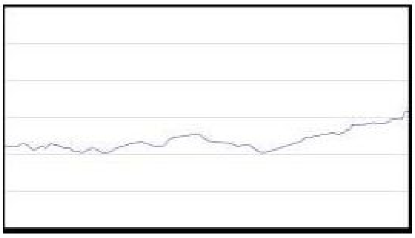
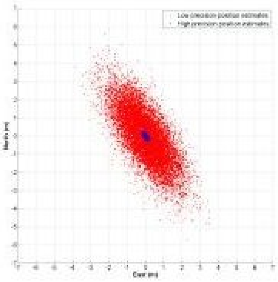
A JOINT OGP & IMCA REVISION OF THE 1994 UKOOA GUIDELINES

Guidelines for GNSS Â-Positioning





The original UKOOA Guidelines for the use of differential GPS in offshore surveying, published in 1994, were widely used within the offshore survey industry. In 2005, the International Oil & Gas Producers Association (OGP) took over the custodianship of the guidelines from Oil & Gas UK (formerly UKOOA). At that time it was recognised that the original guidelines needed updating in order to reflect the rapid technical advances in satellite navigation technology of recent years and to maintain the purpose and relevance of the original guidelines. OGP and the International Marine Contractors Association (IMCA) agreed to work together on the revision.

In late 2008 a joint workgroup was formed, comprising OGP and IMCA members and representatives from the main offshore seismic survey contractors. A scope of work was agreed and the revision commenced in April 2009. Through a series of meetings and virtual conferences the workgroup completed the update of the document towards the end of 2010.

The revised document, published jointly by OGP's Geomatics Committee and IMCA's Offshore Survey Division Management Committee, supersedes the 1994 UKOOA guidelines. To reflect updated practice, the new document is entitled *Guidelines for GNSS Positioning in the Oil & Gas Industry*.

The document provides guidelines for the use of global navigation satellite systems (GNSS) for positioning and surveying during oil & gas exploration and production, renewable energy operations, pipe and cable land-fall operations, and coast management & engineering. It presents an overview of recommended principles for reliable positioning, and some suggested minimum statistical testing and quality measures. Although primarily aimed at E&P related surveying and positioning activities, the principles and recommendations are equally valid for any similar activities where precise position is critical for surveys and positioning tasks associated with, for example, renewable energy plants, pipe and cable land-fall operations, coastal management and engineering.

The Revised Guidelines

Today, satellite-based positioning is a key positioning technology used in both land-based and offshore operations. Indeed, it has been recently estimated that in some countries up to 6-7% of Gross Domestic Product (GDP) may be dependent on satellite-based positioning. This article provides a brief summary of the whole document, which can be downloaded free from www.ogp.org.uk or www.imca-int.com. Others, including training providers, libraries or other groups or individuals wishing to purchase printed copies can do so through the IMCA website.

The main sections of the revised guidelines are arranged in the sequence that would occur during the positioning task.

- The introduction covers the background and describes the various forms of satellite positioning and services available, some of the factors to be considered when selecting positioning systems and considerations for good practice in the design and planning of positioning operations.
- The section on installation and operation outlines the preparatory work, geodetic aspects and the various considerations relating to the installation and setup of satellite-based positioning systems.
- A key section on quality measures describes the main errors affecting GNSS-based positioning and their detection and mitigation. The underlying statistics and quality assessment methods are described in order to provide a general understanding of the methods used to identify, isolate and remove errors.
- A section on competence provides guidance on the competences necessary for personnel operating satellite-based positioning systems.
- A section on data formats briefly describes GNSS receiver data output formats and some commonly used positioning data exchange formats.

- An appendix provides a mathematical treatment of position estimation and quality control.

Installation and Operation

The main factors influencing positioning performance are discussed here. These include preparation, installation and commissioning of satellite-based positioning systems, and a brief summary of geodetic aspects.

Item	Comment	Risk Probability	Risk Severity	Possible Mitigation Measures
Communication satellite	Some service providers offer (on a commercial basis) a choice of broadcast satellites or a 'back-up' satellite covering the same world region. Communication satellite failure is rare	Low	High	• Plan a back-up alternative with the same service provider • Use a different satellite data link • Use a different data link technology
GNSS reference stations	Most service providers maintain at least two 'hubs' with redundant equipment on 'hot' standby and automatic re-routing in the unlikely event of total failure	Low	Low	Discuss with service provider to establish whether there is a single point of failure
PPP solutions	These solutions do not depend on reference stations per se but on a globally integrated network of GNSS tracking stations. These networks are particularly robust and can suffer circa 20% failure before any effect on accuracy is discernible	Low	Low	Ensure there is no single point of failure
Position solution software corrections receiver	If the software comes from a reputable supplier, the chances of errors are very low. However, software can become corrupted	Low	Moderate	• Have a standby package. • Include an independent, e.g. QC processing package • Carry spare system(s) • Have two receiver systems operational

				at all times
GNSS receiver	Stand-alone GNSS receivers can fail or become damaged	Moderate	Moderate	Have at least two systems running at all times. Include an independent, e.g. QC processing package
Installation	The most common single points of failure causes are related to installation	High	Moderate	• Follow correct installation and checking procedures. • Install dual independent and redundant systems

