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Sensors

Shared Use of DGPS for DP and Survey Operations

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Background

Differential Global Navigation Satellite Systems (DGNSS) such as Differential GPS (DGPS) and GLONASS (DGLONASS) are acknowledged as global standards for precise positioning and navigation and are used extensively within dynamic positioning (DP) systems to guide vessels involved in offshore survey and construction operations. Before this, DP vessels would typically use radio-navigation systems provided and operated by a survey-positioning company. These were normally installed for the duration of a particular contract or project. The survey-positioning company retained full responsibility for the system, which would be used for both survey and DP requirements.

The operational straightforwardness of DGNSS has led to its permanent installation and widespread use aboard DP vessels without input from surveyors. This has given vessel operators significant autonomy regarding the positioning of their vessels. When survey services are required on board, the survey contractor is often asked to make use of the DGNSS system permanently installed on the vessel. Whilst usually convenient this can present potential operational problems relating to the control and performance of the system. There is also potential for contractual disputes to arise in any situation where the survey user and the DP user are different companies and where installation, manipulation or reconfiguration of the positioning system for either survey or DP use may impact on the performance of the system for the other party.

It is therefore critical from both safety and operational perspectives that full co-operation is exercised between these two users. To ascertain how this might be facilitated it is first important to understand some basic definitions along with the requirements of both the surveyor and DP operator, which can be quite different. A number of industry guidelines have been produced covering the use of DGNSS for offshore survey applications [1] and also DP operations.

MEASURES OF POSITION QUALITY AND IMPACTING FACTORS

Industry Guidelines

There are a number of terms used for assessing positioning quality, however the most useful are defined in the UKOOA Guidelines [1], which states that position quality can be defined in terms of precision and reliability. UKOOA recommends two measures to represent this:

PRECISION - 95% A Posteriori Horizontal Error Ellipse

A measure of precision, this defines an ellipse giving an approximation of horizontal precision in all directions with a probability of 95% as demonstrated in Figure 1.

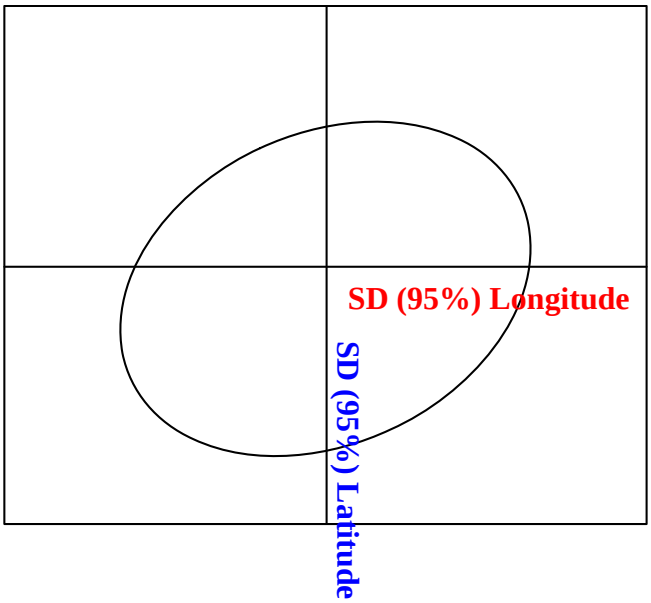

Figure 1 - Error Ellipse – Defines the area within which it is 95% probable that the true position lies

RELIABILITY - External Reliability

Position fix reliability can be considered as the ability to detect errors in the final solution. A marginal detectable error or MDE is the smallest error that can be detected with a certain level of probability. The smaller the error that can be detected the more reliable the fix is said to be. Considering this from the perspective of the fundamental measurement in GNSS, a range, this is referred to as Internal Reliability. More useful is the knowledge of what impact an undetected range error will have on the position. Translation of an undetected range error into its effect on horizontal position is referred to as External Reliability.

