OCTANS Subsea

User Guide

I Part 1: Introduction

IXSEA
AN IXBLUE COMPANY

Table of Contents

I.1 Object

This document is the introduction to the User Guide for the OCTANS Subsea Gyrocompass and Motion Sensor manufactured by iXSea.
This part describes the OCTANS 3000 technology and provides all details on OCTANS export regulation, warranty, customer support and contacts at iXSea.

I.2 Terminology

FOG	Fiber Optical Gyroscope
GPS	Global Positioning System
IMU	Inertial Measurement Unit
NA	Not Applicable
TBD	To Be Defined
WGS-84	World Geodetic System 1984

I.3 How to Use this Guide

I.3.1 TEXT USAGE

Bold	Bold text is used for items you must select or click in the software. It is also used for the field names used into the dialog box.
`Courier`	Text in this font denotes text or characters that you should enter from the keyboard, the proper names of disk Drives, paths, directories, programs, functions, filenames and extensions.
italic	Italic text is the result of an action in the procedures.

I.3.2 ICONS

The **Note** icon indicates that the following information is of interest to the operator and should be read.

THE **CAUTION** ICON INDICATES THAT THE FOLLOWING STATEMENT/CONDITION/PROCEDURE MUST BE READ AND OBSERVED IN ORDER TO PREVENT PARTIAL DAMAGE TO COMPLETE DESTRUCTION OF THE PRODUCT.

THE **WARNING** ICON INDICATES THAT THE FOLLOWING STATEMENT/CONDITION/PROCEDURE MUST BE STRICTLY OBSERVED IN ORDER TO PREVENT POSSIBLE INJURY OR DEATH OF PERSONNEL.

I.4 OCTANS Subsea Technology

I.4.1 OCTANS SUBSEA SYSTEM OVERVIEW

OCTANS is both a fiber-optic survey-grade IMO-certified gyrocompass and a Motion Reference Unit for marine applications. OCTANS 3000 provides true heading, roll, pitch, yaw, heave, surge, sway, rates of turn and accelerations even in highly volatile environments. The core of OCTANS is a compact strap-down Inertial Measurement Unit (IMU), which contains three accelerometers, three Fiber Optic Gyroscopes (FOG), and a real-time computer.

The fiber optic gyroscope is a recent technology generated to meet the requirements of the aeronautical industry. It is totally inert, has no moving parts, and requires neither maintenance nor recalibration. It provides a very wide dynamic range and can tolerate extremely demanding mechanical environments without compromise to its performances.

OCTANS benefits from the fiber-optic gyroscope technology and therefore shares the advantages of not requiring maintenance nor recalibration. Its strap-down IMU structure enables plug-and-play installation together with straightforward use, with which no traditional mechanical gyrocompass can compete. Light in water (4.65 kg) and compact, OCTANS is insensitive to physical shock, can be carried in a case, and is easy to install. Strap-down equation processing enables the system to find North in less than 5 minutes whatever the sea conditions. Notably, it can be powered up at sea, which is impossible with a conventional gyrocompass.

In addition, OCTANS consumes only a small amount of power and directly outputs binary data to NMEA 0183 standard.

I.4.2 OCTANS PHYSICAL PRINCIPLES

OCTANS is a strap-down IMU that contains three fiber optic gyroscopes (FOGs) - 0.05°/hour accuracy class, three milli-g accelerometers, and a real-time DSP computer.

I.4.2.1 Fiber Optic Gyroscopes (FOG) Technology

FOGs do not use the rapidly spinning top employed in mechanical gyroscopes – in fact, they have no moving parts at all. They do not use the gyroscope effect to measure the rotational speeds of mobiles, but a different physical phenomenon – the so-called “Sagnac Effect”.

