IRCC8-07H2

8th Meeting of the IHO Inter-Regional Coordination Committee (IRCC8)

Abu-Dhabi, UAE, 29-31 May 2016

Draft New Edition 1.0.0 of the IHO Publication S-5A *Standards of Competence for Hydrographic Surveyors Category "A"*

Submitted by:	Chair, IBSC
Related Documents:	a) IRCC8-07H1 b) IRCC8-07H3 c) IRCC8-07H4 d) IHO Resolution 2/2007
Related Projects:	Task 3.3.9 of the IHO 2013-2017 Work Programme

Background:

1. The FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) developed a draft new edition 1.0.0 of the IHO Publication S-5A *Standards of Competence for Hydrographic Surveyors Category "A"*, in accordance with task 3.3.9 of the IHO 2013-2017 Work Programme.

New standards development:

2. The development was done intersessionally and during the two working group meetings that were organized in 2015 in Rimouski (Canada) and Antigua and Barbuda (back-to-back with the MACHC16).

3. In accordance with the IHO Resolution 2/2007, the IBSC organized stakeholders' seminar in conjunction with other events in order to get comments and feedback from the broad hydrographic community in order to assure the new draft S-5A is fit for purpose.

4. The first draft S-5A was made available in the IHO website under *Draft Publications for discussion* and the IHB issued Circular Letter 07/2016 Draft New Edition 1.0.0 of the IHO Publication S-5A – *Standards Of Competence For Hydrographic Surveyors Category "A"* seeking feedback from IHO Member States and Stakeholders to the draft S-5A and its accompanying *Guidelines for the Implementation of the Standards of Competence for Hydrographic Surveyors*.

5. Comments arising from Circular Letter 07/2016 were received on 1 April 2016. The Board acknowledged positive and constructive feedbacks from the IHO Member States and other institutions. The Board gave full consideration to the comments and both the feedback and the replies from the IBSC are given in Annex A.

6. The draft IHO Publication S-5A in in Annex B and incorporates valuable improvements extracted from the feedback received from Circular Letter 07/2016.

7. The Board seeks the endorsement of the IRCC to the draft edition 1.0.0 of the IHO Publication S-5A (Annex B) and subject to this endorsement, request the approval of the IHO Member States.

Actions Required of IRCC:

1. IRCC is invited to:

   a) **Note** this report;

   b) **Endorse** the draft edition 1.0.0 of the IHO Publication S-5-A Standards of competence for Hydrographic Surveyors Category "A";

   c) **Take** any other actions as appropriate.

MEMBER STATES’ AND STAKEHOLDERS' COMMENTS TO CL 7/2016 AND COMMENTS FROM THE IBSC.

DRAFT NEW EDITION 1.0.0 OF THE IHO PUBLICATION S-5A – STANDARDS OF COMPETENCE FOR CATEGORY "A" HYDROGRAPHIC SURVEYORS

Member States

Australia

Time Frames

1. The minimum duration of programmes is not as clear as it could be. Some courses are run with Elements every day, each day of the week until complete whereas Universities or Colleges may run them across a year to three years. The use of the term ‘1 academic year ie two full semesters (of 15 weeks including assessments) or equivalent’ is ambiguous. To which academic facility are we benchmarking and how is the 15 weeks timetabled? It is recommended that the duration is clearly stated in a manner such as:
   a. “If the course was to be run in a continuous manner until completion eg 6 hrs per day, it is expected that the minimum course duration would be XXX weeks or approximately XXX hours of classroom, practical and assessment.”
2. The time frames also neglect to advocate Recognised Prior Learning (RPL) which may allow a course to run for less time. RPL may include someone who had previously completed a Cat B / S5B course or survey degree etc. This is a matter for the institution to resolve how they achieve a timetable based on RPL students but nonetheless, RPL should be mentioned within the Guidelines as a means of reducing the course duration.

Element H3.1c – Terrestrial LiDAR

3. This needs to be separated from Airborne LiDAR for bathymetry and terrain. Terrestrial from a vessel has become a significant commercial capability and is within the financial capability of many smaller companies. Vessel based LiDAR is used to provide above water analysis for engineering and environmental purposes and needs to be correctly integrated into the bathymetric dataset. H3.2c does not cover the topic with respect to methodologies. The syllabus should cover ‘Vessel based LiDAR for shoreline and construction’ as a separate module:

a. methods of calibration and validation for vessel based LiDAR systems,
b. establishing shore control for vessel LiDAR,
c. accuracy and errors (It is also recommended that there be a qualitative expectation of a realistic and achievable level of uncertainty written into S-44)
d. differentiation between setups of MBES and vessel LiDAR identifying the important changes required in physical positions of equipment and software setups. As a case in point, many would only have one MRU / INS and therefore how does this change your setup and why?
e. simultaneous acquisition of MBES and vessel LiDAR. How is this achieved? What are the methodologies?

Element H8.1a – Responsibilities of the hydrographic surveyor

Content for consideration:

a. Hydrographic Surveyor should not attempt to practice in an area that they have no competence.
b. Work Health Safety and Environment – Safety is an essential part of any survey operation and there has been very little mention of this. The syllabus needs to include Job Hazard Analysis (JHAs), Hazard Identification workshops (HAZID), Risk Assessment, Environment Plans and Emergency Response. These aspects form a significant component of modern survey and are primarily derived and managed by the project manager in consultation with the team.

Element H8.1b – Contracts

Content: (May consider this for Element H8.1a instead)

a. Introduce types of insurance, Personal Liability, Professional Indemnity, Equipment, Public Liability

Conformity between documentation

4. Terminology used in S-5A with respect to the Guidelines definition of subject matter at para 2.3 ‘Minimum standards’ are not consistent. S-5B uses the defined Essential and Basic whereas S-5A is Foundation Science, Hydrographic Science and Basic. The Guidelines require update to meet the new subject matter expectations or S-5A needs to revert to the defined terms.
5. There is no ‘Level of Knowledge’ associated to elements within S-5A. These should be Basic, Intermediate and Advanced as per the Guidelines. If the entire syllabus is ‘Advanced’, then the instructional programme becomes academic and not as per the intent of the italic statement at the end of at para 2.3.5 ‘Level of Knowledge’. The practical aspects are derived from the definitions of Basic and Intermediate:

a. *Category B courses are intended to deliver Basic and Intermediate levels of knowledge and* ***Category A courses are intended to deliver Basic, Intermediate and Advanced levels of knowledge***.

IBSC Comments:
Acknowledges the constructive feedback.
Point 3: Amended some Content and Learning Outcomes in updated H3.1e, B4.7 and H8.1
Points 1,2,4 and 5:
Timeframes. Ambiguity of timeframes agreed – changes made to Guidelines 3.2.
Note that the IBSC does not dictate the way a course is programmed and will not be prescriptive about length of course in hours as many programmes cover additional subjects that are not in the Standards.
Recognition of Prior Learning (RPL). Guidelines provide an allowance to reduce the course length if exemptions from the Basics or Foundation Science subjects are sought – the IBSC will consider this in conjunction with the programme's entry requirements.
If the institution intends to implement its own RPL for individual students, this should be fully described in its Entry Requirements in its submission. However the institution must comply with the rule of no exemptions for *Essential* subjects (S-5B) and *Hydrographic Science* subjects(S-5A).
Conformity between documentation. The guidelines have been updated to describe the terms *Foundation Science* and *Hydrographic Science* used in S-5A.
Level of Knowledge has been added to individual learning outcomes of S-5A (this is because the IBSC assessed that there are varying knowledge levels required of separate learning outcomes within the same *topic*.

