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DYNAMIC POSITIONING CONFERENCE

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WORKBOAT SESSION

Offshore Supply Vessel Positioning

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Abstract

Positioning offshore supply vessels in close proximity to moving oil and gas production facilities, like tension-leg platforms, is traditionally performed using multi-point anchor systems. These anchor systems protect the rig structure from collision damage, but limit the number of unloading positions around the rig and consume valuable time to attach and release the supply vessel. The use of advanced dynamic positioning algorithms and highly accurate GPS-based position data allow an offshore supply vessel to approach and hold station during unloading without anchors. In December 1998 and February 1999, Seatex installed DARPS (DGPS Absolute Relative Positioning Sensor) on two offshore supply vessels with Simrad dynamic positioning systems. The DARPS system provides two GPS based positions to the DP system -- a DGPS fix using IALA corrections and a target distance/bearing calculation. The relative distance and bearing calculation is not dependent upon differential corrections, thus making the system more robust. The integration of the positioning data with the DP controller allows the offshore supply vessel to work more safely, in higher sea-states, and at multiple loading locations around the platform.

Introduction

Effective dynamic positioning of offshore vessels and drilling platforms depends upon the availability of accurate setpoints and well-tuned control systems. High-quality position setpoints can be obtained from sensors using a wide variety of technologies -- microwave, laser, GPS, hydroacoustic, taut wire (Holvik, 1998).

Acoustic and taut wire systems both require underwater work, which can be expensive. Large vessels and drilling platforms may be able to amortize large capital costs for this underwater hardware if the scheduled occupation of a particular site is sufficiently long. Microwave and laser based systems can be less expensive, but require fixed reference points upon which to reflect the electromagnetic signal. Also, the performance of both electromagnetic systems degrades in rain and fog. Standard GPS does not provide the required absolute accuracy for close proximity dynamic positioning, but improvements in differential correction processing and relative GPS positioning make the GPS-based position reference system a viable option as a dynamic positioning setpoint.

Moreover, the autonomous design and lower cost of many GPS based dynamic positioning systems has allowed supply vessel operators to adopt the technology and discontinue their use of offshore loading methods involving anchors or moorings. This additional positioning technology has allowed supply vessels to perform more safely and efficiently. This paper will discuss absolute and relative positioning systems currently available to offshore supply vessels. The installation and testing of a positioning system will also be discussed.

Absolute Positioning with GPS

As the land-based radio navigation services, like LORAN-C, are terminated (Buhrke, 1998), offshore supply vessels that need absolute positioning setpoints can choose a GPS system for its cost benefits and ease of installation. However, the selective availability (SA) noise applied to the signal by the US Government limits the usefulness of stand-alone GPS systems (Figure 1). The 100 meter error circle is likely sufficient for ocean transit and some coastal piloting, but more

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accurate positioning is required when close proximity increases the risk of vessel to vessel contact.

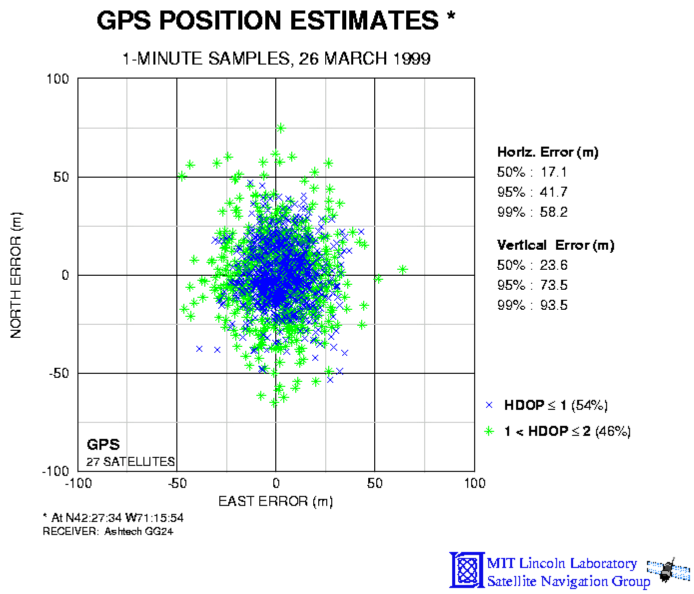

Figure 1. Position errors for the existing GPS constellation (MIT Lincoln Lab).