The Sagnac Effect

The Sagnac Effect is a physical phenomenon of relativistic type. Understanding it requires a good grasp of Special Relativity. However, it is possible to provide a simplified (although inaccurate) physical interpretation of the effect. Imagine a coil of optical fiber. Optical fiber, as is well known, is a good vector for the propagation of light. This coil will in principle have two exits at the two ends of the fiber. If we inject a light pulse into one end, it will come out at the other after a duration equal to the time the light takes to travel through the entire length of the coiled fiber. If we now inject two pulses simultaneously into the two ends of the coil, they will travel in opposite directions, pass each other in the middle and come out at opposite ends of the coil. The time to travel through the coil will be the same irrespective of the direction of travel, and the two pulses will therefore exit the fiber at the same time. If we now imagine that the coil is rotating around its central axis, this movement will “help” one pulse but “hold back” the other. It can be seen therefore that the two pulses will leave the coil at different times. The rotation speed of the coil is assessed through the measurement of this time shift.

FOG description and performance

This time (or phase) shift is measured in optics through interferometry. The interferometer is created by “closing” the coil on itself using an opto-electronic component called an “Integrated Optical Circuit” (see Figure I.1).

A dedicated signal processing, allows to converts the information on optical phase, carrying information on rotation, into a digital signal useable by a calculator.

Figure I.1 - The core of a FOG (i.e., the optical fibre coil with its integrated optical circuit)

FOG performance gets better as FOG dimensions get larger. For example, increased fiber length will translate into a larger time shift between waves for a given rotation speed.

FOG performance can be measured in terms of many parameters. One of the most relevant is known as bias stability, which means the stability of the zero point, or the intrinsic accuracy of the measurement of rotational movement. Bias stability are usually given in degrees per hour (deg/hour), to be directly compared to Earth's rotation rate, which is 15 deg/hour. The bias stability of FOG used in OCTANS is 0.05 degree per hour.

I.4.2.2 Inertial Measurement Unit (IMU)

Actually, a single FOG measures the projection of the instantaneous rotation along the main axis of its coil, and three FOGs are necessary to measure the rotation rate vector for the coil.

This triad of gyroscopes is usually combined with a set of three accelerometers. An accelerometer enables measurement first of the instantaneous acceleration along a given axis (and thereby, through successive integrations, speed and position), and second, knowledge of apparent local gravity, and thereby the local vertical axis.

FOG Gyrocompass : Underlying Principles

By definition, a gyrocompass is a gyroscope-based system for the measurement of true heading, that is to say, angular measurement of a position in relation to geographical North, whatever the movements made by the object on which the gyrocompass is located. This means for example, that the gyrocompass must remain relatively insensitive to pitch and roll movements, which may be at high levels on some ships. In this way, the gyrocompass is to be distinguished from North finders, which need to remain totally immobile in relation to the Earth when the measurement is performed.

North finders

We can begin by assuming that our initial objective is to produce a "static" indicator of North, that is to say, an indicator without any mechanical system (which means that we cannot rotate a single horizontal-axis gyro in order to find the position which cancels out the signal, which will correspond to the East). In order to measure the rotation vector of the Earth $\boldsymbol{\Omega}$, the first thing we need is three gyros for the three spatial axes. However, that is not enough yet to indicate a heading, because we lack information on the horizontality of the assembly. This information can be obtained through measurement of the local gravity vector $\mathbf{g}$ using either a plumb line, electrolytic levels or accelerometers. By projecting the Earth rotation vector $\boldsymbol{\Omega}$ onto the horizontal plane orthogonal to $\mathbf{g}$, the direction of geographical North is obtained (see Figure I.2). The intrinsic accuracy of this measurement depends on the accuracy of the sensors (the bias of the gyros b_{gyro} and of the accelerometers b_{acc} for example) and on the latitude L. It can be expressed in radians as:

$$\Delta\Phi = \frac{b_{gyro}}{\Omega}\,\mathrm{Sec\ L} + \frac{b_{acc}}{g}\,\tan \mathrm{L}$$

