HBB360 - Hydrographic Surveying

Valide le 11-08-2022

Code : HBB360

Unité d'enseignement de type mixte

6 crédits

Volume horaire de référence (+/- 10%) : **50 heures**

Responsabilité nationale : EPN08 - Institut national des sciences et techniques de la mer (INTECHMER) / 1

Présentation

Objectifs pédagogiques

Module Outline:

the main objective of this course is to provide advanced insight into positioning at sea, depth measurements and seabed modelling, and deepening an understanding of the sources of errors and the accuracy that can be achieved with various devices and methods.

Contents

Planimetric Positioning

1. Classification of positioning systems and project types

2. Working principles of planimetric positioning systems

4. Characteristics of radio waves

4. Principles of terrestrial radio positioning systems

5. Principles of acoustic planimetric positioning systems

6. Geometric quality of positioning

Bathymetric Surveys

1. Types of bathymetric sensors SBE, MBE, side-scan

2. Bathymetric equipment: working principles

4. Calibration of Equipment

4. Bathymetric Project Management

Compétences

Learning Outcomes:

1 To clearly and scientifically explain the operation of acoustic, optical and radio positioning systems and bathymetric sensors.

2 To be able to distinguish and estimate the sources of error of acoustic, optical and radio positioning systems.

4 Being able to draw up, apply and evaluate error models for the planimetric or bathymetric measurement values.

4 Being able to predict the expected accuracy with certain equipment and a certain methodology.

5 Being able to draw up digital seabed models and to be able to assess them qualitatively.

6 Being able to prepare a motivated scientific report about a bathymetric measurement or processing.

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Programme

Contenu

I. Planimetric Positioning

Lecture 1

Types of Projects (survey companies projects versus safety of navigation)

Types of Survey projects (capital dredging, maintenance dredging, reclamation, beach nourishment, mining, environmental,…)

Classification of Positioning Systems (historically, acoustic versus optical versus electromagnetic waves, targeted users,…)

Lecture 2 Working principles of planimetric positioning systems

Horizontal positioning fundamentals

- Horizontal control surveys

- Horizontal positioning procedures (e.g. intersection, resection, polar and traverse)

- Appropriate instruments

Distance measurements

- Principles of stadia, microwave, infrared and laser systems, as used for measuring distances and distance LOPs. Distance measurement equipment

Electromagnetic positioning

- Principles of pulsed, differencing (phase and time) and range and bearing systems

Optical positioning: bearing-based (intersection), angle-based (resection), bearing/distance based (polar method)

Angular measurements

- Principles of sextants and theodolites as used for horizontal positioning

- Use sextants and theodolites and evaluate errors

Test 1 On lectures 1 and 2

Lecture 3 Global Navigation Satellite Positioning Systems

satellite systems

- Different satellite positioning systems and for each, their role (primary positioning system or overlay) and orbit geometry (e.g. inclination, ellipticity, altitude)

- Satellite observables

- Satellite coverage and availability

- GNSS concept and principles

- Characteristics of various public and private DGNSS services (single baseline, network, state space)

- Pseudoranging and carrier phase based modes of satellite positioning

- Performance of code vs. carrier; differential vs. autonomous modes; dual vs. single frequency; fixed vs. float ambiguity resolution. Operate GNSS and DGNSS equipment

Lecture 4 Remote Sensing

Multispectral imagery, water penetration and reflectance

Satellite derived bathymetry (DB)

Spatial resolution and accuracy

Geometrical properties of satellite images and aerial photographs.

Test 2 On lectures 3 and 4

Lecture 5 Characteristics of Acoustic waves and principles of acoustic planimetric positioning systems.

