIOT WIRELESS could be set to output in binary instead of ASCII.

Output Record:

Table 9 ‘F’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘F’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	‘0’
6-7	AA	Carriage Return/Line Feed

Table 10 ‘F’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	0x00000001

Examples:

The command to enable binary output mode for the system is:

F1<>

‘G’ – Marker Reference Frame

Description:
This command modifies the translation and/or rotation reference frame coordinates for all launched markers’ P&O measurements. The reference frame may be configured from a launched marker’s current P&O or from user-provided XYZAER values. The reference frame is not a marker-specific setting.

Syntax:
G*command*[*X*,*Y*,*Z*,*A*,*E*,*R*]<>

Part	Description
command	0..........Set reference frame to rotation and translation of lowest launched marker 1..........Set reference frame to rotation of lowest launched marker 2..........Set reference frame rotation and translation to XYZAER values given 3..........Reset reference frame rotation and translation to zero

The following parts apply only to command value 2:

X	X reference frame translation
Y	Y reference frame translation
Z	Z reference frame translation
A	Azimuth reference frame angle of rotation
E	Elevation reference frame angle of rotation
R	Roll reference frame angle of rotation

Remarks:
The default marker reference frame is 0,0,0,0,0,0.

Issuing a G<> will read the current marker reference frame.

Output Record:

Table 11 ‘G’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘G’
3	A	Error Indicator
4	B	ASCII Blank character
5-13	Sxxx.xxxB	X Reference Frame Translation
14-22	Sxxx.xxxB	Y Reference Frame Translation
23-31	Sxxx.xxxB	Z Reference Frame Translation
32-40	Sxxx.xxxB	Azimuth Reference Frame Rotation
41-49	Sxxx.xxxB	Elevation Reference Frame Rotation
50-58	Sxxx.xxxB	Roll Reference Frame Rotation
59-60	AA	Carriage Return/Line Feed

Table 12 ‘G’ Binary Response

Byte Index	Format	Description

0-7		Binary Header
8	FL	X Reference Frame Translation
12	FL	Y Reference Frame Translation
16	FL	Z Reference Frame Translation
20	FL	Azimuth Reference Frame Rotation
24	FL	Elevation Reference Frame Rotation
28	FL	Roll Reference Frame Rotation

Examples:

Scenario 1:

If there were a requirement to mount the anchor receptor upside down (e.g., it is more mechanically feasible this way), then the following command would be used to set the reference frame manually with the orientation rolled 180°:

G2,0,0,0,0,0,180<>

The P&O measurements for all markers will now look as if the anchor had *not* been mounted upside down.

Scenario 2:

Without knowing the exact P&O of the desired frame of reference, the lowest-index marker (e.g. marker 1) could be used to set the frame of reference.

Marker 1 would be positioned at the desired origin and pointing along the desired X-axis. Then that marker's P&O would become the new reference frame for all markers by using the G0<> command. Or, if only the orientation of that marker were needed for the reference, then the G1<> command would be used.

‘M’ – Installed Markers

Description:
This command returns a list of markers that have been “installed” to PATRIOT WIRELESS. Markers are installed using the marker Installation utility in the PiMgr GUI. The list returned by this command reports markers in the order in which they were installed.

Syntax:
M<>

Remarks:
Note that the output record reports markers in the order that they were installed, not in the order of marker Frequency.

Output Record:

Table 13 ‘M’ ASCII Response Header

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘M’
3	A	Error Indicator
4	B	ASCII Blank character

The body of the response will be a variable length block of text described in Table 14 below. The data in italics is defined in the right column.

The binary response frame is described in Table 15.

Table 14 ‘M’ ASCII Response

Format	Description
00M x Marker(s) Installed<>	**3-char ASCII Header + number of markers installed**
The following text data will be repeated for each installed marker:	
Freq x	**Marker Frequency index**
BBB	**3 blanks**
S/N	
BB	**2 blanks**
s<>	**Marker Serial Number/ID string + CRLF**

Table 15 ‘M’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	FL	Installed Marker Count
The following 20 bytes are repeated for each installed marker.		
12	FL	Frequency index
16	CH[16]	Marker ID

Examples:
On a PATRIOT WIRELESS with 7 markers installed, issue the M<> command to produce the following ASCII report of all installed markers:

```
00m 6 Marker(s) Installed
Freq 1      S/N   297A50005
Freq 4      S/N   300A50006
Freq 2      S/N   298A50002
Freq 3      S/N   299A50001
Freq 1      S/N   297A50003
Freq 2      S/N   298A50002
```

‘O’ – Output Data List

Description:
This command allows the user to define the list of variables to be output to the host computer for the specified marker. Any combination of items that produces a P&O response frame of less than or equal to 1000 bytes is permissible.

NOTE: Due to the high output rate of PATRIOT WIRELESS, caution should be used when defining large output records to prevent overwhelming the host communications’ channel.

The output list refers to the subset of data items to be included in a data record.

Syntax:
O[*marker*],[*p1*],[*p2*],...,[*pn*]<>

Part	**Description**
marker	1 to 4, which specifies the relevant marker
p1-pn	Parameters that define the list of variables output to the host. The possible parameters are listed below:

Table 16 Output Data Types

ID	Description	ASCII Data Format	Binary Data
0	ASCII space character	A1	A1
1	ASCII carriage return, linefeed	A2	A2
2	X, Y, Z Cartesian coordinates of position	3(Sxxx.xxxB)	Float
3	X, Y, Z Cartesian coordinates, extended precision	3(Sx.xxxxxxESxxxB)	Float
4	Az, El, Ro Euler orientation angles	3(Sxxx.xxxB)	Float
5	Az, El, Ro Euler angles, extended precision	3(Sx.xxxxxxESxxxB)	Float
6	Direction Cosine Matrix	3(3(Sx.xxxxxB)CRLF)	3(Float)
7	Orientation Quaternion	4(Sx.xxxxxB)	4(Float)
8	Timestamp	A1 ~ A10	DWORD
9	Frame Count	A1 ~ A10	DWORD

Remarks:
If the wildcard (*) is specified instead of *marker*, all active marker output lists will be set to the programmed value. If output list parameters (*p1-pn*) are omitted from the argument list, the current defined output list is returned.

Default is 0*,2,4,1: P&O <cr><lf> for all markers.

Output Record:

Table 17 'O' ASCII Response

Byte Index	**Format**	**Description**
0	A	First Digit of Marker Number
1	A	Second Digit of Marker Number
2	A	'O'
3	A	Error Indicator
4	B	ASCII Blank character
5	x	Data Item #1
6	B	
7-.	xB..	Remaining data items separated by blanks

Table 18 'O' Binary Response

Byte Index	**Format**	**Description**
0-7		Binary Header
8	I	Data Item 1
12	I	Data Item 2
16	I	Data Item 3
…		
84	I	Data Item #20

NOTE: In the binary output format, the list of valid data items will be terminated with a -1 (0xFFFFFFFF).

Examples:
The user may decide to use X, Y, Z direction cosines instead of the default output format. In order to do so, the following command should be sent:

O1,6,1<>

The output data for marker 1 will now be displayed as X, Y, Z direction cosines, plus carriage return / line feed.

O*,2<>

The output for all markers will be position only.

‘U’ – Set Units

Description:
This command sets the distance unit to either metric (centimeters) or English (inches). Subsequent input and output lengths will be interpreted as centimeters or inches respectively.

Syntax:
U[*units*]<>

Part	**Description**
units	Defines the type of input and output Units. The choices are: 0.................. English (Inches) 1.................. Metric (Centimeters)

Remarks:
The system default unit format is inches.

As with all other configuration commands, if the units parameter is not stated in this command, the current units setting will be returned in the default response body.

Output Record:

Table 19 ‘U’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘U’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	0 for inches, 1 for centimeters
6-7	AA	Carriage Return/Line Feed

Table 20 ‘U’ Binary Response

Byte Index	Format	Description
1-8		Binary Header
9-12	I	0x00 for inches, 0x01 for centimeters

Examples:
Assuming the system units had already been changed to centimeters, the following command could be sent to change back to inches:

U0<>

The system will now output data in inches and interpret input data in inches.

If the operator wanted the system to output its measurements in centimeters, the following command should be sent:

U1<>

The system will now output data in centimeters.

‘X’ – Position Filter Parameters

Description:
This command establishes the sensitivity, boundary, and transition control parameters for the adaptive filter that operates on the position outputs of the PATRIOT WIRELESS. The user can adjust the parameters of this command to fine-tune the overall dynamic response of the system.

The filter is a single-pole low-pass type with an adaptive pole location (i.e., a floating filter “parameter/variable”). The pole location is constrained within the boundary values *FLow* and *FHigh* but is continuously self-adaptive between these limits as a function of the sensitivity parameter *F* and the sensed (ambient noise plus rotational rate) input conditions. For input “rate” conditions that fall within the adaptive range, the adaptive feature varies the pole location between the *FLow* and *FHigh* limits so as to maximize the output resolution for static inputs while minimizing the output lag for dynamic inputs. Whenever the input conditions cause the filter to make a transition to a narrower bandwidth (i.e., increased filtering), the transition rate of the pole location is constrained to a maximum allowable rate by the parameter *Factor*. If all of the optional parameters are omitted the current value of each parameter is returned to the user as an output record of type “X”.

Syntax:
X[[F],[FLow],[FHigh],[Factor]]<>

Part	Description
F	A scalar value that establishes the sensitivity of the filter to dynamic input conditions by specifying the proportion of new input data to recent average data that is to be used in updating the floating filter parameter/variable. Allowable range of values: 0 < *F* < 1
FLow	A scalar value that specifies the maximum allowable filtering to be applied to the outputs during periods of relatively static input conditions. Setting this value to 1.0 disables the filter completely. Allowable range of values: 0 < *FLow* < *FHigh* or 1.0 to disable filter
FHigh	A scalar value that specifies the minimum allowable filtering to be applied to the outputs during periods of highly dynamic input conditions. Allowable range of values: *FLow* < *FHigh* < 1
Factor	A scalar value that specifies the maximum allowable transition rate from minimum filtering (for highly dynamic input conditions) to maximum filtering (for relatively static input conditions) by

proportionately limiting the decay to the low filter limit whenever the input conditions effect a transition to a narrower bandwidth.

