Recap on Radio Positioning Systems used for DP over the past twenty years

Syledis

During the early eighties the North Sea was covered by large Syledis networks. This system enabled vessels working in the oil fields to have 24 hour access to 2 - 5 meter accuracies which was a great improvement over previous lower frequency systems. Syledis signals were stable to about 80 kilometers from each base station, and the vessels needed to access a minimum of three sites to obtain an accurate position. Operating in the 420 - 450 MHz band, Syledis was a huge success giving acceptable accuracies even when compared to shorter range microwave systems such as Trisponder and Mini-Ranger.

FIG. 7 - MOBILE UNIT

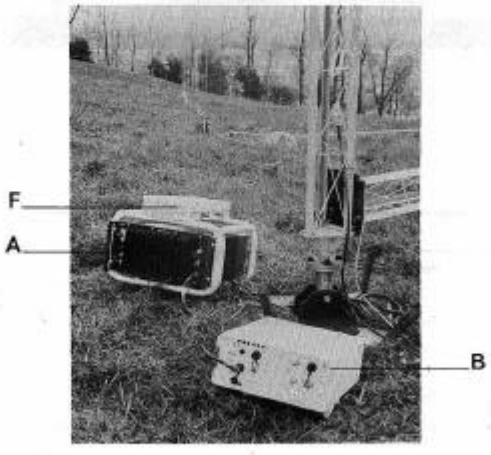


FIG. 8 - BEACON (B) - BOOSTER AMPLIFIER (A) AND L.D. FILTER (F) FOR A SYLEDIS L.D.

Syledis Mobile Unit (1)

III-4 Beacon

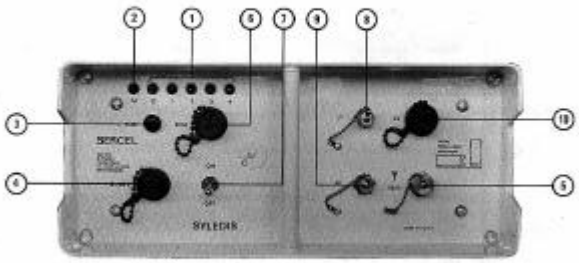


FIG. 10 - FRONT PANNEL OF THE BEACON

Reference	Function
①	Display lights : These lights are turned on when the power is set on. They are turned out when the corresponding channel is locked (See II.6)
②	ON - OFF - Indicator - On when the beacon is under power
③	Fuse
④	Power input - Connects to a 12 or 24 V DC source
⑤	Antenna
⑥	Test - for connection to a specific test meter included in the maintenance kit
⑦	Power switch
⑧ ⑨	Connections to booster amplifier (for long distance)
⑩	Antenna switch control (up to 4 aerials).

Syledis Base Station (2)

Syledis networks remained active and highly utilized until the early 1990's. Syledis was operated in conjunction with DGPS for several years and was used as the primary truth test for the eventual acceptance of DGPS as a stand alone survey positioning system. It should be noted that Syledis accuracies are dependent on the geometry of the fix.

Artemis System:

Artemis Systems were a common sight on offshore drilling structures, and were heavily utilized for DP station keeping. Many were purchased by oil companies and permanently installed on surveyed monuments located on the rig's corners. When dive boats or well intervention vessels came to work alongside the platform the vessel would simply tune to the rig's Artemis channel and have relative position accuracies of 0.5 meters (2 sigma) up to 1400 meters from the structure. High power options were available which could provide positioning out to 25 kilometers at accuracies in the 1.5 - 2 meter range (2 sigma).

Position data of the mobile unit with respect to the reference unit is given as bearing and distance. The measurement of the angle is based on two mutually and automatically tracking microwave antennas. Once locked the reference antenna always points in the direction of the mobile antenna.
The microwave tracking antennas are joined by a continuous wave, bearing is displayed to an accuracy of 0.03 degrees. (2 sigma).

ARGO DM - 54

Artemis System (3)

Argo was a long range radio positioning system that could provide accuracies in the 4 - 7 meter range. It had a range of 400 kms and could utilize data from 4 reference sites in the circular mode. Argo used phase comparison techniques and operated in the 1.6 - 2.0 MHz band Argo was used as a DP input primarily in areas where short range positioning systems were unavailable. As the 'lane' (0.5 of the wavelength) was between 75 - 90 meters a vessel station keeping needed only to check an Analogue Chart Recorder to maintain confidence in the system. As with all other multi-reference station systems working in range - range, positioning accuracy is strongly dependent upon the geometry of the 'fix'.