Bangladesh

In the draft IHO Publication S-5A, the following information may be included:

N.	Page No	Topic	Remarks	Recommendations
1.	2	2.1 Subjects Topics, and Elements.	The subject "H2: Underwater Sensors and Data Processing" is missing in the content list.	The subject heading may be added in the H2 of 2.1 of the content list.
2.	-	Knowledge and Experience.	Existed in S5 ed 11 (Page VII and VIII) as "2.4 Knowledge" and "2.6 Experience.	As practical experience and knowledge is very important in Hydrography, these may be added.
3.	-	Procedures for submission and recognition.	Existed in S5 ed11.	May be added as per "S-5B ed 1.0" (page: 4, para C).
4.	-	Certificate.	Existed in S5 ed11.	Format of certificate may be added as proforma for standardization.
5.	13	Least Square Techniques.	The Least Square Technique is included in Physical Geodesy which is a foundation subject. But if this topic is included in basic subject then it may help the students to understand the foundation subjects.	Least Square Techniques may be included in S-5A under the basic subject "B1: Mathematics, Statistics, and Theory of Observations".
6.	26	Inclusion of optional subjects.	Under the subject "H4: Survey Operations and Applications" a good number of essential topics are included from the Optional Subjects O2, O3, O4, O5 and O7 of existing S-5 ed 11.	Following topics from Optional Subjects of S-5 may be included in the draft IHO Publication S-5A, under the subject "H4: Survey Operations and Applications": a. Survey for Pollution Monitoring. b. Chart compilation and Chart

				Production.

IBSC Comments:
Acknowledges the feedback. Point 1 addressed, Point 5 noted but considered non-standard maths and part of Geomatics degrees for Cat –A (Basics).
Points 2,3,4 and 6 are noted.
Level of Knowledge has been added to individual learning outcomes of S-5A (this is because the IBSC assessed that there are varying knowledge levels required of separate learning outcomes within the same *topic*.
Options
An explanation of the reason for removal of options has been added to the Preface of the Guidelines (p.10)
Optional units cancelled The philosophy of the Standards is to develop a hydrographer that can work with competence across the full spectrum of the profession therefore much of the content within the previous options is considered necessary for all hydrographers and can no longer be considered optional. There is nothing to limit academic institutions from developing and delivering specialist modules in addition to the Standards.

Brazil
After analyzing the subjects, topics, elements, contents and learning outcomes of the first draft Edition of S-5A - Standards of Competence for Category "A" Hydrographic Surveyors - this Directorate would like to suggest the following contents:

I - Elements H3.lb and H6.1 - Airborne LiDAR data products, and real time data acquisition and control: although the LiDAR is a significant technological advance, its operation is still very expensive. Therefore, the learning outcomes related to "Assess results of specific bathymetric LiDAR surveys", "Explain how to incorporate information from full waveform analysis", and the content "Terrestrial and airborne LiDAR" could be presented in "Fundamental" level of knowledge and without practice;

II - Element H4.1a and H4.2d - Hydrographic survey requirements: the contents concerning "Seismic, gravity and geomagnetic surveys", "Pipeline route, pipeline installation, inspection and cable laying surveys" and "Magnetic surveys" are more applicable to industrial activities could, therefore, be presented in "Fundamental" level of knowledge and without practice; and

III - Element 116.1 - Real-time data acquisition and control, the contents concerning "ROVs and AUVs": although the hydrographic surveys using ROVs and AUVs are a relevant technological advance, its operation are still very expensive and other cheaper hydrographic systems can obtain similar quality results. Thus, they could be presented in "Fundamental" level of knowledge and with or without practice, due to high costs, specific applicability and the existence of alternative methods and equipment. In light of the above, this Directorate appreciates the opportunity to comment on this project and to contribute to the upgrade of the Norms elaborated by this Committee.

IBSC Comments:
Acknowledges the feedback.
Points are noted with some amendments after review although the references to the levels of knowledge will be described differently and have been added to individual learning outcomes of S-5A *topics.*

Canada
Canada would like to thank the members of the FIG/IHO/ICA International Board on Standards for Hydrographic Surveyors and Nautical Cartographers (IBSC) for their efforts in drafting this new edition.
Canada has reviewed the draft standards and has no further comments to add.

IBSC Comments:Acknowledged

Chile
Chile has given close attention to the draft new edition of S5-A and we would like to congratulate the IBSC for this product.
As requested, please find the following comments:
- Page 2: reference to H2 Underwater Sensors and Data Processing.
- B4.3 Nautical Charts: No mention to ENCs, only reference to ECDIS and ECS is made.
- B4.4 Navigation Publications: No mention to “Urgent” Notice to Mariners is made.
- F2.1d Waves: No mention to tsunamis is made.

We notice that Options do not longer exist and we suggest a short explanation be given on the rationality for doing so, just to have a record of it.

IBSC Comments:
Acknowledges the feedback. The items raised were each considered and amendments made where it was felt the Standards should be modified.
An explanation of the reason for removal of options has been added to the Preface of the Guidelines (p.10)
Optional units cancelled The philosophy of the Standards is to develop a hydrographer that can work with competence across the full spectrum of the profession therefore much of the content within the previous options is considered necessary for all hydrographers and can no longer be considered optional. There is nothing to limit academic institutions from developing and delivering specialist modules in addition to the Standards.

Cuba
Concerning CL N° 7/2016: DRAFT NEW EDITION 1.0.0 OF THE IHO PUBLICATION S-5A - "STANDARDS OF COMPETENCE FOR CATEGORY "A" HYDROGRAPHERS, we inform you that the Hydrographic and Geodetic Office of the Cuban Republic does not have comments to this respect.

Original in Spanish:
Referente a la CC C 7/2016: PROYECTO DE NUEVA EDICIÓN 1.0.0 DE LA PUBLICACIÓN S-5A - "NORMAS DE COMPETENCIA PARA HIDRÓGRAFOS DE CATEGORÍA "A", le informamos que el Servicio Hidrográfico y Geodésico de la República de Cuba no tiene comentarios al respecto.

IBSC Comments: Acknowledged.

France
General comments
S-5A distinguishes 3 categories of competences: Basic, Foundation, and Hydrographic Science Subjects. It is not clear which of those competences may be optional in case a candidate would already possess one of it.

Specific comments
B1: Mathematics, statistics, theory of observation.
"Describe the parametric equations of curves and surfaces" is missing in geodesy.
B2: information and communication technology
Competences on "information and communication technology" are almost the same as the competences for cat. B surveyors. Yet, cat. A surveyors should be more competent in that field, at least in programming (explicit programming languages or scientific programming software he should know) and databases (capacity to make SQL request for example), as this knowledge should be a basis to H7.1 a competence.
B4.6: nautical science.
Exactly the same table as S-5B except for ECS and ECDIS which should also be present in S-5A as well.
F1.3: classical survey principles
1- There is no apparent link between the F1.3 title "classical surveying principles" and its content. Would "Classical positioning principles" be a more relevant title?
2- The learning outcomes mention GNSS but the content does not. (cf. F1.3 (ix) = Establishing ground control using distance and angle measurements).
F1.6 Trigonometry and least-squares
This item should not be included in Fl (Earth models) but in B1 (Mathematics...)
F3.2a Gravity fields and gravity surveys
This item should be included in H4.2 (survey operations), as are "magnetic surveys" (cf.H4.2d).
H2.2d (Processing of single beam data) could be part of H4 (related to H4.2b)
H4.2: hydrographic survey operations
Gravity surveys, seismic surveys and Lidar surveys should be developed, as the other ones (single beam, multi-beam, side scan sonar and magnetic surveys).
H5: Water levels and flow.
This part should be placed before H4.
H6.2a (Filtering and estimation of single beam data) and H6.2b (Filtering and estimation of multi-beam data):
I - There is no obvious advantage to separate these 2 items since their contents and learning outcomes are almost the same.
2- "Assessing coverage in relation with contour lines" (see H6.2a (viii)) should also be a content of H6.2b item, since coverage is an issue with multi-beam systems as well (simple coverage, double coverage ...).

IBSC Comments:
Acknowledges the feedback.

After review of each of the points, most were considered to be an improvement. Amendments, largely using generic terms, were therefore made. All the points were ether considered to be adequately covered or received some amendment. Some re-organization of the material was also made.

Regarding the General point raised, the Guidelines have been updated to describe the terms *Foundation Science* and *Hydrographic Science* used in S-5A.

Italy

With full collaborative spirit we are happy to provide our comments on the Publication S 5A. We strongly support the need to keep the Publication updated to the technology evolution as well as to consider Cat "A" not an evolution of Cat "B" but a different profession in the hydrographic field.