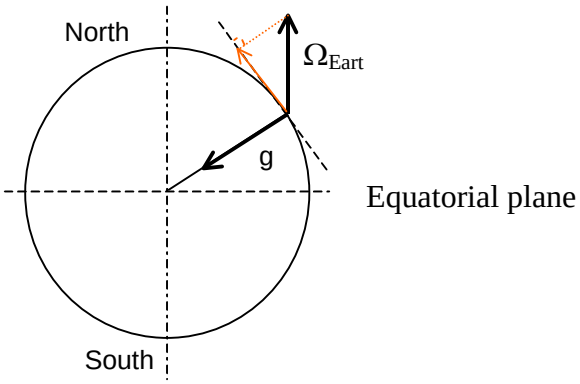

Figure I.2 - North Finder / basic concept

To achieve a North finder capable of rivaling commercially available conventional gyrocompasses, accurate to a few tenths of a degree of the secant of the latitude, it is necessary to select gyros offering accuracy to at least one-hundredth of terrestrial rotation rate (15 °/h), such as the FOG 90 (0.05°/h) produced at iXSea, and accelerometers precise to one-hundredth of apparent gravity. In practice, the accelerometers used in OCTANS provide better performance than this in order to improve dynamic stability.

Gyrocompass

The gyrocompass represents a step up from the above in terms of complexity. At this level, the system has to withstand random movements – which may be violent, such as a ship's pitch and roll. The difficulty is twofold compared with the previous design : first, measurement of terrestrial rotation is disturbed by enormously high rotational values (several orders of magnitude greater than the Earth's rotation rate), and second, measurement of gravity is disturbed by centrifugal accelerations which may also prove to be relatively high.

The basic idea is therefore to abandon the direct use of the measurement of the Earth's rotation rate related to the gyroscopic frame, in favor of a "fixed" reference frame, which is called the Inertial Space.

Described briefly, the system comprises three gyros and three accelerometers: the three gyros enable the rotation rate of the moving object to be measured at any given instant (including the Earth's rotation rate), and the three accelerometers give the sum of the acceleration and apparent gravity. These measurements are both related to a reference bound to the moving object itself. The angular attitude of the moving object compared to the Inertial space is then computed by integration of the rotation rate. The accelerometer data, which is the sum of the acceleration and gravity, is then expressed within the Inertial Space. After filtering out the acceleration values, it is possible to "observe" the slow drift of apparent gravity due to the rotation of the Earth. In fact, it is easy to show that the apparent gravity expressed within the Inertial Space defines a cone whose main axis is the rotational axis of the Earth (see Figure I.3). Examination of the movement of **g** can therefore tell us where geographical North is without need of an external reference.

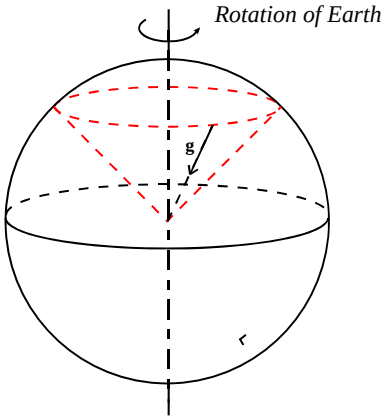

Figure I.3 - Conical movement of the local gravity g in relation to the Inertial Space

Conclusion

The compact assembly formed by the three gyroscopes and the three accelerometers is called an “Inertial Measurement Unit” (IMU) and forms the heart of any inertial reference system. When an IMU is coupled to a calculator and an interface, the result is an “inertial reference system”.

OCTANS is such an inertial reference system capable of providing complete information on the physical attitude of the mobile. The IMU comprises three FOGs (0.05 deg/hour bias stability) and three accelerometers (± 500µg).

But OCTANS does not allow access to the raw data of its IMU heart to comply with export regulations (see section I.5).

I.5 Export Regulation

This product is classified as a dual-use good: it has been developed for non-military use, but could be used for military applications.

As a consequence, this product is subject to dual-use goods export control procedures:

- iXSea can deliver this product freely to France or any other country of the European Union;
- iXSea can export this product under its own Community General Export Authorization EU 001 to the following countries: Australia, Canada, USA, Japan, New-Zealand, Norway and Switzerland;
- iXSea can also export this product to other countries but only through the issuance of an individual export license by the French authorities.

