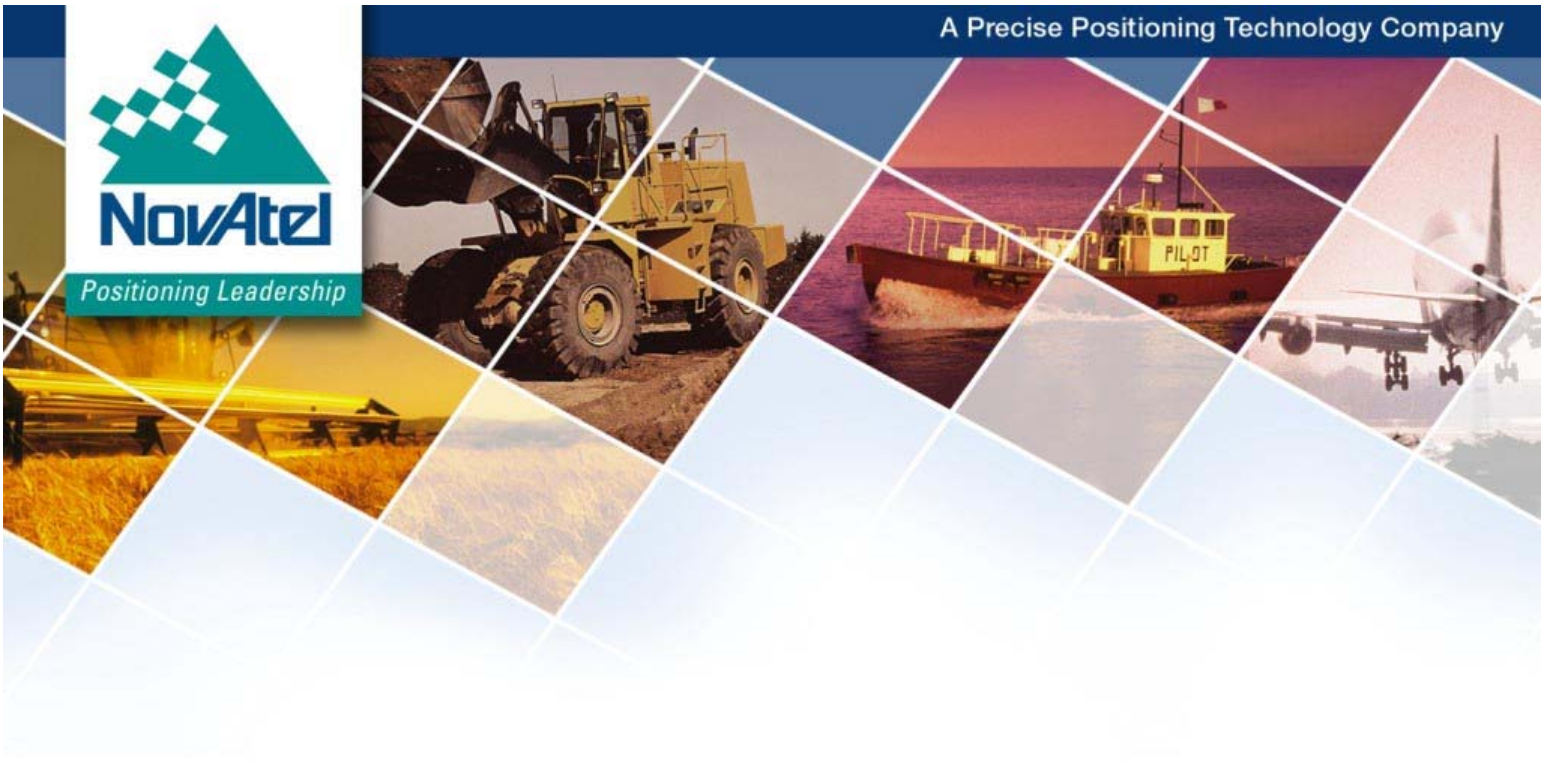

Galileo Test Receiver &
L1/E5a Receiver Card
Technical Summary

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PRELIMINARY

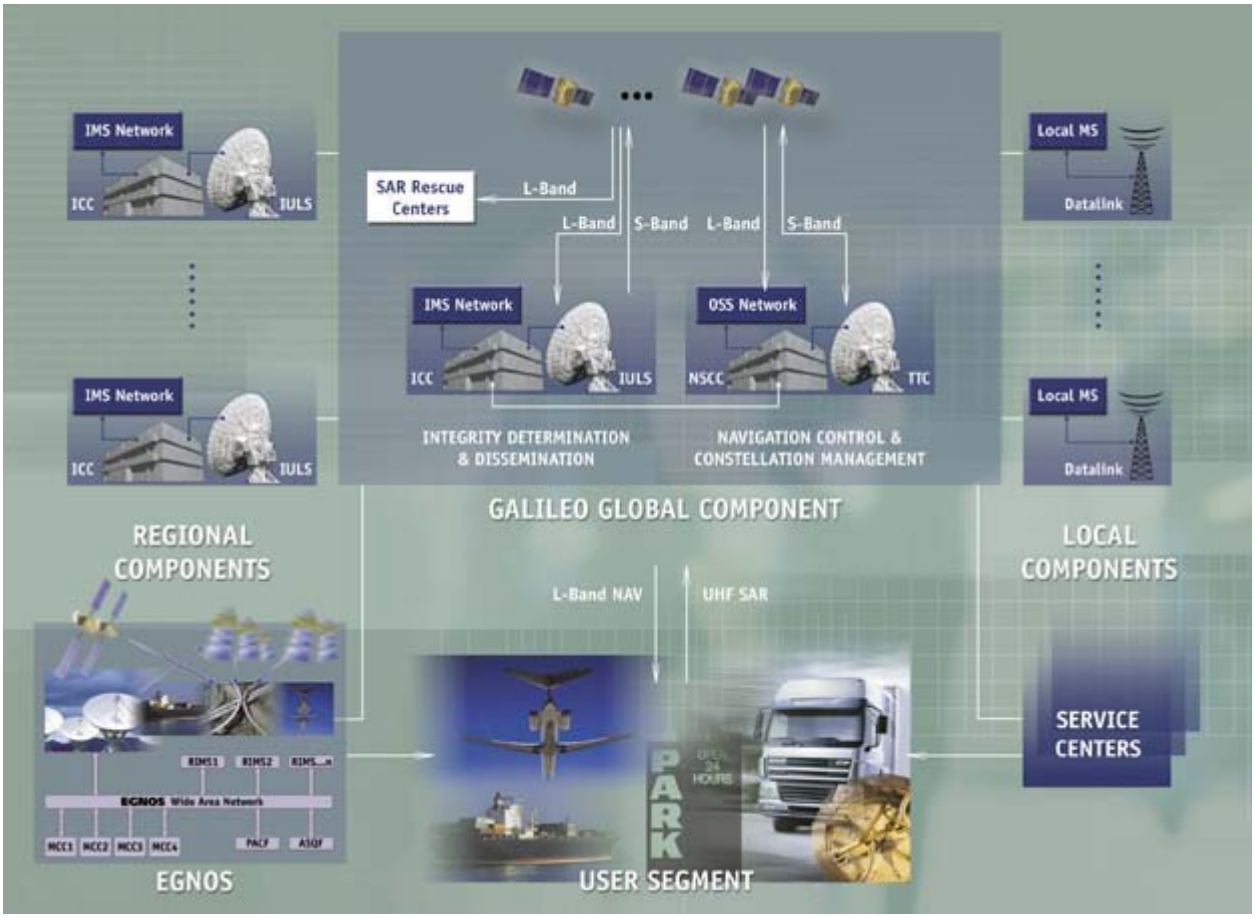
ALL SPECIFICATIONS SUBJECT TO CHANGE

D08923 - Revision C

RESTRICTED PROPRIETARY INFORMATION

GALILEO BACKGROUND

