GNSS for autonomous agriculture machines

A complete solution for the positioning of autonomous machines in agriculture

Today's autonomous machines in agriculture must meet different standards and performance requirements compared to agricultural machines using GNSS in precision farming technologies and manned automation. The design and implementation of the autonomous positioning solution should meet the criteria set out in industry standards such as ISO25119 and ISO18497.

When using GNSS in autonomy, two key elements are essential to maintain maximum machine performance:

1. A robust and accurate working position for efficient and accurate operation of the task.

2. A reliable and precise position of the machine in relation to the operational zone boundary.

Hexagon | NovAtel offers proven hardware and software that simplifies integration and helps you meet challenging industry requirements.

SMART7-SI
The SMART7-SI, as the primary receiver, offers full multi-constellation, multi-frequency support and triple L-Band tracking. Utilising multiple GNSS signals enables greater availability and redundancy under variable terrain and environmental conditions. Designed with our deeply coupled GNSS+Inertial Navigation System (INS) SPAN technology, the SMART7-SI is optimised for the unique dynamics of demanding off road applications like precision agriculture and machine control. SPAN technology provides accurate attitude information and terrain compensation that simplifies the development of vehicle guidance systems and bridges GNSS signal outages caused by trees, buildings and other obstacles, resulting in greater uptime for your autonomous machine.

SMART2
The SMART2, as part of the dual antenna solution, provides multi-constellation, dual-frequency support for position redundancy with L-Band capabilities for delivery of TerraStar corrections. Built to withstand agricultural environments, it is ideally suited for autonomous agriculture machines.

ALIGN firmware
ALIGN technology from NovAtel combined with the SMART7-SI and SMART2 antennas provides high accuracy relative heading, allowing the vehicle's heading to be known at all times, even from startup and a static position, ensuring your operational zone is never compromised.

ROS/ROS 2 drivers and PTP functionality[1]
ROS and ROS 2 drivers provide plug-and-play compatibility with the Robot Operating System. PTP (precision timing protocol) function allows the SMART7-SI to act as a grandmaster clock, synchronising of all your sensors without additional hardware.

1. PTP timing is available with firmware 7.09.00 or newer.

Features & Benefits

- Rugged all-in-one enclosures designed to take on tough agriculture environments

- Heading from startup and during idle periods with ALIGN dual antenna technology

- Redundancy provided throughout the hardware and software solution

- Centimetre-level accuracy using TerraStar-C PRO, TerraStar-X or RTK

- High-quality measurements and stable phase centre for precision applications

- Integrated IMU in SMART7-SI for accurate vehicle attitude, terrain compensation and bridging of GNSS blockages

- Simplified setup and configuration with optional onboard Setup & Monitor (Web) and wireless connectivity on SMART7-SI

- ISO25119 Category 2/3 architecture

- MTTF and MTTF$_d$ metrics available

- Easy integration with industry-standard interfaces through ROS, ROS 2 and PTP

- Easily receive corrections with integrated NTRIP client using optional Ethernet/Wi-Fi interface on SMART7-SI

SMART7-S specifications

Performance[1]

Signal tracking

GPS	L1 C/A, L1C, L2C, L2P, L5
GLONASS[2]	L1 C/A, L2 C/A, L2P, L3, L5
Galileo[3]	E1, E5 AltBOC, E5a, E5b, E6
BeiDou	B1I, B1C, B2I, B2a, B2b, B3I
QZSS	L1 C/A, L1C, L1S, L2C, L5, L6
NavIC (IRNSS)	L5
SBAS	L1, L5
L-Band	up to 5 channels

Horizontal position accuracy (RMS)

Single point L1/L2	1.2 m
SBAS[4]	60 cm
DGPS	40 cm
TerraStar-L[5, 6]	40 cm
TerraStar-C PRO[5, 6]	2.0 cm
TerraStar-X[5, 6]	2.0 cm
RTK	1 cm + 1 ppm

	(95%)
Single point L1/L2	2.4 m
SBAS[4]	120 cm
DGPS	80 cm
TerraStar-L[5, 6]	50 cm
TerraStar-C PRO[5, 6]	2.5 cm
TerraStar-X[5, 6]	2.5 cm
RTK	2.5 cm + 1 ppm

