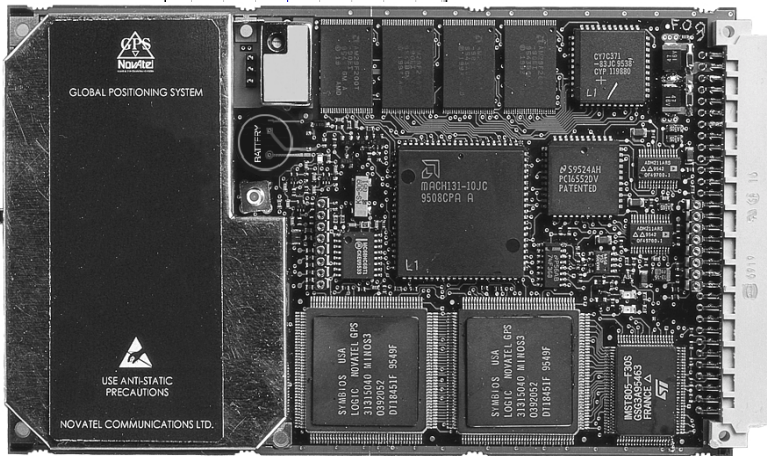


MiLLennium®-GLONASS GPSCard™

User Manual

Channel	0	2	4	6	8	10	12	14
PRN number	19	7	13	10	27	9	6	
Chan State	Lock	Search	Lock	Lock	Lock	Lock	Lock	Idle
Doppler	-2214	3692	-1807	-2790	731	3933	1181	
C/No(db-Hz)	51.74	0.00	52.28	45.27	52.35	44.64	51.77	
Residual	-37.59	0.00	-7.43	-0.33	2.44	-4.87	0.96	
LockTime	17899	0	12799	11810	10797	23	2346	
Reject Code	Good		Good	Good	Good	Good	Good	
System-Corr	GPS-N	GPS-N	GPS-N	GPS-N	GPS-N	GLO-N	GLO-N	GLO-N
Measurement	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A

Channel	1	3	5	7	9	11	13	15
PRN number	2	26	31	18	3	22	1	24
Chan State	Lock	Lock	Lock	Lock	Lock	Lock	Lock	Lock
Doppler	1991	2935	-1803	-4012	-3250	-2816	4324	-4354
C/No(db-Hz)	51.95	43.58	51.36	45.33	45.03	51.36	41.55	40.62
Residual	-2.98	27.20	-7.85	28.03	-1.31	1.68	-8.56	-4.48
LockTime	7071	1725	9117	21985	13861	1027	1772	15633
Reject Code	Good	Good	Good	Good	Good	Good	Good	Good
System-Corr	GPS-N	GPS-N	GPS-N	GPS-N	GPS-N	GLO-N	GLO-N	GLO-N
Measurement	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A	L1-C/A



MiLLennium®-GLONASS GPSCard™

User Manual

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WARRANTY POLICY

NovAtel Inc. warrants that its Global Positioning System (GPS) products are free from defects in materials and workmanship, subject to the conditions set forth below, for the following periods of time:

MiLlennium-GLONASS GPSCard receiver	One (1) Year
GPS/GLONASS Antenna Series	One (1) Year
Battery, Cables and Accessories	Ninety (90) Days
Software Support	One (1) Year

Date of sale shall mean the date of the invoice to the original customer for the product. NovAtel's responsibility respecting this warranty is limited solely to product replacement or product repair at an authorized NovAtel location only. Determination of replacement or repair will be made by NovAtel personnel or by technical personnel expressly authorized by NovAtel for this purpose.

THE FOREGOING WARRANTIES DO NOT EXTEND TO (I) NONCONFORMITIES, DEFECTS OR ERRORS IN THE PRODUCTS DUE TO ACCIDENT, ABUSE, MISUSE OR NEGLIGENT USE OF THE PRODUCTS OR USE IN OTHER THAN A NORMAL AND CUSTOMARY MANNER, ENVIRONMENTAL CONDITIONS NOT CONFORMING TO NovAtel's SPECIFICATIONS, OR FAILURE TO FOLLOW PRESCRIBED INSTALLATION, OPERATING AND MAINTENANCE PROCEDURES, (II) DEFECTS, ERRORS OR NONCONFORMITIES IN THE PRODUCTS DUE TO MODIFICATIONS, ALTERATIONS, ADDITIONS OR CHANGES NOT MADE IN ACCORDANCE WITH NovAtel's SPECIFICATIONS OR AUTHORIZED BY NovAtel, (III) NORMAL WEAR AND TEAR, (IV) DAMAGE CAUSED BY FORCE OF NATURE OR ACT OF ANY THIRD PERSON, (V) SHIPPING DAMAGE; OR (VI) SERVICE OR REPAIR OF PRODUCT BY THE DEALER WITHOUT PRIOR WRITTEN CONSENT FROM NovAtel.

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NovAtel SHALL NOT BE LIABLE FOR ANY LOSS, DAMAGE OR EXPENSE ARISING DIRECTLY OR INDIRECTLY OUT OF THE PURCHASE, INSTALLATION, OPERATION, USE OR LICENSING OR PRODUCTS OR SERVICES. IN NO EVENT SHALL NovAtel BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND OR NATURE DUE TO ANY CAUSE.

There are no user serviceable parts in the MiLlennium-GLONASS GPSCard 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.

NOTE: You must obtain a Return Material Authorization (RMA) number by calling the NovAtel Customer Service Department at **1-800-NOVATEL** (USA and Canada only) or 403-295-4900 before shipping any product to NovAtel or a Dealer.

Once you have obtained an RMA number, you will be advised of proper shipping procedures to return any defective product. When returning any product to NovAtel, please return all original diskettes along with the defective product in the original packaging to avoid ESD and shipping damage.

CUSTOMER SERVICE

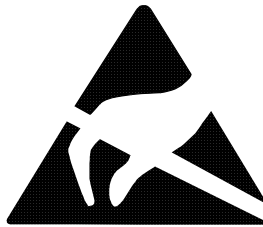
For customer support contact your local NovAtel dealer first. If the problem is still unresolved contact NovAtel directly in any of the following ways:

- GPS/GLONASS Hotline at **1-800-NOVATEL** (U.S. and Canada only)
- telephone: **403-295-4900**
- fax: **403-295-4901**
- e-mail: support@novatel.ca
- web site: <http://www.novatel.ca>
- postal address:

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

CAUTION

Handle with Care



Use Anti-Static Precautions

NOTE: The ProPak II and PowerPak II enclosures incorporate circuitry to absorb most static discharges. However, severe static shock may damage the unit. If the MiLLennium-GLONASS GPSCard is not in a NovAtel-supplied enclosure, special handling precautions must be observed. Please see *Appendix A, Page 47*, for details.

FOREWORD

CONGRATULATIONS

Congratulations on purchasing your MiLLennium-GLONASS positioning system. The MiLLennium-GLONASS GPSCard is the latest example of NovAtel's line of state-of-the-art technology, in an easy-to-integrate single-card format. Your new MiLLennium-GLONASS GPSCard receiver accepts both GPS and GLONASS input signals from a GPS/GLONASS L1 antenna. This system also provides real-time kinematic (RTK) capability, with NovAtel RT-10.

The MiLLennium-GLONASS is a tightly-integrated system that provides a positioning system that meets the accuracy requirements of many applications on a single hardware platform.

SCOPE

This manual addresses in detail the MiLLennium-GLONASS GPSCard hardware attributes and installation information. This *MiLLennium-GLONASS GPSCard User Manual* also describes each of the special commands and logs that the MiLLennium-GLONASS GPSCard is capable of accepting or outputting. Please consult the *MiLLennium Command Descriptions Manual* (NovAtel part number OM-20000041) for other commands and logs available with your MiLLennium-GLONASS GPSCard.

The MiLLennium-GLONASS GPSCard is also available as part of two stand-alone packaged configurations, the ProPak II enclosure or the PowerPak II enclosure. A guide to using the ProPak II enclosure may be found on *Page 59*, and a guide to using the PowerPak II enclosure may be found on *Page 73*.

When you are ready to use your MiLLennium-GLONASS GPSCard for the first time, consult the easy-to-follow Quick Start chapter that is provided on *Page 15*.

The focus of this manual is on your perspective for integration, evaluation and operation purposes. It is beyond the scope of this manual to provide service details. Please consult your local NovAtel dealer for any customer service problems or inquiries. Should the need arise to contact NovAtel directly please see the Customer Support section on *Page 7*.

The standard for measurement throughout this document is metric (SI) units. See *Appendix C, Page 54* for help with any conversions to imperial measurements.

PREREQUISITES

The MiLLennium-GLONASS GPSCard is an OEM product requiring the addition of an enclosure and peripheral equipment before it can become a fully functional combined GPS/GLONASS receiver. *Chapter 3, MiLLennium-GLONASS GPSCard Installation, Page 17*, provides information concerning installation requirements and considerations.

1 INTRODUCTION

1.1 MILLENNIUM-GLONASS GPSCARD

The MiLLennium-GLONASS GPSCard can receive L1 signals from combined GPS/GLONASS satellites. This hybrid receiver offers combined GPS/GLONASS position solutions.

An RTK version of the MiLLennium-GLONASS GPSCard performs significantly better when tracking GPS and GLONASS satellites, than when tracking GPS satellites only. Faster floating-ambiguity solutions mean shorter observations times.

The use of GLONASS in addition to GPS provides very significant advantages:

- increased satellite signal observations
- markedly increased spatial distribution of visible satellites
- reduction in the Horizontal and Vertical Dilution of Precision factor
- no special precision degrading mode in GLONASS (unlike GPS Selective Availability mode)
- single frequency (L1) positioning accuracy is about 4 times better for GLONASS as compared to GPS single frequency signals
- improved RTK performance
- decreased occupation times result in faster surveying

The MiLLennium-GLONASS GPSCard is capable of combined GPS/GLONASS operation. In order to track GLONASS satellites the MiLLennium must track at least one GPS satellite to determine the GPS/GLONASS time offset. In order to determine a position in GPS-Only mode the receiver must track a minimum of four satellites, representing the four unknowns of 3-D position and time. In combined GPS/GLONASS mode the receiver must track five satellites, representing the same four previous unknowns as well as the GPS/GLONASS time offset.

With the availability of combined GPS/GLONASS receivers, users have access to a potential 48-satellite combined system. With 48 satellites, performance in urban canyons and other locations with restricted visibility, such as forested areas, is improved, as more satellites are visible in the non-blocked portions of the sky. A larger satellite constellation also improves real-time carrier-phase differential positioning performance. In addition, stand-alone position accuracies improve with the combined system, and in the absence of deliberate accuracy degradation, differential GLONASS requires a much lower correction update rate.

Table 1.1 lists the two types of NovAtel MiLLennium-GLONASS GPSCards available, each capable of multiple positioning modes of operation:

Table 1.1 Positioning Modes of Operation

Positioning Modes of Operation	MiLLennium-GLONASS GPSCard	
	MiLLen-G	MiLLen-G-RT10
Single Point	√	√
Waypoint Navigation	√	√
Pseudorange differential corrections (TX & RX)	√	√
RTK pseudorange & carrier-phase double differencing: < 10 cm RMS accuracies (floating)	X	√

The NovAtel MiLLennium-GLONASS GPSCards can be applied in mining and machine control, robotics, flight inspection, marine navigation, agriculture, military, direction finding and other custom OEM applications.

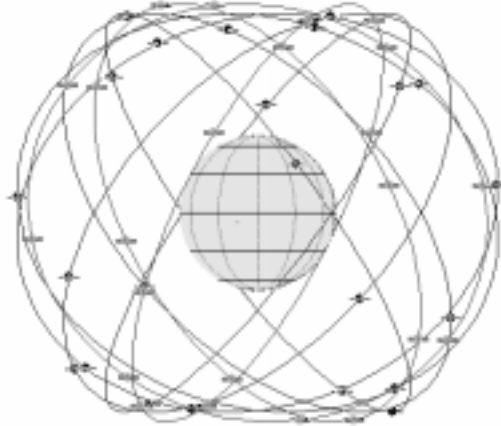
Some of the information used to create the Introduction was obtained from two sources.

1. Langley, Richard B. "GLONASS: Review and Update". *GPS World*, July 1997. 46-51
2. Kleusberg, Alfred. "Comparing GPS and GLONASS". *GPS World*, December 1990. 52-54

1.2 GPS AND GLONASS OVERVIEW

The Global Positioning System (GPS) and the Global Navigation Satellite System (GLONASS) are satellite systems capable of providing autonomous and highly accurate timing and positioning information. GPS and GLONASS provide 24-hour, all-weather, worldwide coverage. See *Table 1.1, Page 14*, for a summary of their characteristics. Refer to *Figure 1.1, Page 10*, for a representation of the GPS and GLONASS combined satellite orbit arrangement.

Figure 1.1 View of GPS and GLONASS Combined Satellite Orbit Arrangement



1.3 GPS SYSTEM DESIGN

The system uses the NAVSTAR (NAVigation Satellite Timing And Ranging) satellites which consists of 24 operational satellites to provide a GPS receiver with six to twelve-satellite coverage at all times depending on the receiver model. A minimum of four satellites in view allows the GPSCard to compute its current latitude, longitude, altitude with reference to ellipsoid mean sea level and the GPS system time.

The GPS system design consists of three parts:

- The Space segment
- The Control segment
- The User segment

All these parts operate together to provide accurate three dimensional positioning, timing and velocity data to users worldwide.

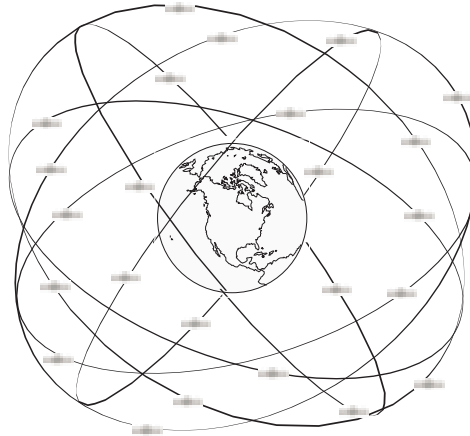
1.3.1 THE SPACE SEGMENT

The space segment is composed of the NAVSTAR GPS satellites. The final constellation of the system consists of 24 satellites in six orbital planes, inclined 55° from the equator, with four satellites in each plane. The orbital period of each satellite is approximately 12 hours at an altitude of 20,183 km. This provides a GPS receiver with six to twelve satellites in view from any point on earth, at any particular time.

The GPS satellite signal identifies the satellite and provides the positioning, timing, ranging data, satellite status and ephemerides (orbit parameters) of the satellite to the receiver. The satellites can be identified either by the Space Vehicle Number (SVN) or the Pseudorandom Code Number (PRN). The PRN is used by the NovAtel GPSCard.

The GPS satellites transmit on two L-band frequencies; one centered at 1575.42 MHz (L1) and the other at 1227.60 MHz (L2). The L1 carrier is modulated by the C/A code (Coarse/Acquisition) and the P code (Precision) which is encrypted for military and other authorized users. The L2 carrier is modulated only with the P code. Please refer to the following figure for a representation of the GPS satellite orbit arrangement.

Figure 1.2 View of GPS Satellite Orbit Arrangement



1.3.2 THE CONTROL SEGMENT

The control segment consists of a master control station, five reference stations and three data up-loading stations in locations all around the globe.

The reference stations track and monitor the satellites via their broadcast signals. The broadcast signals contain the ephemeris data of the satellites, the ranging signals, the clock data and the almanac data. These signals are passed to the master control station where the ephemerides are re-computed. The resulting ephemerides corrections and timing corrections are transmitted back to the satellites via the data up-loading stations.

1.3.3 THE USER SEGMENT

The user segment such as the NovAtel GPSCard receiver, consists of equipment which tracks and receives the satellite signals. The user equipment must be capable of simultaneously processing the signals from a minimum of four satellites to obtain accurate position, velocity and timing measurements.

1.4 GLONASS SYSTEM DESIGN

As with GPS, the GLONASS system uses a satellite constellation to ideally provide a GLONASS receiver with six to twelve satellites at most times. A minimum of four satellites in view allows a GLONASS receiver to compute its position in three dimensions, as well as become synchronized to the system time.

The GLONASS system design consists of three parts:

- The Space segment
- The Control segment
- The User segment

All these parts operate together to provide accurate three dimensional positioning, timing and velocity data to users worldwide.

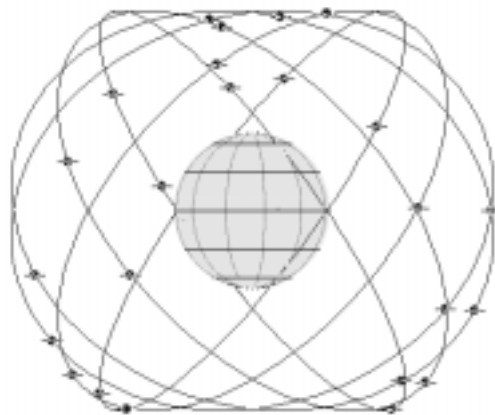
1.4.1 THE SPACE SEGMENT

The Space Segment is the portion of the GLONASS system that is located in space, that is, the GLONASS satellites and any ancillary spacecraft that provide GLONASS augmentation information (i.e., differential corrections, integrity messages, etc.). This segment is composed of the GLONASS satellites which, when complete, will consist of 24 satellites in three orbital planes, with eight satellites per plane, see *Figure 1.3, Page 12*. Following are points about the GLONASS space segment.

- The orbit period of each satellite is approximately 8/17 of a sidereal day such that, after eight sidereal days, the GLONASS satellites have completed exactly 17 orbital revolutions. A sidereal day is the rotation period of the earth and is equal to one calendar day minus four minutes.
- Because each orbital plane contains eight equally spaced satellites, one of the satellites will be at the same spot in the sky at the same sidereal time each day.
- The satellites are placed into nominally circular orbits with target inclinations of 64.8 degrees and an orbital height of about 19,123 km, which is about 1,060 km lower than GPS satellites.
- The GLONASS satellite signal identifies the satellite and provides:
 - the positioning, velocity and acceleration vectors at a reference epoch for computing satellite locations
 - synchronization bits
 - data age
 - satellite health
 - offset of GLONASS time
 - almanacs of all other GLONASS satellites.
- The GLONASS satellites each transmit on different L1 and L2 frequencies, with the P code on both L1 and L2, and with the C/A code, at present, only on L1. L1 is currently centered at 1602 - 1615.5 MHz.
- Some of the GLONASS transmissions initially caused interference to radio astronomers and mobile communication service providers. The Russians consequently agreed to reduce the number of frequencies used by the satellites and to gradually change the L1 frequencies to 1598.0625 - 1609.3125 MHz. Eventually the system will only use 12 primary frequency channels (plus two additional channels for testing purposes).
- System operation (24 satellites and only 12 channels) can be accomplished by having antipodal satellites, satellites in the same orbit plane separated by 180 degrees in argument of latitude, transmit on the same frequency. This is possible because the paired satellites will never appear at the same time in your view. Already, eight pairs of satellites share frequencies.

Unlike GPS satellites, all GLONASS satellites transmit the same codes. They derive signal timing and frequencies from one of three onboard cesium atomic clocks operating at 5 MHz. The signals are right-hand circularly polarized, like GPS signals, and have comparable signal strength.

Figure 1.3 View of GLONASS Satellite Orbit Arrangement



1.4.2 THE CONTROL SEGMENT

The Control Segment consists of the system control center and a network of command tracking stations across Russia. The GLONASS control segment, similar to GPS, must monitor the status of satellites, determine the ephemerides and satellite clock offsets with respect to GLONASS time and UTC (SU) time, and twice a day upload the navigation data to the satellites.

1.4.3 THE USER SEGMENT

The User Segment consists of equipment (such as a NovAtel MiLLennium-GLONASS GPSCard receiver) which tracks and receives the satellite signals. This equipment must be capable of simultaneously processing the signals from a minimum of four satellites to obtain accurate position, velocity and timing measurements. Like GPS, GLONASS is a dual military/civilian-use system. Selective availability, however, will not be implemented on GLONASS C/A code. The system's potential civil applications are many and mirror that of GPS.

1.5 TIME

As stated above, both GPS and GLONASS satellites broadcast their time within their satellite messages. NovAtel's MiLLennium-GLONASS GPSCard is able to receive and record both time references as well as report the offset information between GPS and GLONASS time (see *GCLA/B, Page 91*). Although similar, GPS and GLONASS have several differences in the way they record and report time. Please see the following sections for information on GPS and GLONASS time, as well as how NovAtel's MiLLennium-GLONASS GPSCard is GPS week rollover and Y2K compliant.

1.5.1 GPS TIME VS. LOCAL RECEIVER TIME

All logs report GPS time expressed in GPS weeks and seconds into the week. The time reported is not corrected for local receiver clock error. To derive the closest GPS time, you must subtract the clock offset shown in the CLKA/B log (field 4) from GPS time reported, refer to the *MiLLennium Command Descriptions Manual*.

GPS time is based on an atomic time scale. Universal Time Coordinated U.S. Naval Observatory (UTC(USNO)) time (reported in NMEA logs) is also based on an atomic time scale, with an offset of seconds applied to coordinate Universal Time to GPS time. GPS time is designated as being coincident with UTC(USNO) at the start date of January 6, 1980 (00 hours). GPS time does not count leap seconds, and therefore an offset exists between UTC(USNO) and GPS time (at this date: 13 seconds). The GPS week consists of 604800 seconds, where 000000 seconds is at Saturday midnight. Each week at this time (UTC), the week number increments by one, and the seconds into the week resets to 0 (see *Appendix C, Page 54* for an example).

1.5.2 GLONASS TIME VS. LOCAL RECEIVER TIME

GLONASS time is based on an atomic time scale similar to GPS. This time scale is Universal Time Coordinated as maintained by the former Soviet Union (UTC(SU)).

Unlike GPS, the GLONASS time scale is not continuous and must be adjusted for periodic leap seconds. Leap seconds are applied to all UTC time references about every other year as specified by the International Earth Rotation Service (IERS). Leap seconds are necessary because the orbit of the earth is not uniform and not as accurate as the atomic time references.

GLONASS time is maintained within 1 ms of UTC(SU) by the control segment with the remaining portion of the offset broadcast in the navigation message. As well, the GLONASS time is offset from UTC(SU) by plus three hours due to control segment specific issues. The *GCLA/B* (see *Page 91*) contains the offset information between GPS and GLONASS time.

1.6 DATUM

Because a consistent transformation between WGS84 and the Parametry Zemli 1990 (PZ90) or, in English translation, Parameters of the Earth 1990 (PE-90, see *Page 120*) geodetic datum has not been defined, we have allowed for a new command, PZ90TOWGS84, and a new parameter, PZ90, for the DATUM command.

The PZ90TOWGS84 command (see "*G.1.2 PZ90TOWGS84*", *Page 82*) is intended to define the PZ90 transform for transferring Glonass satellite coordinates to WGS84. However, it can also be used, in conjunction with the DATUM PZ90 command (see "*G.2.6 DATUM*", *Page 85*), to allow for position output in a user-defined PZ90 frame. The PZ90TOWGS84 command will override the default values for the DATUM PZ90 command and set them to the user-defined values. If the PZ90TOWGS84 command is not issued, the DATUM PZ90 command will use the default PZ90 values (see "*G.1.2 PZ90TOWGS84*", *Page 82*) for the output position parameters. The PZ90 transform parameters can be saved in user-configurable memory for immediate use on powerup.

Table 1.2 Comparison of GLONASS and GPS Characteristics

Parameter	Detail	GLONASS	GPS	
Satellites	Number of satellites	21 + 3 spares	21 + 3 spares	
	Number of orbital planes	3	6	
	Orbital plane inclination (degrees)	64.8	55	
	Orbital radius (kilometers)	25 510	26 560	
Signals	Fundamental clock frequency (MHz)	5.0	10.23	
	Signal separation technique ¹	FDMA	CDMA	
	Carrier frequencies (MHz) L1	1602.0 - 1615.5	1575.42	
	Code clock rate (MHz)	C/A	0.511	1.023
		P	5.11	10.23
	Code length (chips)	C/A	511	1 023
P		5.11 x 10 ⁶	6.187104 x 10 ¹²	
C/A-code Navigation	Superframe duration (minutes)	2.5	12.5	
Message	Superframe capacity (bits)	7 500	37 500	
	Superframe reserve capacity (bits)	~620	~2 750	
	Word duration (seconds)	2.0	0.6	
	Word capacity (bits)	100	30	
	Number of words within a frame	15	50	
	Technique for specifying satellite ephemeris	Geocentric Cartesian coordinates and their derivatives	Keplarian orbital elements and perturbation factors	
	Time reference ²	UTC (SU)	UTC (USNO)	
	Position reference (geodatic datum) ³	PZ-90	WGS 84	

NOTES:

¹ Each satellite in the full 24-satellite GLONASS constellation is assigned an antipodal frequency. Such a system of simultaneous multiple transmissions is known as frequency division multiple access (FDMA) and distinguishes GLONASS from GPS, which is a code division multiple access (CDMA) system.

² GLONASS and GPS use different time systems. GLONASS time is referenced to UTC (SU), the Russian National Etalon timescale, whereas, GPS time is referenced to UTC as maintained by the U.S. Naval Observatory – UTC (USNO). The GLONASS control segment periodically applies a time step to bring the system's time within several hundred nano-seconds of UTC time.

³ GLONASS ephemerides are referenced to the Parametry Zemli 1990 (PZ-90 or in English translation, Parameters of the Earth 1990, PE-90) geodetic datum. The realization of the PZ-90 frame through adopted reference station coordinates has resulted in offsets in origin and orientation as well as a difference in scale with respect to WGS 84 used by GPS. Relationships between the PZ-90 and WGS 84 have now been established.

2

QUICK START

2.1 QUICK START STEPS

The total system consists of a combined GPS/GLONASS receiver, an antenna, cables and your PC.

1. Prepare the MiLLennium-GLONASS GPSCard so that it is complete with mounting and wiring interfaces and ready for operation, as described in *Chapter 3, Installation, Page 17*. If you purchased a ProPak II enclosure (see *Page 59*) or a PowerPak II enclosure (see *Page 73*), they are ready for immediate operation.
2. Mount the antenna. See *GPS/GLONASS Antenna Considerations (Page 23)*, *GPS/GLONASS Antenna (Page 56)* and *RF Section (Page 57)*.
3. Connect the antenna to the RF port of the ProPak II enclosure, PowerPak II enclosure or P101 connector on the MiLLennium-GLONASS GPSCard, see *Figure 3.1, Typical System Configuration (Page 17)* and *Figure E.3, ProPak II Enclosure Rear End-Cap (Page 60)*, using interconnecting coaxial cable. A typical coaxial cable is shown in *Figure 2.1* on the left.

Figure 2.1 NovAtel Coaxial and Serial Cables



For more information see *Antenna Cable Considerations (Page 23)* and *RF Section (Page 57)*.

4. Connect COM1 on the receiver to a serial port on your PC with a null-modem serial data cable (NovAtel part number 01016329). A typical serial cable is shown in *Figure 2.1*, on the right. See also *Chapter 4, Operation (Page 24)*, *Digital Electronics Section (Page 57)* and *ProPak II Enclosure Installation (Page 59)*.
5. Connect a power supply to the MiLLennium-GLONASS. The ProPak II enclosure is supplied with a LEMO to cigarette lighter power adapter cable. If an alternative power source is preferred, the cigarette lighter power cable adapter can be removed. When the adapter is cut off, and the cable stripped, it will be observed that two leads are provided for each positive (+) and negative (-) connection. This allows for parallel power sources such as dual batteries. The DC power must be in the range from +10 to +36 V DC and the use of a 3-amp slow-blow fuse is recommended, perhaps the one from the cigarette lighter power adapter if you do not intend to use it. See *Preparing the Data, Signal & Power Harness (Page 19)*, *Principal Power Supply (Page 57)* and *ProPak II Enclosure Installation (Page 59)*.
6. Start GPSolution on your PC. Select Card | Open from the menu. To connect to the MiLLennium-GLONASS in GPSolution you must open a configuration. A configuration is a group of settings that define the type of card, the communication protocol, window positions and file locations. The Open Configuration dialog will appear. All created configurations are displayed in the listbox. Choose a configuration from the list and click the OK button. If there are no configurations available you must create a new configuration. GPSolution will attempt to open MiLLennium-GLONASS using the specifications in the selected configuration. The MiLLennium-GLONASS default port settings are as follows:

RS232C, 9600 bps, no parity, 8 data bits, 1 stop bit, no handshaking, echo off

See *Communications with the MiLLennium-GLONASS GPSCard*, Page 24.

7. Select View | Command Console and then View | ASCII Records from the menu. You may also open other visual displays from the View menu at any stage. See *Getting Started*, Page 25.
8. If high-accuracy GLONASS pseudoranges are desired, run the calibration procedure. See *Calibration Procedure*, Page 27.

3 INSTALLATION

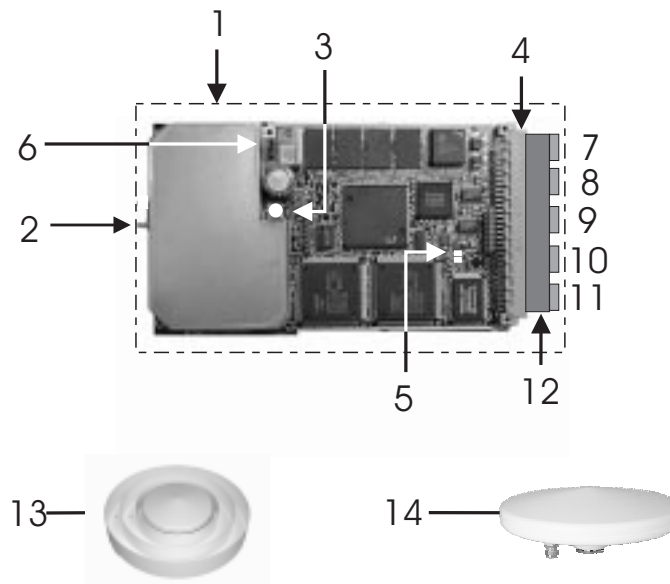
3.1 SYSTEM CONFIGURATION

The MiLLennium-GLONASS GPSCard receiver is an OEM product designed for flexibility of integration and configuration. You are free to select an appropriate data and signal interface, power supply system, and mounting structure. This concept allows OEM purchasers to custom-design their own applications around the MiLLennium-GLONASS.

It also comes in a ProPak II enclosure or PowerPak II enclosure, please see *ProPak II Enclosure (Page 59)* or *PowerPak II Enclosure (Page 73)*.

This section provides the necessary information for you to install and begin to use the MiLLennium-GLONASS GPSCard. A typical system configuration is shown in *Figure 3.1*.

Figure 3.1 Typical System Configuration



Reference	Description	Reference	Description
1	ProPak II enclosure, PowerPak II enclosure or user-supplied enclosure	8	Optional LNA DC power (1 pin)
2	RF signal & LNA power SMB connector P101 (male, right angle) to antenna via interconnecting coaxial cable	9	COM1 (8 pins)
3	Optional external reference clock input SMB connector P301 (male, straight)	10	COM2 (8 pins)
4	Power, data & signals connector, P1 (male, 64-pin, 0.1", DIN 41612, Type B, right angle)	11	Input & output timing strobes (12 pins)
5	Status LEDs (green & red)	12	Matching user-supplied interface i.e. matches item #4
6	LNA power jumper P301, see the <i>External Power</i> section, <i>Page 21</i>	13	Optional choke ring ground plane
7	+5 VDC primary power	14	Antenna model 504 shown with 5/8" adapter or any NovAtel L1 GPS/GLONASS antenna

3.2 MINIMUM CONFIGURATION

In order for the MiLLennium-GLONASS GPSCard to perform optimally, the following additional equipment is required:

- NovAtel GPS/GLONASS antennas (model 504 or model 514)
- NovAtel coaxial cable (note that a conversion is required between the male SMB connector on the MiLLennium-GLONASS GPSCard and the female TNC connector on the GPS/GLONASS antenna)
- A regulated power supply providing +5 V DC (see *Table B.1, Page 49*, for power regulation specifications)
- A 64-pin 0.1" DIN 41612 Type B female connector as an interface for power, communications and signals
- Data communications equipment capable of RS-232C serial communications

3.3 ANTI-STATIC PRECAUTIONS

Electrostatic discharge (ESD) is a leading cause of failure of electronic equipment components and printed circuit boards containing ESD-sensitive devices and components. It is imperative that ESD precautions be followed when handling or installing the MiLLennium-GLONASS GPSCard printed circuit board. See *Appendix A, Page 47*, for more information on ESD precautions.

Leave the MiLLennium-GLONASS GPSCard in its anti-static packaging when not connected in its normal operating environment. When removing the MiLLennium-GLONASS GPSCard from the ESD-protective plastic clamshell, follow accepted standard anti-static practices. Failure to do so may cause damage to the card.

When you remove the MiLLennium-GLONASS GPSCard from the original packing box, it is recommended that you save the box and ESD protective plastic clamshell for future storage or shipment purposes.

REMEMBER

- Always wear a properly grounded anti-static wrist strap when handling the MiLLennium-GLONASS GPSCard.
 - Always hold the MiLLennium-GLONASS GPSCard by its corners or the RF backplane, and avoid direct contact with any of the components.
 - Do not let the MiLLennium-GLONASS GPSCard come in contact with clothing at any time because the grounding strap cannot dissipate static charges from fabrics.
 - Failure to follow accepted ESD handling practices could cause damage to the MiLLennium-GLONASS GPSCard.
 - Warranty may be voided if equipment is damaged by ESD.
-
-

3.4 INSTALLATION PROCEDURE

Installing the MiLLennium-GLONASS GPSCard typically consists of the following:

- mounting the MiLLennium-GLONASS GPSCard in a secure enclosure to reduce environmental exposure, RF interference, and vibration effects
- pre-wiring the I/O harness and the 64-pin DIN female connector for power and communications, then connecting them to the MiLLennium-GLONASS GPSCard
- installing the GPS/GLONASS antenna, then connecting it to the MiLLennium-GLONASS GPSCard
- installing an optional external oscillator (see *Page 80*)

3.4.1 MOUNTING THE PRINTED CIRCUIT BOARD

The MiLLennium-GLONASS GPSCard is an OEM product and therefore the printed circuit board is not enclosed in a housing structure. This allows flexibility in creating a mounting environment to suit particular product and marketing requirements. The mounting and enclosure must provide the following:

- mounting of external connectors
- protection from hostile physical environments (e.g. rain, snow, sand, saltwater, extreme temperatures)
- protection from vibration conditions
- electromagnetic shielding to protect from hostile RF environments (e.g. nearby transmitters)
- electromagnetic shielding so that the final product itself conforms to RF emissions guides
- protection from ESD

The MiLLennium-GLONASS GPSCard can be screwed in place, held by card rails, or both. Please see *Appendix B, Page 49*, for mechanical drawings.

For some applications the *ProPak II Enclosure, Page 59*, or the *PowerPak II Enclosure, Page 73*, in the chapters following, are ideal. They are enclosure kits that come complete with mounting and wiring interfaces, and allow immediate operation of the MiLLennium-GLONASS. The two enclosures are designed for rugged operating environments.

3.4.2 PREPARING THE DATA, SIGNAL & POWER HARNESS

The wiring harness serves the following interconnect functions:

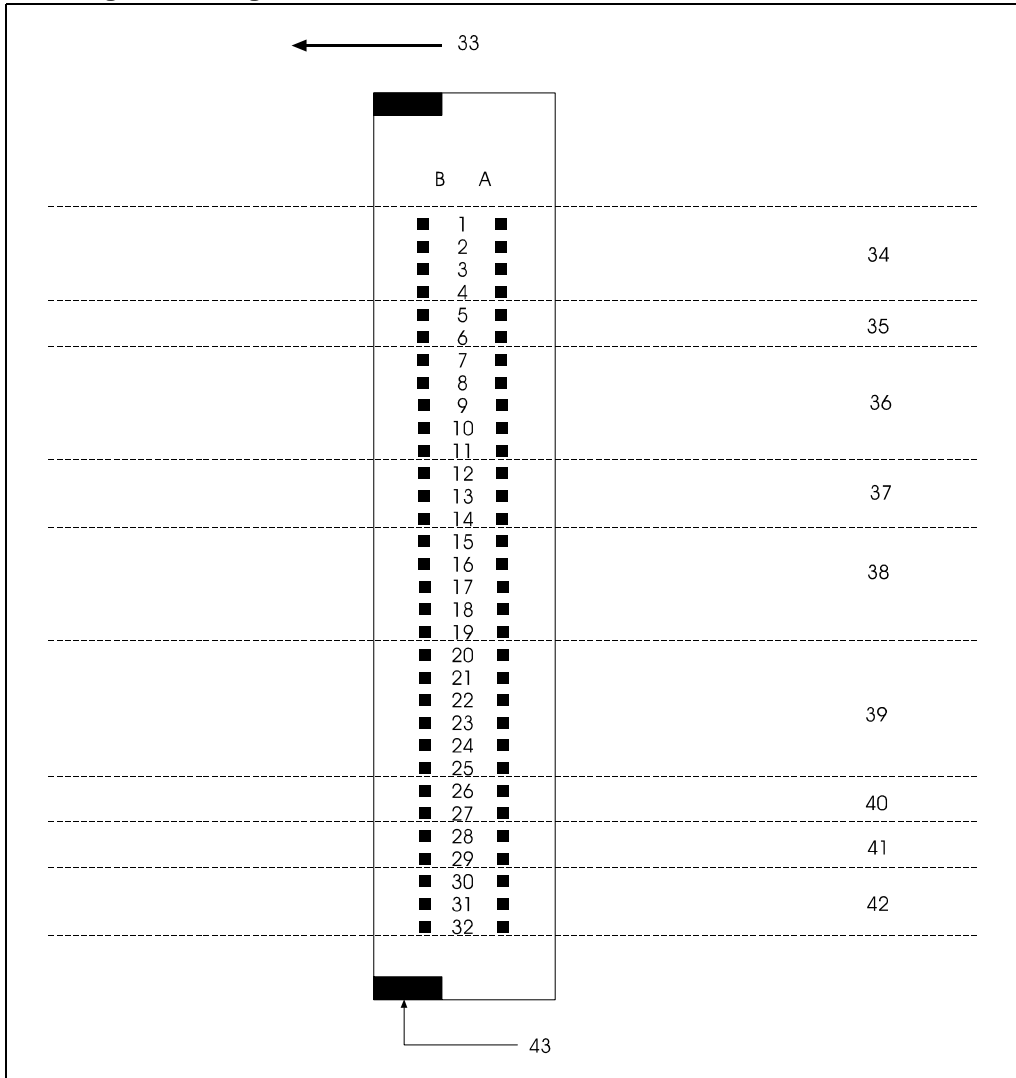
- provide access to COM1 and COM2 serial communications ports
- provide access to input and output timing strobes
- provide power input(s)
- provide access to control signals

A 64-pin / 0.1" / DIN 41612 / Type B / female connector (e.g. Harting #0902 164 6825, #0902 264 6828, or equivalent) is required to interface with connector P1 on the MiLLennium-GLONASS GPSCard (see *Figure 3.2, Page 20*). The connectors you choose for interfacing to the power source(s), COM ports, and strobes will depend on your external equipment requirements. *Figure 3.2, Page 20* shows the pin names and locations on connector P1.