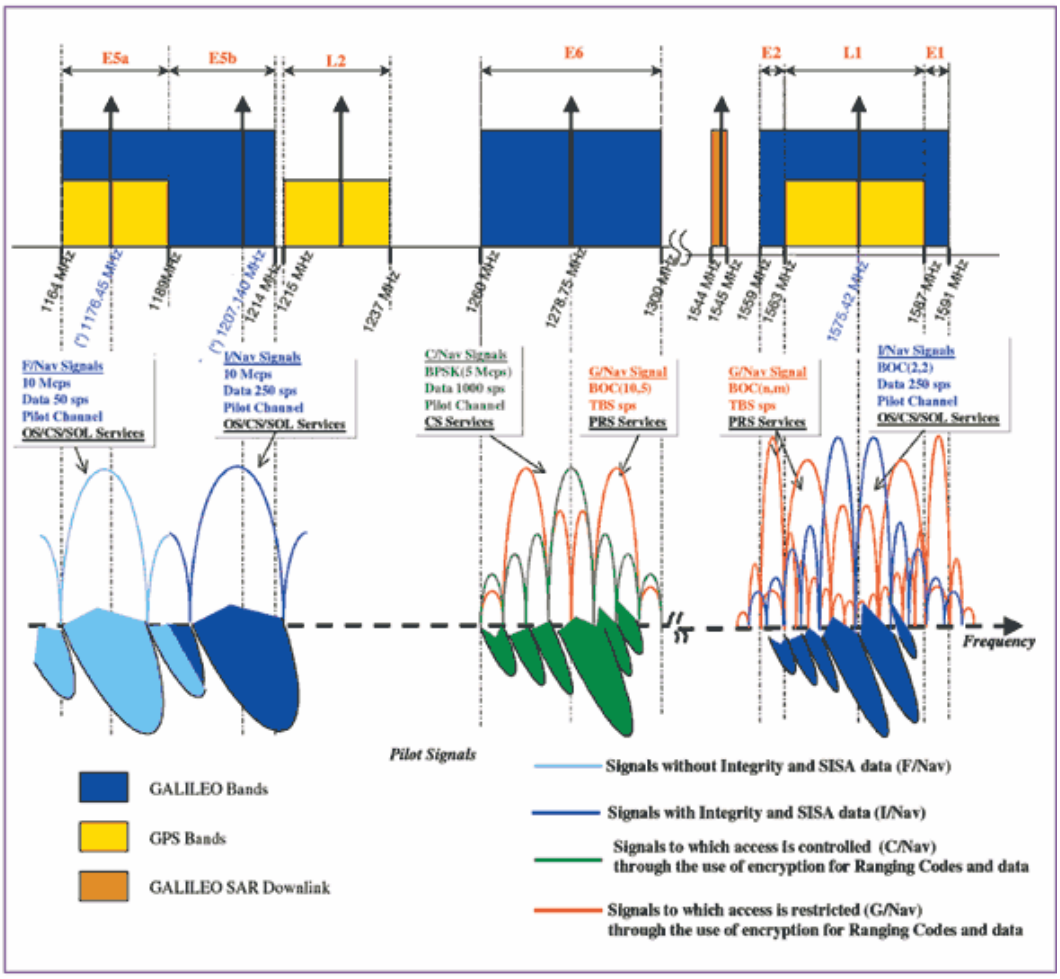
The European Commission (EC) first presented plans for a European Galileo satellite navigation system in 1999. A four-phase development is underway with funding from both public and private sectors. Galileo is designed for both civilian and government purposes; the system will be controlled and operated by civil management. Galileo will be composed of: a constellation of 30 satellites; a number of globally located ground stations; and a ground control and monitoring system – very similar to the structure, format and layout of GPS. Development of the system has been underway since 2001.