There is discussion of installation and operation of GNSS equipment, including specification, required accuracy and redundancy, level of support from service providers, the influence of geographical location and atmospheric effects (see Figure 1). There are also some useful tables on GNSS positioning failure modes and how to manage the risk of failure – see Table 1.

Consideration is given to positioning different kinds of installations, ranging from static base stations through Mobile Offshore Drilling Units (MODUs) and offshore vessels, to land-based vehicles and aircraft. The importance of antenna mounting locations and multipath is covered, as are some specific challenges inherent to positioning in each case. For example, the signal masking that may arise when an offshore vessel is in close proximity to an obstructing structure, or the temporary shielding of antennas caused by the high dynamic movement of small boats is explained. With regard to airborne activities, special attention is drawn to the importance of the vertical component and the relatively high data rates and high 3D accuracy that will be required to maintain positioning integrity and the space and weight restrictions in aircraft that will limit the equipment that can be carried.

Quality Measures

Quality measures are, in a sense, the heart of the document. The revised document contains a detailed section on this subject which describes the types of errors affecting GNSS-based positioning, and their detection and mitigation while remaining operational and within the desired performance levels. Statistics and quality assessment methods are described in order to give the reader a general understanding of the methods used to identify, isolate and remove errors from the positioning calculation. This key section does not provide an in-depth discourse on statistics and numerical testing, but it is supported by an appropriate technical appendix. There is a general non-mathematical review of tests and measures that must take place during position estimation from GNSS data, including

- precision measures;
- reliability measures;
- accuracy;
- statistical testing.

The section on statistical tests and quality measures provides the necessary statistical background to the understanding of the chosen quality measures and gives specific guidelines for their use and concludes with a recommendation that two quality measures be implemented for all offshore GNSS activities, namely:

- the 2D error ellipse or 3D error ellipsoid as a precision measure (see Figure 2);
- the largest horizontal position vector resulting from a marginally detectable error as a measure of external reliability.

Recommendations

The key recommendation is that test statistics and quality measures used for quality control of GNSS-based positioning should be based on the principle of least squares and upon the so-called ‘Delft method’ of quality assessment. The recommended test statistics are the w-test used to detect outliers and the F-test (unit variance test) used to verify the model.

The Future

The revised GNSS guidelines should provide a thorough grounding in GNSS positioning for surveyors, managers, operators, contractors and training providers, and hopefully will be as widely used and respected as the previous document. The recent rapid technical advances in GNSS technology have been measurable even during the review period. Further update and revision of this document is therefore more than likely. Ownership of the document remains with OGP, and it is anticipated that OGP’s Geomatics Committee will continue its collaboration with IMCA in any future revision and dissemination of this document.

Acknowledgements

OGP and IMCA wish to thank the workgroup of industry professionals who prepared this revision between 2008 and early 2011.

Measures	**Effect**	**Recommended Value**
Level of significance	• Probability of rejecting a valid observation • Size of internal and external reliability measures	1%
Detection power	• Probability of rejecting an invalid observation • Size of internal and external reliability measures	80%
F- test	Acceptance or rejection criterion (unit variance) for full functional and stochastic model	n/a
Critical value w-test	Acceptance or rejection criterion for a single observation	2.576 (99%)
Multiplication factor, 1D	Scale standard error ellipse to desired confidence region	1.960 (95% region)
Multiplication factor, 2D	Scale standard error ellipse to desired confidence region	2.448 (95% region)
Multiplication factor, 3D	Scale standard error ellipsoid to desired confidence region	2.796 (95% region)
Ratio major and minor axis	Isotropy of 2D solution	< 2*
Marginally detectable error (MDE)	Effect on 3D position of the minimum error that can just be detected in an observation with a given level of significance and detection power	n/a
*under normal operating conditions, dependent upon geographic location		

More Information

- C.D. de Jong, G Lachapelle, S Skone, IA Elema, 2002. Hydrography, VSSD, ISBN 978-90-407-2359-9
- A. Leick, 2003. GPS satellite surveying. Wiley, ISBN 978-0471059301