NOTE: See *Table B.2, Page 53*, for descriptions of the function of each connector pin.

WARNING: The MiLLennium-GLONASS GPSCard will suspend operation if voltage supplied falls outside input range +4.875 to +5.250 V DC.

Figure 3.2 Edge-view of Connector P1 on the MiLLennium-GLONASS



1A, 1B, 4A, 7A,15A, 21A-32A	GND	19A	DCD2
2A, 2B	Vcc	19B	DSR2
3A, 5B-8B, 12A, 12B-16B, 20A, 20B	N/C	21B	VARF
3B	Reserved for future use	22B	PPS
4B	External LNA power	23B	Measure out
5A, 6A, 13A, 14A, 26B, 27B, 30B-32B	Factory use	24B	Mark in
8A	DTR 1	25B	Status
9A	TXD1	28B	Reset in
9B	CTS1	29B	Reset out
10A	RXD1	33	Component side of MiLLennium-GLONASS GPSCard
10B	RTS1		
11A	DCD1	34	Power
11B	DSR1	35, 37, 40, 42	Factory use
16A	DTR2	36	COM1 (RS-232C)
17A	TXD2	38	COM2 (RS-232C)
17B	CTS2	39	Strobes
18A	RXD2	41	Control
18B	RTS2	43	Keying tab

3.4.3 EXTERNAL POWER

See *Figure 3.2, Page 20* for external power input connections:

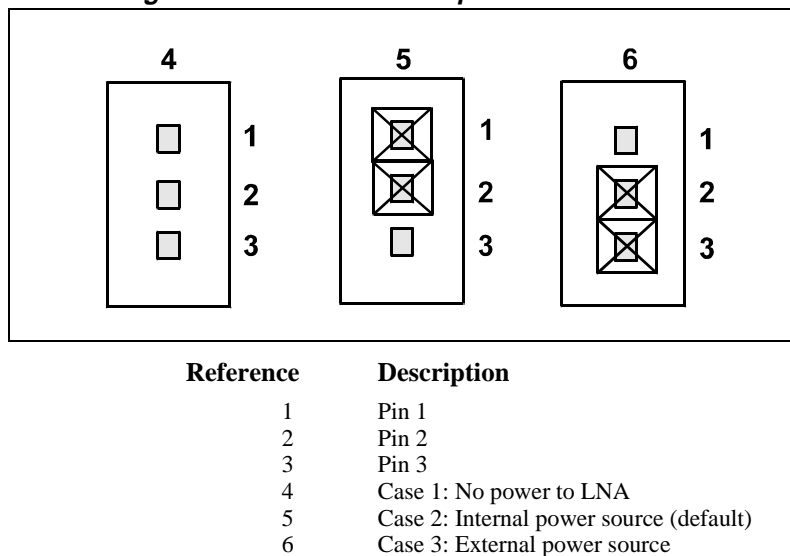
- Digital ground = pins 1A/B (internally connected)
- Vcc, main power (+5 V DC) = pins 2A/B (internally connected)
- Optional external LNA power = pin 4B (30 V DC) and 4A (GND)

See *Table B.1, Page 49*, for specifications concerning external power inputs.

The MiLLennium-GLONASS GPSCard requires only one regulated power input of Vcc = +5 V DC.

It is possible to supply power to the LNA on an active antenna either from the MiLLennium-GLONASS GPSCard or from an external source. The MiLLennium-GLONASS GPSCard is factory-configured for operation with the single-frequency 504 or 514 GPS/GLONASS antenna models, in which case no special wiring or configuration is required: the P301 jumper (see *Figure 3.1* (Page 17) and *Figure 3.3* following) is normally set for internal operation (connects pins 1 and 2). The internal antenna power supply can produce 4.25 - 5.25 V DC at up to 90 mA. If the antenna draws more than 90 mA of current, power to the antenna will be disabled and the antenna self-test status flag set to zero; see *Appendix H, RVSA/B log* (Page 109) and *Table H.2* (Page 96) for receiver self-test status codes.

Figure 3.3 LNA Power Jumper P301 - 3 Cases



If a different antenna is used whose LNA requires voltage and/or current capacity beyond what the MiLLennium-GLONASS GPSCard can produce, then the external LNA power option must be utilized - this requires that P301 must be jumpered between pins 2 and 3. The input cannot exceed +30 V D.C. at 100 mA. When the LNA jumper plug is in the external position, the antenna sensing circuit will cause the self-test status code to always report antenna status as 1 (good). See *Appendix H, RVSA/B log* (Page 109) and *Table H.2* (Page 96) for receiver self-test status codes.

If no LNA power is required, remove the jumper at P301 completely.

In contrast to the physical jumper settings, it is the ANTENNAPOWER command which actually enables or disables the supply of electrical power from the internal power source of the card to Pin 1 of jumper P301. By default, ANTENNAPOWER = ON. *Table 3.1, Page 22* illustrates the usage of this command in relation to the jumper position.

The setting of this command will also affect the way the self-test diagnostics report the antenna's status; please see the description of the ANTENNAPOWER command, *Page 84*.

Table 3.1 Antenna LNA Power Configuration

	P301: plug connects pins 1&2	P301: plug connects pins 2&3	P301: no plug
ANTENNAPOWER = ON	internal power connected to LNA	no external effect	no external effect
ANTENNAPOWER = OFF	internal power cut off from LNA	no external effect	no external effect

CAUTION

- The P301 jumper plug must be jumpered to the external position (pins 2 and 3) before external LNA power is connected to pin 4B of the 64-pin wire harness connector to prevent power from feeding back into the receiver.
- Should it be necessary, due to extended length antenna cable, to supply external power to the GPS/GLONASS antenna or to use an optional in-line LNA amplifier, be careful not to exceed the voltage ratings of either the antenna or LNA.
- No guarantee is made that the MiLLennium-GLONASS GPSCard will meet its performance specifications if a non-NovAtel antenna is used.

It is recommended that appropriate fuses or current limiting be incorporated as a safety precaution on all power lines used. Use a sufficient gauge of wire, for example AWG 24, to ensure that the voltage at the 64-pin connector is within the MiLLennium-GLONASS GPSCard's requirements.

3.4.4 RS232C COMMUNICATIONS

The MiLLennium-GLONASS GPSCard is capable of communications in EIA RS232C serial data format via two ports, COM1 and COM2. See *Figure 3.2, Page 20* for data connections:

- COM1 = pins 7 - 11, A & B
- COM2 = pins 15 - 19, A & B

Each port has a ground connection, and supports the following signals:

- Data Terminal Ready (DTR)
- Clear To Send (CTS)
- Transmitted Data (TXD)
- Request To Send (RTS)
- Received Data (RXD)
- Data Set Ready (DSR)
- Data Carrier Detect (DCD)

The port settings (bit rate, parity, etc.) are software-configurable. These are further described in *Chapter 4, Operation, Page 24*.

See *Table B.2, Page 53*, for further information on data communications characteristics.

3.4.5 STROBE SIGNALS

The MiLLennium-GLONASS GPSCard has 5 TTL-compatible I/O strobe lines. See *Figure 3.2, Page 20* for strobe signal connections:

- Variable-Frequency (VARF) Output = Pin 21B
- One Pulse per Second (PPS) Output = Pin 22B
- Measure Output = Pin 23B
- Mark Input = Pin 24B
- Status Output = Pin 25B

See *Table B.1, Page 49*, for further information on I/O strobe characteristics.

3.4.6 L1 GPS/GLONASS ANTENNA CONSIDERATIONS

The MiLLennium-GLONASS GPSCard has been designed to operate with the NovAtel 504 or 514 single-frequency GPS/GLONASS antenna models. Though it is possible to operate with other single-frequency GPS/GLONASS antennas, no guarantee is made that the MiLLennium-GLONASS GPSCard will meet its performance specifications if a non-NovAtel antenna is used. For further information on GPS/GLONASS antenna systems and extended length cable runs, contact NovAtel Customer Service.

The NovAtel L1 GPS/GLONASS antennas, models 504 and 514, are active antennas designed to operate at the GPS and GLONASS L1 frequency. The 504 antenna is intended for surveying and other kinematic positioning applications, and the 514 is an aviation antenna that is ideally suited for installation on aircraft. For more information on the model 504 antenna please refer to the *NovAtel L1 GPS/GLONASS Antenna Model 504 Brochure* (NovAtel part number OM-20000037), and for more information on the model 514 antenna please refer to the *NovAtel L1 GPS/GLONASS Antenna Model 514 Brochure* (NovAtel part number OM-20000038).

When installing the antenna system,

- choose an antenna location that has a clear view of the sky so that each satellite above the horizon can be tracked without obstruction. (For a discussion on multipath, refer to the relevant appendix in the *MiLLennium Command Descriptions Manual*.)
- mount the antenna on a secure, stable structure capable of safe operation in the specific environment.

3.4.6.1 Antenna Cable Considerations

An appropriate coaxial cable is one that is matched to the impedance of the antenna being used, and whose line loss does not exceed the recommendations shown in *Table 3.2, Page 23*. NovAtel offers a variety of coaxial cables to meet your single-frequency GPS/GLONASS antenna interconnection requirements. Your local NovAtel dealer can advise you about your specific configuration.

NovAtel provides optional coaxial cables in the following lengths:

- 22 cm interconnect adapter cable (SMB female/TNC bulkhead - female; NovAtel part number GPS-C001)
- 5, 15, or 30 m antenna cable (TNC male/TNC male; NovAtel part numbers C005, C015 and C030 respectively)

Though it is possible to use other high-quality antenna cables, no warrant is made that the MiLLennium-GLONASS GPSCard will meet its performance specifications if non-NovAtel-supplied coaxial cable is used.

Table 3.2 Recommended Maximum Cable Loss

Antenna Type	Allowable Cable Loss
Active	13.0 dB
Passive	1.5 dB

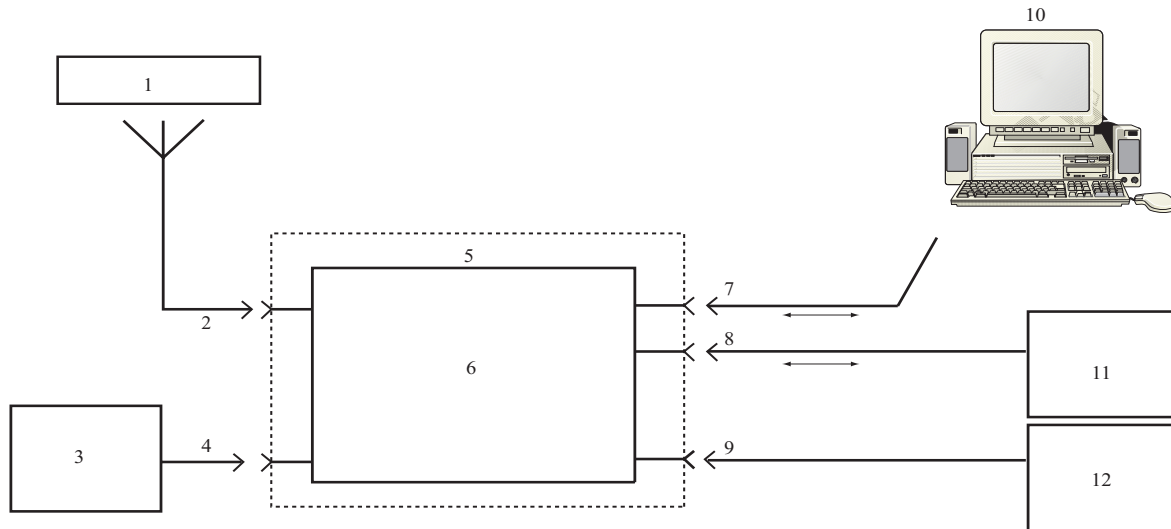
NOTE: The coaxial cable should be connected to the antenna and MiLLennium-GLONASS GPSCard before system power is turned on. If for any reason the cable is disconnected from either the antenna or receiver, you must turn off power before reconnecting the cable(s) otherwise the MiLLennium-GLONASS GPSCard will not be able to sense the antenna and the system will not work. If this occurs, remove power from the receiver, wait a few moments, and then apply it again.

4 OPERATION

4.1 BEFORE OPERATION

Before operating the MiLLennium-GLONASS for the first time, ensure that you have followed the installation instructions of *Chapter 3*. The following instructions are based on a configuration such as that shown in *Figure 4.1*. It is assumed that a personal computer is used during the initial operation and testing for greater ease and versatility.

Figure 4.1 Typical Operational Configuration



Reference	Description	Reference	Description
1	Model 504 or 514 Antenna	7	COM1
2	Combined GPS/GLONASS Signal Input	8	COM2
3	Optional External Oscillator (not available with ProPak II enclosure)	9	Power
4	Clock	10	Command Source or Reference Station
5	GPSCard ProPak II or PowerPak II enclosure	11	Data Logger or Remote Station
6	MiLLennium-GLONASS GPSCard	12	External Power Source

4.2 COMMUNICATIONS WITH THE MILLENNIUM-GLONASS GPSCARD

Communication with the MiLLennium-GLONASS GPSCard is straightforward, and consists of issuing commands through the COM1 or COM2 port from an external serial communications device. This could be either a terminal or an IBM-compatible PC that is directly connected to a MiLLennium-GLONASS GPSCard serial port using a null modem cable. For specific information about any of the GPSCard commands and logs, please consult the *MiLLennium Command Descriptions Manual*.

4.2.1 SERIAL PORT DEFAULT SETTINGS

The MiLLennium-GLONASS GPSCard communicates with your PC or terminal via the COM1 or COM2 serial port. For communication to occur, both the MiLLennium-GLONASS GPSCard and the operator interface have to be configured properly. The MiLLennium-GLONASS GPSCard's default port settings are as follows:

RS232C, 9600 bps, no parity, 8 data bits, 1 stop bit, no handshaking, echo off

Changing the default settings requires using the *COMn* command, which is described in the *MiLLennium Command Descriptions Manual*. It is recommended that you become thoroughly familiar with these commands and logs to ensure maximum utilization of the MiLLennium-GLONASS GPSCard's capabilities.

NOTE: Although the MiLLennium-GLONASS GPSCard can operate at bit rates as low as 300 bps, this may not always be desirable. For example, if several data logs are active (i.e. a significant amount of information needs to be transmitted every second) but the bit rate is set too low, data will overflow the serial port buffers and cause an error condition in the receiver status.

4.2.2 COMMUNICATING USING A REMOTE TERMINAL

One method of communicating with the MiLLennium-GLONASS GPSCard is through a remote terminal. The MiLLennium-GLONASS GPSCard has been pre-wired to allow proper RS232C interface with your data terminal. To communicate with the terminal the MiLLennium-GLONASS GPSCard only requires the RX, TX, and GND lines to be used; handshaking is not required, although it can optionally be used. Ensure that the terminal's communications set-up matches the MiLLennium-GLONASS GPSCard RS232C protocol.

4.2.3 COMMUNICATING USING A PERSONAL COMPUTER

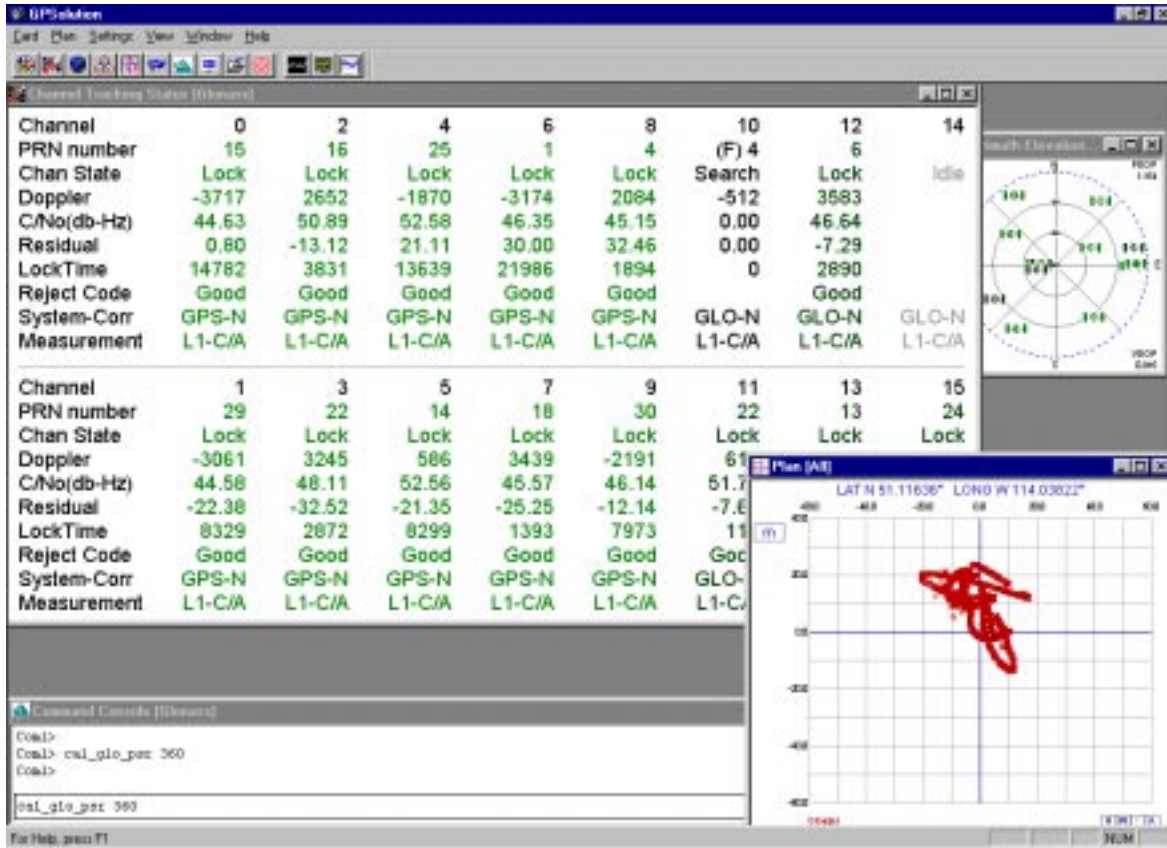
An IBM-compatible PC can be set up to emulate a remote terminal as well as provide the added flexibility of creating multiple-command batch files and data logging storage files. Any standard communications software package that emulates a terminal can be used to establish bi-directional communications with the MiLLennium-GLONASS GPSCard.

You can create command batch files using any text editor; these can then be directed to the serial port that is connected to the MiLLennium-GLONASS GPSCard using a communications software package. This is discussed in greater detail later in this chapter.

4.3 GETTING STARTED

Included with your MiLLennium-GLONASS GPSCard are NovAtel's *GPSolution*, *Convert* and *Loader* programs, together with their on-line help. *GPSolution* is a Microsoft Windows compatible program that allows you to access the MiLLennium-GLONASS GPSCard's many features without struggling with communications protocol or writing special software. *GPSolution* automatically recognizes the model type of the MiLLennium-GLONASS GPSCard that you are using and adjusts the displays accordingly. *Figure 4.2* shows a sample *GPSolution* screen. The *Convert* utility is a Windows-based utility that allows you to convert between NovAtel ASCII and binary file formats, and strips unwanted records for data file compilation. NovAtel's *Loader* program is a DOS utility program designed to facilitate program and model updates.

Figure 4.2 Sample GPSolution Screen



GPSolution is provided to facilitate your interaction with the MiLlennium-GLONASS GPSCard. However, it certainly is possible to communicate with it through DOS or a Windows-based communications program; this is discussed in greater detail later in this section.

4.3.1 POWER-ON

The GPSCard’s software resides in read-only memory. As such, the unit “self-boots” when turned on and undergoes a complete self-test. If an error condition is detected during a self-test, the self-test status word will change; this self-test status word can be viewed in the RGEA/B/D and RVSA/B data output logs (please refer to the *MiLlennium Command Descriptions Manual*). If a persistent error develops, please contact your local NovAtel dealer first. If the problem is still unresolved please contact NovAtel directly through any of the methods in the *Customer Service* section, Page 7.

When the GPSCard is first turned on, no activity information is transmitted from the COM ports except for the port prompt; the external data communications equipment screen will display one of these two messages:

Com1> *if connected to COM1 port,*

or

Com2> *if connected to COM2 port*

Either prompt indicates that the GPSCard is ready and waiting for command input.

Commands are typed at the interfacing terminal’s keyboard, and sent after issuing a carriage return command which is usually the same as pressing the terminal’s *Return* or *Enter* key.

NOTE: Most valid commands do not echo a response to a command input; the indication that they have been accepted is a return of the port prompt from the GPSCard. VERSION, HELP and ? are the only commands that do provide a data response other than the port prompt.

The LOCKOUT and SETHEALTH commands are not for use with GLONASS satellites.

Example:

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

```
COM1>assign 4 120043[Return]
COM1>
```

The above example illustrates command input to the MiLLennium-GLONASS GPSCard's COM1 port which will cause the card to assign the satellite with frequency 12 and slot number 43 to channel 14. However, your only confirmation that the command was actually accepted is the return of the **COM1>** prompt.

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

After initially turning on the MiLLennium-GLONASS GPSCard, you may find the following logs useful for observing the MiLLennium-GLONASS GPSCard's activities. While *GPSolution* is the easiest way to do this, you can also use DOS or a Windows-based communications program; examples of both are provided below.

- Use the RCCA log to list the default command settings. The RCCA log is useful for indicating status of all current command settings. Displaying the RCCA log after a RESET will show the saved configuration (Refer to the description of the SAVECONFIG command in the *MiLLennium Command Descriptions Manual* for more information).
- Use the ETSA log to monitor the channel tracking status.
- Use the SATA log to observe the satellite specific data.
- Use the POSA log to observe the current computed position solutions.
- Use the DOPA log to monitor the dilution of precision of the current satellite constellation.
- Use the RVSA log to monitor the receiver status.
- Use the HELP command to list all available commands.
- Use the HELP LOG command to list all available logs.

Refer to the *MiLLennium Command Descriptions Manual* for procedures and explanations related to data logging.

4.3.2 DOS

One way to initiate multiple commands and logging from the GPSCard is to create DOS boot-up command files relating to specific functions. This will save time when you want to duplicate test situations and minimize set-up time. Any convenient text editor can be used to create command text files.

Example:

For this example, consider a situation where a PC's appropriately-configured COM1 port is connected to the GPSCard's COM1 port, and where a remote terminal is connected to the GPSCard's COM2 port. The PC user wishes to monitor the GPSCard's 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 sata ontime 15
log com2 etsa ontime 15
log com2 rvsa ontime 60 5
log com2 posa ontime 15
log com2 dopa 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 port:

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

C:\GPS>

- The GPSCard is now initialized with the contents of the BOOT1.TXT command file, and logging is directed from the GPSCard's COM2 port to the remote terminal.

4.3.3 MICROSOFT WINDOWS 3.1 OR HIGHER

As any text editor or communications program can be used for these purposes, the use of Windows 95 is described only as an illustration. The following example shows how Windows 95 accessory programs *Notepad* and *HyperTerminal* can be used to create a hypothetical waypoint navigation boot-file on a PC, and send it to the GPSCard. It is assumed that the PC's serial port COM1 is connected to the GPSCard's COM1 port, and that a remote terminal is connected to the GPSCard's COM2 port.

Example:

- 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 posa ontime 15
log com1 spha ontime 15
log com1 nava ontime 15
log com2 gprmb ontime 15 5
log com2 gpvtg ontime 15 5
log com2 rcca ontime 60
```
- Save this with a convenient file name (e.g. C:\GPS\BOOTNAV1.TXT) and exit *Notepad*.
- Ensure that the *HyperTerminal* settings are correctly set up to agree with the MiLlennium-GLONASS GPSCard 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.
- From the *Transfer* menu, use the *Send text file* selection to locate this file to be sent to the MiLlennium-GLONASS GPSCard. Once you double-click on the file or select *Open*, *HyperTerminal* will send the file to the MiLlennium-GLONASS GPSCard.

The above example initializes the GPSCard with origin and destination waypoint coordinates and sets the magnetic variation correction to -21 degrees. The POSA, SPHA, and NAVA logs have been set to output from the GPSCard COM1 port at intervals of once every 15 seconds, whereas the GPRMB and GPVTG NMEA (see *NMEA*, Page 38) logs have been set to be logged out of the GPSCard COM2 port at intervals of 15 seconds and offset by five seconds. The RCCA log has been set to output every 60 seconds from the GPSCard's COM2 port.

Before operating the GPSCard for the first time, ensure that you have followed the installation instructions of *Chapter 3*, and if you have a ProPak II enclosure or PowerPak II enclosure, have reviewed *Appendix E*, Page 59, or *Appendix F*, Page 73, respectively. The following instructions are based on a configuration such as that shown in *Figure 3.1*, Page 17. It is assumed that a personal computer is used during the initial operation and testing for greater ease and versatility.

4.4 COMMANDS COMMON TO ALL GPSCARDS

The GPSCard is capable of responding to over 50 different input commands. You will find that once you become familiar with these commands, the GPSCard offers a wide range in operational flexibility. All commands are accepted through the COM1 and COM2 serial ports.

4.4.1 COMMANDS SPECIFIC TO MILLENNIUM-GLONASS GPSCARD

The MiLlennium-GLONASS GPSCard accepts two GLONASS specific commands:

- DGLOTIMEOUT (see *Page 82*)
- PZ90TOWGS84 (see *Page 82*)

For a listing of commands common to all GPSCards, with the exception of the GLONASS specific commands, refer to the *MiLlennium Command Descriptions Manual*. For details on GLONASS specific commands, see *Page*

82. For details on *Special Data Input Commands*, see *Page 30*.

NOTE: You will find the HELP command a useful tool for inquiring about the various commands available.

The following rules apply when entering commands from a terminal keyboard:

- The commands are not case sensitive (*COMMAND* or *command*).
 - e.g. *HELP* or *help*
 - e.g. *FIX POSITION* or *fix position*
- All commands and required entries can be separated by a space or a comma (*command,variable* OR *command variable*).
 - e.g. *datum,tokyo*
 - e.g. *datum tokyo*
 - e.g. *fix,position,51.3455323,-117.289534,1002*
 - e.g. *fix position 51.3455323 -117.289534 1002*
 - e.g. *com1,9600,n,8,1,n,off*
 - e.g. *com1 9600 n 8 1 n off*
 - e.g. *log,com1,posa,onchanged*
 - e.g. *log com1 posa unchanged*
- At the end of a command or command string issue a carriage return command which is usually the same as pressing the <ENTER> key.
- Most command entries do not provide a response to the entered command. Exceptions to this statement are the VERSION and HELP commands. Otherwise, successful entry of a command is verified by receipt of the COM port prompt (i.e. COM1> or COM2>).

The syntax for a command can contain optional parameters (OPT1, OPT2, ...). OPT2 may only be used if it is preceded by OPT1. OPT3 may only be used if it is preceded by OPT2 and so on. Parameters after and including OPT1 will be surrounded by square brackets.

An optional parameter such as {hold} may be used with the log without any preceding optional parameters

Example:

```
log com1 posa 60 1 hold
log com1 posa hold
```

When the MiLlennium-GLONASS GPSCard is first powered up, or after a FRESET command, all commands will revert to the factory default settings. The SAVECONFIG command can be used to modify the power-on defaults. Use the RCCA log to reference station command and log settings.

NOTE: In a FRESET or a software load, all previously stored configurations that were saved to non-volatile memory are erased (including Saved Config, Saved Almanac, and Channel Config).

NOTE: Please refer to the *MiLlennium Command Descriptions Manual* for a table of *Commands By Function* and an alphabetical listing of commands. Please see *Appendix G, Page 82* for a detailed description of GLONASS specific commands.

4.5 SPECIAL DATA INPUT COMMANDS

These entries are data messages that are generated by one MiLLennium-GLONASS GPSCard and sent to another GPSCard or generated by a MiLLennium-GLONASS GPSCard and saved for later use by that MiLLennium-GLONASS GPSCard (eg. \$CALA). For example, consider a special configuration in which a MiLLennium-GLONASS GPSCard #1 is able to send these data messages to a MiLLennium-GLONASS GPSCard #2 via a serial port. For MiLLennium-GLONASS GPSCard #1, this is no different than sending these data messages to a file or a screen. Each of these data messages has a special header which is interpreted by MiLLennium-GLONASS GPSCard #2 to mean that the data in that message is to be used as an update of its own GLONASS parameters such as time, position, velocity, acceleration or knowledge of satellite ephemeris.

In this general category also belong the RTCM data messages (\$RTCM, \$RTCM3A, \$RTCM9A, \$RTCM16A, \$RTCM31, \$RTCM34 and \$RTCM59A). These are described in further detail in *Chapter 4, Message Formats, Page 33*.

The injection of special command data can take place via COM1 or COM2. Remember, the source of these special data commands are valid NovAtel ASCII data logs.

The special data input commands fall into three categories: **Almanac Data, Differential Corrections and Calibration Data**. Listed below are input commands relevant to GLONASS. To see input commands that work with GPS only, such as \$REPA/B and \$PVAA/B, please refer to the *MiLLennium Command Descriptions Manual*.

4.5.1 ALMANAC DATA

The MiLLennium-GLONASS GPSCard is capable of receiving and using both the GLONASS almanac and the GPS almanac. The GLONASS almanac is stored in the log GALA (see *Page 89*) and the GPS almanac is stored in the log ALMA (see *Page 31*). Please see the following sections for an explanation of both almanacs.

4.5.1.1 GPS Almanac VS GLONASS Almanac

The GPSCard's standard features include GPS and GLONASS almanac data collection. Following a cold-start power-on or system reset, the GPSCard will begin a sky search. Once a valid satellite is acquired, the GPSCard will begin downloading and decoding the almanac information. For a GPS satellite this process will take 12.5 minutes following a cold-start or reset (assuming there are no problems with satellite visibility or the antenna system). It is noted that Ionospheric Correction Data and UTC data are also collected at the same time as almanac data and will also be available following the 12.5 minutes collection period. The GLONASS almanac takes at least 5 minutes to download.

GPSCards with the SAVECONFIG option will automatically save almanacs in their non-volatile memory. They will also automatically load the last saved almanac following a cold start or a reset. The card will save an almanac and ionospheric and UTC data received from a satellite if there is no current data in non-volatile memory (NVM), or if the GPS week number of the received data is newer than the week number of the data in NVM. The save will occur for GPS almanacs from 12.5 - 25 minutes since the last reset, while for GLONASS satellites the save will occur between 5 and 7.5 minutes afterwards. To check if almanac data is saved in the NVM of the GPSCard, check Bit 16 for GPS and Bit 28 for GLONASS in the receiver status word. See *Table H.2, Page 96*, for more information.

There are no specific NovAtel log option commands to independently specify output of ionospheric or UTC parameters. These parameters will always output following the GPS almanac \$ALMA log and will be identified by a \$IONA and \$UTCA header respectively. See *Chapter 4, Page 31* for more information on the ALMA output log command option. The GLONASS almanac is output as a \$GALA log and is not followed by the ionospheric (\$IONA) or UTC (\$UTCA) information. See *Chapter 4 (Page 32)* and *Appendix H (Page 89)* for more information on the \$GALA log command option.

4.5.1.2 Almanac Data Input Types

The GPSCard has the capability to accept injection of previously logged NovAtel-format ASCII almanac data (\$ALMA, \$GALA, \$IONA, and \$UTCA). The GPSCard will interpret this log data as special data input commands. This provides the user with the advantage of being able to inject recent almanac data into non-volatile memory, for example after a FRESET where the almanac information has been erased, without having to wait the 5 - 12.5 minutes described in above paragraphs.

There are various ways by which this can be accomplished.

- By connecting the COM1 or COM2 port from one GPSCard (reference) directly to the COM1 or COM2 port of another GPSCard (remote). The reference card is assumed to be tracking satellites for some time and can be commanded by the ALMA or GALA log command option to output almanac records to the remote card. The remote card can be assumed to be just powered-up or RESET and will recognize the \$ALMA, \$GALA, \$IONA, and \$UTCA data as special input commands and update its almanac tables with this new data.

REMEMBER: When connecting two GPSCard COM ports together, the MESSAGES command option should be set to "OFF" to prevent inter-card "chatter".

- The GPSCard can log current almanac data to a PC connected to its COM1 or COM2 port. Assuming the PC is correctly configured using terminal emulator communications software, then the PC can redirect the GPSCard almanac log to its disk storage device. At a later time following a system restart, the GPSCard can have this almanac file (containing \$ALMA, \$GALA, \$IONA, and \$UTCA records) immediately uploaded as a special input command for immediate use.

NOTE: This procedure will generally not be required as all GPSCards have an almanac save feature built in using non-volatile memory.

\$ALMA...

Use this special data input command to quickly update the MiLLennium-GLONASS GPSCard almanac tables following a system restart. It is generated from a GPSCard ALMA log and is accepted as the following format:

```
$ALMA,1,3.55148E-003,552960,744,-7.8174E-009,6.10457691E-002,-1.1820041E+000,1.90436112E+000,-1.8119E-005,-3.6379E-012,1.45854758E-004,2.65602532E+007,9.55600E-001,1,0,0*0C
...
(one record for each valid satellite)
...
$ALMA,31,4.90379E-003,552960,744,-7.9660E-009,-3.1044479E+000,6.13853346E-001,1.92552900E+000,6.67572E-006,3.63797E-012,1.45861764E-004,2.65594027E+007,9.61670E-001,1,0,0*3F
```

\$GALA...

Use this special data input command to quickly update the MiLLennium-GLONASS GPSCard GLONASS almanac tables following a system restart. It is generated from a MiLLennium-GLONASS GPSCard GALA log and is accepted as the following format:

```
$GALA,993,151144.24,993,114250.25,3,21,1,3.86373E+004,3.12420055E+000,4.37933539E-002,2.68745422E-003,
-2.9627880E+000,-2.6559473E+003,4.88281250E-004,-2.3651123E-004*01
```

...

(one record for each valid satellite)

...