About S 5A Draft First Edition Version 1.0.0 – January 2016 we suggest the inclusion of some items (in yellow):

Element	Content	Learning outcomes
F3.1a Earth structure and ocean shape	(i) Plate tectonics and other Earth processes (ii) Earthquakes zones (iii) Types of continental margins (iv) Seafloor spreading, ocean basin structure and continental margin (v) Seafloor dynamics as evidence of plate tectonics (vi) Ocean basins, trenches, ridges and other ocean floor features (vii) Lithological cycle and different types of rocks in the marine environment (viii) Different types of rocks in the marine environment (iv) Subsidence and uplift	Principles of internal structure, physical characters and dynamics of the Earth referring to ocean basin structure Ocean bottom as a multilayered structure composed of sediment deposits Describe the structure of the Earth and explain the relationship between Earth processes and bathymetric /topographic features of the Earth.
F3.1b Geomorphology	(i) Sedimentary cycle (erosion, transport and deposition) (ii) Type of coast (iii) Seafloor features and bed forms (iv) Coastal and marine environment: beach, estuaries and inlets Estuaries and inlets (v) Seafloor temporal variability	Interpret geological information and relate expected seafloor features to survey methodology and need for repeated surveys.
F3.2c Seismic surveys	(i) Continuous reflection/refraction seismic profiling. (ii) Typical sound sources, receivers and recorders. (iii) Analogue high resolution seismic systems (including pinger, boomers, sparkers, chirp) (iv) Frequency and wavelength in relation to resolution and penetration (v) Equipment configuration for towing, launch and recovery (vi) Applications such as pipeline or hazard detection, seabed sediment identification for mapping, shallow sedimentary channels. (vii) Principles of seismic stratigraphy	Evaluate coverage and penetration of systems and correlate equipment with applications. Distinguish between noise, outliers and real seafloor features and sub-seafloor geometry

Furthermore, we found it strange that the previous Optional Unit section was cancelled. Probably 7 options were too many but we suggest that at least the following three options be kept:

- Hydrography to support Port Management, Coastal Engineering and Nautical charting,
- Offshore construction hydrography and geophysical surveying,
- Inland waters hydrography.

Of course we have considered military hydrography as a specific unit that will be managed outside the standards of competence.

We believe that specific publications S-5A, S-5B, S-8A and S-8B should be assumed under a more general publication, a sort of guideline covering the Standards of Competence for Hydrographic Surveyors and Nautical Cartographers. We feel that the First edition Version 1.0.0 January 2016 of the "Guidelines for the implementation of the standards of competence for Hydrographic surveyors" does not fully meet this requirement. Italy is willing to provide the board with a draft of this guideline for hydrographic surveyors and nautical cartographers.

We take the opportunity to inform you that our Cat A and Cat B courses will undergo a number of changes:

- Cat A in the 2017 will no longer be a master degree and, from 2017, will be a graduate 2 year course (Master of science degree) after the bachelor degree; we suppose a new submission will be required from the board;
- Cat. B will be open to civilian students too; it will be managed by the Italian Hydrographic Office and the International Maritime Safety and Environment Academy in a new campus facility in Arenzano (15 km west of Genoa); we suppose that a new submission is not required as the curriculum will remain exactly as it is.

This will be presented during the next CBSC in Abu Dhabi

IBSC Comments:
Acknowledges the feedback
The first point raised was considered to be already covered sufficiently. Amendments were made to reflect Points 2 & 3
General Points relating to the Guideline:
<u>Optional units cancelled</u>
The philosophy of the Standards is to develop a hydrographer that can work with competence across the full spectrum of the profession therefore much of the content within the previous options is considered necessary for all hydrographers and can no longer be considered optional. There is nothing to limit academic institutions from developing specialist modules in addition to the Standards.
<u>Covering publication.</u>
The Standards are published under the Authority of IBSC following endorsement by IHO Members States, these must be seen as superior documents to the Guidelines. The Guidelines describe the suite of Standards and are published and remain under the full control of the IBSC which allows them to be easily amended and kept up to date.

New Zealand
New Zealand would like to comment that the new structure with Learning Outcomes) is very good and it gives the content some context. The content is denser and more up to date. New Zealand also recommends to add a list of abbreviations and suggests the following clarifications to the text:

B2.4 Integration and allocation of addresses for multiple equipment into an Ethernet
B3.6 What is the intent of this item?
B4.2: (ii) Spelling of EPIRB
(v) Replace "Inmarsat-C" with "SafetyNET". Note: although Inmarsat is the supplier of the system, SafetyNET is the term used. In the future, Iridium is placed to provide a similar service to SafetyNET.
and add the following items:
(vi) Promulgation of Maritime Safety Information (MSI)
(vii) World Wide Navigational Warning Service (WWNWS)
B4.9 (ii): add Autonomous Surface Vehicles (ASV)
F1.2d: add (iii) "Application of site calibrations. Including inclined plane and geoid calibrations"
F1.3: Use of Theodolite is largely superseded by the Total Station; should this tool be considered in legacy context? Or perhaps removed entirely? Consider the re-ordering of principles and equipment, currently the section reads items i-iii: principles, iv-vi equipment, vii-xi principles. GNSS not included in equipment in content section. Does using GNSS for (ix) defeat the purpose?
F1.4a: Spelling of "levelling"
F2.1b: Consider including underway SVP sensors
F3.1b: The survey methods are not listed in the content and could not been found by flicking through the document. It is recommended to add the survey methodologies for geology to the content list.
H4.2a: Location(s) of tidal station(s) is an important aspect of survey planning. Suggest including content on establishing tidal stations to ensure the tidal regime is adequately modeled
H4.2c (IV): add "and ability to meet target detection Requirements"
H5.2a: add after "install, level" the expression "to benchmark(s) and connect to known vertical datum"
H5.4b: change the name of the element from "Vertical Datum" to “Vertical datums, conversions between datums and relationships”
H5.4: amend the first Learning Outcome to read “Explain the relationship between geoid, ellipsoid and chart datum. Apply relevant corrections to convert between land, ellipsoidal and chart datums”
H5.4 (VI): change to "Chart Datum and Sounding Datum"
H7.3b: amend the Learning Outcome: “Evaluate and select the best visualization method to highlight features of interest and data artefacts within a hydrographic data set”

IBSC Comments:
Acknowledges the feedback.
A review of each of the points resulted in the majority of generating some amendment. In some cases the item was considered sufficiently covered and included in the Standards. In addition an abbreviation list is being constructed

Portugal
The Portuguese Hydrographic Institute welcomes the revision of the Standards of Competence for Hydrographic Surveyors Category A. The program offered in this Institute is very much in line with the proposal. The structure of the course will be reviewed to be in accordance with this publication and will be ready for a new accreditation submission in 2016/2017.

IBSC Comments: *Acknowledged.*

Spain
Replying to your above mentioned Circular Letter, I am pleased to communicate the following comments and suggestions:
In the standards which are still in force for Hydrographers, Publication S-5 (11th Edition), version 11.1.0 of December 2014, are included optional contents that provide a guidance about complementary subjects of a more specific interest and that can be included in the different programmes. This allows a better flexibility when offering different educational and training proposals.
In the new Publications S-5A an S-5B these contents have been removed, that is why we recommend to maintain the following optional modules, still in force:

1. Nautical Charting Hydrography
2. Hydrography to Support Port Management and Coastal Engineering
3. Offshore Seismic Surveys
4. Offshore Construction Hydrography
5. Remote Sensing
6. Military Hydrography
7. Inland Waters Hydrography

Original in Spanish:
En contestación a la Carta Circular de la referencia, tengo el gusto de comunicarle los siguientes comentarios y sugerencias:
En las normas todavía en vigor de competencia para hidrógrafos, PublicaciónS-5 (11° edición) versión 11.1.0 de diciembre de 2014, se incluyen contenidos opcionales que proporcionan una orientación sobre temas complementarios de interés más específico, y que pueden ser incluidos en los diferentes programas.
Esto permite una mayor flexibilidad en la oferta de diferentes propuestas educativas y de formación.
En las nuevas publicaciones S-5A y S-5B se han eliminado estos contenidos por lo que se recomienda que se mantengan los siguientes módulos opcional es todavía vigentes:
1 Hidrografía para Cartografía Náutica
2 Hidrografía para apoyar la Gestión de Puertos y la Ingeniería de Costa
3 Levantamientos Geofísicos Offshore
4 Hidrografía para Construcciones Offshore
5 Teledetección
6 Hidrografía Militar
7 Hidrografía de Aguas Interiores

IBSC Comments:
Acknowledges the feedback. Points relating to the Options are now explained in the associated Guidelines:
Optional units cancelled The philosophy of the Standards is to develop a hydrographer that can work with competence across the full spectrum of the profession therefore much of the content within the previous options is considered necessary for all hydrographers and can no longer be considered optional. There is nothing to limit academic institutions from developing and delivering specialist modules in addition to the Standards.

