



FUGRO

SEASTAR® - SAFE AND RELIABLE POSITIONING FOR DP

Seastar® products and services are designed specifically for position reference for dynamic positioning systems and provide your vessel or rig with the highest standards of reliability, availability and coverage for safe operation.

RELIABLE DGNSS FOR DYNAMIC POSITIONING (DP) APPLICATIONS

Fugro offers high performance positioning services, primarily to the offshore energy markets. The users of our services are vessels and rigs equipped with dynamic positioning which requires high availability and integrity in operations, and other marine users who have special demands for navigation requirements. Fugro is viewed to be a market leader within our field of expertise today:

- Worldwide solutions
- Highest levels of service reliability to ensure continuous reception

- Dual independent links in all Inmarsat ocean regions
- Decimeter level accuracy services
- Global Navigation Satellite Systems (GNSS) capability using GPS, GLONASS, BeiDou and Galileo
- Compatible with Kongsberg DPS and DARPS systems

G4 - MORE IS SAFER

For a satellite-based system, this means an unobstructed view of the satellites. But when operating close to large structures, satellites can easily be obscured leading to reduced performance – just when it is most necessary.

The ability to use a wide range of satellites gives more choice and therefore higher probability of a good position solution.

Based upon the use of its worldwide network of reference stations, Fugro is able to calculate corrections to orbit and satellite clock values, for all global GNSS systems (GPS, GLONASS, BeiDou and Galileo).

Access to multiple lines of position, derived from a mix of satellites, means that any satellite with an inconsistent measurement can be treated as an 'outlier' and therefore ignored in the position calculation. Additional satellites confirming the calculated position build confidence and reliability.



A RANGE OF SERVICES

A choice of services are provided, ranging from the Seastar® standard L1 sub metre level, GPS only, single frequency service to the Seastar® G4 decimetre level, integrated GPS/GLONASS/BeiDou/Galileo, dual frequency service.

Use of a wider range of satellites gives more resistance to ionospheric scintillation effects which tend to be localised in a particular part of the sky. Any radio navigation system depends upon effective receipt of signals.

Seastar® G4:

GPS, GLONASS, Galileo and BeiDou, 10cm accuracy phase-based service using orbit clock data valid worldwide.

Seastar® G2:

GPS, GLONASS, 10cm accuracy phase-based service using orbit clock data valid worldwide.

Seastar® XP3:

Accuracy phase-based service, using orbit/clock data valid worldwide, based on GPS, GLONASS and Galileo L1 and L2 frequencies. Independent of G2/G4.

Seastar® XP2:

Accuracy phase-based service, using orbit/clock data valid worldwide, based on GPS and GLONASS L1 and L2 frequencies. Independent of G2/G4.

Seastar® XP:

Accuracy phase-based service, using orbit/clock data valid worldwide, based on GPS L1 and L2 frequencies. Independent of G2/G4.

Seastar® SGG:

Integrated DGPS/DGLONASS, sub metre level, code-based service using orbit/clock data based on GPS, GLONASS, Galileo and BeiDou L1 and L2 frequencies.

Seastar® Std. L1:

Sub metre level, code-based service based on GPS L1 frequency (GLONASS optional).

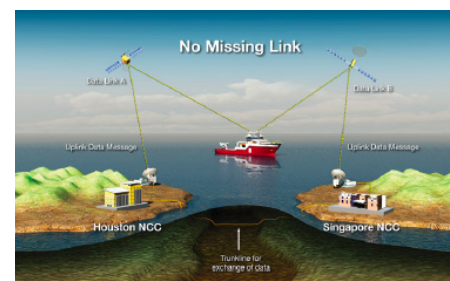
FUGRO DATA NETWORK

Fugro operates a fully duplicated network for the production and delivery of high-performance GNSS augmentation services.

The network includes:

- Independent Network Control Centres (NCC) in Singapore and Houston, USA
- Back up NCC in Australia and USA
- Dual satellite broadcast data links in all ocean regions
- The Seastar® Networked Transport of RTCM via Internet Protocol (NTRIP) DGNSS data delivery option provides a backup to satellite broadcast delivery.

Fugro DGNSS services are delivered over dual independent delivery paths. To complement the standard satellite broadcast delivery channels, we offer Internet delivery of correction data using the NTRIP protocol (Networked Transport of RTCM over Internet Protocol).



No Missing Link

ONBOARD EQUIPMENT

Reception is either via a small dedicated omni-directional antenna or alternatively a connection is made to a compatible existing Inmarsat system. This connection has no impact on use for normal two-way communications and does not affect equipment approvals.

FUGRO SEASTAR® 9410-AUT THE NEW ALL-IN-SKY GNSS RECEIVER

The all new Fugro Seastar® multi-constellation, multi frequency GNSS receiver is preloaded with Fugro Seastar® G4. A 10 cm accuracy phase-based service using orbit clock data valid worldwide.

The Seastar® 9410-AUT is 672-channel GPS/GLONASS/BeiDou/Galileo receiver monitoring.

GPS: L1-C/A, L1C, L2C, L2E, L5

GLONASS: L1-C/A, L1P, L2-C/A,

L2P, L3 Full Cycle Carrier NavIC (IRNSS): L5-C/A

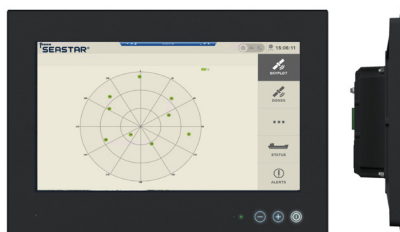
Galileo: E1, E5-A, E5-B, E5-AltBOC, E6

BeiDou: B1, B1C, B2, B2A, B2B, B3

Fugro L-Band DGNSS Service

Multipath signal rejection. High precision multiple correlator for GNSS pseudo range measurements. Prepared for Fugro Satguard®.