Pass-to-pass accuracy (95%)

L1/L2 GLIDE single point	35 cm
TerraStar-L	15 cm
TerraStar-C PRO	2 cm

Maximum data rate

Measurements	up to 20 Hz
Position	up to 20 Hz
INS solution	up to 200 Hz

Time to first fix[7]

Cold start	<40 s (typical)
Hot start	<20 s (typical)

Signal reacquisition

L1	0.5 s (typical)
L2	<1.0 s (typical)

Velocity accuracy
0.03 m/s RMS

Time accuracy[8]
20 ns RMS

Attitude accuracy (deg)[9]

	(95%)	(RMS)
Roll	0.06	0.03
Pitch	0.06	0.03
Heading	0.5	0.1

Physical and electrical

Dimensions
220 L x 192 W x 66 H mm

Weight
<1.1 kg

Connectors
14-pin Tyco Ampseal
Optional M12 D-Coded

Mounting
4 x M4 screw inserts
Integrated magnetic mount

Power

Input voltage range	+7 to +30 VDC
Power consumption[10]	4 W (typical)

Status LEDs
Multi-colored, daylight viewable

Communication ports

RS-232 dedicated ports	3
CAN Bus	1
1 PPS	1
Ground speed output	1
Wi-Fi	optional
Ethernet	optional

Environmental

Temperature

Operating	-40°C to +70°C
Storage	-45°C to +80°C

Humidity
MIL-STD-810G(CH1) Method 507.6

Immersion
MIL-STD-810G(CH1) Method 512.6

Shock
MIL-STD-810G(CH1) Method 516.7

Solar radiation
EN60950-22 8.2
ISO 9022-9, Method 20, Severity Degree 03

Salt fog
IEC 60068-2-11

Sand and dust
MIL-STD-810G(CH1), Method 510.5

Vibration random
MIL-STD-810G(CH1), Method 514.7

Ingress protection rating
IP67, IP69

Compliance

FCC, ISED, CE, E-Mark and Global Type Approvals

Standard features

- 20 Hz data rates
- Field upgradable software
- PAC multipath mitigating technology
- Differential correction support for RTCM 2.1, 2.3, 3.0, 3.1, CMR, CMR+ and RTCA
- Navigation output support for NMEA 0183 and detailed NovAtel ASCII and binary logs
- GLIDE smoothing algorithm
- 1 PPS output
- Ground speed output

Correction services

- TerraStar-L
- TerraStar-C PRO
- TerraStar-X
- RTK ASSIST
- RTK ASSIST PRO

Available hardware options

- SMART7-S with SPAN
- SMART7-SI with SPAN, Wi-Fi and Ethernet

Firmware solutions

- GLONASS tracking
- Galileo tracking
- BeiDou tracking
- L-Band tracking
- ALIGN
- RTK
- SPAN

Optional accessories

- Mounting plate
- Interface cable
- RELAY7

Performance during GNSS outages[1, 11]

Outage duration	Positioning mode	Accumulated position error (m) RMS		Accumulated velocity error (m/s) RMS		Accumulated attitude error (degrees) RMS	
		Horizontal	Vertical	Horizontal	Vertical	Roll/Pitch	Heading
10 s	All	0.50	0.20	0.075	0.020	0.030	0.150

1. Typical values under ideal, open sky conditions.
2. Hardware ready for L5.
3. E1bc and E6bc support only.
4. GPS only.
5. Requires subscription to TerraStar data service.
6. RMS/95% accuracy under ideal conditions and may vary based upon user's geographic region, ionospheric activity, scintillation levels, GNSS availability and constellation health, multipath conditions and presence of interference sources.
7. Cold start: no almanac or ephemerides and no approximate position or time.
   Hot start: almanac and recent ephemerides saved and approximate position and time entered.
8. Time accuracy does not include biases due to RF or antenna delay.
9. With SPAN model firmware installed.
10. Power consumption values for GPS L1/L2.
11. 10s Outages are the Position/Velocity/Attitude error that has accumulated over the GNSS outage duration, initial accuracies are dependent on the positioning mode in which you are operating.