United Kingdom
The draft version of the S-5A is a welcome update to the eleventh edition of the S-5 (last updated in December of 2014). The move to separately published syllabi for both Cat A and Cat B courses is considered of benefit as it permits more detail to be included in each publication and it is perceived that this provides greater clarity for institutions looking to achieve accreditation. In particular, this has enabled the use of lists of contents for both Cat A and Cat B courses, which in turn feed the wider learning outcomes in each area specified (with documents laid out in a two column format to reflect this), and this adds value to the documents as a whole.
As stated in our recent assessment of the S-5B, the desire and reason for moving to separate syllabi for Cat A and Cat B training (effectively removing the need to attend Cat B to progress to Cat A) is understood and has merit but it is considered that a number of institutions around the world will wish to continue with progression from Cat B to Cat A courses (From a pure academic perspective the courses lend themselves naturally to Bachelor and Masters level credits). In so doing, institutions will wish to continue using learning objectives achieved under the Cat B syllabus to support their

Cat A programme. At this juncture (now that both are simultaneously available), the S-5B and the S-5A appear to support this and it is hoped that whilst there will be some movement apart of Cat A and B programmes in future editions (to reflect the intended "practitioner" versus "manager" split), there should be recognition that these programmes are still mutually supportive.
The statement in the guidelines that a Cat A programme may span 6 years appears to support such (the UK's FOST-HM has certainly benefited from the board's interpretation of this clause in this manner) and it is our view that this should continue to be the case as the programmes evolve.
In terms of the S-5A document itself, it is felt that the document as a whole is sound with course content and learning outcomes ultimately supporting the aim of generating trained hydrographic surveyors in-charge / hydrographic managers.
There are some minor areas that may merit further considerations and the following observations are submitted:
B1.1b Numerical methods for linear systems of equations: Cholesky decomposition is mentioned as a method for solving linear equations. It is felt that this is in part a legacy, is too prescriptive and that other methods should be mentioned or a wider statement made.
B3.4 Waves: Fourier analysis should be added.
F1.6c Least Squares: point Viii talks about covariance of estimated parameters. Both A priori and A posteriori methods should be mentioned.
H1.2a GNSS Signals: Describing the role of the IGS should be considered for inclusion in learning outcomes
H1.5b Acoustic Positioning Systems: The learning outcome is to "demonstrate" how acoustic positioning observables etc. are used to achieve subsea rover spatial referencing. Depending upon how the word demonstrate is interpreted, this could prove challenging for institutions to fulfil.
H1.2b Propagation of Acoustic Waves: Students are required to "calculate" propagation loss in practical situations using medium property observations and available tables. The preceding statement about explaining how acoustic mediums and source frequencies affect propagation is considered to be sufficient.
H2.3a Side-Scan Sonar Systems: Consider inclusion of learning outcomes for Multi-beam backscatter and Multi-pulse side-scan sonars.

IBSC Comments: *Acknowledges the feedback.*
On review of the points raised a number of amendments were made and a new H2.5 created. Other points were considered to be already sufficiently covered, often in more generic terms.
Points relating to the Guidelines are reported elsewhere.

USA
In response to Circular Letter 07/2016 "DRAFT NEW EDITION 1.0.0 OF THE IHO PUBLICATION S-5A – STANDARDS OF COMPETENCE FOR CATEGORY “A” HYDROGRAPHIC SURVEYORS," I was asked to forward notice that the U.S. expresses its concurrence with the draft.
Andy Armstrong also remains engaged in the review and drafting process in his capacity on the IBSC drafting group

IBSC Comments: *Acknowledged*

Stakeholders

FIG
General Comments/Overview of Standard/Guideline:

WG 4 .1reviewed the draft standard. WG members consider the content of the draft to be a fair and reasonable representation of the minimum level of competencies required of a practicing hydrographic surveyor.

SSB/SSA Consistency. Some concerns were raised regarding the level of consistency between this draft standard and SSB (eg. in terms of the way the syllabus is defined). In SSB subjects are defined in terms of Essential and Basic whereas in S-SA reference is made to Basic, Foundation Science, and Hydrographic Science.

Comment was also made on the grouping of subjects. For example, Trigonometry is reflected in topic Bl.3 in S-SB but as element Fl.6a in 5-SA.

Course Time frames. There appears to be an issue regarding timeframes. The minimum duration of programmes is not as clear as it could be. Some courses are run with elements every day, each day of the week until complete whereas universities or colleges may run the same elements across one to three years. The use of the term '1academic year (ie. two full semesters) (of 15 weeks including assessments) or equivalent' is ambiguous. To which academic facility is IHO/IBSC benchmarking and how are the 15 weeks timetabled? The duration of topics/elements need to be clearly defined/stated at the start of the document (ie. on P. 3).An explanation might be considered along the following lines:

"If the course was to be run in a continuous manner until completion (eg. 6 hrs per day) it is expected the minimum course duration would be XXX weeks or approximately XXX hours of classroom, practical and assessment."

The timeframes also neglect to consider Recognised Prior Learning (RPL) which may allow a course to run for less time. RPL may include someone who had previously completed a Cat B/SSB course or survey degree etc.

This is obviously a matter for the institution to resolve in terms of how they might realise a timetable cognisant of students demonstrating RPL. Notwithstanding, it is recommended the issue of RPL should be mentioned within the current draft Standard as a clarifying point and as a potential means of reducing course duration.

Recommendations. Most of these issues are considered minor in nature that generally do not detract from the document in its current form. While it is recommended the issue of timeframes and RPL be considered and addressed in the current draft edition prior to IRCC endorsement and publication, he remaining consistency issues noted by the WG might be considered and if necessary addressed in future iterations of the Standard.

Specific Comments

Clause or Paragraph	Page #	Recommended Change, Amendment or Comment
General - various clauses	7	Confusion between spelling of *centre* & *center* eg. B3.2 Gravity. Majority of document uses *centre,* suggest this is the accepted spelling. Document need general tidy up for consistency - table centring/font size/spelling etc.
Definitions *Topics and Elements*	3	Should read .... 'Each Foundation, Hydrographic Science or Basic subject comprises a list of *topics* .....'
Definitions *Learning Outcomes and List of Content*	3	Should read 'a n intended *learning outcome,* that a student should be able to achieve on completion of ...
Basic Subjects *B1.4 Probability and Statistics*	5	In terms of sequential numbering, should this topic read Bl.3 with the associated elements reflecting B1.3a and B1.3b? Preceding topics reflect Bl.1 and Bl.2.
H1.5 *Subsea Positioning*	19	Subsea positioning is a major IOS function, agree with the inclusion of systems/principles/error analysis of LBL/SBL/ USBL etc. systems but Hl.5 appears as an afterthought. Suggest this is expanded to include an overview of subsea positioning application, particularly an introduction to metrology
H3.1c *Terrestrial LiDAR*	24	This element needs to be separated from Airborne LiDAR for bathymetry and terrain. Terrestrial LiDAR from a vessel has become a significant commercial capability and is within the financial capability of many smaller companies. Vessel based LiDAR is used to provide above water analysis for engineering and environmental purposes and needs to be correctly integrated into the bathymetric dataset. H3.2c does not cover the topic with respect to methodologies. The syllabus should cover 'Vessel based LiDAR for shoreline and construct ion' as a separate module: a. methods of calibration and validation for vessel based LiDAR systems; b. establishing shore control for vessel LiDAR; c. accuracy and errors (it is also recommended there be a qualitative expectation of a realistic and achievable level of uncertainty written into 544); d. differentiation between setups of MBES and vessel LiDAR identifying the important changes required in physical positions of equipment and software setups. (As a case in point, many would only have one MRU/INS and therefore how does this change your setup and why?); and e. simultaneous acquisition of MBES and vessel LiDAR. How is this achieved? What are the methodologies?
H8.1a *Responsibilities of*	38	The content for this element might also include the importance of certification (which is not mentioned/referenced). This would cover off on any concerns

the hydrographic surveyor		regarding the competency of the hydrographic surveyor in particular hydrographic disciplines. While the content mentions legal issues and liability associated with hydrographic products, and additional area of responsibility for the hydrographic surveyor that could be considered is 'Liability and types of insurance; personal liability, professional indemnity, and public liability'.