UNDERWATER ACOUSTICS

Acoustic fundamentals

- Plane and spherical waves

- Sound speed and particle velocity

- Active Sonar Equation

- Acoustic units

- Intensities

- Sound levels

Generation of Acoustic Waves

- How acoustic waves are generated

- Source level, frequency, wavelength, amplitude,

- Pulse duration (pulse length), and pulse repetition

Transmission of Acoustic Waves

- Causes of propagation loss

- Differences in water properties that affect propagation loss

Acoustic positioning concepts

- Principles of long, short and supershort baseline acoustic positioning system modes. The deployment and calibration, signal structure, sources of error, and expected uncertainties for each mode

ROV

- types

-use of the camera, diver and ROV in the inspection of sea floor contacts

Lecture 6 Geometric quality of positioning

Sources of errors

- Sources and magnitudes of errors for each positioning method and system

- Problems due to multipath, interference, reradiation, geometry, time-sharing, and power supplies

Performance of each system to be used

- Monitoring of system performance by analyzing results of least squares adjustments of measurements, where appropriate

- Repeatability, relative and absolute accuracy

Test 4 On lectures 5 and 6

II. Bathymetric Surveys

Lecture 7 Types of bathymetric sensors: SBE, MBE, side-scan: advantages and drawbacks.

single beam echo sounders

- Narrow beam and wide beam transducers

- The transducer characteristics that affect beam width

- The piezoelectric principle and its application to transducers

- The arrangement of single element and multielement array transducers

- The methods of mounting transducers: hull, towed, over the side, and boom

Multi beam

- The principles and geometry of multi beam echo sounding

- The combination of transducer elements into transmit and receive arrays

- The basic principles of multi beam sonar transmit and receive beam forming and beam steering

side scan systems

- The effect on side scan sonar performance (range, resolution, target detection) of frequency, beam angle, range scale, gain, towing speed, towing height, and deployment (deep tow, shallow tow, pole mount)

- The set up, deployment and operation of a side scan sonar, for specific applications

- Using available software tools, plot and position sonar contacts and create side scan mosaics

- The determination of height and size of obstructions from sonar records

- The sources of side scan image distortion

- Sonar signatures of such items as debris from wrecks, pipelines, gas, fish and fresh water

Lecture 8 Aerial Bathymetric LIDAR versus terrestrial LIDAR.

NON-ACOUSTIC BATHYMETRIC TECHNIQUES

Laser bathymetry

- The principles, capabilities, and limitations of bathymetric lidar

- Environmental and operational environments in which bathymetric lidar surveys are complementary to echo sounder surveys

- a Secchi Depth and list which environmental factors affect it

Remote sensing bathymetry

- The techniques of passive remote sensing for bathymetry

- Other airborne, shore-based, and satellite active remote sensing techniques for bathymetry

Inertial navigation

Test 4 On lectures 7 and 8

Lecture 9 Working principles of acoustic bathymetric equipment.

Sound Speed and Refraction

- Effects of the physical properties of water on sound speed

- Calculation of sound speed from temperature, pressure, and salinity

- Using software tools, create a sound speed with the profile of the water column

- Effects of variation of sound speed in the water column on the path of sound rays

Reflection and Scattering of Acoustic Waves

- Characteristics of the seafloor that affect the reflection of acoustic waves

Acoustic Noise and the Directivity Index

- The sources of noise in the environment

- The effect of noise on echo sounding

- The directivity index

Reception of Acoustic Waves and System Performance

- Beam width, bandwidth, gain, detection threshold

- Range resolution and spatial resolution

Acoustic Devices

- The purpose and operation of acoustic devices such as: transponders pingers, acoustic releases, and sound speed meters. Operate such acoustic devices

PHASE DIFFERENCING BATHYMETRY (INTERFEROMETRY)

Phase Differencing Systems

- The principles and geometry of interferometry

- Phase differencing bathymetric sonars

- Arrangement of transducer arrays

Deployment and mounting

- Options for deployment and mounting of phase differencing systems

Lecture 10 Calibration of bathymetric vessels

- Definition of the "patch test": Roll, Pitch, Yaw determination methods.

- Sources of Roll, Pitch, Yaw errors.