Allowable range of values: 0 < *Factor* < 1

When the form of the command is X0,1,0,0<> the position filter is disabled.

Remarks:
The default mode for all filter parameters is shown below. Although these parameters are a function of the user's particular environment, the following settings may be used as a starting point for determining optimum filtering in your particular environment.

F	Set to 0.2
FLow	Set to 0.2
FHigh	Set to 0.8
Factor	Set to 0.95

Output Record:

Table 21 'X' ASCII Response

Byte Index	Format	Description
0	A	'0'
1	A	'0'
2	A	'X'
3	A	Error Indicator
4	B	ASCII Blank character
5-11	Sx.xxxB	Filter Sensitivity
12-18	Sx.xxxB	Filter Low Value
19-25	Sx.xxxB	Filter High Value
26-32	Sx.xxxB	Transition Rate Maximum Value
33-34	AA	Carriage Return/Line Feed

Table 22 'X' Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	FL	Filter Sensitivity
12	FL	Filter High Value
16	FL	Filter Low Value
20	FL	Transition Rate Maximum Value

Examples:
To select the above filtering, send the following command to the system:

X .2,.2,.8,.95<>

All active stations will now have filtering applied to the position measurements.

To turn off position filters:

X0,1,0,0<>

'Y' – Attitude Filter Parameters

Description:
This command establishes the sensitivity, boundary, and transition control parameters for the adaptive filter that operates on the attitude outputs of the PATRIOT WIRELESS. The user can adjust the parameters of this command to fine-tune the overall dynamic response of the system.

The filter is a single-pole low-pass type with an adaptive pole location (i.e., a floating filter "parameter/variable"). The pole location is constrained within the boundary values *FLow* and *FHigh* but is continuously self-adaptive between these limits as a function of the sensitivity parameter *F* and the sensed (ambient noise plus rotational rate) input conditions. For input "rate" conditions that fall within the adaptive range, the adaptive feature varies the pole location between the *FLow* and *FHigh* limits so as to maximize the output resolution for static inputs while minimizing the output lag for dynamic inputs. Whenever the input conditions cause the filter to make a transition to a narrower bandwidth (i.e., increased filtering), the transition rate of the pole location is constrained to a maximum allowable rate by the parameter *Factor*. If all of the optional parameters are omitted, the current value of each parameter is returned to the user as an output record of type "Y".

Syntax:
Y[[*F]*,[*FLow*],[*FHigh*],[*Factor*]]<>

Part	Description
F	A scalar value that establishes the sensitivity of the filter to dynamic input conditions by specifying the proportion of new input data to recent average data that is to be used in updating the floating filter parameter/variable. Allowable range of values: 0 < *F* < 1
FLow	A scalar value that specifies the maximum allowable filtering to be applied to the outputs during periods of relatively static input conditions; setting this value to 1.0 disables the filter completely. Allowable range of values: 0 < *FLow* < *FHigh* or 1.0 to disable filter
FHigh	A scalar value that specifies the minimum allowable filtering to be applied to the outputs during periods of highly dynamic input conditions. Allowable range of values: *FLow* < *FHigh* < 1
Factor	A scalar value that specifies the maximum allowable transition rate from minimum filtering (for highly dynamic input conditions) to maximum filtering (for relatively static input conditions) by

proportionately limiting the decay to the low filter limit whenever the input conditions effect a transition to a narrower bandwidth.

Allowable range of values: 0 < *Factor* < 1

When the form of the command is Y0,1,0,0<> the attitude filter is disabled.

Remarks:

The default mode for all filter parameters is shown below. Although these parameters are a function of the user's particular environment, the following settings may be used as a starting point for determining optimum filtering in your particular environment.

F	Set to 0.2
FLow	Set to 0.2
FHigh	Set to 0.8
Factor	Set to 0.95

Output Record:

Table 23 'Y' ASCII Response

Byte Index	Format	Description
1	A	'0'
2	A	'0'
3	A	'Y'
4	A	Error Indicator
5	B	ASCII Blank character
6-12	Sx.xxxB	Filter Sensitivity
13-19	Sx.xxxB	Filter Low Value
20-26	Sx.xxxB	Filter High Value
27-33	Sx.xxxB	Transition Rate Maximum Value
34-35	AA	Carriage Return/Line Feed

Table 24 'Y' Binary Response

Byte Index	Format	Description
1-8		Binary Header
9-12	FL	Filter Sensitivity Value
13-16	FL	Filter Low Value
17-20	FL	Filter High Value
21-24	FL	Transition Rate Maximum Value

Examples:

To select the above filtering, send the following command to the system:

Y.2,.2,.8,.95<>

All active stations will now have filtering applied to the attitude measurements.

To turn off attitude filters:

Y0,1,0,0<>

‘^E’ – Set Echo Mode

Description:
This command enables and disables the communications “echo” mode. In echo mode, PATRIOT WIRELESS responds to configuration-modifying commands by “echoing” back the command that was received. (Recall that without echo mode, configuration-modifying commands generate no response message from the PATRIOT WIRELESS. See Configuration Commands on page 51.) This allows feedback to the user when modifying configuration settings. In binary mode, the echo is prefixed by the standard 8-byte binary header.

Syntax:
^E[*echo*]<>

Part	Description	
echo	0..................	No echo mode
	1..................	Echo mode

Remarks:
The system default for echo mode is OFF.

Output Record:

Table 25 ‘^E’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘e’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	1 = on, 0 = off
6-7	AA	Carriage Return/Line Feed

Table 26 ‘^E’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	1 = on, 0 = off

Examples:

^E1<>

^E0<>

Default is off.

‘^G’ – Set Autolaunch Criteria

Description:
In Autolaunch mode, PATRIOT WIRELESS detects and automatically launches or unlaunches wireless markers as they enter and leave the motion tracking environment. Thresholds for marker detection may be set and read with this command.

Syntax:
^G[*launch range, unlaunch range*]<>

Part	Description
Launch range	Range index from 0 to 100. Lower index corresponds to shorter range.
Unlaunch range	Range index from 0 to 100. Lower index corresponds to shorter range.

Remarks:
In the PATRIOT WIRELESS, the launch and unlaunch range indices are translated into minimum detected signal levels at which the PATRIOT WIRELESS will automatically launch and unlaunch markers. A lower launch range index means that a marker must be closer to a receptor and thus produce a higher detected signal level to cause it to be automatically launched. Similarly, a higher unlaunch range index means that the marker may travel farther away and thus produce a lower detected signal level in a receptor before it will be automatically unlaunched. See also ‘^P’ – Phase Step on page 93.

The default launch range index criterion is 50.

The default unlaunch range index criterion is 50.

Output Record:

Table 27 ‘^G’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘g’
3	A	Error Indicator
4	B	ASCII Blank character
5-8	xxxB	Launch range index
9-12	xxxB	Unlaunch range index
13,14	AA	Carriage Return/Line Feed

Table 28 ‘^G’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	DW	Launch range index
12	DW	Unlaunch range index

Examples:
To increase the distance from a receptor at which a marker will be autolaunched, increase the launch range index.

To increase the distance from a receptor at which a launched marker may travel before it is automatically unlaunched, increase the unlaunch range index.

To instruct PATRIOT WIRELESS to automatically launch a marker when a signal level corresponding to an index of 60 or more is detected and to unlaunch when a signal level corresponding to an index of 40 or less is detected, use the following command:

^G60,40<>

‘^N’ – Increment

Description:
This command sets position and orientation thresholds for new data. When these thresholds are set, the position and orientation reported in the continuous data stream does not change until the threshold has been passed. Position data for each axis changes only when the position threshold has been exceeded on that axis; and only that axis’ position changes. Orientation changes when the total rotation vector changes by the attitude threshold. Thresholds are measured from the P&O of the marker when this command is issued. Continuous data *does* continue to flow with the unchanged P&O information. See also Configuration Changes on page 41.

Syntax:
^N[*marker*][,*position increment, attitude increment*]<>

Part	Description
marker	1-4, frequency index of marker.
position increment	Position delta threshold in inches or centimeters (0-18).
attitude increment	Attitude delta threshold in degrees (0-45).

Remarks:
The position increment argument is specified in either inches or centimeters, depending on the units specified by the ‘U’ – Set Units command, page 59.

Output Record:

Table 29 ‘^N’ ASCII Response

Byte Index	Format	Description
0	A	First digit of marker number
1	A	Second digit of marker number
2	A	‘n’
3	A	Error Indicator
4	B	ASCII Blank character
5-11	Sxx.xxxB	Position increment
12-18	Sxx.xxxB	Angle increment
19-20	A	Carriage Return/Line Feed

Table 30 ‘^N’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	FL	Position increment
12	FL	Attitude increment

Examples:
To set the P&O increments for launched marker one to 1 inch and 15 degrees:

^N1,1.0,15.0<>

'^O' – RS-232 Port Configuration

Description:
This command sets the RS-232 port configuration. The system output port settings include RS-232 BAUD rate and parity only.

Syntax:
^O[*rate*],[*parity*]<>

Part	Description
rate	bits per second. Valid arguments include:

Table 31 ASCII Baud Rate Values

Rate	Baud Rate
24	**2,400**
48	**4,800**
96	**9,600**
192	**19,200**
384	**38,400**
576	**57,600**
1152	**115,200**

parity

Table 32 ASCII Parity Values

Parity	Meaning
"0"	**None**
"1"	**Odd**
"2"	**Even**

Remarks:
See RS-232 I/O on page 23 for reference on the use of RS-232 for communicating with PATRIOT WIRELESS.

