SPAN™ Technology System

USER MANUAL

SPAN Technology System User Manual

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> #6,721,657 B2
> #6,750,816 B1
> 10/758,363 (pending)
> 10/932,497 (pending)

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There are no user serviceable parts in the GPS receiver and no maintenance is required. When the status code indicates that a unit is faulty, replace with another unit and return the faulty unit to NovAtel Inc.

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Please refer to the *PC Software and Firmware* chapter in *Volume 1* of the *OEM4 User Manual* set.

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Contact your local NovAtel dealer first for more information. To locate a dealer in your area or if the problem is not resolved, contact NovAtel Inc. directly using one of the following methods:

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Fax: 403-295-4901

E-mail: support@novatel.ca

Website: http://www.novatel.com

Write: NovAtel Inc., Customer Service Dept., 1120 - 68 Avenue NE, Calgary, AB., Canada, T2E 8S5

✉ Before contacting NovAtel Customer Service regarding software concerns, please do the following:

1. Issue a FRESET command

2. Log the following data to a file on your PC for 30 minutes

RXSTATUSB	once
RAWEPHEMB	onchanged
RANGEB	ontime 1
BESTPOSB	ontime 20
RXCONFIGA	once
VERSIONB	once
RAWIMUSB	onnew

3. Send the file containing the logs to NovAtel Customer Service using the support@novatel.ca e-mail address.

Notices

 CAUTION

1. This device incorporates circuitry to absorb most static discharges. However, severe static shock may cause inaccurate operation of the unit. Use anti-static precautions where possible.
2. This device is a precision instrument. It performs best when handled with care.

Foreword

Congratulations!

Congratulations on purchasing your Synchronized Position Attitude Navigation (SPAN) Technology system, an inertial navigation system (INS), including a SPAN-capable OEM4-G2 enclosure and an IMU. The SPAN-capable receivers are the ProPak-G2*plus*, the ProPak-LB*plus* and the DL-4*plus*. These receiver names are not used in this manual unless a specific detail refers to it alone. The term receiver infers that the text is applicable to all three unless otherwise stated.

The SPAN Technology system (SPAN system) is capable of continuous operation with fast data rates and attitude determination. The SPAN system computes position, velocity, and rotation about three axis at a 100 Hz rate. This system also provides real-time 2 cm positional accuracy with the aid of RT-2 global positioning system (GPS) software, and high data output rates.

The SPAN system provides high positional accuracy coupled with triple-axis attitude measurements. The system can be applied in avionics, sea vessels, land vehicles, navigation, mining and machine control, robotics, agriculture, military and other OEM applications.

This manual will help you get the hardware operational and provide further technical information with examples.

Scope

This manual contains sufficient information on the installation and operation of the SPAN system to allow you to effectively integrate and fully operate its units. It is beyond the scope of this manual to provide details on service or repair. Contact your local NovAtel dealer for any customer-service related inquiries, see *Customer Service* on *Page 10*.

After the addition of accessories, an antenna and a power supply, the SPAN system is ready to go.

The OEM4-G2/G2L in the receiver utilizes a comprehensive user-interface command structure, which requires communications through its communications (COM) ports. This manual also describes the INS specific commands and logs. Other supplementary manuals are included to aid you in using the other commands and logs available with OEM4 family products. It is recommended that these documents be kept together for easy reference.

SPAN system output is compatible with post-processing software from Waypoint, a NovAtel Precise Positioning Company. Visit their website at www.waypnt.com for more details.

Prerequisites

The installation chapters of this document provide information concerning the installation requirements and considerations for the different parts of the SPAN system.

To run the SPAN system software, your personal computer must meet or exceed this minimum configuration:

*   Microsoft Windows user interface (Windows 98 or higher)
*   Pentium Microprocessor recommended
*   VGA Display
*   Windows compatible mouse or pointing device

Although previous experience with Windows is not necessary to use the SPAN system software, familiarity with certain actions that are customary in Windows will assist in the usage of the program. This manual has been written with the expectation that you already have a basic familiarity with Windows.

Chapter 1 | Introduction

Figure 1: SPAN System Receiver and IMU

NovAtel's SPAN technology brings together two very different but complementary positioning and navigation systems namely GPS and an Inertial Navigation System (INS). By combining the best aspects of GPS and INS into one system, SPAN technology is able to offer a solution that is more accurate and reliable than either GPS or INS could provide alone. The combined GPS/INS solution has the advantage of the absolute accuracy available from GPS and the continuity of INS through traditionally difficult GPS conditions.

The SPAN system consists of the following components:

- NovAtel *plus* series GPS receiver - These include the ProPak-G2*plus*, the ProPak-LB*plus* and the DL-4*plus*. All of these variations are capable of receiving and tracking the L1 C/A code, L1 and L2 carrier phase code and L2 P-Code (or encrypted Y-Code) of up to 12 satellites. Satellite Based Augmentation Systems (SBAS), such as WAAS and EGNOS, signal tracking is available as an option. Patented Pulsed Aperture Correlator (PAC) technology combined with a powerful microprocessor make possible multipath-resistant processing. Excellent acquisition and re-acquisition times allow this receiver to operate in environments where very high dynamics and frequent interruption of signals can be expected. Built-in Compact Flash Card data logging capability is available on the DL-4*plus*. The OEM-4 family also supports the timing requirements of the IMU and runs the real-time INS Kalman filter.

- IMU Enclosure - The Inertial Measurement Unit (IMU) is housed in the IMU enclosure that provides a steady power supply to the IMU, which decodes and times the IMU output data. The IMU itself consists of three accelerometers and 3 gyroscopes (gyros) so that accelerations along specific axis and angular rotations can be measured. Several IMU types are supported and are listed in *Table 2, IMU Enclosure Models* on *Page 17* and *Table 12, IMU Type* on *Page 57*.

- PC Software - Real-time data collection, status monitoring and receiver configuration is possible through the GPSolution4 utility, see *Section 3.1* on *Page 28*.

The GPS receiver is connected to the IMU enclosure with an RS-232 or RS-422 serial link. A GPS antenna must also be connected to the receiver to track GPS signals. Once the IMU enclosure, GPS antenna and an appropriate power supply are attached to the receiver, and a few simple configuration commands are entered, the SPAN system will be up and running and ready to navigate.

GPS positioning observes range measurements from orbiting Global Positioning System Satellites. From these observations, the receiver can compute position and velocity with high accuracy. NovAtel GPS positioning systems have been established as highly accurate positioning tools, however GPS in general has some significant restrictions, which limit its usefulness in some situations. GPS positioning requires line of site view to at least four satellites simultaneously. If these criteria are met, differential GPS positioning can be accurate to within a few centimetres. If however, some or all of the satellite signals are blocked, the accuracy of the position reported by GPS degrades substantially, or may not be available at all.

In general, an INS uses forces and rotations measured by an IMU to calculate acceleration, velocity and attitude. This capability is embedded in the firmware of our *plus* series of receivers. Forces are measured by accelerometers in three perpendicular axis within the IMU and the gyros measure rotations around those axis. Over short periods of time, inertial navigation gives very accurate acceleration, velocity and attitude output. The IMU must have prior knowledge of its initial position, initial velocity, initial attitude, Earth rotation rate and gravity field. Since the IMU sensor measures changes in orientation and acceleration, the INS determines changes in position and attitude, but initial values for these parameters must be provided from an external source. Once these parameters are known, an INS is capable of providing an autonomous solution with no external inputs. However, because of errors in the IMU sensor measurements that accumulate over time, an inertial-only solution degrades with time unless external updates such as position, velocity or attitude are supplied.

The SPAN system's combined GPS/INS solution integrates the raw inertial measurements with all available GPS solution and raw measurement information to provide the optimum solution possible in any situation. By using the high accuracy of the GPS solution, the INS measurement errors can be modeled and mitigated. Conversely, the continuity and relative accuracy of the INS solution enables faster GPS signal reacquisition and RTK solution convergence.

The advantages of using SPAN technology are its ability to:

- Provide a full attitude solution (roll, pitch and azimuth)
- Provide continuous solution output (in situations when a GPS-only solution is impossible)
- Provide faster signal reacquisition and RTK solution resolution (over stand-alone GPS because of the tightly integrated GPS and INS filters)
- Output high-rate (up to 100 Hz) position, velocity and attitude solutions for high-dynamic applications
- Use raw phase observation data (to constrain INS solution drift even when too few satellites are available for a full GPS solution)

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1.1   Models and Features

All SPAN system receivers are factory configurable for L1/L2 RTK capability and are compatible with an IMU. See *Table 1* for firmware model details.

Table 1: SPAN-Compatible Receiver Models

Model Name	Firmware Feature
ProPak-G2+DB9-RT2Wi	RS-232, IMU support, L1/L2 plus pseudorange differential corrections, RT-2 INS real-time or post-processed and SBAS corrections
ProPak-G2+DB9-424-RT2Wi	RS-422[a], IMU support, L1/L2 plus pseudorange differential corrections, RT-2 INS real-time or post-processed and SBAS corrections
DL-4+RT2Wi	Integrated data logging, RS-232, IMU support, L1/L2 plus pseudorange differential corrections, RT-2 INS real-time or post-processed and SBAS corrections
DL-4+424-RT2Wi	Integrated data logging, RS-422[a], IMU support, L1/L2 plus pseudorange differential corrections, RT-2 INS real-time or post-processed and SBAS corrections
ProPak-LB+HP-RT2i	OmniSTAR-enabled, RS-232, IMU support, L1/L2 plus pseudorange differential corrections, RT-2 INS real-time or post-processed and SBAS corrections

a. The RS-422 version provides COM1 and COM3 at RS-422 levels. COM2 remains at RS-232 levels.

Each model is capable of multiple positioning modes of operation. For a discussion on GPS positioning and details on the enclosures, please refer to *Volume 1* of the *OEM4 User Manual* set and/ or the *DL-4plus User Manual.*

Each model has the following standard features:

- Rugged shock, water, and dust-resistant enclosure

- NovAtel's advanced OEM4 L1/L2 GPS and PAC technology

- Three bi-directional COM ports which support data transfer rates of up to 115,200 bits/second

- A serial port capable of communication with an IMU. See also *Table 2, IMU Enclosure Models* on *Page 17*.

- Field-upgradeable firmware (program software). What makes one model different from another is software, not hardware. This unique feature means that the firmware can be updated any time, anywhere, without any mechanical procedures whatsoever. For example, a model with L1/L2-only capabilities can be upgraded to a model with L1/L2 RT-2 in only a few minutes in your office (instead of the days or weeks that would be required if the receiver had to be sent to a service depot). All that is required to unlock the additional features is a special authorization code. Refer to *Volume 1* of the *OEM4 User's Guide* for further details on this topic.

SPAN currently supports the Honeywell HG1700 IMU family. The most common HG1700 models are the AG58 (also known as the AG11) and the AG62 (also known as the AG17). The AG11/AG58 IMUs have a 1 degree/hour gyro bias and the AG17/AG62 have a 10 degrees/hour gyro bias.

When using a Honeywell IMU with SPAN, it is housed in an enclosure with a PCB board to handle power, communication and data timing. The enclosure comes in the following models.

Table 2: IMU Enclosure Models

Model Name	Description	Compatible Receiver Enclosures
IMU-G2-000	IMU-G2 enclosure without an IMU for customers who will be supplying their own IMU [a]	ProPak-G2*plus* and DL-4*plus*
IMU-G2-H11	IMU-G2 enclosure with an HG1700 AG11 IMU	
IMU-G2-H17	IMU-G2 enclosure with an HG1700 AG17 IMU	
IMU-G2-H58	IMU-G2 enclosure with an HG1700 AG17 IMU and 1 degree/hour gyro bias	
IMU-G2-H62	IMU-G2 enclosure with an HG1700 AG17 IMU and 10 degrees/hour gyro bias	
IMU-LB-000	IMU-LB enclosure without an IMU for customers who will be supplying their own IMU	ProPak-LB*plus*
IMU-LB-H11	IMU-LB enclosure with an HG1700 AG11 IMU	
IMU-LB-H17	IMU-LB enclosure with an HG1700 AG17 IMU	
IMU-LB-H58	IMU-LB enclosure with an HG1700 AG17 IMU and 1 degree/hour gyro bias	
IMU-LB-H62	IMU-LB enclosure with an HG1700 AG17 IMU and 10 degrees/hour gyro bias	

a. See also *Appendix E, IMU Gyro Installation* starting on *Page 97*

Chapter 2   SPAN Installation

2.1   Hardware Description

The hardware setup consists of an OEM4-G2 receiver (see *Figure 2*), an IMU (see *Figure 3*), a GPS antenna, power and a radio link (if your application requires real time differential operation). If your IMU enclosure and IMU have come separately, additional installation instructions for installing the IMU can be found in *Appendix E, IMU Gyro Installation* starting on *Page 97*.

Figure 2: DL-4*plus*

Figure 3: IMU

Your SPAN system receiver is factory configured and ready to install into the system for data collection. *Figure 4, Basic Set-Up on Page 19* shows a typical set-up. For single point operation, you only need to use the connections in the figure with black cables.
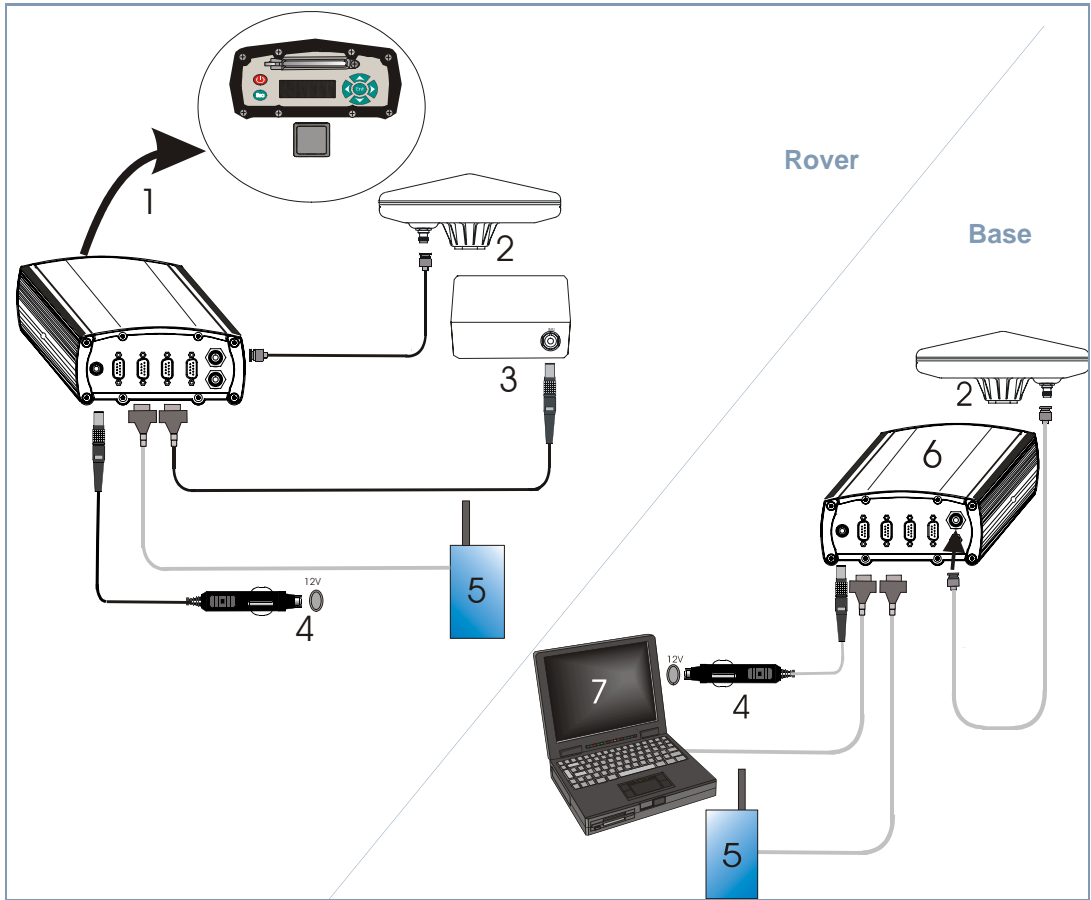
Reference	Description
1	A *plus* receiver (the DL-4*plus* has a Compact Flash Card while the ProPaks may be connected to a laptop for data storage)
2	User-supplied NovAtel GPS antenna
3	IMU and IMU interface cable to COM3 ▦ on the ProPak-LB*plus* or AUX on the Propak-G2*plus* and DL-4*plus*
4	User-supplied power supply
5	User-supplied radio device to COM2
6	User-supplied base station OEM4 Family receiver
7	User-supplied PC, for setting up and monitoring, to COM1

Figure 4: Basic Set-Up

Unlike the ProPak-G2*plus* and the DL-4*plus*, the ProPak-LB*plus* does not power the IMU directly through a straight IMU interface cable. The ProPak-LB*plus* connections with its IMU interface cable are shown in the *Figure 5* on *Page 20*. Note the use of a W-shaped cable for communication and power between the receiver and IMU.
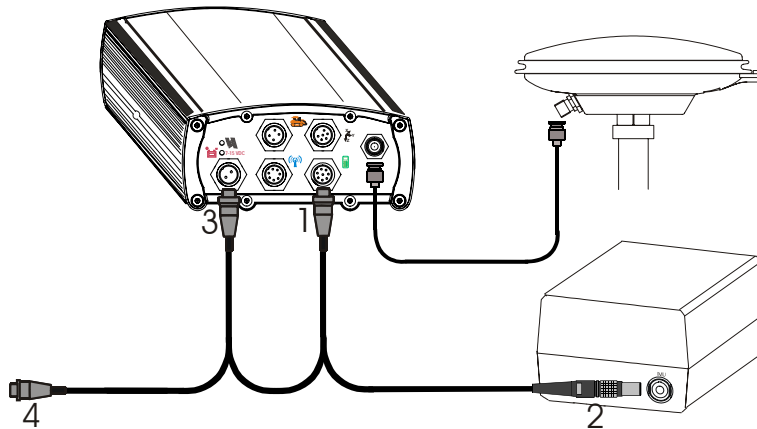
Figure 5: IMU Interface Cable Connections (ProPak-LB*plus*)

Reference	Description
1	8-pin Switchcraft connector to COM3
2	10-pin LEMO connector to IMU
3	2-pin Switchcraft connector to power port
4	2-pin Switchcraft connector to power source

The setup that follows outlines how to set up the system's parts and cables. See *Appendix A Technical Specifications s*tarting on *Page 36*, and refer to your DL-4*plus* or *Volume 1* of the *OEM4 User Manual* set for the NovAtel part numbers of cables and their pinouts.

