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DYNAMIC POSITIONING CONFERENCE
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SENSORS I SESSION

NASNet® DPR - NASNet® as a deepwater acoustic DP position reference

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Introduction

Recent operations in the Gulf of Mexico around the Macondo well have cast a spotlight on the challenges of carrying out large scale simultaneous operations (SIMOPs). In excess of 15 vessels and rigs have been operating within an area of approximately 1sqkm, many of which also had ROVs deployed and were additionally deploying objects to the seabed using cranes.

The combination of multiple users, relatively deep water and close proximity made both surface and subsea positioning absolutely critical, and highlighted the challenges and limitations of the subsea positioning systems in common use today. Surface positioning is very much dependent on Global Navigation Satellite Systems (GNSS) of which GPS (Global Positioning System) is the current preeminent example.

Although often perceived as ever reliable, GNSS signals are vulnerable to interference with one major source being from charged particles in the earth's atmosphere. During periods of increased sunspot activity a charged stream of solar particles (the solar wind) interacting with the earth's ionosphere can create geomagnetic 'storms' which can affect all radio signals (including those used by GNSS) up to and including complete loss of signal. These effects are often referred to as scintillation, which is a rapid fluctuation in signal phase and amplitude.

Acoustic positioning solutions are therefore a critical component of the DP system, but historically seen as a poor relation to satellite positioning.

The unprecedented scale of operations at Macondo brought the limitations of the acoustic systems in use into sharp focus. These challenges, and their potential solution, will be explained and discussed over the next few pages.

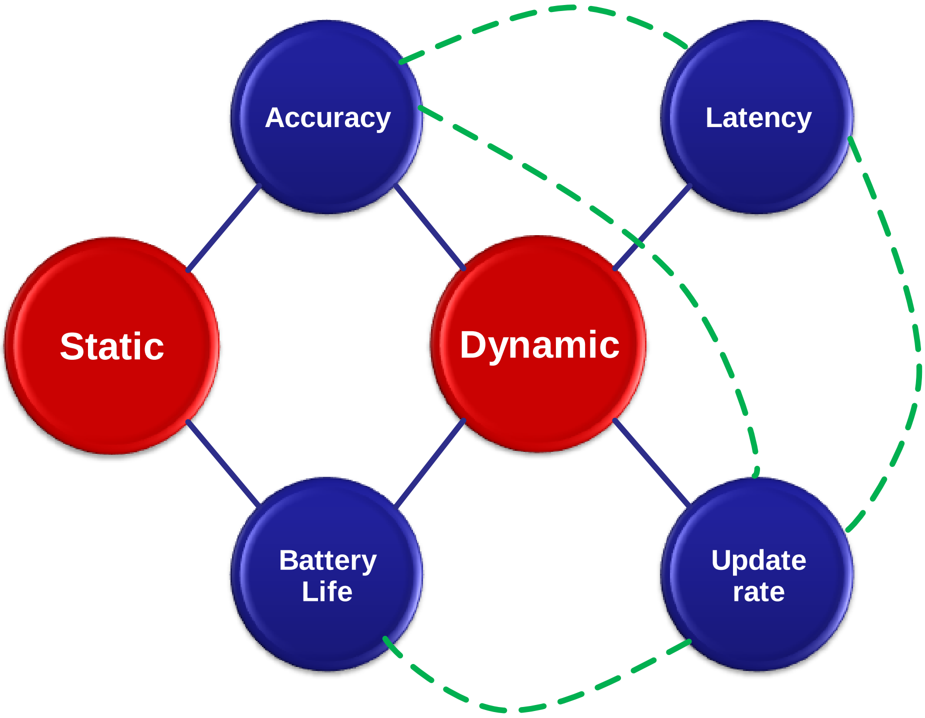

Figure 1 illustrates the main issues to be considered in acoustic positioning. For positioning of a static object the speed of position update and age of position are irrelevant, however for the purpose of a DP position input the positioned vessel is obviously dynamic and therefore all four factors are significant.