WIMPOL

Technical Information

TIS 13

Argo DM54

- 400 km plus range
- High resolution, up to 3 to 5 metres
- Portable
- Circular (up to 4 ranges) or Hyperbolic Modes
- Multi-user
- Un-manned Shore Transmitter Stations
- Rugged packaging

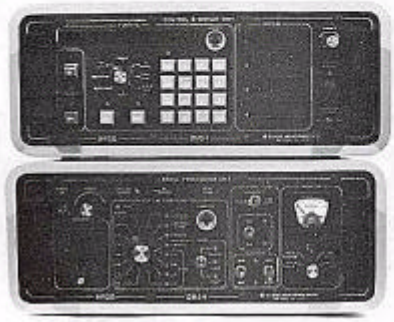
Description

ARGO DM-54 is one of the most recently developed positioning systems. It uses phase comparison techniques in the 1.6 to 2.0 MHz frequency band to achieve exceptionally high resolution and long range. Up to twelve users can simultaneously access an Argo Chain with two ranges and up to nine users with three ranges.

The maximum working range of all radio navigation systems is a function of physics and local environmental factors. However as a guide, typical maximum ranges in temperate climates are 740 km (400 nm) by day and 550 km (300 nm) by night. The range accuracy of the system is 0.02 lanes instrumental and 0.05 lanes, achieved field accuracy. Assuming a lane width of 80 metres for example, the field accuracy would be 4 metres per range. Positioning accuracy is also clearly dependent upon the geometry of the 'fix'.

The system displays ranges (or Hyperbolic comparison ranges) in 'lanes'. A 'lane' is considered to be half of the wavelength of the particular frequency in use at an assumed velocity of propagation, and typically would be between 75 and 95 metres - constant in circular mode but dependent upon the lane expansion factor in Hyperbolic mode.

When required, a second frequency approximately 10% higher than the 'measuring' frequency can be used to provide a Lane Identification facility which resolves the user's position to five lanes (i.e. approximately 400 metres) for each range. In other cases an Analogue Chart Recorder (ACR) connected to the Control & Display Unit (CDU) will show the vessel's progress through the ranging patterns and serves as a useful record in the detection of lane slip (due to power failure or breaks in transmission).



Specification

Fixed Station Installation	1 Range processing unit 1 Antenna loading unit Interconnecting cable 1 Antenna
Mobile Station Installation	1 Control and display unit 1 Range processing unit 1 Antenna loading unit Interconnecting Cable 1 Antenna
System Capacity	12 users with 2 ranges 9 users with 3 ranges 7 users with 4 ranges Unlimited users in Hyperbolic mode
Frequency	A single pre-determined frequency between 1.8 and 2.0 MHz for range measurement. An optional second frequency 9 to 10.5% higher for Lane Identification. Up to 18 frequency pairs may be factory pre-programmed to suit users' frequency allocation.
Transmitter Output Power	100 W peak
Bandwidth	80 Hz
Data Output	Analogue (for strip chart recorder) GPIB RS232 (optional)
Data Rate	Up-dated every 2 seconds
Input Power	22 to 32 VDC for all stations

Cont

Argo (4)