The default RS-232 communications parameters are 115,200 baud, no parity.

In addition:
- The number of data bits is always eight (8).
- The number of stop bits is always one (1).
- Hardware Handshake is always disabled.

Output Record:

Table 33 '^O' ASCII Response

Byte Index	Format	Description
0	A	'0'
1	A	'0'
2	A	'o'
3	A	Error Indicator
4	B	ASCII Blank character
5-10	A	Baud Rate (see Table 31 on page 68)
11	B	Blank
12	A	Parity (see Table 32 on page 68)
13-14	A	Carriage Return/Line Feed

Table 34 ‘^O’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	Baud Rate (see Table 35, below)
12	I	Parity (see Table 35, below)

Examples:

Suppose there is a requirement to change the baud rate (in software) to 19,200 baud after startup. It can be accomplished with the following command, without turning off and restarting the system.

^O192,1,8,0<>

The system serial communication parameters will now be 19200-baud, no parity, 8 data bits, and 1 stop bit.

NOTE: The host communication software may have to be re-set to the new baud rate (19,200) in order for communication with PATRIOT WIRELESS to continue.

Table 35 Binary RS-232 Codes

Code	Baud Rate
1	**2400**
2	**4800**
3	**9600**
4	**19200**
5	**38400**
6	**57600**
7	**115200**

Code	Parity
0	**None**
1	**Odd**
2	**Even**

'^S' – Startup Receptor Alignment Configuration

Description:
This command stores or erases the Receptor Alignments. If "store" is selected, the current receptor alignment data is saved. When this data is saved to flash, the receptor alignment process does not need to be repeated when PATRIOT WIRELESS is started or restarted. If the data is not saved, alignment must be repeated after each startup or restart.

Syntax:
^S*command*<>

Part	Description	
command	0..................	Erase
	1..................	Store

Remarks:
None.

Output Record:
None.

Examples:
To store the current receptor alignment data, type:

^S1<>

'^U' – Active Marker Map

Description:
The purpose of this command is to allow the host to turn a launched marker "on" or "off" in software.

A marker is enabled by launching, but it can then be disabled (or enabled again) by using this command. When a marker is launched and enabled, data records for that marker will be transmitted. If the marker is disabled, no data records from that marker will be transmitted.

Syntax:
^U[*marker*][,*state*]<>

or

^U0[,bitmap]<>

Part	Description
marker	1-4 ...... Frequency index of launched marker to enable/disable. 0.......... Causes active station bitmap to be retrieved or set.
state	0.......... Disabled 1.......... Enabled n/a if *marker* = 0
bitmap	16-bit bitmap reflecting state of each marker, represented as a hexadecimal number

Remarks:
If *marker* is supplied **without** a *state*, then the current states of all launched markers are returned. See 'O' – Output Data List on page 57. The default condition depends on the number of markers that are currently launched. The default condition of a launched marker is "1" or "enabled". The default condition of an unlaunched marker frequency is "0" or "disabled."

If zero "0" is supplied as the marker number, this command will take a hexadecimal bitmap to identify ALL the enabled markers:

e.g.: ^U0,3fff<> enables all markers.

NOTE: Do not place '0x' in front of the input hex bitmap!

If no bitmap is supplied, the current active marker bitmap will be returned in the default response body. This bitmap will indicate the launched markers in the upper 16 bits, and the active markers in the lower 16 bits. A marker must be launched ***and*** enabled to be active.

Enabling or disabling a marker number that does not exist (e.g. marker 13 or any unlaunched marker frequency) has no effect.

Output Record:

Table 36 '^U[marker]' ASCII Response

Byte Index	Format	Description
0	A	First Digit of Marker Number
1	A	Second Digit of Marker Number
2	A	'u'
3	A	Error Indicator
4	B	ASCII Blank character
5	X	Marker Freq #1 state (1=Active, 0=InActive)
6	X	Marker Freq #2 state (1=Active, 0=InActive)
7-18	X	Marker Freq 3-12 state (1=Active, 0=InActive)
19,20	AA	Carriage Return/Line Feed

Table 37 '^U0' ASCII Response

Byte Index	Format	Description
0	A	'0'
1	A	'0'
2	A	'u'
3	A	Error Indicator
4	B	ASCII Blank character
5-8	XXXX	Hex bitmap of launched markers
9-12	XXXX	Hex bitmap for active markers
13,14	AA	Carriage Return/Line Feed

Table 38 '^U' Binary Output Format

Byte Index	Format	Description
0-7		Binary Header
8-11	I	Launched and Active Marker bitmap

Binary output is the same for both ^U[*marker*]<> and ^U0<>

Examples:

A user could launch four markers and then collect a data point from two markers at a time, after disabling the other two. To do so, the following commands would be sent:

1. Send the command ^U3,0<> to turn marker 3 off.
2. Send the command ^U4,0<> to turn marker 4 off.
3. Press P to collect a data point from marker 1 and 2.
4. Send the command ^U3,1<> to turn marker 3 on.
5. Send the command ^U4,1<> to turn marker 4 on.
6. Send the command ^U1,0<> to turn marker 1 off.
7. Send the command ^U2,0<> to turn marker 2 off.
8. Press P to collect a data point from markers 3 and 4.
9. Repeat steps 1 through 8 as necessary.

To turn on markers 1 and 3 while turning off markers 2 and 4, send:

^U0,05<>

where 05 corresponds to:

0x05 = 00000101

Bits corresponding to markers 1 and 3 are set and those corresponding to 2 and 4 are cleared. See bitmap syntax part description for this command.

'^X' – Operational Configuration ID

Description:
This command allows a 16 character "ID" to be assigned to the current operational system configuration. This command also allows the user to view the IDs of all valid stored configurations within PATRIOT WIRELESS non-volatile configuration memory.

Syntax:

^X*string*<>

Part	Description
string	A 15 character ASCII *string* ID that describes the current configuration.

Remarks:
A valid configuration ID is up to 15 characters plus a null terminator.

If no string argument is supplied with this command, PATRIOT WIRELESS will respond with a list of the currently saved configuration IDs.

A string of 15 asterisks followed by the null character indicates an undefined configuration. ("***************\0")

Output Record:

Table 39 '^X' ASCII Response

Byte Index	Format	Description
0	A	'0'
1	A	'0'
2	A	'x'
3	A	Error Indicator
4	B	ASCII Blank character
5-21	16(A)B	Current Configuration Record ID
22-37	16(A)B	Configuration Record ID #1
38-53	16(A)B	Configuration Record ID #2
54-69	16(A)B	Configuration Record ID #3
70-71	AA	Carriage Return/Line Feed

Table 40 '^X' Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	CH[16]	Current Config ID
24	CH[16]	Default Config ID
40	CH[16]	Config slot 1 ID
56	CH[16]	Config slot 2 ID
72	CH[16]	Config slot 3 ID
88	CH[16]	Startup Config ID

Examples:
To determine what configurations are available in the PATRIOT WIRELESS, issue the following command:

^X<>

The returned record could display the following:

Current:	Configuration 1
0	Default
1	Configuration 1
2	Configuration 2
3	***************
Startup	Configuration 1

In this case two unique configurations are stored in PATRIOT WIRELESS configuration memory. The third configuration is not defined.

To set an ID for the third configuration, do the following:

^XConfiguration#3<>

^K3<>

To make this configuration the startup configuration:

^W3<>

‘@A’ – Autolaunch Mode

Description:
This two-character command sets and reads PATRIOT WIRELESS’ current autolaunch mode status.

Syntax:
@A[*mode*] <>

Part	Description	
mode	0...................	Autolaunch disabled (Default mode)
	1...................	Autolaunch enabled

Remarks:
Autolaunch mode enables the PATRIOT WIRELESS system to automatically launch and unlaunch markers by user-defined signal level criteria. This criteria is set with the ‘^G’ – Set Autolaunch Criteria command on page 65. When a marker’s signal level above the launch criteria is detected, that marker is automatically launched. When the signal level falls below the unlaunch criteria, the marker is unlaunched.

Since the marker is being launched from an unknown position and orientation, the PATRIOT WIRELESS is unable to guarantee that the orientation is correct. For an automatic launch there are four possibilities for orientation:

1. The correct orientation
2. 180 degree error in azimuth
3. 180 degree error in roll
4. 180 degree error in azimuth and roll (same as 180 in elevation)

If while using the Autolaunch feature orientation accuracy is of concern, the ‘^P’ – Phase Step command on page 93 should be used to set the proper phase.

Output Record:

Table 41 ‘@A’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘@’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	Autolaunch Mode: ‘0’ disabled, ‘1’ enabled
6,7	AA	Carriage Return/Line Feed

Table 42 ‘@A’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	Autolaunch Mode: 0 disabled, 1 enabled

Examples:
To enable Autolaunch, issue the following command:

@A1<>

'@B' – USB Buffering Mode

Description:
This command enables or disables USB output buffering before USB transmission to the host. When USB buffering is disabled, PATRIOT WIRELESS operates in a 'real time' mode in which only the most current frame of motion data is transmitted. When enabled, buffering mode allows host delays in requests for data without frame loss, but with possible latency introduced.

Syntax:
@B[*mode*] <>

Part	Description
mode	Defines the status of USB Buffering Mode. The choices are: 0 … Disabled 1 … Enabled (default)

Remarks:
By default, USB buffering mode is enabled.

As with other configuration commands, if no *mode* argument is provided, the current value of the setting is returned in the default response frame.

Buffering Mode applies to USB data I/O only. RS-232 data buffering is controlled by the host computer.

With USB buffering enabled, a First-In-First-Out (FIFO) buffer collects motion data in scenarios where the host computer is not able to capture it at the rate that it is generated. This does not guarantee that data is not lost, but it helps in transient conditions where the host computer does not have continuously available CPU and memory resources to capture every frame over USB. PATRIOT WIRELESS can buffer up to 2,300 bytes of data.