2.1.1   SPAN System Receivers

The DL-4*plus* is the only receiver with a data storage device. To store data on a ProPak-G2*plus* or ProPak-LB*plus*, connect a laptop computer to it. The laptop computer should be equipped with a data storage device such as a Compact Flash Card, CD or MP3 disc.

The back panels of the ProPak-G2*plus* and DL-4*plus* are the same, see *Figure 6* on the left. The ProPak-LB*plus* back panel uses mostly Switchcraft rather than DB9 connectors and is shown on the right.

Figure 6: Receiver Enclosure Back Panels

The communication port names and pinouts also differ. For example, the ProPak-LB*plus* does not have an I/O port but COM1 has PPS and MARK input signal lines. Please refer to *Volume 1* of the *OEM4 User Manual* set for details. *Table 3* shows a summary of the receivers' back panel port names.

⊠ When you input a command that requires a port name, you **must** type in COM3 for the ProPak-G2*plus* and ProPak-LB*plus* **and** you **must** type in AUX for the DL-4*plus*. This is true, even if the port is labelled differently.

Table 3: Receiver Enclosure Back Panel Labels

SPAN Enclosure	Port Label	Description
DL-4*plus* and ProPak-G2plus	**9-18 VDC**	Power
	COM1	COM1
	COM2	COM2
	AUX	COM3 (ProPak-G2*plus*) or AUX (DL-4*plus*)
	I/O	I/O
	GPS	Antenna
	EXT OSC	External Oscillator
ProPak-LB*plus*	(antenna icon)	Antenna
	(battery icon)	Power
	(X Y Z axes icon)	COM1 or I/O
	(antenna tower icon)	COM2
	(handheld icon)	COM3

Table 4: Enclosure Port Used for IMU Connection

SPAN Enclosure	Port Label	Port Name for Software [a]
ProPak-G2*plus*	AUX	COM3
ProPak-LB*plus*	(handheld icon)	COM3
DL-4*plus*	AUX	AUX

a. This is the name given to the port when described in a command or output in a log

2.1.2   Antenna

For maximum positioning precision and accuracy, as well as to minimize the risk of damage, ensure that the antenna is securely mounted on a stable structure that will not sway or topple. Where possible, select a location with a clear view of the sky to the horizon so that each satellite above the horizon can be tracked without obstruction. The location should also be one that minimizes the effect of multipath interference. For a discussion on multipath, please refer to the *GPS+ Reference Manual*.

⊠   1.   The closer the antenna is to the IMU, the more accurate the position solution. Also, your measurements when using the SETIMUTOANTOFFSET command must be as accurate as possible, or at least more accurate than the GPS positions being used. **For example, a 10 cm error in recording the antenna offset will result in at least a 10 cm error in the output. Millimeter accuracy is preferred.**

2.   The offset from the IMU to the antenna, and/or a user point device, must remain constant especially for RTK or DGPS data. Ensure the IMU, antenna and user point device are bolted in one position perhaps by using a custom bracket.

2.1.3   IMU Mounting

Mount the antenna in a fixed location where the distance from the antenna to the receiver is fixed. Ensure that the orientation with respect to the vehicle and antenna is also constant.

For attitude output to be meaningful, the IMU should be mounted such that the positive Z-axes marked on the IMU enclosure points up and the Y-axes points forward through the front of the vehicle, in the direction of track.

Also, it is important that the measurement of the IMU to Antenna Lever Arm is on the axis defined on the IMU enclosure. See also *Section 3.2.4, Lever Arm Calibration Routine* starting on *Page 33*. *Appendix A, Technical Specifications* starting on *Page 36* gives dimensional drawings of the IMU enclosure and its mounting feet.

2.1.4   Cables and Ports

Refer to your receiver's hardware manual for more information on its ports and cables (*Volume 1* of the *OEM4 User Manual* set or the *DL-4plus User Manual).*

Each connector can be inserted in only one way, to prevent damage to both the receiver and the cables. Furthermore, the connectors that are used to mate the cables to the receiver require careful insertion and removal. Observe the following when handling the cables.

- To insert a cable, make certain you are using the appropriate cable for the port - the serial cable has a different connector (number of pins) than the power cable
- Insert the connector until it is straight on and secure
- To remove a cable, grasp it by the connector

WARNING: **DO NOT PULL DIRECTLY ON THE CABLE.**

2.1.4.1 I/O Port & Cables (ProPak-G2*plus* and DL-4*plus* only)

The ProPak-G2*plus* and DL-4*plus* receivers incorporates an I/O port. This port may be part of an interconnected system composed of devices that need to be synchronized with each other. For example, you could connect the SPAN system to an aerial camera in such a way that the SPAN system recorded its position whenever the shutter button was pressed.

The receivers have TTL-compatible I/O strobe lines. Typically, the I/O strobe lines can be accessed by inserting the connector of an I/O strobe port cable into the I/O port. The other end of the cable is provided without a connector so that you can provide an application-specific one. The jacket insulation is cut away slightly from the end but the insulation on each wire is intact.

Refer to the hardware manual for your receiver for more information on signals, wiring and pin-out information of the I/O port and its cable (*Volume 1* of the *OEM4 User Manual* set or the *DL-4plus User Manual)*.

2.1.4.2 Power Port and Cable

The SPAN system requires an input supply voltage between +12 VDC and +18 VDC (+12 to +15 VDC for a ProPak-LB*plus* model). An automotive adapter is supplied but power can come from a wall outlet adapter or batteries. The receiver has an internal power module that does the following:

- filters and regulates the supply voltage
- protects against over-voltage, over-current, and high-temperature conditions
- provides automatic reset circuit protection

There is always a drop in voltage between the power source and the power port due to cable loss. Improper selection of wire gauge can lead to an unacceptable voltage drop at the SPAN system. A paired wire run represents a feed and return line. Therefore, a 2-m wire pair represents a total wire path of 4 m. For a SPAN system operating from a 12 V system, a power cable longer than 2.1 m (7 ft.) should not use a wire diameter smaller than 24 AWG.

For pin-out information on the power connector on your receiver, refer to its hardware manual (*Volume 1* of the *OEM4 User Manual* set or the *DL-4plus User Manual*).

2.2 Hardware Set-Up

Complete the following steps to set up and power your SPAN system where the example graphics show the connections on the back of a DL-4*plus* or ProPak-G2*plus* receiver. Refer to your *ProPak-LBplus Quick Start Guide* for graphics of its connectors.

1. Mount the IMU and antenna securely to a vehicle. Ensure they cannot move due to dynamics and that the distance and relative direction between them is fixed. See also *Section 2.3.2, SPAN IMU Configuration* starting on *Page 25*.

2. Connect the IMU to the receiver using the IMU cable provided. For the ProPak-LB*plus* the IMU cable plugs into the ▦ (COM3) port. For the DL-4*plus* and ProPak-G2*plus* receivers, the IMU plugs into the port labelled AUX. See also *Steps 1* and *2* in the *SPAN IMU Configuration* section on *Page 25*.

3. Connect COM1 of the receiver to a computer COM port using a null modem cable.
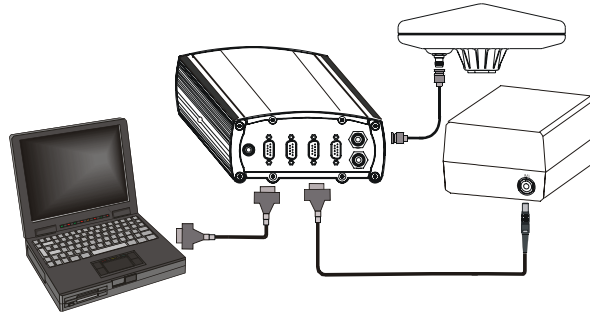
4. Connect the GPS antenna to the antenna port on the receiver using an appropriate antenna cable.

5. Apply power to the receiver and in the case of the DL-4*plus*, push its power button to turn it on. It is recommended that a back-up battery is placed between the receiver and its voltage supply to act as a power buffer if installed in a vehicle. When a vehicle engine is started, power can dip to 9.6 VDC or cut-out to ancillary equipment causing the receiver and IMU to lose lock and calibration settings.
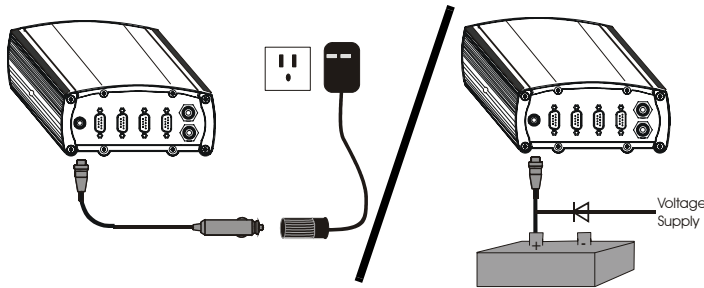
⊠ *For advanced users*: You may also have a user point device such as video equipment. Connect the device to the receiver's I/O port using a cable that is compatible to both the receiver and the device. Refer to your device's documentation for information on its connectors and cables. The arrow along the cable in the figure indicates a MARKIN pulse, refer to *Volume 2* of the *OEM4 User Manual* set, from the user device on the right to the DL4*plus* I/O port.
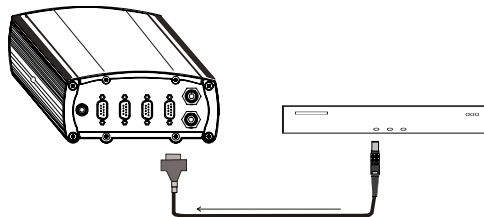
2.3 Software Configuration

2.3.1 GPS Configuration

The GPS configuration can be set up for different accuracy levels such as single point, SBAS, DGPS and RTK (RTCA, RTCM, RTCM V3 and CMR). ProPak-LB*plus* receivers can also be set up for Omnistar HP, Omnistar VBS or CDGPS. Refer to the *OEM4 User Manual* set for details on DGPS, RTK, L-Band or SBAS setup and operation.

With no additional configuration, the system operates in single point mode.

2.3.2 SPAN IMU Configuration

Follow these steps to enable INS as part of the SPAN system using software commands or turn the page to see the alternate method using GPSolution:

1. Issue the INTERFACEMODE command to specify the receiver port connected to the IMU:

Receiver Type	INTERFACEMODE Command
ProPak-G2*plus*	INTERFACEMODE COM3 IMU IMU OFF [a]
ProPak-LB*plus*	INTERFACEMODE COM3 IMU IMU OFF
DL-4*plus*	INTERFACEMODE AUX IMU IMU OFF

a. Enter this command even if the port is labelled AUX on the ProPak-G2*plus*

See also the port tables on *Page 21* and the INTERFACEMODE command on *Page 47*.

2. Issue the SETIMUTYPE command to specify the type of IMU being used:

IMU Type	SETIMUTYPE Command
AG11 *or* AG58	setimutype imu_hg1700_ag11
AG17 *or* AG62	setimutype imu_hg1700_ag17

See also the SETIMUTYPE command on *Page 57*.

Basic configuration of the SPAN system is now complete. The inertial filter starts once the GPS solution is solved and the IMU is connected.

☒ Alternatively, select View | INS Window in GPSolution to select the type of IMU and to configure the receiver port, connected to the IMU, to accept IMU data:

INS Position, Velocity, Attitude - MYSPAN1		
INS Configuration and Status		**Position (Std Dev)**

INS Configuration and Status		Position (Std Dev)		
INS Status	INS_COARSE_ALIGN_COMPLETE	Latitude	51.11636241°	(0.407 m)
IMU Type	IMU_HG1700_AG11	Longitude	-114.03825009°	(0.437 m)
IMU Port	COM3	Height	1045.768 m (MSL)	(0.627 m)

Velocity (Std Dev)			Attitude (Std Dev)		
North Velocity	-0.001 m/s	(0.012 m/s)	Roll	-0.453°	(0.053°)
East Velocity	-0.001 m/s	(0.012 m/s)	Pitch	0.604°	(0.053°)
Up Velocity	0.001 m/s	(0.007 m/s)	Azimuth	184.946°	(5.149°)

Right-click on the *INS* window and select *Configure INS* to see the *Configure INS* dialog:

Configure INS

IMU Type | IMU_HG1700_AG11 ▼
IMU Port | COM3 ▼

[Enable INS] [Disable INS] [Cancel]

When you have made your selections in the *IMU Type* and *IMU Port* fields, click on the *Enable INS* button.

3. Enter the distance from the IMU to the GPS antenna using the SETIMUTOANTOFFSET command, see *Page 56*.

   The offset between the antenna phase centre and the IMU axis must remain constant and be known accurately (m). The X (pitch), Y (roll) and Z (azimuth) directions are clearly marked on the IMU. The SETIMUTOANTOFFSET parameters are (where the standard deviation fields are optional):

   x_offset y_offset z_offset [x_stdev] [y_stdev] [z_stdev]

   A typical RTK GPS solution is accurate to a few centimeters. For the integrated INS/GPS system to have this level of accuracy, the offset must be measured to within a millimeter. Any bias between the two systems shows up directly in the output position. For example, a 10 cm error in recording this offset will result in at least a 10 cm error in the output.

2.3.2.1   Configuration for Fast Alignment

If a course alignment routine cannot be performed because the vehicle cannot remain stationary for at least 1 minute, an alternate fast alignment routine is available. The fast or moving alignment is performed by estimating the attitude from the GPS velocity vector and injecting it into the SPAN filter as the initial system attitude. For fast alignment follow the configuration steps above plus the following:

1. Specify which IMU axes is mostly aligned with gravity using the SETIMUORIENATATION command, see *Page 53*. If the IMU is installed, as recommended, with the markings on the IMU enclosure aligned with the axis of the vehicle, this command is:

   ```
   SETIMUORIENATION 5
   ```

2. Specify the angular offsets between the IMU body frame (as marked on the IMU enclosure) and the vehicle frame using the VEHICLEBODYROTATION command, see *Page 59*. If installed, as recommended, with the IMU Z-axes up and the Y-axes aligned with the direction of track of the vehicle, the parameters for this command are zeros.

   ```
   VEHICLEBODYROTATION 0 0 0
   ```

Alternatively, the angular offsets between the IMU and vehicle frame can be solved by the system through a calibration process. See *Section 3.2.5, Vehicle to Body Frame Angular Offsets Calibration Routine* starting on *Page 34* for more details.

Chapter 3   SPAN Operation

Before operating your SPAN system, ensure that you have followed the installation and setup instructions in *Chapter 2, SPAN Installation* starting on *Page 18.*

You can use NovAtel's GPSolution4 software to monitor data in real-time, between a rover SPAN system and base station, or, for example, to analyze data after logging to the DL-4*plus* Compact Flash Card.

SPAN system output is compatible with post-processing software from Waypoint, a NovAtel Precise Positioning Company. Visit their website at www.waypnt.com for more details.

WARNING: **Ensure the Control Panel's Power Settings on your PC are not set to go into Hibernate or Standby modes. Data will be lost if one of these modes occurs during a logging session.**

3.1   Communicating with the SPAN System

Once the receiver is connected to the PC, antenna, and power supply, install NovAtel's GPS PC Utilities (GPSolution, DL4Tool and Convert). You can find installation instructions in your receiver's *Quick Start Guide*. (Alternatively, you can use a terminal emulator program such as HyperTerminal to communicate with the receiver.) Refer also to *Volume 1* of the *OEM4 User Manual* set for details.

Start GPSolution4 on your PC to enable communication:

1. In the GPSolution menu, select Device | Open.

2. Select the *New...* button in the *Open* dialog box.
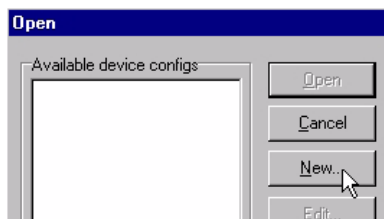
3. Enter a name for the new device configuration in the *Name* field of the *New Config* dialog box.

4. Select the *Settings* button.

5. Select the PC serial port the receiver is connected to from the *PC Port* drop-down list, 57600 from the *Baud Rate* list and uncheck the *Use hardware handshaking* checkbox.

6. Select *OK* to save the settings and *OK* again to close the *New Config* dialog box and return to the *Open* dialog.

7. Select your configuration (*Name*) in the *Open* dialog and click on the *Open* button.

8. Select View | Logging Control from the menu to control the GPSCard's logging to files and serial ports. Refer to GPSolution4's on-line Help for more information.

---

9. Use the *Console* window to enter commands. See also *Section 3.3, Data Collection for Post Processing* on *Page 34*.

⊠ If you have to power down your receiver, ensure that all windows, other than the Console window, are closed in GPSolution and then use the SAVECONFIG command.