Galileo System Outline

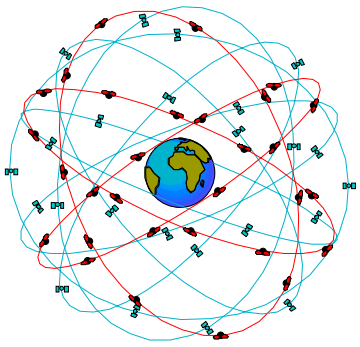
Galileo will offer several worldwide service levels, including open access and restricted access for various segments of users. These services include:

- A basic Open Service (OS), supplied free of charge to the general public. This service is equivalent to that provided by L1 C/A GPS, however the intent is to provide improved quality and reliability.
- A Commercial Service (CS) facilitating the development of professional applications where high precision is required and premium cost can be supported.
- A Safety of Life Service (SoL) providing enhanced accuracy and integrity information for safety-critical applications, such as aviation, shipping and other vehicle control applications.
- A Search and Rescue (SAR) service that will greatly improve existing recovery services using the COSPAS-SARSAT system.
- A Public Regulated Service (PRS), which will be encrypted and resistant to jamming and interference. Access will be reserved principally for public authorities responsible for civil protection, national security and law enforcement where a high level of secure and reliable service is required.



These services are largely compatible with existing GPS services, and the expectation is that users will demand the added signal reliability, integrity, and functionality that a combined GPS and Galileo capability will provide when used together. Typical advantages to a user of a receiver utilizing both systems, include:

- Twice as many satellites means twice the probability of receiving good signals from open parts of the sky when visibility is reduced such as in a valley or in an urban centre.
- Vehicles in cities will have more signals, more often and will suffer less from signal blockage.
- Surveyors will be able to make higher accuracy measurements more consistently.
- Automated guidance for agricultural sprayers, combines and harvesters will be more accurate and signal reception will be improved, reducing signal outages.
- Difficult inshore navigation on rivers and canals will be safer and more reliable.
- Aircraft enroute navigation, final approach and landing will have far greater signal redundancy, which could well result in improved safety margins and decision heights for landing.