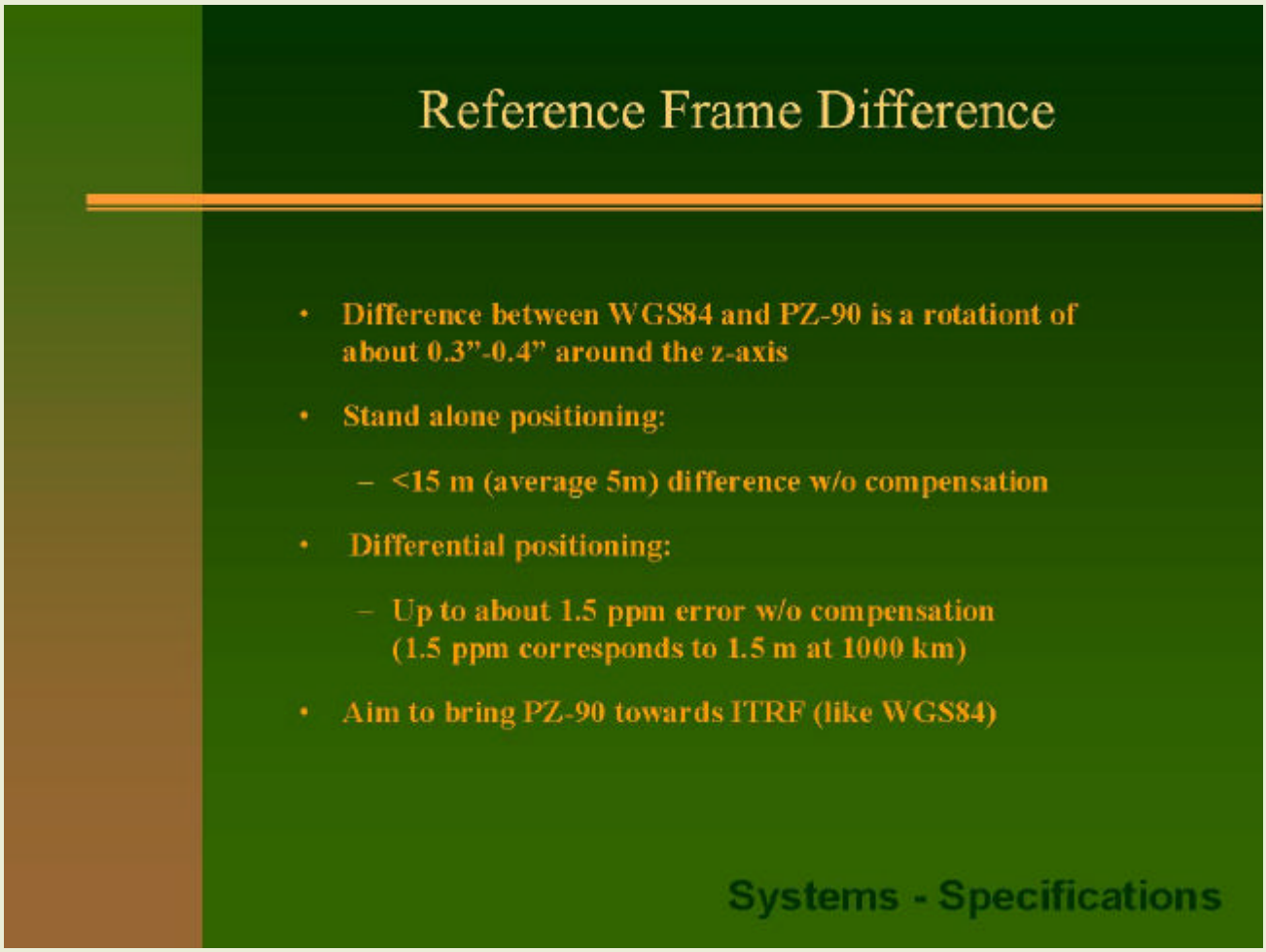
Artemis systems are still in common use around the world for DP station keeping. Other radio positioning systems also used extensively over this period included Pulse - 8, Micro-fix and Geoloc.

DGPS / Glonass

WHERE ARE WE?

Glonass / GPS (5)

GPS and Glonass are separate systems giving excellent correlation. Our trials show that when using dual systems both differentially corrected a base line of 1000 km would give errors of only 1.5 ppm which equates to 1.5 m without compensation. (Papers from Fugro Starfix Europe AS are available on request).