A consequence of enabling USB buffering mode is that the FIFO operation may result in data latency. When the buffer is *full*, P&O frames delivered to the host computer are not real-time. As such, they may not reflect the P&O of the stations at that instant in time. The P&O reported may be several frames behind real time, depending on the frame rate, frame size, and buffer size.

With USB buffering mode disabled, the FIFO buffer does not fill up with motion data. Each time the host computer requests a new frame, the frame delivered is guaranteed to be as close to real-time as possible, thus avoiding data latency.

Output Record:

Table 43 ‘@B’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	’0’
2	A	‘@’
3	A	Error Indicator
4	B	ASCII Blank character
5	A	‘0’ Disabled, ‘1’ Enabled
6-7	AA	Carriage Return/Line Feed

Table 44 ‘@B’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	0x00 Disabled, 0x01 Enabled.

Examples:

The command to disable USB buffering mode is:

@B0<>

‘@R’ – Receptor Close-Range Mode

Description:
This command enables or disables “Close-Range Mode” for one or all receptors. Close-Range Mode may be useful in environments where markers are expected to track within 12-18 inches of the receptor.

Syntax:
@R*receptor*[,*mode*] <>

Part	Description	
receptor	1-2	Specifies which receptor to read or set mode; *Wildcard may be used to read all receptor arguments.
mode	Defines the status of Close-Range mode for *receptor*. The choices are:	
	0 …	Off, Extended Range Mode
	1 …	On, Close Range Mode (default)

Remarks:
By default, Close-Range mode is enabled for all receptors.

As with other configuration commands, if no *mode* argument is provided, the current value of the setting is returned in the default response frame.

NOTE: When Close-Range mode is employed for a receptor, that receptor’s effective range becomes approximately half that of Extended Range Mode (~96 inches).

Disable Close Range Mode in the following circumstances:

- Where markers are tracked in larger volumes; ***or***
- Where markers will not be tracked within 12-18 inches of receptors; ***or***
- in smaller areas where 2 receptors are in use and receptors are positioned within 3-4 feet of each other.

Output Record:

Table 45 '@R' ASCII Response

Byte Index	Format	Description
0	A	First digit of receptor number
1	A	Second digit of receptor number
2	2A	‘@R’
4	A	Error Indicator
5	B	ASCII Blank character
6	A	‘0’ Normal-Range, ‘1’ Close-Range
7	AA	Carriage Return/Line Feed

Table 46 ‘@R’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	0x00 Normal-Range, 0x01 Close-Range.

Examples:

The command to enable Close-Range mode for receptor 1 is: @R1,1<>
The command to enable Close-Range mode for all receptors is: @R*,1<>

4.6 *Operational Commands*

Operational commands are typically executed during normal system operation. They do not affect the configuration of the PATRIOT WIRELESS.

‘C’ – Continuous Print Output

Description:
This command enables the continuous print output mode. When the system is in continuous mode, the data points from all enabled and launched markers are requested automatically and are streamed to the host continuously. If more than one marker is enabled, then the data from each marker will be sent in numerical order (marker 1 first, marker 2 second, etc.).

Output mode refers to whether the system automatically transmits data records to the host (continuous mode), or the host must request data records by polling the system each time (non-continuous mode).

Syntax:
C<>

Remarks:
The system default disables Continuous print output mode.

If the system is being used in an application where a fast update rate is critical, then the continuous print output configuration should be enabled.

Issuing a ‘P’ – Single Data Record Output command (see page 86) disables continuous print output mode. See also Step **Error! Reference source not found.** of Getting Started on page **Error! Bookmark not defined.** for details on collecting motion data from a marker.

Output Record:
Continuous print output frame data. See also ‘P’ – Single Data Record Output on page 86.

Examples:
To enable continuous output mode, send the command as follows:

C<>

Data from PATRIOT WIRELESS will now flow continuously to the host computer.

‘D’ – Marker Tip Offset

Description:
This command allows the user to introduce a custom “tip” offset to a selected marker. This offset then acts as the measurement reference instead of the source coil inside the marker.

Marker tip offset settings are not saved in the PATRIOT WIRELESS configuration. They must be re-applied each time PATRIOT WIRELESS is restarted.

Syntax:
N*marker*[,[*Xoff*],[*Yoff*],[*Zoff*]]<>

Part	Description
marker	1 to 4, frequency index of marker
Xoff	X direction tip offset.
Yoff	Y direction tip offset
Zoff	Z direction tip offset.

Remarks:
The marker does not have to be launched for the tip offset to be stored.

Output Record:

Table 47 'D' ASCII Response

Byte Index	Format	Description
0	A	First Digit of Marker Frequency Index
1	A	Second Digit of Marker Frequency Index
2	A	‘N’
3	A	Error Indicator
4	B	ASCII Blank character
5-11	Sx.xxxB	X offset
12-18	Sx.xxxB	Y offset
19-25	Sx.xxxB	Z offset
26-27	AA	CRLF

Table 48 ‘D’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	FL	X offset
12	FL	Y offset
16	FL	Z offset

Examples:
If the user created a special marker attachment that extended exactly one inch from the end of marker one, an marker tip offset would have to be made to use that attachment as the marker reference point. To do so, the following steps should be taken.

1. Verify that PATRIOT WIRELESS is measuring units in “inches” by sending the ‘U’ – Set Units command (see page 59).
2. To add one inch in X to the marker tip offset, , type D1,1.0,0,0<>

To verify that the tip offset was entered correctly, type D1<> to read it back.

The D1<> command should produce the ASCII response below, indicating that the marker with frequency index 1 has the new tip offset.

```
01D    1.000   0.000   0.000
```

‘L’ – Launch Marker

Description:
This command instructs PATRIOT WIRELESS to detect a new marker near the specified receptor.

Syntax:
L*receptor*[,*marker*,*hemisphere*]<>

Part	Description
receptor	1 or 2, the receptor at which a new marker will be launched.
marker	1, 2, 3 or 4, frequency index of marker to be launched, or -1 to launch any marker detected in the specified *hemisphere* (below).
hemisphere	0-5, hemisphere of the marker in which the launching *receptor* is positioned. The choices are: 0.......+X (default) 2 ...... +Y 4....... +Z 1........-X 3 .... -Y 5........ -Z

Remarks:
To provide the correct position and orientation, a marker must be started (launched) from a known position and orientation with respect to a given receptor. This allows the system to phase lock onto the marker and compute accurate runtime marker P&O.

Use the ‘L’ command in one of two ways:

- Specify only the launching *receptor* to launch any marker that is detected in the default marker launch position. Place any marker (1-4) behind the receptor with the front of the marker positioned in line with the tail of the receptor. The marker and the receptor are oriented with the same or similar (az, el, ro) orientation. This is the default marker launch position depicted in Figure 1-5 on page 4. With the marker oriented this way, the receptor is in the marker’s default +X hemisphere.
- If there is more than one powered marker in the launch vicinity of the launching receptor, specify the *receptor* plus the optional *marker* and marker *hemisphere* arguments. This enables the system to identify the correct frequency for launch. Use the *hemisphere* parameter to indicate how the marker is oriented with respect to the specified *receptor*. More than one *hemisphere* value may appear to be correct. To determine the correct *hemisphere*:

  Imagine a vector extending from the marker to the receptor. The x, y, or z component of that vector with the largest magnitude is the launch *hemisphere* you should specify. See the **Examples** below.

Output Record:
None.

Examples:

To launch any marker positioned in the default marker launch position behind Receptor 2 as depicted in Figure 1-5:	L2<>
To launch any marker positioned above Receptor 2 so that the receptor is in the marker's +Z (4) hemisphere:	L1,-1, 4<>
Two markers 1 and 3 are positioned behind Receptor 2. Both are in the default launch position: the receptor is in their +X (0) hemisphere. To launch marker 3 only:	L2,3,0<>
In launch position, Receptor 1 is estimated to be at position (-8, 0, -16) relative to Marker 2. (The receptor 8 inches above and 16 inches to the left of the marker.) The Z component of this vector has the largest magnitude (16) and its sign is negative so the launch hemisphere is –Z (5). To launch marker 2:	L1,2,5<>

'N' – Launched Marker ID

Description:
The command sets or reads the marker ID of a specified launched marker. The launched marker is specified in this command by its Frequency Index.

Syntax:
N*marker*[,*string*]<>

Part	Description
marker	1 to 4, Frequency index of launched marker
string	16 character marker ID string.

Remarks:
When a marker is launched, PATRIOT WIRELESS associates the launched marker with an installed marker record.

This command may be used to confirm that the launched marker matches the retrieved data from non-volatile memory or to change the marker data being used. This command will seldom be used.

Output Record:

Table 49 'N' ASCII Response

Byte Index	Format	Description
0	A	First Digit of Marker Frequency Index
1	A	Second Digit of Marker Frequency Index
2	A	'N'
3	A	Error Indicator
4	B	ASCII Blank character
5-21	16(A)B	Marker ID string

Table 50 'N' Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	CH[16]	Marker ID string

Examples:
The N2<> command may produce the ASCII response below, indicating that the launched marker with frequency index 2 has the serial number/ID "298A50002."

```
02N  298A50002
```

‘P’ – Single Data Record Output

Description:
In non-continuous output mode, this command polls PATRIOT WIRELESS for a single data record. If more than one marker is launched and enabled, then data from each active marker will be sent in numerical order (marker 1 first, marker 2 second, etc.; that is, a complete cycle of active markers will be output).

Output mode refers to whether the system automatically transmits data records to the host (continuous output mode), or the host must request data records by polling the system each time (non-continuous mode).

Syntax:
P **NOTE:** This is the ***only*** PATRIOT WIRELESS command that **does *NOT*** require a <>.

Remarks:
The system default enables single data record output mode.