```
$GALA,993,151144.24,993,115025.72,24,1,0,3.94127E+004,3.12265458E+000,4.52344569E-002,2.80475616E-003,
-3.0648936E+000,-2.6519570E+003,0.00000000E+000,0.00000000E+000*18
```

\$IONA...

Use this special data input command to quickly update the GPSCard ionospheric corrections tables following a system restart (always appended to \$ALMA records unless intentionally stripped). This data will ensure that the initial position solutions computed by the GPSCard are as accurate as possible. It is generated from a GPSCard ALMA log and is accepted by any GPSCard as the following format:

```
$IONA,1.0244548320770265E-008,1.4901161193847656E-008,-5.960464477539061E-008,
-1.192092895507812E-007,8.8064000000000017E+004,3.2768000000000010E+004,-1.966080000000001E+005,
-1.966080000000001E+005*02
```

\$UTCA...

Use this special data input command to quickly update the GPSCard Universal Time Coordinated (UTC) parameters following a system restart (always appended to \$ALMA records unless intentionally stripped).

The UTC data is required before the GPSCard can accurately compute UTC time. If not input with \$UTCA, it may take up to 12.5 minutes after a reset for the GPSCard to receive current UTCA data.

In order to comply with NMEA standards (see *NMEA*, Page 38 or refer to the *References* section of the *MiLLennium Command Descriptions Manual*), the MiLLennium-GLONASS GPSCard will null NMEA log data fields until valid UTC parameters are collected or injected by the \$UTCA input command. This command is generated from a MiLLennium-GLONASS GPSCard ALMA log and is accepted as the following format:

```
$UTCA,-1.769512891769409E-008,-1.776356839400250E-015,552960,744,755,9,10,5*03
```


4.5.2 DIFFERENTIAL CORRECTIONS DATA

NovAtel GPSCards can utilize the special data input commands \$RTCA and \$RTCM. These special data input commands are utilized by a GPSCard operating as a remote station to accept NovAtel ASCII format differential corrections. The data is generated by a GPSCard operating as a reference station with intent to be received by remote stations. To correctly interpret these commands, the remote GPSCard must have its ACCEPT command option set to "COMMANDS" (default). Refer to the *MiLLennium Command Descriptions Manual, Appendix A*, for further information on differential positioning. The \$RTCA message is supported by the MiLLennium-GLONASS GPSCard but is GPS-only. Please refer to the *MiLLennium Command Descriptions Manual* for more information on the \$RTCA message.

\$RTCM

The \$RTCM message works with the MiLLennium-GLONASS GPSCard in the following message formats:

\$RTCM, \$RTCM3A, \$RTCM9A, \$RTCM16A, \$RTCM31, \$RTCM34, \$RTCM59A.

Use this special data input command to directly input RTCM differential correction data, ASCII format (RTCM data converted to ASCII hexadecimal, with NovAtel header added). The data can be accepted using COM1 or COM2. The differential corrections will be accepted and applied upon receipt of this special data input command.

The data is generated from a MiLLennium-GLONASS GPSCard RTCM log and is accepted by a MiLLennium-GLONASS GPSCard remote station as in the following format

```
$RTCM,664142404E7257585C6E7F424E757D7A467C47414F6378635552427F73577261624278777  
F5B5A525C7354527C4060777B4843637C7F555F6A784155597D7F6763507B77496E7F7A6A426F55  
5C4C604F4E7F467F5A787F6B5F69506C6D6A4C*2B
```

NOTE : The \$RTCM commands allow the user to intermix differential corrections along with other ASCII commands or logs over a single port. (You must, however, ensure that the ACCEPT command option is set to "COMMANDS"). The use of a dedicated port for differential operation is described in Section 4.7, Page 39.

TIP : The decoding success and status of \$RTCM records can be monitored using the CDSA/B data log. These commands will not generate any reply response from the command interpreter. They will simply be processed for valid format and checksum and used internally. If there is any problem with the data, characters missing or checksum fail, the data will be discarded with no warning message.

4.5.3 CALIBRATION DATA

NovAtel MiLLennium-GLONASS GPSCards can utilize the special data input command \$CALA/B. This special data input command is utilized by a MiLLennium-GLONASS GPSCard and provides a method of calibrating pseudorange biases for a MiLLennium-GLONASS GPSCard receiver. The CALA log is specific to a single receiver. This log has the same format as the output CALA/B log, see *Page 88*. This information will be stored in non-volatile memory when the SAVECONFIG command is issued.

\$CALA/B...

```
$CALA,992,453075,2,FFFFFFF00,-0.491,0.050,-0.640,0.055,-0.687,  
0.050,-0.977,0.050,-1.066,0.049,-1.334,0.047,-1.291,0.049,-1.661,  
0.054,-1.504,0.055,-1.967,0.054,-1.927,0.052,-2.308,0.053,-2.428,  
0.050,-2.534,0.051,-2.621,0.054,-3.027,0.054,-2.740,0.049,-3.039,  
0.051,-2.865,0.055,-3.310,0.049,-3.903,0.060,-3.970,0.070,-4.359,  
0.055,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,0.000,  
5.000,0.000,5.000,0.000,5.000,*03
```

4.6 LOGS COMMON TO ALL GPSCARDS

The MiLLennium-GLONASS GPSCard receiver is capable of generating many NovAtel-format output logs, in either ASCII or binary format. Please refer to the *MiLLennium Command Descriptions Manual's Logs Chapter* for a complete list of logs categorized by function.

4.6.1 LOGS SPECIFIC TO MILLENNIUM-GLONASS GPSCARD

The MiLLennium-GLONASS GPSCard generates four GLONASS specific logs:

- CALA/B (see *Page 88*)
- GALA/B (see *Page 89*)
- GCLA/B (see *Page 91*)
- GEPA/B (see *Page 93*)

For a listing of logs common to all GPSCards, with the exception of the GLONASS specific logs, refer to the *MiLLennium Command Descriptions Manual*. For details on GLONASS specific logs, see *Page 88*.

4.6.2 OUTPUT LOGGING

The MiLLennium-GLONASS GPSCard provides versatility in your logging requirements. You can direct your logs to either COM1 or COM2, or both ports, as well as combine data types. The MiLLennium-GLONASS GPSCard has four major logging formats:

- NovAtel Format Data Logs (ASCII/Binary)
- NMEA Standard Format Data Logs (ASCII)
- RTCM Standard Format Data Logs (Binary)
- RTCA Standard Format Data Logs (Binary)

NOTE: RTCM and RTCA are used for differential position operation, which is described in *Section 4.7, Page 39*.

All data types can be logged using several methods of triggering each log event. Each log is initiated using the LOG command. The LOG command and syntax are listed on the following page.

Syntax

```
log [port],[datatype],[trigger],[period],[offset],[hold]
```

Syntax	Description	Example
LOG		
port	COM1 or COM2	COM1
datatype	Enter one of the valid ASCII or Binary Data Logs (see later in this chapter and <i>Appendix H, Page 88</i>)	POSA
trigger	Enter one of the following <i>triggers</i> . ONCE Immediately logs the selected data to the selected port once. Default if trigger field is left blank. ONMARK Logs the selected data when a MARKIN electrical event is detected. Outputs internal buffers at time of mark - does not predict to mark time. Use MKBA/B for predicted position at time of mark. ONNEW Logs the selected data each time the data is new even if the data is unchanged. ONCHANGED Logs the selected data only when the data has changed. ONTIME [period], [offset] Immediately logs the selected data and then periodically logs the selected data at a frequency determined by the <i>period</i> and <i>offset</i> parameters. The logging will continue until an UNLOG command pertaining to the selected data item is received (refer to the <i>UNLOG Command, MiLlennium Command Descriptions Manual</i>). CONTINUOUSLY Will log the data all the time. The GPSCard will generate a new log when the output buffer associated with the chosen port becomes empty. The <i>continuously</i> option was designed for use with differential corrections over low bit rate data links. This will provide optimal record generation rates. The next record will not be generated until the last byte of the previous record is loaded into the output buffer of the UART.	ONTIME
period	Use only with the ONTIME trigger. Units for this parameter are seconds. The selected period may be any of the following values: 0.05, 0.10, 0.20, 0.25, 0.50, 1, 2, 3, ... , 3600 seconds but may be limited by the GPSCard model and previously requested logs. Selected data is logged immediately and then periodic logging of the data will start at the next even multiple of the period. If a period of 0.20 sec is chosen, then data will be logged when the receiver time is at the 0.20, 0.40, 0.60 and the next (0.80) second marks. If the period is 15 seconds, then the logger will log the data when the receiver time is at even 1/4 minute marks. The same rule applies even if the chosen period is not divisible into its next second or minute marks. If a period of 7 seconds is chosen, then the logger will log at the multiples of 7 seconds less than 60, that is, 7, 14, 21, 28, 35, 42, 49, 56 and every 7 seconds thereafter.	60
offset	Use only with the ONTIME trigger. Units for this parameter are seconds. It provides the ability to offset the logging events from the above startup rule. If you wished to log data at 1 second after every minute you would set the period to 60 seconds and the offset to 1 second (Default is 0).	1
hold	Will prevent a log from being removed when the UNLOGALL command is issued	HOLD

Example:

```
log com1,posa,ontime,60,1
```

If the LOG syntax does not include a *trigger* type, it will be output only once following execution of the LOG command. If *trigger* type is specified in the LOG syntax, the log will continue to be output based on the *trigger* specification. Specific logs can be disabled using the UNLOG command, whereas all enabled logs will be disabled by using the UNLOGALL command (refer to the *MiLlennium Command Descriptions Manual, Appendix C*). All activated logs will be listed in the receiver configuration status log (RCCA).

4.6.3 NOVATEL FORMAT DATA LOGS

4.6.3.1 General

The NovAtel GPSCard is capable of executing more than 40 NovAtel format log commands. Each log is selectable in ASCII and Binary formats. The one exception to this rule is the RGE log, which can be logged as RGED. The “D” indicates a compressed binary format to allow higher speed logging. Any format can be selected individually or simultaneously over the same COMn ports.

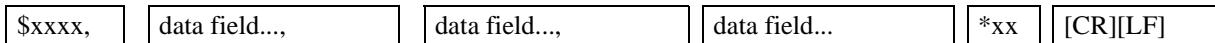
Log descriptions of some logs used by the MiLLennium-GLONASS GPSCard, as well as GLONASS specific logs, are listed in alphabetical order in *Appendix I*. Each log first lists the ASCII format, followed by the Binary format description.

4.6.3.2 ASCII Log Structure

Log types ending with the letter A (or a) will be output in ASCII format (e.g., CALA). The structures of all ASCII logs follow the general conventions as noted here:

1. The lead code identifier for each record is '\$'.
2. Each log is of variable length depending on amount of data and formats.
3. All data fields are delimited by a comma ',' with the exception of the last data field, which is followed by an * to indicate end of message data.
4. Each log ends with a hexadecimal number preceded by an asterisk and followed by a line termination using the carriage return and line feed characters, e.g., *xx[CR][LF]. This 8-bit value is an exclusive OR (XOR) of all bytes in the log, excluding the '\$' identifier and the asterisk preceding the two checksum digits.

Structure:



4.6.3.3 Binary Log Structure

Log types ending with the letter B (or b) will be output in Binary format (e.g., CALB). The structures of all Binary logs follow the general conventions as noted here:

1. Basic format of:

Sync	3 bytes
Checksum	1 byte
Message ID	4 bytes unsigned integer
Message byte count	4 bytes unsigned integer
Data	x
2. The Sync bytes will always be:

Byte	Hex	Decimal
First	AA	170
Second	44	68
Third	11	17

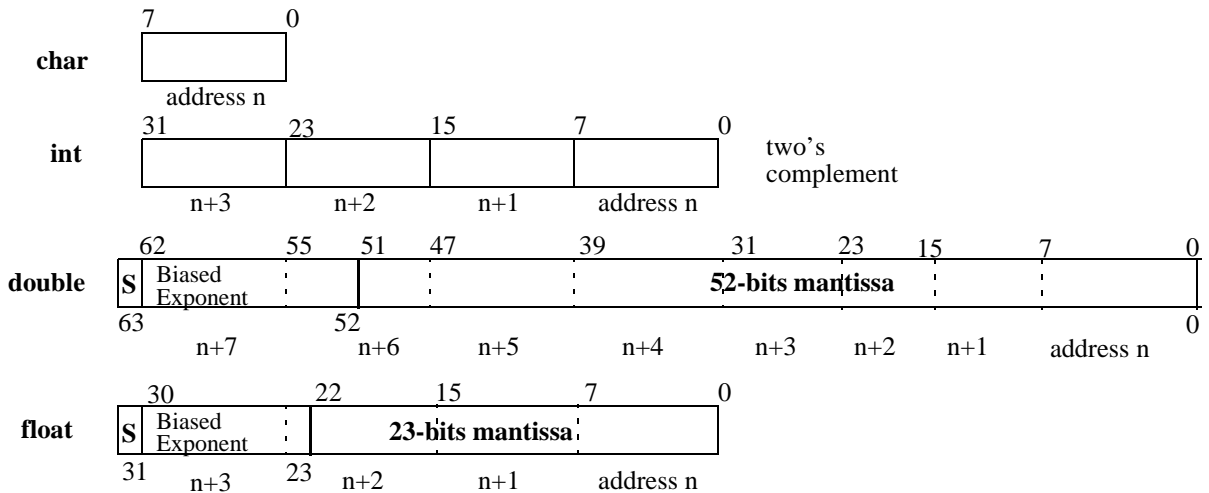
3. The Checksum is an XOR of all the bytes (including the 12 header bytes) and is initially set to 00.
4. The Message ID identifies the type of log to follow.
5. The Message byte count equals the total length of the data block including the header.

NOTE: Maximum flexibility for logging data is provided to you by these logs. The user is cautioned, however, to recognize that each log requested requires additional CPU time and memory buffer space. Too many logs may result in lost data and degraded CPU performance. CPU overload can be monitored using the idle-time and buffer overload bits from the RCSA/B log. See *Table H.2, Page 96* (GPSCard receiver Self-test Status Codes).

The following table describes the format types used in the description of binary logs.

Type	Size (bytes)	Size (bits)	Description
char	1	8	The char type is used to store the integer value of a member of the representable character set. That integer value is the ASCII code corresponding to the specified character.
int	4	32	The size of a signed or unsigned int item is the standard size of an integer on a particular machine. On a 32-bit processor (such as the NovAtel GPSCard), the int type is 32 bits, or 4 bytes. The int types all represent signed values unless specified otherwise. Signed integers are represented in two's-complement form. The most-significant bit holds the sign: 1 for negative, 0 for positive and zero.
double	8	64	The double type contains 64 bits: 1 for sign, 11 for the exponent, and 52 for the mantissa. Its range is $\pm 1.7E308$ with at least 15 digits of precision.
float	4	32	The float type contains 32 bits: 1 for the sign, 8 for the exponent, and 23 for the mantissa. Its range is $\pm 3.4E38$ with at least 7 digits of precision.

Each byte within an **int** has its own address, and the smallest of the addresses is the address of the int. The byte at this lowest address contains the eight least significant bits of the doubleword, while the byte at the highest address contains the eight most significant bits. The following illustration shows the arrangement of bytes within words and doublewords. Similarly the bits of a "double" type are stored least significant byte first. This is the same data format used by IBM PC computers.



4.6.4 NMEA FORMAT DATA LOGS

4.6.4.1 General

The NMEA log structures follow format standards as adopted by the National Marine Electronics Association (NMEA). The reference document used is "Standard For Interfacing Marine Electronic Devices NMEA 0183 Version 2.20". For further information, refer to the *Millennium Command Descriptions Manual, Appendix F, Standards and References*. The following table contains excerpts from the NMEA Standard which defines the variables for the NMEA logs. The actual format for each parameter is indicated after its description.

Field Type	Symbol	Definition
Special Format Fields		
Status	A	Single character field: A = Yes, Data Valid, Warning Flag Clear V = No, Data Invalid, Warning Flag Set
Latitude	llll.ll	Fixed/Variable length field: degrees minutes.decimal - 2 fixed digits of degrees, 2 fixed digits of minutes and a <u>variable</u> number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyy.yy	Fixed/Variable length field: degrees minutes.decimal - 3 fixed digits of degrees, 2 fixed digits of minutes and a <u>variable</u> number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required
Time	hhmmss.ss	Fixed/Variable length field: hours minutes seconds.decimal - 2 fixed digits of hours, 2 fixed digits of minutes, 2 fixed digits of seconds and <u>variable</u> number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined field		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following which are used to indicate field types within this standard: "A", "a", "c", "hh", "hhmmss.ss", "llll.ll", "x", "yyyy.yy"
Numeric Value Fields		
Variable numbers	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10 = 73.1 = 073.1 = 73)
Fixed HEX field	hh___	Fixed length HEX numbers only, MSB on the left
Information Fields		
Variable text	c--c	Variable length valid character field.
Fixed alpha field	aa___	Fixed length field of uppercase or lowercase alpha characters
Fixed number field	xx___	Fixed length field of numeric characters
Fixed text field	cc___	Fixed length field of valid characters
NOTES:		
<ol style="list-style-type: none"> 1. Spaces may only be used in variable text fields. 2. A negative sign "-" (HEX 2D) is the first character in a Field if the value is negative. The sign is omitted if value is positive. 3. All data fields are delimited by a comma (,). 4. Null fields are indicated by no data between two commas (,). Null fields indicate invalid or no data available. 5. The NMEA Standard requires that message lengths be limited to 82 characters. 		

4.6.4.2 NMEA Logs From The MiLLennium-GLONASS GPSCard

NMEA messages start with a \$ sign followed by five letters. The first two letters represent the type of receiver broadcasting the message (i.e. GP for a GPS-only receiver, GL for GLONASS and GN for a combined receiver), and the last three letters represent the message type. To log a supported NMEA message on the MiLLennium-GLONASS GPSCard, the log type is given by the prefix 'NM' followed by the NMEA message type. For example, to log the NMEA geographic position (GLL) message every 10 seconds the command would be the following:

Example:

```
Log com1 NMGLL ontime 10
```

The receiver will choose the receiver type for the output message. If GPS and GLONASS satellites are being used in the position calculation, the above command would output a \$GNGLL log every ten seconds. In all cases, the output will conform to the NMEA version 2.2 specification. For reference information see the *MiLLennium Commands Description Manual, Appendix F*. For a listing of NMEA messages that are supported by the MiLLennium-GLONASS GPSCard please see *Table 4.1*.

NOTE: The 'GP' log types (i.e. GPGLL) will still be accepted to support backwards compatibility but the output will always conform to the NMEA specification with respect to the output prefix.

Table 4.1 NMEA Messages Supported By The MiLLennium-GLONASS GPSCard

NovAtel Log Type	NMEA Message Identifier	Description
NMGLL	GLL	Geographic position - Latitude/Longitude
NMGNS	GNS	GNSS position fix
NMGST	GST	GNSS Pseudorange error statistics
NMGSV	GSV	GNSS Satellites in view
NMRMB	RMB	Recommended minimum navigation information
NMRMC	RMC	Recommended minimum specific GNSS data
NMVTG	VTG	Course over ground and ground speed
NMZDA	ZDA	UTC time and date
NMZTG	ZTG	UTC, time to destination waypoint

4.7 DIFFERENTIAL POSITION OPERATION

Differential operation involves setting up a radio link between a stationary MiLLennium-GLONASS GPSCard receiver at a known point and one or more MiLLennium-GLONASS GPSCard receivers at unknown locations. The stationary receiver, known as the reference receiver, broadcasts various messages which can be received by the various remote receivers. Internally, the remote MiLLennium-GLONASS GPSCard is capable of utilising this information in the navigation filter. It is possible in this manner to eliminate most common error sources and improve the level of position accuracy. A more detailed description of differential positioning can be found in *Appendix A* of the *MiLLennium Commands Description Manual*. It is your responsibility to provide a data communications link between the reference and remote stations. Generally, a communications link capable of 4800 bits per second or higher is sufficient. Refer to the *MiLLennium Commands Description Manual* for additional information.

There are two types of differential positioning available with the MiLLennium-GLONASS GPSCard. These include pseudorange (PSR) differential positioning and Real-Time Kinematic (RTK) differential positioning. RTK positioning is more complicated and CPU intensive than pseudorange positioning and is available as an option on the MiLLennium-GLONASS GPSCard. Implementation for both modes is explained following.

NOTE: It is not necessary for the remote receiver to remain fixed although this could improve solution convergence time in RTK positioning.

4.7.1 PSEUDORANGE (PSR) DIFFERENTIAL POSITIONING

PSR positioning utilizes the satellite pseudorange information from the reference and remote receiver. The reference receiver at a known location broadcasts the difference between the measured range to a satellite and the true range. Currently, the MiLLennium-GLONASS GPSCard supports RTCM standard types 31 and 34 for GLONASS operation. Type 31 messages are the equivalent of Type 1 for GPS while Type 34 are equivalent to Type 9 for GPS. Descriptions of the RTCM message types can be found in RTCM SC-104 version 2.2 available from the Radio Technical Commission for Maritime services. The contact information for this organization is given in *Appendix F* of the *MiLLennium Commands Description Manual*.

Type 9 and Type 34 message types contain only a subset of the full correction set and are intended for use with stable external oscillators at the reference station. Generally, the update rate of the corrections should be at least once every five seconds. The default time-out values for GPS and GLONASS corrections is 60 seconds but are user-configurable using the *DGLOTIMEOUT* (see *Page 82*) and *DGPSTIMEOUT* (refer to the *MiLLennium Command Descriptions Manual*) commands. GLONASS measurements, which do not suffer from Selective Availability (SA), will degrade at a slower rate than GPS after about 30 seconds. The following sets of commands will enable PSR differential positioning for two MiLLennium-GLONASS GPSCard receivers assuming a radio link has been provided. Two examples have been shown for the reference station representing the full correction set (RTCM Type 1,31) and partial correction set (RTCM Type 9,34) configurations.

1A Reference Station Initialization (full correction message)

```
fix position lat, lon, height, station ID
log comn,rtcm1,ontime,interval
log comn,rtcm31,ontime,interval
```

example:

```
fix position 51.11358042,-114.04358013,1059.4105,1024
log com1, rtcm1, ontime, 2
log com1, rtcm31, ontime, 2
```

1B Reference Station Initialization (partial correction message)

```
fix position lat, lon, height, station ID
log comn,rtcm9,ontime,interval
log comn,rtcm34,ontime,interval
```

example:

```
fix position 51.11358042,-114.04358013,1059.4105,1024
log com1, rtcm9, ontime, 2
log com1, rtcm34, ontime, 2
```

2 Remote Station Initialization

```
accept comn, rctm
```

example:

```
accept com2, rctm
```

NOTE: The MiLLennium-GLONASS GPSCard also supports the NovAtel ASCII and Binary versions of the new RTCM Type 31 and 34 messages. These are of the same form but are wrapped in a NovAtel header and checksum. The ASCII version has the RTCM data portion converted to hexadecimal before transmission. If the COM port on the remote receiver is set to *accept COMn commands*, the receiver will be able to decode and use the \$RTCM1, \$RTCM9A, \$RTCM31A and \$RTCM34A message types. See the *Message Formats* section of the *MiLLennium Commands Description Manual* for more details.

4.7.2 REAL-TIME KINEMATIC (RTK) DIFFERENTIAL POSITIONING

Available as an option on the MiLLennium-GLONASS GPSCard is R10 positioning which makes use of the precise carrier-phase measurement. This implementation is similar to the RT20 software available on the standard MiLLennium GPSCard but has been augmented to allow the use of GLONASS satellites. The position accuracy achievable with RT10 positioning is substantially greater than PSR differential positioning. The data transfer rate must be high enough to ensure that sufficient base station messages reach the rover station to keep prediction errors from growing too large. *Table 4.2, Page 41* shows the base station prediction error to be expected from GPS measurements.

Table 4.2 Latency-Induced Prediction Error

Time since last base station observation	Typical base station prediction error (CEP) rate
0-2 seconds	1 cm/sec
2-7 seconds	2 cm/sec
7-30 seconds	5 cm/sec

Table 4.3 RT10 Convergence Summary^a

Tracking Time (sec)	S/K ^b	Data Delay (sec)	Distance (km)	Accuracy (cm) (CEP)
1 to 280	S	0	1	100 to 18
280 to 600	S	0	1	18 to 10
600 to 3000	S	0	1	10 to 5
over 3000	S	0	1	5 or less ^c
1 to 600	K	0	1	100 to 12
600 to 3000	K	0	1	12 to 5
over 3000	K	0	1	5 or less
	S/K	0 to 2	1	+1 per sec
	S/K	2 to 7	1	+2 per sec
	S/K	7 to 30	1	+5 per sec
	S/K	30 to 60	1	+7 per sec ^d
	S/K	60 or more	1	Single Point
	S/K	0	0 to 10	+0.5 per km ^e
	S/K	0	10 to 20	+0.75 per km ^e
	S/K	0	20 to 50	+1.0 per km ^e

- For 12 or more satellites above the mask where the RTK mask angle ranges from 11° to 14° as the baseline goes from 0 to 15 km. Above 15 km it is 14°.
- K = Kinematic (during initial ambiguity resolution)
S = Static (during initial ambiguity resolution)
- The accuracy specifications refer to the PRTKA/B logs which include about 3 cm prediction error. RTKA/B logs are more accurate but have more latency associated with them.
- Between 30 and 60 seconds assumes pseudorange differential positioning. If Type 1 corrections have not been transmitted, the accuracy drops to single point mode after 30 seconds.
- For typical tropospheric and ionospheric errors.

A new message type based on the RTCA format has been created to allow for combined GPS/GLONASS operation. This is a proprietary message following the RTCA Type 7 subtype N protocol described in the RTCA specifications for SCAT-1 approaches. The reference information for RTCA messaging is found in *Appendix F* of the *MiLLennium Commands Description Manual*. The new RTCA message is significantly more efficient for L1 only operation. Along with the observation records, reference station information must also be sent in the form of an RTCAREF message which follows RTCA Type 7 subtype N protocol as well. It is recommended that the observation information be sent at 2 second intervals while the reference station information be sent at 10 second intervals. The following commands for the reference and remote stations will initialize RTK operation.

- 1 **Reference Station initialization**
 fix position lat, lon, height, *station ID*
 log comn,rtcaref,ontime,*interval*
 log comn,rtcaobs2,ontime,*interval*
 example:
 fix position 51.11358042,-114.04358013,1059.4105,"RW34"
 log com1, rtcaref, ontime, 10
 log com1, rtcaobs2, ontime, 2

- 2 **Remote Station initialization**
 accept comn, rtca
 example:
 accept com2, rtca

Once initialized, the RTK system is ready to go.

NOTE: The form of the station ID for RTCA messaging can contain alphanumeric characters unlike the RTCM format.

4.7.3 MONITORING YOUR RTK OUTPUT DATA

The accuracy that can be achieved using RTK positioning is dependent on many external factors including satellite visibility, satellite geometry, data latency and distance between the remote and reference receiver. All of this information is available as output from the MiLLennium-GLONASS GPSCard receiver. Estimates of the remote receiver position are also accompanied by estimates of possible receiver error and care should be taken to monitor these values. Some of the logs that can be output from the remote receiver, and the information they contain, are given following:

BSLA/B	inter-antenna baseline information
PRTKA/B	best low-latency position
RPSA/A	base station position and health
RTKA/B	matched observation position
RTKOA/B	RTK position filter parameters

The RTKA/B position solution is based on time-matching reference and remote observations. This is the most accurate form of positioning available and is recommended for static users. There will be a solution latency for this log that is dependent on the latency of the data-link. The PRTKA/B log contains a low-latency solution which predicts the last received reference station observations ahead to the current time of observation. This is a method for eliminating the effects of radio-link data latency and is recommended for kinematic users.

4.7.4 GPS-ONLY OPERATION WITH STANDARD MILLENNIUM-GLONASS GPSCARD

The MiLLennium-GLONASS GPSCard is also capable of supporting a number of GPS-Only messages that can be broadcast to standard MiLLennium GPSCards for GPS-Only pseudorange or RT-20 positioning. The MiLLennium-GLONASS GPSCard can also receive GPS-Only messages and perform GPS-Only RT-20 positioning if enough satellites are available. The following message types are supported for GPS-Only operation. For further information on these message types refer to the *MiLLennium Commands Description Manual*.

RTCA	PSR positioning
RTCM59	RTK positioning
CMROBS	RTK positioning
RTCAOBS	RTK positioning
RTCM1819	RTK positioning

NOTE: RTCM Type 1's and Type 9's can be broadcast by themselves and used for GPS-Only operation similar to section 4.7

4.8 INTEGRITY ALGORITHM

NovAtel Inc. has implemented an integrity algorithm to improve the reliability of the MiLlennium-GLONASS receiver. The increased redundancy offered by tracking more satellites improves the chance of statistically catching a measurement blunder. The integrity algorithm is designed to detect, and attempt to isolate, single-satellite failures. A satellite failure, in this instance, is defined as a ranging error on a pseudorange measurement. The detection algorithm is based on a least-squares-residuals approach (see Brown et al., *A Baseline GPS RAIM Scheme and a Note on the Equivalence of Three RAIM Methods*, Journal of the Institute of Navigation, Vol. 39, No. 3, Fall 1992).

When an integrity failure is detected, the solution status flag is set to BAD INTEGRITY. If a satellite was successfully isolated then the reject code for that satellite will be set to BAD INTEGRITY and the satellite will be removed from subsequent processing for 30 minutes. If operating in RTK mode, the RTK filter will be reset and the isolated satellite will be rejected in the ensuing processing for the same period of time. If an integrity failure is detected but a satellite cannot be isolated, then all Glonass satellites will be flagged as BAD INTEGRITY and a GPS-only solution will be attempted on the next measurement epoch.

This integrity algorithm differs from a RAIM algorithm in that it is not designed to protect against specified minimum performance levels. In RAIM, the position solution is considered suspect if the satellite geometry is insufficient to detect a measurement error that could cause a position error greater than a given threshold. This approach is very conservative and was developed for stringent in-flight position tolerances. The integrity algorithm in the NovAtel MiLlennium-GLONASS card does not use this minimum detectable blunder concept but will check for any satellite failure based on the strength of the current satellite geometry.

5 FIRMWARE UPDATES AND UPGRADES

5.1 UPDATE/UPGRADE OVERVIEW

The MiLLennium-GLONASS GPSCard stores its program firmware in non-volatile memory, which allows you to perform firmware updates without having to return the MiLLennium-GLONASS GPSCard to the factory. New firmware can be transferred to the MiLLennium-GLONASS GPSCard through a serial port, and the unit will immediately be ready for operation at a higher level of performance.

The first step in updating your receiver is to contact your local NovAtel dealer. Your dealer will assist you in selecting the best update option that suits your specific combined GPS/GLONASS needs. If your needs are still unresolved after seeing your dealer then you can contact NovAtel directly through any of the methods described in the *Customer Service* section, *Page 7*, at the beginning of this manual.

When you call, be sure to have available your MiLLennium-GLONASS GPSCard model number, serial number, and program revision level. This information is printed on the original shipping box as well as on the back of the MiLLennium-GLONASS GPSCard itself. You can also verify the information by issuing the VERSION command at the port prompt.

After establishing which new model/revision level would best suit your needs, and having discussed the terms and conditions, your dealer or NovAtel Customer Service will issue to you the authorization code (“auth-code”) which is required to unlock the new features according to your authorized upgrade/update model type.

There are two procedures to choose from, depending on the type of upgrade/update you require:

- If you are **upgrading** to a higher performance model at the same firmware revision level (e.g. upgrading from a MiLLennium-GLONASS Standard rev. 7.46, to a MiLLennium-GLONASS RT-10 rev. 7.46), you can use the \$AUTH special command from a terminal program on the data collector or from GPSolution.
- If you are **updating** to a higher firmware revision level of the same model (e.g. updating a MiLLennium-GLONASS Standard rev. 7.46 to a 7.47 of the same model), you will need to transfer new program firmware to the MiLLennium-GLONASS GPSCard using the *Loader* utility program. As the *Loader* and update programs are generally provided in a compressed file format, you will also be given a file decompression password. The *Loader* and update files can be found on NovAtel’s FTP site at <http://www.novatel.ca>, or can be sent to you on floppy disk or by e-mail.

These procedures are described more completely in this chapter.

Your local NovAtel dealer will provide you with the information you require to update or upgrade your receiver.

5.1.1 UPGRADING USING THE \$AUTH COMMAND

The \$AUTH command is a special input command which authorizes the enabling or unlocking of the various model features. Use this command when upgrading to a higher performance MiLLennium-GLONASS GPSCard model available within the same revision level as your current model (e.g., upgrading from a MiLLennium-GLONASS Standard rev. 7.46, to a MiLLennium-GLONASS RT-10 rev. 7.46). This command only functions in conjunction with a valid auth-code.

The upgrade can be performed directly from Loader’s built-in terminal emulator, or any other communications software. The procedure is as follows:

- Turn on the GPSCard and establish communications over a serial port.
- Issue the VERSION command to verify the current firmware model number, revision level, and serial number.
- Issue the \$AUTH command, followed by the auth-code and model type. The syntax is as follows:

Syntax:

```
$AUTH auth-code
```

where

\$AUTH is a special command that allows program model upgrades
auth-code is the upgrade authorization code, expressed as *hhhh, hhhh, hhhh, hhhh, hhhh, model#*
where the *h* characters are an ASCII hexadecimal code, and the *model#* would be ASCII text

Example:

```
$auth 17cb,29af,3d74,01ec,fd34,millennrt2
```

Once the \$AUTH command has been executed, the MiLlennium-GLONASS GPSCard resets itself. Issuing the VERSION command produces a response confirming the new upgrade model's type and version number.

5.1.2 UPDATING USING THE LOADER UTILITY

Loader is required when updating previously released firmware with a newer version of program and model firmware (e.g., updating a MiLlennium-GLONASS GPSCard Standard rev. 7.46 to a higher revision level of the same model). *Loader* is a DOS utility program designed to facilitate program and model updates. Once *Loader* is installed and running, it will allow you to select a host PC serial port, bit rate, directory path, and file name of the new program firmware to be transferred to the MiLlennium-GLONASS GPSCard.

5.1.2.1 Transferring Firmware Files

To proceed with your program update, you must first acquire the latest firmware revision. You will need a file with a name such as OEMXYZ.EXE (where XYZ is the firmware revision level). This file is available from NovAtel's FTP site (<http://www.novatel.ca>), or via e-mail (support@novatel.ca). If transferring is not possible, the file can be mailed to you on floppy disk. For more information on how to contact NovAtel Customer Service please see *Page 7* at the beginning of this manual.

You will need at least 1 MB of available space on your hard drive. For convenience, you may wish to copy this file to a GPS sub-directory.

Example:

```
C:\GPS\LOADER
```

The file is available in a compressed format with password protection; your local dealer will provide you with the required password. After copying the file to your computer, it must be decompressed. The syntax for decompression is as follows:

Syntax:

```
[filename] -s[password]
```

where

filename is the name of the compressed file (but not including the .EXE extension)
-s is the password command switch
password is the password required to allow decompression

Example:

```
oem746 -s12345678
```

The self-extracting archive will then generate the following files:

- LOADER.EXE *Loader* utility program
- LOADER.TXT Instructions on how to use the *Loader* utility
- XYZ.BIN Firmware version update file, where XYZ = program version level (e.g. 746.BIN)

5.1.2.2 Using the LOADER Utility

The *Loader* utility can operate from any DOS directory or drive on your PC. The program is comprised of three parts: *Program Card* (authorization procedure), *Setup* (communications configuration) and *Terminal* (terminal emulator). The main screen is shown in *Figure 5.1* following.

Figure 5.1 Main Screen of LOADER Program



If you are running *Loader* for the first time, be sure to access the *Setup* menu (step 3 following) before proceeding to *Program Card* (step 4 following); otherwise, you can go directly from step 2 following to step 4. The procedure is as follows:

1. Turn off power to the MiLLennium-GLONASS GPSCard receiver.
2. Start the *Loader* program.
3. From the main menu screen (*Figure 5.1*), select **Setup** to configure the serial port over which communication will occur (default: COM1), and the data transfer rates for both programming (default: 115 200 bits per second) and terminal emulation (default: 9600 bps). To minimize the time required, select the highest serial bit rate your PC can reliably support. *Loader* will verify and save your selections in a file named LOADER.SET, and return to the main menu screen.
4. From the main screen, select **Program Card**.
5. Select the disk drive (e.g., A, B, C, D) in which the update file (e.g. 746.BIN) is located. Select the path where the update program file is located (e.g., C:\GPS\LOADER); the directory from which you started *Loader* is the default path. Select the required update file (e.g. 746.BIN).
6. At the prompt, enter your update auth-code (e.g. 17b2,32df,6ba0,92b5,e5b9,GLONASS2).
7. When prompted by the program, turn on power to the MiLLennium-GLONASS GPSCard receiver. *Loader* will automatically establish communications with the MiLLennium-GLONASS GPSCard. The time required to transfer the new program data will depend on the bit rate which was selected earlier.
8. When the transfer is complete, use the terminal emulator in *Loader* (select **Terminal**), or any other one, to issue the VERSION command; this will verify your new program version number. When using the terminal emulator in *Loader*, a prompt does not initially appear; you need to enter the command first, which then produces a response, after which a prompt will appear.
9. Exit *Loader* (select **Quit**).

This completes the procedure required for field-updating a MiLLennium-GLONASS GPSCard.

A ANTI-STATIC PRACTICES

This appendix only applies if you are handling a Millennium-GLONASS GPSCard without a ProPak II enclosure or a PowerPak II enclosure. If you purchased either enclosure then the sections that follow are not applicable.

A.1 OVERVIEW

Static electricity is electrical charge stored in an electromagnetic field or on an insulating body. This charge can flow as soon as a low-impedance path to ground is established. Static-sensitive units can be permanently damaged by static discharge potentials of as little as 40 volts. Charges carried by the human body, which can be thousands of times higher than this 40 V threshold, can accumulate through as simple a mechanism as walking across non-conducting floor coverings such as carpet or tile. These charges may be stored on clothing, especially when the ambient air is dry, through friction between the body and/or various clothing layers. Synthetic materials accumulate higher charges than natural fibres. Electrostatic voltage levels on insulators may be very high, in the order of thousands of volts.

Various electrical and electronic components are vulnerable to electrostatic discharge (ESD). These include discrete components, hybrid devices, integrated circuits (ICs), and printed circuit boards (PCBs) assembled with these devices.

A.2 HANDLING ESD-SENSITIVE DEVICES

ESD-sensitive devices must only be handled in static-controlled locations. Some recommendations for such handling practices follow:

- Handling areas must be equipped with a grounded table, floor mats, and wrist or ankle straps.
- A relative humidity level must be maintained between 20% and 80% non-condensing.
- No ESD-sensitive board or component should be removed from its protective package, except in a static-controlled location.
- A static-controlled environment and correct static-control procedures are required at both repair stations and maintenance areas.
- ESD-sensitive devices must be handled only after personnel have grounded themselves via wrist or ankle straps and mats.
- Boards or components should never come in contact with clothing, because normal grounding cannot dissipate static charges on fabrics.
- A circuit board must be placed into an anti-static plastic clamshell before being removed from the work location and must remain in the clamshell until it arrives at a static-controlled repair/test center.
- Circuit boards must not be changed or moved needlessly. Handles or finger holes may be provided on circuit boards for use in their removal and replacement; care should be taken to avoid contact with the connectors and components.
- On-site repair of ESD-sensitive equipment should not be undertaken except to restore service in an emergency where spare boards are not available. Under these circumstances repair station techniques must be observed. Under normal circumstances a faulty or suspect circuit board must be sent to a repair center having complete facilities, or to the manufacturer for exchange or repair.
- Where protective measures have not been installed, a suitable alternative would be the use of a Portable Field Service Grounding Kit. This consists of a portable mat and wrist strap which must be attached to a suitable ground.
- A circuit board in a static-shielding bag or clamshell may be shipped or stored in a cardboard carton, but the carton must not enter a static-controlled area such as a grounded or dissipative bench top or repair zone. Do not place anything else inside the bag (e.g. repair tags).
- Treat all PCBs and components as ESD sensitive. Assume that you will damage the PCB or component if you are not ESD conscious.
- Do not use torn or punctured static-shielding bags. A wire tag protruding through the bag

could act as a “lightning rod”, funneling the entire charge into the components inside the bag.

- Do not allow chargeable plastics, such as binders, within 0.6 m of unshielded PCBs.
- Do not allow a PCB to come within 0.3 m of a computer monitor.

A.3 PRIME STATIC ACCUMULATORS

Table A.1 provides some background information on static-accumulating materials.

Table A.1 Prime Static Accumulators

Surface	Accumulator
Work Surfaces	<ul style="list-style-type: none"> • formica (waxed or highly resistive) • finished wood • synthetic mats • writing materials, note pads, etc.
Floors	<ul style="list-style-type: none"> • wax-finished • vinyl
Clothes	<ul style="list-style-type: none"> • common cleanroom smocks • personal garments (all textiles except virgin wool) • non-conductive shoes
Chairs	<ul style="list-style-type: none"> • finished wood • vinyl • fiberglass
Packing and handling	<ul style="list-style-type: none"> • common polyethylene bags, wraps, envelopes, and bubble pack • pack foam • common plastic trays and tote boxes
Assembly, cleaning, test and repair areas	<ul style="list-style-type: none"> • spray cleaners • common solder sucker • common solder irons • common solvent brushes (synthetic bristles) • cleaning, drying and temperature chambers

A.4 HANDLING PRINTED CIRCUIT BOARDS

ESD damage to unprotected sensitive devices may occur at any time. ESD events can occur far below the threshold of human sensitivity. Follow this sequence when it becomes necessary to install or remove a circuit board:

1. After you are connected to the grounded wrist strap, remove the circuit board from the frame and place it on a static-controlled surface (grounded floor or table mat).
2. Remove the replacement circuit board from the static-shielding bag or clamshell and insert it into the equipment.
3. Place the original board into the shielding bag or clamshell and seal it with a label.
4. Do not put repair tags inside the shielding bag or clamshell.

Disconnect the wrist strap.

B TECHNICAL SPECIFICATIONS

B.1 MILLENNIUM-GLONASS GPSCARD

Table B.1 MiLLennium-GLONASS GPSCard Specifications

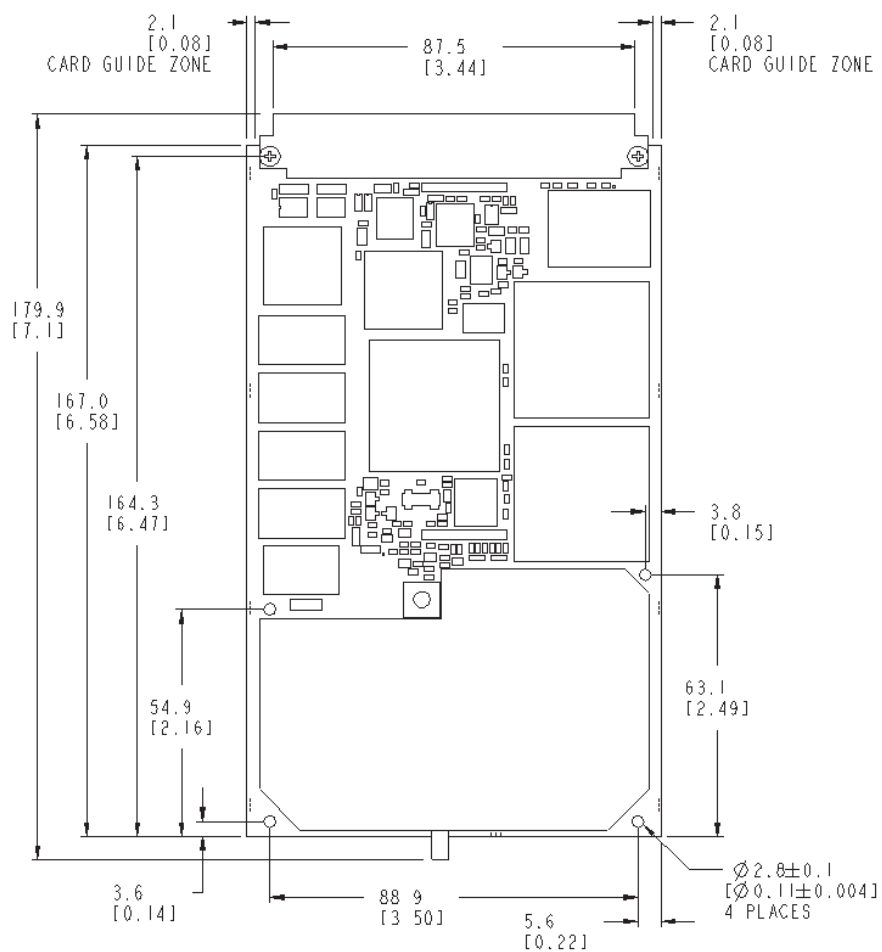
<i>PHYSICAL</i>	
Size	100.00 x 179.27 x 18.09 mm with connectors; Eurocard format
Weight	175 grams
<i>MECHANICAL DRAWINGS</i>	
Figure B.1 OEM5 Board Dimensions	
	
All dimensions in millimeters followed by inches	

Table B.1 MiLlennium-GLONASS GPSCard Specifications

Figure B.2 L1/L1 Series Side & End Views

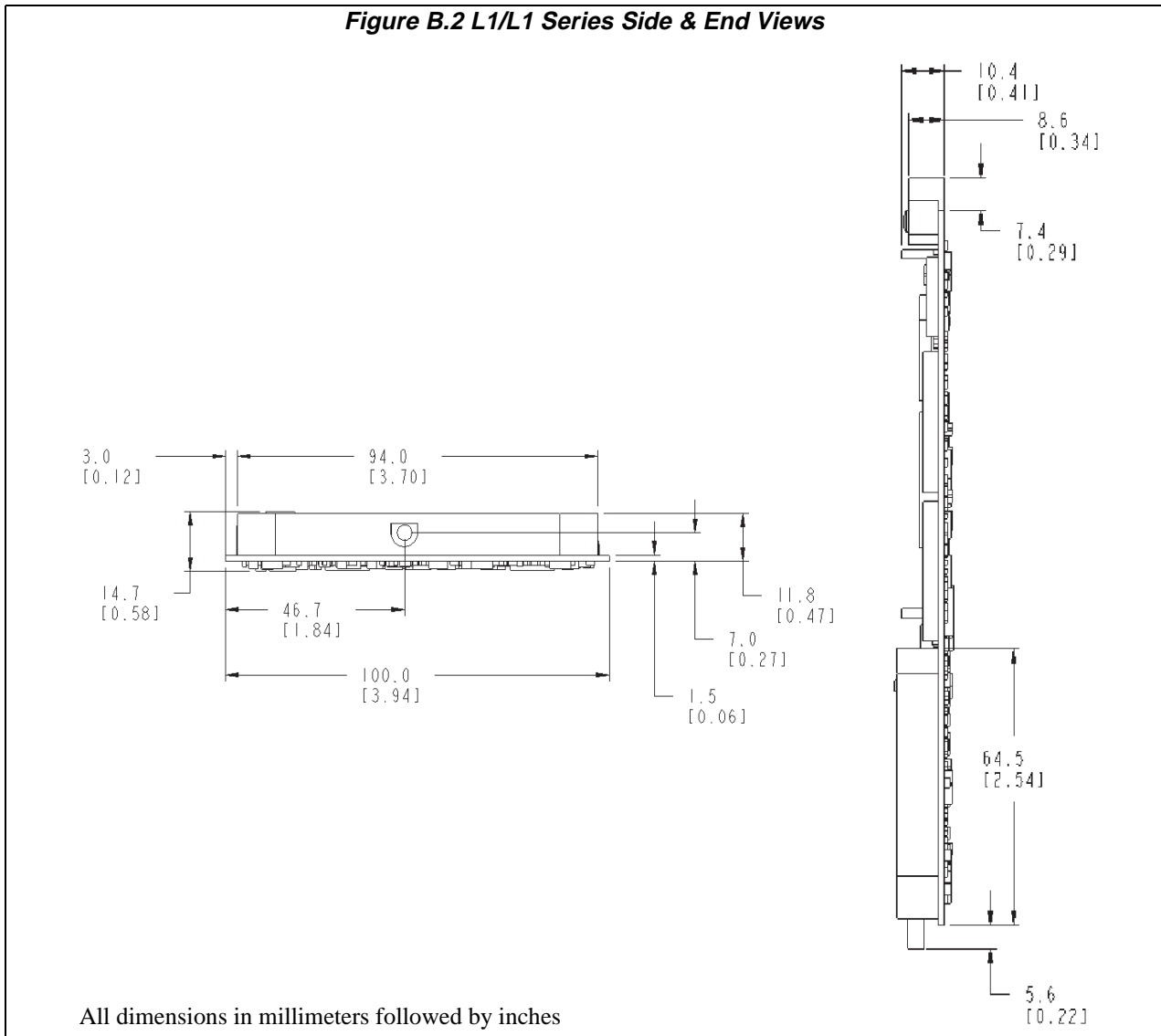


Table B.1 MiLLennium-GLONASS GPSCard Specifications (continued)

ENVIRONMENTAL	
Operating Temperature	-40°C to +85°C
Storage Temperature	-45°C to +95°C
Humidity	95% non-condensing (max.)
Altitude	Sea level to 5000 m [may operate above 5000 m in a controlled environment, however is not certified as such]
ACCELERATION	
Acceleration	6g maximum (sustained tracking)
POWER REQUIREMENTS	
Voltage	4.875 - 5.250 V DC
Allowable voltage ripple	75 mV p-p (max.)
Power	7.5 W (typ.), 9.2 W (max.)
POWER & DATA CONNECTOR ON THE MILLENNIUM-GLONASS GPSCARD	
Connector	64 pin 0.1" DIN 41612 Type B male right-angle
EXTERNAL CLOCK INPUT ON THE MILLENNIUM-GLONASS GPSCARD	
Connector	SMB male jack
External Clock Input	Frequency: 5 MHz or 10 MHz CW Input Impedance: 50 Ω nominal Input VSWR: 2.0:1 Signal Level: 4.0 dBm minimum to 10.0 dBm maximum Freq. stability: \pm 0.5 ppm maximum
RF INPUT / LNA POWER OUTPUT;	
Connectors	SMB male jack
RF Input	GPS = 1575.42 MHz GLONASS = 1602 - 1615.5 MHz
LNA Power Output	LNA power output is determined by the LNA jumper plug P301 position (internal/external)
Internal	4.25 - 5.25 V DC @ 0 - 180 mA (current limit 200 \pm 20 mA)
External	\leq 30 V DC, 100 mA max. (user-supplied)

Table B.1 MiLLennium-GLONASS GPSCard Specifications (continued)

PERFORMANCE (Subject To GPS and GLONASS System Characteristics)	
Frequency (L1)	GPS = 1575.42 MHz (± 0.5) GLONASS = 1602 - 1615.5 MHz
Codes tracked	C/A codes
Channels	10 GPS, 6 GLONASS (10 GPS, 8 GLONASS channel configuration is an option)
Re-acquisition	1.5-5 s typical
Computed Position Update Rate	Up to 4 solutions per second
Measured Data Update Rate	4 data records per second
Height Limit	Up to 18,288 m (60,000 feet), in accordance with export licensing
Velocity Limit	Up to 515 m/s (1000 Nmi/hr), in accordance with export licensing
Time to First Fix	70 s typical (cold start: no initial time or almanac)
Data Latency	Delay from measurement epoch until the first bit of transmitted log. PRTKB (differential) 160 ms typical
Pseudorange Position Accuracy (real-time)	Standalone: 10 m CEP, GDOP < 2 Differential: Code (with choke ring, HDOP < 2) = CEP < 0.75 m
RTK Position Accuracy	see Table 4.3 RT10 Convergence Summary on Page 41
Velocity Accuracy	0.03 m/s nominal (differential); 0.15 m/s nominal (single point)
Time Accuracy (relative)	50 ns (SA off); 250 ns (SA on)
INPUT/OUTPUT DATA INTERFACE	
Dual RS-232C Serial	Bit rates: 300, 1200, 4800, 9600, 19200, 57600, 115200 bps (9600 bps default)
Signals supported	TX, RX, RTS, CTS, DTR, DSR, DCD
Electrical format	EIA RS232C Standard
INPUT/OUTPUT STROBES	
VARF Output	A programmable variable frequency output ranging from 0.15 Hz - 5 MHz (refer to the FREQUENCY_OUT command in the <i>MiLLennium Command Descriptions Manual</i>), with pulse width from 100 ns to 6.55 ms. This is a normally high, active low pulse. There may be as much as 50 ns jitter on this signal.
PPS Output	A one-pulse-per-second time synchronization output. This is a normally high, active low pulse (1 ms \pm 50 ns) where the falling edge is the reference.
Measure Output	4 pulses-per-second output, normally high, active low where the pulse width is 1 ms. The falling edge is the receiver measurement strobe.
Mark Input	An input mark (negative pulse > 55 ns), time tags output log data to the time of the falling edge of the mark input pulse (refer to the LOG command syntax - ONMARK in the <i>MiLLennium Command Descriptions Manual</i>).
Status Output	Indicates a valid GPS position solution is available. A high level indicates a valid solution or that the FIX POSITION command has been set (refer to the FIX POSITION command in the <i>MiLLennium Command Descriptions Manual</i>).
RESETOUT	Polarity- positive pulse; 140 ms \leq pulse duration \leq 280 ms
RESETIN	A high to low transition causes a system reset.
The electrical specifications of the strobe signals are as follows:	
Output	Voltage: Standard TTL levels Sink Current: 64 mA Source Current: 15 mA
Input	Voltage: Standard TTL levels Current: \leq 5 mA

Table B.2 64 Pin I/O Connector Description

Row B	Descriptions	Pin	Row A	Descriptions
GND	Digital Ground	1	GND	Digital Ground
+5V	Input, power supply	2	+5V	Input, power supply
*	Reserved for future use	3	N/C	
LNA_PWR	Optional external power to antenna other than a standard NovAtel GPS/GLONASS antenna (jumper plug P301 must be correctly set)	4	GND	Digital Ground
N/C		5	*	For factory use only
N/C		6	*	For factory use only
N/C		7	GND	Digital Ground
N/C		8	DTR1	Data Terminal Ready for COM 1
CTS1	Clear to Send for COM 1	9	TXD1	Transmitted Data for COM 1
RTS1	Request to Send for COM 1	10	RXD1	Received Data for COM 1
DSR1	Data Set Ready for COM 1	11	DCD1	Data Carrier Detected for COM 1
N/C		12	N/C	
N/C		13	*	For factory use only
N/C		14	*	For factory use only
N/C		15	GND	Digital Ground
N/C		16	DTR2	Data Terminal Ready for COM 2
CTS2	Clear to Send for COM 2	17	TXD2	Transmitted Data for COM 2
RTS2	Request to Send for COM 2	18	RXD2	Received Data for COM 2
DSR2	Data Set Ready for COM 2	19	DCD2	Data Carrier Detected for COM 2
N/C		20	N/C	
VARF Output	Variable-frequency pulse train; normally high, active low. Pulse width: 100 ns - 6.55 ms. Frequency range: 0.15 Hz - 5 MHz.	21	GND	Digital Ground
1PPS Output	Normally high, active low, 1 ms \pm 50 ns pulse is output at 1 Hz (\pm 50 ns when clock steering on). Falling edge is used as reference.	22	GND	Digital Ground
Measure Output	Normally high, active low pulse is 1 ms \pm 50 ns wide. Falling edge is used as the reference. 10 Hz repetition rate.	23	GND	Digital Ground
Mark Input	Normally high, active low input pulse must exceed 55 ns in duration. The falling edge is the reference. TTL or contact closure compatible.	24	GND	Digital Ground
STATUS	High level output indicates 'good solution' or valid GPS position. Low level output indicates 'no solution'.	25	GND	Digital Ground
*	For factory use only	26	GND	Digital Ground
*	For factory use only	27	GND	Digital Ground
\ RESET_IN	Reset TTL signal input from external system; active low.	28	GND	Digital Ground
RESET_OUT	Reset TTL signal output to external system; active high; 140 - 280 ms duration.	29	GND	Digital Ground
*	For factory use only	30	GND	Digital Ground
*	For factory use only	31	GND	Digital Ground
*	Kept high; for factory use only	32	GND	Digital Ground

C COMMON UNIT CONVERSIONS

Section C.1 to C.4 list commonly used equivalents between the SI (Système Internationale) units of weights and measures used in the metric system, and those used in the imperial system. A complete list of hexadecimal values with their binary equivalents is given in Section C.5 while an example of the conversion from GPS time of week to calendar day is shown in Section C.6. GLONASS time conversion is explained in Section C.7, and angular conversions may be found in Section C.8.

C.1 DISTANCE

1 meter (m) = 100 centimeters (cm) = 1000 millimeters (mm)

1 nautical mile = 1852 meters (m)

1 international foot = 0.3048 meter

1 kilometer (km) = 1000 meters (m)

1 statute mile = 1609 meters (m)

1 US survey foot = 0.3048006096 meter (m)

C.2 VOLUME

1 liter (l) = 1000 cubic centimeters (cc)

1 gallon (British) = 4.546 liters (l)

1 gallon (US) = 3.785 litres (l)

C.3 TEMPERATURE

degrees Celsius = $(5/9) \times [(\text{degrees Fahrenheit}) - 32]$

degrees Fahrenheit = $[(9/5) \times (\text{degrees Celsius})] + 32$

C.4 WEIGHT

1 kilogram (kg) = 1000 grams

1 pound = 0.4536 kilogram (kg)

C.5 HEXADECIMAL TO BINARY CONVERSION

Hexadecimal	Binary	Hexadecimal	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

C.6 GPS TIME OF WEEK TO WEEK AND TIME OF DAY (EXAMPLE)

511200 seconds	Day	$511200 / 86400$ seconds per day	5.916666667 days
	Hour	$0.916666667 \times 86400 / 3600$ seconds per hour	22.0000 hours
	Minute	$0.000 \times 3600 / 60$ seconds per minute	0.000 minutes
	Second	0.000×60	0.000 seconds

Day 5 (Thursday) + 22 hours, 0 minutes, 0 seconds into Friday.

C.6.1 CALENDAR DATE TO GPS TIME

Example:

Days from January 6, 1980 to January 28, 2005 = 6 years x 365 days /year =	9125 days
Add one day for each leap year (a year is a leap year if it is divisible by 4 but not by 100, except for years that are divisible by 400)	7 days
Days into 2005 (28th is not finished)	27 days
Total days	9159 days
Deduct 5 days: (Jan. 1 - 5, 1980)	9154 days
GPS Week: 9154 x 86400 seconds per day = 790905600 seconds/ 604800 sec per week	
Every 1023 weeks the week rolls over to 0	283 weeks
Seconds into week 6th day: 13.5 hrs x 3600 sec/hr	48600 seconds
GPS time of week:	Week 283, 48600 second

C.7 ANGULAR CONVERSIONS

$\pi = 3.1415927\dots$

$$\text{radians} = \text{degrees} \times (180/\pi)$$

$$\text{degrees} = \text{radians} \times (\pi/180)$$

$$\text{Magnetic bearing} = \text{True bearing} + \text{Magnetic variation}^1$$

$$\text{True bearing} = \text{Magnetic bearing} - \text{Magnetic variation}^1$$

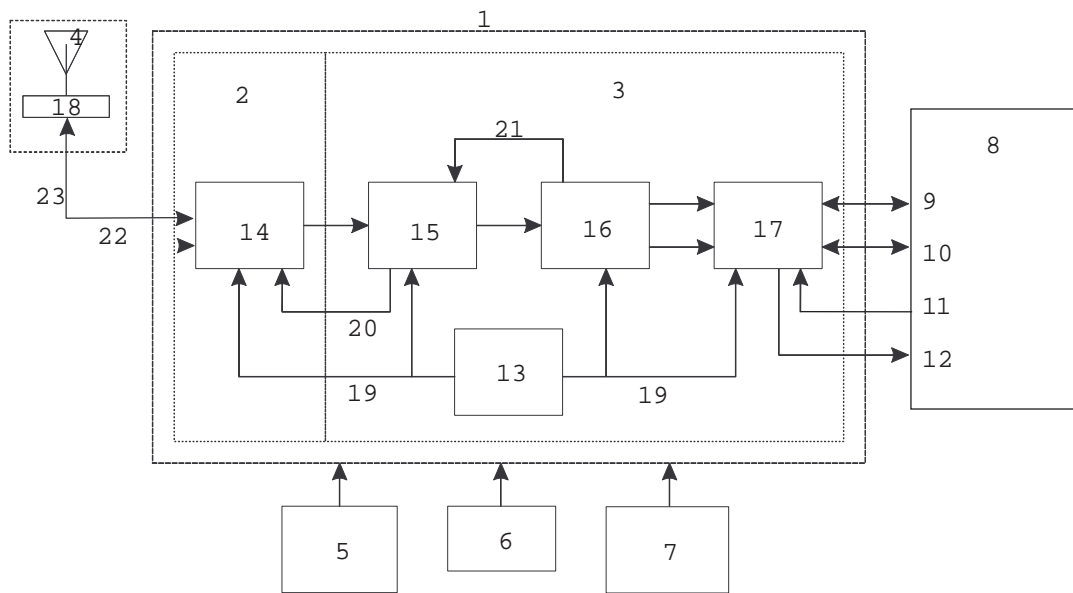
NOTE: ¹ A variation west is negative while a variation east is positive, see *Pages 86 and 103* for illustrations.

D FUNCTIONAL OVERVIEW

D.1 MILLENNIUM-GLONASS GPSCARD SYSTEM

The MiLLennium-GLONASS GPSCard consists of a radio frequency (RF) and a digital electronics section. Prior to operation, a GPS/GLONASS antenna, power supply, and data and signal interfaces must be connected. The installation instructions for a MiLLennium-GLONASS GPSCard and a ProPak II or PowerPak II may be found in *Chapter 3 (Page 17)*, *Appendix E (Page 59)* and *Appendix F (Page 73)* respectively. The overall system is represented in *Figure D.1*. A brief description of each section follows.

Figure D.1 MiLLennium-GLONASS GPSCard System Functional Diagram



Reference	Description	Reference	Description
1	MiLLennium-GLONASS GPSCard	11	Input timing strobe
2	RF section	12	Output timing strobe
3	Digital section	13	VCTCXO
4	Antenna capable of receiving L1 signal NovAtel GPS/GLONASS antenna or user-supplied	14	RF - IF sections
5	Optional user-supplied LNA power (0 - 30 VDC)	15	Signal Processor
6	User-supplied power (5 VDC)	16	32-bit CPU
7	Optional external oscillator (5 or 10 MHz)	17	System I/O
8	User-supplied data and signal processing equipment	18	LNA
9	COM1	19	Clock signals
10	COM2	20	AGC signals
		21	Control signals
		22	RF and power connectors
		23	Primary antenna feed

D.1.1 GPS/GLONASS ANTENNA

The purpose of the GPS/GLONASS antenna is to convert the electromagnetic waves transmitted by the combined GPS/GLONASS satellites at the L1 frequency (1575.42 MHz for GPS and 1602 - 1615.5 MHz for GLONASS) into RF signals. The MiLLennium-GLONASS GPSCard will function best with an active GPS/GLONASS antenna; there is a hardware provision to select an internal or external DC power supply for an active GPS/GLONASS antenna. Note that the antenna self-test will return a “fail” condition if a passive antenna is used (for further information on self-test status codes, please see *RVSA/B log, Page 109*). NovAtel active antennas are

recommended.

NovAtel offers the 504 and 514 model antennas to work with your MiLLennium-GLONASS GPSCard system. Both antennas use low-profile microstrip technology and include band-pass filtering and an LNA. The GPS/GLONASS antenna you choose will depend on your particular application. The NovAtel antennas available to work with your MiLLennium-GLONASS GPSCard system are single-frequency models, and each of these models offers exceptional phase-center stability as well as a significant measure of immunity against multipath interference. Both models have an environmentally-sealed radome.

NovAtel also offers high-quality coaxial cable in standard 5 (Model C005), 15 (Model C015) and 30 m (Model C030) lengths. These come with a TNC male connector at each end. Should your application require the use of cable longer than 30 m you will find the application note *Extended Length Antenna Cable Runs* at our website, <http://www.novatel.ca>, or you may obtain it from NovAtel Customer Service directly, see Page 7.

While there may be other coaxial cables and antennas on the market which may also serve the purpose, please note that the performance specifications of the MiLLennium-GLONASS GPSCard are warranted only when it is used with NovAtel-supplied accessories.

D.1.2 PRINCIPAL POWER SUPPLY

A single external power supply (4.875 - 5.250 V DC) is all that is necessary to meet the MiLLennium-GLONASS GPSCard's 8 W (typical) power consumption.

D.1.3 OPTIONAL LNA POWER SUPPLY

The MiLLennium-GLONASS GPSCard provides power to its GPSAntennas out of the primary 5 V DC input. However, if a different type of antenna is required that is incompatible with this supply, then you could connect an additional power source (≤ 30 V DC, 100 mA maximum and user-supplied) to the MiLLennium-GLONASS GPSCard. In either case, the power is fed to the antenna through the same coaxial cables used for the RF signals.

D.1.4 RADIO FREQUENCY (RF) SECTION

The MiLLennium-GLONASS GPSCard receives partially filtered and amplified GPS and GLONASS signals from the antenna via the coaxial cable. The RF section does the following:

- filters the RF signals to reduce noise and interference
- down-converts (with further band-limiting) the RF signals to intermediate frequencies (IFs) that are suitable for the analog-to-digital (A/D) converter in the digital electronics section
- amplifies the signals to a level suitable for the A/D converter in the digital electronics section
- receives an automatic gain control (AGC) input from the digital signal processor (DSP) to maintain the IF signals at a constant level
- supplies power to the active antenna through the coaxial cable while maintaining isolation between the DC and RF paths. A hardware jumper configuration is provided to select an internal or external DC power supply for the active GPS/GLONASS antenna.

The RF section can reject a high level of potential interference (e.g., MSAT, Inmarsat, cellular phone, and TV sub-harmonic signals).

D.1.5 DIGITAL ELECTRONICS SECTION

The digital section of the MiLLennium-GLONASS GPSCard receives down-converted, amplified combined GPS/GLONASS signals which it digitizes and processes to obtain a GPS solution (position, speed, direction and time). The digital section consists of an analog-to-digital converter, a 32-bit 25 MHz system processor, memory, control and configuration logic, signal processing circuitry, serial peripheral devices, and supporting circuitry. I/O data and timing strobe signals are routed to and from the board via a 64-pin DIN 41612 Type B male connector. Two EIA RS-232C serial communications ports support user-selectable bit rates of 300 - 115,200 bps, with a default of 9600 bps. The digital section does the following:

- converts the IF analog signals to a digital format
- tracks the C/A codes and carrier phases of the satellites in use
- performs channel and loop control
- performs position computation

- executes navigation software
- performs database management
- monitors self-test system status
- controls diagnostic LEDs: a red one which only lights up to indicate an error condition, and a green one (the “heartbeat”) which blinks on and off at approximately 1 Hz to indicate normal operation.
- controls I/O functions

The strobe signals are described as follows:

- *Mark input*: this signal provides a time tag to the signal processors, which respond to a falling edge of the signal provided from an external device. It can be enabled by you to provide a precise time and data output event.
- *Measure output*: an output set to 10 pulses per second. This output is also routed to the signal processors, where it provides a trigger for the measurement collection.
- *Variable-frequency (VARF) output*: a user-programmable, variable-frequency pulse train (not available in the ProPak II enclosure option)
- *PPS output*: a 1 ms pulse repeating at a 1 Hz rate that is used to synchronize the board with external devices.
- *Status output*: an output that changes logic states when a valid GPS position is obtained (not available in the ProPak II enclosure option)

You configure the MiLlennium-GLONASS GPSCard using special commands (see *Quick Start, Page 15*). In turn, the MiLlennium-GLONASS GPSCard presents information to you in the form of pre-defined logs in a number of formats. In addition, when a MiLlennium-GLONASS GPSCard is linked to a NovAtel GPSCard receiver or second MiLlennium-GLONASS GPSCard for differential positioning, they can communicate directly through their serial ports.

E PROPAK II ENCLOSURE

E.1 INTRODUCTION

The ProPak II enclosure, see *Figure E.1*, is rugged, reliable, and designed for adverse environments. It offers you unparalleled flexibility. It is intended to be used with the following NovAtel accessories and options:

- A NovAtel Model 504 or Model 514 L1 GPS/GLONASS antenna - single frequency
- Model C005, C015, or C030 (5, 15 or 30 m lengths) coaxial cable - to connect the GPS/GLONASS antenna to the ProPak II enclosure
- 33.5 cm or 75 cm 4-pin LEMO plug to 4-pin LEMO plug connector (NovAtel part numbers 01016724 and 01016725 respectively)
- Model GPS-APRO auto-ranging AC/DC converter and power cables.

Figure E.1 ProPak II Enclosure



After the addition of these accessories together with user-supplied data communications equipment and a power supply, the ProPak II enclosure will be ready for the most demanding applications.

E.1.1 FEATURES

The ProPak II enclosure comes with the following:

- rugged, shock, water, EMC, EMI and dust-resistant enclosure
- two serial communication ports
- an I/O strobe port
- one RF port
- an input power port
- a mounting plate
- one straight and one null-modem serial data cable
- one I/O strobe cable
- one 4-pin LEMO socket connector to cigarette lighter plug with built-in 3 amp slow-blow fuse

The enclosure measures 251 mm x 130 mm x 62 mm, weighs 1.3 kg and is constructed of extruded aluminum. The enclosure is sealed by two end-caps, and the entire unit is closed with five mounting screws.

NOTE: The unit is sealed to provide protection against adverse environmental conditions; therefore, any attempt to open the case will impair the water-resistant qualities of the enclosure, and void the warranty.

E.1.2 CONNECTIONS AND INDICATORS

The ProPak II enclosure features front and rear end-caps (*Figure E.2* and *Figure E.3*), each with appropriate indicator lights and connectors. The front end-cap indicator glows red when power is on, and green when a valid position is computed.

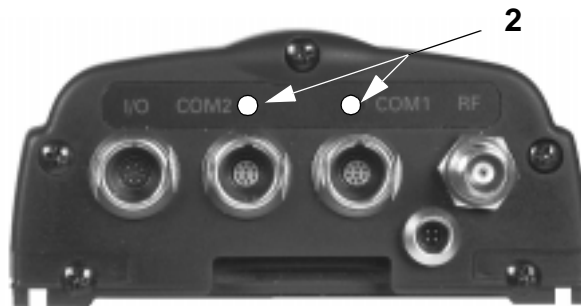
Figure E.2 ProPak II Enclosure Front End-Cap



1 Indicator	Status
Red	Power on
Green	Valid position computed

On the rear end-cap there are connections for the I/O strobe signals, COM1 and COM2 serial ports, power input and an RF input from the GPS/GLONASS antenna. There is an LED above each serial port connector. If an LED glows red, data is being received by the ProPak II enclosure on that port, while if an LED glows green, data is being transmitted by the ProPak II enclosure on that port.

Figure E.3 ProPak II Enclosure Rear End-Cap




2 Indicator	Status
Red	Receiving
Green	Transmitting
Yellow	Both the above

E.2 SPECIFICATIONS

Only those specifications which differ from the MiLLennium-GLONASS GPSCard (see *Table B.1, Page 49*) will be shown in *Table E.1*.

Table E.1 ProPak II Enclosure Specifications

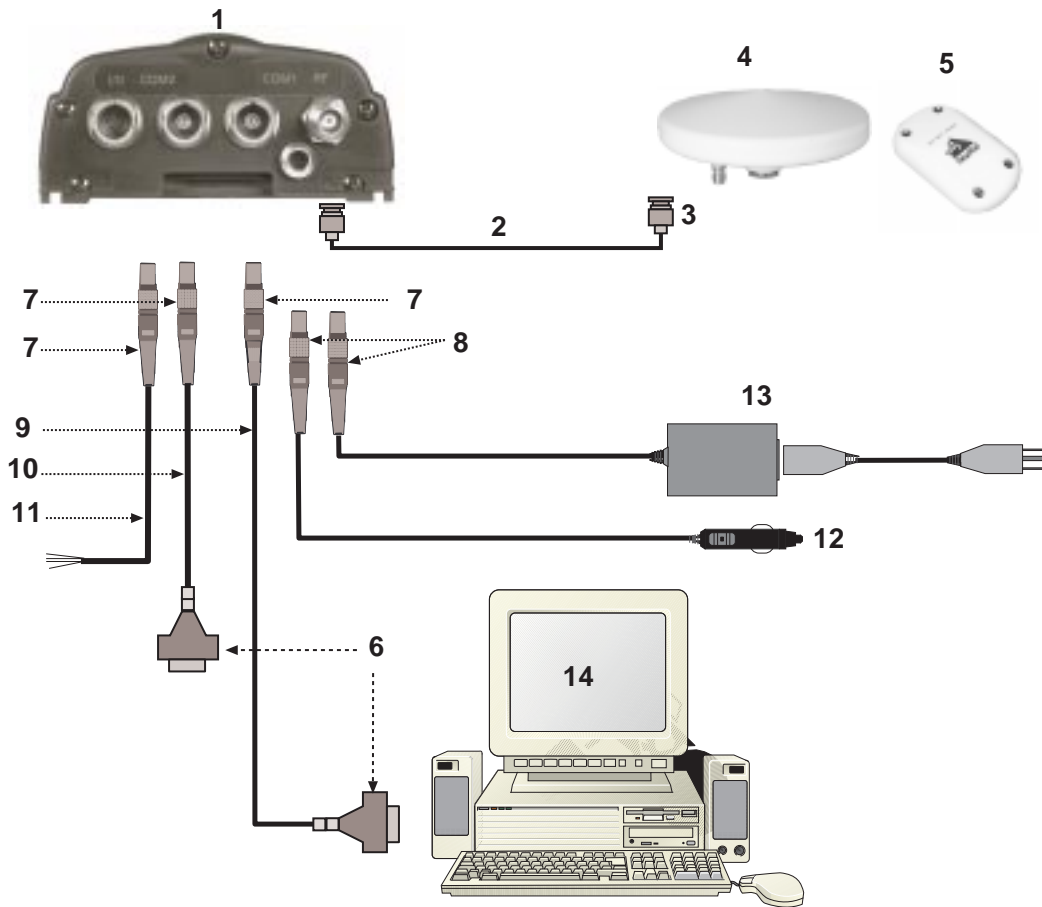
PHYSICAL						
Size:	251 mm x 130 mm x 62 mm					
Weight:	1.3 kg					
ENVIRONMENTAL						
Operating Temperature	-40°C to +55°C					
Storage Temperature	-45°C to +85°C					
Resistance Characteristics	Dust tight, water tight					
Humidity	5% to 95% RH (non-condensing) at +40°C					
POWER REQUIREMENTS						
Voltage	+10 to +36 V DC					
Power	12 W (typical)					
RF INPUT / LNA POWER OUTPUT						
Connectors on ProPak II enclosure	One TNC female connector					
RF Input	GPS: 1575.42 MHz GLONASS: 1602 - 1615.5 MHz					
Power Output to LNA	4.25 - 5.25 V DC @ 0 - 90 mA (current limit: 200 ± 20 mA).					
VIBRATION (Random Profile)						
The MiLLennium-GLONASS GPSCard will acquire and track satellites while undergoing vibration levels as shown below. This assumes that it is mounted using full-length clamped rail mounts and that no vibrating object is touching it. It also assumes that $C/N_0 > 45$ dB-Hz and that the MiLLennium-GLONASS GPSCard is in high-dynamics mode.						
Frequency	< 10 Hz	10 Hz	40 Hz	1000 Hz	2000 Hz	>2000 Hz
Magnitude (g^2/Hz)	+ 80 dB/decade	0.00125	0.02	0.02	0.005	-80 dB/decade
Typical Mounting Configuration - Mount the MiLLennium-GLONASS GPSCard securely using screws driven through the card's four corner mounting holes. Superior Mounting Configuration - Mount the card using full length clamped rail mounts. Note: The card is sensitive to anything that rattles against it.						
PHOTOGRAPHS						
ProPak II enclosure side view, front end-cap view and rear end-cap view respectively:						
						

E.3 HARDWARE CONFIGURATION

Installing the ProPak II enclosure is a straightforward process. As shown in *Figure E.4*, a minimum configuration is established with the following setup:

- Set up the GPS/GLONASS antenna, see *GPS/GLONASS Antenna Considerations, Page 23*.
- Route and connect coaxial cable between the GPS/GLONASS antenna and the ProPak II enclosure.
- Connect an RS232C communication interface to one of the serial ports of the ProPak II enclosure. The supplied null-modem cables are intended for RS232C communications only.
- Connect the output of the optional power converter to the input power jack of the ProPak II.

Figure E.4 Typical ProPak II Enclosure Installation Configuration



Reference	Description
1	ProPak II enclosure
2	RF antenna cable
3	RF antenna connection
4	Model 504 antenna*
5	or Model 514 antenna
6	9-pin D-connector
7	Male LEMO socket
8	Female LEMO plug
9	Null-modem serial data cable (female connector attaches to user-supplied operator interface)

Reference	Description
10	Straight serial data cable (male connector attaches to user-supplied modem or radio transmitter)
11	I/O strobe cable
12	Automotive cigarette-lighter adapter
13	Auto-ranging AC/DC converter
14	Operator interface

* Or any L1 GPS/GLONASS antenna model

NOTE: The 4-pin LEMO socket connector to 4-pin LEMO plug connector, auto-ranging AC/DC converter and AC power cord do not come with the ProPak II enclosure but are optional accessories.

The term plug/socket refers to the outside of the connector while the term male/female refers to the pin type.

E.3.1 POWER SUPPLY CONSIDERATIONS

The ProPak II enclosure incorporates a DC/DC power converter providing filtering, automatic reset circuit protection and voltage regulation. It accepts a single input voltage between the range +10 to +36 V DC, which can be supplied either from an automotive DC source or by the optional auto-ranging AC/DC converter (NovAtel part number GPS-APRO) which operates over a range of 110 - 220 V AC and 50 - 60 Hz. The power input is reverse-polarity protected. Refer to *Table E.1, Page 61*, for further information.

WARNING: The MiLLennium-GLONASS GPSCard will suspend operation if voltage supplied falls outside input range +10 to +36 V DC.

E.3.2 MOUNTING CONSIDERATIONS

A mounting kit is provided with the ProPak II enclosure (see *Section E.3.2.1, Page 64*) to facilitate mounting it to a surface. The mounting kit includes the following materials:

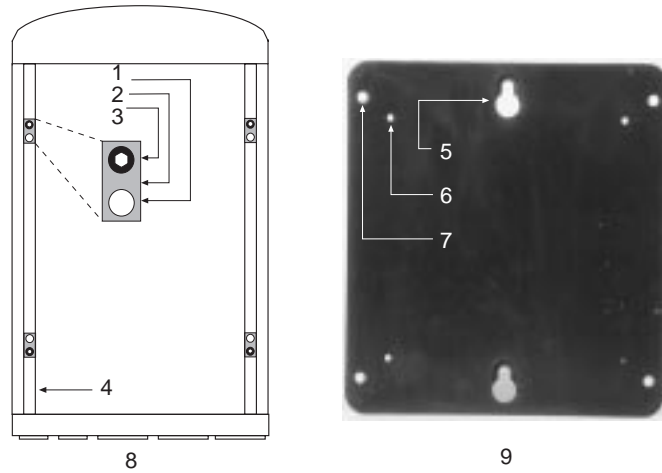
- four self-tapping screws (#10-16 x $\frac{1}{2}$ " LG)
- two wood screws (#10 x $\frac{3}{4}$ " LG)
- four flat screws (M3 x 8, 90° countersink)
- aluminum mounting plate (see *Page 64*)

First, the mounting plate needs to be attached to the ProPak II enclosure. There are two channels running the length of the bottom of the ProPak II enclosure. In each of these channels there are two rectangular nuts, held in place by grub screws. These four nuts are factory-positioned so that the mounting plate can be attached to the ProPak II enclosure using the four flat screws. Please ensure that the four flat screws are mounted from the countersunk side of the mounting plate.