IBSC Comments:
Acknowledges the feedback.
The Specific Comments raised have been reviewed and amendments made to reflect these.
Points relating to the Guidelines:
Conformity between documentation. The guidelines have been updated to describe the terms *Foundation Science* and *Hydrographic Science* used in S-5A.
Timeframes. Ambiguity of timeframes agreed – changes made to guidelines 3.2.

Note that the IBSC does not dictate the way a course is programmed and will not be prescriptive about length of course in hours as many programmes cover additional subjects that are not in the Standards.

Recognition of Prior Learning (RPL). Guidelines provide an allowance to reduce the course length if exemptions from the Basics or Foundation Science subjects are sought – the IBSC will consider this in conjunction with the programme's entry requirements. If the institution intends to implement its own RPL for individual students, this should be fully described in its Entry Requirements in its submission. However the institution must comply with the rule of no exemptions for *Essential* subjects (S-5B) and *Hydrographic Science* subjects(S-5A).

University of Southern Mississippi
It is our pleasure to commend the FIG/IHO/ICA International Board for their very thorough and professional review of competency standards for hydrographers. Our assessments of the draft new edition of S-5A standards discussed by Reference (a) conclude that it is a well done reflection of the hydrographic competencies needed to conduct hydrography with the latest survey practices. We are also pleased that the Board reduced some legacy or little used competencies which enables the addition of new competencies but still allow for the execution of a Category A educational program within one year. We also offer some comments:
a. Recommend Elements B1.2b, "Differential equations" and B1.2b, "Numerical solutions of non-linear equation" be deleted from 1. "Basic Subjects/ B1 Mathematics, statistics, theory of observations." Our reasoning is that hydrography has few applications for solving differential equations or using numerical methods for solving non-linear equations.
b. It is our understanding that retaining Optional Units and competencies, such as, the ability to maneuver a small boat is at the discretion of the training institution.
c. The new draft standards, if approved, may require structural changes to existing programs at a number of training institutions. We believe that the implementation of the new draft standards needs to be pushed back from IBSC40 (presumably April 2017) to IBSC41 (presumably April 2018).

IBSC Comments:
Acknowledges the feedback.
Points relating to the Guidelines: Points relating to the Options are now explained in the associated Guidelines:
Optional units cancelled The philosophy of the Standards is to develop a hydrographer that can work with competence across the full spectrum of the profession therefore much of the content within the previous options is considered necessary for all hydrographers and can no longer be considered optional. There is nothing to limit academic institutions from developing and delivering specialist modules in addition to the Standards.

Draft IHO Publication S-5A Standards of Competence for Category "A" Hydrographic Surveyors

(Also available from www.iho.int → Standards & Publications → Download → Draft Publications for discussion → S-5A)

INTERNATIONAL FEDERATION OF SURVEYORS

INTERNATIONAL HYDROGRAPHIC ORGANIZATION

INTERNATIONAL CARTOGRAPHIC ASSOCIATION

STANDARDS OF COMPETENCE FOR CATEGORY "A" HYDROGRAPHIC SURVEYORS

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Comments arising from the experience gained in the application of the guidance are welcome. They should be addressed to the Chairman of the International Board for Standards of Competence of Nautical Hydrographers and Nautical Cartographers at the above address. This document is published periodically. Please check with IHB for the latest edition, including current amendments.

1. INTRODUCTION

All components of the hydrographic surveying and nautical cartography profession face challenges as to how best to ensure the continuance of high standards and how best to ensure the continuation of best practices based on minimum standards of competence world-wide. In order to achieve these objectives, three international organizations (FIG, IHO and ICA) have developed Standards of competence that institutions or professional bodies may adopt for their educational/training programmes and competency schemes.

Standards indicate the minimum competences necessary for hydrographic surveyors. Standards recognize two levels of competence. Category A programmes introduces competences from the underlying principles level. Category B programmes introduce the competences from a practical level.

The intention is that a Category A individual with appropriate experience, would be a senior professional in their chosen field (government, industry, academia). Category B individuals with appropriate experience would be technical professionals leading and delivering products and services to meet specifications and outcomes.

2. DEFINITIONS

2.1 Subjects, topics, and elements

The S5-A standard contains the following list of ***B****asic subjects*, ***F****oundation Science subjects* and ***H****ydrographic Science subjects*:

Topics and Elements:

- Each **Foundation, Hydrographic Science** or **Basic** *subject* comprises a list of *topics* which are denoted by Bx.y, Fx.y, or Hx.y;
- Each *topic* contains *elements* which are denoted by Bx.y<c> Fx.y<c> or Hx.y<c>.

For example, the *subject* H1 “Positioning” contains the *topic* H1.1 Vessel and sensor reference frames that has the *element* H1.1a “Common reference frames for sensors”.

2.2 Learning outcomes and list of content

It is important to understand that each *element* is associated with:

- one or more intended *learning outcomes*, that a student should be able to achieve on completion of the programme. All *learning outcomes* should be assessed. This may be done through one of, or a combination of, the following: examination, assessed exercise or presentation, laboratory report, or final project work.
- a list of *content*. This list is associated with one or more *learning outcomes* and describes the theoretical knowledge or practical/technical context which the course syllabi should address in order to meet a particular *learning outcome*.

S-5A STANDARDS:

INTENDED LEARNING OUTCOMES
AND
ASSOCIATED CONTENT

1. BASIC SUBJECTS

B1 Mathematics, statistics, theory of observations						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
B1.1 Geometry and Linear Algebra						
B1.1a Geometry *(B)*					(i) Conic Sections, geometry of the ellipse and of the ellipsoid. (ii) Parametric equations of curves and surfaces.	Express curves and surfaces in parametric form. Compute lengths and coordinates on an ellipse.
B1.1b Linear Algebra *(I)*					(i) Vector and affine spaces, vector and inner products, norms. (ii) Linear operators, matrix representation, composition, transpose. (iii) Translations, rotations, coordinate transformations, similitudes, orthogonal projection.	Derive and compute 2D and 3D transformations, as typically involved in geodesy, surveying and survey data geo-referencing.
B1.1c Numerical methods for linear systems of equations *(I)*					(iv) Systems of linear equations, Gauss elimination. (v) Matrix decomposition, and factorisation. (vi) Condition number of a matrix.	Solve linear equations by numerical methods in a scientific computing environment and analyze error bounds.
B1.2 Differential calculus and differential equations						
B1.2a Differential and integral calculus *(B)*					(i) Real and vector valued functions. (ii) Series, Taylor expansions (iii) Gradient of a real-valued functions. (iv) Jacobian matrix (v) Integrals of real-valued functions. (vi) Numerical integration methods.	Apply differential calculus to real and vector valued functions from a n-dimensional vector space. Calculate integral of classical functions and approximate numerical values.

B1.2b Differential equations *(I)*					(i) Linear ordinary differential equations, general solution with right hand side. (ii) Non linear differential equations, and linearization. (iii) Numerical methods for non-linear ordinary differential equations.	Compute explicit solutions for linear ordinary differential equations and apply numerical methods to approximate solutions to non-linear differential equations.
B1.2c Numerical solutions of non-linear equation *(B)*					(iv) Iterative methods. (v) Rounding and numerical errors.	Apply numerical methods to find approximate solutions for non-linear equations.
B1.3 Probability and statistics						
B1.3a Probabilities and Bayesian estimation *(B, I)*					(i) Probability measures, density functions (ii) Mathematical expectation, variance (iii) Co-variance, correlation (iv) Conditional probabilities, Bayes law (v) Minimum mean square estimation (vi) Distributions including normal, chi2, t and F	Define probability measures, derive associated formulae and calculate values from data. *(B)* Select a distribution for a given random variable and apply a Bayesian estimation method. *(I)*
B1.3b Statistics *(I)*					(i) Random variables, mean, variance, standard deviation (ii) Estimation of mean, variance, co-variance (iii) Statistical testing, confidence intervals	Compute confidence intervals and associated statistical measures for random variables using various distributions.