3.1.1   INS Window in GPSolution4

GPSolution4 is a 32 bit Windows application. The application provides a graphical user interface to allow you to set-up and monitor the operation of the SPAN system by providing a series of windows.

The INS Window in GPSolution4 is described below. Please refer to *Volume 1* of the *OEM4 User Manual* set for more details on GPSolution4 and other OEM4 family PC software programs.

INS   •**INS Window:** This window displays INS position, velocity and attitude information as well as status and configuration indicators.

INS Position, Velocity, Attitude - MYSPAN1				_ □ ×
INS Configuration and Status		**Position (Std Dev)**		
INS Status	INS_COARSE_ALIGN_COMPLETE	Latitude	51.11636241°	(0.407 m)
IMU Type	IMU_HG1700_AG11	Longitude	-114.03825009°	(0.437 m)
IMU Port	COM3	Height	1045.768 m (MSL)	(0.627 m)
Velocity (Std Dev)		**Attitude (Std Dev)**		
North Velocity	-0.001 m/s (0.012 m/s)	Roll	-0.453°	(0.053°)
East Velocity	-0.001 m/s (0.012 m/s)	Pitch	0.604°	(0.053°)
Up Velocity	0.001 m/s (0.007 m/s)	Azimuth	184.946°	(5.149°)

Please also see GPSolution4's on-line help for more details. The Help is accessed by choosing Help from the menu in GPSolution4.

3.2   Real-Time Operation

SPAN operates through the OEM4 command and log interface. Commands and logs specifically related to SPAN operation are documented in *Appendices B* and *C* of this manual respectively.

Real-time operation notes:

*   Inertial data does not start until time is set and therefore, the SPAN system does not function unless a GPS antenna is connected with a clear view of the sky.

*   The Inertial solution is computed separately from the GPS solution. The GPS solution is available from the SPAN system through the GPS-specific logs even without SPAN running. The integrated INS/GPS solution is available through special INS logs documented in *Appendix C* of this manual.

*   The IMU solution is available at the maximum rate of output of the IMU (100 Hz). Because of this high data rate, a shorter header format was created. These shorter header logs are

defined with an S (RAWIBUSB rather than RAWIMUB). We recommend you use these logs instead of the standard header logs to save throughput on the COM port.

Status of the inertial solution can be monitored using the inertial status field in the INS logs. *Table 5* is a subset of the *INS Status Definitions* table on *Page 60*.

Table 5: Solution Status Subset

Binary	ASCII	Description
0	INS_INACTIVE	IMU logs are present, but the alignment routine has not started
1	INS_ALIGNING	INS is in alignment mode
3	INS_SOLUTION_GOOD	The INS filter is in navigation mode
6	INS_BAD_GPS_AGREEMENT	The INS filter is in navigation mode, and the GPS solution is suspected to be in error. This may be due to multipath or limited satellite visibility. The inertial filter has rejected the GPS position and is waiting for the solution quality to improve.
7	INS_ALIGNMENT_COMPLETE	The INS filter is in navigation mode, but not enough vehicle dynamics have been experienced for the system to be within specifications.

3.2.1   System Start-Up and Alignment Techniques

The system requires an initial attitude estimate to start the navigation filter. This is called system alignment. On start-up the system has no position, velocity or attitude information. When the system is first powered up, the following sequence of events happens:

1.   The first satellites are tracked and coarse time is solved

2.   Enough satellite are tracked to compute a position

3.   Receiver "fine time" is solved, meaning the time on board the receiver is accurate enough to begin timing IMU measurements

4.   Raw IMU measurements begin to be timed by the receiver and are available to the INS filter. They are also available to you in the RAWIMU log, see *Page 87*. The INS Status field reports INS_INACTIVE.

5.   The inertial alignment routine starts and the INS Status field reports INS_ALIGNING.

6.   Alignment is complete and the INS Status field changes to INS_ALIGNMENT_COMPLETE. The system transitions to navigation mode.

7.   The solution is refined using updates from GPS. Once the system is operating within specifications and after some movement, the INS Status field changes to INS_SOLUTION_GOOD.

3.2.1.1   Coarse Alignment

The coarse alignment is the default alignment routine for SPAN. The alignment starts as soon as a GPS solution is available, the receiver has computed fine time and the IMU is connected and configured. The vehicle must remain stationary for the alignment to happen. During the coarse alignment, accelerometer and gyro measurements are averaged over a period of time to measure Earth rotation and gravity. From these averaged measurements, initial estimates of roll, pitch and heading are computed. Because the coarse alignment uses averaged sensor output, the vehicle must remain stationary for the duration of the alignment, which is approximately 1 minute. The attitude estimates solved by the alignment are larger than the system specified attitude accuracy and vary upon the characteristics of the sensor and the geographic latitude of the system. Attitude converges with motion after the coarse alignment is complete (see *Section 3.2.2, Navigation Mode* on *Page 31*).

3.2.1.2   Fast Alignment

If the preferred coarse alignment routine cannot be performed because the vehicle cannot remain stationary for the length of time required, an alternate alignment routine is available. The fast or moving alignment is performed by estimating the attitude from the GPS velocity vector and injecting it into the SPAN filter as the initial system attitude.

Additional configuration parameters are necessary to enable the fast alignment. In order to simplify this configuration it is strongly suggested that you mount the IMU coincidentally with the vehicle frame so that the graphics on the IMU enclosure align with the axis of the vehicle.

Specify which IMU axes is most closely aligned with gravity using the SETIMUORIENTATION command. If the IMU is mounted coincidentally with the vehicle, then the command would be:

```
SETIMUORIENTATION 5
```

Specify the angular offsets between the IMU frame and the vehicle frame (known as vehicle/body rotation or RVB) using the VEHICLEBODYROTATION command. If the IMU is mounted coincidentally with the vehicle, then the command would be:

```
VEHICLEBODYROTATION 0 0 0
```

Alternatively, solve the vehicle to IMU frame angular offsets using the RVBCALIBRATE routine. See also *Section 3.2.5, Vehicle to Body Frame Angular Offsets Calibration Routine* starting on *Page 34*.

The fast alignment begins when the receiver has a good GPS position, fine time is solved, the configuration parameters have been set and a GPS velocity of 5 m/s is observed.

The accuracy of the initial attitude of the system following the fast alignment varies and depends on the dynamics of the vehicle and the accuracy of the RVB estimates. The attitude accuracy will converges to within specifications once some motion is observed by the system. This transition can be observed by monitoring the INS Status field in the INS logs.

3.2.2   Navigation Mode

Once the alignment routine has successfully completed, SPAN enters navigation mode.

The solution is computed by accumulating velocity and rotation increments from the IMU to generate position, velocity and attitude. System errors are modeled using a Kalman filter. States in the filter include position error, velocity error, attitude error, gyroscope biases and accelerometer biases. If the

lever arm is being calibrated, lever arm errors are also included as states. Updates to the Kalman filter are provided by the GPS solution, GPS phase observations and automatic zero velocity updates (ZUPTs).

Following the alignment the attitude is coarsely defined, especially in heading. Vehicle dynamics, specifically turns, allow you to observe the heading error. Dynamics allow the heading accuracy to converge. Three to five changes in heading should be sufficient to resolve the heading accuracy. The INS Status field changes to INS_SOLUTION_GOOD once this convergence is complete.

3.2.3   *Data Collection*

The INS solution is available in the INS-specific logs with either a standard or short header. Other parameters are available in the log shown in *Table 6*:

Table 6: Solution Parameters

Parameter	Log
Position	INSPOS INSPOSS INSPVA INSPVAS
Velocity	INSVEL INSVELS INSSPD INSSPDS INSPVA INSPVAS
Attitude	INSATT INSATTS INSPVA INSPVAS
Solution Uncertainty	INSCOV INSCOVS

Note that the position, velocity and attitude are available together in the INSPVA and INSPVAS logs.

The inertial solution is available up to the rate of the IMU data (100 Hz for the HG1700). Data can be requested at a specific rate up to the maximum IMU output rate, or can be triggered by the mark input trigger at rates up to 20 Hz.

The GPS-only solution is still available through the GPS-only logs such as RTKPOS, PSRPOS and OMNIHPPOS. When running SPAN, rates of non-INS logs should be limited to a maximum rate of 5 Hz. Refer to *Volume 2* of the *OEM4 User Manual* set for more details on these logs. INS-only data logging and INS-only data output can be at rates of up to 100 Hz.

⊠   The highest rate that you should request GPS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GPS logs can be requested at rates up to 20 Hz.

Specific logs need to be collected for post-processing. See *Section 3.3, Data Collection for Post Processing* on *Page 34*.

To store data on a ProPak-G2*plus* or ProPak-LB*plus*, connect a laptop computer to it. The laptop computer should be equipped with a data storage device such as a Compact Flash Card, CD or MP3 disc. For data logging to a compact flash card on the DL-4*plus*, refer to the *DL-4plus User Manual*.

3.2.4   *Lever Arm Calibration Routine*

Each time the system is re-mounted on a vehicle, or the IMU or antenna is moved on the vehicle, the lever arm must be redefined either through manual measurement or through calibration. The lever arm calibration routine should only be done when the receiver is operating in RTK mode. Initial estimates and uncertainties for the lever arm are entered using the SETIMUTOANTOFFSET command, see *Page 56*. The calibration routine uses these values as the starting point for the lever arm computation. The steps involved in the calibration are:

1. Power the receiver and the IMU, see *Section A.1, IMU Interface Cable* starting on *Page 38*.

2. Configure the RTK corrections and make sure that the BESTGPSPOS log, see *Page 62*, reports a good RTK solution.

3. Configure the IMU, see *Section 2.3.2, SPAN IMU Configuration* starting on *Page 25*.

4. Enter the initial estimate for the lever arm using the SETIMUTOANTOFFSET command, see *Page 56.*

5. Specify the limits of the calibration through the LEVERARMCALIBRATE command, see *Page 51*. The calibration can be limited by time or accuracy of the lever arm. A recommended accuracy threshold is 0.02 m.

6. Monitor the calibration, log BESTLEVERARM, see *Page 69*, using the ONCHANGED trigger.

7. Remain stationary long enough for the coarse alignment to finish. The alignment is complete when the INS status changes to INS_ALIGNMENT_COMPLETE. See also *Table 13* on *Page 60*.

8. Start to move the system. The lever arm is not observable while the system is stationary. Drive a series of manoeuvres such as circles and figure eights. Some height variation in the route is also useful for providing observability in the Z-axes. When the calibration is complete, either because the specified time has passed or the accuracy requirement has been met, the BESTLEVERARM log outputs the solved lever arm.

The lever arm is saved automatically in NVM. If the IMU or GPS antenna are re-mounted, the calibration routine should be re-run to compute an accurate lever arm.

3.2.5 *Vehicle to Body Frame Angular Offsets Calibration Routine*

Kinematic fast alignment requires that the angular offset between the vehicle and IMU body frame is known approximately. If the angles are simple (that is, a simple rotation about one axes) the values can easily be entered manually through the VEHICLEBODYROTATION command, see *Page 59*. If the angular offset is more complex (that is, rotation is about 2 or 3 axis), then the calibration routine provides a more accurate estimation of the values. As with the lever arm calibration, the vehicle to body frame angular offset calibration requires RTK GPS. The steps for the calibration routine are:

1. Apply power to the receiver and IMU, see *Section A.1, IMU Interface Cable* starting on *Page 38*.

2. Configure the RTK corrections and make sure that the BESTGPSPOS log, see *Page 62*, reports a good RTK solution.

3. Configure the IMU, see *Section 2.3.2, SPAN IMU Configuration* starting on *Page 25*.

4. Ensure that an accurate lever arm has been entered into the system either manually or through a lever arm calibration, see *Page 31*.

5. Enable the lever arm calibration using the RVBCALIBRATE ENABLE command, see *Page 52*.

6. Start to move the system. As with the lever arm calibration, movement of the system is required for the observation of the angular offsets. Drive a series of manoeuvres such as circles and figure eights with some height variation to provide the system with dynamics. Approximately 2-5 minutes of motion should be sufficient to solve the offsets.

7. When the uncertainties of the offsets are low enough to be used for a fast alignment, the calibration stops and the VEHICLEBODYROTATION log, see *Page 92*, is overwritten with the solved values. To monitor the progress of the calibration, log VEHICLEBODYROTATION using the ONCHANGED trigger.

The rotation parameters are saved in NVM for use on start-up in case a fast-alignment is required. Each time the IMU is re-mounted this calibration should be performed again. See also *Sections 3.2.1.1* and *3.2.1.2* on *Page 31* for details on coarse and fast alignment.

3.3 Data Collection for Post Processing

Some operations such as aerial measurement systems do not require real-time information from SPAN. These operations are able to generate the position, velocity or attitude solution post-mission in order to generate a more robust and accurate solution than is possible in real-time.

In order to generate a solution in post-processing, data must be simultaneously collected at a base station and each rover. The following logs must be collected in order to successfully post process data:

From a base:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONNEW

From a rover:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONNEW
- RAWIMUSB ONNEW

Post processing is performed through the Waypoint Inertial Explorer software package available from Waypoint, a NovAtel Precise Positioning Company. Visit their website at www.waypnt.com for more details.

☒ The highest rate that you should request GPS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GPS logs can be requested at rates up to 20 Hz.

Appendix A Technical Specifications

Refer to your SPAN system enclosure's hardware manual for more information on its technical specifications and cables (*Volume 1* of the *OEM4 User Manual* set or the *DL-4plus User Manual*).

Table 7: IMU Specifications

PHYSICAL	
IMU Size	160 mm x 160 mm x 100 mm (6.3" x 6.3" x 3.9")
IMU Weight	3.4 kg (7.49 lb.)
MECHANICAL DRAWINGS	
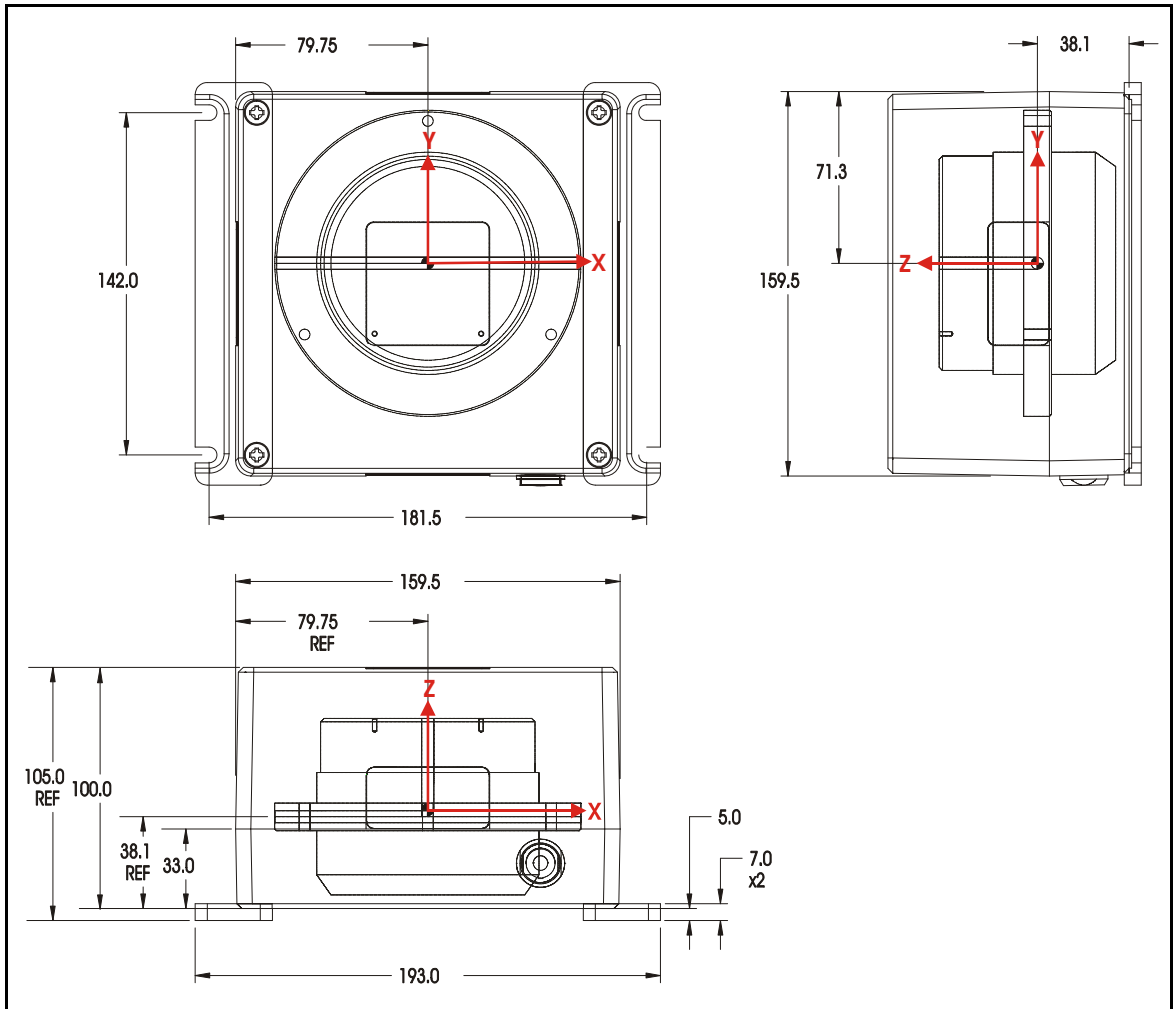
Figure 7: IMU Dimensions
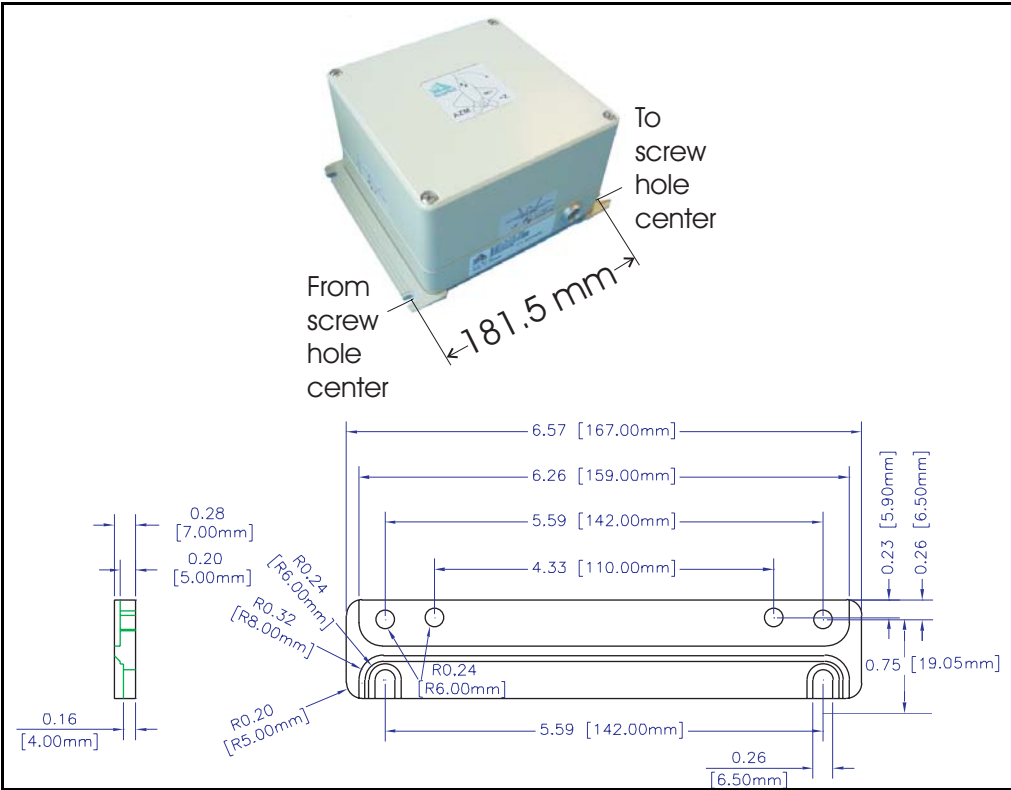
Figure 8: Mounting Bracket Dimensions