Precision & Accuracy

Precision and accuracy are two completely different values and it is essential that the difference between them is understood. The measures of precision and reliability above relate to the particular performance of each individual position calculation. Let us now consider the behavior of consecutive positions over time. If position was measured by a perfect system, then the co-ordinates would not only be correct but would not vary at all over time – the position would be said to be accurate and precise. Accuracy can therefore be defined as the degree of closeness or conformity of the position to its true value – inaccuracy in position appears as a bias or offset from its true value.

Precision is the degree of repeatability or closeness that successive positions display – high-precision appears as low dispersion whilst low precision appears as high dispersion. Both of these attributes can be seen in Figure 2.

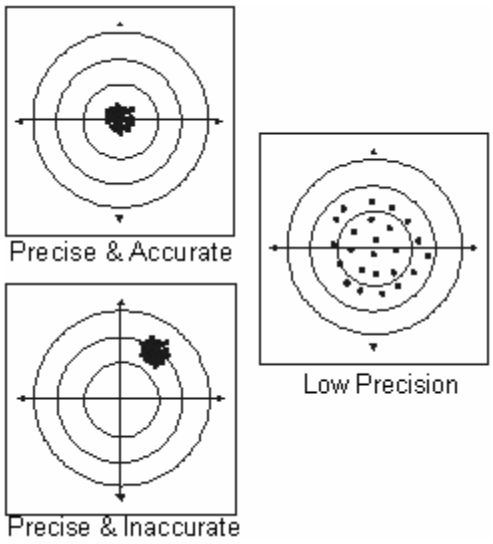

Figure 2 - Measures of Dispersion

Factors Impacting Precision

Factors that will directly impact position precision include:

i. Increased age of DGNSS corrections
ii. Interruption to satellite tracking e.g. multi-path or obstructions to local antennas such as when working close to platforms
iii. Radio-frequency Interference
iv. Ionospheric scintillation
v. Loss of DGNSS correction data through failed reference station or correction link
vi. Specification of equipment used
vii. Quality of installation
viii. Adjustments to GPS network performance by US DoD such as jamming or Selective Availability (SA)

Factors Impacting Accuracy

Factors that will directly impact position accuracy include:

i. Change of satellite geometry through
- Elevation mask
- Satellite Masking
- Satellite de-selection
- Changing constellation availability

ii. Change of reference station or reference station combination used
iii. Ionospheric activity causing failure of differential process to cancel Ionospheric delays
iv. Conflicting geodetic datum selection
v. Local multi-path e.g.
- Working close to structure / platform

- Crane movements

vi. Helicopter operations

vii. Adjustments to GPS network performance by US DoD such as jamming or Selective Availability (SA)

System Redundancy

The notion of multiple DGPS systems providing full redundancy and system independence is not necessarily correct as there will always be the common element that is the GPS satellites. However, it is generally felt that GPS in itself has a very large degree of redundancy in the number of satellites available and their capability to operate autonomously from the GPS ground segment for extended periods. To increase satellite availability some service providers have added access to the GLONASS satellite network . Further augmentation may be achieved through use of ranging signals provided by Inmarsat communication satellites such as that used in the WAAS and EGNOS systems .

Transmissions from satellites are generally in the microwave band and therefore the signals require line of sight – if clear visibility between receiving antenna and satellite does not exist then no measurement is possible. Often DP vessels will work close to obscuring structures such as platforms and therefore, it is imperative that consideration be made whether two independent DGNSS systems can provide the level of precision and accuracy required.

Redundancy of Delivery Links

To achieve acceptable levels of redundancy in a DGNSS solution the user must consider the use of at least two completely independent differential correction links. Normally this is achieved by use of one of the following options:

- Two or more satellite based links
- Two or more terrestrial radio links
- Combination of satellite and terrestrial links

Note that if satellite links only are used, the satellites should be located in different segments of the sky to avoid common masking.

Redundancy of Hardware

In general, appropriate levels of spare hardware, either installed or in storage, are maintained on the vessel for each DGNSS position solution supplying the DP system.

