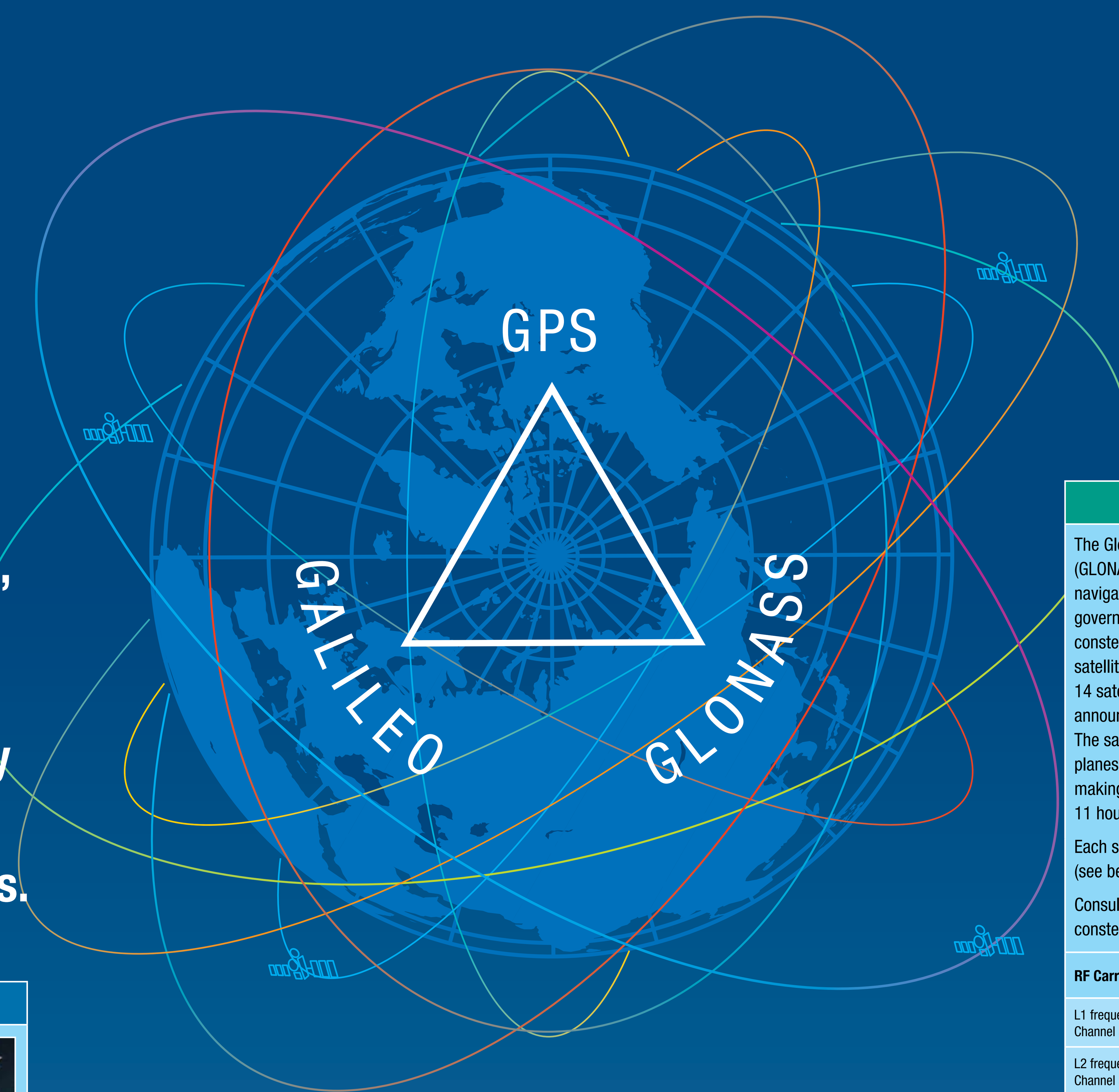
Global Navigation Satellite Systems (GNSS)

NovAtel



NovAtel's complete line of precise positioning engines, enclosures, antennas and software is developed to meet a wide range of accuracy and cost requirements for all satellite navigational systems.

GALILEO

The emerging Galileo system, sponsored by the European Union and managed by the European Space Agency (ESA) launched the GIOVE-A test satellite in April 2006. Full deployment of operational satellites is expected by 2010. A ground-based control system will also be developed and deployed, similar to the GPS Control Segment. In addition to controlling the satellites, the Galileo Ground Mission Segment will also generate integrity information for Safety of Life users similar to the US FAA Wide Area Augmentation System.

30 satellites will be organized into three orbital planes with an inclination of 56 degrees, making a complete orbit in approximately 14 hours (exact time unknown).