Output Record:

Table 51 ‘P’ ASCII Response

Byte Index	Format	Description
0	A	First Digit of Marker Number
1	A	Second Digit of Marker Number
2	A	Error Indicator
3	B	Blank
4-m	See Table 16, page 57	Data Item #1
M+1 – n	See Table 16, page 57	
..	See Table 16, page 57	Data Item #n

Table 52 ‘P’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8-n	See Table 16, page 57	Data Output Item #1, configured by ‘O’ – Output Data List command; see page 57
N+1 – m	See Table 16, page 57	Data Output Item #2
..	See Table 16, page 57	Data Output Item #n

Examples:
If the system is being used in an application where data is only needed a certain number of times, or on command, then the single data record output should be used. To poll the system for a single data record, send the command as follows:

P

One data record from PATRIOT WIRELESS will be sent to the host computer.

'Q' – Reset Counters

Description:
This command allows the user to zero the frame counting and the frame timestamp feature. The frame counting feature is always enabled; however, it is only output when specified through the 'O' – Output Data List command on page 57. The framecount is a positive integer value indicating the relative frame number since system start or the last reset. Rollover occurs after 232 frames.

The timestamp feature is always enabled; however, the timestamp is only output if it has been specified in the 'O' – Output Data List command on page 57. The timestamp is a positive integer value indicating the number of milliseconds since the last reset operation or system start. Rollover occurs after 232 milliseconds.

Syntax:
Q*counter*<>

Part	Description	
counter	0	Reset both framecount and timestamp
	1	Reset framecount only
	2	Reset timestamp only

Remarks:
None.

Output Record:
None.

Examples:
To zero the framecount, execute the following:

Q1<>

‘^A’ – Receptor Alignments

Description:
This command manually sets or reads the alignment P&O data for a specified receptor. Receptor P&O may be configured using either Euler angles page A-5 or quaternions (see “Orientation Angles,” Figure 0-1).The alignment P&O is the actual P&O of the receptor in the PATRIOT WIRELESS alignment frame.

Syntax:
^A*receptor*,[*X*,*Y*,*Z*,*Az*,*El*,*Ro*]<>

or

^A*receptor*,[*X*,*Y*,*Z*,*Q1*,*Q2*,*Q3*,*Q4*]<>

Part	**Description**
receptor	1-2 Specifies which receptor to read or set alignment; *Wildcard may be used to read all receptor arguments.
X	X coordinate of receptor position
Y	Y coordinate of receptor position
Z	Z coordinate of receptor position
Az	Azimuth coordinate of receptor Euler orientation
El	Elevation coordinate of receptor Euler orientation
Ro	Roll coordinate of receptor Euler orientation
Q1	Parameter 1 of receptor orientation quaternion
Q2	Parameter 2 of receptor orientation quaternion
Q3	Parameter 3 of receptor orientation quaternion
Q4	Parameter 4 of receptor orientation quaternion

Remarks:
Although the alignment orientation may be set using either Euler angles or quaternions, when reading the receptor alignment the orientation is always expressed as Euler angles.

Output Record:

Table 53 ‘^A’ ASCII Response

Byte Index	**Format**	**Description**
0	A	First digit of receptor number
1	A	Second digit of receptor number
2	A	‘a’
3	A	Error Indicator
4	B	ASCII Blank character
5	3(Sxxx.xxxB)	Receptor alignment position
17	4(Sx.xxxxxB)	Receptor alignment Euler orientation
29,30	AA	Carriage Return/Line Feed

Table 54 '^A' Binary Output Format

Byte Index	Format	Description
0-7		Binary Header
8	FL	X
12	FL	Y
16	FL	Z
20	FL	Azimuth
24	FL	Elevation
28	FL	Roll

Examples:

The ^A1<> command may produce the ASCII response below, indicating that receptor 1 has an alignment position of (0.0, 0.0, 0.0) and orientation of (0.0, 0.0, 0.0).

These alignment values indicate that receptor 1 is the anchor receptor.

```
01a  0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
```

‘^B’ – Aligned Receptors Map

Description:
This command returns bitmap reflecting detected receptors and aligned receptors. This is a read-only command.

Syntax:
^B<>

Remarks:
The returned value of this command is a 16-bit hexadecimal bitmap. This bitmap indicates detected receptors are indicated in the upper 16 bits, and aligned receptors are indicted in the lower 16 bits.

Output Record:

Table 55 ‘^B’ ASCII Response

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘b’
3	A	Error Indicator
4	B	ASCII Blank character
5-8	XXXX	Hex bitmap of detected receptors
9-12	XXXX	Hex bitmap of aligned receptors
13,14	AA	Carriage Return/Line Feed

Table 56 ‘^B’ Binary Output Format

Byte Index	Format	Description
0-7		Binary Header
8-11	I	Detected and Aligned Receptor bitmap

Examples:
The ^B<> command may produce the ASCII response below, indicating that receptors 1 and 2 are detected, and only receptor 1 is aligned.

```
00b  00030001
```

'^K' – Save Operational Configuration

Description:
This command allows the user to save an operational configuration to one of three configuration records stored in PATRIOT WIRELESS non-volatile configuration memory. The configuration saved is the configuration currently defined.

Syntax:
^Kslotnum<>

Part	Description
slotnum	1 – 3: One of three user-definable operational configurations that are stored within PATRIOT WIRELESS

Remarks:
Configuration slot number 0 is reserved for the factory default configuration.

A 15 character null-terminated ID string should be assigned to the user-defined configuration before a '^K' is issued. See the '^X' – Operational Configuration ID command on page 73, and the '^W' – Set Operational Configuration on page 95.

Output Record:
None.

Examples:
Assume a user wants to save the current custom operational configuration for use later. The user also wants to make this configuration the default 'power up' configuration for the user's PATRIOT WIRELESS. The following commands should be issued:

^X*NewIDstring*<>	Assigns an ID string to current configuration
^K1	Saves current configuration to first config slot
^W1	Sets Config Slot 1 to startup config

'^L' – Unlaunch Marker

Description:
This command instructs PATRIOT WIRELESS to remove the specified marker from the launched marker list. After unlaunch, PATRIOT WIRELESS no longer collects data for the marker.

Syntax:
^L*marker*<>

Part	Description
marker	1 to 4, Frequency index of launched marker.

Remarks:
A marker should be unlaunched whenever it is turned off, the battery needs to be recharged, or it is removed from the motion capture area. If this is not done, the PATRIOT WIRELESS will continue to report a P&O solution from the ambient noise.

Output Record:
None.

‘^P’ – Phase Step

Description:
The phase step command is used in conjunction with the autolaunch mode to set the correct orientation for the markers.

Syntax:
^P*marker*<>

Part	Description
marker	1 to 4, Frequency index of launched marker.

Remarks:
When in autolaunch mode the orientation has four possibilities:

1. The correct orientation
2. 180 degree error in azimuth
3. 180 degree error in roll
4. 180 degree error in azimuth and roll (same as 180 in elevation)

Each time the phase step command is applied, PATRIOT WIRELESS steps to the next of these phases. When the marker’s reported orientation data is correct, the correct phase has been reached and the ^P command should not be applied again. See also ‘^G’ – Set Autolaunch Criteria on page 65.

Output Record:
None.

'^V' – WhoAmI

Description:
This command returns the basic identification and firmware version of the PATRIOT WIRELESS.

Syntax:
^V[*receptor*]<>

Part	Description	
receptor	1-2	Specifies which receptor to read version information

Output Record:

Table 57 '^V' ASCII Response

Format	Description
00vAB<>	5-char ASCII header string
Polhemus PATRIOT WIRELESS	
<>	
Boot Loader Version: *version string*<>	Boot Loader Version
System Controller Version: *version string*<>	System Controller Version
I/O Processor Version: *version string*<>	I/O Processor Version
<>	

Table 58 '^V'<> Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	UC	Receptor count (2)
9	UC	PATRIOT WIRELESS Type 4 = PATRIOT WIRELESS
10	UC	Max marker count (4)
11-end	CH[]	Same as ASCII response minus ASCII header

Table 59 '^V[receptor]' ASCII Response

Format	Description
nnvAB	5-char ASCII header string
Receptor n ID: *id string*<>	Receptor num + product ID
Receptor n Serial Number: *sernum string*<>	Receptor num + serial number

Table 60 '^V[receptor]' Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	I	ID
12	CH[]	Serial Number

Examples:
To determine the firmware version of the System Controller module in PATRIOT WIRELESS issue the following command:

^V<>

The record returned will contain the version number of the System Controller, Sensor Processor, I/O Processor, and Boot Loader, as well as the firmware package part number.

‘^W’ – Set Operational Configuration

Description:
This command sets the system non-volatile operational configuration to one of four values. This new ‘default’ configuration will be used upon subsequent system initializations. ***This command does not change the current configuration of the device until the device is restarted.***

Syntax:
^W*slotnum*<>

Part	Description	
slotnum	0	Default Factory configuration
	1-3	Custom user-defined configurations

Remarks:
When using the ‘^W’ command, the ‘^Y’ – Initialize System on page 96 or system power cycle must be applied to make PATRIOT WIRELESS use the operational configuration.

Output Record:
None.

Examples:
If the PATRIOT WIRELESS’ configuration had been altered (by sending various other commands and saving the result to the configuration non-volatile memory) and the user wanted to return the system to its original factory default settings, then the following commands should be sent:

^W0
^Y

After initialization, the system non-volatile configuration memory will be set with all of the factory default parameters. This exercise is especially useful when the system has been modified to the point where the user is not sure how to get back to factory defaults.

NOTE: Care should be taken because ***all*** non-saved custom settings will be lost as a result of the reset.

'^Y' – Initialize System

Description:
This command reinitializes the entire system to an advanced power up state. The user should allow sufficient time for the system to run through its self test and initialization (as signified by completion of LED flashing explained in Step 8 of Getting Started on page 5) before attempting to send the system additional commands.