USE OF DGNSS FOR SURVEY AND DP OPERATIONS

Requirements for DP Operations

Both precision and accuracy are important for DP operations. However, precision is the most important parameter for station keeping. The main requirement of a DP position reference therefore is to provide a reliable and stable position solution.

DP operations require instantaneous solutions whose validity and quality can be assessed immediately such that action can be taken without hesitation which requires a user-friendly system.

Requirements for Survey Operations

Survey requires both absolute accuracy and precision. In general, survey activities will involve data logging and subsequent review and post-processing. A high degree of knowledge of position quality and reliability is also required. This is usually achieved by the use and comparison of independent position solutions and complex statistical analysis of the position derivation processes. Additionally, raw GPS observation and correction data may be logged to permit post-processing of the position fix as required.

Shared Use of DGNSS

Generally, the data provided by a DGNSS service operator will be categorized by the type of delivery mechanism and by the level of position accuracy it can provide. Consideration should always be given to the performance specification of the system being shared and whether or not it will meet the requirements of the sharing party as outlined above.

The available level of service and technical support for any shared DGNSS system should be considered by the sharing party for its requirements. For example some systems may not possess essential characteristics such as 24-hour support, ready access to station information and infrastructure redundancy. Survey orientated systems normally include additional features relating to quality control such as broadcast integrity information, a higher level of onshore support and comprehensive performance monitoring and analysis software.

Risks of Sharing Correction Signal

There is no inherent risk in sharing a differential correction signal provided that the system meets the technical requirements of each sharing party.

Risks of Sharing Hardware

There is a risk associated with the sharing of GNSS and DGNSS hardware.

For example consider a vessel permanently fitted with a DGPS system which is being utilised for both survey-positioning and DP operations. If one user makes changes to the system such as reference station selection or change of GPS configuration during operations, there is a risk that the resultant position solution will not be appropriate for the other user’s application.

A detailed assessment of the risk of sharing hardware and its impact is should be conducted and example of which is included in Appendix 1.

Hardware includes the following:

i. Receiving RF antennae
   - Inmarsat tracking antennas
   - Omni-directional L-band antennas (Correction services and GNSS reception)

ii. Signal demodulators

iii. GNSS receivers

iv. Position processing / QC software
v. Interfacing peripherals

Clearly, when hardware is shared, there is potential for one user to adversely impact the other, which may result in degradation of the positioning solution for one party.

Conclusions

In conclusion:

- The use of the same DGNSS correction signal on a single vessel for different applications should not present operational issues.
- There is a risk associated with sharing of GNSS and DGNSS hardware

When considering sharing use of a DGNSS system between DP and survey operations the following is recommended:

i. The importance of carrying out a rigorous and comprehensive risk assessment cannot be over emphasised. This should be carried out as soon as practicable before mobilisation and should, as a minimum, address the potential hazards of sharing hardware as listed in the attached example in Appendix 2. Participants in the risk assessment should include the DGNSS service provider and personnel experienced in DP and survey operations.

ii. Implement any training requirements identified during the risk assessment process.

iii. Procedures should be produced and implemented, which mitigate all identified risks, and which should include:
    - System configuration
    - A communications plan
    - Definition of responsibilities
    - Change management process to cover modifications of system installation and settings
    - Contingencies

iv. A toolbox talk should be completed by DP and survey personnel on the vessel before installation and should address all procedures and methods.

v. All parties involved in using the systems should possess appropriate levels of competency as defined by associated recommendations and guidelines e.g. Reference2.