B2 Information and Communication Technology						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
B2.1 Computer systems *(I)*					(i) Central Processing Unit (ii) RAM, data storage devices and standards (iii) Communication board, serial links, communication ports and standards, buffers, Ethernet links, data transmission rates (iv) Communication protocols (v) Clocks, clocks drift, time tagging and synchronization of data (vi) Operating systems (vii) Device drivers	Describe the different components of a real-time data acquisition system, including various modes of communication and time-tagging. Describe the role of a device driver and its relation to data exchange. Create/Configure a data link and evaluate any time delays across the link.
B2.2 Office work software suites *(B)*					(i) Word processors (ii) Spreadsheets (iii) Graphics software	Use classical office work software suites. Prepare a poster describing scientific or project results.
B2.3 Programming *(B)*					(i) Basic operations of a computer program or script (ii) Algorithms (loops, conditional instructions) (iii) Scientific computation environments (iv) Application to data exchange, file conversion	Write a program or script for data format conversion and/or basic algorithm computation. Configure a small network and transfer data over that network
B2.4 Web and network services *(B)*					(i) Networks (LANs) (ii) Network and cloud storage (iii) Internet (iv) Networks integrity (v) Communication protocols	Describe the different network options used in remote data exchange and storage applications.
B2.5 Databases *(B)*					(i) File types (binary, text, XML) (ii) Relational databases (iii) Geospatial databases (iv) Database management systems and query languages	Describe different types of geospatial data and their representation. Construct a database, populate it and query its content using a database language, such as SQL.

B3 Physics						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
B3.1 Kinematics *(B)*					(i) Angular and linear velocities, accelerations (ii) Angular velocities addition rules, accelerations due to rotational motion, Coriolis Law	Explain the principle and the relationship between position, velocity and acceleration for both rotational and linear motion.
B3.2 Gravity *(B)*					(iii) The inertial frame (iv) Newton's law, forces, accelerations, energy (v) Center of gravity, center of instantaneous rotation (vi) Gravitational field (vii) Potential fields	Differentiate between inertial and Earth fixed frames. Differentiate center of gravity from center of instantaneous rotation. Develop the mathematical relationship between potential and acceleration in a gravitational field.
B3.3 Magnetism *(B)*					(i) Magnetic characteristic of ferrous bodies (ii) Magnetic field	Describe ferromagnetic properties and resulting magnetic field.
B3.4 Waves *(B)*					(i) Harmonic waves modeling and wave parameters (amplitude, frequency, wavelength, celerity and phase) (ii) Longitudinal and transverse waves (iii) Intensity, Decibel scale (iv) Attenuation (v) Doppler effect (vi) Interferometric principles	Explain harmonics in the context of waves and resulting constructive and destructive interferences patterns from multiple waves and sources. Use the Decibel scale to define intensity and characterize attenuation. Explain the Doppler effect.
B3.5 Electromagnetic waves *(B)*					(i) Electromagnetic waves properties and propagation (ii) Radiation, emission and absorption (iii) Reflection, refraction, diffraction (iv) Optical reflectance	Calculate field of view and resolving power of optics. Describe aberrations. Describe the effect of wavelength on the propagation in a medium. Describe the effect of a medium in the propagation of an electromagnetic wave
B3.6 Geometrical optics *(B)*					(i) Mirror, prisms, lenses and filters (ii) Telescopic optics and magnification (iii) Snell-Descartes law	Model a light ray-path through medium with various reflective and refractive properties. Use the characteristics of a lens to calculate geometrical properties of an image.
B3.7 Lasers *(B)*					(i) Principle of lasers (ii) Laser parameters (frequency, wavelength) (iii) Types of lasers	Describe the operation, unique properties, and applications of stimulated sources of emission.

					(iv) Laser attenuation	
B3.8 Transducers and clocks *(B)*					(i) Pressure transducers (ii) Thermal transducers (iii) Types of clocks (iv) Measurement of ellapsed time	Describe different types of transducers and their calibration requirements. Describe time measurement devices in relation to their drift coefficient and accuracy.

B4 Nautical science						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
B4.1 Conventional aids to navigation *(B)*					(i) Types of buoys and beacons (ii) Radar beacons (iii) AIS systems	Describe the characteristics and purposes of fixed and floating aids to navigation and the use of automatic identification systems.
B4.2 GMDSS *(B)*					(i) Sea areas (ii) EPIRBs and SARSAT (iii) Digital selective calling (iv) NAVTEX (v) SafetyNET (vi) Promulgation of Maritime Safety Information (MSI) (vii) World Wide Navigational Warning Service (WWNWS)	Describe the components and purpose of GMDSS.
B4.3 Nautical charts *(B)*					(i) Content, datum, projection, scale and types of nautical charts (ii) Chart symbols (iii) Chart graticules (iv) Uncertainty indicators (e.g. source diagram, reliability diagram, zone of confidence, notes) (v) Navigational hazards (vi) Plotting instruments (vii) ECDIS, ENC, RNC and ECS	Plan and layout a route on a nautical chart, enter/plot positions, identify navigational hazards and revise navigational plan as required. Describe the content of a nautical chart and explain datum, projection and scale. Describe the uncertainty indicators associated with nautical charts.
B4.4 Navigation publications *(B)*					(i) Sailing directions, (ii) Light and radio lists, (iii) Tides and current tables (iv) Notice to Mariners and Urgent Notice to Mariners	Use content of nautical publications in a survey planning context.
B4.5 Compasses *(B)*					(i) Magnetic compasses (ii) Gyros (iii) Compass error and corrections	Describe the capabilities, limitations and sources of errors of magnetic and gyro compasses. Determine and apply corrections for magnetic and gyro compass error.
B4.6 Emergency procedures *(B)*					(i) Fire extinguishers (ii) Life preservers and cold water survival suits, life rafts (iii) Distress signals and EPIRB (iv) Procedures for man-overboard, fire, and abandoning ship	Explain the importance of the emergency equipment and procedures. Identify types of fire extinguishers and their use.
B4.7 Safe working practice *(B)*					(i) Water-tight doors and hatches (ii) Suspended loads (iii) Enclosed spaces	Describe procedures for maintaining a safe working environment. Design safe cable routes for survey instruments.

					(iv) Working aloft, with equipment over the side, life lines. (v) Work permitting (vi) Securing equipment for sea (vii) Cables and antenna installation (viii) Earthing (grounding) of electrical equipment (ix) High voltage electrical safety (x) Personal protective equipment	Define procedures for securing equipment for heavy weather.
B4.8 Rope and wires *(B)*					(i) Types of wire and rope (ii) Characteristics (stretch, floating, strength) of ropes and wires. (iii) Basic knots	Select and tie basic knots. Select appropriate wire or rope.
B4.9 Towed and over the side instruments *(I)*					(i) Rosette systems and instruments (ii) ROVs, AUVs, ASVs, towed systems, catenary and layback (iii) A-frames, cable blocks, electro-mechanical wire, wire strength factor for deep casts, slip rings and optical cabling (iv) Moon pools (v) Launch and recovery (vi) Station keeping and maneuvering	Specify procedures for deployment and recovery of oceanographic and hydrographic equipment.
B4.10 Anchoring *(B)*					(i) Shipboard ground tackle including anchor, chain, windlass, stoppers (ii) Small boat anchoring (iii) Multiple anchors	Describe ship and small boats anchoring and ground tackle. Explain how the final position of the vessel can be adjusted through the use of anchors.
B4.11 Instrument moorings *(I)*					(i) Launch and recovery (ii) Anchors and acoustic releases (iii) Scope, wire, flotation, tension (iv) Weights	Specify types of mooring and procedures for mooring underwater instruments.