Syntax:
^Y<>

Remarks:
This command should be used in conjunction with the command '^K' – Save Operational Configuration on page 91, command '^W' – Set Operational Configuration on page 95, and/or the command '^X' – Operational Configuration ID on page 73.

Output Record:
None.

Examples:
If the user wanted to set the system configuration back to its original, factory default condition, the following commands should be sent:

^W0<>

^Y<>

The system will now be in its original factory default condition. The ^Y simulates turning the system power off, then back on again.

‘^Z’ – Read Operational Configuration

Description:
This command allows the user to view the operational configuration settings for the current, factory default and saved custom configurations.

Syntax:
^Z[*slotnum*]<>

Part	Description	
slotnum	0	Factory default configuration
	1-3	One of three user-definable operational configurations that are stored within PATRIOT WIRELESS

Remarks:
If no *slotnum* is supplied, the current operational configuration will be returned.

Output Record:
The ASCII response to ‘^Z’ will be prepended by only the first 3 characters of the normal 5-byte ASCII header:

Table 61 ‘^Z’ ASCII Response Header

Byte Index	Format	Description
0	A	‘0’
1	A	‘0’
2	A	‘z’

The body of the response will be a variable length block of text in the format below. Data in italics will vary according to the configuration settings being reported. Table 62 on page 98 describes the text block line-by-line.

The binary response frame is described by Table 63 on page 99.

Table 62 '^Z' ASCII Response

Format	Description
00z *Configuration name*<>	3-char ASCII Header Config ID string
<>	
Binary: *Yes*|*No*<>	
Metric: *Yes*|*No*<>	
Sync Mode: *0*|*1*<>	0 = Off, 1 = On
Frame Rate: *3*|*4*<>	3 = Half, 4 = Default
Echo Mode: *On*|*Off*<>	
<>	
Buffering: *On*|*Off*<>	
Autolaunch Mode: *On*|*Off*<>	
Autolaunch Criteria: S*x.xxxxx* S*x.xxxxx*<>	
RS-232 Baud Rate: *baudrate*<>	See Table 36 on page 72
RS-232 Parity: *parity*<>	See Table 37 on page 72
<>	
Position Filter Sensitivity: S*x.xxx*<>	
Position Filter Low Value: S*x.xxx*<>	
Position Filter High Value: S*x.xxx*<>	
Position Transition Rate Maximum Value: S*x.xxx*<>	
<>	
Attitude Filter Sensitivity: S*x.xxx*<>	
Attitude Filter Low Value: S*x.xxx*<>	
Attitude Filter High Value: S*x.xxx*<>	
Attitude Transition Rate Maximum Value: S*x.xxx*<>	
<>	
Receptor 1: Close-Range Mode: *On*|*Off*<>	
Receptor 2: Close-Range Mode: *On*|*Off*<>	
<>	

The following text data will be repeated 12 times, for each possible marker on PATRIOT WIRELESS:

Format	Description
Marker x<>	Marker number
Position Increment: S*x.xxx*<>	
Attitude Increment: S*x.xxx*<>	
Output List: (*x*B)..<>	List of Output Data Items See Table 23 on page 63)

Table 63 '^Z' Binary Response

Byte Index	Format	Description	
0-7		Binary Header	
8	A	Config ID	
24	I	Bits	Meaning
		0-2	Baud rate (Table 36 on page 72)
		3-4	Parity (Table 37 on page 72)
		4-31	Reserved
28	I	Bits	Meaning
		0	Continuous Mode (0=Off/1=On)
		1	Binary Mode (0=ASCII/1=Binary)
		2	Units Mode (0=Inches/1=CM)
		3-4	Sync Mode (N/A for PATRIOT WIRELESS)
		5-7	Reserved
		8-9	Reserved
		10-25	Station Bitmap (1=Active)
		26	Echo Mode (0=Off/1=On)
		27	Buffering Mode (0=Off/1=On)
		28-31	Reserved
32	FL	Attitude Filter: Sensitivity	
36	FL	Attitude Filter: FLow	
40	FL	Attitude Filter: FHigh	
44	FL	Attitude Filter: FACTOR	
48	FL	Position Filter: Sensitivity	
52	FL	Position Filter: FLow	
56	FL	Position Filter: FHigh	
60	FL	Position Filter: FACTOR	
64	I	Frame Rate (4=Default 50Hz)	
68	I	Autolaunch mode (1=Enabled/0=Disabled)	
72	FL[2]	Autolaunch Criteria	
80	FL[4]	Position Increment, 4 possible active Markers	
96	FL[4]	Attitude Increment, 4 possible active Markers	
112	I[2]	Receptor Close-Range Mode (0=Off/1=On), 2 Receptors	
The following 80 bytes will be repeated 12 times for each possible active PATRIOT WIRELESS marker:			
Byte Index	Format	Description	
120 + (64 * (station count-1))	I[20]	Output Data List (See Table 23 on page 63)	

Examples:

To view the configuration settings for the *current* configuration issue the following command:

^Z<>

To view the configuration settings for the *factory default* configuration issue the following command:

^Z0<>

‘@S’ – Signal Strength

Description

This command is a diagnostic command that allows a user to see the relative signal strengths of the different marker frequencies that the PATRIOT WIRELESS is receiving. To sample the environment for interfering frequencies, this command would be executed with no markers activated. Values with exponents in the e^{-5} range are reasonable. When this command is issued to the tracker, a signal strength value for each of the twelve marker frequencies is output. This allows a user to determine if interference exists for one or more markers in the tracking environment.

Syntax:

@S<>

Remarks:

This is a read-only command.

Output Record

Table 64 ‘@S’ ASCII Response

Byte Index	Format	Description
0	00vAB	5-char ASCII header string
6	BB	
8	4(x.xxxxBB)	Signal Strength 1-4 det by Receptor 1
40	<>	CRLF
42	4(x.xxxxBB)	Signal Strength 1-4 det by Receptor 2
74	<>	CRLF

Table 65 ‘@S’ Binary Response

Byte Index	Format	Description
0-7		Binary Header
8	FL	Signal Strength 1 detected by Receptor 1
12	FL	Signal Strength 2 detected by Receptor 1
16	FL	Signal Strength 3 detected by Receptor 1
20	FL	Signal Strength 4 detected by Receptor 1
24	FL	Signal Strength 1 detected by Receptor 2
28	FL	Signal Strength 2 detected by Receptor 2
32	FL	Signal Strength 3 detected by Receptor 2
36	FL	Signal Strength 4 detected by Receptor 2

Examples:

Example output for the @S<> command:

```
00@S     0.343366   0.000096   0.000040   0.000072
     0.040266  0.000050  0.000032  0.000087
```

Appendices

APPENDIX A. Terms/Acronyms

6DOF The **6**-**D**egrees-**O**f-**F**reedom (XYZAER) needed to define the position and orientation of an object in 3D space.

Alignment Reference Location Location from which each receptor position and orientation is measured during alignment. This will also be the default reference point (origin) for marker tracking.

Anchor Receptor The receptor in a PATRIOT WIRELESS motion tracking environment to which the system references all marker P&O data.

API **A**pplication **P**rogramming **I**nterface. Programming library used to develop custom host software for driving the instrument. Sometimes used interchangeably with "SDK."

ASCII **A**merican national **S**tandard **C**ode for **I**nformation **I**nterchange defines a certain 8-bit code for display and control characters.

Attitude Matrix A three-by-three matrix containing the direction cosines of the sensor's X axis in column one, the direction cosines of the sensor's Y axis in column two, and the direction cosines of the sensor's Z axis in column three. The order of the Euler angle rotation sequence is azimuth, elevation, and roll.

X Direction Cosines	Y Direction Cosines	Z Direction Cosines
CA*CE	CA*SE*SR - SA*CR	CA*SE*CR + SA*SR
SA*CE	CA*CR + SA*SE*SR	SA*SE*CR – CA*SR
-SE	CE*SR	CE*CR

where:

CA = Cos (azimuth)
CE = Cos (elevation)
CR = Cos (roll)
SA = Sin (azimuth)
SE = Sin (elevation)
SR = Sin (roll)

Azimuth The coordinate of orientation tracking in the horizontal plane where an increase in the angle is clockwise when viewed from above. Azimuth is a rotation around the "Z" or vertical axis. The term “yaw” is often substituted for azimuth, especially in the context of flight.

Baud Rate The signaling rate on a serial line. For example, to convey an 8-bit byte normally requires at least two additional bit times, a start bit and a stop bit so that synchronization is possible without a separate clocking line. For example, such an arrangement implies for a 9600 baud rate conveyance of data at a 9600*8/10 = 7680 bit rate.

Benign Environment A tracking environment free of the need for special calibration or compensation brought on by the unique features of a particular installation and its environment (e.g. high light levels for optical tracking, high sound levels for sonic tracking, or high metallic distortion for magnetic tracking). If not otherwise noted, all measurements and statements pertaining to PATRIOT WIRELESS performance shall be regarded as occurring in such a benign environment.

Binary Mathematical system based on two digits: 0 and 1.

bps Bits per second. Not to be confused with the signaling, or baud rate, which is always equal to or higher than the bit rate. (See baud rate.)

Direction Cosines The cosines of the angles between the sensor’s x, y, z axes and the X, Y, Z axes of the measurement reference (alignment) frame.

Elevation Coordinate of orientation tracking in the vertical plane where an increase in the angle is upward from the horizontal. A term often substituted for elevation, especially as it concerns flight, is pitch.

Factory Defaults The values assigned to certain system variables by the factory. Stored in non-volatile memory, they are used to reinitialize the variables if configuration information is lost.

Firmware Term used to describe the software programmed into PATRIOT WIRELESS non-volatile memory.

Format The interchange coding used to present data. PATRIOT WIRELESS outputs either ASCII or BINARY data, but accepts only ASCII inputs from the host.