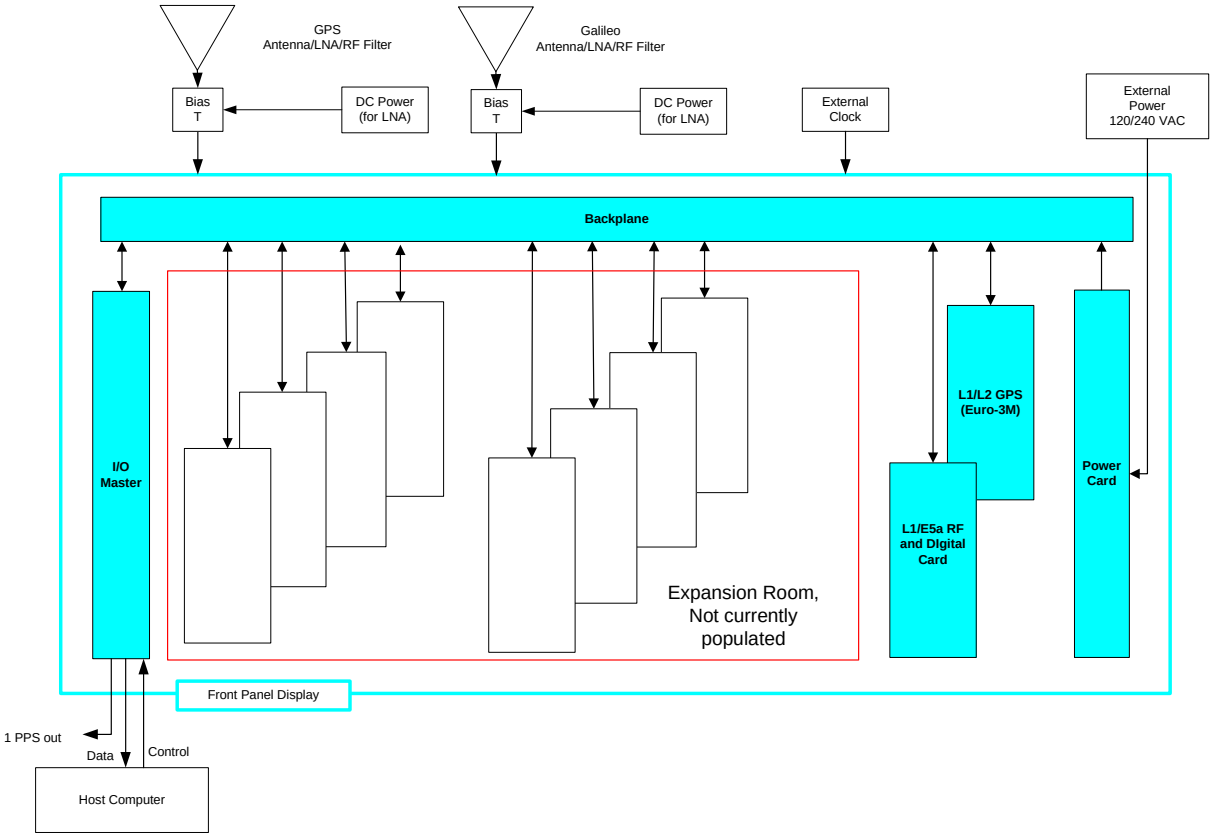


Together, GPS and Galileo will provide around 60 satellites, and more than double the number of available signals for all user segments.

NOVATEL'S GALILEO TEST RECEIVER (GTR) PROGRAM

Under a program supported by the Canadian Space Agency, NovAtel has developed a GTR. The GTR enclosure has been derived from a Wide Area Augmentation System (WAAS) reference receiver 19 inch rack enclosure, with an integral backplane, power supplies, receiver card housing, RF antenna distribution, cooling fans and LCD monitor display. The GTR has the provision for future expandability and is capable of holding up to ten Euro form factor cards. The additional receiver cards and receiver sections may be used to track any of GPS, Galileo, or SBAS signals.

The GTR consists of one Galileo L1/E5a card, one Euro-3M GPS L1/L2 receiver card, and an I/O Master card contained in an EIA standard 19-inch enclosed rack with an LCD on the front panel. The receiver cards are connected to the I/O Master card through a passive backplane. The backplane allows digitized intermediate frequency (IF) data to be shared between multiple receiver cards, thereby increasing the number of available correlators while eliminating inter-card radio frequency (RF) biases. The backplane also allows inter-card communication over a USB interface. The I/O Master card coordinates the inter-card communication. The I/O Master card also provides the timing synchronization for the receiver cards.



GTR INTERFACES

The GTR Receiver has an LCD on the front panel which reports version information and status of all receiver cards, the fans and the lock state to the external oscillator. Warnings and errors are also reported on the LCD, with the backlight of the LCD flashing if a fatal error occurs. There are 2 contrast buttons on the front panel to control the contrast of the LCD.

DATA INTERFACE

The receiver has four serial communication ports that support RS-232 communications, and three USB communication ports. Each RS-232 serial data interface communication speed supports a minimum data rate of 9,600 bps and a maximum data rate of 230,400 bps. The default baud rate is 9,600 bps.

The receiver has the following data interfaces.

Card	USB	RS-232
I/O Master	DATA	DATA
	MONITOR	TIME
Euro-3M	TIME	DATA
		TIME

The MONITOR and TIME ports are output only to allow monitoring of the receiver logs without disconnecting the receiver. The DATA ports allow 2 way communication for full control of the receiver.

EXTERNAL FREQUENCY INPUT INTERFACE

Provision of an external frequency standard input can significantly improve the tracking capability and accuracy of data outputs. The GTR accepts a 10MHz signal from an external frequency standard using a female BNC connector. The receiver can accept an input power from 0dBm minimum to 17 dBm maximum. The frequency stability of the external input has to be within ±2ppm.

ANTENNA INTERFACE

The GTR has two separate female TNC connectors, one to receive the GPS L1/L2 frequencies for the Euro-3M receiver card and one to receive the Galileo L1/E5a and GPS L1/L5 frequencies for the L1/E5a receiver card.

EURO-3M

The EURO-3M receiver card is a EURO form factor card based on the fourth generation NovAtel receiver, the OEM4. The EURO-3M receiver cards is populated with 3 MINOS4 Digital Signal Processing ASICs and can be linked together in a Master/slave relationship to increase the number of satellites tracked or to provide timing information to other cards such as the L1/E5a receiver card.