The Russian navigation constellation (GLONASS) can provide increased accuracy when sufficient satellites are in view. Unfortunately, the GLONASS constellation remains incomplete due to insufficient launches, and the minimum number of satellites (4) is rarely in view more than a few hours at a time. Three new GLONASS vehicles were launched in December 1998 (Figure 2) to fill slots in one of the rotation planes which did improve the coverage but not enough to make GLONASS by itself a viable option for dynamic positioning (Figure 3).

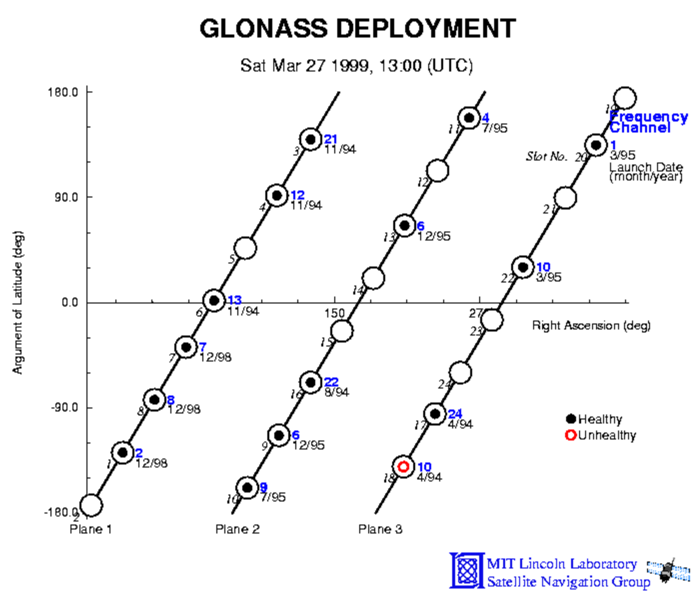

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Figure 2. GLONASS constellation showing the recent launch of three vehicles (2, 7, and 8) into Plane 1 (MIT Lincoln Lab).

The combined use of GPS and GLONASS results in a larger number of satellites in view (Figure 4) and a better position estimate (Figure 5). Systems, such as the Seatex DPS 200, are available to calculate this combined position and perform appropriate quality control (Figure 6).

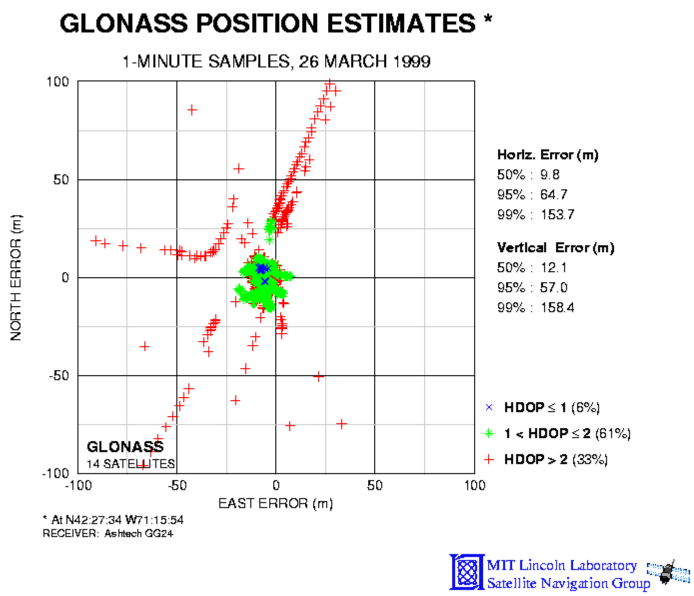

Figure 3. Position errors for existing GLONASS constellation (MIT Lincoln Lab).