Consult www.esa.int for exact development status of the Galileo constellation and capabilities.

Fundamental frequency (Fo)		10.23 MHz
RF Carrier		
E1 frequency (Galileo)		1575.42 MHz
E5A frequency (Galileo) (115 * Fo)		1176.45 MHz
ALT BOC signal covers the bandwidth of both E5A and E5B (116.5 * Fo)		1191.795 MHz (centre frequency)
E5B frequency (Galileo) (118 * Fo)		1207.14 MHz
E6 frequency (Galileo) (125 * Fo)		1278.75 MHz
Code chip		
E1 code chip (Galileo A-channel) (Fo/4) Frequency		616 L1 cycles / chip 2.5575 MHz
E1 code chip (Galileo B&C channel) (Fo/10) Frequency		1540 cycles / chip 1.023 MHz
E5A code chip (Galileo) (Fo) Frequency		115 E5a cycles / chip 10.23 MHz
E5B code chip (Galileo) (Fo) Frequency		118 E5b cycles / chip 10.23 MHz
E6 B/C code chip (Galileo) (Fo) Frequency		250 E6 cycles / chip 5.115 MHz
Alt-BOC code chip (Galileo) (Fo) Frequency		N/A cycles / chip 10.23 MHz
Pseudorandom noise (PRN) sequence		
E1A channel	BOC (15, 2.5)	Not published
E1B channel pseudorandom noise sequence Length Primary code period Secondary code length	BOC (1,1)	4092 E1B code chips 4 msec N/A
E1C channel pseudorandom noise sequence Length Primary code period Secondary code length	BOC (1,1)	4092 E1C code chips 4 msec 25 chips
E5A I channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK (10)	10230 E5A code chips 1 msec 20 chips
E5A Q channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK (10)	10230 E5A code chips 1 msec 100 chips
E5B I channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK (10)	10230 E5B code chips 1 msec 4 chips
E5B Q channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK (10)	10230 E5B code chips 1 msec 100 chips
E6 channel pseudorandom noise sequence		Not published
Nav bit		
Open Service data	(E5A-I channel)	50 symbols / second
Galileo Navigation Word Safety of Life Service data	(L1B and E5B-I channels)	250 symbols / second

GPS

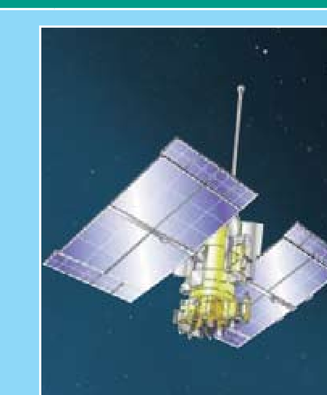
Declared fully operational in 1995, the Global Positioning System (GPS) constellation in 2006 consists of 29 satellites in Full Operation Capability (FOC) status. The satellites are organized into six orbital planes with an inclination of 55 degrees, making a complete orbit in approximately 11 hours, 58 minutes.

All satellites are dual-frequency and broadcast on L1 and L2 using spread-spectrum modulation. Each satellite uses a separate Gold PRN (pseudorandom sequence) to distinguish its broadcast from the other satellites in the constellation.

Consult www.navcen.uscg.gov/gps/ for exact operational status of the GPS constellation and capabilities.