SMART2 specifications

Performance[1]

Signal tracking

GPS	L1, L2, L2C
GLONASS	L1, L2
Galileo	E1, E5b
BeiDou	B1I, B2I, B2b
QZSS	L1, L2
SBAS	L1
L-Band	

Horizontal position accuracy (RMS)

Single point L1		1.5 m
Single point L1/L2		1.2 m
SBAS[2]		60 cm
DGPS		40 cm
	(95%)	(RMS)
TerraStar-L[3, 4]	50 cm	40 cm
TerraStar-C PRO[3, 4]	2.5 cm	2 cm

Pass-to-pass accuracy (95%)

L1/L2 GLIDE single point	35 cm
TerraStar-L	15 cm
TerraStar-C PRO	2 cm

Maximum data rate

Measurements	up to 20 Hz
Position	up to 20 Hz

Time to first fix[5]

Cold start	<50 s (typ)
Hot start	<35 s (typ)

Signal reacquisition

L1	< 0.5 s (typ)
L2	< 1.0 s (typ)

Velocity accuracy   < 0.055 m/s RMS

Time accuracy[6]   20 ns RMS

Terrain compensation accuracy (deg)[7]

Roll/Pitch	<1.0 RMS

Physical and electrical

Dimensions   155 diameter x 81 height mm

Weight   470 g

Connector   14-pin Tyco Ampseal

Mounting
4 x M4 screw inserts
Integrated magnetic mount

Power

Input voltage range	+7 to +30 VDC
Power consumption[8]	2.5 W (typical)

Status LED
Multi-colored, daylight viewable

Communication ports

RS-232 dedicated ports	3
CAN Bus	1
Event mark input	1
1 PPS	1
Ground speed output	1
Bluetooth	optional

Environmental

Temperature

Operating	-40°C to +70°C
Storage	-45°C to +75°C

Humidity   MIL-STD-810G(CH1), Method 507.6

Immersion   MIL-STD-810G(CH1), Method 512.6

Shock   MIL-STD-810G(CH1), Method 516.7

Solar radiation   MIL-STD-810G(CH1), Method 505.6

Salt fog   MIL-STD-810G(CH1), Method 509.6

Sand and dust   MIL-STD-810G(CH1), Method 510.6

Vibration random   MIL-STD-810G(CH1), Method 514.7

Ingress protection rating   IP67 and IP69

Compliance

FCC, ISED, CE and Global Type Approvals

Standard features

- GPS L1 position, velocity and time with SBAS support
- 20 Hz data rates
- Field upgradable software
- PAC multipath mitigating technology
- Navigation output support for NMEA 0183 and detailed NovAtel ASCII and binary logs
- 1 PPS output
- Ground speed output

Correction services

- TerraStar-L
- TerraStar-C PRO

Available hardware options

- SMART2
- SMART2-B with Bluetooth
- SMART2-TB with Bluetooth and terrain compensation

Firmware solutions

- GLONASS tracking
- Galileo tracking
- BeiDou tracking
- Dual-frequency tracking
- L-Band tracking
- GLIDE smoothing algorithm

Optional accessories

- Mounting plate
- Pole mount adapter
- Interface cable

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1. *Typical values under ideal, open sky conditions.*
2. *GPS-only.*
3. *Requires subscription to TerraStar data service.*
4. *RMS/95% accuracy under ideal conditions and may vary based upon user's geographic region, ionospheric activity, scintillation levels, GNSS availability and constellation health, multipath conditions and presence of interference sources.*
5. *Cold start: no almanac or ephemerides and no approximate position or time.*
   Hot start: almanac and recent ephemerides saved and approximate position and time entered.
6. *Time accuracy does not include biases due to RF or antenna delay.*
7. *With optional Terrain Compensation software and hardware installed.*
8. *Power consumption values for GPS L1/L2.*

We are the global leader in OEM precise positioning and perception technology, trusted by the world's top agriculture companies.

Hexagon | NovAtel is a global technology leader, pioneering solutions for assured autonomy and positioning for integrators across a wide range of industries and environments. Our Global Navigation Satellite System (GNSS) receivers, antennas and correction services are found in the control, guidance and steering systems of the world's top precision agriculture, implement and vehicle manufacturers' products. With decades of field-proven reliability, our solutions optimize growers' productivity and efficiency, allowing them to save time, lower input costs and increase profits.

Contact Hexagon | NovAtel

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