A.1   IMU Interface Cable

The NovAtel part number for the IMU interface cable is either 01017384 for the DL-4*plus* and ProPak-G2*plus* (see *Figure 9* and *Figure 10 below*), or 01017393 for the ProPak-LB*plus* (see *Figure 11* and *Figure 12* on *Page 39*.)

The IMU interface cable supplied provides power to the IMU from the receiver, and enables input and output between them.

Figure 9: IMU Interface Cable (ProPak-G2*plus* and DL-4*plus*)
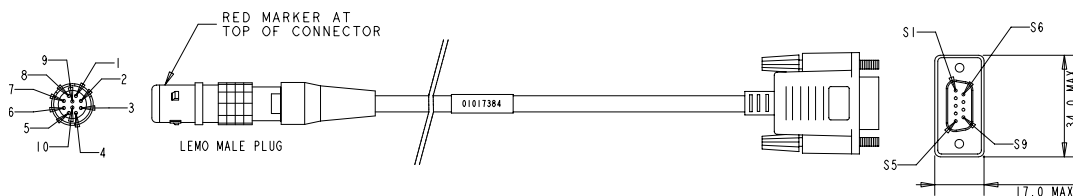
WIRING TABLE		
LEMO PIN-OUT	SIGNAL	D-SUB PIN-OUT
1	RTS_TXD-	7
2	TXD_TXD+	3
3	RXD_RXD+	2
4	CTS_RXD-	8
5	+V IN	4
6	+V IN	4
7	-V IN	5
8	-V IN	5
9	N/C	N/C
10	N/C	N/C

Figure 10: IMU Interface Cable Pin-Out (ProPak-G2*plus* and DL-4*plus*)

⊠   In *Figure 10* above, -V IN pin-outs are also Ground (GND).
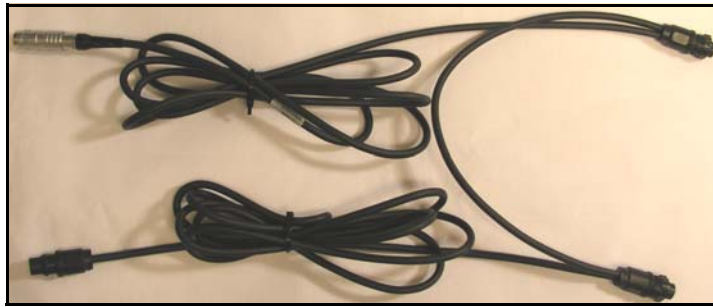
Figure 11: IMU Interface Cable (ProPak-LB*plus*)
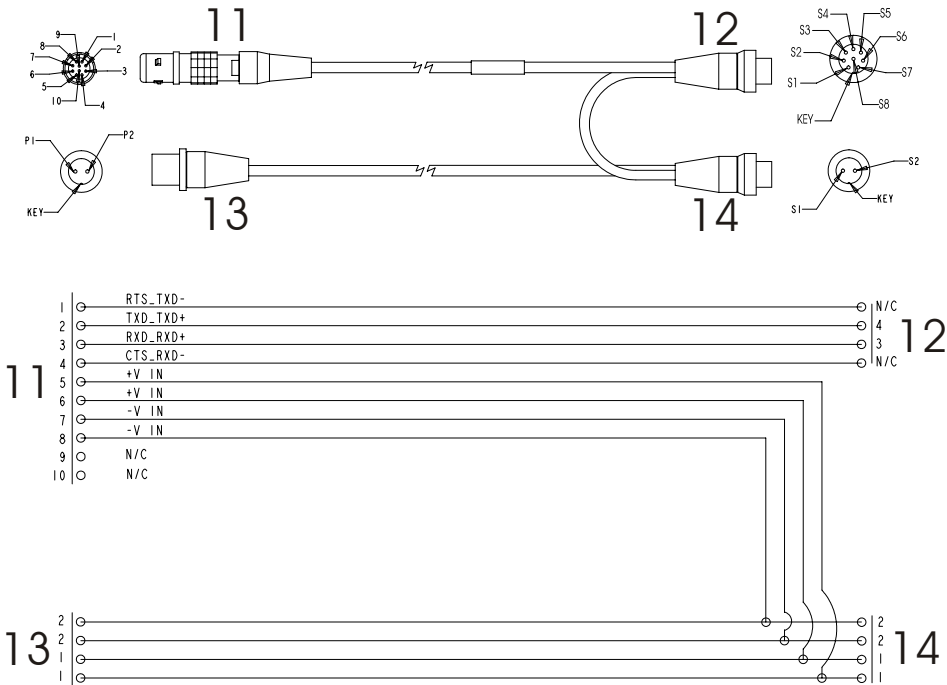
Figure 12: IMU Interface Cable Pin-Out (ProPak-LB*plus*)

✉ In *Figure 12* above, -V IN pin-outs are also Ground (GND).

Reference	Description
11	10-pin LEMO connector (connect to IMU)
12	8-pin Switchcraft socket connector (connect to ProPak-LB*plus* COM3 port 📟)
13	2-pin Switchcraft plug connector (connect to power source)
14	2-pin Switchcraft socket connector (connect to ProPak-LB*plus* power port 🔋)

A.2   SPAN System Performance

PERFORMANCE *(SPAN SYSTEM WITH IMU)*		
Position Accuracy [a]	Single Point L1 Single Point L1/L2 WAAS L1 WAAS L1/L2 DGPS (L1, C/A) OmniSTAR VBS [b][c] OmniSTAR HP [b][c] CDGPS [c] RT-20 [d] RT-2	1.8 m (5.91 ft.) CEP 1.5 m (4.92 ft.) CEP 1.2 m (3.94 ft.) CEP 0.8 m(2.62 ft.) CEP 0.45 m (1.48 ft.) CEP 1.0 m (3.28 ft.) CEP 0.10 m (0.33 ft.) CEP 0.7 m (2.30 ft.) CEP < 20 cm (<7.87") CEP 1 cm (0.39") + 1 ppm
Velocity Accuracy [a]	0.02 m/s (0.045 m.p.h.) RMS (nominal)	
Attitude Accuracy [a]	Pitch: 0.015° Roll: 0.015° Azimuth: 0.05°	
Acceleration Accuracy [a]	0.03 m/s^2 (0.098 ft./s^2)	
Time Accuracy [e][f]	20 ns RMS	
Time to First Fix (TTFF) [g]	Cold Start: 50 s Warm Start: 40 s Hot Start: 30 s	
Signal Reacquisition	L1: 0.5 s (typical) L2: 1.0 s (typical)	
Data Rates	INS Measurements 100 Hz INS Position 100 Hz INS Attitude 100 Hz INS Velocity 100 Hz	
GPS Measurement Precision	L1 C/A Code 6 cm (2.36") RMS L2 P(Y) Code 25 cm (9.84") RMS (anti-spoofing on) L1 Carrier Phase 0.75 mm (0.03") RMS (differential channel) L2 Carrier Phase 2 mm (0.08") RMS (differential channel)	
Velocity [h]	514 m/s (1,150 m.p.h.)	
Altitude [i]	18,288 m (60,000 ft.)	
Channels	L1: 12 L2: 12	

a. The specifications given assume GPS measurements at a 1 Hz rate. Accuracy over time degrades with inertial data alone.
b. Requires a subscription to the OmniSTAR service.
c. Where available and only with the ProPak-LB*plus* receiver.
d. Expected accuracy after three minute static convergence.
e. Typical values. Performance specifications are subject to GPS system characteristics, U.S. DOD operational degradation, ionospheric and tropospheric conditions, satellite geometry, baseline length and multipath effects.
f. Time accuracy does not include biases due to RF or antenna delay.
g. Refer to the appendix on *TTFF and Satellite Reacquisition* in *Volume 1*of the *OEM4 User Manual*
h. Export licensing restricts operation to a max. of 18,288 m (60,000 ft.) and 514 m/s (1,150 m.p.h.).

A.3   IMU Performance

PERFORMANCE *(IMU)*		
IMU-G2$_{H58}$	Gyro Input Range	± 1000 degrees/s
	Gyro Rate Bias	1.0 degree/hr
	Gyro Rate Scale Factor	150 ppm
	Angular Random Walk	0.125 degrees/rt hr
	Accelerometer Range	± 50 g
	Accelerometer Linearity	500 ppm
	Accelerometer Scale Factor	300 ppm
	Accelerometer Bias	1.0 mg
IMU-G2$_{H62}$	Gyro Input Range	± 1000 degrees/s
	Gyro Rate Bias	10.0 degrees/hr
	Gyro Rate Scale Factor	150 ppm
	Angular Random Walk	0.5 degrees/rt hr
	Accelerometer Range	± 50 g
	Accelerometer Linearity	500 ppm
	Accelerometer Scale Factor	300 ppm
	Accelerometer Bias	3.0 mg

A.4   Electrical and Environmental

ELECTRICAL		
IMU Power Consumption	12 W (typical)	
Receiver Power Consumption	DL-4*plus*	3.5 W (typical)
	ProPak-G2*plus*	2.8 W (typical)
	ProPak-LB*plus*	3.7 W (typical)
System Power Consumption	DL-4*plus*	15.5 W (typical)
	ProPak-G2*plus*	14.8 W (typical)
	ProPak-LB*plus*	15.7 W (typical)
IMU Connector	10-pin LEMO	
IMU Interface	RS-232 or RS-422	
ENVIRONMENTAL *(IMU)*		
Temperature	Operating	-30°C to +60°C (-22°F to 140F)
	Storage	-45°C to +80°C (-49°F to 176°F)
Humidity	95% non-condensing	

Appendix B   INS Commands

The INS-specific commands are described further in this chapter.

For information on other available commands, refer to *Volume 2* of the *OEM4 User Manual* set.

B.1   Using a Command as a Log

All NovAtel commands may be used for data input, as normal, or used to request data output (a unique OEM4 Family feature). INS-specific commands may be in Abbreviated ASCII, ASCII, or Binary format.

Consider the *lockout* command (refer to *Volume 2* of the *OEM4 User's Guide*) with the syntax:

> lockout prn

You can put this command into the receiver to de-weight an undesirable satellite in the solution, or you can use the *lockout* command as a log to see if there is a satellite PRN that has already been locked out. In ASCII, this might be:

> log com1 lockouta once

Notice the 'a' after *lockout* to signify you are looking for ASCII output.

☒   The highest rate that you should request GPS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GPS logs can be requested at rates up to 20 Hz.


B.2   INS-Specific Commands

Please refer to *Volume 2* of the *OEM4 User Manual* set for a complete list of commands categorized by function and then detailed in alphabetical order.

B.2.1   FRESET

This command clears data which is stored in non-volatile memory. Such data includes the almanac, ephemeris, and any user-specific configurations. The receiver is forced to hardware reset.

Abbreviated ASCII Syntax: **Message ID: 20**

FRESET [target]

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	target	See *Table 8*		What data is to be reset by the receiver.	Enum	4	H

Input Example:

FRESET COMMAND

Table 8: FRESET Target

Binary	ASCII	Description
0	STANDARD	Resets commands, ephemeris, and almanac (default). Also resets all OmniSTAR related data except for the subscription information.
1	COMMAND	Resets the stored commands (saved configuration)
2	GPSALMANAC	Resets the stored almanac
3	GPSEPHEM	Resets stored ephemeris
5	MODEL	Resets the currently selected model
11	CLKCALIBRATION	Resets the parameters entered using the CLOCKCALIBRATE command
20	SBASALMANAC	Resets the stored SBAS almanac
21	LAST_POSITION	Resets the position using the last stored position
22	VEHICLE_BODY_R	Resets stored vehicle to body rotations
24	INS_LEVER_ARM	Resets the GPS antenna to IMU lever arm

B.2.2   INSCOMMAND

This command allows you to enable or disable INS positioning. When INS positioning is disabled, no INS position, velocity or attitude is output. Also, INS aiding of RTK initialization and tracking reacquisition is disabled. If the command is used to disable INS and then re-enable it, the INS system has to go through its alignment procedure (equivalent to issuing a RESET command). See also *Section 3.2.1, System Start-Up and Alignment Techniques* starting on *Page 30*

Abbreviated ASCII Syntax: **Message ID: 379**

INSCOMMAND action

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	action	RESET	0	Resets the GPS/INS alignment and restarts the alignment initialization.	Enum	4	H
		DISABLE	1	Disables INS positioning.			
		ENABLE	2	Enables INS positioning where alignment initialization starts again. (default)			

Abbreviated ASCII Example:

INSCOMMAND ENABLE

B.2.3   INSINITRTK

This command allows you to enable or disable the initialization of the RTK GPS solution with the INS solution.

Abbreviated ASCII Syntax: **Message ID: 380**

INSINITRTK action

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	action	DISABLE	0	Disable RTK initialization with the INS.	Enum	4	H
		ENABLE	1	Enable RTK initialization with the INS. (default)			

Abbreviated ASCII Example:

INSINITRTK ENABLE

B.2.4   INSPHASEUPDATE

This command allows you to control the INS delta-phase updates.

When enabled, raw GPS phase measurements are used to control errors in the inertial filter. In a typical INS/GPS integration, GPS positions are used to control inertial drifts. Also by using:

- Raw phase observations, updates can be performed even when too few satellites are available to compute a GPS solution.
- Inertial observations, multipath signals are more easily removed than with traditional position updates.
- Phase updates, system performance is significantly improved in conditions challenging to GPS such as urban canyons and foliage.

Abbreviated ASCII Syntax: **Message ID: 639**

INSPHASEUPDATE switch

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	switch	DISABLE	0	Disable INS delta-phase updates.	Enum	4	H
		ENABLE	1	Enable INS delta-phase updates. (default)			

Abbreviated ASCII Example:

INSPHASEUPDATE ENABLE

B.2.5   INTERFACEMODE

This command allows the user to specify what type of data a particular port on the receiver can transmit and receive. The receive type tells the receiver what type of data to accept on the specified port. The transmit type tells the receiver what kind of data it can generate. For INS operation, please see the port tables on *Page 21* and *Section 2.3.2, SPAN IMU Configuration* starting on *Page 25*.

As another example, you could set the receive type on a port to RTCA in order to accept RTCA differential corrections.

It is also possible to disable or enable the generation or transmission of command responses for a particular port. Disabling of responses is important for applications where data is required in a specific form and the introduction of extra bytes may cause problems, for example RTCA, RTCM, RTCMV3 or CMR. Disabling a port prompt is also useful when the port is connected to a modem or other device that will respond with data the receiver does not recognize.

When INTERFACEMODE *port* NONE NONE OFF is set, the specified port is disabled from interpreting any input or output data. Therefore, no commands or differential corrections are decoded by the specified port. Data can be passed through the disabled port and be output from an alternative port using the pass-through logs PASSCOM, PASSXCOM, PASSAUX and PASSUSB. Refer to *Volume 2* of the *OEM4 User Manual* set, for information on pass-through logging and the COMCONFIG log.