Heave

- Principles and limitations of heave compensation systems

- The role of filtering in making heave measurements

ORIENTATION

- The operation of heading sensors (e.g. flux-gate and other magnetic, fibre-optic and gyro compasses)

- The principles of inertial roll and pitch sensors

- The principles and limitations of GNSS attitude sensors

Vertical positioning fundamentals

Reference Surface

- The concept and process of establishing a reference surface and assessing the performance of an integrated survey system

- Characteristics of height systems (e.g. dynamic, orthometric and normal heights)

- Gravity-related and ellipsoidal heights

Datums

- The role of, and methods of establishing, the various vertical datums used in hydrographic operations (e.g. Chart, Sounding, MSL, LAT, LW, and HW datums)

Mechanical techniques

- Wire and bar sweeps

- The calibration of an echo-sounder by bar check, leadline, sound speed profile measurements and CTD measurements

Test 5 On lectures 9 and 10

Lecture 11 Sounding accuracy and uncertainty changes

- The use of available uncertainty values for individual sensors,

- The calculation and assessment of the uncertainty in soundings due to errors in the positioning system, echo-sounder, water level measurement, vessel motion and sound speed

- The dependence of depth coverage and uncertainty on bandwidth, beam-width, swath width, beam elevation angle, grazing and incident angles, depth, pulse repetition rate

- Prediction of the nominal sounding density on the seafloor using available information for depth, vessel speed, beam dimensions, and total swath angle

Sounding reduction

- The reductions to measured depths due to water level variations, draft, dynamic draft (settlement, squat, fuel depletion, and buoyancy)

Lecture 12

Bathymetric Project Management: Planning, acquisition, On-line and Off-line quality control. Quality prediction/simulation.

System selection

The primary system characteristics that affect range resolution, spatial resolution, depth capability, and bottom penetration. The effect of changes in those characteristics

Acoustic sweeps

The effect of transducer spacing and survey speed

real-time data acquisition and control

management, processing and analysis of acquired data

- introduction

- Methods for estimating and approximating static and dynamic survey measurements

- Analyze filtering and cleaning functions using appropriate software

- The effects on depth and position uncertainty of uncertainty in sensor locations, system latency, and alignments within the vessel reference frame

Data recording

- Analogue and digital recording systems and media

- The selection of the appropriate range, scale, and pulse repetition rate for specific applications

- The interpretation of echosounder records

Presentation

On a technical topic selected out of a list, related to one of the subjects above, that will be discussed in-depth. The outcome is a double document: a pdf with slides and a pdf with text about the topic.

Lecture 13 Bathymetric Project Management: Making reports, Creating technical drawings and performing accurate volume computations

Tutorial

Learning to use the software package (Qinsy and/or WinToPo) that will allow to execute the assignment below, creating drawings and performing volume computations.

Assignment

Creating a report of a bathymetric Survey with a groundmap with bathymetric contour lines and depth values, creating cross-section drawings with 2 surveys and a design layout, performing volume computations using difference grid models.

Modalités de validation

- Contrôle continu
- Projet(s)
- Examen final

Description des modalités de validation

Evaluation

Evaluation form:

Periodic evaluation and continuous assessment using 5 multiple-choice computer tests

Examination methods in case of periodic evaluation during the first examination period

Written examination with oral defense. Presentation and written assignment.

Examination methods in case of periodic evaluation during the second examination period

Written examination with oral defense. Presentation and written assignment.

Assessment methodology: Calculation of the examination mark:

1/2 on the theoretical exam, 1/6 on the 5 tests, 1/6 on the presentation and 1/6 on the assignment

Assessment criteria

In addition to general overview questions, the exam also asks more specific detailed questions that gauge the depth of knowledge, the ability to make connections, the insight to distinguish main issues from side issues, and the ability to formulate a scientifically precise and clear answer. , also to questions that expect a transposition of knowledge to areas of untreated applications. Students are also expected to have one or two presentations on a mutually agreed hydrographic topic.