Figure 1 Euro-3M Measurement Engine

The default channel configuration of the Euro-3M receiver card for use in the GTR is:

- 12 GPS L1 signals
- 12 GPS L2 signals
- 2 channels that provide continuous noise floor calculations;

MINOS4

The WAAS Receiver uses NovAtel's custom 4th generation MINOS4 ASIC for providing raw measurements to the tracking algorithms. The MINOS4 has 24 hardware channels that are capable of tracking 24 satellite signals. Qualified for airborne applications to RTCA DO-254 Level B, this DSP ASIC provides the certifiable core for safety-of-life ground applications.

L1/E5A RECEIVER TECHNICAL DESCRIPTION

NovAtel's L1/E5a receiver card offers superior tracking of multiple L1 or L5/E5a Galileo, GPS, or SBAS signals in a Euro form factor card - stand-alone, or when integrated into other receivers such as the GTR. The L1/E5a receiver card is capable of tracking up to 16 channels configurable to certain combinations of Galileo L1, Galileo E5a, GPS L1, GPS L5, WAAS L1, WAAS L5.

L1/E5A RECEIVER CARD

The L1/E5a receiver card is a EURO form factor card based on the NovAtel L5EURO receiver. The L1/E5a receiver card is populated with a Field Programmable Gate Array (FPGA) that allows tracking of the Galileo L1 and E5a as well as the GPS L1 and L5 signals. A maximum of 16 signals can be tracked at one time, with the number of channels allocated to each signal is factory configurable.

Figure 2 L1/E5a Measurement Engine

The default channel configuration for the L1/E5a receiver is:

- 6 GPS L1 signals
- 5 Galileo L1 signals
- 5 Galileo E5a signals

Due to the unavailability of sufficient Galileo signals (both L1 and E5a), the L1/E5a receiver card needs to track a minimum of 4 GPS signals (a minimum of 6 is preferable), in order to determine time and a position. The other ten signal channels may be configured to track Galileo signals. Alternate channel configurations which are user selectable are as follows:

Option 1 (available only in the GTR, or when timing is available from another receiver):

- 8 Galileo L1 signals
- 8 Galileo E5a signals

Option 2:

- 8 GPS L1 signals
- 8 GPS L5 signals

FPGA

The L1/E5a receiver card uses a Altera Stratix II Field Programmable Gate Array (FPGA) which is capable of tracking up to 16 satellite signals. An FPGA is used to make the L1/E5a card more versatile, allowing it to be easily configured to track different signal types, and to accommodate the evolving Galileo signal characteristics.

NARROW CORRELATOR TECHNOLOGY

The L1/E5a receiver card tracks GPS signals using NovAtel's patented Narrow Correlator technology. By utilizing Narrow Correlator techniques, the receiver is capable of pseudorange measurement improvements better than 2 to 1 when compared to standard correlation techniques. As well, the Narrow Correlator inherently reduces multipath reception (approaching a factor of eight compared to a standard correlator) by virtue of its narrow autocorrelation function.

NovAtel's Narrow Correlator® technology enhances the reception of satellite data for highly accurate range measurements. A NovAtel proprietary algorithm is used to detect and eliminate side-peak tracking for the Galileo Binary Offset Carrier (BOC) signal on L1.

RADIO FREQUENCY INTERFERENCE (RFI) MITIGATION

NovAtel's involvement in the current WAAS reference station receiver development for over eight years has provided a wealth of experience in RFI mitigation. The improvements in receiver performance developed on the WAAS program have all been implemented on this L1/E5a receiver card.

Digital Pulse Blanking

Digital pulse blanking involves removing or attenuating pulses in the RF signal that exceed a specified level, from such sources as radars and pulsed DMEs. The L1/E5a receiver card provides digital pulse blanking for both Galileo and GPS signals.

EUROPAK ENCLOSURE

There are plans to make the L1/E5a receiver card available in a EuroPak enclosure. The following interfaces are available:

DATA INTERFACE

The receiver has two serial communication ports that support RS-232 communications. Each serial data interface communication speed supports a minimum data rate of 9,600 bps and a maximum data rate of 230,400 bps. The default baud rate is 9,600 bps.