Abbreviated ASCII Syntax: **Message ID: 3**

INTERFACEMODE [port] rxtype txtype [responses]

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	port	See *Table 10, COM Serial Port Identifiers,* on *Page 49*		Serial port identifier (default = THISPORT)	Enum	4	H
3	rxtype	See *Table 9, Serial Port Interface Modes,* on *Page 48*		Receive interface mode	Enum	4	H+4
4	txtype			Transmit interface mode	Enum	4	H+8
5	responses	OFF	0	Turn response generation off	Enum	4	H+12
		ON	1	Turn response generation on (default)			

ASCII Example:

INTERFACEMODE COM1 RTCA NOVATEL ON

Table 9: Serial Port Interface Modes

Binary Value	ASCII Mode Name	Description
0	NONE	The port accepts/generates nothing
1	NOVATEL	The port accepts/generates NovAtel commands and logs
2	RTCM	The port accepts/generates RTCM corrections
3	RTCA	The port accepts/generates RTCA corrections
4	CMR	The port accepts/generates CMR corrections
5-6	Reserved	
7	IMU	This port supports communication with a NovAtel supported IMU
8	RTCMNOCR	RTCM with no CR/LF appended [a]
9	CDGPS	The port accepts GPS*C data [b]
10-13	Reserved	
14	RTCMV3	The port accepts/generates RTCM Version 3.0 corrections
15	NOVATELBINARY	The port only accepts/generates binary messages. If an ASCII command is entered when the mode is set to binary only, the command is ignored. Only properly formatted binary messages are responded to and the response is a binary message.

a. An output interfacemode of RTCMNOCR is identical to RTCM but with the CR/LF appended. An input interfacemode of RTCMNOCR is identical to RTCM and functions with or without the CR/LF.

b. CDGPS has three options for output of differential corrections - NMEA, RTCM, and GPS*C. If you have a ProPak-LB*plus* receiver, you do not need to use the INTERFACEMODE command with CDGPS as the argument. The CDGPS argument is for use with obsolete external non-NovAtel CDGPS receivers. These receivers use GPS*C (NavCanada's proprietary format differential corrections from the CDGPS service).

Table 10: COM Serial Port Identifiers

Binary	ASCII	Description
1	COM1	COM port 1
2	COM2	COM port 2
3	COM3	COM port 3
6	THISPORT	The current COM port
8	ALL	All COM ports
9	XCOM1 [a]	Virtual COM1 port
10	XCOM2 [a]	Virtual COM2 port
13	USB1 [b]	USB port 1
14	USB2 [b]	USB port 2
15	USB3 [b]	USB port 3
16	AUX [c d]	AUX port

a.   The XCOM1 and XCOM2 identifiers are not available with the COM command but may be used with other commands. For example, INTERFACEMODE and LOG.

b.   The only other field that applies when a USB port is selected is the echo field. Place holders must be inserted for all other fields to use the echo field in this case.

c.   The AUX port is only available on OEM4-G2-based (hardware Rev. 3 and higher) and DL-4*plus* products.

d.   You **must** type in COM3 for the ProPak-G2*plus* and Pro-Pak-LB*plus* **and** you **must** type in AUX for the DL-4*plus*. This is true, even if the port is labelled differently.

B.2.6   INSZUPT

This command allows you to manually perform a Zero Velocity Update (ZUPT), that is, to update the receiver when the system has stopped.

NovAtel's SPAN Technology System does ZUPTs automatically. It is not necessary to use this command under normal circumstances.

WARNING: **This command should only be used by advanced users of GPS/INS.**

Abbreviated ASCII Syntax: **Message ID: 382**
INSZUPT

B.2.7 *LEVERARMCALIBRATE*

The LEVERARMCALIBRATE command is used to control the IMU to antenna lever arm calibration.

The IMU to antenna lever arm is the distance from the centre of each marked IMU side to the phase centre of the antenna. See also *Section B.2.10, SETIMUTOANTOFFSET* starting on *Page 56* and *Section 3.2.4, Lever Arm Calibration Routine* starting on *Page 33*.

The calibration runs for the time specified or until the specified uncertainty is met. The BESTLEVERARM log outputs the lever arm calculations once the calibration is complete, see also *Page 69*.

Abbreviated ASCII Syntax: **Message ID: 675**
LEVERARMCALIBRATE [switch] maxtime [maxstd]

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	switch	OFF	0	Offset along the IMU X axis	Enum	4	H
		ON (default)	1				
3	maxtime	30 - 1000		Maximum calibration time (s)	Double	8	H+4
4	maxstd	0.02 – 0.5		Maximum offset uncertainty (m)	Double	8	H+12

Abbreviated ASCII Example:

LEVERARMCALIBRATE 600

B.2.8   RVBCALIBRATE

The RVBCALIBRATE command is used to enable or disable the calculation of the vehicle to body angular offset. This command should be entered when the IMU is re-mounted in the vehicle or if the rotation angles available are known to be incorrect.

WARNING: **After the RVBCALIBRATE ENABLE command is entered, there are no vehicle-body rotation parameters present and a kinematic alignment is NOT possible. Therefore this command should only be entered after the system has performed either a static or kinematic alignment and has a valid INS solution.**

A good INS solution and vehicle movement are required for the SPAN system to solve the vehicle-body offset. The solved vehicle-body rotation parameters are output in the VEHICLEBODYROTATION log when the calibration is complete, see *Page 92*. When the calibration is done, the rotation values are fixed until the calibration is re-run by entering the RVBCALIBRATE command again.

Abbreviated ASCII Syntax: **Message ID: 641**
RVBCALIBRATE reset

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	Log Header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	Switch	RESET	0	Control the vehicle/ body rotation computation	ENUM	4	H
		DISABLE	1				
		ENABLE	2				

Abbreviated ASCII Example:

RVBCALIBRATE reset

B.2.9   SETIMUORIENTATION

The SETIMUORIENTATION command is used to specify which of the IMU axis is aligned with gravity. The IMU orientation can be saved using the SAVECONFIG command so that on start-up, the SPAN system does not have to detect the orientation of the IMU with respect to gravity. This is particularly useful for situations where the receiver is powered while in motion.

⊠   1. The default IMU axis definitions are:

  Y - forward

  Z - up

  X - out the right hand side

It is strongly recommended that you mount your IMU in this way with respect to the vehicle.

2. You only need to use this command if the system is to be aligned while in motion using the fast alignment routine, see *Section 3.2.1.2, Fast Alignment* on *Page 31*.

WARNING: Ensure that all windows, other than the Console, are closed in GPSolution and then use the SAVECONFIG command to save settings in NVM. Otherwise, unnecessary data logging occurs and may overload your system.

This orientation command serves to transform the incoming IMU signals in such a way that a 5 mapping is achieved, see *Table 11 on Page 55*. For example, if the IMU is mounted with the X-axis pointing UP and a mapping of 1 is specified then this transformation of the raw IMU data is done:

  Y⇒X, Z⇒Y, X⇒Z (where the default is X⇒X, Y⇒Y, Z⇒Z)

Notice that the X-axis observations are transformed into the Z axis, resulting in Z being aligned with gravity and a 5 mapping. The body frame is defined so that Z is always pointing up along the gravity vector. If the IMU mapping is set to 1, the X axis of the IMU enclosure is mapped to the body frame Z axis (pointing up), its Y axis to body frame X and its Z axis to body frame Y.

The X (pitch), Y (roll) and Z (azimuth) directions of the inertial frame are clearly marked on the IMU, see *Figure 13 below*. Also, *Figure 7, IMU Dimensions* on *Page 36* includes the measurement defaults.

Figure 13: Frame of Reference

Abbreviated ASCII Syntax: **Message ID: 567**
SETIMUORIENTATION switch

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	Log Header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	Switch	0	0	IMU determines axis orientation automatically during coarse alignment. (default)	ENUM	4	H
		1	1	IMU **X** axis is pointing **UP**			
		2	2	IMU **X** axis is pointing **DOWN**			
		3	3	IMU **Y** axis is pointing **UP**			
		4	4	IMU **Y** axis is pointing **DOWN**			
		5	5	IMU **Z** axis is pointing **UP**			
		6	6	IMU **Z** axis is pointing **DOWN**			

Abbreviated ASCII Example:

SETIMUORIENTATION 1

Table 11: Full Mapping Definitions

Mapping	Body Frame Axes	Frame Axes Marked on the IMU Enclosure
1	X	Y
	Y	Z
	Z	X
2	X	Z
	Y	Y
	Z	-X
3	X	Z
	Y	X
	Z	Y
4	X	X
	Y	Z
	Z	-Y
5 (default)	X	X
	Y	Y
	Z	Z
6	X	Y
	Y	X
	Z	-Z

B.2.10 SETIMUTOANTOFFSET

Although it is recommended that you mount the IMU as close as possible to the GPS antenna, particularly in the horizontal plane, this command can be used to enter an offset between the IMU and the GPS antenna. The measurement should be done as accurately as possible, preferably to within millimeters especially for RTK operation. The x, y and z fields represent the vector from the IMU to the antenna phase center in the IMU enclosure co-ordinate frame. The a, b and c fields allow you to enter any possible errors in your measurements. If you think that your 'x' offset measurement is out by a centimeter for example, enter 0.01 in the 'a' field.

The X (pitch), Y (roll) and Z (azimuth) directions of the inertial frame are clearly marked on the IMU, as shown in *Figure 13 on Page 53*.

This command must be entered before or during the INS alignment mode (not after).

Abbreviated ASCII Syntax: **Message ID: 383**

SETIMUTOANTOFFSET x y z [a] [b] [c]

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	x	± 1		x offset (m)	Double	8	H
3	y	± 1		y offset (m)	Double	8	H+8
4	z	± 1		z offset (m)	Double	8	H+16
5	a	± 0.1		Uncertainty in x (m) Defaults to 10% of the x offset (default = +0.1)	Double	8	H+24
6	b	± 0.1		Uncertainty in y (m) Defaults to 10% of the y offset (default = +0.1)	Double	8	H+32
7	c	± 0.1		Uncertainty in z (m) Defaults to 10% of the z offset (default = +0.1)	Double	8	H+40

Abbreviated ASCII Example:

SETIMUTOANTOFFSET 0.1 0.1 0.1 0.01 0.01 0.01

B.2.11 *SETIMUTYPE*

The SETIMUTYPE command is used to specify the type of IMU connected to the receiver. The IMU type can be saved using the SAVECONFIG command so that on startup, the receiver does not have to detect the type of IMU connected.

WARNING: Ensure that all windows, other than the Console, are closed in GPSolution and then use the SAVECONFIG command to save settings in NVM. Otherwise, unnecessary data logging occurs and may overload your system.
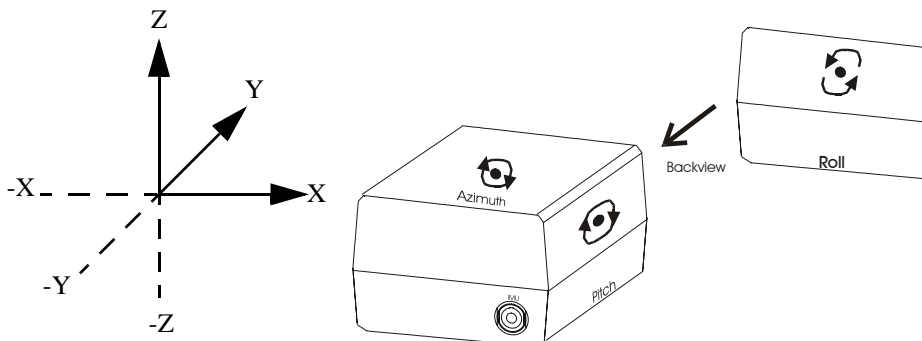

Abbreviated ASCII Syntax: **Message ID: 569**
SETIMUTYPE switch

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	Log Header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	Switch	See *Table 12 below*		IMU Type	ENUM	4	H

Table 12: IMU Type

Binary	ASCII	Description
0	IMU_UNKNOWN	Unknown IMU type (default)
1	IMU_HG1700_AG11	Honeywell HG1700 AG11 or AG58
2-3	Reserved	
4	IMU_HG1700_AG17	Honeywell HG1700 AG17 or AG62
5-6	Reserved	

Abbreviated ASCII Example:

SETIMUTYPE IMU_HG1700_AG11

B.2.12   SETINSOFFSET

The SETINSOFFSET command is used to specify an offset from the IMU for the output position and velocity of the INS solution. This command shifts the position and velocity in the INSPOS, INSPOSS, INSVEL, INSVELS, INSSPD, INSSPDS, INSPVA and INSPVAS logs by the amount specified in metres with respect to the IMU axis.

Abbreviated ASCII Syntax: **Message ID: 676**

SETINSOFFSET xoffset yoffset zoffset

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	X offset	± 100		Offset along the IMU X axis (m)	Double	8	H
3	Y offset	± 100		Offset along the IMU Y axis (m)	Double	8	H+8
4	Z offset	± 100		Offset along the IMU Z axis (m)	Double	8	H+16

Abbreviated ASCII Example:

SETINSOFFSET 0.15 0.15 0.25

B.2.13 VEHICLEBODYROTATION

The VEHICLEBODYROTATION command can be used to set initial estimates for the angular offset. The uncertainty values are optional (defaults = 0.0). Please see *Section 3.2.5, Vehicle to Body Frame Angular Offsets Calibration Routine* starting on *Page 34* for more details. See also the VEHICLEBODYROTATION log starting on *Page 92* for more details, a syntax table and an ASCII example.

Abbreviated ASCII Syntax:
VEHICLEBODYROTATION X Y Z [σx] [σy] [σz]

Appendix C INS Logs

The INS-specific logs follow the same general logging scheme as normal OEM4 Family logs. They are available in ASCII or binary formats and are defined as being either synchronous or asynchronous. All the logs in this chapter can be used only with the SPAN system.

For information on other available logs and output logging, please refer to *Volume 2* of the *OEM4 User Manual* set.

One difference from the standard OEM4 family logs is that there are two possible headers for the ASCII and binary versions of the logs. Which header is used for a given log is described in the log definitions in this chapter. The reason for having the alternate short headers is that the normal OEM4-G2 binary header is quite long at 28 bytes. This is nearly as long as the data portion of many of the INS logs, and creates excess storage and baud rate requirements. Note that the INS-related logs contain a time tag within the data block in addition to the time tag in the header. The time tag in the data block should be considered the exact time of applicability of the data. All the described logs except the covariance log (see *Page 72*) can be obtained at rates up to 100 Hz, subject to the limits of the output baud rate. The covariance log is available once per second.

⊠ The highest rate that you should request GPS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GPS logs can be requested at rates up to 20 Hz.

Please also refer to *Volume 1* of the *OEM4 User Manual* set for information on the supplied Convert4 program that lets you change binary to ASCII data, or short binary to short ASCII data, and vice versa. Convert4 is also capable of RINEX conversions to and from ASCII or binary.

Table 13 shows the status values included in the INS position, velocity and attitude output logs. If you think you have an IMU unit hooked up properly and you are not getting a good status value, something is wrong and the hardware setup must be checked out. This situation can be recognized in the RAWIMU data by observing accelerometer and gyro values which are not changing with time.

Table 13: INS Status Definitions

ASCII	Binary	Definition
INS_INACTIVE	0	INS is inactive
INS_ALIGNING	1	INS is aligning
INS_SOLUTION_NOT_GOOD	2	INS solution is not good
INS_SOLUTION_GOOD	3	INS solution is good
INS_TEST_ALIGNING	4	INS test is aligning
INS_TEST_SOLUTION_GOOD	5	INS test solution is good
INS_BAD_GPS_AGREEMENT	6	GPS agreement is good but the INS solution is bad
INS_ALIGNMENT_COMPLETE	7	The state immediately after the alignment is finished but before enough vehicle velocity has been observed for the attitude, specifically azimuth, to become converged

C.1 Description of ASCII and Binary Logs with Short Headers

These logs are set up in the same way normal ASCII or binary logs are, except that a normal ASCII or binary header is replaced with a short header (see *Tables 14 and 15*). For the message header structure of OEM4-G2 regular Binary and ASCII logs, please refer to *Volume 2* of the *OEM4 User Manual* set.

Table 14: Short ASCII Message Header Structure

Field #	Field Type	Field Type	Description
1	%	Char	% symbol
2	Message	Char	This is the name of the log
3	Week Number	Ushort	GPS week number
4	Milliseconds	Ulong	Milliseconds from the beginning of the GPS week

Table 15: Short Binary Message Header Structure

Field #	Field Type	Field Type	Description	Binary Bytes	Binary Offset
1	Sync	Char	Hex 0xAA	1	0
2	Sync	Char	Hex 0x44	1	1
3	Sync	Char	Hex 0x13	1	2
4	Message Length	Uchar	Message length, not including header or CRC	1	3
5	Message ID	Ushort	Message ID number	2	4
6	Week Number	Ushort	GPS week number	2	6
7	Milliseconds	Ulong	Milliseconds from the beginning of the GPS week	4	8

C.2 INS-Specific Logs

The receivers are capable of generating many NovAtel-format output logs, in either Abbreviated ASCII, ASCII or binary format. Please refer to *Volume 2* of the *OEM4 User Manual* set for a complete list of logs categorized by function and then detailed in alphabetical order.

INS-specific commands and logs provide attitude data such as roll, pitch and azimuth.

C.2.1 BESTGPSPOS Best GPS Position

This log contains the best available GPS position (without INS) computed by the receiver. In addition, it reports several status indicators, including differential age, which is useful in predicting anomalous behavior brought about by outages in differential corrections. A differential age of 0 indicates that no differential correction was used.

With the system operating in an RTK mode, this log reflects the latest low-latency solution for up to 30 seconds after reception of the last base station observations. After this 30 second period, the position reverts to the best solution available; the degradation in accuracy is reflected in the standard deviation fields. If the system is not operating in an RTK mode, pseudorange differential solutions continue for 60 seconds after loss of the data link, though a different value can be set using the DGPSTIMEOUT command, refer to *Volume 2* of the *OEM4 User Manual* set.