B5 Meteorology						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
B5.1 Weather fundamentals and observations *(B)*					(i) Vertical structure and the variability of the atmosphere (ii) Temperature, humidity, dew-point, frost-point (iii) Atmospheric pressure, winds (iv) Clouds and precipitations (v) Rain, snow (vi) Visibility, advection fog and radiation fog (vii) Pressure systems (viii) Geostrophic winds, anabatic and katabatic winds (ix) Instruments and sensors used to register temperatures, pressure, direction and intensity of wind (x) Sea state scales, weather warning categories, wave height, periods and direction	Define physical meteorological parameters Operate instruments and sensors used to register temperature, pressure, direction and intensity of wind. Record these parameters according to internationally accepted standards. Identify characteristics of weather by simple observation of the sea and the sky.
B5.2 Wind, waves and seas *(B)*						Explain the relation between atmospheric pressure, temperature and wind. Describe wind circulation around pressure systems and the effect of friction
B5.3 Weather forecasting *(B)*					(i) Synoptic charts (ii) Weather forecast	Interpret a synoptic chart. Produce an operational short range forecast based on meteorological information, weather bulletins and facsimile charts.

2. FOUNDATION SUBJECTS

F1 : Earth Models						
Element	**Hours**			**Course and content**	**Content**	**Learning outcomes**
	T	P	SG			
F1.1 Physical geodesy						
F1.1aThe gravity field of the Earth *(B)*					(i) Newton's law of gravitation (ii) Centrifugal acceleration (iii) Gravity (acceleration) (iv) Gravity potential (v) Level or equipotential surfaces (vi) The Geoid (vii) Normal gravity and ellipsoidal models such as GRS80. (viii) Gravity anomalies (ix) Gravity observations	Describe relationships between the gravity field of the Earth, normal gravity and level surfaces.
F1.1b Gravity observations and their reduction. *(B)*						Explain methods for observing gravity and computation of gravity anomalies
F1.1c Height systems and height determination *(B)*					(i) Dynamic heights (ii) Orthometric heights (iii) Normal heights (iv) Level ellipsoid	Describe different height models and the role of gravity-based heights in modern levelling networks.

F1.1d Geopotential and geoidal Modelling *(I)*					(v) Theoretical misclosure of a leveling loop (vi) Geopotential models (vii) High resolution global and local geoid grids (viii) Deflection of the vertical	Describe techniques used to model the Earth's geopotential. Discuss the application and limitations of geopotential models and their verification in height determination.
F1.2 Coordinate Systems						
F1.2a Coordinate Systems for Positioning *(I)*					(i) Traditional geodetic datums (ii) Terrestrial reference systems and reference frames. (iii) Modern geodetic datums based on terrestrial reference frames. (iv) Datum transformation techniques including similarity transformations and grid based approaches.	Explain principles of astronomic and geocentric datums together with their practical realisations.
F1.2b Datum transformation techniques *(A)*						Compare datum transformation methods and transform coordinates between datums and between reference frames. Estimate transformation parameters from observations.
F1.2c Geodetic computations on the ellipsoid *(I)*					(i) Grid computations and spherical trigonometry. (ii) Forward and inverse computations for geodesic and normal section curves on the ellipsoid.	Assess the various solutions available for forward and inverse computations on the ellipsoid. Compare grid and spherical methods with ellipsoidal computations.
F1.2d Three-Dimensional Geodetic Modeling *(A)*					(i) Local and global Cartesian coordinate frames. Reference to physical plumb line and ellipsoidal normal. Geoid heights and deflections of the vertical. (ii) 3D observation equations and 3D adjustment. Laplace equation.	Explain the mathematical model of 3D geodesy, integrating satellite and terrestrial observations. Evaluate a typical hybrid network, using commercial software. Describe application of 3D Geodesy to hydrogra-phic survey control and 3D positioning of survey vessels.
F1.3 Land surveying methods and techniques						
F1.3a Trigonometric surveys *(I)*					(i) Principles of distance measurement and angle measurement (ii) Atmospheric and radiometric corrections for optical measurements. (iii) Calibration requirements and documentation (iv) Sextant (in legacy context) (v) Theodolite (vi) Total Station (vii) Intersection, Resection, Polar and Traverse (viii) Astronomic methods for determination of orientation. (ix) Establishing ground control using GNSS, distance and angle measurements. (x) Control station recovery (xi) Logistical aspects of providing control	Select appropriate methods and use corresponding instruments for local positioning.
F1.3b Existing survey control *(I)*						Recover survey marks and associated documentation with an appreciation for the datum and accuracy associated with the historical survey.
F1.3c Establishing survey control *(I)*						Establish terrestrial control using GNSS in accordance with published quality control procedures
F1.3d Instrument tests *(I)*						Field test and use distance and angle measurement instruments. Select appropriate field validation procedures
F1.3e Historical surveys *(B)*						Relate historical surveys to legacy positioning systems.

F1.4 Levelling						
F1.4a Levelling instruments *(I)*					(i) Levelling instruments (ii) Total stations (iii) Effects of curvature and refraction (iv) Reduction of levels and correction to the relevant height datum (v) Calibration requirements and documentation	Explain the principles of operation of instruments used in determination of height differences.
F1.4b Height reduction *(A)*						Conduct surveys in accordance with standards. Reduce elevation measurements and use adjustment procedures.
F1.5 Map Projections						
F1.5a Map Projections *(A)*					(i) Equidistant, equal area, azimuthal and conformal projections. (ii) Properties and applications of cylindrical, conical and stereographic projections. (iii) Grids, graticules and associated coordinates. (iv) Convergence, scale factors and arc to chord corrections. (v) Worldwide cartographic systems Including UTM, GK and UPS.	Classify the properties of projections. Use parameters associated with map projections to compute distortion and apply corrections between geodetic and grid coordinates. Use geometrical properties of map projections to contrast and compare the use of different projections for different applications.
F1.6 Trigonometry and least-squares						
F1.6a Trigonometry *(B)*					(i) Plane trigonometry (ii) Sphere, great circle, rhumb lines, spherical triangles and spherical excess	Apply plane and spherical trigonometry to surveying problems.
F1.6b Theory of observations *(I)*					(vi) Measurements and observation equations (vii) Notion of uncertainty related to observations (viii) Accuracy, precision, reliability, repeatability (ix) Linearized observation equations and variance propagation law (x) Propagation of uncertainty in observations through multiple measurements (xi) Relative and absolute confidence ellipse	Differentiate between accuracy, precision, reliability and repeatability of measurements. Relate these notions to statistical information. Apply the variance propagation law to a simple observation equation, and derive an estimate uncertainty as a function of observations co-variances.
F1.6c Least squares *(A)*					(i) Least squares principle (ii) Covariance of observation (iii) Weighted least squares (iv) Orthogonal least square (v) Total Least Square (vi) Problems with explicit solutions (vii) Condition equations (viii) Covariance of estimated parameters (ix) Unit variance factor estimate (x) Internal and external reliability	Solve geodetic problems by least squares estimation. Determine quality measures for least square solution to geodetic problems, to include reliability and confidence levels.

F2 : Oceanography

Element	Hours			Course and content	Content	Learning outcomes
	T	P	SG			
F2.1						
F2.1a Water masses and circulation *(I)*					(i) Global ocean circulation (ii) Mechanisms of regional circulation. (iii) Global and local water masses and their physical properties. (iv) World oceanographic databases (v) Seasonal and daily variability of temperature and salinity profiles. (vi) Types of estuaries and their associated salinity profiles.	Use the knowledge of spatial and temporal variability of the water masses to plan surveys. Establish a water column sampling regime for use within survey operations.
F2.1b Physical properties of sea water *(A)*					(i) Sound Velocity Profilers, Conductivity, Temperature, Depth sensors, Expendable probes. (ii) Units used in measuring and describing physical properties of sea water, normal ranges and relationships including: salinity, conductivity, temperature, pressure, density. (iii) Sound speed equations (iv) Oceanographic sampling. (v) oceanographic sensors: • Current meters • ADCP • Turbidity sensors and need for calibration	Specify oceanographic sensors to measure physical properties of sea water. Apply appropriate equation to estimate density and speed of sound. Create a sound speed profile.
F2.1c Oceanographic measurements *(I)*						Specify equipment and procedures for oceanographic measurement to meet survey requirements. Configure and use oceanographic sensors and sampling equipment.
F2.1d Waves *(B)*					(i) Wave measurement by radar and buoys (ii) Wave parameters and elements involved in the wave growth process including fetch and bathymetry (iii) Tsunamis (iv) Breaking waves, long-shore drift and rip current processes in relation to beach surveys. (v) Beach profiles	Outline wave generation processes. Describe the principles of wave measurement systems. Describe how beach survey monitoring strategies are related to wave regimes.