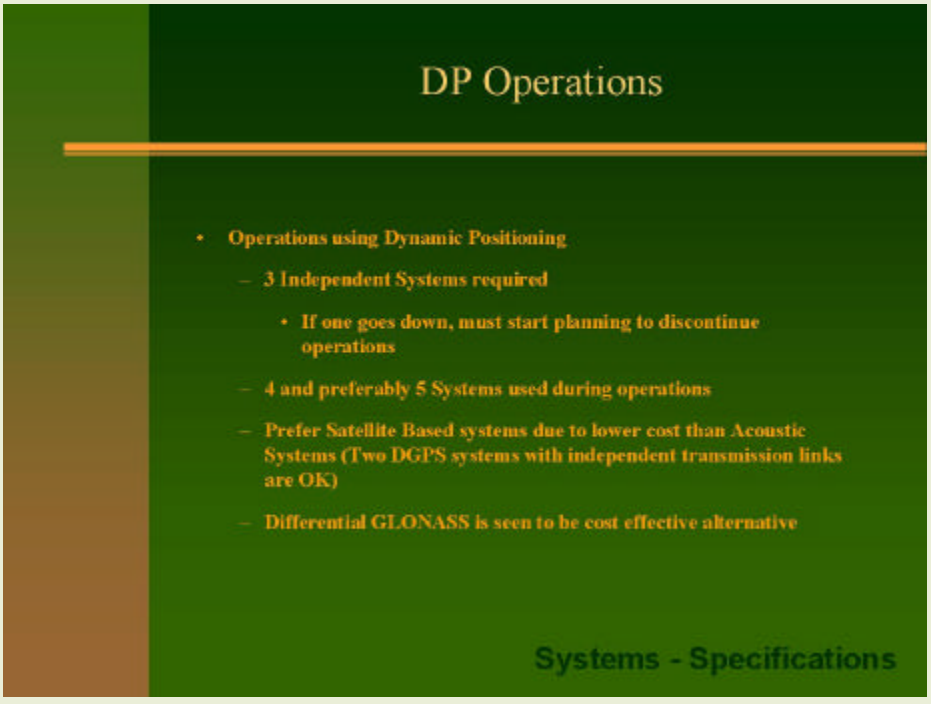


Reference Frame Difference (6)

The basics of radio navigation apply to GPS/Glonass as well as terrestrial systems. Firstly, we must know exactly where our reference stations are at a particular time. Using GPS; satellites are our reference points. We then measure our distance from each satellite by looking at how long it takes for the signal to reach us. The GPS receiver computes where it is by a processor using space segment survey calculations. Each satellite helps the receiver define where it is. Ranges intersect circles and after three measurements the receiver has established its position to two possible locations. As you usually tell the receiver where it is approximately, a fourth measurement is not absolutely necessary as one of the positions obtained offered by a third measurement would be so unlikely i.e., off the planet, that the receiver would automatically reject it.

Differential DGPS/ GPS and differential Glonass is a simple principle. Reference stations are installed over highly accurate survey monuments. Receivers at these sites look at the data coming in from each satellite. The receiver knows where it is and can calculate what adjustment needs to be made to each range to make that measurement a perfect fit. The GPS receiver then outputs these differentials which are broadcast to the DP vessel. In the worldwide DGPS systems currently available, data from each site is transmitted at high speed to control hubs where compression and QC functions are performed, strings of corrections are sent out to users containing information from up to 30 reference sites. DGPS software on the vessels running on either a PC or imbedded into processors calculate which sites they need data from, for example, the nearest ten, and merge this with raw GPS to create an optional solution. DGPS additionally helps us remove errors from the following sources:

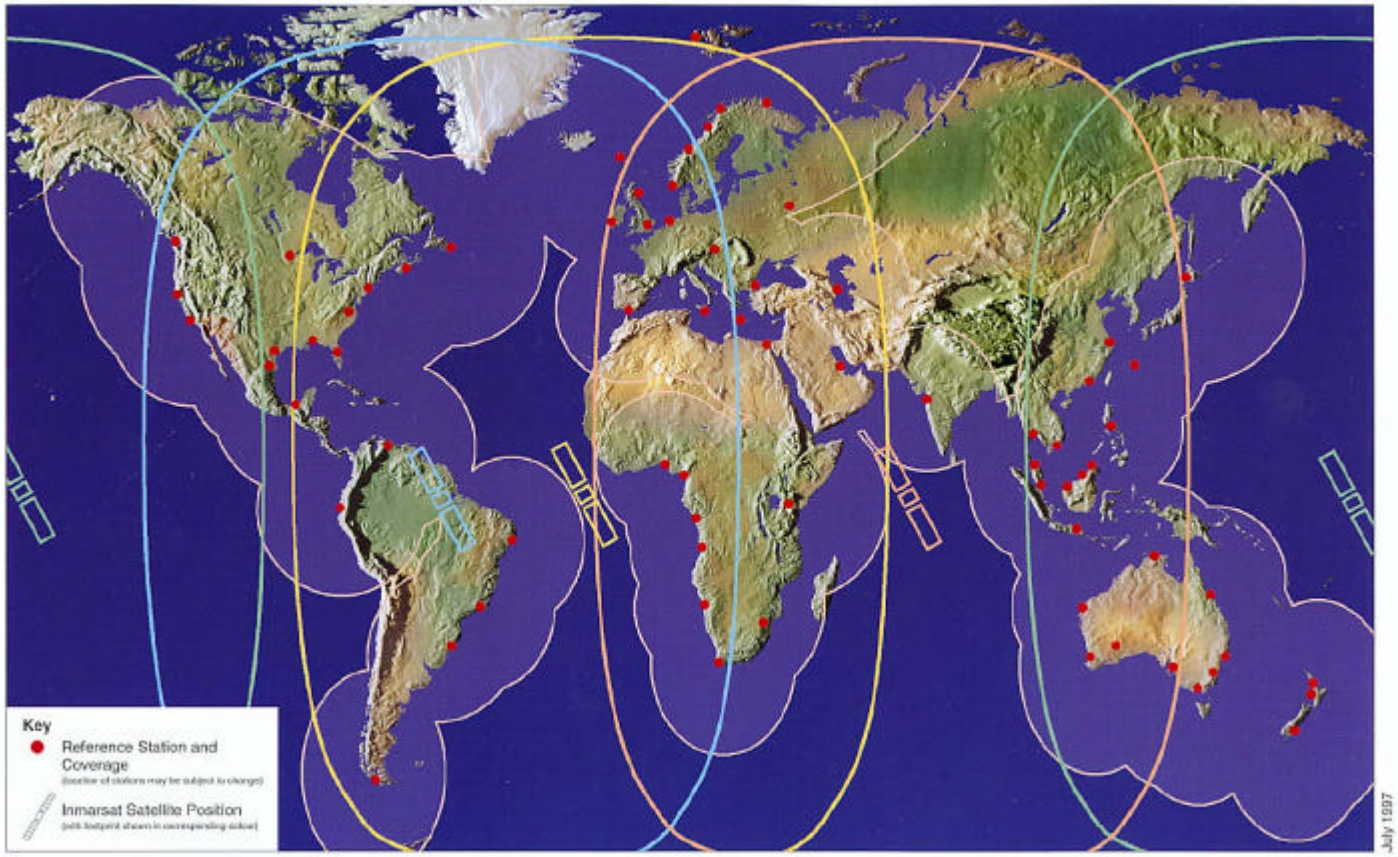
- Satellite Time Errors
- Signal Delays by the Ionosphere and Troposphere
- Receiver Clock Errors
- 'Selective Availability" (SA) DoD induced Clock and Orbit errors
- Ephemeris Error, Imprecise Satellite Orbit Data



OPS Using DP (7)

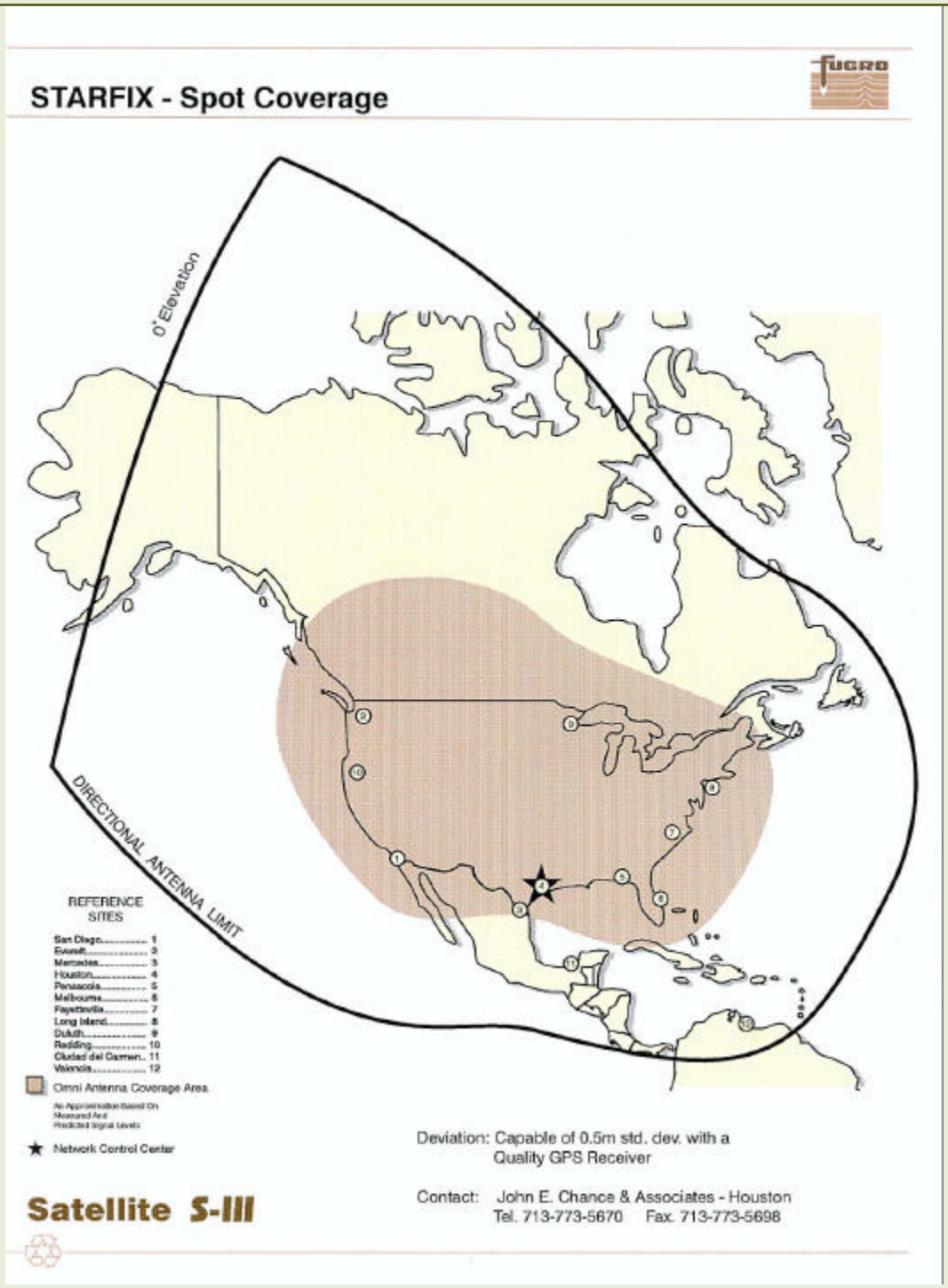
Many areas of the world are covered by wide area differential systems. The largest providers of this service are Fugro, with the Starfix system and Racal in SkyFix. As an example here are two of the Starfix coverage areas, one global and the other a 'spot' system used in North/Central American and the Caribbean. These systems have commonality in the same reference sites but have independent space segments to minimize potential interference localized on a vessel.