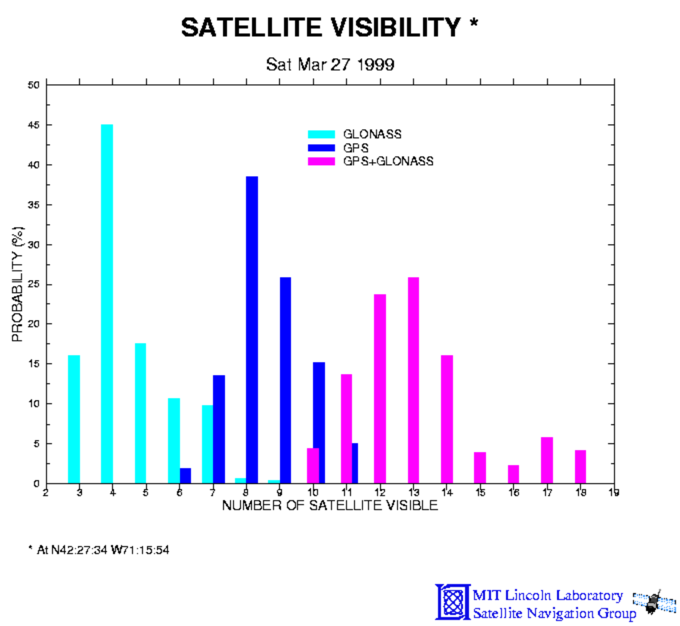

Figure 4. Satellite availability for GPS, GLONASS, and GPS+GLONASS (MIT Lincoln Lab).

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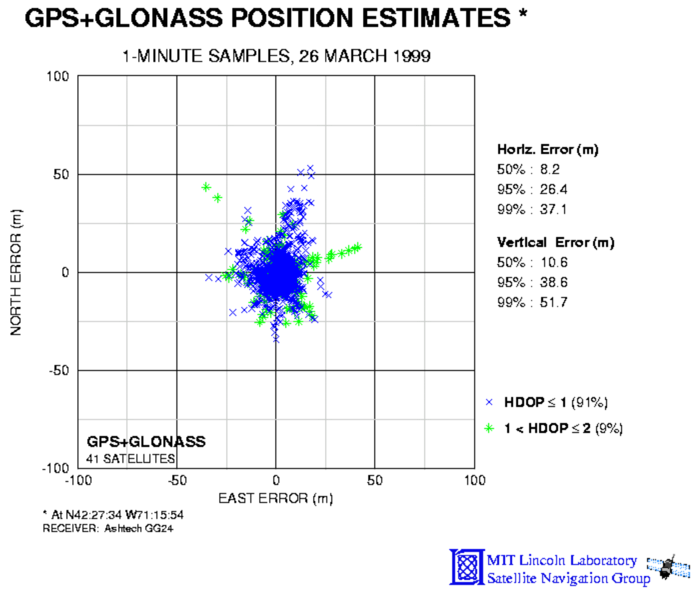

Figure 5. Position error for GPS+GLONASS system (MIT Lincoln Lab).