References

[1] UKOOA Recommendations for Use of DGPS Offshore

Operation	***Hazard***	***Possible Consequence***	***Controls to Reduce Risk***
Sharing DGPS systems in general	System inadequate for survey requirements	Position solution unacceptable for Survey purposes: - Client specifications not met. - Undetected erroneous positioning	Identify an alternative acceptable system
	Lack of access to hardware and connections on arrival onboard vessel.	Prolonged mobilization resulting in project delay.	Agree configuration and interfacing diagram in advance of mobilization between all parties concerned.
	Lack of or access to required raw data in event of project specific logging requirements.	Client specifications not met. Effective survey operations not achievable	Review specifications with survey contractor prior to mobilization and agree an appropriate solution.
	Lack of clear responsibilities for operation and maintenance of DGPS system	Positioning system failure resulting in: DP run-off, vessel down time, Project delays	Sharing parties agree responsibilities for operation of DGPS systems and define clearly in operational procedures and contractual terms
	Loss of Power	Loss or degradation of positioning	Use UPS systems as effectively as possible
Shared differential signal reception antennas	Damage to signal cables sharing a common routing between antennae and hardware	Loss of position inputs to DP and survey operations - Potential DP run off - Vessel down time - Project delays	Assess impact of any increased risk or damage by using shared equipment. Consider alternative routing or antenna arrangements. Consider independent hardware
Shared differential signal reception antennas cont…	When using vessel Inmarsat terminals, vessel requires access to a different communications satellite to that required by survey team.	No survey positioning or Survey Positioning out of specification	Review requirements with survey contractor prior to mobilisation and agree an appropriate solution.
	Degradation of signal due to splitting signals from a single antenna	Reduced signal reliability and loss of correction service: - Positioning out of Specification - DP run-off - Damaged vessel communications and positioning equipment	- Use of appropriate coupling components - Split signal to a maximum of 2 demodulators (assuming appropriate buffering) - Minimize the length of any interconnecting cables

Operation	***Hazard***	***Possible Consequence***	***Controls to Reduce Risk***
	Masking of satellite dome	Loss of DGPS positioning leading to: - - Inability of survey to operate - Reduction of DP position reference options	Review requirements with survey contractor prior to mobilization and agree an appropriate solution such as an independent DGPS correction delivery system, additional hardware or alternative positioning solution
Shared signal demodulator	Inappropriate electrical interfacing	Loss of or unreliable correction data: - Positioning out of specification - DP run-off - Damaged vessel communications and positioning equipment	Agree configuration and interfacing in advance of mobilization between all parties concerned.
	Long cable runs from bridge to survey room	Loss of or unreliable correction data: - Positioning out of specification - DP run-off	Agree configuration and interfacing in advance of mobilization between all parties concerned.
	Differing reference station output requirements	No survey positioning or Survey Positioning out of specification	Consider additional demodulator equipment to allow autonomous reference station selection for survey
Shared signal demodulator cont…	Differing output data rate requirements	Loss or degradation of DGPS positioning leading to Inability of survey to operate - Loss of positioning or positioning out of specification - Signal strength reduction due to use of inappropriate splitters leading to poor satellite tracking especially for low elevation satellites and during periods of heightened ionospheric activity. Outcome being reduced position performance	Consider independent demodulator to allow autonomous system configuration to meet survey requirements
Shared GPS Hardware	GPS antenna type and location unsuitable for survey applications	Loss of or unreliable GPS reception:	Consider independent GPS Hardware

Operation	***Hazard***	***Possible Consequence***	***Controls to Reduce Risk***
	Long GPS antenna cable runs to survey room.		
Shared GPS Hardware cont…	Differing configuration requirements for DP and survey operations	Degraded survey positioning performance due to incompatible setting of:- - Elevation mask - Satellite de-selection - Data telegram output parameters - Communication parameters - Height Aiding - Reference station selection - Geodetic configuration - Position filters - Processing parameters	Consider independent GPS hardware or QC system, permitting configuration of equipment to meet individual user requirements
	Automatic remote control and configuration of GPS receiver by external equipment or software e.g. multi-ref or DGPS QC software	Positioning system failure resulting in: - Potential DP run off - Vessel down time - Project delays	Implement appropriate controls to protect DP configuration. Consider independent GPS hardware.
Shared QC / Multi-Ref Software	Inappropriately configured for survey requirements	- Inadequate QC information - Positioning outside client specification	Mobilize independent software, permitting configuration of software to meet individual user requirements