EXTERNAL FREQUENCY INPUT INTERFACE

Provision of an external frequency standard input can significantly improve the tracking capability and accuracy of data outputs. The L1/E5a receiver card accepts a 5MHz or 10MHz signal from an external frequency standard using a female BNC connector. The receiver can accept an input power from 0dBm minimum to 13 dBm maximum. The frequency stability of the external input has to be within ±5ppm.

ANTENNA INTERFACE

The L1/E5a receiver has a single female TNC connector to receive both the Galileo L1/E5a and GPS L1/L5 frequencies.

PERFORMANCE	
ALL VALUES SUBJECT TO GPS & GALILEO SYSTEM CHARACTERISTICS	
Galileo Test Receiver	
Frequency	L1(1575.42 MHz), L2 (1227.60MHz), L5/E5a (1176.45 MHz),
Codes Tracked	GPS L1-C/A Code GPS L2 P(Y) (Codeless) GPS L5-C5 Code Galileo E1 Code Galileo E5a Code SBAS GEO L1-C/A Code SBAS GEO L5-C5 Code GPS SVN (PRN 0-37) GEO SVN (PRN 120-138)
Satellite Tracking Channels	**Default on L1/E5a card** 6 GPS L1 signals 5 Galileo L1 signals 5 Galileo E5a signals **Default on GTR** 12 GPS L1 signals 12 GPS L2 signals 8 Galileo L1 signals 8 Galileo E5a signals
Position Accuracy (stand-alone)	1.5 M CEP (TBC)
Pseudorange Measurement Accuracy Galileo L1 Galileo E5a GPS L1 GPS L2 SBAS L1 SBAS L5	 7 cm at 44 dB-Hz, 0.05 Hz DLL BW 4 cm at 44 dB-Hz, 0.05 Hz DLL BW 10 cm at 44 dB-Hz, 0.05 Hz DLL BW 50 cm at 38 dB-Hz, 0.05 Hz DLL BW 100 cm at 44 dB-Hz, 0.05 Hz DLL BW 100 cm at 44 dB-Hz, 0.05 Hz DLL BW
Single Channel Phase Accuracy Galileo L1 Galileo E5a GPS L1 GPS L2 SBAS L1 SBAS L5	 3 mm at 44 dB-Hz, 3 Hz PLL BW 3 mm at 44 dB-Hz, 3 Hz PLL BW 3 mm at 44 dB-Hz, 3 Hz PLL BW 5 mm at 38 dB-Hz, 0.20 Hz PLL BW 3 mm at 44 dB-Hz, 3 Hz PLL BW 3 mm at 44 dB-Hz, 3 Hz PLL BW
Raw Data Availability Rate Raw Data Status Data Time Almanac Data	 One message per second One message per second One message per second < 15 minutes after reset
Time to First Fix	100 seconds (95%) with stabilized internal and external oscillators and initial time, almanac and position. (TBC)
Height Measurements	Up to 18,288 metres (60,000 feet) maximum[1]

PHYSICAL	
L1/E5a Receiver Card	
Size	160 x 100 x 16 mm
Weight	150 g
EuroPak L1/E5a Receiver	
Size	235 x 154 x 71 mm
Weight	1.2 kg
GTR Receiver	
Size	177 x 449 x 375 mm
Weight	9.0 kg

ENVIRONMENTAL	
L1/E5a Receiver Card	
Operating Temperature	0° C to +50° C
Storage Temperature	-45° C to +95° C
Humidity	95% non-condensing
Altitude[2]	3,000 metres
EuroPak L1/E5a Receiver	
Operating Temperature	0° C to +40° C
Storage Temperature	-45° C to +95° C
Humidity	95% non-condensing
Altitude[2]	3,000 metres
GTR Receiver	
Operating Temperature	0° C to +40° C
Storage Temperature	-40° C to +85° C
Humidity	10 – 80%
Altitude[2]	3,000 metres

1. In accordance with export licensing.
2. May operate above 3,000 m in a controlled environment, however is not certified as such

Note: The L1/E5a receiver card has not undergone qualification testing and should be considered prototype standard equipment for experimental use and evaluation.