Structure: **Message ID: 423**

Log Type: Synch

Field #	Field type	Data Description	Format	Binary Bytes	Binary Offset
1	header	Log header	-	H	0
2	Sol Status	Solution status, see *Table 17, Solution Status* on *Page 66*	Enum	4	H
3	Pos Type	Position type, see *Table 16, Position or Velocity Type* on *Page 64*	Enum	4	H+4
4	Lat	Latitude	Double	8	H+8
5	Lon	Longitude	Double	8	H+16
6	Hgt	Height above mean sea level	Double	8	H+24
7	Undulation	Undulation	Float	4	H+32
8	Datum ID	Datum ID (refer to the DATUM command in *Volume 2* of the *OEM4 User Manual* set)	Enum	4	H+36
9	Lat σ	Latitude standard deviation	Float	4	H+40
10	Lon σ	Longitude standard deviation	Float	4	H+44
11	Hgt σ	Height standard deviation	Float	4	H+48
12	Stn ID	Base station ID	Char[4]	4	H+52
13	Diff_age	Differential age	Float	4	H+56
14	Sol_age	Solution age in seconds	Float	4	H+60
15	#obs	Number of observations tracked	Uchar	1	H+64
16	#GPSL1	Number of GPS L1 ranges used in computation	Uchar	1	H+65
17	#L1	Number of GPS L1 ranges above the RTK mask angle	Uchar	1	H+66
18	#L2	Number of GPS L2 ranges above the RTK mask angle	Uchar	1	H+67

Field #	Field type	Data Description	Format	Binary Bytes	Binary Offset
19	Reserved		Uchar	1	H+68
20			Uchar	1	H+69
21			Uchar	1	H+70
22			Uchar	1	H+71
23	xxxx	32-bit CRC (ASCII and Binary only)	Hex	4	H+72
24	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

log bestgpsposa ontime 1

ASCII Example:

```
#BESTGPSPOSA,COM1,0,62.5,FINESTEERING,1036,484878.000,00000028,63e2,0;
SOL_COMPUTED,SINGLE,51.11629893124,-114.03820302746,1052.3434,
-16.271287293,61,19.6934,13.1515,23.8561,"",0.0,60.000,10,10,0,0,
0,0,0,0*1051ada9
```

Table 16: Position or Velocity Type

Position Type (binary)	Position Type (ASCII)	Description
0	NONE	No solution
1	FIXEDPOS	Position has been fixed by the FIX POSITION command or by position averaging
2	FIXEDHEIGHT	Position has been fixed by the FIX HEIGHT, or FIX AUTO, command or by position averaging
3	Reserved	
4	FLOATCONV	Solution from floating point carrier phase ambiguities
5	WIDELANE	Solution from wide-lane ambiguities
6	NARROWLANE	Solution from narrow-lane ambiguities
7	Reserved	
8	DOPPLER_VELOCITY	Velocity computed using instantaneous Doppler
9-15	Reserved	
16	SINGLE	Single point position
17	PSRDIFF	Pseudorange differential solution
18	WAAS	Solution calculated using corrections from an SBAS
19	PROPOGATED	Propagated by a Kalman filter without new observations
20	OMNISTAR	OmniSTAR VBS position (L1 sub-meter) [a]
21-31	Reserved	
32	L1_FLOAT	Floating L1 ambiguity solution
33	IONOFREE_FLOAT	Floating ionospheric-free ambiguity solution
34	NARROW_FLOAT	Floating narrow-lane ambiguity solution
48	L1_INT	Integer L1 ambiguity solution
49	WIDE_INT	Integer wide-lane ambiguity solution
50	NARROW_INT	Integer narrow-lane ambiguity solution

Position Type (binary)	Position Type (ASCII)	Description
51-65	Reserved. Please refer to *Volume 2* of the *OEM4 Manual* set for a complete table including GPS-only receiver log details	
66	CDGPS	Position solution using CDGPS corrections [a]

a. In addition to a NovAtel receiver with L-Band capability, a subscription to the OmniSTAR, or use of the free CDGPS, service is required. Contact NovAtel for details.

Table 17: Solution Status

Binary	ASCII	Description
0	SOL_COMPUTED	Solution computed
1	INSUFFICIENT_OBS	Insufficient observations
2	NO_CONVERGENCE	No convergence
3	SINGULARITY	Singularity at parameters matrix
4	COV_TRACE	Covariance trace exceeds maximum (trace > 1000 m)
5	TEST_DIST	Test distance exceeded (maximum of 3 rejections if distance > 10 km)
6	COLD_START	Not yet converged from cold start
7	V_H_LIMIT	Height or velocity limits exceeded (in accordance with COCOM export licensing restrictions)
8	VARIANCE	Variance exceeds limits
9	RESIDUALS	Residuals are too large
10	DELTA_POS	Delta position is too large
11	NEGATIVE_VAR	Negative variance
12	Reserved	
13	INTEGRITY_WARNING	Large residuals make position unreliable
14	INS_INACTIVE	INS has not started yet
15	INS_ALIGNING	INS doing its coarse alignment
16	INS_BAD	INS position is bad
17	IMU_UNPLUGGED	No IMU detected
18	PENDING	When a FIX POSITION command is entered, the receiver computes its own position and determines if the fixed position is valid [a]
19	INVALID_FIX	The fixed position, entered using the FIX POSITION command, is not valid

a. PENDING implies there are not enough satellites being tracked to verify if the FIX POSITION entered into the receiver is valid. The receiver needs to be tracking two or more GPS satellites to perform this check. Under normal conditions you should only see PENDING for a few seconds on power up before the GPS receiver has locked onto its first few satellites. If your antenna is obstructed (or not plugged in) and you have entered a FIX POSITION command, then you may see PENDING indefinitely.

C.2.2   BESTGPSVEL   Best Available GPS Velocity Data

This log contains the best available GPS velocity information (without INS) computed by the receiver. In addition, it reports a velocity status indicator, which is useful in indicating whether or not the corresponding data is valid. The velocity measurements sometimes have a latency associated with them. The time of validity is the time tag in the log minus the latency value.

The velocity is typically computed from the average change in pseudorange over the time interval or the RTK Low Latency filter. As such, it is an average velocity based on the time difference between successive position computations and not an instantaneous velocity at the BESTGPSVEL time tag. The velocity latency to be subtracted from the time tag is normally 1/2 the time between filter updates. Under default operation, the positioning filters are updated at a rate of 2 Hz. This translates into a velocity latency of 0.25 second. The latency can be reduced by increasing the update rate of the positioning filter being used by requesting the BESTGPSVEL or BESTGPSPOS messages at a rate higher than 2 Hz. For example, a logging rate of 10 Hz would reduce the velocity latency to 0.005 seconds. For integration purposes, the velocity latency should be applied to the record time tag.

A valid solution with a latency of 0.0 indicates that the instantaneous Doppler measurement was used to calculate velocity.

Structure: **Message ID: 506**

                                                                                          Log Type: Synch

Field #	Field type	Data Description	Format	Binary Bytes	Binary Offset
1	header	Log header	-	H	0
2	Sol Status	Solution status, see *Table 17, Solution Status* on *Page 66*	Enum	4	H
3	Vel Type	Velocity type, see *Table 16, Position or Velocity Type* on *Page 64*	Enum	4	H+4
4	Latency	A measure of the latency in the velocity time tag in seconds. It should be subtracted from the time to give improved results.	Float	4	H+8
5	Age	Differential age	Float	4	H+12
6	Hor Spd	Horizontal speed over ground, in metres per second	Double	8	H+16
7	Trk Gnd	Actual direction of motion over ground (track over ground) with respect to True North, in degrees	Double	8	H+24
8	Vert Spd	Vertical speed, in metres per second, where positive values indicate increasing altitude (up) and negative values indicate decreasing altitude (down)	Double	8	H+32
9	Reserved		Float	4	H+40
10	xxxx	32-bit CRC (ASCII and Binary only)	Hex	4	H+44
11	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

> log bestgpsvela ontime 1

ASCII Example:

> #BESTGPSVELA,COM1,0,62.5,FINESTEERING,1049,247755.000,00000128,f7e3,0;
> SOL_COMPUTED,SINGLE,0.250,0.000,0.1744,333.002126,0.3070,6.0082*dfdc635c

C.2.3   BESTLEVERARM   IMU to Antenna Lever Arm

This log contains the distance between the IMU and the GPS antenna in the IMU enclosure frame and its associated uncertainties. If the you enter the lever arm through the SETIMUTOANTOFFSET command, see *Page 56*, these values are reflected in this log. When the lever arm calibration is complete, see the LEVERARMCALIBRATE command on *Page 51*, the solved values are also output in this log.

The X (pitch), Y (roll) and Z (azimuth) directions of the inertial frame are clearly marked on the IMU, see *Figure 13* on *Page 53*.

Structure: **Message ID: 674**

Log Type: Synch

Field	Field Type	Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log Header	-	H	0
2	X Offset	IMU Enclosure Frame (m)	Double	8	H
3	Y Offset	IMU Enclosure Frame (m)	Double	8	H+8
4	Z Offset	IMU Enclosure Frame (m)	Double	8	H+16
5	X Uncertainty	IMU Enclosure Frame (m)	Double	8	H+24
6	Y Uncertainty	IMU Enclosure Frame (m)	Double	8	H+32
7	Z Uncertainty	IMU Enclosure Frame (m)	Double	8	H+40
8	xxxx	32-bit CRC	Hex	4	H+48
9	[CR][LF]	Sentence Terminator (ASCII only)	-	-	-

Recommended Input:

    log bestleverarma onchanged

ASCII Example:

    #BESTLEVERARMA,COM1,0,39.0,FINESTEERING,1264,144254.891,00000000,39e4,1541;
    0.150000000000000,0.670000000000000,-1.530000000000001,0.020000000000000,
    0.020000000000000,0.030000000000000,5*a362ddb7

C.2.4   INSATT   INS Attitude

This log, and the INSATTS log, contains the most recent attitude measurements corresponding to the X, Y and Z axis of the IMU mounted according to the installation instructions provided in *Section 2.2, Hardware Set-Up* starting on *Page 23* and *Section 2.3.2, SPAN IMU Configuration* starting on *Page 25* of this manual. The attitude measurements may or may not correspond to other definitions of the terms pitch, roll and azimuth.

Structure: **Message ID: 263**

Log Type: Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Roll	Right handed rotation from local level around y-axis in degrees.	Double	8	H+12
5	Pitch	Right handed rotation from local level around x-axis in degrees.	Double	8	H+20
6	Azimuth	Left handed rotation around z-axis. Degrees clockwise from North.	Double	8	H+28
7	Status	INS status, see *Table 13* on *Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

log insatta ontime 1

ASCII Example:

```
#INSATTA,COM3,0,0.0,EXACT,1105,425385.000,00040000,0638,0;
1105,425384.996167250,4.822147742,0.035766158,123.262113519,
INSSolutionGood*3563a760
```

✉   The structure of the INSATT log is different in this firmware version (1.3) than in any earlier beta versions. This is because the order of the roll and pitch fields have been reversed.

C.2.5   INSATTS   Short INS Attitude

This is a short header version of the *INSATT* log on *Page 70*.

Structure: **Message ID: 319**

Log Type: Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Roll	Right handed rotation from local level around y-axis in degrees.	Double	8	H+12
5	Pitch	Right handed rotation from local level around x-axis in degrees.	Double	8	H+20
6	Azimuth	Left handed rotation around z-axis. Degrees clockwise from North.	Double	8	H+28
7	Status	INS status, see *Table 13* on *Page 60*.	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
   log insattsa ontime 1

ASCII Example:
```
%INSATTSA,1105,425385.000;
1105,425384.996167250,4.822147742,0.035766158,123.262113519,
INSSolutionGood*3563a760
```

✉ The structure of the INSATTS log is different in this firmware version (1.3) than in any earlier beta versions. This is because the order of the roll and pitch fields have been reversed.

C.2.6 INSCOV   INS Covariance Matrices

The position, attitude, and velocity matrices in this log each contain 9 covariance values, with respect to the IMU's local axis, as follows:

$$\begin{bmatrix} xx & xy & xz \\ yx & yy & yz \\ zx & zy & zz \end{bmatrix}$$

and are displayed within the log output as:

$$\ldots, xx, xy, xz, yx, yy, yz, zx, zy, zz, \ldots$$

These values are computed once per second and are only available after alignment. See also *Section 3.2.1, System Start-Up and Alignment Techniques* starting on *Page 30*.

Structure: **Message ID: 264**

                                                                          Log Type: Asynch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Position Covariance	Position covariance matrix in local level frame (Meters squared)	List of 9 Doubles	72	H+12
5	Attitude Covariance	Attitude covariance matrix in local level frame. (Degrees squared - rotation around the given axis)	List of 9 Doubles	72	H+84
6	Velocity Covariance	Velocity covariance matrix in local level frame. (Meters/second squared)	List of 9 Doubles	72	H+156
7	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+228
8	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

log inscova onchanged

ASCII Example:

```
#INSCOVA,COM3,0,0.0,EXACT,1105,425385.020,00040000,c45c,0;
1105,425385.000000000,
0.0997319969301073,-0.0240959791179416,-0.0133921499963209,
-0.0240959791179416,0.1538605784734939,0.0440068023663888,
-0.0133921499963210,0.0440068023663887,0.4392033415009359,
0.0034190251365443,0.0000759398593357,-0.1362852812808768,
0.0000759398593363,0.0032413999569636,-0.0468473344270137,
-0.1362852812808786,-0.0468473344270131,117.5206493841025100,
0.0004024901765302,-0.0000194916086028,0.0000036582459112,
-0.0000194916086028,0.0004518869575566,0.0000204616202028,
0.0000036582459112,0.0000204616202028,0.0005095575483948*1fc92787
```

C.2.7   INSCOVS   Short INS Covariance Log

This is a short header version of the *INCOV* log on *Page 72*. These values are also computed once per second.

Structure: **Message ID: 320**

Log Type: Asynch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Position Covariance	Position covariance matrix in local level frame. (Meters squared) xx,xy,xz,yx,yy,yz,zx,zy,zz	List of 9 Doubles	72	H+12
5	Attitude Covariance	Attitude covariance matrix in local level frame. (Degrees squared - rotation around the given axis) xx,xy,xz,yx,yy,yz,zx,zy,zz	List of 9 Doubles	72	H+84
6	Velocity Covariance	Velocity covariance matrix in local level frame. (Meters/second squared) xx,xy,xz,yx,yy,yz,zx,zy,zz	List of 9 Doubles	72	H+156
7	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+228
8	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

log inscovsa onchanged

ASCII Example:

```
%INSCOVSA,1105,425385.020;
1105,425385.000000000,
0.0997319969301073,-0.0240959791179416,-0.0133921499963209,
-0.0240959791179416,0.1538605784734939,0.0440068023663888,
-0.0133921499963210,0.0440068023663887,0.4392033415009359,
0.0034190251365443,0.0000759398593357,-0.1362852812808768,
0.0000759398593363,0.0032413999569636,-0.0468473344270137,
-0.1362852812808786,-0.0468473344270131,117.5206493841025100,
0.0004024901765302,-0.0000194916086028,0.0000036582459112,
-0.0000194916086028,0.0004518869575566,0.0000204616202028,
0.0000036582459112,0.0000204616202028,0.0005095575483948*1fc92787
```

C.2.8   INSPOS   INS Position

This log contains the most recent position measurements in WGS84 coordinates and includes an INS status indicator. The position is measured from the center of the IMU and not from the antenna phase center.

Structure: **Message ID: 265**

Log Type:Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Latitude	Latitude (WGS84)	Double	8	H+12
5	Longitude	Longitude (WGS84)	Double	8	H+20
6	Height	Ellipsoidal Height (WGS84)	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
>   log insposa ontime 1

ASCII Example:
>   #INSPOSA,COM3,0,0.0,EXACT,1105,425385.000,00040000,323a,0;
>
>   1105,425384.996167250,51.058410364,-114.065465722,
>
>   1067.791685696,INSSolutionGood*9bfd5a12

C.2.9   INSPOSS   Short INS Position

This is a short header version of the *INSPOS* log on *Page 75*.

Structure: **Message ID: 321**

Log Type:Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Latitude	Latitude (WGS84)	Double	8	H+12
5	Longitude	Longitude (WGS84)	Double	8	H+20
6	Height	Ellipsoidal Height (WGS84)	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
  log inspossa ontime 1

ASCII Example:
```
%INSPOSSA,1105,425385.000;
1105,425384.996167250,51.058410364,-114.065465722,
1067.791685696,INSSolutionGood*9bfd5a12
```

C.2.10 INSPOSSYNC   *Time Synchronised INS Position*

This log contains the time synchonised INS position. It is synchronised with GPS each second.

Structure: **Message ID: 322**

Log Type: Asynch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Sec	Age of synchronised INS solution (s)	Double	8	H
3	X	ECEF X coordinate	Double	8	H+8
4	Y	ECEF Y coordinate	Double	8	H+16
5	Z	ECEF Z coordinate	Double	8	H+24
6	Cov	ECEF covariance matrix (a 3 x 3 array of length 9). Refer also to the CLOCKMODEL log in *Volume 2* of the *OEM4 Family* manual set.	Double[9]	72	H+32
7	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+104
8	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

    log inspossynca onchanged

ASCII Example:

    #INSPOSSYNCA,COM1,0,47.5,FINESTEERING,1332,484154.042,00000000,c98c,34492;
    484154.000000000,-1634523.2463,-3664620.7609,4942494.6795,
    1.8091616236414247,0.0452272887760925,-0.7438098675219428,
    0.0452272887760925,2.9022554471257266,-1.5254793710104819,
    -0.7438098675219428,-1.5254793710104819,4.3572293495804546*9fcd6ce1

C.2.11 INSPVA INS Position, Velocity and Attitude

This log allows INS position, velocity and attitude to be collected in one log, instead of using three separate logs.