Once in its country of first destination:

- From a country member of European Union, this product is free of movement (travel) as long as it remains within the European Union;
- From a country member of European Union, this product can only be re-exported to a non European Union member country under the dual-use goods export control procedures set forth by the national authorities;
- From another country, this product can only be re-exported under both the conditions of the original export license from France (depending on its type and content) and the dual-use goods export control procedures set forth by the national authorities.

If an individual export license has to be issued by the French authorities, iXSea requires you to provide as needed a description of your usual activity (and the one of the end-user if different) and the end-user to fill out an end-user certificate which includes:

- The description of the intended application of the product
- A commitment not to re-export the product (without applying for an export license to the competent national authorities as set above).

This product cannot be exported or re-exported to Cuba, Syria, North Korea, Libya, Sudan and Iran.

I.6 Verification of Pack Contents

You will find in the shipping case a Packing List detailing all the items delivered. This Packing List has been completed and checked by iXSea shortly before shipment, and should match the contents of the pack you have received.

However, **we recommend that you check the contents of the pack and the equipment immediately on receipt of your OCTANS unit**. Specifically, you should check that all the items referred to above are present on delivery and that none has sustained damage.

If you observe any non-conformity or damage, please inform the carrier and iXSea without delay by certified mail, describing in detail the problem encountered.

I.7 Warranty

iXSea provides a standard warranty of one (1) year covering this product against any defect in materials or manufacture. The warranty starts from the date of shipment of the product from iXSea's manufacturing premises to customer's location and its duration is indicated in the certificate of warranty delivered with the product. In the event that a defect in materials or manufacture becomes obvious during the stipulated warranty period, iXSea will undertake, at its sole discretion, either to repair the defective product, bearing the cost of all parts and labor, or to replace it with an identical product.

In order to avail itself of this warranty, Customer must notify iXSea of the defect before expiry of the warranty period and take all steps necessary to enable iXSea to proceed. Customer shall be responsible for the packaging and the shipment of the defective product to the repair center notified by iXSea, the cost of such shipment being borne by Customer. iXSea agrees to bear the cost of return freight, based on CPT (Cost Paid To) Customer's airport location, import tax-free.

This warranty shall not be construed as covering defects, malfunctions or damages caused by improper use or inadequate maintenance of the product. Under no circumstances shall iXSea be due to provide repair or replacement under this warranty in order a) to repair damage caused by work done by any person not representing iXSea for the installation, repair or maintenance of the product ; b) to repair damage caused by improper use or connection to incompatible equipment, and specifically, the opening of the housing of the equipment under warranty shall cause the warranty to be automatically cancelled ; c) to maintain any product that has been modified or integrated into a larger configuration, if such modification or integration increases the duration or difficulty of the maintenance of said product.

This warranty covers the product hereunder and is provided by iXSea in place of all and any other warranty whether expressed or implied. iXSea does not guarantee the suitability of the product under warranty for sale or any specific use. iXSea's liability is limited to the repair or replacement of defective products, this being the sole remedy open to Customer in the event the warranty becomes applicable. iXSea cannot be held liable for indirect, special, subsequent or consequential damage, irrespective of whether iXSea has or has not received prior notification of the risk of occurrence of such damage.

I.8 Customer Support

Customer's technical support on OCTANS Subsea is available:

- By e-mail: **support@ixsea.com**
- By phone through iXSea 24/7 hot-line:
  - **+33 (0)1 30 08 98 98 for EMEA**
  - **+1 888 660 8836 (toll free) or +1 781 937 8803 for US**
  - **+65 6747 7027 for Asia**

Contact iXSea support for any request:

- On technical matters related to OCTANS
- On OCTANS software and protocols updates

iXSea customer's support commits to provide a quick response to your query.

I.9 Contact

To obtain information on any iXSea product, you can contact iXSea headquarters in France, or one of its offices around the world:

Contact	Phone	Fax
iXSea SAS FRANCE	+33 1 30 08 98 88	+33 1 30 08 88 01
iXBlue BV THE NETHERLANDS	+31 23 750 5110	+31 23 750 51 11
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