As can be seen, there are various links between the factors and so a change in one may well have knock on effects to the others.

Accuracy

Accuracy is often defined as ‘the closeness of the calculated value to the true value’, and is affected by a range of factors.

Acoustic positioning systems are generally divided into the categories of USBL (Ultra Short Baseline), SBL (Short Baseline) or LBL (Long Baseline). The two former categories are vessel based systems using a single reference transponder on the seabed, while LBL requires an array of seabed transponders. The 3 system types are listed in order of increasing accuracy with LBL providing the most accurate positioning in deep water.

Sound velocity is usually the main contributor of errors to acoustic positioning systems. An error in SV will affect the accuracy of the ranges measured by any system and so it is important to measure SV through the water column regularly. With LBL systems all is not lost if there is inaccuracy in the SVP, as the use of ranges from multiple transmitters can be used to reduce the impact of errors in ranges on the final calculated position. The most important contribution to this error mitigation is by array geometry.

For DP purposes geometry is often simplified by the use of a separate array of transponders for each vessel or rig being positioned. This means that the array can be set to provide best geometry for that individual vessel. If using an existing array that has been deployed to also fulfil other purposes the geometry may be more complex and it is important that the combination of transmitters providing the best geometry is selected.

Simply put, good geometry is provided by a reasonable number of transmitters (>5) evenly surrounding the positioned object. Less than 5 transmitters mean that identification of a single incorrect range cannot be carried out reliably, while a biased array provides little or no mitigation against error sources such as sound velocity or depth inaccuracies. The worst case of this would be positioning outside of the array, with all transmitters being on the same side of the vessel. Although this does not guarantee that the position will be inaccurate, it does ensure that if there are errors in the ranges the position will be similarly inaccurate. With good geometry the effect of errors in ranges can cancel themselves out meaning that an accurate position can be derived from inaccurate measurements.

Latency

Latency can be formally defined as the time delay between the moment something is initiated, and the moment one of its effects begins. In acoustic positioning that effectively means the age of the position. A highly accurate conventional LBL system can measure very accurate ranges, and subsequent position, but by the time the position is calculated and used it is typically 4-8 seconds old and the vessel may well have moved.

Latency increases with water depth due to the travel time of the signal from surface to seabed and back again. Latency for conventional LBL systems is also affected by the 'wait window' – a user defined period that the system will wait for range data before calculating a position. This approach means that no ranges are used in the position calculation until (hopefully) all have been received. The value can be adjusted to try and minimise the effect but this requires increased user interaction with the system and can't remove the effects.

Update rate

Update rate is an important factor in positioning, both as a contributor to dynamic accuracy and also as a credibility factor for the DP system. As a side benefit faster (and stable) position updates generally improve the fuel economy of DP vessels with many small adjustments being more economical than few large ones.

Position update rate of typical acoustics systems is generally considerably slower than that from GNSS systems. Traditionally the process of determining a position has been a cyclic process – interrogation, response and calculation of position, then repeat. The time taken to complete a cycle is dependent primarily (for DP purposes) on the water depth, with a typical update being between 4 and 8 seconds.

In a typical run off scenario a vessel or rig can easily achieve a 2 knot velocity. For an acoustic system providing update rates at 8 second interval this equates to an 8m vessel move between updates. The GNSS is updating every second and so the DP system will tend to reject the correct acoustic solution and retain only GPS, making the situation worse if the run off is caused by an issue with the GNSS.

Battery life

Although battery life doesn't directly affect the performance of an acoustic system, practicality dictates that a longer battery life is desirable for both reliability and because of the logistics and time involved in changing units or batteries in deep water.

Physics again has a large say in where advantages can be gained in battery life, with a given amount of energy being required to transmit a certain amount of data a particular distance. This applies regardless of the signaling technique employed. Often, however, much more energy is used than is actually required because of a range of factors; acoustic noise, sub optimal detection methods, and inefficient encoding of signal data.