Structure: **Message ID: 507**

Log Type: Synch

Field	Field Type	Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds	Seconds from week start	Double	8	H+4
4	Latitude	Latitude (WGS84)	Double	8	H+12
5	Longitude	Longitude (WGS84)	Double	8	H+20
6	Height	Ellipsoidal Height (WGS84)	Double	8	H+28
7	North Velocity	Velocity in a northerly direction (a -ve value implies a southerly direction) LSB 0.0005 revolutions	Double	8	H+36
8	East Velocity	Velocity in an easterly direction (a -ve value implies a westerly direction	Double	8	H+44
9	Up Velocity	Velocity in an up direction	Double	8	H+52
10	Roll	Right handed rotation from local level around y-axis in degrees	Double	8	H+60
11	Pitch	Right handed rotation from local level around x-axis in degrees	Double	8	H+68
12	Azimuth	Left handed rotation around z-axis Degrees clockwise from North	Double	8	H+76
13	Status	INS Status, see *Table 13 on Page 60*	Enum	4	H+84
14	xxxx	32-bit CRC	Hex	4	H+88
15	[CR][LF]	Sentence Terminator (ASCII only)	-	-	-

Recommended Input:

log inspvaa ontime 1

ASCII Example:

```
#INSPVAA,COM1,0,31.0,FINESTEERING,1264,144088.000,00040000,5615,1541;
1264,144088.002284950,51.116827527,-114.037738908,401.191547167,
354.846489850,108.429407241,-10.837482850,1.116219952,-3.476059035,
7.372686190,INS_ALIGNMENT_COMPLETE*af719fd9
```

C.2.12 INSPVAS   Short INS Position, Velocity and Attitude

This log allows INS position, velocity and attitude to be collected in one log, instead of using three separate logs.

Structure: **Message ID: 508**

Log Type: Synch

Field	Field Type	Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds	Seconds from week start	Double	8	H+4
4	Latitude	Latitude (WGS84)	Double	8	H+12
5	Longitude	Longitude (WGS84)	Double	8	H+20
6	Height	Ellipsoidal Height (WGS84)	Double	8	H+28
7	North Velocity	Velocity in a northerly direction (a -ve value implies a southerly direction) LSB 0.0005 revolutions	Double	8	H+36
8	East Velocity	Velocity in an easterly direction (a -ve value implies a westerly direction)	Double	8	H+44
9	Up Velocity	Velocity in an up direction	Double	8	H+52
10	Roll	Right handed rotation from local level around y-axis in degrees	Double	8	H+60
11	Pitch	Right handed rotation from local level around x-axis in degrees	Double	8	H+68
12	Azimuth	Left handed rotation around z-axis Degrees clockwise from North	Double	8	H+76
13	Status	INS Status, see *Table 13 on Page 60*	Enum	4	H+84
14	xxxx	32-bit CRC	Hex	4	H+88
15	[CR][LF]	Sentence Terminator (ASCII only)	-	-	-

Recommended Input:

log inspvasa ontime 1

ASCII Example:

```
%INSPVASA,1264,144059.000;
1264,144059.002135700,51.116680071,-114.037929194,515.286704183,
277.896368884,84.915188605,-8.488207941,0.759619515,-2.892414901,
6.179554750,INS_ALIGNMENT_COMPLETE*855d6f76
```

C.2.13 INSSPD INS Speed

This log contains the most recent speed measurements in the horizontal and vertical directions, and includes an INS status indicator.

Structure: **Message ID: 266**

Log Type: Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Trk gnd	Actual direction of motion over ground (track over ground) with respect to True North, in degrees	Double	8	H+12
5	Horizontal Speed	Magnitude of horizontal speed in m/s where a positive value indicates you are moving forward and a negative value indicates you are reversing.	Double	8	H+20
6	Vertical Speed	Magnitude of vertical speed in m/s where a positive value indicates speed upward and a negative value indicates speed downward.	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
log insspda ontime 1

ASCII Example:
```
#INSSPDA,COM3,0,0.0,EXACT,1105,425385.000,00040000,efce,0;
1105,425384.996167250,223.766800423,0.019769837,
-0.024795257,INSSolutionGood*15b864f4
```

C.2.14 INSSPDS Short INS Speed

This is a short header version of the *INSSPD* log on *Page 82*.

Structure: **Message ID: 323**

Log Type: Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	Trk gnd	Track over ground	Double	8	H+12
5	Horizontal Speed	Horizontal speed in m/s	Double	8	H+20
6	Vertical Speed	Vertical speed in m/s	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
　　　log insspdsa ontime 1

ASCII Example:
```
%INSSPDSA,1105,425385.000;
1105,425384.996167250,223.766800423,0.019769837,
-0.024795257,INSSolutionGood*15b864f4
```

C.2.15 INSUPDATE   INS Update

This log contains the most recent INS update information. It gives you information about what updates were performed in the INS filter at the last update epoch.

Structure: **Message ID: 757**

Log Type:Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Solution Type	Type of GPS solution used for the last update, see *Table 16* on *Page 64*	Enum	4	H
3	Reserved		Integer	4	H+4
4	#Phase	Number of raw phase observations used in the last INS filter update	Integer	4	H+8
5	Reserved		Integer	4	H+12
6	Zupt Flag	A zero velocity update was performed during the last INS filter update: 0 = False 1 = True	Boolean	2	H+16
7	Reserved		Ulong	4	H+18
8			Ulong	4	H+22
9	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+26
10	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

> log insupdate onchanged

ASCII Example:

> #INSUPDATEA,COM1,0,24.0,FINESTEERING,1322,250565.000,00000008,0776,34631;
>
> OMNISTAR_HP,6,0,6,FALSE,0,0*d2618c20

C.2.16   INSVEL   INS Velocity

This log contains the most recent North, East, and Up velocity vector values, and also includes an INS status indicator.

Structure:　　　　　　　　　　　　　　　　　　　　　　　**Message ID: 267**

Log Type:Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	North Velocity	Velocity North in m/s	Double	8	H+12
5	East Velocity	Velocity East in m/s	Double	8	H+20
6	Up Velocity	Velocity Up in m/s	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:
　　log insvela ontime 1

ASCII Example:
```
#INSVELA,COM3,0,0.0,EXACT,1105,425385.000,00040000,7d4a,0;
1105,425384.996167250,-0.014277009,-0.013675287,
-0.024795257,INSSolutionGood*2f3fe011
```

C.2.17   INSVELS   *Short INS Velocity*

This is a short header version of the *INSVEL* log on *Page 85*.

Structure: **Message ID: 324**

Log Type:Synch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	North Velocity	Velocity North m/s	Double	8	H+12
5	East Velocity	Velocity East m/s	Double	8	H+20
6	Up Velocity	Velocity Up m/s	Double	8	H+28
7	Status	INS status, see *Table 13 on Page 60*	Enum	4	H+36
8	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
9	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

Recommended Input:

    log insvelsa ontime 1

ASCII Example:

    %INSVELSA,1105,425385.000;
    1105,425384.996167250,-0.014277009,-0.013675287,
    -0.024795257,INSSolutionGood*2f3fe011

C.2.18   RAWIMU   Raw IMU Data

This log contains an IMU status indicator and any output changes from the accelerometers and gyros.

Structure: **Message ID: 268**

                                                                              Log Type: Asynch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	IMU Status	The status of the IMU. This field is given in a fixed length (n) array of bytes in binary but in ASCII or Abbreviated ASCII is converted into 2 character hexadecimal pairs. See *Table 18, IMU Status* on *Page 88, the ASCII Example and Table 19, IMU Status Example* on *Page 89*.	Long	4	H+12
5	Z Accel Output	Change in velocity along z axis in m/s [a]	Long	4	H+16
6	- (Y Accel Output)	- (Change in velocity along y axis) in m/s [a, b]	Long	4	H+20
7	X Accel Output	Change in velocity along x axis in m/s [a]	Long	4	H+24
8	Z Gyro Output	Change in angle around z axis in radians [c] Right-handed	Long	4	H+28
9	- (Y Gyro Output)	- (Change in angle around y axis) in radians [b, c] Right-handed	Long	4	H+32
10	X Gyro Output	Change in angle around x axis in radians [c] Right-handed	Long	4	H+36
11	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
12	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

a. Scale Factor for change in velocity (acceleration):
   (0.3048/((double)134217728.0)) for the AG11 and AG58
   (0.3048/((double)67108864.0)) for the AG17 and AG62
   See *Table 2, IMU Enclosure Models* on *Page 17* for a list of IMU enclosures.
b. A negative value implies that the output is along the positive Y-axis marked on the IMU. A positive value implies that the change is in the direction opposite to that of the Y-axis marked on the IMU.
c. Scale Factor for change in angle:
   (1.0/((double)8589934592.0)) for the AG11, AG58, AG17 and AG62
   See *Table 2, IMU Enclosure Models* on *Page 17* for a list of IMU enclosures.

Table 18: IMU Status

Nibble #	Bit #	Mask	Description	Range Value
N0	0	0x00000001	4-bit counter	Read binary and convert to decimal to give a simple counter incremented by 6
	1	0x00000002		
	2	0x00000004		
	3	0x00000008	← msb	
N1	4	0x00000010	IMU test	Passed = 0, Failed = 1
	5	0x00000020	Z-axis gyro path-length control	Good = 0, Reset =1
	6	0x00000040	Y-axis gyro path-length control	Good = 0, Reset =1
	7	0x00000080	X-axis gyro path-length control	Good = 0, Reset =1
N2	8	0x00000100	Accelerometer temperature	Read binary and convert to decimal to give an internal temperature of the receiver in degrees Celsius.
	9	0x00000200		
	10	0x00000400		
	11	0x00000800		
N3	12	0x00001000		
	13	0x00002000		
	14	0x00004000		
	15	0x00008000	← msb	
N4	16	0x00010000	Software version number	Read binary and convert to decimal to give the IMU manufacturer's software version number.
	17	0x00020000		
	18	0x00040000		
	19	0x00080000		
N5	20	0x00100000		
	21	0x00200000		
	22	0x00400000		
	23	0x00800000	← msb	
N6	24	0x01000000	Reserved	
	25	0x02000000		
	26	0x04000000		
	27	0x08000000	Gyro tests	Passed = 0, Failed = 1
N7	28	0x10000000	Accelerometer tests	Passed = 0, Failed = 1
	29	0x20000000	Other tests	Passed = 0, Failed = 1
	30	0x40000000	Memory tests	Passed = 0, Failed = 1
	31	0x80000000	Processor tests	Passed = 0, Failed = 1

Recommended Input:

    log rawimua onnew

ASCII Example:

```
#RAWIMUA,COM3,0,0.0,EXACT,1105,425384.180,00040000,b8ed,0;
1105,425384.156166800,111607,43088060,430312,-3033352,
-132863,186983,823*5aa97065
```

Table 19 shows how to change the bolded field, IMU Status, in the example above into its binary equivalent, and then how to read *Table 18, IMU Status* on *Page 88* as a result.

Table 19: IMU Status Example

Nibble#	N7		N6		N5		N4		N3		N2		N1		N0	
0x	0		0		1		1		1		6		0		7	

Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Binary [a]	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	1	1	1
Data	Processor Tests	Memory Tests	Other Tests	Accelerometer Tests	Gyro Tests	Reserved			Software Version Number								Accelerometer Temperature								X-axis gyro path-length control	Y-axis gyro path-length control	Z-axis gyro path-length control	IMU tests	Counter			
Value	Passed	Passed	Passed	Passed	Passed				= Decimal 17								= Decimal 22°C								Good	Good	Good	Passed	= Decimal 7			

a. For a complete list of hexadecimal and binary equivalents please refer to the section on Unit Conversion in the *GPS+ Reference Manual* available on our website at http://www.novatel.ca/support/docupdates.htm

C.2.19 RAWIMUS   Short Raw IMU Data

This is a short header version of the *RAWIMU* log on *Page 87*.

Structure: **Message ID: 325**

Log Type: Asynch

Field #	Field Type	Data Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	Week	GPS Week	Ulong	4	H
3	Seconds into Week	Seconds from week start	Double	8	H+4
4	IMU Status	The status of the IMU. This field is given in a fixed length (n) array of bytes in binary but in ASCII or Abbreviated ASCII is converted into 2 character hexadecimal pairs. See *Table 18, IMU Status* on *Page 88,* the *ASCII Example* and *Table 19, IMU Status Example* on *Page 89*.	Long	4	H+12
5	Z Accel Output	Change in velocity along z axis in m/s [a]	Long	4	H+16
6	- (Y Accel Output)	- (Change in velocity along y axis) in m/s [a, b]	Long	4	H+20
7	X Accel Output	Change in velocity along x axis in m/s [a]	Long	4	H+24
8	Z Gyro Output	Change in angle around z axis in radians [c] Right-handed	Long	4	H+28
9	- (Y Gyro Output)	- (Change in angle around y axis) in radians [b, c] Right-handed	Long	4	H+32
10	X Gyro Output	Change in angle around x axis in radians [c] Right-handed	Long	4	H+36
11	xxxx	32-bit CRC (ASCII, Binary and Short Binary only)	Hex	4	H+40
12	[CR][LF]	Sentence terminator (ASCII only)	-	-	-

a. Scale Factor for change in velocity (acceleration):
     (0.3048/((double)134217728.0)) for the AG11 and AG58
     (0.3048/((double)67108864.0)) for the AG17 and AG62
     See *Table 2, IMU Enclosure Models* on *Page 17* for a list of IMU enclosures.
b. A negative value implies that the output is along the positive Y-axis marked on the IMU. A positive value implies that the change is in the direction opposite to that of the Y-axis marked on the IMU.
c. Scale Factor for change in angle:
     (1.0/((double)8589934592.0)) for the AG11, AG58, AG17 and AG62
     See *Table 2, IMU Enclosure Models* on *Page 17* for a list of IMU enclosures.

Recommended Input:

    log rawimusa onnew

ASCII Example:

```
%RAWIMUSA,1105,425384.180;
1105,425384.156166800,111607,43088060,430312,-3033352,
-132863,186983,823*5aa97065
```

C.2.20   *VEHICLEBODYROTATION*

The VEHICLEBODYROTATION log reports the angular offset from the vehicle frame to the body frame. The body frame is defined by the transformed IMU axis with Z pointing up, see the SETIMUORIENTATION command on *Page 53*. The vehicle frame is defined as follows:

- Vehicle Z Axis - points up through the roof of the vehicle perpendicular to the ground
- Vehicle Y Axis - points out the front of the vehicle in the direction of travel
- Vehicle X Axis - completes the right-handed system (out the right-hand side of the vehicle when facing forward)

The rotation values are used to perform a kinematic alignment using the GPS velocity, and track model roll and pitch estimates measured in the vehicle frame, as an initial estimate of the system attitude. The rotation is used to transform the vehicle frame attitude estimates into the body frame.

The uncertainty values report the accuracy of the angular offsets.

The VEHICLEBODYROTATION log can also be used as a command to set initial estimates for the angular offset. The uncertainty values are optional. Follow these steps:

1. Start with the vehicle frame as described above.
2. Rotate about the vehicle X-axis to align the Y-Z plane with the body frame. This angle is the X-angle in the command.
3. Rotate about the new Y-axis to align the X-Z plane with the body frame. This angle is the Y-angle in the command.
4. Finally, rotate about the new Z-axis to align the X-Y plane with the body frame. This angle is the Z-angle in the command.

Abbreviated ASCII Syntax:

VEHICLEBODYROTATION X Y Z [σx] [σy] [σz]

Structure: **Message ID: 642**

Log Type: Asynch

Field	Field Type	Description	Format	Binary Bytes	Binary Offset
1	Log Header	Log header	-	H	0
2	X Angle	Right hand rotation about vehicle frame X axis, degrees	Double	8	H
3	Y Angle	Right hand rotation about vehicle frame Y axis, degrees	Double	8	H+8
4	Z Angle	Right hand rotation about vehicle frame Z axis, degrees	Double	8	H+16
5	X Uncertainty	Uncertainty of X rotation, degrees (default = 0)	Double	8	H+24
6	Y Uncertainty	Uncertainty of Y rotation, degrees (default = 0)	Double	8	H+32
7	Z Uncertainty	Uncertainty of Z rotation, degrees (default = 0)	Double	8	H+40
8	xxxx	32-bit CRC	Hex	4	H+48
9	[CR][LF]	Sentence Terminator (ASCII only)	-	-	-

Recommended Input:

log vehiclebodyrotationa onchanged

ASCII Example:

```
#VEHICLEBODYROTATIONA,COM1,0,36.5,FINESTEERING,1264,144170.094,00000000,bcf2,
1541;1.5869999997474209,2.6639999995760122,77.6649999876392343,2.000000000000
0000,2.0000000000000000,5.0000000000000000*25f886cc
```

Appendix D Command Prompt Interface

When the SPAN system turns on, no activity information is transmitted from the serial ports except for the port prompt. A terminal connected to the receiver display a messages on its monitor. For example:

Com1> *if connected to COM1 port*

The COM port can be COM1, COM2, COM3 or AUX. Commands are typed at the interfacing terminal's keyboard, and sent after pressing the terminal's <↵> or <Enter> key.

⊠ Most valid commands do produce a visible response on the screen. The indication that they have been accepted is a return of the port prompt from the receiver.