Once the plate has been attached to the ProPak II enclosure, the entire assembly can then be mounted onto a surface using either the four self-drilling screws through the screw mount holes, or the two tapping screws through the quick-mount holes.

WARNING: The mounting kit is not designed for use in high-dynamics or high-vibration environments. Contact your dealer or NovAtel Customer Service if your application requires the ProPak II enclosure to be mounted in these types of environment.

E.3.2.1 Mounting Plate (NovAtel part number 70015024)



Reference	Description	Reference	Description
1	Thread for flat screw	6	Holes to mount plate to enclosure using flat screw
2	Rectangular nut	7	Holes to mount assembly to a surface using self-tapping screws
3	Grub screw	8	Back of receiver enclosure
4	Channel	9	Front of mounting plate
5	Quick-mount holes to mount assembly to surface using wood screws		

E.3.3 CABLES

Please see the following sections for the technical specifications of all cables and optional accessories. For field replacement of the LEMO connectors, and to find part numbers of optional accessories, please see *Appendix K, Page 126*.

E.3.3.1 I/O Strobe Port Cable

The I/O strobe lines can be accessed by inserting the 8 pin LEMO connector of the I/O strobe port cable (NovAtel part number 01016330) 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. The *Input/Output Strobes* section of *Table B.1, Page 52* contains descriptions of each of the I/O strobes, along with their electrical specifications.

For field replacement of the LEMO connector, please consult *Appendix K, Page 126* for a list of the manufacturers' part numbers.

Note that the STATUS line is used to toggle the valid-position LED on the front end-cap between red (power on) and green (valid position).

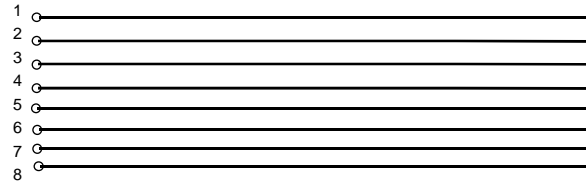
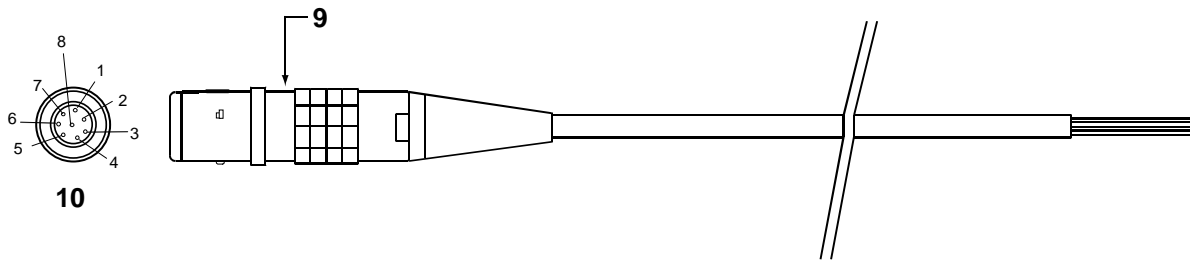
Please see *Section E.3.3.1.1* for a drawing of the cable.

Two serial data cables are supplied with the ProPak II enclosure to connect the receiver to a PC or modem/radio. They both look identical but their uses and part numbers differ.

The straight cable (see *Section E.3.3.2.1*), 10-pin LEMO plug to 9-pin D-connector (DE9P plug), is used to connect the receiver to a modem or radio transmitter to propagate differential corrections. Its NovAtel part number is 01016383.

The null-modem cable (see *Section E.3.3.2.2*), 10-pin LEMO plug to 9-pin D-connector (DE9S socket), is used to connect the receiver to a serial (RS232C) communication port on a terminal or computer. Its NovAtel part number is 01016329.

E.3.3.1.1 I/O Strobe Port Cable (NovAtel part number 01016330)

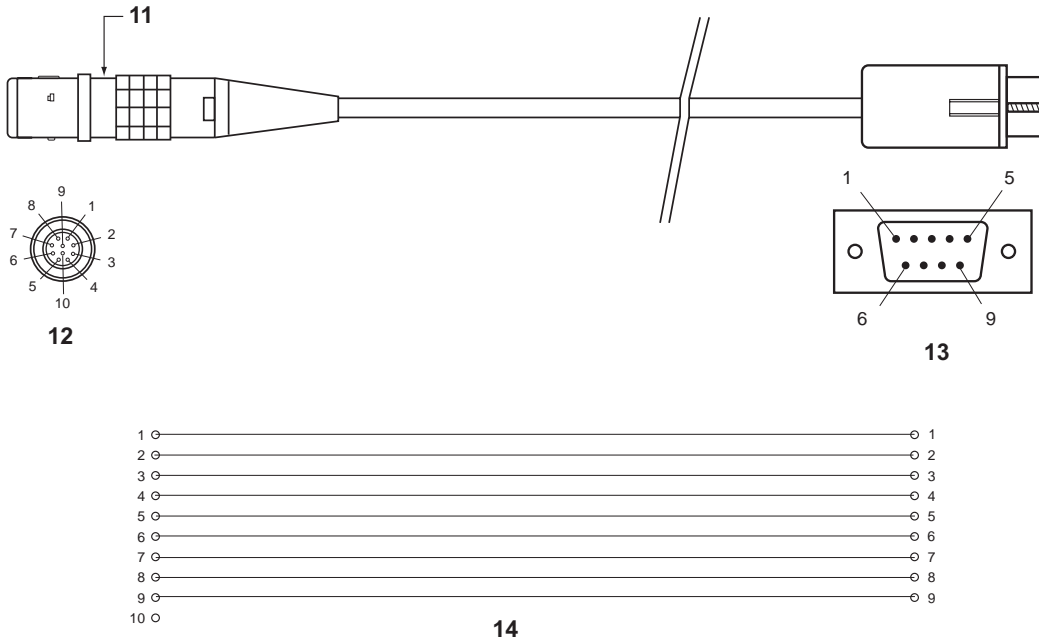


11

LEMO Pin Number	Pin Description	Wire Color Code
Pin 1	VARF, variable frequency	Brown
Pin 2	1 PPS, one pulse per second	Black
Pin 3	MSR, measure output	Red
Pin 4	MKI, mark input	Orange
Pin 5	STATUS , valid solutions available	Yellow
Pin 6	GND	Green
Pin 7	GND	Blue
Pin 8	GND	White

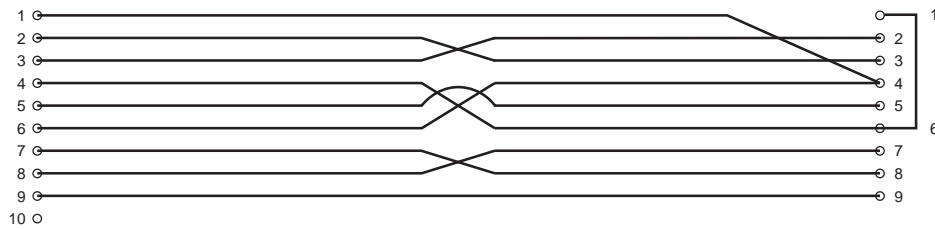
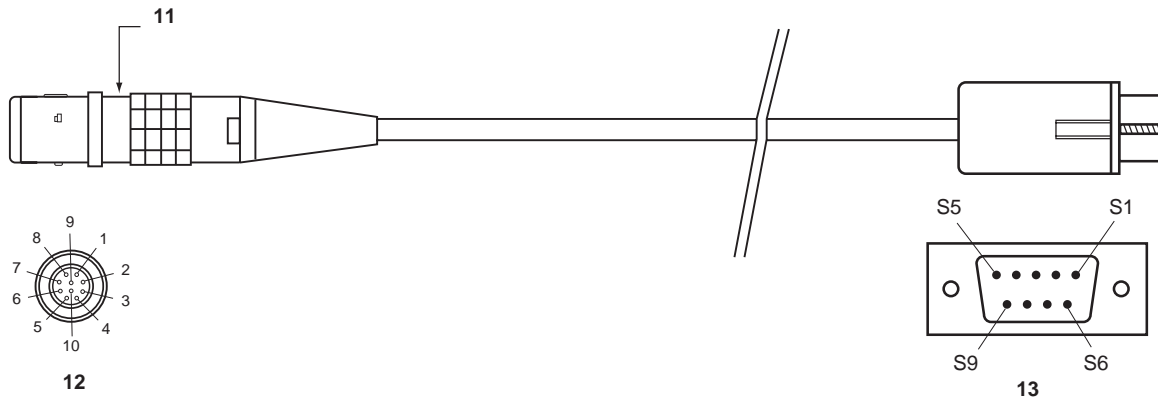
Reference	Description
9	Red marker at top of connector
10	LEMO 8-pin plug (female)
11	8-conductor wireE.3.3.2 Serial Data Cables

E.3.3.2.1 Straight Serial Cable - receiver to PC (NovAtel part number 01016383)



LEMO Pin Number	RS232C Signal	Wire Color Code	DE9P Pin Number
Pin 1	DCD	Brown	Pin 1
Pin 2	RXD	Black	Pin 2
Pin 3	TXD	Red	Pin 3
Pin 4	DTR	Orange	Pin 4
Pin 5	GND	Yellow	Pin 5
Pin 6	DSR	Green	Pin 6
Pin 7	RTS	Blue	Pin 7
Pin 8	CTS	Violet	Pin 8
Pin 9	NULL	Gray	Pin 9
Pin 10		White (not used)	

Reference	Description
11	Red marker at top of connector
12	Male LEMO 10-pin plug
13	DE9P (male connector)
14	10-conductor wire

E.3.3.2.2 Null-modem Serial Cable - Receiver to radio (NovAtel part number 01016329)


14

LEMO Pin Number	RS232C Signal	Wire Color Code	DE9S Pin Number
Pin 1	DCD	Brown	Pin 4
Pin 2	RXD	Black	Pin 3
Pin 3	TXD	Red	Pin 2
Pin 4	DTR	Orange	Pin 6
Pin 5	GND	Yellow	Pin 5
Pin 6	DSR	Green	Pin 4
Pin 7	RTS	Blue	Pin 8
Pin 8	CTS	Violet	Pin 7
Pin 9	NULL	Gray	Pin 9
Pin 10		White (not used)	Pin 1 jumpered to Pin 6

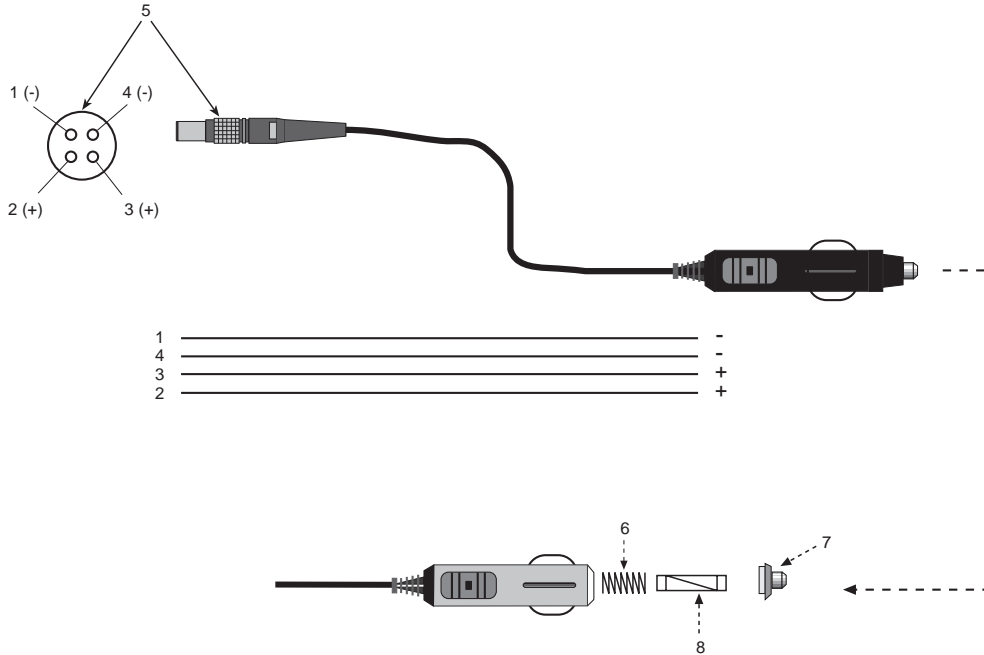
Reference	Description
11	Red marker at top of connector
12	Male LEMO 10-pin plug
13	DE9S (female connector)
14	10-conductor wire

E.3.3.3 Input Power Cables

The following cables allow you to power the ProPak II enclosure from either an AC source, an automotive DC source or a battery.

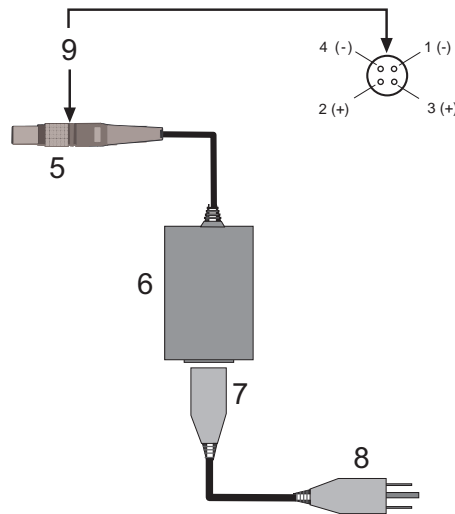
- 4-pin LEMO socket connector to cigarette-lighter plug with built-in 3 amp slow-blow fuse (NovAtel part number 01016331)
- Optional 4-pin LEMO socket connector to auto-ranging AC/DC converter, and AC power cord (NovAtel part number GPS-APRO)
- Optional 33.5 cm or 75 cm 4-pin LEMO plug to 4-pin LEMO plug connector (NovAtel part numbers 01016724 and 01016725 respectively)

E.3.3.3.1 Input Power Cable (NovAtel part number 01016331)



Reference	Description	Reference	Description
1	Brown - GND	5	Red marker at top of connector
2	Orange + +10 to +36 V DC	6	Spring
3	Red + +10 to +36 V DC	7	Universal tip
4	Black - GND	8	3 amp slow-blow fuse

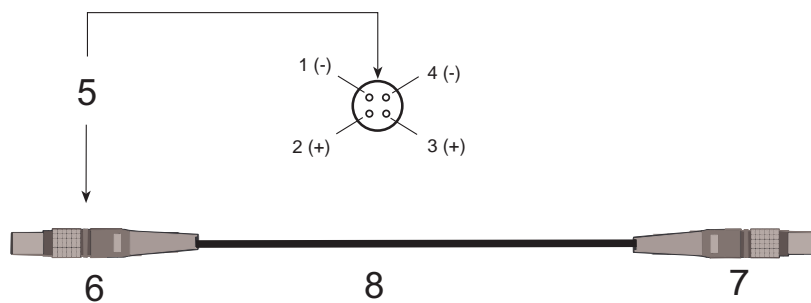
E.3.3.3.3 Auto-ranging AC/DC Converter & Power Cord (NovAtel part number GPS-APRO)



LEMO Pin Number	Signal	Color Code
1	Negative	Black
2	Positive	White
3	Positive	Red
4	Negative	Green

Reference	Description	Reference	Description
5	Female LEMO plug	8	AC plug
6	Auto-ranging AC/DC converter	9	Red marker at top of connector
7	AC socket		

E.3.3.3.4 Straight Power Cable In 33.5 cm and 75 cm lengths (NovAtel part numbers 01016724 and 01016725 respectively)



LEMO Pin Number	Signal	Color Code
1	Negative, GND	Brown
2	Positive, +10 to +36 V DC	Orange
3	Positive, +10 to +36 V DC	Red
4	Negative, GND	Black

Reference	Description
5	Red marker at top of connector
6	LEMO 4 pin plug
7	LEMO 4 pin plug
8	Extension

E.4 OTHER OPTIONAL PROPAK II ACCESSORIES

E.4.1 BATTERY ASSEMBLY (NOVATEL PART NUMBER 01016698)

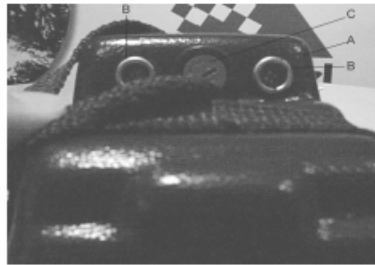
The optional NovAtel battery for the ProPak-II (NovAtel part number 01016698), see *Figure E.5*, has been selected to offer the best compromise between availability, ease of maintenance and duration of operation. It should be handled with care, and prevented from being severely knocked or dropped.

Figure E.5 Battery Assembly



WARNING: Be sure that the battery is positioned upright during the charging process – it must not be upside-down, as this will damage the battery.

Figure E.6 Battery Cap



The battery cap (A) is designed to allow you to change the battery fuse without removing the cap. The cap, see *Figure E.6*, is raised in the center with a flat edge that contains two lemo connectors (B) and the fuse holder (C). The fuse holder is located between the two lemo connectors, and it is easily opened with a flat head screwdriver, enabling you to quickly gain access to, and change, the fuse.

The life of this type of battery is typically between one to four years, depending on the amount of usage. If it becomes necessary to replace the battery you can purchase a complete battery assembly from NovAtel; otherwise the following procedure is recommended.

1. Select a sealed lead-acid battery having the same or comparable ampere-hour (A-h) rating.
2. Remove the existing positive lead (marked + and colored red) and negative lead (marked “-” and colored black).
3. Insert the RED (+ positive terminal) lead of the battery cable onto the RED (+ positive terminal) of the battery. Insert the BLACK (- negative terminal) lead of the battery cable onto the BLACK (- negative terminal) of the battery.
4. Secure battery cap to battery using velcro straps.
5. Recycle the old or worn battery by contacting your local recycling authority, or NovAtel (1-800-NOVATEL), for instructions on proper disposal. This battery is a recyclable product and should NOT be discarded in a landfill site.

DISPOSAL: Sealed lead-acid batteries are considered as Hazardous Waste by most local and Federal Waste Control Boards and must be disposed of properly. This means that spent batteries must be taken or shipped to an appropriate disposal site. Contact your local battery dealers or Waste Control authority to find out the specific regulations in your area concerning battery disposal.

NOTE: Before using the battery for the first time, charge the battery for a minimum of 10 hours. The battery is shipped in a discharged condition.

E.4.1.1 Battery Specifications:

The battery has the following specifications:

Description:	Absorbed electrolyte, sealed lead-acid in flame retardant case	
Dimensions:	Height:	94 mm (3.70 in.)
	Length:	151 mm (5.95 in.)
	Width:	64.5 mm (2.54 in.)
Weight:	Approx. 2270 g (5.0 lb.)	
Voltage:	12 V DC typical	
Rated Capacity:	20 hour rate	7.2 A-h
Capacity at 77° F (25° C)	20 hour rate (360 mA)	7.2 A-h
	10 hour rate (680 mA)	6.8 A-h
	5 hour rate (1260 mA)	6.3 A-h
	1 hour rate (4900 mA)	4.9 A-h
	1.5 hour discharge to 10.5V	3.5 A
Capacity as affected by temp. (20 hour rate)	104° F (40° C)	102%
	77° F (25° C)	100%
	32° F (0° C)	85%
	5° F (-15° C)	65%
Internal resistance:	Full charged battery	40 mV
Self-discharge 77° F (25° C)	Capacity after 3 month storage	91%
	Capacity after 6 month storage	82%
	Capacity after 12 month storage	64%
Terminals:	Standard	LCR12V6.5BP AMP Faston type 187
Operating temperature:	-15° to +50° C (5° to 122° F)	
Storage temperature:	Low humidity, no direct sunlight	-15° to +40° C (5° to 104° F)

Remaining battery capacity can be estimated by measuring the open circuit voltage.

Capacity	OPEN CIRCUIT VOLTAGE	
	Minimum	Maximum
0%	11.5	11.8
20%	11.7	12.1
40%	12.0	12.4
60%	12.3	12.7
80%	12.5	12.9
100%	12.7	13.3

E.4.1.2 BATTERY CARE

- Do not disassemble the battery, as its strong acid electrolyte may burn your skin.
- Do not short the battery as it can burn the connections, wires, and could damage the equipment.
- Do not incinerate. Batteries may explode if thrown into fire.
- Keep the battery clean. Wipe the battery with a dry cloth or a water-dampened cloth. Never use oil, gasoline, thinner, or other petrochemicals.
- The battery may be charged in the backpack but it is recommended to keep the backpack flap open to allow proper ventilation of the battery during recharging. The battery must be charged while being in an upright position.
- If the battery is accidentally broken and electrolyte (sulfuric acid) leaks out, wipe it up with a cloth, neutralize the acid with some available alkaline substance such as ammonia solution, or baking powder (sodium hydrogen carbonate). In the event electrolyte contacts skin, immediately flush with water and consult a doctor immediately.
- For extended periods of non-usage of equipment, remove the battery from within the backpack and store within the following conditions
 - Relative humidity should be $55\% \pm 30\%$
 - -15° to $+40^{\circ}$ C (5° to 104° F)
 - Clean and avoid direct sunlight
 - Refresh the charge if an open circuit voltage test is below 12.5 Volts, or, every three months.

F POWERPAK II ENCLOSURE

F.1 POWERPAK II ENCLOSURE

The PowerPak II mounting enclosure provides a protective environment for the MiLLennium-GLONASS GPSCard. The mounting enclosure houses the internal power card, interconnect back plane, and front panel connections for COM1, COM2, strobes, GPS/GLONASS antenna, external oscillator, and power input.

NOTE: The PowerPak II enclosure is intended for stationary operation in benign surroundings such as those found in a laboratory or on a test bench; it is not designed for environments with feature vibration, dust, moisture or extremes of temperature.

The PowerPak II enclosure, see *Figure F.1*, is intended to be used with the following NovAtel accessories and options:

- A NovAtel Model 504 or Model 514 L1 GPS/GLONASS antenna - single frequency
- Model C005, C015, or C030 (5, 15 or 30 m lengths) coaxial cable - to connect the GPS/GLONASS antenna to the PowerPak II enclosure
- Cigarette lighter adaptor
- Optional AC/DC power converter and power cables.
- Y-type null-modem data cable
- External oscillator cable (user-supplied)

Figure F.1 PowerPak II Enclosure



After the addition of these accessories together with user-supplied data communications equipment and a power supply, the PowerPak II enclosure will be a fully-functioning combined GPS/GLONASS receiver. This is only one possible application of the PowerPak II; it can also be used by a system integrator to test and evaluate MiLLennium-GLONASS GPSCards.

F.1.1 FEATURES

The PowerPak II enclosure comes with the following:

- a mounting enclosure complete with a power converter and PCB interconnect back plane
- two serial-data communication ports
- an I/O port for strobe signals
- an input RF port
- an input power port
- an input port capable of interfacing with an external oscillator

- an electrostatic discharge (ESD) wrist grounding strap
- an external automotive cigarette-lighter power adapter
- a RS232C Y-type null-modem cable to facilitate communications with a PC
- (Optional) an autoranging AC to DC power converter
- an electrostatic discharge (ESD) wrist grounding strap

The enclosure measures 210 mm x 111 mm x 47mm, weighs 980 g (with a MiLLennium-GLONASS GPSCard) and is constructed of extruded aluminum. The enclosure is sealed with an end plate by four mounting screws.

F.1.2 CONNECTIONS AND INDICATORS

The PowerPak II enclosure features a front panel (See *Figure F.2*), with appropriate indicator lights and connectors. The front panel indicator glows red when power is on, and green when a valid position is computed. On the front panel there are connections for the cigarette lighter adaptor, optional AC-DC power converter, Y-type null-modem data cable, user-supplied external oscillator cable, COM1 and COM2 serial ports and an RF input from the GPS/GLONASS antenna.

Figure F.2 PowerPak II Enclosure Front Panel



1 Indicator	Status
Red	Power on
Green	Valid position computed

F.1.3 PCB INTERCONNECT BACK PLANE

The interconnect back plane is a printed circuit board vertically mounted directly behind the PowerPak II front panel. Its purpose is to provide direct interconnection between the GPSCard, power card, and the front panel input and output connections.

Except for a ground wire and a coaxial interconnect cable, all other input, output, and interconnect connectors are directly soldered to the back plane. The MiLLennium-GLONASS GPSCard and power card connect directly to the back plane.

F.1.4 INTERNAL POWER CARD

The internal power card is a DC-to-DC power converter providing filtering, fuse protection, and voltage regulation for the GPSCard. It accepts a single input voltage between the range of +10 to +36 V DC and converts it to the +5 V DC which the GPSCard requires. The power input is reverse-polarity protected and is protected by a replaceable 2-amp fuse.

The power card is held in place by card guides located inside the mounting enclosure. It fits into the second slot from the bottom of the enclosure. It couples to the back plane by means of a special power connector.

F.2 SPECIFICATIONS

Only those specifications which differ from the MiLLennium-GLONASS GPSCard, see *Table B.1, Page 49*, will be shown in *Table F.1*.

Table F.1 PowerPak II Enclosure Specifications

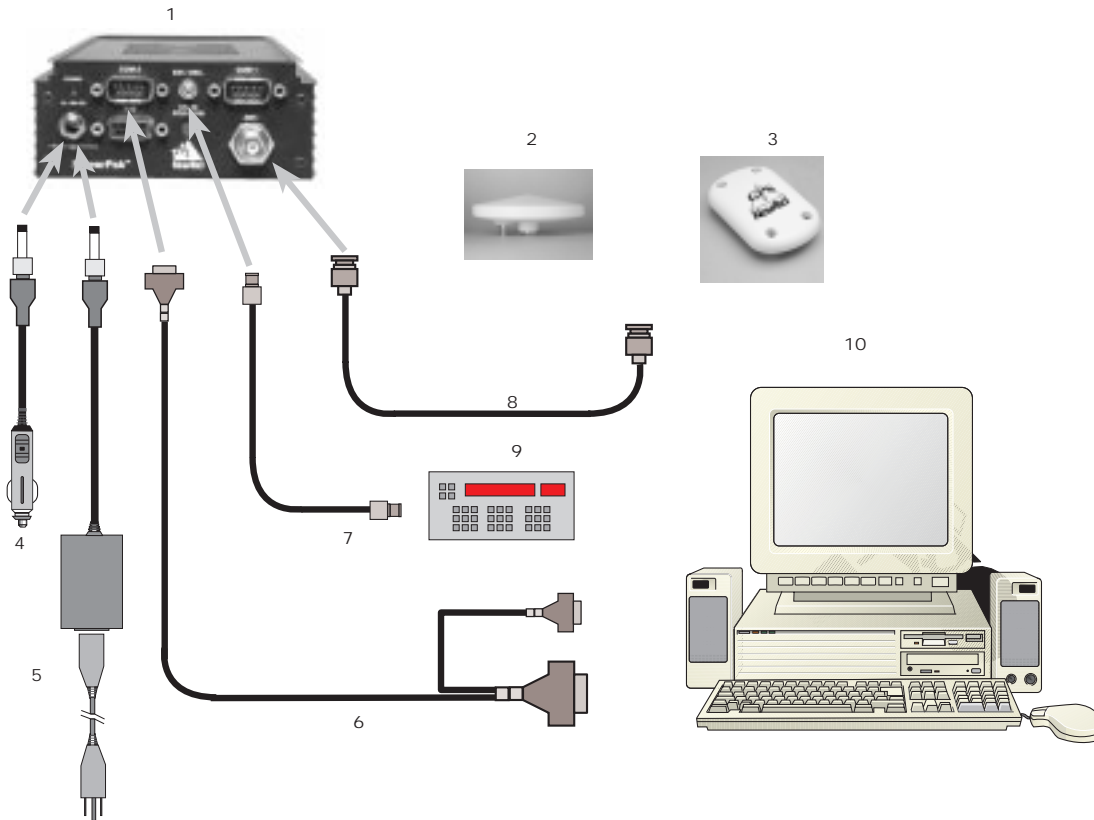
INPUT/OUTPUT CONNECTORS						
Power	2.1 mm plug, centre positive (+10 to +36 V DC), with screw-on retaining nut					
External Oscillator Input	SMB male jack Frequency: 5MHz or 10 MHz CW Input Impedance: 50 Ω nominal Input VSWR: 2.0:1 Signal Level: 0.0 dBm minimum, 13.0 dBm maximum Freq. stability: \pm 0.5 ppm maximum					
COM1, COM2 Strokes	DE9P connector DE9S connector					
PHYSICAL						
Size:	210 mm x 111 mm x 47mm					
Weight:	980 g (Including MiLLennium-GLONASS GPSCard)					
ENVIRONMENTAL						
Operating Temperature	-40°C to +60°C					
Storage Temperature	-40°C to +85°C					
Altitude	Not to exceed 5000 meters above sea-level					
Humidity	Not to exceed 90% non-condensing					
RF INPUT / LNA POWER OUTPUT						
Connector	TNC connector					
RF Input	GPS: 1575.42 MHz GLONASS: 1602 - 1615.5 MHz					
Power Output to LNA	4.25 - 5.25 V DC, 90mA max					
VIBRATION (Random Profile)						
The MiLLennium-GLONASS GPSCard will acquire and track satellites while undergoing vibration levels as shown below. This assumes that it is mounted using full-length clamped rail mounts and that no vibrating object is touching it. It also assumes that $C/N_0 > 45$ dB-Hz and that the MiLLennium-GLONASS GPSCard is in high-dynamics mode.						
Frequency	< 10 Hz	10 Hz	40 Hz	1000 Hz	2000 Hz	>2000 Hz
Magnitude (g^2/Hz)	+ 80 dB/decade	0.00125	0.02	0.02	0.005	-80 dB/decade
Typical Mounting Configuration - Mount the MiLLennium-GLONASS GPSCard securely using screws driven through the card's four corner mounting holes.						
Superior Mounting Configuration - Mount the card using full length clamped rail mounts.						
Note: The card is sensitive to any external rattling that occurs next to the card.						
PHOTOGRAPHS						
PowerPak II enclosure perspective view and rear end-cap view respectively:						
 						

F.3 HARDWARE CONFIGURATION

Installing the PowerPak II enclosure is a straightforward process. As shown in *Figure F.3, Page 76*, a minimum configuration is established with the following setup:

- Set up the GPS/GLONASS antenna, see *GPS/GLONASS Antenna Considerations, Page 23*.
- Route and connect the RF coaxial cable between the GPS/GLONASS antenna and the PowerPak II enclosure.
- Connect an RS232C communication interface to one of the serial ports of the PowerPak II enclosure.
- Supply power to the input jack of the PowerPak II.

Figure F.3 Typical PowerPak II Enclosure Installation Configuration



Reference	Description	Reference	Description
1	PowerPak II enclosure	6	Y-type null-modem data cable
2	Model 504 antenna	7	External oscillator cable (user-supplied)
3	or Model 514 antenna	8	RF Cable
4	Cigarette lighter adaptor	9	External oscillator
5	Optional AC-DC power converter	10	User interface

* Or any GPS/GLONASS antenna model

NOTE: The 4-pin LEMO socket connector to 4-pin LEMO plug connector, auto-ranging AC/DC converter and AC power cord do not come with the PowerPak II enclosure but are optional accessories.

The term plug/socket refers to the outside of the connector while the term male/female refers to the pin type.

F.3.1 POWER SUPPLY CONSIDERATIONS

The PowerPak II enclosure incorporates a DC/DC power converter providing filtering, automatic reset circuit protection and voltage regulation. It accepts a single input voltage between the range +10 to +36 V DC, which can be supplied either from an automotive DC source or by the optional auto-ranging AC/DC converter (NovAtel part number GPS-APRO) which operates over a range of 110 - 220 V AC and 50 - 60 Hz. The power input is reverse-polarity protected. Refer to *Table F.1, Page 75*, for further information.

WARNING: The MiLLennium-GLONASS GPSCard will suspend operation if voltage supplied falls outside input range +10 to +36 V DC.

F.3.2 ACCESSING THE POWER BOARD FUSE

The power board incorporates a 2-amp normal-blow fuse, located near the rear of the power board. Follow these instructions to check or replace this fuse.

CAUTION

- Be sure that the power plug is disconnected from the PowerPak II before you attempt to remove the front panel.
 - Use the wrist strap to properly discharge static build-up before handling the printed circuit boards.
 - Use anti-static precautions whenever the PowerPak II is opened.
-
-

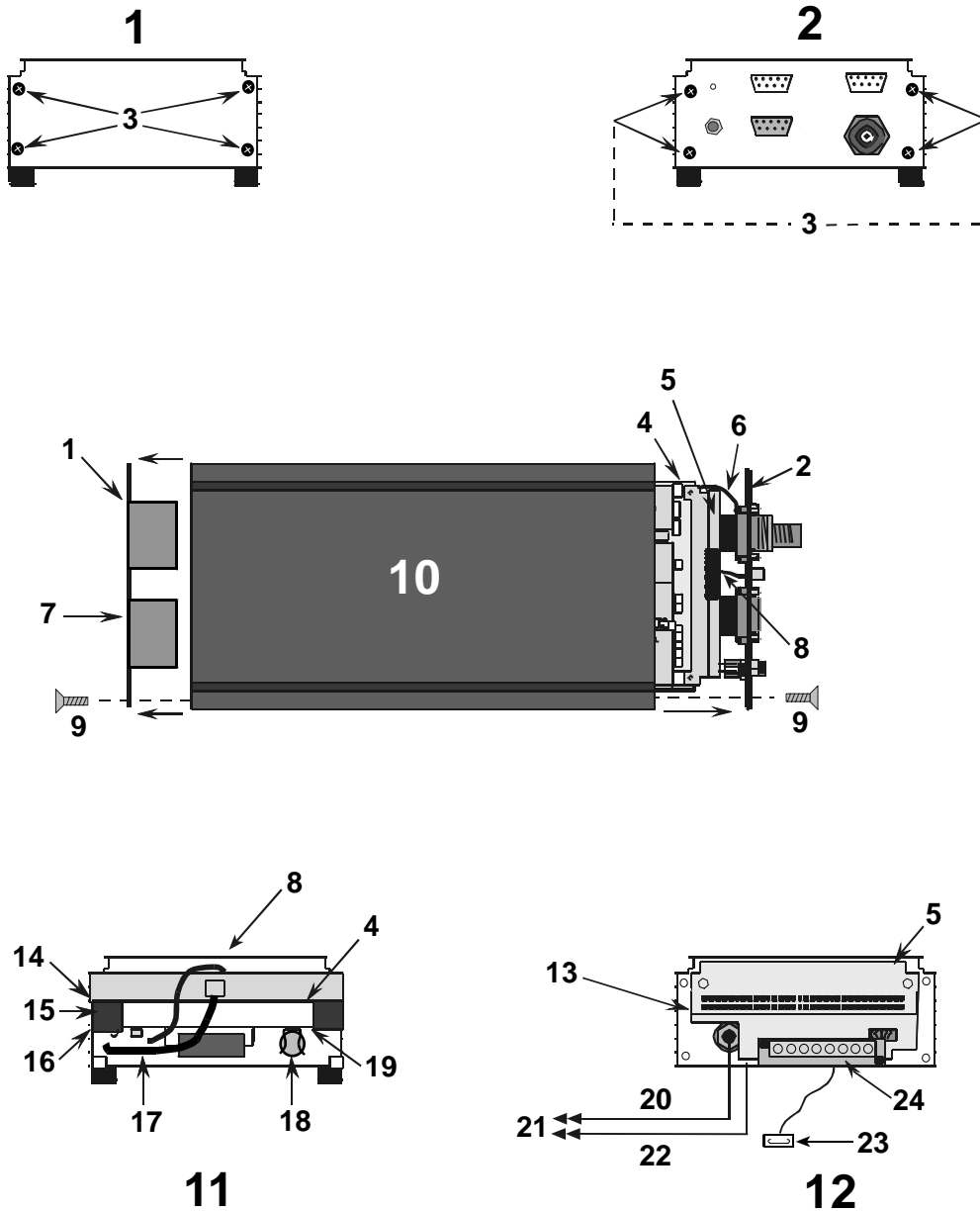
To access the power fuse follow these steps:

1. Remove the four corner screws from each of the front and back panels of the PowerPak II enclosure.
2. Remove the rear panel to create an opening into the enclosure.
3. Through this opening, push both the GPSCard and power card forward as far as you can. This will expose the back plane, GPSCard, and the power board.
4. Now, from the other end, grasp the exposed edges of the GPSCard and the power card and gently pull until approximately 3/4 of both cards are extended beyond the front panel opening.
5. The fuse will now be fully exposed for checking or replacement.
6. When finished, push on the front panel until it is seated against the main enclosure; then replace the screws on the front and rear panels.

See *Figure F.4, Page 78* for more details.

CAUTION: Do not pull on the front panel in order to remove the GPSCard and power card from the PowerPak II enclosure; cable damage will result.

Figure F.4 Opening the PowerPak II Enclosure



Reference	Description	Reference	Description
1	Back panel	13	GPSCard 64 pin connector P1
2	Front panel	14	Second slot from top
3	Remove screws	15	Spacer bumper
4	GPSCard	16	Second slot from bottom
5	Back plane PCB	17	Antenna cable
6	Ground wire with connector	18	Power fuse
7	Rear bumper	19	Power card
8	External oscillator cable	20	Internal antenna cable (right-angled SMB connector)
9	Panel screw (4 places)	21	To GPSCard
10	PowerPak II (top view)	22	Internal oscillator cable (right-angled SMB connector)
11	Back panel removed (rear view)	23	Spade connector socket on end of ground wire
12	Front panel (back plane view)	24	Power card connector P2

F.3.3 CABLES

Please see the following sections for the technical specifications of all cables and optional accessories. For field replacement of the LEMO connectors, and to find part numbers of optional accessories, please see *Appendix K, Page 126*.

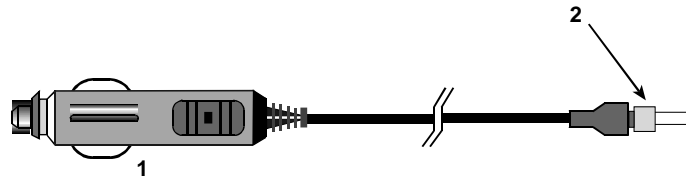
F.3.3.1 Input Power Cables

The following cables allow you to power the PowerPak II enclosure from either an AC source, an automotive DC source or a battery.

- Cigarette-lighter power adapter with replaceable 3 amp slow-blow fuse, see *section F.3.3.1.1* for a drawing of the cable (NovAtel part number 01014989)
- Optional auto-ranging AC/DC converter, and AC power cord, see *section F.3.3.1.2* for more information (NovAtel part number GPS-APWR)

F.3.3.1.1 Cigarette-Lighter Power Adapter (NovAtel part number 01014989)

The cigarette-lighter power adapter included with the PowerPak II supplies +12 V DC while operating from an automotive source. On the end of the cord which is inserted into the PowerPak II there is a retaining nut; it threads onto the socket to keep the plug from accidentally being pulled out. A replaceable 3 amp fuse is built into the assembly which is inserted into the cigarette lighter.



Reference	Description
1	Cigarette lighter adapter
2	Retaining nut

F.3.3.1.2 Optional AC to DC Power Converter (NovAtel part number GPS-APWR)

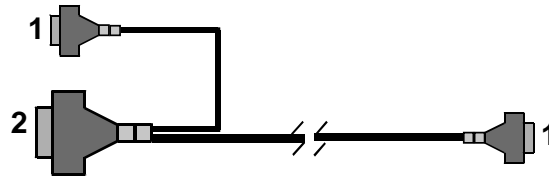
An optional AC to DC power converter is available for the PowerPak II, which allows you to operate the unit from an AC outlet. The converter is autoranging to accommodate standard line voltages (110 to 220 V AC) and frequencies (50 to 60 Hz). It features a retaining nut on the connector that is inserted into the PowerPak II; when threaded onto the socket, it prevents the plug from accidentally being pulled out. Its output voltage is compatible with the PowerPak II's requirements. For replacement purposes, the NovAtel part number is *GPS-APWR*.

F.3.3.2 Serial Data Cables

The RS232C Y-type null-modem cable, 10-pin LEMO plug to 9-pin D-connector (DE9S socket), is used to connect the receiver to a serial (RS232C) communication port on a terminal or computer. Its NovAtel part number is 60715062. Please see section F.3.3.2.1 for a drawing of this cable.

F.3.3.2.1 RS232C Y-type Null-Modem Cable (NovAtel part number 60715062)

This serial data cable supplied with the PowerPak II provides a means of communications with a personal computer. As shown in the following figure, the cable is equipped with a 9-pin connector at the PowerPak II end which can be plugged into either COM1 or COM2. At the computer end, both a 9-pin and a 25-pin connector are provided to accommodate most serial (RS232C) communication ports.



Reference	Description
1	DE9S socket
2	DB25S socket

F.4 OTHER OPTIONAL POWERPAK II ACCESSORIES

F.4.1 USER-SUPPLIED EXTERNAL OSCILLATOR

For certain applications requiring greater precision than what is possible using the 20 MHz on-board, voltage-controlled temperature-compensated crystal oscillator (VCTCXO), you may wish to connect the GPSCard to an external, high-stability oscillator. This is only possible with a MiLLennium-GLONASS GPSCard on its own or in a PowerPak II enclosure, not if the MiLLennium-GLONASS GPSCard is in a ProPak II enclosure. Refer to *section F.4.1.1* for instructions to connect the MiLLennium-GLONASS GPSCard or the PowerPak II to an External Oscillator.

The external oscillator can be either 5 MHz or 10 MHz. The MiLLennium-GLONASS GPSCard has built-in clock models for OCXO, rubidium and cesium oscillators, but you can also set custom clock model parameters for other types of oscillators. Two commands relate to external oscillator operation; EXTERNALCLOCK and EXTERNALCLOCK FREQUENCY.

If there is no external oscillator, you should use the EXTERNALCLOCK DISABLE command.

EXTERNALCLOCK determines if the GPSCard uses its own internal temperature-compensated crystal oscillator, or an external oscillator as a frequency reference. It also sets which clock model is used for external oscillators.

Command	Reference Oscillator	Clock Model
EXTERNALCLOCK DISABLE	internal	-
EXTERNALCLOCK OCXO	external	OCXO
EXTERNALCLOCK CESIUM	external	cesium
EXTERNALCLOCK RUBIDIUM	external	rubidium
EXTERNALCLOCK CUSTOM	external	user-defined parameters

NOTE: The EXTERNALCLOCK DISABLE command forces the GPSCard to use the internal oscillator, whether there is an external oscillator connected or not. Do not use the EXTERNALCLOCK OCXO, CESIUM, RUBIDIUM or CUSTOM command if no external oscillator is connected.

The EXTERNALCLOCK FREQUENCY command sets the GPSCard to accept either 5 MHz or 10MHz external oscillator frequency.

Command	External Oscillator Frequency
EXTERNALCLOCK FREQUENCY 5	5 MHz
EXTERNALCLOCK FREQUENCY 10	10 MHz

For more information on the EXTERNALCLOCK command refer to the *MiLlennium Command Descriptions Manual*.

F.4.1.1 Connection to an External Oscillator

To connect the external oscillator to the MiLlennium-GLONASS GPSCard simply connect the cable from the external oscillator to connector P301 (see *Figure 3.1, Page 17*) on the MiLlennium-GLONASS GPSCard. The MiLlennium-GLONASS GPSCard does not have to be powered down during this procedure. If handling the MiLlennium-GLONASS GPSCard directly, anti-static practices must be observed; please see *Appendix A, Page 47* for details.

To connect an external oscillator to a PowerPak II, connect the coaxial cable from the external oscillator output port to the *Ext. Osc.* input port (SMB male jack) on the front panel of the PowerPak II.

NOTE: For optimal results, power down the PowerPak II before connecting or disconnecting the external oscillator.

Once the external oscillator has been installed, you must issue the EXTERNALCLOCK command to define the clock frequency (e.g. cesium, rubidium, or ovenized crystal).

NOTE: If the input clock rate is 5 MHz, the EXTERNALCLOCK FREQUENCY command must also be issued to change the 10 MHz default setting.

After the EXTERNALCLOCK FREQUENCY command is issued, the VCTCXO attempts to lock onto this low-phase-noise reference frequency. The synthesizer's lock is software-configurable provided that the frequency of the external clock is either 5 or 10 MHz.

The EXTERNALCLOCK DISABLE command will return internal VCTCXO operation to normal. The EXTERNALCLOCK command can also be used to optimize the MiLlennium's clock model. Refer to the *MiLlennium Command Descriptions Manual* for further details on these commands.

G GLONASS COMMANDS

G.1 GLONASS-SPECIFIC COMMANDS

This chapter describes MiLLennium-GLONASS GPSCard commands important to GLONASS.

GLONASS-specific commands are generated by using information obtained from the GLONASS satellite system. Please see the following sections for definitions of these commands.

G.1.1 DGLOTIMEOUT

The differential GLONASS time out (DGLOTIMEOUT) command's function is to set the maximum age of differential data that will be accepted when operating as a remote station. Differential data received that is older than the specified time will be ignored.

The ephemeris delay of the reference station is the same as for GPS and can be set using the DGPSTIMEOUT command (refer to the *MiLLennium Command Descriptions Manual* for information on this command).

Since there is no Selective Availability (SA) on the GLONASS correction the degradation over time is considerably less. It could be useful to allow a longer timeout for GLONASS than GPS.

Syntax:

DGLOTIMEOUT delay

Options:

delay: 2 - 1000 (seconds) (default 60)

G.1.2 PZ90TOWGS84

This command allows the user to input the Helmert transformation relating the GLONASS PZ90 reference frame to the GPS WGS-84 reference frame. The Helmert transformation is defined as:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix} + (1 + \delta s * 10^{-6}) \begin{bmatrix} 1 & \omega & -\phi \\ -\omega & 1 & \epsilon \\ \phi & -\epsilon & 1 \end{bmatrix} \begin{bmatrix} u \\ v \\ w \end{bmatrix}_{PZ90}$$

Here, (x,y,z) is the desired WGS-84 coordinate set and (u,v,w) is the given coordinate set in PZ90. The transformation is defined by an origin offset $(\Delta x, \Delta y, \Delta z)$, a linear scale factor (δs) and a series of small angle rotations (ϵ, ϕ, ω) , given in radians, around the u, v and w axes respectively. By default, the values are set to those published by Misra et al. (ION GPS 96, pg 307) given by:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} 0 \\ 2.5 \\ 0 \end{bmatrix} + \begin{bmatrix} 1 & -1.9 * 10^{-6} & 0 \\ 1.9 * 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u \\ v \\ w \end{bmatrix}_{PZ90}$$

There are a number of different transformations that have been published but the majority of them are optimized for the particular region of the planet that the data was collected in. One of the objectives of the current International Glonass Experiment (IGE) is to accurately determine a PZ90 to WGS-84 transformation that is consistent on a global scale.

The PZ90TOWGS84 command can be used in conjunction with the DATUM PZ90 command (see "1.6 Datum", Page 13) to allow for position output in a user-defined PZ90 frame.

The relevant parameters for the PZ90 ellipsoid are from the GLONASS Interface Control Document (ICD) version

4.0, 1998 Coordination Scientific Information Center (CSIC). Please see the following table for the reference ellipsoid constants.

ELLIPSOID	a (metres)	1/f	f
Parameters of Earth 1990	6378136.0	298.257839303	0.00335280374302

Syntax:

PZ90TOWGS84 option [Δx] [Δy] [Δz] [δs] [ϵ] [ϕ] [ω]

Options:

ARGUMENT	DESCRIPTION
DEFAULT	Set to default Helmert transformation parameters
SET	Set to user specified values (all must be specified, see following table)

PARAMETER	DESCRIPTION
Δx	Origin offset in x direction [m]
Δy	Origin offset in y direction [m]
Δz	Origin offset in z direction [m]
δs	Scale factor given in parts per million (ppm), final linear scale factor given as $(1 + \delta s * 10^{-6})$
ϵ	Small angle rotation around u axis [arcsec]. A positive sign for counter clockwise direction and a negative sign for clockwise direction taking into consideration that the transformation is going from PZ90 to WGS84.
ϕ	Small angle rotation around v axis [arcsec]. A positive sign for counter clockwise direction and a negative sign for clockwise direction taking into consideration that the transformation is going from PZ90 to WGS84.
ω	Small angle rotation around w axis [arcsec]. A positive sign for counter clockwise direction and a negative sign for clockwise direction taking into consideration that the transformation is going from PZ90 to WGS84.

Example:

PZ90TOWGS84 DEFAULT
PZ90TOWGS84 SET 0.1,0.4,-0.3,6,0,0,4

NOTE: The format and sign conventions in this command are set up to conform to the given reference and differ from the NovAtel USERDATUM command.

G.2 OTHER RELEVANT GPSCARD COMMANDS

Please refer to the *MiLLennium Command Descriptions Manual's* commands chapter for a list of GPSCard commands categorized by function. For a complete description of individual commands please consult *Appendix C* of the same manual, where commands are listed alphabetically.

NOTE: To determine the GLONASS PRN for commands that require entry of a PRN, such as ASSIGN, use this equation:

$$\text{FREQUENCY} * 10000 + \text{SLOT} + 37$$

where the SLOT and FREQUENCY are in the range 1 to 24 inclusive

G.2.1 ASSIGN

The ASSIGN command for Glonass channels will accept a standard NovAtel Glonass satellite identifier (i.e. frequency*10000 + slot + 37). The search is done by frequency and not by slot number which is ignored by the ASSIGN command. Since antipodal satellites could have the same frequency but different slot numbers, the satellite that ends up being tracked will have the slot number of the current visible satellite for that frequency. Note that this will NOT necessarily match the value of the slot number entered for the ASSIGN command.

Example:

Entering the command:

```
assign 14 120043
```

is the same as entering the command:

```
assign 14 120000
```

where 14 is the channel, 12 is the frequency and 6 is the slot number.

Assigning two GLONASS satellites with the same frequency but different slot numbers may not give the desired result:

```
assign 3 60046
```

```
assign 4 60052
```

G.2.2 ANTENNAPOWER

On MiLLennium-GLONASS GPSCards this command enables or disables the supply of electrical power from the internal power source of the card to the low-noise amplifier (LNA) of an active antenna. Jumper P301 allows you to power the LNA either by an internal power source (plug connects pins 1&2) or an optional external power source (plug connects pins 2&3); or, you can cut off all power to the antenna (plug removed). The ANTENNAPOWER command, which is only relevant when Jumper P301 is set to connect pins 1&2, determines whether or not internal power is applied to pin 1 of Jumper P301. *Table 3.1, Page 22* summarized the combinations.

The setting of this command (on/off) will affect the way the MiLLennium-GLONASS GPSCard's self-test diagnostics (see *Table H.2, Page 96*) report the antenna's status.

Example:

```
antennapower off
```

G.2.3 COMn

This command permits you to configure (bps, parity, data bits, stop bits, handshake, echo and FIFO) the MiLLennium-GLONASS GPSCard COM port's asynchronous drivers.

Examples:

```
com2 19200,e,7,1,n,on,off
```

```
com1 1200,e,8,1,n,on,off
```

G.2.4 COMn_DTR

This command enables versatile control of the DTR handshake line [control (high, low or toggle), active (high or low), lead time and tail time] for use with *output data logging* in conjunction with external devices such as a radio transmitter. The default state for the COM1 or COM2 DTR line is always high.

Examples:

```
com1_dtr toggle,high,300,150
com2_dtr toggle,low,200,110
```

G.2.5 COMn_RTS

This command enables versatile control of the RTS handshake line [control (high, low or toggle), active (high or low), lead time and tail time] for use with *output data logging* in conjunction with external devices such as a radio transmitter. The default state for the COM1 or COM2 RTS line is always high. COMn_RTS will not influence the COMn command handshake control of incoming commands.

Example:

```
com1_rts toggle,high,200,100
com2_rts toggle,low,250,125
```

G.2.6 DATUM

This command permits you to select the geodetic datum for operation of the receiver. If not set, the value is defaulted to WGS84. Refer to *Table G-2 in Appendix G of the MiLLennium Command Descriptions Manual 4.50* for a complete listing of all available predefined datums. See the *USERDATUM* command in the *MiLLennium Command Descriptions Manual 4.50* for user definable datums. The datum you select will cause all position solutions to be based on that datum (except PXYA/B which is always based on WGS84).

Syntax:

```
DATUM option
```

Syntax	Datum Option	Description	Default
DATUM	any one of 63 predefined datums	For a list of 62 predefined datums, refer to <i>Table G-2 in Appendix G of the MiLLennium Command Descriptions Manual 4.50</i> . To see the 63rd predefined datum, refer to the table below.	WGS84
	USER	User defined datum with parameters specified by the <i>USERDATUM^a</i> command (Default WGS84)	

- a. In the *MiLLennium Command Descriptions Manual*, the units of the X, Y and Z datum rotation angles are shown to be arc seconds when in fact they are radians.

Example:

```
datum tokyo           Sets the system datum to Tokyo
```

NOTE: The actual datum name must be entered in this command as listed in the NAME column of *Table G-2 in the MiLLennium Command Descriptions Manual 4.50*. Also note that references to datum in the following logs use the GPSCard Datum ID#: MKPA/B, PRTKA/B, POSA/B and RTKA/B.

The DATUM PZ90 command will use the default values as set to those published by Misra et al. (ION GPS 96, pg 307), see *Page 82* for more information. To define the values you must issue the PZ90TOWGS84 command (see “G.1.2 PZ90TOWGS84”, *Page 82*). The PZ90 transform parameters can be saved in user-configurable memory for immediate use on powerup.

GPSCard Datum ID number	NAME	DX	DY	DZ	DATUM DESCRIPTION	ELLIPSOID
64	PZ90	0	2.5	0	Parameters of Earth 1990*	Parameters of Earth 1990*

* See the PZ90TOWGS84 command (“G.1.2 PZ90TOWGS84”, *Page 82*) for more information

Example:

```
datum PZ90           Sets the default PZ90 values for the output position parameters
```

G.2.7 MAGVAR

Two field options are included; a standard deviation field and an auto field.

The MiLLennium-GLONASS GPSCard computes directions referenced to True North. Use this command (magnetic variation correction, see *Figure G.1, Page 86*) if you intend to navigate in agreement with magnetic compass bearings. The correction value entered here will cause the "bearing" field of the NAVA/B log, see *Page 102*, to report bearing in degrees Magnetic. The magnetic variation correction is also reported in the GPRMC and GPVTG logs. The MiLLennium-GLONASS GPSCard will compute the magnetic variation correction if you use the auto option.

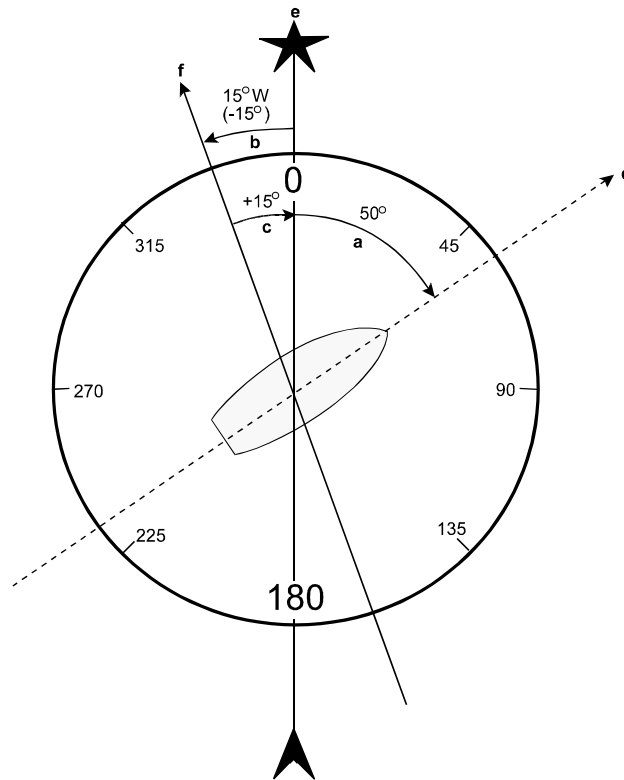
Example 1:

magvar +15.0

Example 2:

magvar auto

Figure G.1 Illustration of Magnetic Variation & Correction



Reference	Description
a	True bearing
b	Local magnetic variation
c	Local magnetic variation correction (negative of magnetic variation)
d	Heading = 50× True = 65× Magnetic
e	True North
f	Local Magnetic North
	a + (c) = Magnetic bearing

G.2.8 SAVECONFIG

This command saves your present configuration in non-volatile memory.

Example:

```
SAVECONFIG
```

G.2.9 SETNAV

This command permits entry of one set of navigation waypoints.

The origin (FROM) and destination (TO) waypoint coordinates entered are considered on the ellipsoidal surface of the current datum (default WGS84). Once SETNAV has been set (from-lat, from-lon, to-lat, to-lon, track offset from port name and to port name) you can monitor the navigation calculations and progress by observing the NAVA/B log, see *Page 102*.

Track offset is the perpendicular distance from the great circle line drawn between the FROM lat-lon and TO lat-lon waypoints. It establishes the desired navigation path, or track, that runs parallel to the great circle line, which now becomes the offset track, and is set by entering the track offset value in meters. A negative track offset value indicates that the offset track is to the left of the great circle line track. A positive track offset value (no sign required) indicates the offset track is to the right of the great circle line track (looking from origin to destination).

See the NAVA/B log, *Page 102* and *Figure H.1, Page 103* for clarification.

Example:

```
setnav 51.1516,-114.16263,51.16263,-114.1516,-125.23,from,to
```

G.3 UNIMPLEMENTED COMMANDS

Currently, the ability to set satellite health, and the ability to de-weight the range of a satellite in the solution computations, is not enabled for GLONASS. Because of this, the following commands will not work with the MiLLennium-GLONASS GPSCard for GLONASS satellites.

- SETHEALTH
- RESETHEALTH
- RESETHEALTHALL
- LOCKOUT

NOTE: The unimplemented commands are disabled for GLONASS satellites only. These commands can still be used with GPS satellites.

If, by mistake, you issue an unimplemented command to the MiLLennium-GLONASS GPSCard for a GLONASS satellite, the MiLLennium-GLONASS GPSCard will simply inform you that the PRN is invalid. The MiLLennium-GLONASS GPSCard is unable to accept a GLONASS PRN as an argument.

For further information on these commands, please consult the *MiLLennium Command Descriptions Manual*.



H NOVATEL FORMAT LOGS

H.1 GLONASS-SPECIFIC LOGS

GLONASS-specific logs provide data by using information obtained from the GLONASS satellite system. Following are the descriptions of MiLLennium-GLONASS GPSCard's CALA/B, GALA/B, GCLA/B and GEPA/B logs. The syntax and fields are as described below.

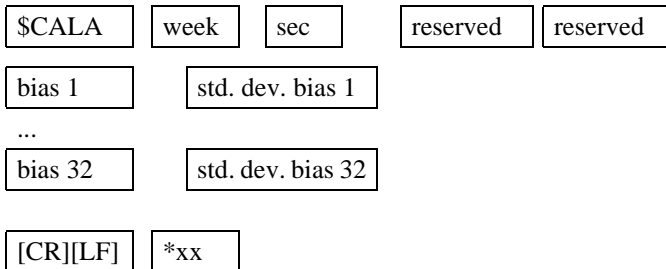
H.1.1 CALA/B CALIBRATION INFORMATION

GPS satellites all broadcast on the same frequency but broadcast different codes. GLONASS satellites broadcast on different frequencies but use the same code. The former technique is known as Code Division Multiple Access (CDMA) while the latter is known as Frequency Division Multiple Access (FDMA).

Frequency dependent characteristics of the hardware result in small biases in the GLONASS pseudoranges. You can enter calibration numbers for the various frequencies which will be subtracted from each pseudorange with the CALA/B input. The numbers can also be output as a log, CALA/B.

CALA

Structure:



Field #	Field	Description	Example
1	\$CALA	Log Header	\$CALA
2	Week	GPS week number	992
3	Sec	GPS time into week, in seconds	453075
4	Reserved for future use		
5	Reserved for future use		
6,7 8, 9, 10, 11, ... 50, 51, 52, 53, 54, 55, ... 68, 69,	Bias 1, Std. Dev. Bias 1 Bias 2, Std Dev Bias 2 Bias 3, Std Dev Bias 3 ... Bias 23, Std Dev Bias 23 Bias 24, Std Dev Bias 24 Bias 25, Std Dev Bias 25 ... Bias 32, Std Dev Bias 32	Pseudorange bias for frequency, Std Dev of bias in meters	-0.491, 0.050 1.070,0.041 1.029,0.041 ... -1.999,0.500, -2.813,0.500, 0.000,5.000 ... 0.000,5.000
70	* xx	Checksum	*03
71	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```

$CALA,4,480377,2,FFFFFF00,1.070,0.041,1.029,0.041,1.054,0.043,0.646,0.041,0.735,0.041,0.526,0.040,0.456,0.039,
0.520,0.040,0.148,0.040,0.469,0.039,0.156,0.040,0.000,0.000,0.115,0.039,-0.281,0.040,-0.269,0.039,-0.246,0.039,
-0.685,0.039,-0.391,0.039,-0.661,0.039,-0.967,0.040,-1.121,0.500,-1.471,0.500,-1.999,0.500,
-2.813,0.500,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,0.000,5.000,
0.000,5.000*2A[CR][LF]
    
```


CALB

Format: Message ID = 87 Message byte count = 32 + (16 * 32)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
	Checksum	1	char		3
	Message Id	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Reserved for future use				
5	Reserved for future use				
6	GloBias (*32)	8	double	meters	32
	dBias	8	double	meters	
	dStdev	8	double	meters	

H.1.2 GALA/B ALMANAC INFORMATION

The GLONASS almanac reference time and week are in GPS time coordinates. GLONASS ephemeris information is available through the GEPA/B log.

GALA

Structure:

\$GALA	week	seconds	week	time	SVID	freq	health	TlambdaN
--------	------	---------	------	------	------	------	--------	----------

LambdaN	deltal	ecc	argperig	deltaT	deltaTD	tau	*xx	[CR][LF]
---------	--------	-----	----------	--------	---------	-----	-----	----------

Field #	Field	Description	Example
1	\$GALA	Log Header	\$GALA
2	Week	GPS Week, in weeks	991
3	Seconds	GPS Time, in seconds	496470.59
4	Week	GPS Week for almanac reference time (GLONASS time in GPS format), in weeks	991
5	Time	GPS Time for almanac reference time (GLONASS time in GPS format), in seconds	374232.88
6	SVID	Slot number for satellite, ordinal	16
7	Freq	Frequency for satellite, ordinal	22
8	Health	Ephemeris Health (1 = GOOD, 0 = BAD)	1
9	TlambdaN	GLONASS Time of ascending node equator crossing, in seconds	3.94199E+004
10	LambdaN	Longitude of ascending node equator crossing (PZ90), in radians	-9.2257260E-001
11	Deltal	Correction to nominal inclination, in radians	3.02841363E-002
12	Ecc	Eccentricity	1.49440765E-003
13	ArgPerig	Argument of perigee (PZ90), in radians	1.04694189E-001
14	DeltaT	Offset to nominal orbital period, in seconds	-2.6561113E+003
15	DeltaTD	Rate of orbital period, in seconds per orbital period	3.66210937E-004
16	Tau	Clock offset, in seconds	-2.0217896E-004*38

Example:

```
$GALA,991,496470.59,991,374232.88,16,22,1,3.94199E+004,-9.2257260E-001
3.02841363E-002,1.49440765E-003,1.04694189E-001,-2.6561113E+003,
3.66210937E-004,-2.0217896E-004*38
```

GALB

Format:

Message ID = 78

Message byte count = 112

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
	Checksum	1	char		3
	Message Id	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Reference week (GLONASS time in GPS format)	4	integer	weeks	24
5	Reference time (GLONASS time in GPS format)	8	double	seconds	28
6	Slot number	4	integer	ordinal	36
7	Frequency	4	integer	ordinal	40
8	Health	4	integer	-	44
9	Ascending node time	8	double	seconds	48
10	Ascending node longitude	8	double	rad	56
11	Inclination correction	8	double	rad	64
12	Eccentricity	8	double	-	72
13	Argument of perigee	8	double	rad	80
14	Orbital period correction	8	double	seconds	88
15	Orbital period rate	8	double	s/orbit	96
16	Clock offset to UTC	8	double	seconds	104

H.1.3 GCLA/B CLOCK INFORMATION

This log contains the time difference information between GPS and GLONASS time as well as status flags. The status flags are used to indicate the type of time processing used in the least squares adjustment. GPS and GLONASS time are both based on the Universal Time Coordinated (UTC) time scale with some adjustments. GPS time is continuous and does not include any of the leap second adjustments to UTC applied since 1980. The result is that GPS time currently leads UTC time by 13 seconds.

GLONASS time applies leap seconds but is also three hours ahead to represent Moscow time. The nominal offset between GPS and GLONASS time is therefore due to the three hour offset minus the leap second offset. Currently this value is at 10787 seconds with GLONASS leading. As well as the nominal offset, there is a residual offset on the order of nanoseconds which must be estimated in the least squares adjustment. The GLONASS-M satellites will broadcast this difference in the navigation message.

This log will also contain information from the GLONASS navigation data relating GLONASS time to UTC.

GCLA

Structure:

Field #	Field	Description	Example
1	\$GCLA	Log Header	\$GCLA
2	Week	GPS week number	994
3	Sec	GPS time into week	149871.00
4	Nominal Offset	Nominal offset between GPS and GLONASS time references, in seconds	10787
5	Residual Offset	Residual offset estimated in filter, in meters	10.62179349
6	Residual Offset Variance	Variance of residual offset, in meters	167.82950123
7	N ^A	Calendar day number within four year period beginning since the leap year, in days	1121
8	τ_c	From GLONASS almanac - GLONASS time scale correction to UTC(SU) given at beginning of day N ^A , in seconds	-3.0544738044739E-007
9	# GPS sv	Number of good GPS sv tracked	9
10	# GLONASS sv	Number of good GLONASS sv tracked	4
11	Time Status	Time status (see below)	00000000
12	* xx	Checksum	*7B
13	[CR][LF]	Sentence terminator	[CR][LF]

Time Status

Value	Description
0	GLONASS time floating
1	GLONASS time fixed

Example:

```
$GCLA,994,149871.00,10787,10.62179349,167.82950123,1121,
-3.0544738044739E-007,9,4,00000000*7B,[CR][LF]GCLB
```

GCLB

Format:

Message ID = 88

Message byte count = 68

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
	Checksum	1	char		3
	Message Id	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Leap seconds plus three hour Moscow time offset	4	integer	seconds	24
5	Fractional offset calculated by filter	8	double	meters	28
6	Variance of fractional offset	8	double	metres^2	36
7	Calendar day number within four year period beginning since the leap year	4	integer	day	44
8	From GLONASS almanac - GLONASS time scale correction to UTC(SU) given at beginning of day N ^A	8	double	seconds	48
9	Number of GPS satellites	4	integer		56
10	Number of GLONASS satellites	4	integer		60
11	Status flags	4	integer	-	64

H.1.4 GEPA/B EPHEMERIS INFORMATION

GLONASS ephemerides are referenced to the Parametry Zemli 1990 (PZ-90) geodetic datum, and GLONASS ephemeris information is available through the GEPA/B log. GLONASS coordinates are reconciled internally through a position filter and output to WGS84. Refer to the SVDA/B log in the *MiLLennium Command Descriptions Manual* for information on WGS84.

GEPA

Structure:

\$GEPA	week	seconds	ephweek	ephtime	time offset	
svid	freq	issue	health	posX	posY	posZ
velX	velY	velZ	LSAccX	LSAccY	LSAccZ	tau
gamma	tk	age	flags	*xx	[CR][LF]	

Field #	Field	Description	Example
1	\$GEPA	Log Header	\$GEPA
2	Week	GPS Week of log output	991
3	Seconds	GPS Time of log output	496487
4	EphWeek	Reference week of ephemeris (in GPS time)	991
5	EphTime	Reference time of ephemeris (in GPS time)	495913
6	Time offset	Integer seconds between GPS and GLONASS Time + implies GLONASS ahead of GPS	10787 ¹
7	SVID	Slot number for satellite	4
8	Freq	Frequency number for satellite	12
9	Issue	15-minute interval number corresponding to ephemeris reference time	83
10	Health	Ephemeris Health (0 = GOOD, 1 = BAD)	0
11	PosX	X coordinate for satellite at reference time (PZ90), in meters	-2.102581933593754E+007
12	PosY	Y coordinate for satellite at reference time (PZ90), in meters	-1.216645166015627E+007
13	PosZ	Z coordinate for satellite at reference time (PZ90), in meters	7.7982763671875110E+006
14	VelX	X coordinate for satellite velocity at reference time (PZ90), in meters/s	-9.655075073242192E+002
15	VelY	Y coordinate for satellite velocity at reference time (PZ90), in meters/s	-5.014476776123048E+002
16	VelZ	Z coordinate for satellite velocity at reference time (PZ90), in meters/s	-3.387468338012698E+003
17	LSAccX	X coordinate for lunisolar acceleration at reference time (PZ90), in meters/s/s	-1.862645149230957E-006
18	LSAccY	Y coordinate for lunisolar acceleration at reference time (PZ90), in meters/s/s	9.3132257461547851E-007
19	LSAccZ	Z coordinate for lunisolar acceleration at reference time (PZ90), in meters/s/s	-9.313225746154785E-007
20	Tau	Clock offset from GLONASS time, in seconds	-3.913920372724533E-004
21	Gamma	Frequency Correction, in seconds/second	7.2759576141834267E-012
22	Tk	Time of frame start (since start of GLONASS day), in seconds	73800
23	Age	Age of data, in days	0
24	Flags	Information flags (see <i>Table H.1, Page 94</i>)	13
25	*xx	Checksum	*49
26	[CR][LF]	Sentence Terminator	[CR][LF]

NOTE: ¹ Time offset = 3 hours + GPS UTC offset. See *Section 1.5 (Page 13)* for more information on GLONASS and GPS time.



Example:

\$GEPA,991,496487.00,991,495913.00,10787,4,12,83,0,-2.102581933593754E+007
 -1.216645166015627E+007,7.7982763671875110E+006,-9.655075073242192E+002
 -5.014476776123048E+002,-3.387468338012698E+003,-1.862645149230957E-006
 9.3132257461547851E-007,-9.313225746154785E-007,-3.913920372724533E-004
 7.2759576141834267E-012,73800,0,13,*49,[CR][LF]

GEPB

Format:

Message ID = 77

Message byte count = 156

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
	Checksum	1	char		3
	Message Id	4	integer		4
	Message byte count	4	integer	bytes	8
2	GPS week of log output	4	integer	weeks	12
3	GPS time of log output	8	double	seconds	16
4	Reference week of ephemeris (in GPS time)	4	integer	weeks	24
5	Reference time of ephemeris (in GPS time)	8	double	seconds	28
6	GLONASS time - GPS time	4	integer	seconds	36
7	Slot number	4	integer	ordinal	40
8	Frequency	4	integer	ordinal	44
9	Issue 15 min. reference	4	integer	900s	48
10	Health	4	integer	-	52
11	X position (PZ90)	8	double	meters	56
12	Y position (PZ90)	8	double	meters	64
13	Z position (PZ90)	8	double	meters	72
14	X velocity (PZ90)	8	double	meters/s	80
15	Y velocity (PZ90)	8	double	meters/s	88
16	Z velocity (PZ90)	8	double	meters/s	96
17	X lunisolar acceleration (PZ90)	8	double	meters/s/s	104
18	Y lunisolar acceleration (PZ90)	8	double	meters/s/s	112
19	Z lunisolar acceleration (PZ90)	8	double	meters/s/s	120
20	Tau	8	double	seconds	128
21	Gamma	8	double	seconds/second	136
22	Time of frame start	4	long	seconds	144
23	Age of data	4	integer	days	148
24	Flags (See Table H.1 below)	4	integer	-	152

Table H.1 GLONASS Ephemeris Flags Coding

N 7	N 6	N 5	N 4	N 3	N 2	N 1	N 0	<< <	Nibble Number	Bit	Description	Range Values	Hex Value
										15b	P1 FLAG - TIME INTERVAL BETWEEN ADJACENT iISSUE (tb) VALUES	See Table below	00000001
										= 0			
										1			00000002
										2	P2 FLAG - ODDNESS OR EVENNESS OF iISSUE (tb) VALUE	0 = even, 1 = odd	00000004
										3	P3 FLAG - NUMBER OF SATELLITES WITH ALMANAC INFORMATION WITHIN CURRENT SUBFRAME	0 = four, 1 = five	00000008
										4			
										:	RESERVED		
										31			

Table H.1, Bits 0 - 1: P1 Flag Range Values

State	Description
00	0 minutes
01	30 minutes
10	45 minutes
11	60 minutes

H.2 OTHER RELEVANT GPSCARD LOGS

Please refer to the *MiLLennium Command Descriptions Manual's* logs chapter for a list of GPSCard logs categorized by function. The binary format descriptions and further details on individual logs may be found in *Appendix D* of the same manual, where logs are listed alphabetically.