Most users will err on the side of caution where noise is concerned, tending to set the transmission power to a high value to 'guarantee' reception. One fairly elegant solution to this issue is the continuous monitoring of signal to noise ratio at the receiver. The volume of the transponder can then be automatically adjusted to the most efficient levels via commands from the topside unit. This approach does have limitations though, most notably in multi-user applications. What may work for one receiver may be completely unacceptable to another, due to noise levels, sensitivity etc. Having separate controlling units with their own automatic agenda would be a disaster for the less efficient receiver.

Multiple users are also a challenge to batteries, with most systems being required to respond to additional interrogations if more users are involved, and therefore using a proportionally greater amount of power from the battery pack.

As discussed with regards to update rates, ping stacking can improve the rate of position update but at a cost to the battery life. Ping stacking is effectively increasing the interrogation and subsequent response rate which obviously reduces the life of the battery.

The Solution?

It is apparent that of the various limitations of commonly used acoustic systems, some are imposed by the laws of physics, some are caused by the basic techniques used by the systems, and some are a combination of the two.

NASNet® DPR was developed, in response to demand from the industry, as an application of the proven NASNet® subsea positioning system and uses a fundamentally different approach to other systems to remove a number of the limitations completely, while optimizing those that are constrained by laws of physics.

NASNet® is essentially a long baseline (LBL) acoustic positioning system but the most fundamental improvement over conventional systems is in the method used to measure the ranges from which positions are subsequently calculated. Pulses are transmitted from NASNet® Stations at preset intervals, typically every 4-5 seconds. There is no interrogation of the Station required to prompt a response, unlike conventional systems. This does, however, mean that the time that each signal is transmitted must be known which therefore necessitates synchronization of all units to a common time reference.

The benefits that this approach provides are significant with respect to dynamic accuracy, latency, update rate and, in some circumstances, battery life.

The dynamic accuracy is, as previously discussed, largely linked to latency – the age of the ranges used in the solution, and the age of the solution itself. Use of 1-way ranging removes the majority of latency in the solution in 2 ways. Firstly the range itself is subject to no latency error when received by the positioned object; because the time of reception is timestamped.

The second difference is that, because there is no fixed cycle of interrogation and receive, ranges can be entered into the position solution immediately as they are received, minimizing the latency between measurement of the range and calculation of the position. NASNet® DPR uses each range as soon as it is received, replacing the previous range from the applicable Station, and therefore ensures a more up to date position solution. The other benefit of this approach is that the position is recomputed when any individual range is received, rather than waiting for a complete set of ranges to be received. This has the effect of increasing the frequency of position update significantly. The actual frequency is dependent on both the transmission rate of the Stations, and the number of Stations being used. An example using 5 Stations with a 5 second transmission interval would provide, on average, 1 Hz position updates. The same scenario but using 10 Stations would increase the update rate to 2Hz. This update rate is not only equal to GNSS, but better, meaning the NASNet® acoustic solution can be weighted as heavily as GNSS within the DP system.

As one of the key contributors to positioning accuracy, NASNet® DPR also monitors the geometry of the array being used, using Nautronix GSUP (Geometric Support) indicator. This provides a single percentage value which reflects both the number of ranges and their angles of intersection making the judgment of array geometry intuitive and simple. The system monitors the online solution and warns if poor geometry is experienced, while also providing a predictive indicator when the user is selecting or deselecting ranges from the solution.

It can be seen that the increased update rate over conventional systems is not at the cost of battery life, as each Station is typically only transmitting every 5 seconds. A huge gain over conventional approaches is in the multi-user environment when multiple users are using the same array. Even the latest generation conventional systems require additional interrogations and response for multiple users, and these impact drastically on battery life. By making use of the one way transmission technique multiple users can position from the same array with no increase in demand on the NASNet® Stations, as each pulse can be received and used by an unlimited number of receivers.

Conclusion

NASNet® DPR provides an acoustic solution for DP reference which significantly increases the performance achievable by acoustic positioning systems. NASNet® DPR provides a comparable performance to GNSS positioning, making it the ideal back-up for deepwater DP positioning.