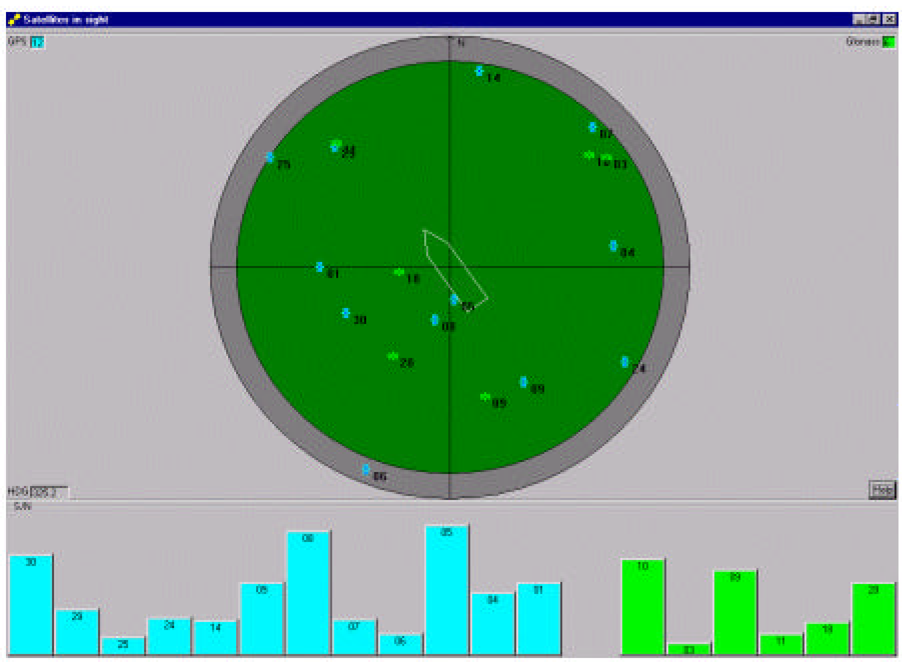

Figure 6. Satellite view for DPS 200.

Absolute Positioning with Differential GPS

The position fix obtained from GPS can be improved considerably if differential corrections are added to the calculation. Differential GPS (DGPS) signals are available from a number of sources, but all rely upon land-based reference stations and communication with the

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vessel. The resulting accuracy, reliability, and coverage area reflects the costs associated with each system.

One of the least expensive DGPS systems uses the International Association of Lighthouse Authorities (IALA) beacons that are maintained regionally by countries with extensive coastlines. In the United States, the US Coast Guard is responsible for these beacons. The signal is broadcast from an array of coastal antennas and is freely available to vessels that purchase a commercially available receiver (approximately US$5,000). The accuracy within the broadcast region (Figure 7) is 1.5 to 3.0 meters, but can be degraded by bad weather, obstructions in the line-of-sight, or noise in the 283.5 to 325 kHz frequency band.

Figure 7. IALA beacon coverage near the coastal United States.

A more accurate DGPS position (1.0 to 1.5 meters) can be obtained by blending data from multiple reference stations to create a model of the differential corrections at the location of the vessel, like the SATLOC product. The long-term cost of this type of system lies in the US$100 per day range for a subscription to the proprietary signal, while the size and initial cost of this type of modeled DGPS system is similar to an IALA receiver. The coverage area for this type of correction system is larger than the coastal IALA systems because corrections are transmitted to the vessel by a regional satellite, hence the need for a daily subscription.

In order to receive DGPS signals beyond the limit of coastal systems, the DGPS communication between the land-based reference stations and the vessel must travel via satellite. Both regional and worldwide (INMARSAT) based communication systems are available with subscription rates between US$200 and US$500 per day. Differential correction data from multiple reference stations is processed at the vessel to obtain a position fix with 1.0 to 1.5 meter accuracy. The position accuracy can degrade in remote areas at the rate of 1 meter per 100 km distance from the closest reference station (Buhrke, 1998). Gulf of Mexico coverage is quite good (Figure 8). In addition, DGLONASS reference stations have recently begun transmitting in Miami, FL and Rio De Janeiro, Brazil.