Hemisphere Each receptor can be thought of as existing within a magnetic field or sphere of space, with the positive hemisphere above and the negative hemisphere below. Only half of the total spatial sphere surrounding a receptor can be utilized at any one time, and the launching of a marker into the tracking environment must be performed in the prescribed orientation for unambiguous position measurement. Because of the inversion symmetry of the magnetic fields generated by the markers, there are two possible mathematical solutions for the X, Y, Z position coordinates for each set of marker data processed, and PATRIOT WIRELESS is unable to determine which solution is the correct one if the marker has not been launched properly.

Host Any device capable of supporting an RS-232C interface or the high speed USB interface and capable of bi-directional data transmission. Devices may range from a dumb terminal to a mainframe computer.

Increment Position or orientation threshold for new data. When increments are configured, P&O reported in the continuous data stream does not change until the threshold has been passed.

Installed Marker An installed marker is one whose data records have been downloaded to the PATRIOT WIRELESS. A PATRIOT WIRELESS may have multiple wireless marker data sets installed in non-volatile memory. When a new marker is launched and activated, the new marker is identified and its data is located in the list of installed known wireless markers.

I/O Latency The interval of time needed by the host computer to transfer data from the PATRIOT WIRELESS into the host application.

Lag The interval of time between requesting a PATRIOT WIRELESS data point and receiving it into the host computer.

Latency The interval of time between when measurement data were collected and when the P&O result is formatted ready for transfer to the host computer. In some systems, namely active PATRIOT WIRELESS, there is a time interval between when the data is collected and when the P&O computation can be done. Hence, this definition is intended to correspond to the center point of data collection time so that latency is straightforward and understandable as stated. Other tracking systems (e.g., inertial) may produce raw data continuously or nearly continuously. PATRIOT WIRELESS latency in this case reduces to the computation time for producing the answer ready for transfer to the host computer.

Launched Marker An activated wireless marker. The process of activating a marker is known as *launching* the marker. A marker is activated by default when launched into the system. It can subsequently be deactivated but is still considered as launched. A wireless marker from which data results are expected must be both launched and activated.

Line Of Sight (LOS) Not obscured or blocked from view, such as a clear line of sight for optical uses.

LSB **L**east **S**ignificant **B**it.

LSD **L**east **S**ignificant **D**igit.

Marker A wireless rechargeable-battery powered module that creates a unique set of orthogonal signals that the tracking environment receptors use to gather data for computing marker position and orientation. Markers are referenced by their Frequency Index. Up to 4 marker frequencies, and thus 4 active markers, can be tracked by PATRIOT WIRELESS.

Marker Frequency Index Index by which markers are referenced. Up to 4 marker frequencies can be tracked by PATRIOT WIRELESS, one marker per frequency. Multiple markers of the same frequency may be installed in PATRIOT WIRELESS' non-volatile memory, but only one may be active (or 'launched') at one time. Once launched, markers are referenced by their index 1-4; also called "Marker Index" or "Marker Number." This number is reflected on the marker as M1, M2, etc.

MSB **M**ost **S**ignificant **B**it.

Motion Tracking Environment The volume in which motion tracking is specified to perform as prescribed. Receptors are placed in a contiguous pattern to define this environment where markers can be tracked.

Orientation Angles The azimuth, elevation, and roll angles that define the current orientation of the marker coordinate frame with respect to the designated reference frame.

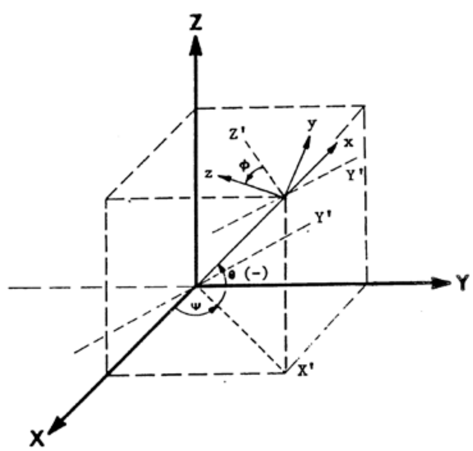
The Euler angle coordinates that are output by PATRIOT WIRELESS as one measure of marker orientation are graphically defined in Figure 0-1. The Euler angles, azimuth, elevation and roll, are designated ψ, θ, and ϕ. These angles represent an azimuth-primary sequence of frame rotations that define the current orientation of the marker with respect to the zero-orientation state of the reference receptor or a user-defined reference orientation. The defining rotation sequence is an azimuth rotation followed by an elevation rotation followed by a roll rotation.

The azimuth angle ψ is defined as a rotation of the X and Y reference axes about the Z reference axis. Note that the transition axes labeled X' and Y' represent the orientation of the X and Y axes after the azimuth rotation.

The elevation angle θ is defined as a rotation of the Z reference axis and the X' transition axis about the Y' transition axis. Note that the transition axis labeled Z' represents the orientation of the Z reference axis after the elevation rotation. Note also that the current x-axis of the current sensor frame represents the orientation of the X' transition axis after the elevation rotation.

Lastly, the roll angle ϕ is defined as a rotation of the Y' and Z' transition axes about the x-axis of the marker frame. Note that the y and z-axes of the current sensor frame represent the orientation of the Y' and Z' transition axes after the roll rotation.

Note also that in the example of Figure 0-1, the azimuth, elevation and roll rotations are positive, negative and positive respectively.



X, Y, Z = Anchor Receptor Reference Frame

x, y, z = Rotated Marker Coordinate Frame

Ψ = Azimuth

θ = Elevation

ϕ = Roll

Figure 0-1: Euler Angles

Output List A list of the data items included in a data record.

P&O Position and Orientation, the six pieces of data needed to fully describe tracking of an object in 3D space. Some tracking devices, by virtue of their principle of operation, can produce only position or only orientation whereas others can produce both P&O (although the user usually can opt for only those parameters desired).

PATRIOT WIRELESS A generation of wireless and expandable motion tracking tools. PATRIOT WIRELESS can be configured with 1 or 2 receptors. PATRIOT WIRELESS provides 6DOF tracking parameters on up to 4 wireless markers.

Pitch Same as elevation.

Quaternion A four-parameter quantity representing a vector and a scalar. The quaternion $q = q_0 + i\,q_1 + j\,q_2 + k\,q_3$ can be used to represent the sensor's orientation without the need for trigonometric functions. The attitude matrix output from PATRIOT WIRELESS can be equivalently represented by the following matrix using quaternions:

$$\begin{array}{c}
\begin{array}{ccc}\text{X Directional Cosines} & \text{Y Directional Cosines} & \text{Z Directional Cosines}\end{array} \\
\begin{bmatrix}
q_0^2+q_1^2-q_2^2-q_3^2 & 2(q_1q_2-q_0q_3) & 2(q_1q_3+q_0q_2) \\
2(q_3q_0+q_1q_2) & q_0^2-q_1^2+q_2^2-q_3^2 & 2(q_2q_3-q_0q_1) \\
2(q_1q_3-q_0q_2) & 2(q_1q_0+q_3q_2) & q_0^2-q_1^2-q_2^2+q_3^2
\end{bmatrix}
\end{array}$$

Receptor A special sensor connected to the PATRIOT WIRELESS SEU for monitoring marker signals needed to compute marker P&O.

Reference Location An arbitrary point (P&O) near the motion tracking environment that can be defined to PATRIOT WIRELESS for basing all reported marker P&O measurements. If an "Anchor Receptor" is in use, the Reference Location is the P&O of the Anchor.

Response The interval of time between a request to the PATRIOT WIRELESS to collect a data point and when that data is available for input from the PATRIOT WIRELESS.

Roll Coordinate of orientation tracking about the azimuth-elevation axis where an increase of the angle is clockwise as viewed from behind or in the same direction as the object is facing.

SDK	**S**oftware **D**eveloper's **K**it. Software development toolset available for Polhemus motion tracking systems; consists of programming libraries, help files, and sample code. Sometimes referred to as "API," although API refers specifically to the programming libraries used to control the instrument.
Station	Generic term for marker or receptor in tracker command syntax.
Sync	Synchronization. For example, sync signal.
System Electronics Unit (SEU)	PATRIOT WIRELESS chassis.
Units	The unit of assumed distance. PATRIOT WIRELESS allows measurement in either inches or centimeters.
Update Rate	The rate at which motion-tracking data can be made available from the PATRIOT WIRELESS.
Useful Range	The maximum distance at which the resolution and noise performance of the PATRIOT WIRELESS can be realized.
User Defaults	The values assigned to certain system variables by the user. Stored in non-volatile memory, the system receives these variable values at power-up.
XYZ or X, Y, Z	The Cartesian coordinates of position tracking where normally +X is in the forward direction; +Y is in the right hand direction; and +Z is downward.
XYZAER	The output string of data reporting the position, (XYZ) and orientation (AER: Azimuth, Elevation and Roll) of the tracking marker.
Yaw	Same as azimuth.
<>	Used in text to indicate the "Enter" key.
^	Used in text to indicate the "Ctrl" key.

APPENDIX B. System Output Data Records

ASCII FORMAT

Table 66 Initiating Commands ASCII Format…P or C (continuous mode)

	Byte Index	Format	Description
HEADER	0	A	First Digit of Marker Number
	1	A	Second Digit of Marker Number
	2	A	Command Letter
	3	A	Error Indicator
	4	B	ASCII Blank character
	5 thru n	A	See Possible Formats below
	n+1, n+2	<>	A P&O response frame may not contain a Carriage Return/Line Feed as specified by the user with the 'O' command

Original Precision:

?* ..	x,y,z position Cartesian Coordinates	3(Sxxx.xxx)
?* ..	az,el,roll Euler orientation angles	3(Sxxx.xxx)
?* ..	direction cosines of the sensor's x,y,z axis	3(Sx.xxxxx)
?* ..	Orientation Quaternion (Q0-Q3)	4(Sx.xxxxx)
?* ..	Stylus Switch x where: x = 0 or 1	

Extended precision:

?* ..	x,y,z position Cartesian coordinates	3(Sx.xxxxxESxxb)
?* ..	az,el,roll Euler orientation angles	3(Sx.xxxxxESxxb)

?* The system data record contents are specified by the user using the "O" command and may vary from configuration to configuration. Therefore, the specific location of a data item in the output record is not determined until the record contents are defined.