Example:

An example of no echo response to an input command is the SETIMUTOANTOFFSET command. It can be entered as follows:

```
COM2>setimutoantoffset 0.1 0.1 0.1[Return]
COM2>
```

The above example illustrates command input to the receiver COM2 serial port, which sets the antenna to IMU offset. However, your only confirmation that the command was actually accepted is the return of the **COM2>** prompt.

If a command is incorrectly entered, the receiver responds with "Invalid Command Name" (or a more detailed error message) followed by the port prompt.

D.1   DOS

One way to initiate multiple commands and logging from the receiver is to create DOS command files relating to specific functions. This minimizes the time required to set up duplicate test situations. Any convenient text editor can be used to create command text files.

Example:

For this example, consider a situation where a laptop computer's appropriately configured COM1 serial port is connected to the receiver's COM1 serial port, and where a rover terminal is connected to the receiver's COM2 serial port. If you wish to monitor the SPAN system activity, the following command file could be used to do this.

1.   Open a text editor on the PC and type in the following command sequences:

```
log com2 satvisa ontime 15
log com2 trackstata ontime 15
log com2 rxstatusa ontime 60 5
log com2 bestposa ontime 15
log com2 psrdopa ontime 15
```

2.   Save this with a convenient file name (e.g. C:\GPS\BOOT1.TXT) and exit the text editor.

3.   Use the DOS *copy* command to direct the contents of the BOOT1.TXT file to the PC's COM1 serial port:

```
C:\GPS>copy boot1.txt com1
1 files(s) copied
C:\GPS>
```

4.   The SPAN system is now initialized with the contents of the BOOT1.TXT command file, and logging is directed from the receiver's COM2 serial port to the rover terminal.

D.2   WINDOWS

As any text editor or communications program can be used for these purposes, the use of Windows 98 is described only as an illustration. The following example shows how Windows 98 accessory programs *Notepad* and *HyperTerminal* can be used to create a hypothetical waypoint navigation file on a laptop computer, and send it to the receiver. It is assumed that the laptop computer's COM1 serial port is connected to the receiver's COM1 serial port, and that a rover terminal is connected to the receiver's COM2 serial port.

Example:

1.   Open *Notepad* and type in the following command text:

```
setnav 51.111 -114.039 51.555 -114.666 0 start stop
magvar -21
log com1 bestposa ontime 15
log com1 psrvela ontime 15
log com1 navigatea ontime 15
log com2 gprmb ontime 15 5
log com2 gpvtg ontime 15 5
log com2 rxconfiga ontime 60
```

2.   Save this with a convenient file name (e.g. C:\GPS\BOOTNAV1.TXT) and exit *Notepad*.

3.   Ensure that the *HyperTerminal* settings are correctly set up to agree with the receiver communications protocol; these settings can be saved (e.g. C:\GPS\OEMSETUP.HT) for use in future sessions. You may wish to use XON / XOFF handshaking to prevent loss of data.

4.   Select Transfer | Send Text File to locate the file that is to be sent to the receiver. Once you double-click on the file or select Open, *HyperTerminal* sends the file to the receiver.

The above example initializes the SPAN system with origin and destination waypoint coordinates and sets the magnetic variation correction to -21 degrees. The BESTPOSA, PSRVELA, and NAVIGATEA logs have been set to output from the receiver's COM1 serial port at intervals of once every 15 seconds, whereas the GPRMB and GPVTG NMEA logs have been set to be logged out of the receiver's COM2 serial port at intervals of 15 seconds and offset by five seconds. The RXCONFIGA log has been set to output every 60 seconds from its COM2 serial port.

Appendix E IMU Gyro Installation

E.1 Introduction

The following procedure provides the necessary information to install the Gyro unit HG1700AG11 (NovAtel number 80023510) or HG1700AG17 (NovAtel number 80023511) into the IMU Enclosure (NovAtel part number 01017394).

The IMU consists of the IMU Enclosure and the IMU Gyro Installation Kit (NovAtel part number 01017022). To assemble these parts into a working IMU you will need the parts mentioned above.

E.2 Safety Precautions

- Ensure you use a ground strap before installing the internal circuit boards.
- Do NOT scratch any surfaces of the unit.

E.3 General Steps of the Procedure

- Disassemble the IMU Enclosure.
- Install the IMU Gyro unit.
- Reassemble the IMU Enclosure.

E.4 IMU Gyro Installation.

1.   As mentioned in *Section E.1* above, the assembly parts required for the product include the IMU Installation Kit, the IMU Enclosure and the Gyro. *Figure 14* below and *Figure 15* on *Page 98*, display these parts respectively.

Figure 14: Installation Kit and Enclosure

Figure 15: Gyro

2.   The Installation Kit includes 2 small screws for the IMU connector, 3 larger screws for the Gyro installation and a flex interconnect cable, see *Figure 16*.

Figure 16: Contents of Installation Kit

3.   Carefully unscrew and remove the IMU Enclosure lid, see *Figure 17*.

Figure 17: Remove the Lid

4. The IMU flex cable must be connected to its mating connector on the power board. First, pull the friction lock of the connector, see *Figure 18* and *Figure 19*, outward so the flex cable can be pushed into the socket. Push the flex cable in all the way, ensure it is straight, and then push the friction lock back to its original position to secure the cable. Tug slightly on the cable to test for a tight connection.
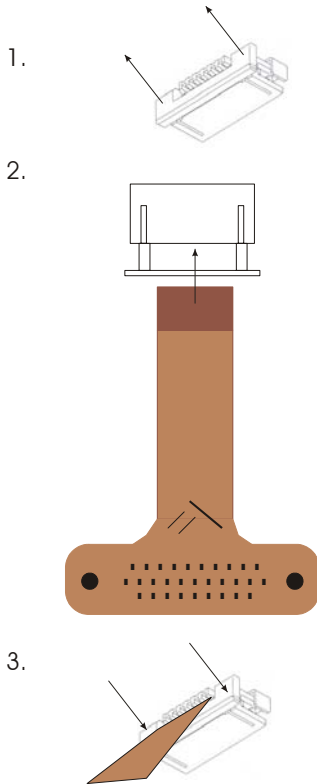
Reference	Description
1.	Pull friction lock away from connector
2.	Insert flex into open socket
3.	Push friction lock all the way in to secure the flex cable

Figure 18: Flex Cable Mating Connector
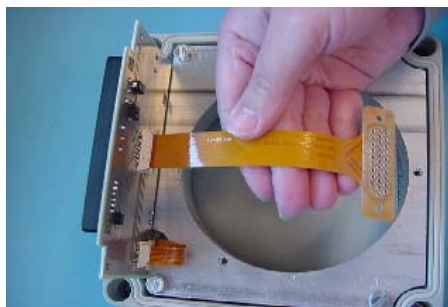
Figure 19: Installing the IMU Flex Cable

5.   *Figure 20* on *Page 100* shows the IMU Gyro being installed.

CAUTION!: Careful handling of this Gyro is CRITICAL. Do NOT drop or bump this assembly.

Orientate the IMU Enclosure and IMU Gyro as in *Figure 20*. Gently pull the flex cable out of the way and place the Gyro into its base.

Figure 20: Install the IMU Gyro into the Enclosure Base

Reference	Description
1	Flex cable holes
2	Matching pins

6.   Secure the Gyro with 3 screws, using threadlock (for example Threadlocker 222). Torque the

screws to 10 pound-force inch (1.130 newton meter), see *Figure 21*.

Figure 21: Threadlock and Torque 3 Screws

7.   *Figure 22* displays the flex cable being connected to the IMU Gyro assembly.

CAUTION!:   *1.*   *DO NOT bend any of the connector pins on the Gyro.*
              2.   *Ensure that the flex cable is pressed firmly onto the IMU pins before inserting the screws.*

Orientate the IMU Gyro as in *Figure 22* and tilt the flex connector up slightly to see its rear row of sockets. Align the rear row of sockets to the rear row of pins and while holding it in place, gradually tilt the connector forward over all the pins, and then check to see if all pins will enter their respective sockets. When assured of proper alignment, press down on the connector until it is seated all the way down on the Gyro.
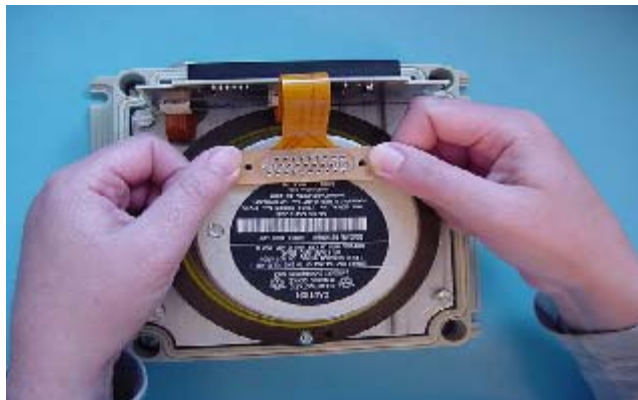
Figure 22: Connect the IMU Flex Cable

Figure 20 on *Page 100* shows the flex cable holes (1) and matching pins (2) as the gyro is lowered into its base. The flex cable's connector (1) must sit flat on top of the IMU. Do not screw the flex cable down until all the pins (2) are inserted all the way into the cable.

Figure 23 shows an incorrect installation of the flex cable where it is bowed in the middle. It

will not operate properly in this position. *Figure 24* shows the proper installation of the flex cable. Notice how the flex cable sits flush against the IMU surface.
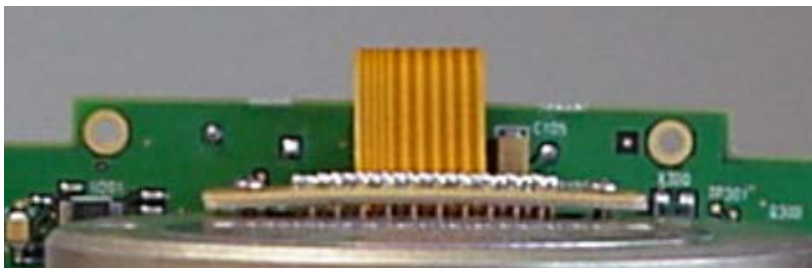
Figure 23: Incorrect (Bowed) Flex Cable Installation

Figure 24: Correct (Flat) Flex Cable Installation

8.   *Figure 25* displays the flex cable connector being secured to the Gyro. Once the connector is pushed all the way down onto the Gyro, use 2 screws to secure the connector. Use threadlock on each screw (for example Threadlocker 222) and torque to 2.5 pound-force inch (0.282 newton meter).

Figure 25: Secure the Connector

9.   The enclosure lid must be gently set into place over the base, see *Figure 26*. Notice that one side of the lid has a label that reads "IMU CONNECTOR". This side MUST BE located on the same side as the I/O connector for proper orientation. Once all screws are threaded all the

way down, tighten them to 12 pound-force inch (1.356 newton meter), see *Figure 27*.
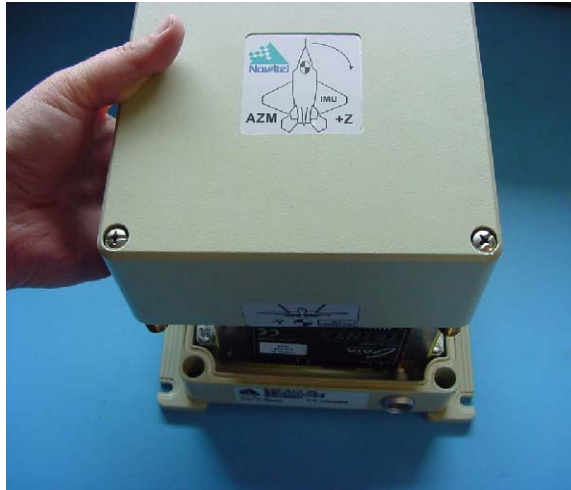
Figure 26: Replace the Enclosure Lid

Figure 27: Tightening the Lid

10.   This concludes the installation procedure, see *Figure 28*.

Figure 28: Completed IMU Assembly

Appendix F   Frequently Asked Questions

1. *How do I know if my hardware is connected properly?*
    When powered, the HG1700 IMU will make a noticeable humming sound.

2. *I don't hear any sound from my IMU. Why?*
    a. When powered, the IMU makes a noticeable humming sound. If no sound is heard, check that the cable between the receiver and IMU is connected properly. The cable should be connected to the AUX port on the DL-4*plus* or Propak-G2*plus* and to the COM3 port on Propak-LB*plus*.
    b. If the cable is connected properly and you still hear no sound from the IMU, check the flex cable mounted on top of the IMU. Refer to the instructions in this manual on proper IMU installation to ensure that the cable is seated properly on the IMU pins. See *Appendix E, IMU Gyro Installation* starting on *Page 97* for more details.
    c. Check the input power supply. A minimum of 12V should be supplied to the system for stable IMU performance. The supply should also be able to output at least 12W over the entire operating temperature range.

3. *What system configuration do I need to do to get the system running?*
    a. Set the interface of the receiver port being used for IMU communication using the INTERFACEMODE command, see *Page 47*.

        INTERFACEMODE COM3 IMU IMU OFF (for ProPak-G2*plus* and Propak-LB*plus*)
        INTERFACEMODE AUX IMU IMU OFF (for DL-4)
    b. Set the IMU type using the SETIMUTYPE command, see *Page 57*.

4. *What types of IMUs are supported?*
    a. SPAN currently supports the HG1700 IMU family. The SETIMUTYUPE command specifies the type of IMU used.
    b. For the **AG11** and **AG58** IMUs the configuration command is:

        SETIMUTYPE IMU_HG1700_AG11
    c. For the **AG17** and **AG62** IMUs the configuration command is:

        SETIMUTYPE IMU_HG1700_AG17

5. *Why don't I have any INS logs?*
    a. On start-up, the INS logs are not available until the system has solved for time. This requires that an antenna is attached, and satellites are visible, to the system. You can verify that time is solved by checking the time status in the header of any standard header SPAN log such as BESTPOS. When the time status reaches FINETIME, the inertial filter starts and INS messages are available.
    b. Check that the system has been configured properly. See question *3* above.

6. *How can I access the inertial solution?*
    The INS/GPS solution is available from a number of specific logs dedicated to the inertial filter. The INSPOS, INSPVA, INSVEL, INSSPD, INSATT and INSCOV logs are the most commonly used logs for extracting the INS solution. These logs can be logged at any rate up to the rate of the IMU data (100 Hz for the HG1700 IMU). These logs can also be triggered by the mark input signal by requesting the logs "ONMARK". Further details on these logs are available in *Appendix C, INS Logs* starting on *Page 60*.

7. *Can I still access the GPS-only solution while running SPAN?*

    The GPS only solution used when running the OEM4 receiver without the IMU is still available when running SPAN. Logs such as PSRPOS, RTKPOS and OMNIPOS are still available. Any non-INS logs should be logged at a maximum rate of 5 Hz when running SPAN. Only INS-specific logs documented in *Appendix C, INS Logs* starting on *Page 60* should be logged at rates higher than 5 Hz when running SPAN.

8. *What will happen to the INS solution when I lose GPS satellite visibility?*

    When GPS tracking is interrupted, the INS/GPS solution bridges through the gaps with what is referred to as free-inertial navigation. The IMU measurements are used to propagate the solution. Errors in the IMU measurements accumulate over time to degrade the solution accuracy so that after one minute of GPS outage, the position accuracy is approximately 2 m. The SPAN solution continues to be computed for as long as the GPS outage lasts, but the solution uncertainty increases with time. This uncertainty can be monitored using the INSCOV log, see *Page 72*.

Appendix G Replacement Parts

The following are a list of the replacement parts available. Should you require assistance, or need to order additional components, please contact your local NovAtel dealer or Customer Service.

G.1 SPAN System

Part Description	NovAtel Part
IMUs (see *Table 2, IMU Enclosure Models* on *Page 17* for details)	IMU-G2-xxx IMU-LB-xxx
Receivers (see *Table 1, SPAN-Compatible Receiver Models* on *Page 16* for details)	DL-4*plus* ProPak-G2*plus* ProPak-LB*plus*
IMU interface cable (ProPak-LB*plus*)	01017393
IMU interface cable (ProPak-G2*plus* or DL-4*plus* see *Page 38*)	01017384
OEM4, GPSolution4 and Convert4 disk (refer to *Page 28* and *Volume 1* of the *OEM4 User Manual*)	01017464
SPAN Technology System User Manual	OM-20000062
OEM4 Family User Manual, Volume 2, Commands and Logs	OM-20000047
OEM4 Family User Manual, Volume 1, Installation and Operation	OM-20000046
DL-4*plus* User Manual	OM-20000063

G.2 Accessories and Options

Part Description		NovAtel Part
Optional NovAtel GPSAntennas:	Model 532 (for aerodynamic applications)	GPS-532
	Model 702 (for high-accuracy applications)	GPS-702
	Model 702L (for L-Band applications)	GPS-702L
	Model 533 (for high-performance base station applications)	GPS-533
Optional RF Antenna Cable:	5 meters	C006
	15 meters	C016

G.3 Manufacturer's Part Numbers

The following original manufacturer's part numbers, for the IMU interface cables (see *Page 38*), are provided for information only and are not available from NovAtel as separate parts:

Part Description	LEMO Part	Switchcraft Part
2-pin socket connector (ProPak-LB*plus* to IMU interface cable)	-	EN3C2F16
2-pin plug connector (ProPak-LB*plus* to IMU interface cable)	-	EN3C2M16
8-pin socket connector (ProPak-LB*plus* to IMU interface cable)	-	EN3C8F
10-pin LEMO plug connector on both IMU interface cables	FGG.1K.310.CLAC60Z	-

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