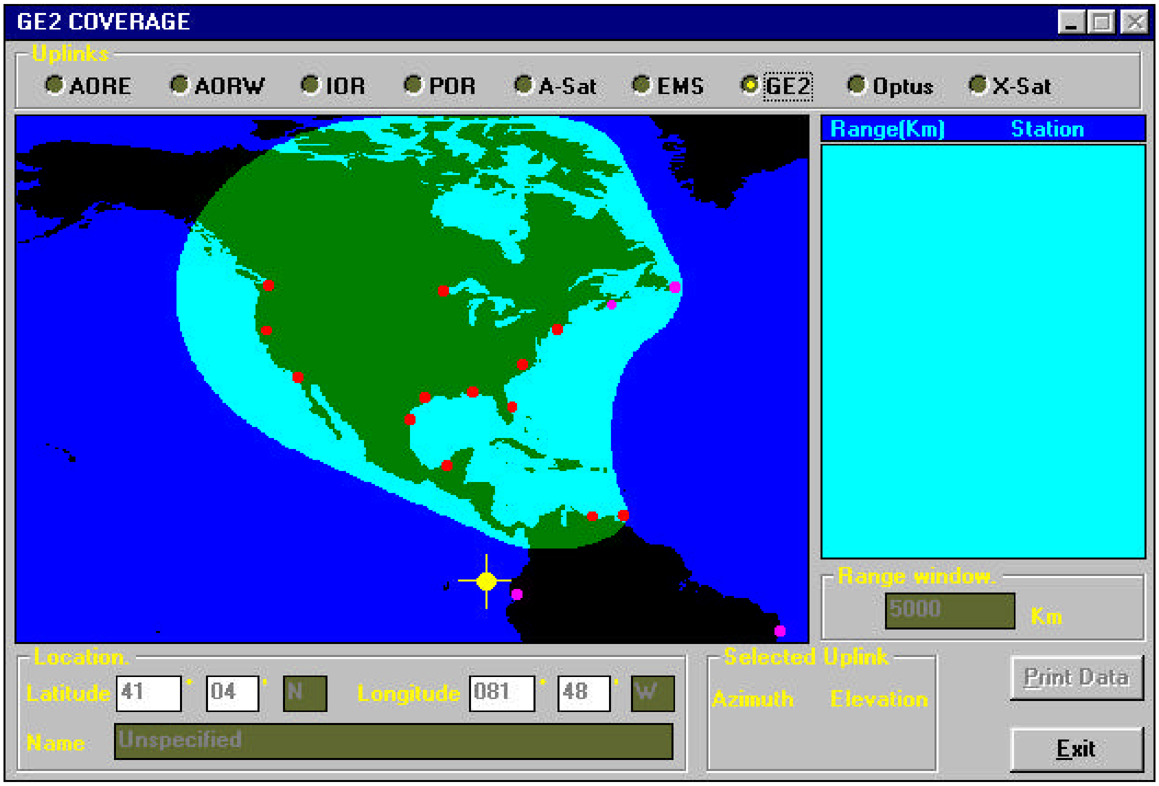

Figure 8. Regional coverage for satellite DGPS signal (Fugro Starfix).

On larger vessels, the INMARSAT equipment is routinely installed as part of the standard suite of communication equipment, and consequently, the initial cost of the INMARSAT antenna and controller is not included in the DGPS budget. However, on offshore supply vessels that do not have INMARSAT equipment as part of the vessel outfitting, the initial cost of INMARSAT DGPS can be quite significant (US$30,000-$40,000).

Relative Positioning with GPS

When the position setpoint for an offshore supply vessel is fixed, the absolute positioning fix obtained from DGPS is sufficiently accurate to maintain a steady vessel location. However, the position setpoint for a tension-leg platform or floating production vessel is likely to be in motion, which introduces a challenge for an absolute reference system. During loading operations at moving offshore platforms the critical parameters needed to maintain the position of the supply vessel are the relative distance and bearing between the platform and supply vessel.

One possible solution to the problem of moving platforms involves the calculation of precise absolute positions for both vessel and platform followed by a geodetic transformation to XYZ coordinates to obtain the vector between the two points. A more elegant method takes advantage of the close proximity of the platform and vessel to directly calculate a relative distance and bearing in the absence of accurate absolute position fix. This second calculation method is used in the Seatex DARPS system.

This relative positioning system collects GPS data on both the vessel and platform and forwards the platform data to the vessel in real time via a UHF radio link (Figure 9). All of the calculations take place aboard the vessel and the relative positioning data is relayed to the dynamic positioning system through a direct connection. The platform system is completely controlled by the vessel system through the radio link. As the supply vessel approaches an activation signal is sent to the platform system. Upon receipt of the signal, the platform system begins sending the GPS data to the vessel. Once the radio connection is established, the vessel system transmits a confirmation message at regular intervals. After the vessel leaves the site and the confirmation messages ceases, the platform system stops transmitting and waits for a new activation signal.

The true value of the relative positioning system lies in its ability to provide 1.0 meter relative position accuracy in the absence of differential signals. Differential correction data obtained from one of the previously mentioned providers will improve the absolute fix, but has no effect on the relative accuracy.