STARFIX GLOBAL COVERAGE – 2000 KM RANGE



STARFIX centres: John E. Chance & Assoc. Inc., USA. Tel: +1 713 773 5670 Fugro Starfix Pty Ltd., Australia. Tel: +61-8 9322 5295 Fugro Starfix (Europe) AS, Norway. Tel: +47 22 13 47 00

Starfix Coverage (8)

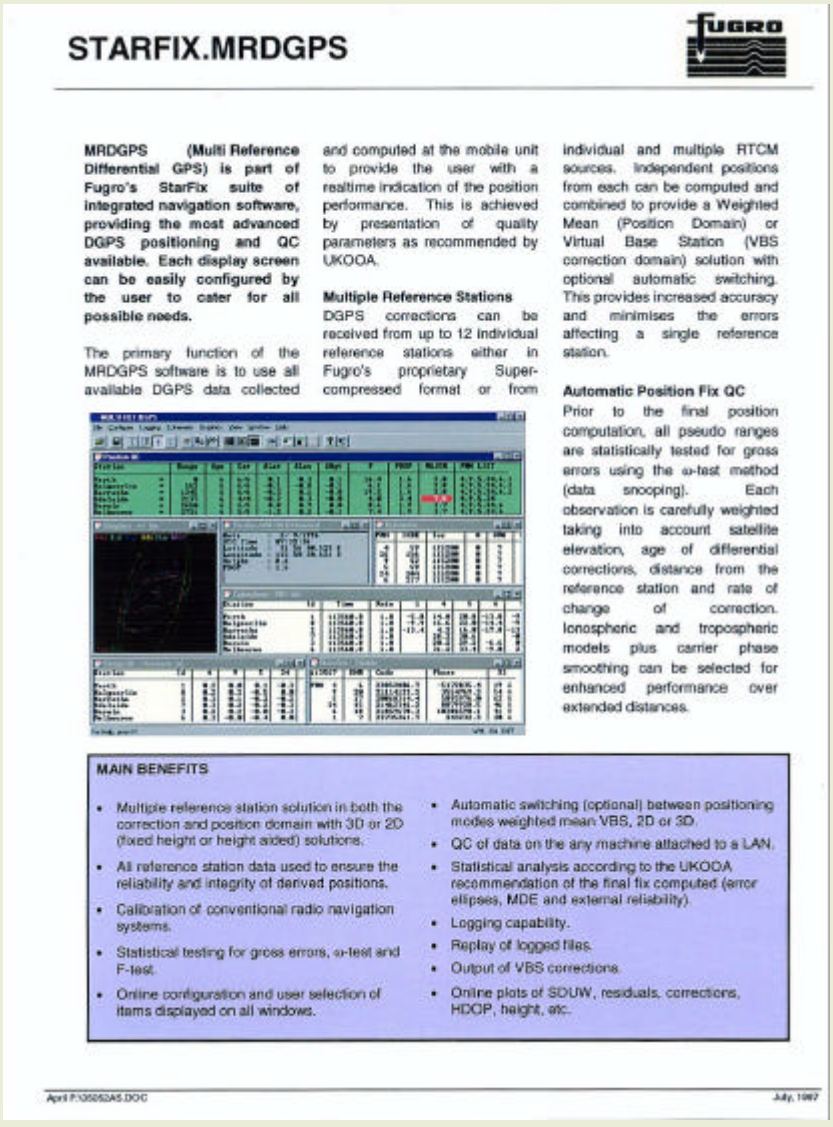


Starfix Spot Coverage (9)

Starfix DGPS corrections are broadcast over Inmarset and Starfix - Spot are on a “C” band commercial satellite.

User Equipment on the Vessel

There are currently two primary ways of incorporating all the information available from a Wide Area DGPS system into a position string for input into a DP System. The user can mobilize computers running multiple reference DGPS software such as Fugro's MRDGPS or Racal's Multi-Fix which handshake with survey quality GPS receivers to provide a NEMA position string.



STARFIX.MRDGPS

MRDGPS (Multi Reference Differential GPS) is part of Fugro's StarFix suite of integrated navigation software, providing the most advanced DGPS positioning and QC available. Each display screen can be easily configured by the user to cater for all possible needs.

The primary function of the MRDGPS software is to use all available DGPS data collected and computed at the mobile unit to provide the user with a realtime indication of the position performance. This is achieved by presentation of quality parameters as recommended by UKOOA.

Multiple Reference Stations

DGPS corrections can be received from up to 12 individual reference stations either in Fugro's proprietary Super-compressed format or from individual and multiple RTCM sources. Independent positions from each can be computed and combined to provide a Weighted Mean (Position Domain) or Virtual Base Station (VBS correction domain) solution with optional automatic switching. This provides increased accuracy and minimises the errors affecting a single reference station.

Automatic Position Fix QC

Prior to the final position computation, all pseudo ranges are statistically tested for gross errors using the ω-test method (data snooping). Each observation is carefully weighted taking into account satellite elevation, age of differential corrections, distance from the reference station and rate of change of correction. Ionospheric and tropospheric models plus carrier phase smoothing can be selected for enhanced performance over extended distances.

MAIN BENEFITS

- Multiple reference station solution in both the correction and position domain with 3D or 2D (fixed height or height aided) solutions.
- All reference station data used to ensure the reliability and integrity of derived positions.
- Calibration of conventional radio navigation systems.
- Statistical testing for gross errors, ω-test and F-test.
- Online configuration and user selection of items displayed on all windows.
- Automatic switching (optional) between positioning modes weighted mean VBS, 2D or 3D.
- QC of data on the any machine attached to a LAN.
- Statistical analysis according to the UKOOA recommendation of the final fix computed (error ellipses, MDE and external reliability).
- Logging capability.
- Replay of logged files.
- Output of VBS corrections.
- Online plots of SDUW, residuals, corrections, HDOP, height, etc.

Starfix MRDGPS (10)

These systems have high end statistical testing routines and perform numerous tasks that may not be applicable for all DP applications and may in some cases be duplicated by the DP control system.

A relatively new concept in DP positioning is the Virtual Base Station (VBS) The VBS takes technology used in MRDGPS and combines it into an intelligent black box with a visual display panel. A VBS system uses all reference stations in the vicinity of the receiver and computes an optimal set of RTCM corrections for the users position. In this way the user is provided with corrections world wide, without the need to manually select the closest reference stations. VBS technology allows a demodulator, processor and high quality survey GPS receiver to be combined into one unit so eliminating various cables, VCU's, and computers. An integrated key-pad and display additionally allow operators to monitor real time performance. Key system parameters may also be accessed via a simple menu system.

