

**The accuracy of the GPS Intelligent Buoy (GIB-Lite) system for use in shallow water offshore underwater positioning application was recently evaluated in cooperation with Fugro-TopNav. The trials proved that system accuracy could be brought up to centimetre level, the distance between two simultaneously tracked acoustic pingers having a standard deviation of 8cm**

# Underwater Positioning

## Centimetric Accuracy Underwater-GPS

Additional works next to an offshore production platform are often required to increase oil recovery from an existing reservoir or to maintain its production rate over a longer period of time. The seabed near such a production platform typically shows pipelines, electric cables, constructions and debris: all obstacles to the jack-up rig. Site investigation of objects must be carried out prior to jack-up insertion, so as to locate and accurately map any such objects. Underwater positioning techniques are mandatory for such survey. Just a few hours are sufficient to inspect a hundred-metre radius around the production platform. A standard LBL network requires an installation and calibration period greatly superseding that of the survey. USBL is not of advantage in such a noisy industrial environment and in shallow water. In the assessment of Fugro-Topnav, the GIB (GPS Intelligent Buoy) system is particularly well fitted for these applications. GIB-Lite provides operational advantages such as:



GIB-Lite buoy during tracking operation

- size and weight small enough for easy shipment
- no calibration
- easy and fast installation, anywhere
- high rate of positioning repetition (1Hz).

The last characteristic for evaluation was ability to achieve sub-metric accuracy, a requirement for most oil & gas undersea work.

### GIB Principle

The GIB has already been fully presented in a previous paper (see Hydro International, October 2002). The GIB portable tracking system was developed by ACSA based on a network of surface buoys that measures the travel time of acoustic signals emitted by a pinger clamped on submarine vehicles such as AUVs and ROVs or carried

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Diver carrying a GIB pinger.

by a diver. Every cycle (typically one second), the acoustic source transmits two successive signals, one synchronous to GPS time and the other delayed proportionally to depth. Each buoy measures the GPS time of arrival of the two signals and transmits this information together with its own D-GPS position to the Control and Display Unit (radio link). Propagation time is directly converted to pinger/buoy distance, sound velocity being known. As depth is precisely known, i.e. measured on each buoy, the position of the acoustic source is given by the intersection of circles having a radius equal to the projected slant range onto the horizontal plan. The positions of the buoys



GIB-Lite Pinger.



General view of trial site - four buoys (green: B1 to B5) and pingers (blue and red: P1 & P2; horizontal & vertical grid: 1,000m.

are known in WGS-84 coordinates, as is acoustic source position.

### Dynamic Test

A positioning network of 400 x 400m consisting of four GIB-Lite buoys was deployed within just half an hour. Two small asynchronous pingers, or acoustic transmitters, were immersed on the starboard and port flanks of a moving Zodiac: the first tuned to 32kHz, the second to 37kHz. The zodiac evolved inside the network for about fifteen minutes, long enough to simulate diver survey. GIB hydrophone positions and acoustic pseudo-range measurements between pingers and the four hydrophones were recorded, sampling at 1Hz. Aquatic Tracking Software, a software tool attached to the GIB-Lite system, was used for real-time pinger localisation, mapping and logging.

Post-processing was carried out using independent software and focusing particularly on accuracy and reliability. The data process was performed solving for three unknowns: horizontal coordinates (X,Y), and clock offset (T). At least three pseudo-ranges are mandatory to enable localisation. A fourth enables redundancy enough for quality control of data. Each epoch was taken into account for the post-processing, but only those that led to solutions producing less than 1-metre standard deviation were considered

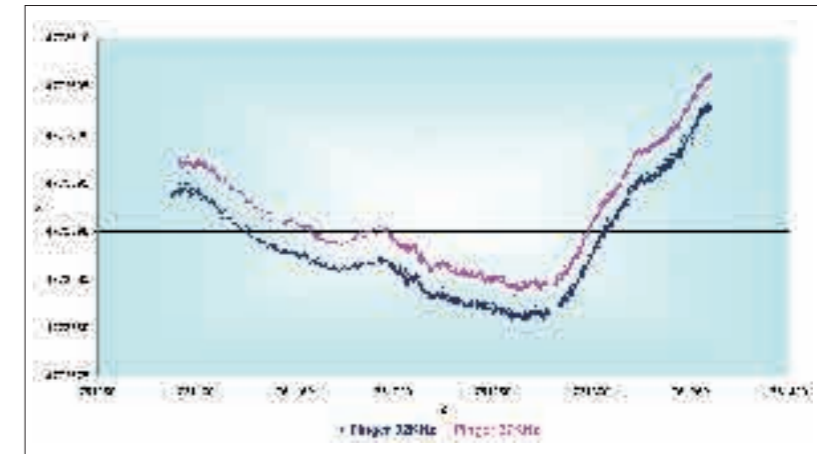


Figure 1: GIB-Lite tracks, two pingers. The process also returns instantaneous clock bias, revealing clock drift for each pinger (Figure 2). This measured drift is compatible with the internal drift of the embedded clock.