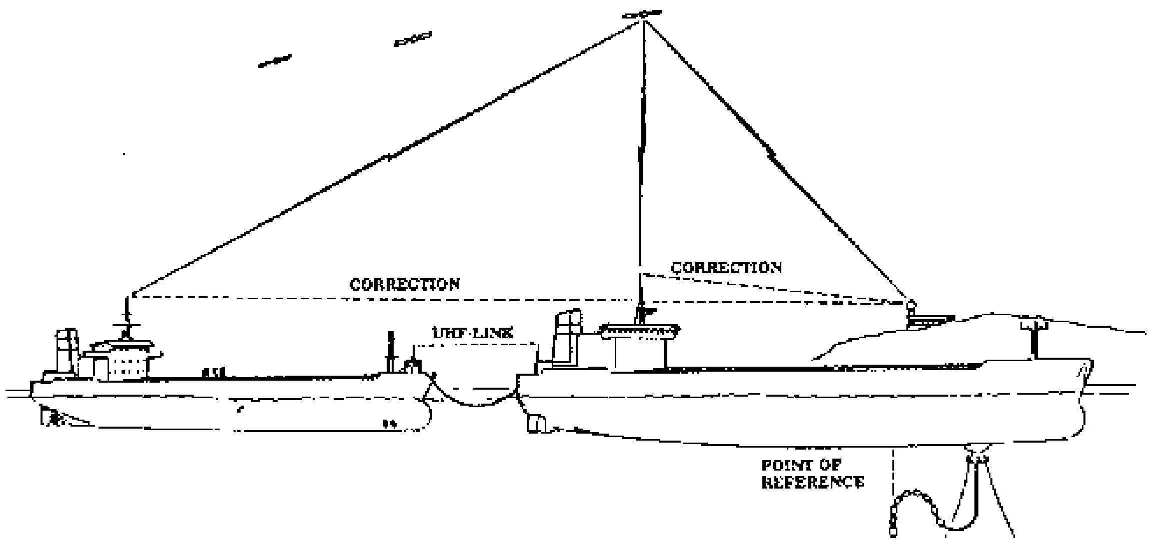

Figure 9. Schematic of DARPS operation.

Installation and Acceptance Testing of Relative Positioning System

In December 1998, a DARPS positioning system was installed on board the C-Empress, an offshore supply vessel based in the Gulf of Mexico. An IALA beacon receiver was used to obtain an absolute DGPS position for transit, electronic charting, and redundancy. The initial acceptance testing took place at a stationary platform off the Louisiana coast (WD-105). The platform system was temporarily installed on WD-105 and the vessel commenced the approach and maneuvering routines. This first test allowed the vessel crew to determine the procedures for acquiring the UHF link and to become familiar with the response of the DP system. The C-Empress maintained a steady position at a distance of 5-10 meters from the platform for approximately 8 hours.

The next test occurred at the URSA TLP while the platform was in transit to a permanent site. The supply vessel approached and established the UHF link at a distance of 10 km. Then, the vessel moved to multiple locations under DP control to test for GPS antenna shadowing and UHF interruption. This test continued over a period of two days and involved equipment and fuel transfer. The C-Empress maintained a steady position in close proximity to the moving platform (Figure 10). The final testing took place after the tension legs were connected to the seafloor with similar success. Both the C-Empress and C-Endeavor, a sister

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ship, maintained a safe, reliable position under DP control while the URSA TLP moved in a lazy figure eight pattern.

Figure 10. The C-Empress transferring fuel to the URSA TLP under DP control.

Conclusion

Advances in GPS positioning technology and the resulting lower costs of the technology have allowed offshore supply vessels to acquire dynamic positioning systems. The flexibility and accuracy of these GPS based DP systems have given the vessels the ability to perform their functions more safely, in higher sea-states, and at multiple loading locations around a moving platform without the use of anchors or acoustic positioning beacons. Futhermore, the GPS based positioning systems have proven to be reliable and robust in a variety of weather conditions in both the Gulf of Mexico and the North Sea.

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