STARFIX DGPS VIRTUAL BASE STATION

STARFIX VBS

The STARFIX Virtual Base Station (VBS) provides users requiring accurate worldwide positioning with an RTCM correction message optimised for their location.

The VBS uses all reference stations in the vicinity of the receiver and computes an optimal set of RTCM corrections for the user's position. In this way, the user is provided with corrections worldwide, without the need to manually select the closest reference station, and is protected from temporary failure of a reference station. The VBS also comes with an optional, integral GPS receiver providing the user with an accurate, differentially corrected position.

The STARFIX system

The Fugro STARFIX system provides differential GPS corrections from multiple GPS reference stations via the Inmarsat satellite communication system.

The STARFIX system now covers most of the world with some 60 reference stations. Corrections are transmitted via all four Inmarsat satellites. Data from the worldwide STARFIX reference station network is available to users with an existing Inmarsat terminal, a dedicated M-Dome, or a flat plate antenna. The STARFIX system is designed and operated to meet the exacting requirements of the offshore industry.

The accuracy of the STARFIX system is 1-2 m with 95% probability in the horizontal plane at short and medium ranges (approx. 1000 km); and 3 m with 95% probability at ranges exceeding 2000 km. User accuracy is dependent on the GPS receiver used.

Features

- Small, lightweight, rugged built unit
- Compatible with a variety of antenna systems
- Built-in GPS receiver (optional)
- Optimised DGPS correction messages (RTCM format) or corrected position output (user selected)
- Integrated key-pad and display
- Real-time performance indicators
- Key operating parameters may be accessed and edited via a simple menu system
- Remote access facility (via satellite link)
- Built-in messaging capability (receive only)

January 1996

VBS (11)

The two major providers of Satellite delivered DGPS corrections utilize Inmarsat. To access these data sets on the vessel it is usually possible to connect into an existing Inmarsat system. DGPS signal reception does not effect the performance of the client's Inmarsat system. Small receive only domes are available as a back up to the vessels existing antenna or as prime, if required.

Microdome™

Chance has a history of leadership in innovative and cost-effective technological solutions for its international land and maritime clients.

The unit is portable, making it ideal for various positioning applications.

The latest development in the STARFIX® DGPS service to be provided by John E. Chance & Associates, Inc. (Chance) is the revolutionary Microdome. This unit is the world's smallest integrated Inmarsat (L-Band) satellite antenna and demodulator for Inmarsat delivered DGPS corrections.

Measuring a mere 55cm x 35cm, Microdome weighs only 8kg and can be easily carried by hand, making it the ideal choice for a variety of positioning applications.

In one package, Microdome provides the user with standard RTCM format DGPS correction messages for precise navigation.

The system's unique design overcomes any cable re-wrap and RF continuity and confirms Chance's position as an industry leader in the field of DGPS technology.

Technical Specifications

Dimensions:	35 cm diameter, 55 cm height
Weight:	8 kilos (17.6 lbs.)
Power consumption:	18 - 36 VDC, 30 Watts
Mounting:	on 50 mm or 2" pole
Operational temperature range:	-20 to +40 deg C
Humidity:	up to 100%
Azimuth stabilization:	Angular rate gyro, 50 deg/sec max
Elevation stabilization:	None, not required
Unwrap requirements:	None, continuous
Roll/pitch:	Less than 15 degrees 95% of the time
Antenna (patent pending):	L-band, RHCP, 12-13 dBic, 40 deg beam (-3dB)
User output data rate:	1200 bits per second
Data output:	RS232, 9600 baud
Output formats:	STARFIX format, optional RTCM 104 rev 2

Microdome Features

- Low cost
- Small size
- Fully integrated L-Band/ INMARSAT receiver and demodulator
- Easy to install and to operate
- Reliable operation
- Azimuth stabilized
- Fast azimuth motor, full turn 360 deg in 5 secs
- No unwrap requirements
- RS232 output
- Low power operation, 30W
- Optional RTCM 104 rev 2 output

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Microdome (12)

To summarize, Multiple Reference DGPS has become the standard surface position input for DP. In areas such as the Gulf of Mexico that have numerous reference sites in close proximity. DGPS can provide stable sub-meter positioning. Glonass receivers continue to improve and difference between WGS-84 and PZ-90 are being effectively modeled and applied. Differential Glonass is available now on a project basis in specific geographic regions. Accuracies will continue to improve at a rapid pace as new technologies are fully implemented.