Table H.2, Page 96 is a table of the receiver's self-test status codes. The status field output consists of 8 hexadecimal numbers which you must then convert to binary, see *Page 54*. Reading from right to left the first bit indicates if the antenna signal is good(1) or bad(0). This bit is an OR condition of the antenna. If the signal from the antenna is good then the status is good(1). If the antenna signal is bad then the status is bad (0). This table is referenced by the RGEA/B/D log, *Page 106* and the RVSA/B log, *Page 109*.

Bit 18, Table H.3, Page 99 is used for the antenna. This table is referenced by the ETSA/B log, *Page 101* and the RGEA/B/D log, *Page 106*.

Table H.4, Page 100 is an updated list of the GPSCard range reject codes. This table comes into effect when using the ETSA/B log, *Page 101* or the SATA/B log, *Page 110*.

NOTE: To determine the GLONASS PRN for commands that require entry of a PRN, such as ASSIGN, use this equation:

$$\text{FREQUENCY} * 10000 + \text{SLOT} + 37$$

where the SLOT and FREQUENCY are in the range 1 to 24 inclusive

Table H.2 Receiver Self-Test Status Codes

N 7		N 6		N 5		N 4		N 3		N 2		N 1		N 0		<- Nibble Number		Bit	Description	Range Values	Hex Value										
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
																		Isb = 0	ANTENNA	1 = good, 0 = bad	00000001										
																		1	PRIMARY PLL	1 = good, 0 = bad	00000002										
																		2	RAM	1 = good, 0 = bad	00000004										
																		3	ROM	1 = good, 0 = bad	00000008										
																		4	DSP	1 = good, 0 = bad	00000010										
																		5	PRIMARY AGC	1 = good, 0 = bad	00000020										
																		6	COM 1	1 = good, 0 = bad	00000040										
																		7	COM 2	1 = good, 0 = bad	00000080										
																		8	WEEK	1 = not set, 0 = set	00000100										
																		9	NO COARSE TIME	1 = not set, 0 = set	00000200										
																		10	NO FINETIME	1 = not set, 0 = set	00000400										
																		11	PRIMARY JAMMER	1 = present, 0 = normal	00000800										
																		12	BUFFER COM 1	1 = overrun, 0 = normal	00001000										
																		13	BUFFER COM 2	1 = overrun, 0 = normal	00002000										
																		14	BUFFER CONSOLE	1 = overrun, 0 = normal	00004000										
																		15	CPU OVERLOAD	1 = overload, 0 = normal	00008000										
																		16	ALMANAC SAVED IN NVM	1 = yes, 0 = no	00100000										
																		17	SECONDARY AGC	1 = good, 0 = bad	00020000										
																		18	SECONDARY JAMMER	1 = present, 0 = normal	00040000										
																		19	SECONDARY PLL	1 = good, 0 = bad	00080000										
																		20	OXC0 PLL	1 = good, 0 = bad	00100000										
																		21	SAVED ALMA. NEEDS UPDATE	1 = yes, 0 = no	00200000										
																		22	ALMANAC INVALID	1 = invalid, 0 = valid	00400000										
																		23	POSITION SOLUTION INVALID	1 = invalid, 0 = valid	00800000										
																		24	POSITION FIXED	1 = yes, 0 = no	01000000										
																		25	CLOCK MODEL INVALID	1 = invalid, 0 = valid	02000000										
																		26	CLOCK STEERING DISABLED	1 = disabled, 0 = enabled	04000000										
																		27	DO NOT HAVE WAAS ALMANAC	1 = not have, 0 = have	08000000										
																		28	DO NOT HAVE GLONASS ALMANAC	1 = not have, 0 = have	10000000										
																		29	TIMEOFFSET	Proprietary Information	20000000										
																		30	RESERVED		40000000										
																		31	RESERVED		80000000										

Notes on Table H.2:

- Bit 3:** On OEM GPSCards, "ROM" includes all forms of non-volatile memory.
- Bits 12-15:** Flag is reset to 0 five minutes after the last overrun/overload condition has occurred.
- Bits 1, 5, 11:** Refer to the primary L1 RF/digital path (For GPS).
- Bits 17-19:** Refer to the secondary L1 RF/digital path (For GLONASS).
- Bit 29:** Is used by the NovAtel "GPS Time Simulator" firmware.

Receiver Status - Detailed Bit Descriptions of Self-Test (Table H.2)

Bit State	Description
Bit 0	Antenna
0	If the antenna connection is shorted together then this bit will be clear (0) indicating a possible antenna port problem.
1	This bit will be set good if the antenna is drawing the appropriate amount of current from the GPSCard antenna jack. Overcurrent is tested not undercurrent.
Bit 1	Primary PLL
0	If a fault is detected in the Primary RF downconverter, this bit is set to 0.
1	When the Primary RF downconverter passes self-test, the bit will be set to 1.
Bit 2	RAM
0	If the bit has been set to 0, then RAM test has failed; please contact NovAtel Customer Service.
1	When this bit is set to 1, the receiver RAM has passed the self-test requirements.
Bit 3	ROM (Note: "ROM" includes all forms of non-volatile memory (NVM))
0	A zero bit indicates the receiver has failed the ROM test.
1	When this bit is set to 1, the receiver ROM test has passed the self test requirements.
Bit 4	DSP
0	If this bit is set to 0, one or both of the DSP chips has failed self-test; please contact NovAtel Customer Service.
1	This bit will be set to 1 when the digital signal processors (DSP) have passed the self-test requirements.
Bit 5	Primary AGC
0	This bit will be set clear if the Primary AGC is operating out of normal range. Failure of this test could be the result of various possibilities, such as: bad antenna LNA, excessive loss in the antenna cable, faulty RF downconverter, or a pulsating or high power jamming signal causing interference. If this bit is continuously set clear, and you cannot identify an external cause for the failed test, please contact NovAtel Customer Service.
1	When set to 1, the Primary AGC circuits are operating within normal range of control.
Bit 6	COM1
0	If set to 0, the COM1 UART has failed self-test and cannot be used for reliable communications.
1	When set to 1, the COM1 UART has passed the self-test requirements.
Bit 7	COM2
0	If set to 0, the COM2 UART has failed self-test and cannot be used for reliable communications.
1	When set to 1, the COM2 UART has passed the self-test requirements.
Bits 8, 9, 10	Week / No Coarsetime / No Finetime
0	These bits indicate the state of the receiver time and are set only once, generally in the first few minutes of operation, in the presence of adequate numbers of satellite signals to compute position and time.
1	If these bits are not all set to zero, then the observation data, pseudorange measurement, carrier phase, and Doppler <u>measurements may jump</u> as the clock adjusts itself.
Bit 11	Primary Jammer Detection
0	Normal operation is indicated when this bit is 0.
1	If set to 1, the receiver has detected a high power signal causing interference. When this happens, the receiver goes into a special anti-jamming mode where it re-maps the A/D decode values as well as special Primary AGC feedback control. These adjustments help to minimize the loss that will occur in the presence of a jamming signal. You should monitor this bit, and if set to 1, do your best to remedy the cause of the jamming signal. Nearby transmitters or other electronic equipment could be the cause of interference; you may find it necessary to relocate your antenna position if the problem persists.

Bit State	Description
Bits 12, 13, 14 0 1	Buffer COM 1 / COM 2 Normal operation is indicated by a 0 value. These bits are set to 1 to inform you when any of the 8-Kbyte output buffers have reached an over-run condition (COM1 or COM2). Over-run is caused by requesting more log data than can be taken off the GPSCard because of bit rate limitations or slow communications equipment. If this happens, the new data attempting to be loaded into the buffer will be discarded. The receiver will not load a partial data record into an output buffer. The flag resets to 0 five minutes after the last overrun occurred.
Bit 15 0 1	CPU Overload * see note 1 below Normal operation is indicated by a 0 value. A value of 1 indicates that the CPU is being over-taxed. This may be caused by requesting an excessive amount of information from the GPSCard. If this condition is occurring, limit redundant data logging or change to using binary data output formats, or both. You should attempt to tune the logging requirements to keep the idle time above 20% for best operation. If the average idle % drops below 10% for prolonged periods of time (2-5 seconds), critical errors may result in internal data loss and the over-load bit will be set to 1. You can monitor the CPU % idle time by using the RVSA log message. The flag resets to 0 five minutes after the first overload occurred.
Bit 16 0 1	Almanac Saved Almanac not saved in non-volatile memory. Almanac saved in non-volatile memory.
Bit 17 0 1	Secondary AGC This bit will be set clear if the Secondary AGC is operating out of normal range. Failure of this test could be the result of various possibilities, such as: bad antenna LNA, excessive loss in the antenna cable, faulty RF downconverter, or a pulsating or high power jamming signal causing interference. If this bit is continuously set clear, and you cannot identify an external cause for the failed test, please contact NovAtel Customer Service. When set to 1, the Secondary ARG circuits are operating within a normal range of control.
Bit 18 0 1	Secondary Jammer Detection Normal operation is indicated when this bit is 0. If set to 1, the receiver has detected a high power signal causing interference. When this happens, the receiver goes into a special anti-jamming mode where it re-maps the A/D decode values as well as special Secondary AGC feedback control. These adjustments help to minimize the loss that will occur in the presence of a jamming signal. You should monitor this bit, and if set to 1, do your best to remedy the cause of the jamming signal. Nearby transmitters or other electronic equipment could be the cause of interference; you may find it necessary to relocate your antenna position if the problem persists.
Bit 19 0 1	Secondary PLL If a fault is detected in the Secondary RF downconverter, this bit is set to 0. When the Secondary RF downconverter passes self-test, the bit will be set to 1.
Bit 20 0 1	OCXOPLL If a fault is detected in the OCXOPLL bit, this bit is set to 0. When the OCXOPLL bit passes self-test, the bit will be set to 1.
Bit 21 0 1	Saved Almanac Needs Update This bit will be set to 0 if an almanac has not been received that is newer than the one stored in memory. When the almanac received is newer than the one currently stored in NVM (non-volatile memory), the bit will be set to 1.
Bit 22 0 1	Almanac Invalid Valid almanac in use. No almanac in use

Bit State	Description
Bit 23	Position Solution Invalid
0	Valid position computed
1	Position solution is not valid
Bit 24	Position Fixed
0	Position has not been fixed.
1	A fix position command has been accepted
Bit 25	Clock Model Invalid
0	Clock model is valid
1	Clock model has not stabilized
Bit 26	Clock Steering Disabled
0	Clockadjust is enabled
1	Clockadjust disable command has been accepted
Bit 27	Do Not Have WAAS Almanac
0	Have WAAS almanac
1	Do not have WAAS almanac
Bit 28	Do Not Have GLONASS Almanac
0	Have GLONASS almanac
1	Do not have GLONASS almanac
Bit 29	TIMEOFFSET
	Proprietary use

Note 1: As the amount of CPU power becomes limited, the software will begin to slow down the position calculation rate. If the CPU becomes further limited, the software will begin to skip range measurement processing. Priority processing goes to the tracking loops.

Note 2: Primary refers to GPS satellites and Secondary refers to GLONASS satellites.

Table H.3 Channel Tracking Status

Bit	Description	Range Values	Hex.
Is b = 0			
1	Tracking state	0 - 11 See below	1
2			2
3			4
4			8
5			10
6	Channel number	0 - n (0 = first, n = last) (n depends on GPS Card)	20
7			40
8			80
9	Phase lock flag	1 = Lock, 0 = Not locked	200
10	Parity known flag	1 = Known, 0 = Not known	400
11	Code locked flag	1 = Lock, 0 = Not locked	800
12			1000
13	Correlator spacing	0 - 7 See below	2000
14			4000
15			8000
16	Satellite system	0 = GPS 3 = Pseudolite GPS 1 = GLONASS 4-7 Reserved	10000
17		2 = WAAS	20000
18	Reserved		
19	Grouping	1 = Grouped, 0 = Not Grouped	80000
20	Frequency	1 = L2, 0 = L1	100000
21	Code type	0 = C/A 2 = P-codeless 1 = P 3 = Reserved	200000
22			400000
23	Forward error correction	1 = FEC enabled, 0 = no FEC	800000
24			
:	Reserved		
29			
30	External range	1 = Ext. range, 0 = Int. range	
31	Channel assignment	1 = Forced, 0 = Automatic	

Table H.3, Bits 0 - 3: Channel Tracking State

State	Description
0	L1 Idle
1	L1 Sky search
2	L1 Wide frequency band pull-in
3	L1 Narrow frequency band pull-in
4	L1 Phase-lock loop
5	L1 Re-acquisition
6	L1 Steering
7	L1 Frequency-lock loop

Higher numbers are reserved for future use

Table H.3, Bits 12-14: Correlator Spacing

State	Description
0	Unknown: this only appears in versions of software previous to x.4x, which didn't use this field
1	Standard correlator: spacing = 1 chip
2	Narrow Correlator tracking technology: spacing < 1 chip

Higher numbers are reserved for future use

Table H.4 GPSCard Range Reject Codes

Value	Description
0	Observations are good
1	Bad satellite health is indicated by ephemeris data
2	Old ephemeris due to data not being updated during last 3 hours
3	Eccentric anomaly error during computation of the satellite's position
4	True anomaly error during computation of the satellite's position
5	Satellite coordinate error during computation of the satellite's position
6	Pitch error due to the satellite being below the cutoff angle (user-configurable)
7	Misclosure too large due to excessive gap between estimated and actual positions
8	No differential correction is available for this particular satellite
9	Ephemeris data for this satellite has not yet been received
10	Invalid IODE due to mismatch between differential stations
11	Locked Out: satellite is excluded by user (LOCKOUT command)
12	Low Power: satellite rejected due to low signal/noise ratio
13	L2 measurements are not currently used in the filter
14	Reserved
15	Undetermined GLONASS slot #
16	Bad Integrity

Higher numbers are reserved for future use

H.2.1 ETSA/B EXTENDED CHANNEL TRACKING STATUS

This log provides channel tracking status information for each of the MiLLennium-GLONASS GPSCard parallel channels.

NOTE: This log is intended for status display only; since some of the data elements are not synchronized together, they are not to be used for measurement data. Please use the RGEA/B/D log, *Page 106*, or the SATA/B log, *Page 110*, to obtain synchronized data for post processing analysis.

ETSA

Structure:

\$ETSA	week	seconds	solution status ¹	# of observations	
prn ⁴	tracking status ²	dopp frequency	C/No	residual in meters	
locktime	pseudorange	reject code ³			
:					
prn	tracking status ²	dopp frequency	C/No	residual in meters	
locktime	pseudorange	reject code ³			
*xx	[CR][LF]				

NOTES: ¹ See Table H.8 (Page 111) ² See Table H.3 (Page 99) ³ See Table H.4 (Page 100) ⁴ GLONASS PRN = FREQUENCY * 10000 + SLOT + 37

Example (carriage returns have been added between observations for clarity):

```
$ETSA,993,601238.00,0,16,
4,2E04,3754.0,44.893,0.000,1851.8,23840800.24,16,
2,2E14,-1640.0,52.283,0.000,17750.3,21307036.11,16,
7,2E24,278.8,52.620,0.000,10495.6,20256363.18,16,
26,2E34,-2706.7,45.828,0.000,12436.2,23949547.80,16,
8,2E44,3819.7,41.938,0.000,404.3,24858796.71,16,
9,2E54,2217.6,50.991,0.000,4090.3,22084643.13,16,
5,2E64,3367.5,41.902,0.000,116.5,25234194.37,16,
15,2E74,-2168.4,47.324,0.000,9610.5,23182672.06,16,
27,2E84,-3962.1,44.486,0.000,21429.9,24183438.98,16,
0,2090,0.0,0.000,0.000,0.0,0.00,9,
60046,AEA4,1526.5,51.330,-0.642,6666.7,20159777.89,0,
240054,AEB4,-3587.0,45.926,2.094,17258.1,22564127.88,0,
220053,AEC4,-2926.0,51.674,0.524,151.1,20285415.40,0,
210040,AED4,4038.5,42.807,-3.985,482.1,23919984.64,0,
90047,AEE4,4272.8,44.638,1.729,445.1,23902690.30,0,
0,A0F0,0.0,0.000,0.000,0.0,0.00,9*27
```

H.2.2 NAVA/B WAYPOINT NAVIGATION DATA

This log reports the status of your waypoint navigation progress. It is used in conjunction with the SETNAV command.

REMEMBER: The SETNAV command must be enabled before valid data will be reported from this log.

NAVA

Structure:

\$NAVA	week	seconds	distance to destination	bearing to destination
along track	xtrack	estimated week at destination		
estimated seconds at destination	navigation status ¹			
solution status ²	*xx	[CR][LF]		

NOTES: ¹ See Table H.5 below ² See Table H.8 (Page 111)

Example:

```
$NAVA,640,333115.00,6399.6305,88.017,6396.9734,184.3929,657,51514.000,0,1
*11[CR][LF]
```

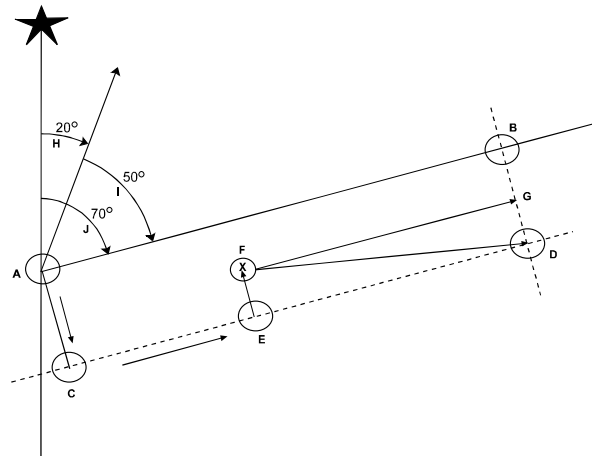
NOTE: All distances and angles are calculated using Vincenty's long line geodetic equations that operate on the currently selected user datum.

See Figure H.1 for an illustration of navigation parameters.

Table H.5 Navigation Status

Status	Description
0	Good
1	No velocity
2	Bad navigation calculation

Figure H.1 Navigation Parameters



Reference	Description	Reference	Description
A	FROM, lat-lon	F	Current GPS position
B	TO, lat-lon	FD	Current distance and bearing from F to D
AB	Great circle line drawn between FROM A lat-lon and TO B lat-lon	E	Xtrack perpendicular reference point
AC	Track offset from A to C	EF	Xtrack error from E to F (perpendicular to CD)
BD	Track offset from B to D	FG	Along track from F to G (perpendicular to BD)
CD	Offset track to steer (parallel to AB)	I	Magnetic bearing
H	Variation (local MAGVAR correction = -20°)		
J	True bearing		

AB - True bearing = 70° AB - Magnetic bearing = True + (MAGVAR correction) = 70° + (-20°) = 50°

H.2.3 POSA/B COMPUTED POSITION

This log will contain the last valid best-available-position and time-calculated referenced to the antenna phase center. The position is in geographic coordinates in degrees based on your specified datum (default is WGS84). The height is referenced to mean sea level. The receiver time is in GPS weeks and seconds into the week. The estimated standard deviations of the solution and current filter status are also included.

POSA

Structure:

\$POSA	week	seconds	lat	lon	hgt	undulation	datum ID
lat std	lon std	hgt std	sol status ¹		*xx	[CR][LF]	

Note: ¹See Table H.8 (Page 111)

Example:

```
$POSA,991,428326.00,51.11638173,-114.03824540,
1092.104,-16.271,61,14.412,8.799,25.020,0*1E
```

H.2.4 PRTKA/B COMPUTED POSITION

This log contains the best available position computed by the receiver, along with three status flags. In addition, it reports other status indicators, including differential lag, which is useful in predicting anomalous behavior brought about by outages in differential corrections.

This log replaces the P20A log; it is similar, but adds extended status information. With the system operating in an RTK mode, this log will reflect the latest low-latency solution for up to 30 seconds after reception of the last reference 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, and is summarized in *Chapter 4, Table 4.2, Page 41*. 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 for GPS using the DGPSTIMEOUT command (refer to the *MiLLennium Command Descriptions Manual*) and for GLONASS using the DGLOTIMEOUT command (see *Page 82*).

PRTKA

Structure:

\$PRTKA	week	sec	lag	#sv	#high
L1L2 #high	lat	lon	hgt	undulation	datum ID
lat σ	lon σ	hgt σ	soln status ¹		rtk status ²
posn type ³	idle	stn ID	*xx	[CR][LF]	

NOTES: ¹ See *Table H.8 (Page 111)*, ² See *Table H.10 (Page 112)*, ³ See *Table H.9 (Page 112)*

Example:

```
$PRTKA,993,597206.00,0.000,12,0,0,51.11633600370,-114.03830984516,
1072.4348,-16.2712,61,14.3281,8.8081,24.7753,0,8,1,45,0*6F[CR][LF]
```

H.2.5 PVAA/BXYZ POSITION, VELOCITY AND ACCELERATION

The PVAA/B log contains the MiLLennium-GLONASS GPSCard receiver's latest computed best-available-position, velocity and acceleration in ECEF coordinates. Compare this to the VLHA/B log where the velocity latency is an average velocity based on the time difference between successive position computations.

In the PVAA/B log, position, velocity and acceleration status fields indicate whether or not the corresponding data are valid.

This command supports INS (Inertial Navigation System) integration. PVA logs can be injected into the receiver from an INS. This information is only used by the tracking loops of the receiver to aid in reacquisition of satellites after loss of lock, otherwise it is ignored. This command is only useful for very high dynamics where expected velocity changes during the signal blockage of more than 100 meters per second can occur.

NOTE: These quantities are always referenced to the WGS84 ellipsoid, regardless of the use of the DATUM or USERDATUM commands.

PVAA

Structure:

\$PVAA	week	seconds	Pos-x	Pos-y	Pos-z	Vel-x	Vel-y	Vel-z
Acc-x	Acc-y	Acc-z	Pos-status ¹		Vel-status ¹		Acc-status ¹	
*xx	[CR][LF]							

NOTE: ¹ 0 = bad; 1 = good

Example:

```
$PVAA,991,428492.00,-1634529.404,-3664640.553,4942523.994,0.114,-0.462,0.228,-0.159,0.983,-0.955,1,1,1*23
```

H.2.6 RCCA RECEIVER CONFIGURATION

This log outputs a list of all current GPSCard command settings. It will include MiLlennium-GLONASS GPSCard configurations. Observing this log is a good way to monitor the GPSCard configuration settings.

The RCCA log is used to view the current configuration of the MiLlennium-GLONASS GPSCard receiver. The log will identify the setting of every user-configurable parameter. An excerpt from the RCCA log will look something like this:

```
$RCCA,COM1,57600,N,8,1,CTS,OFF,ON*1A
$RCCA,COM1_DTR,HIGH*70
$RCCA,COM1_RTS,HIGH*67
$RCCA,ACCEPT,COM1,COMMANDS*5B
$RCCA,COM2,9600,N,8,1,N,OFF,ON*28
$RCCA,COM2_DTR,HIGH*73
$RCCA,COM2_RTS,HIGH*64
$RCCA,ACCEPT,COM2,COMMANDS*58
$RCCA,UNDULATION,TABLE*56
$RCCA,DATUM,WGS84*15
$RCCA,USERDATUM,6378137.000,298.257223563,0.000,0.000,0.000,0.000,0.000,0.000*6A
$RCCA,SETNAV,DISABLE*5C
$RCCA,MAGVAR,0.000,30.000*02
$RCCA,DYNAMICS,AIR*4F
$RCCA,UNASSIGNALL*64
$RCCA,UNLOCKOUTALL*20
$RCCA,RESETHEALTHALL*37
$RCCA,UNFIX*73
$RCCA,ANTENNAPOWER OFF*50
$RCCA,SETDGPSID,ALL*1D
$RCCA,RTCMRULE,6CR*32
$RCCA,RTCM16T,*48
$RCCA,CSMOOTH,20.00,20.00*7E
$RCCA,ECUTOFF,0.00*45
$RCCA,FREQUENCY_OUT,DISABLE*12
$RCCA,EXTERNALCLOCK,DISABLE*12
$RCCA,CLOCKADJUST,ENABLE*47
$RCCA,SETTIMESYNC,DISABLE*17
$RCCA,SETL1OFFSET,0.000000*3F
$RCCA,MESSAGES,ALL,ON*67
$RCCA,DGPSTIMEOUT,60.00,120.00*51
$RCCA,DGLOTIMEOUT,60.00*60
$RCCA,SAVEALMA,ONNEW*4E
$RCCA,POSAVE,DISABLE*59
$RCCA,RTKMODE,DEFAULT*16
$RCCA,CONFIG,DEBUG*48
$RCCA,DIFF_PROTOCOL,DISABLED*47
$RCCA,IONOMODEL,CALCULATED*5B
$RCCA,WAASCORRECTION,DISABLE*55
$RCCA,LOG,COM1,TM1B,ONTIME,30.00*58
$RCCA,LOG,COM1,PRTKB,ONTIME,10.00*6F
$RCCA,LOG,COM1,ETSB,ONTIME,2.00,0.50*34
$RCCA,LOG,COM1,MKPB,ONNEW*6E
$RCCA,LOG,COM1,POSB,ONTIME,1.00*0E
```

H.2.7 RGEA/B/D CHANNEL RANGE MEASUREMENTS

The receiver supports differential combined GPS/GLONASS, RT-10 GPS/GLONASS and most single-point logs and commands described in the *MiLLennium Command Description Manual*. GLONASS pseudorange data is transmitted along with the GPS pseudoranges in the RGEA/B/D log, and can be discerned by monitoring the channel tracking status bits in the range logs.

The RGEA/B/D log contains the channel range measurements for the currently observed satellites. The RGEA example was produced using the MiLLennium-GLONASS GPSCard. The RGED message is a compressed form of the RGEB message. When using these logs, please keep in mind the constraints noted in the detailed description in the *MiLLennium Command Descriptions Manual*.

It is important to ensure that the receiver clock has been set and can be monitored by the bits in the *receiver status* field. Large jumps in range as well as ADR will occur as the clock is being adjusted. If the ADR measurement is being used in precise phase processing, it is important not to use the ADR if the "parity known" flag in the *tracking-status* field is not set as there may exist a half (1/2) cycle ambiguity on the measurement. The tracking error estimate of the pseudorange and carrier phase (ADR) is the thermal noise of the receiver tracking loops only. It does not account for possible multipath errors or atmospheric delays.

RGEA and RGEB contain all of the new extended channel tracking status bits (see *Table H.3, Page 99*), while RGED contains only the lowest 24 bits.

NOTE: In the RGED log, the limited number of bits available means that the GLONASS prns are reported as slot + 37 without the frequency information (i.e. 48 instead of 40048).

RGEA/B/D

Structure:

\$RGEA	week	seconds	# satellite observations	receiver status ¹
prn	pseudorange measurement	pseudorange measurement std	carrier phase	
carrier phase std	Doppler frequency	C/No	locktime	tracking-status ²
:				
prn ³	pseudorange measurement	pseudorange measurement std	carrier phase	
carrier phase std	Doppler frequency	C/No	locktime	tracking-status ²
*xx	[CR][LF]			

NOTES: ¹ See *Table H.2 (Page 96)* ² See *Table H.3 (Page 99)* ³ GLONASS PRN = FREQUENCY * 10000 + SLOT + 37

Example (carriage returns have been added between observations for clarity):

```
$RGEA,991,429633.75,10,B00FF,
15,22509752.053,0.062,-118289596.426,0.009,-295.846,50.4,6058.250,2E04,
2,20703387.186,0.030,-108797043.280,0.002,-648.690,52.8,6133.680,2E14,
9,23557992.104,0.126,-123798100.030,0.008,3242.123,46.0,1381.840,2E34,
26,22620451.324,0.071,-118871293.335,0.006,-1558.346,49.7,6059.250,2E54,
27,22289907.868,0.072,-117134240.976,0.008,-3309.252,49.6,6105.110,2E64,
21,25638806.808,0.451,-134732816.918,0.026,-158.909,35.6,808.330,2E74,
7,20787884.888,0.035,-109241144.038,0.003,1688.748,52.5,6056.480,2E84,
60046,21451363.958,0.152,-114871116.673,0.012,3404.079,49.1,3731.660,AEA4,
220053,19346534.447,0.082,-104180633.540,0.011,-707.671,52.0,188.950,AED4,
240054,20870849.133,0.127,-112467321.221,0.012,-3016.171,50.1,6270.474,AF14*1B
```

Table H.6 Range Record Format (RGED only)

Data	Bit(s) from first to last	Length(bits)	Format	Scale Factor
PRN 1	0..5	6	integer	1
C/No 2	6..10	5	integer	(20+n)dB-Hz
Lock time 3	11..31	21	integer	1/32 s
ADR 4	32..63	32	integer 2's comp.	1/256 cycles
Doppler frequency	68..95	28	integer 2's comp.	1/256 Hz
Pseudorange	64..67 msn; 96..127 lsw	36	integer 2's comp.	1/128 m
StdDev - ADR	128..131	4	integer	(n+1)/512 cyc
StdDev - pseudorange	132..135	4		see ⁵
Channel Tracking status 6	136..159	24	integer	see Table H.3, Page 99

Higher numbers are reserved for future use

Notes on Table H.6:

- 1 The PRN values for GLONASS are 38-62, representing the GLONASS slot number plus 37 (frequency information not provided due to lack of space).
- 2 C/No is constrained to a value between 20 - 51 dB-Hz. Thus, if it is reported that C/No = 20 dB-Hz, the actual value could be less. Likewise, if it is reported that C/No = 51 dB-Hz, the true value could be greater.
- 3 Lock time rolls over after 2,097,151 seconds.
- 4 ADR (Accumulated Doppler Range) is calculated as follows:

```

ADR_ROLLS = (-RGED_PSR / WAVELENGTH - RGED_ADR) / MAX_VALUE
Round to the closest integer
IF(ADR_ROLLS < -0.5)
    ADR_ROLLS = ADR_ROLLS - 0.5
ELSE
    ADR_ROLLS = ADR_ROLLS + 0.5
At this point integerise ADR_ROLLS
CORRECTED_ADR = RGED_ADR + (MAX_VALUE * ADR_ROLLS)
where:
ADR has units of cycles
WAVELENGTH = 0.1902936727984 for GPS L1
    
```

5

Code	RGED	Code	RGED
0	0.00 to 0.050	8	0.855 to 1.281
1	0.051 to 0.075	9	1.282 to 2.375
2	0.076 to 0.113	10	2.376 to 4.750
3	0.114 to 0.169	11	4.751 to 9.500
4	0.170 to 0.253	12	9.501 to 19.000
5	0.254 to 0.380	13	19.001 to 38.000
6	0.381 to 0.570	14	38.001 to 76.000
7	0.571 to 0.854	15	76.001 to 152.000

6 Only bits 0-23 are represented in the RGED log

H.2.8 RTKA/B COMPUTED POSITION - TIME MATCHED

This log represents carrier phase positions that have been computed from time matched reference and remote observations. There is no reference station prediction error on these positions, but because they are based on buffered measurements, they lag real time by some amount depending on the latency of the data link. If the remote receiver has not been enabled to accept RTK differential data, or is not actually receiving data leading to a valid solution, this will be reflected by the code shown in field #16 (RTK status) and #17 (position type).

The data in the logs will change only when a reference observation changes. If the log is being output at a fixed rate and the differential data is interrupted, then the RTKA/B logs will continue to be output at the same rate but the position and time will not change.

A good message trigger for this log is "ONCHANGED". Then, only positions related to unique reference station messages will be produced, and the existence of this log will indicate a successful link to the reference station.

RTKA

Structure:

\$RTKA	week	seconds	#sv	#high	L1L2 #high
lat	lon	hgt	undulation	datum ID	
lat σ	lon σ	hgt σ	soln status ¹	rtk status ²	
posn type ³	dyn mode ⁴	stn ID	*xx	[CR][LF]	

NOTES: ¹ See Table H.8 (Page 111) ² See Table H.10 (Page 112) ³ See Table H.9 (Page 112) ⁴ 0= static, 1= kinematic

Example:

```
$RTKA,872,174962.00,8,7,7,51.11358039754,-114.04358003164,1059.4105,
-16.2617,61,0.0036,0.0039,0.0066,0,0,4,0,119*33[CR][LF]
```

H.2.9 RTKOA/B RTK SOLUTION PARAMETERS

This is the “RTK output” log, and it contains miscellaneous information regarding the RTK solution. It is based on the matched update. Note that the length of the log messages will vary depending on the number of matched satellites in the solution, a quantity represented by #sv in the field numbers.

The PRN fields for GLONASS satellites use the convention of the RGEA/B logs.

RTKOA

Structure:

\$RTKOA	week	sec	status ¹	#sat	#high	L1L2 #high	#sv	
dyn ²	search ³	comb	σ_{xx}	σ_{xy}	σ_{xz}	σ_y	σ_{yy}	σ_{yz}
σ_{zx}	σ_{zy}	σ_{zz}	Δx	Δy	Δz	$\sigma_{\Delta x}$	$\sigma_{\Delta y}$	$\sigma_{\Delta z}$
rsrv	rsrv	ref id	#res					
sat id	amb ⁴	res						
:								
sat id	amb	res						
*xx	[CR][LF]							

NOTES: ¹ See Table H.13 (Page 113) ² 0=static, 1=kinematic ³ See Table H.12 (Page 113) ⁴ See Table H. 11 (Page 112)

Example:

```
$RTKOA,929,237639.00,1,8,8,8,8,0,4,1,0.000006136,0.000003797,
-0.000006287,0.000003797,0.000013211,-0.000007043,-0.000006287,
-0.000007043,0.000018575,3.2209,-3.0537,-1.2024,0.0183,0.0138,0.0124,
0.0.0000,1,7,21,6,-0.001199,23,6,0.005461,31,6,0.009608,9,6,0.001963,
15,6,0.000208,29,6,-0.005643,25,6,-0.004366*60[CR][LF]
```

H.2.10 RVSA/B RECEIVER STATUS

This log conveys various status parameters of the receiver system. The RVSA example was produced using the MiLlennium-GLONASS GPSCard. If the system is a multiple-GPSCard unit with a master card, certain parameters are repeated for each individual GPSCard. If the system is composed of only one GPSCard, then only the parameters for that unit are listed. Together, the RVSA/B and VERA/B logs supersede older receiver status logs.

RVSA

Structure:

\$RVSA	week	seconds	# of sat_chan	# of sig_chan
# of cards	reserved	% CPU idle time	receiver status ¹	
:				
% CPU idle time	receiver status ¹	*xx	[CR][LF]	

NOTE: ¹ See Table H.2 (Page 96)

Example:

```
$RVSA,991,430123.00,18,18,1,,53.00,B00FF*55
```

H.2.11 SATA/B SATELLITE SPECIFIC DATA

This log provides satellite specific data for satellites actually being tracked. The SATA example was produced using MiLLennium-GLONASS GPSCard. The record length is variable and depends on the number of satellites.

Each satellite being tracked has a reject code indicating whether it is used in the solution, or the reason for its rejection from the solution. The reject value of 0 indicates the observation is being used in the position solution. Values of 1 through 15 indicate the observation has been rejected for the reasons specified in *Table H.4, Page 100*. A range reject code of 8 only occurs when operating in differential mode and an interruption of corrections has occurred or the DGPSTIMEOUT has been exceeded. The mask angle is user-configurable, and a range reject code of 6 will indicate that the satellite is below the mask angle.

The GLONASS PRN fields use the convention given for the RGEA/B log.

SATA

Structure:

\$SATA	week	seconds	solution status ¹	# satellite obs
prn ³	azimuth	elevation	range residual	reject code ²
:				
prn	azimuth	elevation	range residual	reject code ²
*xx	[CR][LF]			

NOTES: ¹ See *Table H.8 (Page 111)* ² See *Table H.4 (Page 100)* ³ GLONASS PRN = FREQUENCY * 10000 + SLOT + 37

Example:

```
$SATA,991,430994.00,0,10,15,50.52,26.76,0.556,0,2,93.52,62.80,
-36.584,0,4,169.37,6.37,d17.976,0,9,307.29,28.99,15.237,0,26,254.78,
26.92,18.238,0,27,153.64,21.33,d10.992,0,7,197.30,72.72,0.208,0,60046,
316.16,43.16,d3.227,0,220053,211.96,61.86,2.582,0,240054,53.20,31.05,0.633,0*24
```

H.2.12 VERA/B RECEIVER H/W & S/W VERSION NUMBERS

This log contains the current hardware type and software version number for the MiLLennium-GLONASS GPSCard. The VERA example was produced using the MiLLennium-GLONASS GPSCard. Together with the RVSA/B log, *Page 109*, it supersedes any previous receiver status logs.