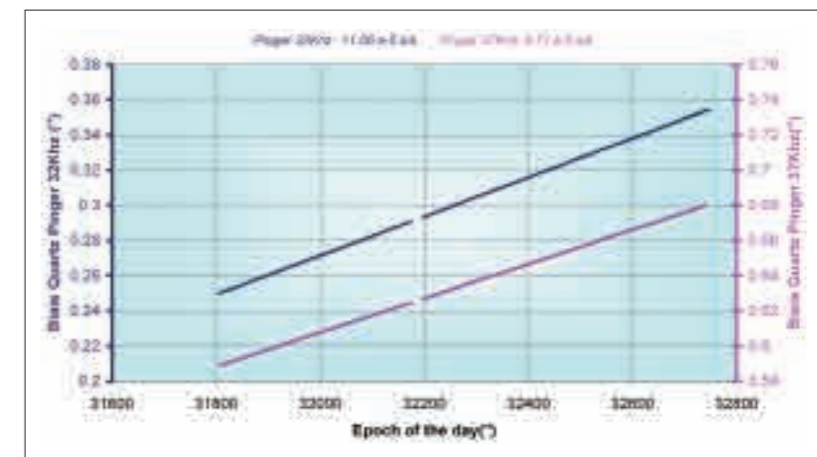


Figure 2: GIB-Lite pinger clock drift. At last the process returns the standard deviation of valid positions. The noise magnitude average lies within 0.4 metres. Amplitude variations are most often correlated, denoting a common noise source. Further analyses have identified the source as being related to the DGPS accuracy limitation.



GIB-Lite buoys in Zodiac before deployment.

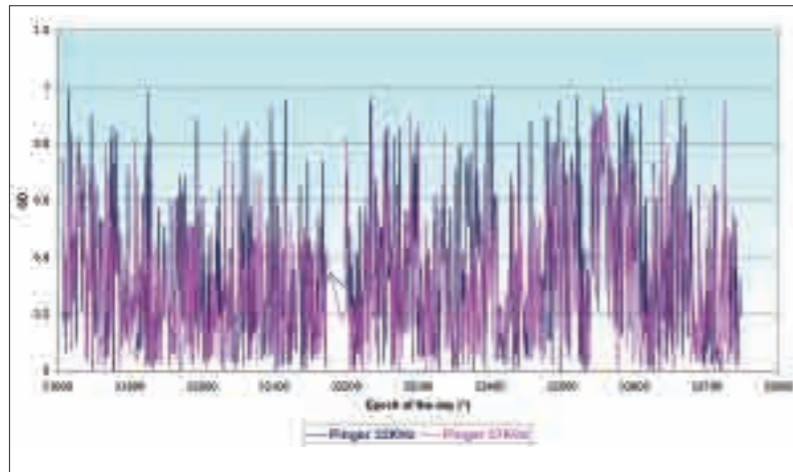


Figure 3: Standard deviation of GIB-Lite positioning.

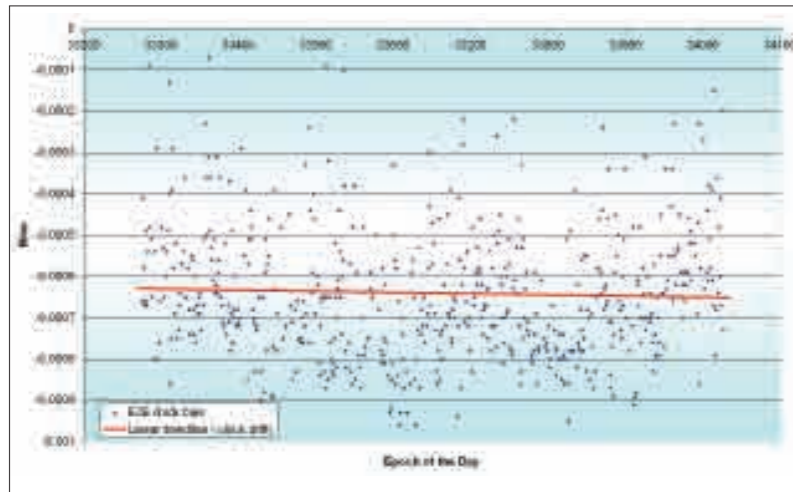


Figure 4: Clock bias and drift, synchronous and static pinger.

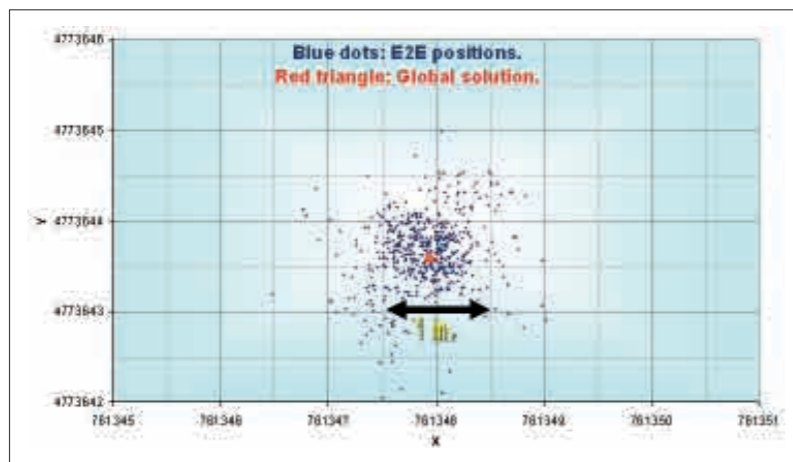


Figure 5: Static position of 32kHz pinger.