NOTE: Original precision is retained for compatibility with previous Polhemus 3SPACE systems. Also, note that some item values are repeated as extended precision items, although no output difference is made (i.e., space, <cr lf>). Original and extended precision may be freely mixed in an output record, but it is recommended that extended precision be used if compatibility is not required, as the original precision may be deleted in future systems.

BINARY FORMAT

Table 67 Initiating Commands Binary Format…P or C (continuous mode)

	Byte Index	TYPE	Description
HEADER	0,1	US	Frame Tag, always 'LU' or 0x4C55 for PATRIOT WIRELESS
	2	UC	Marker Number
	3	UC	Initiating command
	4	UC	Error Indicator
	5	UC	Reserved
	6,7	SH	Response size; number of bytes in the response body
	8 - n		Binary Response body

?* ... x,y,z position Cartesian coordinates FL[3]
?* ... az,el,roll Euler orientation angles FL[3]
?* ... direction cosines of the sensor's x,y,z axes. FL[3]

?* The system data record contents are specified by the user using the "O" command and may vary from configuration to configuration. Therefore, the specific location of a data item in the output record is not determined until the record contents are defined.

The notation FL[3] refers to the ANSI/IEEE Standard for Binary Floating-Point Arithmetic 754-1985 format of data. This is defined in the standard as:

MSB LSB

<table>
<tr><td colspan="2">Bit 31</td><td colspan="2">Bit 30-23</td><td colspan="3">Bit 22-0</td></tr>
<tr><td colspan="2">Sign</td><td colspan="2">Exponent</td><td colspan="3">Fraction</td></tr>
<tr><td colspan="3">Byte 3</td><td colspan="2">Byte 2</td><td>Byte 1</td><td>Byte 0</td></tr>
</table>

The IEEE floating-point format uses sign magnitude notation for the mantissa, and an exponent offset by 127. In a 32-bit word representing a floating-point number, the first bit is the sign bit. The next 8 bits are the exponent, offset by 127 (i.e., the actual exponent is e - 127). The last 23 bits are the absolute value of the mantissa with the most significant 1 implied. The decimal point is after the implied 1, or in other words, the mantissa is actually expressed in 24 bits. In the normal case an IEEE value is expressed as:

(-1)S * (2**(e-127)) * (01.f) If 0 < e < 255

APPENDIX C. Limited Warranty and Limitation of Liability

Polhemus warrants that the Product shall be free from defects in material and workmanship for a period of two years from the date of Polhemus’s delivery to the Buyer, or two years and 30 days from the date ownership of Product passed to the Buyer, whichever occurs first, with the exception of FastSCAN, Marker, and mechanical failure of a battery assembly which have a warranty period of only one year. Batteries have a 90 day warranty period. Polhemus shall, upon notification within the warranty period, correct such defects by repair or replacement with a like serviceable item at Polhemus's option. This warranty shall be considered void if the Product is operated other than in accordance with the instructions in Polhemus's User Manual or is damaged by accident or mishandling. Parts or material which are disposable or expendable or subject to normal wear beyond usefulness within the warranty period such as lamps, fuses, etc., are not covered by this warranty.

In the event any Product or portion thereof is defective, Buyer shall promptly, and within the warranty period, notify Polhemus in writing of the nature of the defect and return the defective parts to Polhemus at the direction of Polhemus’s Customer Service representative. Upon determination by Polhemus that the parts or Products are defective and covered by the warranty set forth above, Polhemus, at its option shall repair or replace the same without cost to Buyer. Buyer shall be responsible for any import/export duties/tariffs and pay all charges for transportation and delivery costs to Polhemus's factory for defective parts where directed to be sent to Polhemus, and Polhemus shall pay for transportation costs to Buyer's facility only for warranty replacement parts and Products. Removed parts covered by claims under this warranty shall become the property of Polhemus.

In the event that allegedly defective parts are found not to be defective, or not covered by warranty, Buyer agrees that Polhemus may invoice Buyer for all reasonable expenses incurred in inspecting, testing, repairing and returning the Products and that Buyer will pay such costs on being invoiced therefor. Buyer shall bear the risk of loss or damage during transit in all cases.

Any repaired or replaced part or Product shall be warranted for the remaining period of the original warranty or thirty (30) days, whichever is longer.

Warranties shall not apply to any Products which have been:

(a) repaired or altered other than by Polhemus, except when so authorized in writing by Polhemus; or
(b) used in an unauthorized or improper manner, or without following normal operating procedures; or
(c) improperly maintained and where such activities in Polhemus's sole judgment, have adversely affected the Products. Neither shall warranties apply in the case of damage through accidents or acts of nature such as flood, earthquake, lightning, tornado, typhoon, power surge(s) or failure(s), environmental extremes or other external causes. Warranties shall not apply to any Products if the Products are defective because of normal wear and tear; or
(d) used for any purpose without obtaining any applicable regulatory approvals.

POLHEMUS DOES NOT WARRANT AND SPECIFICALLY DISCLAIMS THE WARRANTY OF MERCHANTABILITY OF THE PRODUCTS OR THE WARRANTY OF FITNESS OF THE PRODUCTS FOR ANY PARTICULAR PURPOSE. POLHEMUS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, EXCEPT OF TITLE AND AGAINST PATENT INFRINGEMENT, OTHER THAN THOSE SPECIFICALLY SET FORTH HEREIN.

IN NO EVENT SHALL POLHEMUS BE LIABLE UNDER ANY CIRCUMSTANCES FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO LOSS OF PROFITS OR REVENUE. WITHOUT LIMITING THE FOREGOING POLHEMUS'S MAXIMUM LIABILITY FOR DAMAGES FOR ANY CAUSE WHATSOEVER, EXCLUSIVE OF CLAIMS FOR PATENT INFRINGEMENT AND REGARDLESS OF THE FORM OF THE ACTION (INCLUDING BUT NOT LIMITED TO CONTRACT NEGLIGENCE OR STRICT LIABILITY) SHALL BE LIMITED TO BUYER'S ACTUAL DIRECT DAMAGES, NOT TO EXCEED THE PRICE OF THE GOODS UPON WHICH SUCH LIABILITY IS BASED.

The Products are not certified for medical or bio-medical use. Any references to medical or bio-medical use are examples of what medical companies have done with the Products after obtaining all necessary or appropriate medical certifications. The end user/OEM/VAR must comply with all pertinent FDA/CE and all other regulatory requirements.

APPENDIX D. Specifications

Update Rate
50 Hz

Latency
20 milliseconds

Number of Receptors
1 to 2

Number of Wireless Markers
1 to 4

I/O Ports
USB; RS-232 to 115,200 Baud, both are standard

Static Accuracy
1.0 degree and 0.3 inch (0.75cm) using 1 marker and 1 receptor at 30 inches (76.2cm). Accuracy is installation dependent, typical accuracy may normally result in 1 to 3 degrees and 1 to 3 inches (2.54cm to 7.62cm)

Resolution
0.002 in. (0.05 mm) at 12 in. (30 cm) range; 0.005° orientation

Range
Individual receptors have a range of 8 foot radius (16 foot diameter); depending on receptor arrangement range may increase somewhat

Angular Coverage
All-attitude

Data Format
Operator selectable ASCII or IEEE 754 binary; English/Metric Units

Physical Characteristics

SEU w/power supply:
6.7 in. (17 cm) L x 6.25 in. (15.9 cm) W x 1.75 in. (4.44 cm) H
Weight 14.1 oz. (0.4 kg)

Extended Wireless Marker
3.00 in. (7.62cm) L x 1.66 in. (4.22cm) W x 0.97 in (2.46cm) H; weight 2.8 oz. (79.4 gm)

Standard Wireless Marker (discontinued):
2.92 in. (7.4cm) L x 1.56 in. (3.96cm) W x 0.85 in. (2.16cm) H; weight 2 oz. (56.7 gm)

Receptor:
2.5 in. (6.35cm) L x 1.4 in. (3.56cm) W x 1.4 in. (3.56cm) H; weight 3.2 oz. (90.7 gm)
Cable length: 20 ft. (6.1m) or 60 ft. (18.3m)

Power Requirements
100-240VAC, 50/60 Hz. Nominal (85-264 VAC, 47 – 440 Hz. max rating), single phase 10 W

APPENDIX E. Customer Service

If problems are encountered with the PATRIOT WIRELESS or if you are having difficulty understanding how the commands work, help is just a telephone call away.

Call Polhemus at the numbers listed below and select "2" for Customer Service and then "1" for Technical Support. Polhemus is open Monday through Friday, 8:00 AM to 5:00 PM, Eastern Standard Time. For the most part, our customer service representatives are usually able to solve problems over the telephone and get you back into the fast lane right away.

Help is also available on our web page at www.polhemus.com. Simply double-click Technical Support, and then select techsupport@polhemus.com to send us an email describing the problem or question.

If a problem requires repair of your system, the customer service representative will issue a Return Merchandise Authorization (RMA) number and you may then return the system to the factory. ***Do not return any equipment without first obtaining an RMA number.*** Please retain and use the original shipping container, if possible, to avoid transportation damages (for which you or your shipper would be liable). If your system is still under warranty, Polhemus will repair it free of charge according to the provisions of the warranty as stated in APPENDIX C of this document. The proper return address is:

Polhemus
40 Hercules Drive
Colchester, VT 05446
Attention RMA #_______

From within the U.S. and Canada: (800) 357-4777
From outside the U.S. or Canada: (802) 655-3159
Fax #:(802) 655-1439

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