The Seastar® 9410-AUT can also be supplied with an IALA version. All through one antenna. A dedicated PC based QC applications system is also available. Capable of displaying DGNSS Position Sky Plot, Position Monitoring, Fugro Satguard® as well as system status and alerts.



RECEIVING CORRECTIONS OVER INTERNET - NTRIP

The internet can provide a useful data delivery backup to standard broadcast channels – particularly if there is any obstruction to the antenna visibility of the broadcast satellite.

However, the internet and shipborne VSAT are not considered to be reliable enough for dependence as a primary delivery channel.

For this reason, NTRIP is not available as an independent commercial service but is only supplied as a backup solution for the primary broadcast channels.

In addition to internet access, a compatible Seastar® receiver or demodulator is required.

Low bandwidth data set

For vessels without broadband communications or operating outside of VSAT coverage, a compact data set of only the Seastar® G2 corrections is available. This requires interfacing through an Iridium system.

| Receivers | Fugro Seastar® Positioning Services | | | | | | | |
|------------------|-------------------------------------|-------------|--------------|--------------|-------------|--------------|------------------|----------------|
| | Seastar® G4 | Seastar® G2 | Seastar® XP3 | Seastar® XP2 | Seastar® XP | Seastar® SGG | Seastar® Std. L1 | Seastar® Ntrip |
| Fugro 9410AUT | X | X | X | X | X | | X | X |
| DPS i4 | X | X | X | X | X | | X | X ¹ |
| DPS i2 | | X | | X | X | | X | X ¹ |
| DPS i1 | X | X | X | X | X | | | |
| Legacy receivers | | | | | | | | |
| Fugro 9205 | X | X | X | X | X | | X | X |
| DPS 432 | X | X | X | X | X | | X | X ¹ |
| DPS 232 | | X | | X | X | | X | X ¹ |
| DPS 132 | | | | | X | | X | X ¹ |
| DPS 116/200 | | | | | | | X | X ¹ |
| DPS 114 | X | X | X | X | X | | | |
| DPS 112 | | (X) | | (X) | | X | | |
| DPS 110 | | | | | | X | | |

¹ Ntrip available through dedicated demodulator 3610 or 3710

KONGSBERG RECEIVERS AND INTEGRATED SYSTEMS

DPS i4 with Seastar® HP/XP/G4 engine:

A multi-constellation GPS/GLONASS/BeiDou/Galileo receiver, multi frequency sensor, 4 RTCM inputs, with display and extended QC capabilities. Including graphs. Made by Kongsberg. Prepared for Fugro Satguard®.

DPS i2 with Seastar® HP/XP/G2 engine:

GPS and GLONASS multi frequency sensor, 4 RTCM inputs, with display and extended QC capabilities. Including graphs. Made by Kongsberg. Prepared for Fugro Satguard®.

DPS i1 with Seastar® G4/XP engine:

Integrated GPS/GLONASS/BeiDou/Galileo sensor and L-Band receiver/demodulator, with IALA beacon receiver; 3 x RS 232/RS422 serial ports, 2 x LAN & 1 x USB port and built-in display. Made by Kongsberg.



GNSS CYBER SECURITY, SPOOFING AND JAMMING

Today, man-made technology is available at a moderate cost which can be used to deliberately disturb the normal operation of GNSS equipment. GNSS signals coming from satellites are weak and even a low-power transmitter can easily affect GNSS receivers within a radius of several nautical miles.

It is common to talk about two different forms of interference: Spoofing and Jamming.

SPOOFING:

A GNSS spoofing attack attempts to deceive a GNSS receiver by broadcasting incorrect GNSS signals, or by rebroadcasting genuine signals captured elsewhere.

The effect is that the vessel appears to be in the wrong position. The attacker can further manipulate the fake signal in such a way that he, in effect, gains full control of the vessel.

SPOOFING DETECTION

Fugro Satguard® is a unique, Fugro developed technique for GNSS Navigation Message Authentication. This method applies the Fugro network of more than 100 reference stations worldwide.

Satguard® monitors the status of data received from each individual GNSS satellite. A unique signature for each satellite is transmitted to the vessel as part of the Fugro G2/G4 correction service.

By comparing the satellite data seen by the vessel with the Fugro data, fake satellites can be identified and discarded.

JAMMING:

Jamming is the blocking of GNSS signals by local transmissions, which may come from own ship or from nearby vessels and installations, or ashore. GNSS frequency bands are reserved but malfunctioning or incorrectly configured equipment can produce noise in these bands. Intentional interference should not be overlooked. The symptoms of such interference can vary from position instability if only some satellites or frequencies are affected, to a complete positioning black-out under severe conditions.

JAMMING MITIGATION

To effectively mitigate jamming and other types of interference, local transmissions need to be neutralised with specialised hardware. Seastar® applies two techniques to prevent the effect of jamming.

1: The Fugro G4 correction solution utilising GPS, GLONASS, BeiDou and Galileo. These GNSS systems operate on different (multiple) frequencies and multi constellation receivers and are therefore less prone to be affected by interference.

2: A specialised high-performance antenna with optimised filters which reduce interference in the applicable frequency bands.