VERA

Structure:

\$VERA	week	seconds	version	*xx	[CR][LF]
--------	------	---------	---------	-----	----------

Example:

```
$VERA,991,431836.00,OEM-3 GLO-RTK CGL97230083 HW 3-1 SW 6.48D18/2.03DB Jan 05/99*3D
```

H.2.13 VLHA/BVELOCITY, LATENCY, & DIRECTION OVER GROUND

The actual speed and direction of the antenna over ground is provided. The VLHA/B log provides a measure of the latency in the velocity time tag and a new velocity status word which gives you quality velocity information. The velocity status indicates varying degrees of velocity quality. To ensure healthy velocity, the position *solution status* must also be checked. If the *solution status* is non-zero, the velocity will likely be invalid. Also, it includes the age of the differential corrections used in the velocity computation. It should be noted that the MiLLennium-GLONASS GPSCard does not determine the direction a vessel, craft, or vehicle is pointed (heading), but rather the direction of motion of the antenna relative to ground.

VLHA

Structure:

\$VLHA	week	seconds	velocity time tag latency	age of GPS data
hor speed		direction wrt True North		vert speed
solution status ¹	velocity status ²	*xx	[CR][LF]	

NOTES: ¹ See Table H.8 (Page 111) ²See Table H.7 below

Example:

\$VLHA,991,489504.00,0.500,0.000,0.099,56.492,0.139,0,3*3B[CR][LF]

Table H.7 Velocity Status

Value	Description
0	Velocity computed from differentially corrected carrier phase data
1	Velocity computed from differentially corrected Doppler data
2	Old velocity from differentially corrected phase or Doppler (higher latency)
3	Velocity from single point computations
4	Old velocity from single point computations (higher latency)
5	Invalid velocity

Higher values reserved for future use

Table H.8 GPSCard Solution Status

State	Description
0	Solution computed
1	Insufficient observations
2	No convergence
3	Singular A ^T PA Matrix
4	Covariance trace exceeds maximum (trace > 1000 m)
5	Test distance exceeded (maximum of 3 rejections if distance > 10km)
6	Not yet converged from cold start
7	Height or velocity limit exceeded. (In accordance with COCOM export licensing restrictions)
8	Bad integrity

Higher numbers are reserved for future use

Table H.9 Position Type

State	Description
0	No position
1	Single point position
2	Differential pseudorange position (GPS)
3	RT-20 position (GPS)
4	RT-2 position (GPS)
5	WAAS position solution
6	Differential combined GPS/GLONASS
7	DGPS with uncorrected GLONASS
8	RT-10 GPS/GLONASS
9	Reserved
10	Reserved
11	Differential pseudorange position (GLONASS)
12	DGLONASS with uncorrected GPS

Higher numbers are reserved for future use

Table H.10 RTK Status for Position Type 3 and Type 8

State	Description
0	Floating ambiguity solution (converged)
1	Floating ambiguity solution (not yet converged)
2	Modeling reference phase
3	Insufficient observations
4	Variance exceeds limit
5	Residuals too big
6	Delta position too big
7	Negative variance
8	RTK position not computed

Higher numbers are reserved for future use

Table H.11 Ambiguity Types

Ambiguity Type	Definition
0	L1 only floating
1	Wide lane fixed integer
2	Reserved
3	Narrow lane floating
4	Iono-free floating
5	Reserved
6	Narrow lane fixed integer
7	Iono-free fixed discrete
8	L1 only fixed integer
9	Reserved
10	Undefined type

Higher numbers are reserved for future use

Table H.12 Searcher Status

Searcher Status	Definition
0	No search requested
1	Searcher buffering measurements
2	Currently searching
3	Search decision made
4	Hand-off to L1 and L2 complete

Higher numbers are reserved for future use

Table H.13 RTK Status

RTK Status	Definition
1	Good narrowlane solution
2	Good widelane solution
4	Good L1/L2 converged float solution
8	Good L1/L2 unconverged float solution
16	Good L1 converged solution
32	Good L1 unconverged solution
64	Reserved for future use
128	Insufficient observations
256	Variance exceeds limit
512	Residuals exceed limit
1024	Delta position too large
2048	Negative variance
4096	Undefined
8192	RTK initialize

Higher numbers are reserved for future use

I

GPS/GLONASS GLOSSARY OF TERMS

ASCII — A 7 bit wide serial code describing numbers, upper and lower case characters, special and non-printing characters.

Accuracy — The degree of conformance between the estimated or measured position, time, and/or velocity of a GPS receiver and its true time, position, and/or velocity as compared with a constant standard. Radionavigation system accuracy is usually presented as a statistical measure of system error and is characterized as follows:

Predictable - The accuracy of a radionavigation system's position solution with respect to the charted solution. Both the position solution and the chart must be based upon the same geodetic datum.

Repeatable - The accuracy with which a user can return to a position whose coordinates have been measured at a previous time with the same navigation system.

Relative - The accuracy with which a user can measure position relative to that of another user of the same navigation system at the same time.

Address field — for sentences in the NMEA standard, the fixed length field following the beginning sentence delimiter "\$" (HEX 24). For NMEA approved sentences, composed of a two character talker identifier and a three character sentence formatter. For proprietary sentences, composed of the character "P" (HEX 50) followed by a three character manufacturer identification code.

Almanac — a set of orbit parameters that allows calculation of approximate GPS satellite positions and velocities. The almanac is used by a GPS receiver to determine satellite visibility and as an aid during acquisition of GPS satellite signals.

Almanac data — a set of data which is downloaded from each satellite over the course of 12.5 minutes. It contains orbital parameter approximations for all satellites, GPS to universal time conversion parameters, and single-frequency ionospheric model parameters.

Analog — A type of transmission characterized by variable waveforms representing information, contrasted with digital. Modern computers are invariably digital, but when they communicate over telephone lines, their signals must be converted to analog using a modem (a modulator/demodulator). The analog signal is converted back into a digital form before delivering it to a destination computer.

Antipodal Satellites — Satellites in the same orbit plane separated by 180 degrees in argument of latitude.

Arrival alarm — an alarm signal issued by a voyage tracking unit which indicates arrival at or at a pre-determined distance from a waypoint [see *arrival circle*].

Arrival circle — an artificial boundary placed around the destination waypoint of the present navigation leg, and entering of which will signal an arrival alarm.

Arrival perpendicular — crossing of the line which is perpendicular to the course line and which passes through the destination waypoint.

Attenuation — reduction of signal strength.

Attitude — the position of an aircraft or spacecraft in relation to a given line or plane, as the horizon.

Availability — The percentage of time that the services of a navigation system can be used within a particular coverage area. Signal availability is the percentage of time that navigational signals transmitted from external sources are available for use. Availability is a function of both the physical characteristics of the operational environment and the technical capabilities of the transmitter facilities.

Azimuth — the horizontal direction of a celestial point from a terrestrial point, expressed as the angular distance from 000° (reference) clockwise through 360°. The reference point is generally True North, but may be Magnetic North, or Relative (ship's head).

- Bandwidth** — The range of frequencies in a signal.
- Bearing** — the horizontal direction of one terrestrial point from another terrestrial point, expressed as the angular distance from a reference direction, usually measured from 000° at the reference direction clockwise through 360°. The reference point may be True North, Magnetic North, or Relative (ship's head).
- Carrier** — the steady transmitted RF signal whose amplitude, frequency, or phase may be modulated to carry information.
- Carrier Phase Ambiguity** (or sometimes ambiguity for short) — the number of integer carrier phase cycles between you and the satellite at the start of tracking.
- Carrier phase measurements** — these are “accumulated delta range” measurements. They contain the instantaneous phase of the signal (modulo 1 cycle) plus some arbitrary number of integer cycles. Once the receiver is tracking the satellite, the integer number of cycles correctly accumulates the change in range seen by the receiver. When a “lock break” occurs, this accumulated value can jump an arbitrary integer number of cycles (this is called a cycle slip).
- CEP** — circular error probable; a circle's radius, centered at the true antenna position, containing 50 percent of the points in the horizontal scatter plot.
- Channel** — A channel of a combined GPS/GLONASS receiver consists of the circuitry necessary to receive the signal from a single GPS/GLONASS satellite.
- Checksum** — by NMEA standard, a validity check performed on the data contained in the sentences, calculated by the talker, appended to the message, then recalculated by the listener for comparison to determine if the message was received correctly. Required for some sentences, optional for all others.
- Circular Error Probable (CEP)** — the radius of a circle, centered at your true location, that contains 50 percent of the individual position measurements made using a particular navigation system.
- Clock Bias** — The difference between the clock's indicated time and true universal time.
- Clock Offset** — Constant difference in the time reading between two clocks.
- Coarse Acquisition (C/A) Code** — a spread spectrum direct sequence code that is used primarily by commercial GPS receivers to determine the range to the transmitting GPS satellite. Uses a chip rate of 1.023 MHz. Also known as the "civilian code."
- Communication protocol** — a method established for message transfer between a talker and a listener which includes the message format and the sequence in which the messages are to be transferred. Also includes the signalling requirements such as bit rate, stop bits, parity, and bits per character.
- Control segment** — the Master Control Station and the globally dispersed reference Stations used to manage the satellites, determine their precise orbital parameters, and synchronize their clocks. GLONASS and GPS have their own control segments and use their own time for determining clock offset.
- Course** — the horizontal direction in which a vessel is to be steered or is being steered; the direction of travel through the air or water. Expressed as angular distance from reference North (either true, magnetic, compass, or grid), usually 000° (north), clockwise through 360°. Strictly, the term applies to direction through the air or water, not the direction intended to be made good over the ground (see *track, Page 122*). Differs from heading.
- Course Made Good (CMG)** — the single resultant direction from a given point of departure to a subsequent position; the direction of the net movement from one point to the other. This often varies from the track caused by inaccuracies in steering, currents, cross-winds, etc. This term is often considered to be synonymous with Track Made Good, however, track made good is the more correct term.
- Course Over Ground (COG)** — the actual path of a vessel with respect to the Earth (a misnomer in that courses are directions steered or intended to be steered through the water with respect to a reference meridian); this will not be a straight line if the vessel's heading yaws back and forth across the course.
- Crab** — the apparent sideways motion of an aircraft with respect to the ground when headed into a crosswind.

Cross Track Error (XTE) — the distance from the vessel's present position to the closest point on a great circle line connecting the current waypoint coordinates. If a track offset has been specified in the GPSCard SETNAV command, the cross track error will be relative to the offset track great circle line.

Cycle Slip — when the carrier phase measurement jumps by an arbitrary number of integer cycles. It is generally caused by a break in the signal tracking due to shading or some similar occurrence.

Dead Reckoning (DR) — the process of determining a vessel's approximate position by applying from its last known position a vector or a series of consecutive vectors representing the run that has since been made, using only the courses being steered, and the distance run as determined by log, engine rpm, or calculations from speed measurements.

Destination — the immediate geographic point of interest to which a vessel is navigating. It may be the next waypoint along a route of waypoints or the final destination of a voyage.

Differential GPS (DGPS) — a technique to improve GPS accuracy that uses pseudorange errors at a known location to improve the measurements made by other GPS receivers within the same general geographic area.

Digital — Generally, information is expressed, stored and transmitted by either analog or digital means. In a digital form, this information is seen in a binary state as either a one or a zero, a plus or a minus. The computer uses digital technology for most actions.

Dilution of Precision (DOP) — a numerical value expressing the confidence factor of the position solution based on current satellite geometry. The lower the value, the greater the confidence in the solution. DOP can be expressed in the following forms.

GDOP - estimated uncertainty for all parameters (latitude, longitude, height, clock offset)

PDOP - estimated uncertainty for all 3D parameters (latitude, longitude, height)

HTDOP - estimated uncertainty for all time and 2D parameters (latitude, longitude, time)

HDOP - 2D parameters are uncertain (latitude, longitude)

VDOP - estimated uncertainty for height

TDOP - estimated uncertainty for clock offset

Distance root mean square (drms) — The root-mean-square value of the distances from the true location point of the position fixes in a collection of measurements. As typically used in GPS positioning, 2 drms is the radius of a circle that contains at least 95 percent of all possible fixes that can be obtained with a system at any one place.

Doppler — the change in frequency of sound, light or other wave caused by movement of its source relative to the observer.

Doppler aiding — a signal processing strategy, which uses a measured Doppler shift to help a receiver smoothly track the GPS signal, to allow more precise velocity and position measurement.

Double-Difference — a position estimation mechanization which uses observations which are differenced between receiver channels and between the reference and remote receivers.

Double-Difference Carrier Phase Ambiguity (or sometimes double difference ambiguity or ambiguity, for short) — carrier phase ambiguities which are differenced between receiver channels and between the reference and remote receivers. They are estimated when a double difference mechanism is used for carrier phase positioning.

Earth-Centered-Earth-Fixed (ECEF) — a right-hand Cartesian coordinate system with its origin located at the center of the Earth. The coordinate system used by GPS to describe three-dimensional location.

- ECEF** — Earth-Centered-Earth-Fixed. This is a coordinate-ordinate system which has the X-coordinate in the earth's equatorial plane pointing to the Greenwich prime meridian, the Z-axis pointing to the north pole, and the Y-axis in the equatorial plane 90° from the X-axis with an orientation which forms a right-handed XYZ system.
- Ellipsoid** — a smooth mathematical surface which represents the earth's shape and very closely approximates the geoid. It is used as a reference surface for geodetic surveys.
- Ellipsoidal Height** — height above a defined ellipsoid approximating the surface of the earth.
- Ephemeris** — a set of satellite orbit parameters that is used by a combined GPS/GLONASS receiver to calculate precise GPS/GLONASS satellite positions and velocities. The ephemeris is used in the determination of the navigation solution and is updated periodically by the satellite to maintain the accuracy of combined GPS/GLONASS receivers.
- Ephemeris Data** — the data downlinked by a GPS/GLONASS satellite describing its own orbital position with time.
- Epoch** — same as measurement time epoch. The local time at which a GPSCard takes a measurement.
- Field** — a character or string of characters immediately preceded by a field delimiter.
- Fixed Ambiguity Estimates** — carrier phase ambiguity estimates which are set to a given number and held constant. Usually they are set to integers or values derived from linear combinations of integers.
- Fixed Discrete Ambiguity Estimates** — carrier phase ambiguities which are set to values which are members of a predetermined set of discrete possibilities, and then held constant.
- Fixed field** — a field in which the number of characters is fixed. For data fields, such fields are shown in the sentence definitions with no decimal point. Other fields which fall into this category are the address field and the checksum field (if present).
- Fixed Integer Ambiguity Estimates** — carrier phase ambiguities which are set to integer values and then held constant.
- Flash ROM** — Programmable read-only memory.
- Floating Ambiguity Estimates** — ambiguity estimates which are not held to a constant value, but are allowed to gradually converge to the correct solution.
- Frequency Division Multiple Access (FDMA)** — GLONASS satellites transmit carrier signals in different L-band channels. The GLONASS receiver uses the FDMA procedure, assigning different frequencies to its tracking channels, to separate the total incoming signal from all visible satellites.
- GDOP** — Geometric Dilution of Precision - A numerical value expressing the confidence factor of the position solution based on current satellite geometry. Assumes that 3D position (latitude, longitude, height) and receiver clock offset (time) are variables in the solution. The lower the GDOP value, the greater the confidence in the solution.
- Geoid** — the shape of the earth if it were considered as a sea level surface extended continuously through the continents. The geoid is an equipotential surface coincident with mean sea level to which at every point the plumb line (direction in which gravity acts) is perpendicular. The geoid, affected by local gravity disturbances, has an irregular shape. Refer to the PRTKA/B log in the *MiLLennium Command Descriptions Manual, Appendix D*.
- Geodetic datum** — the reference ellipsoid surface that defines the coordinate system.
- Geostationary** — a satellite orbit along the equator that results in a constant fixed position over a particular reference point on the earth's surface. (GPS satellites are not geostationary.)

- Global Positioning System (GPS)** — full name NAVSTAR Global Positioning System, a space-based radio positioning system which provides suitably equipped users with accurate position, velocity and time data. When fully operational, GPS will provide this data free of direct user charge worldwide, continuously, and under all weather conditions. The GPS constellation will consist of 24 orbiting satellites, four equally spaced around each of six different orbiter planes. The system is being developed by the Department of Defence under U.S. Air Force management.
- GLONASS** — The Soviet Ministry of Defense Global Navigation Satellite System: A constellation of 24 antipodal satellites orbiting the earth at a very high altitude. GLONASS satellites transmit signals that allow one to determine, with great accuracy, the locations of GLONASS receivers. The receivers can be fixed on the Earth, in moving vehicles, aircraft, or in low-Earth orbiting satellites. GLONASS is used in air, land and sea navigation, mapping, surveying and other applications where precise positioning is necessary.
- GPS** — The U.S. Department of Defense Global Positioning System: A constellation of 24 satellites orbiting the earth at a very high altitude. GPS satellites transmit signals that allow one to determine, with great accuracy, the locations of GPS receivers. The receivers can be fixed on the Earth, in moving vehicles, aircraft, or in low-Earth orbiting satellites. GPS is used in air, land and sea navigation, mapping, surveying and other applications where precise positioning is necessary.
- Great circle** — the shortest distance between any two points along the surface of a sphere or ellipsoid, and therefore the shortest navigation distance between any two points on the Earth. Also called Geodesic Line.
- HDOP** — Horizontal Dilution of Precision - A numerical value expressing the confidence factor of the horizontal position solution based on current satellite geometry. Makes no constraint assumptions about time, and about height only if the FIX HEIGHT command has been invoked. The lower the HDOP value, the greater the confidence in the solution.
- HTDOP** — Horizontal position and Time Dilution of Precision - A numerical value expressing the confidence factor of the position solution based on current satellite geometry. Assumes height is known if the FIX HEIGHT command has been invoked. If not, it will give the normalized precision of the horizontal and time parameters given that nothing has been constrained. The lower the HTDOP value, the greater the confidence factor.
- Heading** — the direction in which a vessel points or heads at any instant, expressed in degrees 000° clockwise through 360° and may be referenced to True North, Magnetic North, or Grid North. The heading of a vessel is also called the ship's head. Heading is a constantly changing value as the vessel oscillates or yaws across the course due to the effects of the air or sea, cross currents, and steering errors.
- Integer Ambiguity Estimates** — carrier phase ambiguity estimates which are only allowed to take on integer values.
- Iono-free Carrier Phase Observation** — a linear combination of L1 and L2 carrier phase measurements which provides an estimate of the carrier phase observation on one frequency with the effects of the ionosphere removed. It provides a different ambiguity value (non-integer) than a simple measurement on that frequency.
- Ionosphere** — The band of charged particles 80 to 120 miles above the earth's surface, which represent a nonhomogeneous and dispersive medium for radio signals.
- Ionospheric Delay** — A wave propagating through the ionosphere experiences delay. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well and affects signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.
- Ionospheric Refraction** — The change in the propagation speed of a signal as it passes through the ionosphere.
- Kinematic** — Your GPS antenna is moving. In GPS, this term is typically used with precise carrier phase positioning, and the term dynamic is used with pseudorange positioning.
- L-band** — The group of radio frequencies extending from 390 MHz to 1550 MHz. The GPS carrier frequencies (1227.6 MHz and 1575.42 MHz) are in the L-band.

- L1 frequency** — the 1575.42 MHz GPS carrier frequency which contains the course acquisition (C/A) code, as well as encrypted P-code, and navigation messages used by commercial GPS receivers.
- L2 frequency** — a secondary GPS carrier, containing only encrypted P-code, used primarily to calculate signal delays caused by the ionosphere. The L2 frequency is 1227.60 MHz.
- Lane** — a particular discrete ambiguity value on one carrier phase range measurement or double difference carrier phase observation. The type of measurement is not specified (L1, L2, L1-L2, iono-free)
- Local Observation Set** — an observation set, as described below, taken by the receiver on which the software is operating as opposed to an observation taken at another receiver (the reference station) and transmitted through a radio link.
- Local Tangent Plane** — a coordinate system based on a plane tangent to the ellipsoid's surface at your location. The three coordinates are east, north and up. Latitude, longitude and height positions operate in this coordinate system.
- Low-latency Solution** — a position solution which is based on a prediction. A model (based on previous reference station observations) is used to estimate what the observations will be at a given time epoch. These estimated reference station observations are combined with actual measurements taken at the remote station to provide a position solution.
- Magnetic bearing** — bearing relative to magnetic north; compass bearing corrected for deviation.
- Magnetic heading** — heading relative to magnetic north.
- Magnetic variation** — the angle between the magnetic and geographic meridians at any place, expressed in degrees and minutes east or west to indicate the direction of magnetic north from true north.
- Mask angle** — the minimum GPS satellite elevation angle permitted by a particular receiver design. Satellites below this angle will not be used in the position solution. For GLONASS the mask angle is 9 degrees.
- Matched Observation Set Pair** — it contains observations from both the reference station and the local receiver which have been matched by time epoch, contain the same satellites, and are corrected for any known offsets.
- Measurement error variance** — the square of the standard deviation of a measurement quantity. The standard deviation is representative of the error typically expected in a measured value of that quantity.
- Measurement Time Epoch** — the local time at which a GPSCard takes a measurement.
- Multipath errors** — Interference caused by reflected combined GPS/GLONASS signals arriving at the receiver, typically as a result of nearby structures or other reflective surfaces. Signals travelling longer paths produce higher (erroneous) pseudorange estimates and, consequently, positioning errors.
- Nanosecond** — 1×10^{-9} second
- Nautical mile** — any of various units of distance for sea and air navigation; in the U.S. since 1959, an international unit of linear measure equal to 1 minute of arc of a great circle of the Earth, 1,852 meters (6,076 feet).
- Non-Volatile Memory** — a type of memory device that retains data in the absence of a power supply.
- Null field** — by NMEA standard, indicates that data is not available for the field. Indicated by two ASCII commas, i.e., "," (HEX 2C2C), or, for the last data field in a sentence, one comma followed by either the checksum delimiter "*" (HEX 2A) or the sentence delimiters <CR><LF> (HEX 0D0A). [Note: the ASCII Null character (HEX 00) is not to be used for null fields.]
- Obscuration** — term used to describe periods of time when a GPS receiver's line-of-sight to GPS satellites is blocked by natural or man-made objects.
- Observation** — an input to an estimation algorithm. The two observations used in NovAtel's RTK algorithms are the pseudorange measurement and the carrier phase measurement.

- Observation Set** — a set of GPSCard measurements taken at a given time which includes one time for all measurements, and the following for each satellite tracked: PRN number, pseudorange or carrier phase or both, lock time count, signal strength, and channel tracking status. Either L1 only or L1 and L2 measurements are included in the set. The observation set is assumed to contain information indicating how many satellites it contains and which ones have L1-only and which ones have L1/L2 pairs.
- Origin waypoint** — the starting point of the present navigation leg, expressed in latitude and longitude.
- Parallel receiver** — a receiver that monitors four or more satellites simultaneously with independent channels.
- P-Code (precise or protected)** — a spread spectrum direct sequence code that is used primarily by military GPS receivers to determine the range to the transmitting GPS satellite. Uses a chipping rate of 10.23 MHz.
- PDOP** — Position Dilution of Precision. This is related to GDOP. It describes the effects of geometry on 3 dimensional positioning accuracy. It is defined to be the square root of the sum of the three diagonals of a normalized (assume measurement noise = 1) covariance matrix which correspond to position error.
- PE-90** — See PZ90
- Pitch** — the rising and falling of the bow and stern of a ship in a rough sea or the movement up or down of the nose and tail of an airplane.
- Precise Positioning Service (PPS)** — the GPS positioning, velocity, and time service which will be available on a continuous, worldwide basis to users authorized by the U.S. Department of Defence (typically using P-Code).
- PRN number** — a number assigned by the GPS system designers to a given set of pseudorandom codes. Typically, a particular satellite will keep its PRN (and hence its code assignment) indefinitely, or at least for a long period of time. It is commonly used as a way to label a particular satellite.
- Pseudolite** — an Earth-based transmitter designed to mimic a satellite. May be used to transmit differential corrections.
- Pseudorange** — the calculated range from the GPS receiver to the satellite determined by taking the difference between the measured satellite transmit time and the receiver time of measurement, and multiplying by the speed of light. This measurement generally contains a large receiver clock offset error.
- Pseudorange Measurements** — measurements made using one of the pseudorandom codes on the GPS signals. They provide an unambiguous measure of the range to the satellite including the effect of the satellite and user clock biases.
- PZ90** — Parametry Zemli 1990 or, in English translation, Parameters of the Earth 1990, PE-90. PE-90 and PZ90 can be used interchangeably, though the Russian translation (PZ90) is used most commonly.
- Receiver channels** — a GPS receiver specification which indicates the number of independent hardware signal processing channels included in the receiver design.
- Reference Satellite** — in a double difference implementation, measurements are differenced between different satellites on one receiver in order to cancel the clock bias effect. Usually one satellite is chosen as the “reference”, and all others are differenced with it.
- Reference Station** — the GPS receiver which is acting as the stationary reference. It has a known position and transmits messages for the "remote" receiver to use to calculate its position.
- Relative bearing** — bearing relative to heading or to the vessel.
- Remote Receiver** — the GPS receiver which does not know its position and needs to receive measurements from a reference station to calculate differential GPS positions. (The terms remote and rover are interchangeable.)

- Residual** — in the context of measurement, the residual is the misclosure between the calculated measurements, using the position solution and actual measurements.
- RMS** — root-mean-square, a probability level of 68%. This is true only for 1-D Gaussian distributions. For 2-D or 3-D Gaussian Distribution, the percentage of the values distributed inside a circle (or sphere), with a radius equal to the RMS value depends on distribution shape.
- Roll** — to move by turning on an axis or to rotate about its axis lengthwise, as an aircraft in flight.
- Route** — a planned course of travel, usually composed of more than one navigation leg.
- Rover Receiver** — the GPS receiver which does not know its position and needs to receive measurements from a reference station to calculate differential GPS positions. (The terms rover and remote are interchangeable.)
- RT-10** — NovAtel's Double Differencing Technology for real-time kinematic (RTK) carrier phase floating ambiguity resolution.
- RTCA** — Radio Technical Commission for Aeronautics, an organization which developed and defined a message format for differential positioning.
- RTCM** — Radio Technical Commission for Maritime Services, an organization which developed and defined the SC-104 message format for differential positioning.
- RTK** — real-time kinematic, a type of differential positioning based on observations of carrier phase. In this document it is also used with reference to RT-20 and RT-10.
- Satellite Constellation** — The arrangement in space of a set of satellites. In the case of GPS, the fully operational constellation is composed of six orbital planes, each containing four satellites. GLONASS has three orbital planes containing eight satellites each.
- Satellite elevation** — the angle of the satellite above the horizon.
- Selected waypoint** — the waypoint currently selected to be the point toward which the vessel is travelling. Also called "**to**" **waypoint**, **destination** or **destination waypoint**.
- Selective Availability (SA)** — the method used by the United States Department of Defence to control access to the full accuracy achievable by civilian GPS equipment (generally by introducing timing and ephemeris errors).
- Sequential receiver** — a GPS receiver in which the number of satellite signals to be tracked exceeds the number of available hardware channels. Sequential receivers periodically reassign hardware channels to particular satellite signals in a predetermined sequence.
- Sidereal Day** — the rotation period of the earth, and is equal to a calendar day minus four minutes
- Space Segment** — The portion of the GPS or GLONASS system that is located in space, that is, the GPS or GLONASS satellites and any ancillary spacecraft that provide GPS or GLONASS augmentation information (i.e., differential corrections, integrity messages, etc.)
- Spherical Error Probable (SEP)** — the radius of a sphere, centered at your true location, that contains 50 percent of the individual three-dimensional position measurements made using a particular navigation system.
- Spheroid** — sometimes known as ellipsoid; a perfect mathematical figure which very closely approximates the geoid. Used as a surface of reference for geodetic surveys. The geoid, affected by local gravity disturbances, is irregular.
- Standard Positioning Service (SPS)** — a positioning service made available by the United States Department of Defence which will be available to all GPS civilian users on a continuous, worldwide basis (typically using C/A Code).
- Static Positioning**— Location determination accomplished with a stationary receiver. This allows the use of various averaging or differential techniques.

- SV** — Space Vehicle ID, sometimes used as SVID; also used interchangeably with Pseudo-Random Noise Number (PRN).
- SEP** — spherical error probable; a sphere's radius, centered at the true antenna position, containing 50 percent of the points in the three-dimensional scatter plot.
- Static** — your GPS antenna does not move.
- TDOP** — Time Dilution of Precision - A numerical value expressing the confidence factor of the position solution based on current satellite geometry. The lower the TDOP value, the greater the confidence factor.
- Three-dimensional coverage (hours)** — the number of hours-per-day when four or more satellites are available with acceptable positioning geometry. Four visible satellites are required to determine location and altitude.
- Three-dimensional (3D) navigation** — navigation mode in which altitude and horizontal position are determined from satellite range measurements.
- Time-To-First-Fix (TTFF)** — the actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design.
- Track** — a planned or intended horizontal path of travel with respect to the Earth rather than the air or water. The track is expressed in degrees from 000° clockwise through 360° (true, magnetic, or grid).
- Track made good** — the single resultant direction from a point of departure to a point of arrival or subsequent position at any given time; may be considered synonymous with Course Made Good.
- True bearing** — bearing relative to true north; compass bearing corrected for compass error.
- True heading** — heading relative to true north.
- Two-dimensional coverage (hours)** — the number of hours-per-day with three or more satellites visible. Three visible satellites can be used to determine location if the GPS receiver is designed to accept an external altitude input.
- Two-dimensional (2D) navigation** — navigation mode in which a fixed value of altitude is used for one or more position calculations while horizontal (2D) position can vary freely based on satellite range measurements.
- Undulation** — the distance of the geoid above (positive) or below (negative) the mathematical reference ellipsoid (spheroid). Also known as geoidal separation, geoidal undulation, geoidal height.
- Universal Time Coordinated (UTC)** — this time system uses the second-defined true angular rotation of the Earth measured as if the Earth rotated about its Conventional Terrestrial Pole. However, UTC is adjusted only in increments of one second. The time zone of UTC is that of Greenwich Mean Time (GMT).
- Update rate** — the GPS receiver specification which indicates the solution rate provided by the receiver when operating normally.
- User Segment** — The part of the whole combined GPS/GLONASS system that includes the receivers of combined GPS/GLONASS signals.
- VDOP** — Vertical Dilution of Precision. This is related to GDOP. It describes the effects of geometry on vertical positioning accuracy. It is defined to be the square root of the diagonal of a normalized (assume measurement noise = 1) covariance matrix which corresponds to vertical position error.
- Variable field** — by NMEA standards, a data field which may or may not contain a decimal point and which may vary in precision following the decimal point depending on the requirements and the accuracy of the measuring device.

WGS84 — World Geodetic System 1984 is an ellipsoid designed to fit the shape of the entire Earth as well as possible with a single ellipsoid. It is often used as a reference on a worldwide basis, while other ellipsoids are used locally to provide a better fit to the Earth in a local region. GPS uses the center of the WGS84 ellipsoid as the center of the GPS ECEF reference frame.

Waypoint — a reference point on a track.

Wide Lane — a particular integer ambiguity value on one carrier phase range measurement or double difference carrier phase observation when the difference of the L1 and L2 measurements is used. It is a carrier phase observable formed by subtracting L2 from L1 carrier phase data: $F' = F_1 - F_2$. The corresponding wavelength is 86.2 cm

World Geodetic System — A consistent set of parameters describing the size and shape of the Earth, the positions of a network of points with respect to the center of mass of the Earth, transformations from major geodetic datums, and the potential of the Earth (usually in terms of harmonic coefficients).

J GPS GLOSSARY OF ACRONYMS

1PPS:	One Pulse Per Second	HTDOP	Horizontal position and Time Dilution Of Precision
2D:	Two Dimensional	Hz	Hertz
2DRMS	Twice distance RMS	IC	Integrated Circuit
	3DThree Dimensional	ICD	Interface Control Document
A/D	Analog-to-Digital	IERS	International Earth Rotation Service
ADR	Accumulated Doppler Range	IF	Intermediate Frequency
AGC	Automatic Gain Control	IGRF	International Geomagnetic Reference Field
ASCII	American Standard Code for Information Interchange	I/O	Input/Output
BIH	Bureau l'International de l'Heure	IODE	Issue of Data (Ephemeris)
BIST	Built-In-Self-Test	IRQ	Interrupt Request
BPS	Bits per Second	LF	Line Feed
C/A Code	Coarse/Acquisition Code	LHCP	Left Hand Circular Polarization
C/No	Carrier to Noise Density Ratio	LNA	Low Noise Amplifier
CDMA	Code Division Multiple Access	LO	Local Oscillator
CEP	Circular Error Probable	lsb	Least significant bit
CPU	Central Processing Unit	MET	Multipath Elimination Technology
CR	Carriage Return	MEDLL	Multipath Estimation Delay Lock Loop
CRC	Cyclic Redundancy Check	MKI	Mark In
CSIC	Coordination Scientific Information Center	MKO	Mark Out
CTP	Conventional Terrestrial Pole	msb	Most significant bit
CTS	Conventional Terrestrial System	msec	millisecond
CTS	Clear To Send	MSL	Mean sea level
dB	Decibel	N. mi.	Nautical mile
DCE	Data Communications Equipment	NAVSTAR	NAVigation Satellite Timing And Ranging (synonymous with GPS)
DGNSS	Differential Global Navigation Satellite System	NCO	Numerically Controlled Oscillator
DGPS	Differential Global Positioning System	NMEA	National Marine Electronics Association
DOP	Dilution Of Precision	ns	nanosecond
DSP	Digital Signal Processor	NVM	Non-volatile Memory
DSR	Data Set Ready	OCXO	Oven Controlled Crystal Oscillator
DTR	Data Terminal Ready	OEM	Original Equipment Manufacturer
ECEF	Earth-Centered-Earth-Fixed	PC	Personal Computer
EMC	Electromagnetic Compatibility	P Code	Precise Code
EMI	Electromagnetic Immunity	PDOP	Position Dilution Of Precision
ESD	Electrostatic Discharge	PE-90	Parameters of the Earth 1990 (see PZ90)
FDMA	Frequency Division Multiple Access	PLL	Phase Lock Loop
FEC	Forward Error Correction	PPS	Precise Positioning Service or Pulse Per Second
FIFO	First In First Out	PRN	Pseudo Random Noise number
GDOP	Geometric Dilution Of Precision	PZ90	Parametry Zemli 1990 (see PE-90)
GLONASS	GLObal NAVigation Satellite System	RAM	Random Access Memory
GMT	Greenwich Mean Time	RF	Radio Frequency
GND	Ground	RHCP	Right Hand Circular Polarization
GPS	Global Positioning System	ROM	Read Only Memory
HDOP	Horizontal Dilution Of Precision	RTCA	Radio Technical Commission for
HEX	Hexadecimal		

RTCM	Aviation Services Radio Technical Commission for Maritime Services
RTK	Real Time Kinematic
RTS	Request To Send
RXD	Received Data
SA	Selective Availability
SCAT-I	Special Category I
SEP	Spherical Error Probable
SNR	Signal-to-Noise Ratio
SPS	Standard Positioning Service
SV	Space Vehicle
SVN	Space Vehicle Number
TCXO	Temperature Compensated Crystal Oscillator
TDOP	Time Dilution Of Precision
TTFF	Time-To-First-Fix
TTL	Transistor Transistor Logic
TXD	Transmitted Data
UART	Universal Asynchronous Receiver Transmitter
UDRE	User Differential Range Error
UTC	Universal Time Coordinated
VARF	Variable Frequency
VCTCXO	Voltage Controlled Temperature Compensated Crystal Oscillator
VDOP	Vertical Dilution of Precision
WGS	World Geodetic System
WPT	Waypoint
XTE	Crosstrack Error

K REPLACEMENT PARTS AND ACCESSORIES

Part Description	NovAtel Part Number
MiLLennium-GLONASS GPSCard	GLONASS
GPSolution and Convert Disk	01015790
GPS/GLONASS Receiver User Manual	OM-20000040
MiLLennium Command Descriptions Manual	OM-20000041
Optional ProPak II enclosure	01016564
Straight serial data cable	01016383
Null-modem serial data cable	01016329
Power cable assembly: LEMO 4-pin socket to cigarette lighter plug	01016331
I/O strobe cable	01016330
Optional AC/DC converter to LEMO 4-pin socket and an AC power cord	GPS-APRO
Optional power cable assembly: LEMO 4-pin plug to LEMO 4-pin plug	
33.5 cm length	01016724
75 cm length	01016725
Universal ProPak Mounting Bracket	70015024
Optional PowerPak II enclosure	
Cigarette lighter power adapter	01014989
Y-type null modem cable	60715062
Optional AC/DC power converter	GPS-APWR
Optional NovAtel GPS/GLONASS antennas	
Model 504 (L1 only)	GPS-504
Model 514 Aviation Antenna (L1 only)	GPS-514
Optional RF Antenna Cable	
5 meters	C005
15 meters	C015
30 meters	C030
22 cm interconnect adapter cable	GPS-C001
Optional battery assembly	01016698
Optional battery charger	GPS-ACDL

The following original manufacturer's part numbers are provided for information only. They are not available from NovAtel as separate parts.

Part Description	LEMO part number
10-pin plug connector on both serial data cables	FGG.1K.310.CLAC55Z
4-pin plug connectors on power cable	FGM.0B.304.CLLD52Z FGJ.0B.304.CLLD52Z
4-pin plug connector on I/O strobe cable	FGG.0B.304.CLAD52Z

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NovAtel Inc.
1120 - 68 Avenue NE
Calgary, Alberta, Canada, T2E 8S5

GPS Hotline: 1-800-NOVATEL (Canada & U.S. only)
GPS Fax: (403) 295-4901

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