Fundamental frequency (Fo)	10.23 MHz
RF Carrier	
L1 Frequency (GPS) (154 * Fo)	1575.42 MHz
L2 frequency (GPS) (120 * Fo)	1227.6 MHz
L1C frequency (154 * Fo) DRAFT	1575.42 MHz
L2C frequency (120 * Fo)	1227.6 MHz
L5 frequency (115 * Fo)	1176.45 MHz
C/A code chip	
L1 C/A code chip (GPS) (Fo / 10 = 1.023 MHz)	1540 L1 cycles / chip
L1C code chip (Fo / 10 = 1.023 MHz) DRAFT	1540 L1 cycles / chip
L1 P-code chip (GPS) (Fo = 10.23 MHz)	154 L1 cycles / chip
L2 P-code chip (GPS) (Fo = 10.23 MHz)	120 L2 cycles / chip
L2C code chip Time multiplexed; resulting apparent chipping rate of 1.023 MHz.	(L2C-CM + PRN data) first half of period of 1.023 usec. (L2C-CL, no PRN data) second half of period of 1.023 usec.
L5 code chip (Fo = 10.23 MHz)	115 L5 cycles / chip
C/A pseudorandom noise (PRN) sequence	
L1 C/A code pseudorandom noise sequence (Fo / 10 / 1023)	Length = 1023 C/A chips Period = 1 msec
L1 P-code pseudorandom noise sequence (Fo / 1023)	Length = 6.187 X 1012 chips Period = 1 week
L1C pseudorandom noise sequence DRAFT	Length = 10,230 code chips Primary period = 10 msec Secondary period = 18 seconds
L2 P-code pseudorandom noise sequence	Length = 6.187 X 1012 chips Period = 1 week
L2C-CM pseudorandom noise sequence	10,230 chips Period = 20 msec
L2C-CL pseudorandom noise sequence	767,250 chips Period = 1500 msec
L5-I pseudorandom noise sequence	10,230 chips Period = 1 msec
L5-Q pseudorandom noise sequence	10,230 chips Period = 1 msec
Nav bit	
GPS L1 Navigation bit (Fo / 10 / 1023 / 20)	Length = 20 PRN sequences 50 bps
GPS Navigation Word (Fo / 10 / 1023 / 20 / 30) of L1 1 word length	1 word length = 30 Nav bits
GPS L1P navigation bit	Unpublished
GPS L1C DRAFT (FEC encoded, express in symbols)	100 symbols / sec Primary code of 10 bits, 10 msec period Secondary code (pilot) of 18 seconds
GPS L2C navigation bit (FEC encoded, express in symbols) 1 symbol = 1 combined L2C-CM data and secondary code (pilot) length; 2 symbols per bit	Data: 50 symbols / sec Primary code of 10 bits, 10 msec period Secondary code (pilot) of 20 bits, 10 msec period
GPS L2P navigation bit	Unpublished
GPS L5 navigation bit *(FEC encoded, express in symbols)* 1 symbol = one combined L5 data and secondary code (pilot) length; 2 symbols per bit	100 symbols / sec Data: Primary code of 10 bits, 10 msec period Pilot: Secondary code of 20 bits, 20 msec period

GLONASS



The Global Navigation Satellite Systems (GLONASS) constellation is a radio satellite navigation system operated for the Russian government by the Russian Space Forces. The constellation had dwindled to seven operational satellites in 2001. As of 2006 there are now 14 satellites declared operational, with plans announced to increase this total to 18 by 2007. The satellites are organized into three orbital planes with an inclination of 64.8 degrees, making a complete orbit in approximately 11 hours, 15 minutes, 40 seconds.

Each satellite broadcasts L1 and L2 signals on unique frequency channels (see below). Plans have been announced for an L3 signal.

Consult www.glonass-ianc.rsa.ru for exact operation status of the GLONASS constellation and capabilities.

RF Carrier	
L1 frequency (GLONASS) for Fk = 0, K = (-7 to +13) Channel spacing = 562.5 kHz	1602.000 MHz (k = 0)
L2 frequency (GLONASS) for Fk = 0, K = (-7 to +13) Channel spacing = 437.5 kHz	1246.000 MHz (k = 0)
C/A code chip	
L1 standard accuracy code chip (GLONASS) Frequency	3135.03 L1 cycles / chip 0.511 MHz
L1 high accuracy code chip (GLONASS) Frequency	243.836 L2 cycles / chip 5.11 MHz
L2 standard accuracy code chip (GLONASS) Frequency	2438.36 L2 cycles / chip 0.511 MHz
L2 high accuracy code chip (GLONASS) Frequency	243.836 L2 cycles / chip 5.11 MHz
C/A pseudorandom noise sequence	
GLONASS L1 standard accuracy pseudorandom noise sequence	Length = 511 code chips Period = 1 msec
GLONASS L2 standard accuracy pseudorandom noise sequence	Length = 511 code chips Period = 1 msec
Nav bit	
GLONASS Navigation Bit 1 bit length (1 data bit is made up of two meander bits)	20 PRN sequences per data bit 100 bps (meander) / 50 bps (data)
GLONASS Navigation String (applicable for L1 and L2 on M-class satellites only)	String length 85 data bits @ 50 bps +30 bits time mark @ 100 bps String data rate 0.5 Hz per string

NovAtel's GPS and INS Technology

GPS Only GPS & INS

The advantage of combining an Inertial Measurement Unit (IMU) with a dual-frequency GPS receiver to deliver accurate position and attitude with an integrated solution is clearly shown in this view of SPAN Technology performance versus GPS in downtown Calgary, Canada (51.04N, 114.07W).

Urban canyon environments limit satellite visibility and makes GPS insufficient for navigation with less than 4 satellites in view. SPAN Technology has a tight coupling of GPS and an IMU to maintain accurate navigation in reduced satellite visibility conditions, and to reject poor GPS outlier solutions caused by multipath and poor satellite geometry. The duration of the satellite outage is proportional to the quality of the inertial sensors.