reliable: 96.2% of the resulting points passed the quality check. Looking at the scatter plot (Figure 1), blackout of localisation may be noted for 20" due to a temporary lack of differential signal on GIB-Lite buoy Number 1. The natural GPS position is unreliable for sub-metric surveying and is intentionally rejected. The three

remaining lines of positions are sufficient for localisation but insufficient for derivation of quality measurements.

**Static Tests**

Two pingers tied just over the anchor of a floatation line were arbitrarily

submerged within the same GIB network. One pinger was of synchronous class (clock drift < 10-8 s/s) whilst the other was the 37KHz asynchronous device used in the dynamic stage. The pingers are assumed to remain quasi-static throughout this ten-minute recording session.

**32KHz Synchronous Pinger**

**Epoch to Epoch processing method (E2E)**

Processing is run solving for three dimensions: X, Y and T. Solving the clock bias is not a requirement for the synchronous pinger since the device matched the Ipps DGPS signal just before dropping it into the water and quartz drift is about null. However, computing 'T' should lead to retrieving a value compliant with manufacturer's specification. As before, only solutions with better than 1m standard deviation are considered. The relevant population is shown as blue dots on the scatter plot in Figure 5.

The clock bias plot shows quartz stability evaluation. The average (-0.7") is about stable, with a small trend towards drift (-1.10-8 s/s) in accordance with the class of the equipment.

**Global Processing**

Overall measurements are gathered into a single input matrix and processing is run solving for four dimensions, X, Y, T and dt, where dt is clock drift. Because the input matrix is largely overabundant, statistical analyses allow detection and eradication of casual outliers. As a final point, the process preserves 2,959 measures among 3,009 entries (98.3%). Pinger localised at position: X= 761347.44 Y= 4773643.61. Standard deviation: SD= 0.58 m. Clock bias: T = -0.6ms. Clock drift: dt = 0.36 E-8 s/s.

**37 KHz Asynchronous Pinger**

**Epoch to Epoch processing (E2E)**

Processing is run solving for three dimensions (X, Y, T). Solutions ending with standard deviation lower than a metre are picked and plotted as blue dots on the graph (Figure 6).

**Global Processing**

All measurements are gathered within a single input matrix. Processing is run solving for four dimensions, X, Y, T and

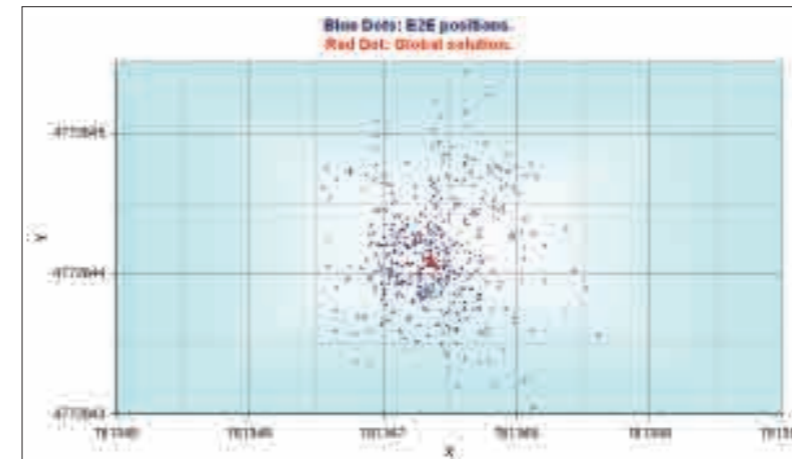


Figure 6: Static position of 37kHz pinger.

dt, where dt is clock drift. Because the input matrix is largely overabundant, statistical analyses allow detection and eradication of eventual outliers. As a final fix, the process preserves 2,620 measures on 2,669 entries (98.2%). The pinger is localised at position: X= 761347.36 Y= 4773643.59. Standard deviation: SD = 0.59m. Clock bias: T = 0.73 s. Clock drift: dt = 9.7

E-5 s/s (matching the drift computed for the dynamic phase).

**Concluding Remarks**

Both pingers share the same anchoring line: their horizontal positions are physically alike. Processing results should assert the expectation. The position of the synchronous pinger:

X= 761347.44 Y= 4773643.61. The positions are akin at decimetre near. The tests thus proved the high level of accuracy of the GIB-Lite system in shallow water. This opens up the possibilities for its use in many coastal applications.

**Biographies**

François Boucquaert is technical manager with Fugro-Topnav. Camille Bechaz joined ACSA underwater GPS in 1998 as project manager. She participated in conception of the first GIB system and now works on new designs and evolutionary developments. She is also in charge of the software development department. She holds a PhD in underwater acoustics and an MS in signal processing.

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