F3 : Geology and geophysics						
Element	**Hours**			**Course and content**	**Content**	**Learning outcomes**
	T	P	SG			
F3.1 Geology						
F3.1a Earth structure *(B)*					(i) Plate tectonics and other Earth processes (ii) Earthquakes zones (iii) Types of continental margins (iv) Ocean basins, trenches, ridges and other ocean floor features (v) Different types of rocks in the marine environment (vi) Subsidence and uplift	Describe the structure of the Earth and explain the relationship between Earth processes and bathymetric /topographic features of the Earth.
F3.1b Geomorphology *(A)*					(i) Types of coast (ii) Seafloor features and bed forms (iii) Erosion, transport and deposition (iv) Estuaries and inlets (v) Seafloor temporal variability	Interpret geological information and relate expected seafloor features to hydrographic survey methodology and need for repeated hydrographic surveys.
B3.1c Substrates *(I)*					(i) Sediment types (ii) Outcropping rocks (iii) Submerged aquatic vegetation (iv) Corals	Predict seafloor type and characteristics based on observations of local geological information.
F3.2 Geophysics						
F3.2a Gravity fields and gravity surveys *(B)*					(i) Gravity meters (ii) Relative and absolute gravity measurements (iii) Bathymetric corrections for gravity measurements (iv) Local gravity anomalies and gravity surveys (v) Influence of gravity on sea surface topography and correlation with seafloor features	Explain the principle of operation of gravity meters and the need for corrections. Discuss the objectives of gravity surveys in relation to seabed features.
F3.2b Magnetic fields *(B)*					(i) Magnetic fields of the Earth (ii) Magnetic anomalies in relation to rock types and tectonic history (iii) Temporal variations (iv) Magnetic Earth models and databases	Describe the Earth magnetic field, its spatial and temporal variability.

F3.2c Seismic surveys *(I)*					(i) Continuous reflection/refraction seismic profiling. (ii) Typical sound sources, receivers and recorders. (iii) Analogue high resolution seismic systems (including pinger, boomers, sparkers, chirp) (iv) Frequency and wavelength in relation to resolution and penetration (v) Equipment configuration for towing, launch and recovery (vi) Applications such as pipeline or hazard detection, seabed sediment identification for mapping, shallow sedimentary channels. (vii) Principles of seismic stratigraphy	Evaluate coverage and penetration of systems and correlate equipment with applications. Distinguish between noise, outliers, and real seafloor features and sub-seafloor geometry

3. HYDROGRAPHIC SCIENCE SUBJECTS

H1: POSITIONING						
Element	**Hours**			**Course and content**	**Content**	**Learning outcomes**
	T	P	SG			
H1.1 Vessel and sensor reference frames						
H1.1a Common reference frames for sensors *(A)*					(i) Identification of a common reference point and reference frame for the vessel (ii) Centre of rotation for the vessel (iii) Centres of measurement for sensors (iv) Sensor offset measurements.	Specify a suitable vessel reference frame for sensor offsets and configure software to use values accordingly. Reconcile the application of offsets between various hardware and software components of the survey system.
H1.1b Integration of reference frames *(A)*					(i) Sensor body reference frames. (ii) Transformations between reference frames associated with sensor bodies, the vessel and local geodetic frame.	Define and apply appropriate transformations between the different frames in the navigation solution.
H1.2 GNSS positioning						
H1.2a GNSS Signals *(I, B)*					(i) GNSS Systems, such as GPS, GLONASS, Galileo, Beidou, etc. (ii) Signal structure. (iii) Frequencies, time keeping and logistical segments: Ground, Space, User. (iv) Broadcast almanac ephemerides and precise orbit information. (v) Ionospheric and tropospheric effects. (vi) Earth rotation information.	Describe the structure of signals broadcast by GNSS and explain the impact of the atmosphere on these signals. *(I)* Describe the characteristics of different components of GNSS and detail sources of information relating to the orbital and timing parameters. *(B)*
H1.2b GNSS observables *(A)*					(i) Code phase and carrier phase observables, mixed observables. (ii) Differencing using carrier phase including single, fixed and float double, and triple differences. (iii) Corrections for earth rotation, ionosphere, and troposphere.	Write observation equations for different GNSS observables and develop mathematical and stochastic models for the solutions that include earth rotation and ionospheric elements.
H1.2c Relative and absolute techniques *(A)*					(i) Differential and Wide area augmentation services. (ii) Real time kinematic and post-processed kinematic techniques. (iii) Precise Point Positioning techniques and services. (iv) System selection in alignment with survey requirements.	Evaluate and select appropriate system for applications by aligning survey requirements with capabilities and limitations of GNSS techniques

H1.2d Installation and operation *(A)*					(i) Antenna installation to consider coverage, stability and multipath environment. (ii) Levels of redundancy in systems and communications (iii) Data exchange formats and protocols such as RINEX and NMEA	Specify, supervise and test the installation of GNSS hardware and software for both inshore and offshore operations.
H1.2e Quality control *(A)*					(i) Sources of error including multipath, atmospheric effects, base station network, sensor offsets, etc. (ii) Measures and monitoring of precision (DOP variations) and reliability (statistical testing). (iii) Integrity monitoring of base station data. (iv) Verification checks between systems or against known points.	Develop a quality control plan for GNSS operations including risk management associated with GNSS components and services. Assess the performance of GNSS positioning against the defined quality control criteria.
H1.3 Inertial navigation systems						
H1.3a Accelerometers and gyroscopes, inclinometers, and compass *(A)*	T				(i) Accelerometers technology (pendulums, vibrating elements) (ii) Gyroscopes (FOG, Ring laser, Sagnac effect) (iii) MEMS (iv) Inclinometers (v) Flux gate compass	Describe accelerometer technologies, and differentiate between inclinometers, compass and gyroscopes. Describe error sources associated with these devices.
H1.3b Strapdown inertial measurement units *(A)*					(i) Technologies available for IMU measurements through gyrometers and accelerometers (ii) Sources of error in inertial sensors: bias; scale factor; and, noise. (iii) The inertial navigation equation and error equations. (iv) Static alignment of the IMU. (v) Heave estimation from gyros and accelerometers. (vi) Induced heave.	Describe the technologies used in inertial measurements and quantify associated navigation errors. Undertake static alignment of an IMU. Develop strategies for mitigating induced heave and select filter parameters for heave estimation.
H1.3c Kalman filtering *(I)*					(i) Bayesian estimation (ii) State representation of a dynamic observation equation, observability (iii) Continuous, Semi-discrete and discrete Kalman filtering (iv) Optimal smoothing	Apply Kalman filtering methods to a dynamic observation process. Define the parameters of a Kalman Filter in relation with sensors performances and dynamic model uncertainty. Differentiate between stationary and non-stationary observation processes
H1.3d Aided inertial navigation *(I)*					(i) INS and GNSS loosely and tightly coupled solutions. (ii) Velocity and ranging aided INS navigation.	Describe the role of aiding sensors to reduce INS navigation drift. Apply appropriate settings to filtering and smoothing for aided navigation solutions.

					(iii) Dynamic and aided alignment of INS by Kalman filtering. (iv) INS solutions from IMU and other sensors by Kalman filtering and smoothing.	
H1.5 Subsea positioning						
H1.5a Acoustic positioning principles *(A)*					(i) Long base line (ii) Short baseline (iii) Ultra-short baseline (iv) Doppler velocity log (v) Transponders (vi) Acoustic modems (vii) Subsea INS (viii) Water column structure (ix) Acoustic ray multipath (x) Time synchronization	Describe the signal structure and observables of mobile and fixed acoustic positioning devices. Relate observables and platform orientation to relative positions through observation equations.
H1.5b Acoustic positioning systems *(A)*						Explain how acoustic positioning observables, orientation and surface positioning data are used to achieve subsea rover spatial referencing. Specify the deployment and calibration methods for fixed and mobile acoustic positioning systems.
H1.5c Acoustic positioning error analysis *(I)*						Compute the total propagated uncertainty in acoustic positioning, accounting for time, sound speed and other observable errors.
H1.5d. Acoustic positioning applications *(B)*					(i) Towed vehicles (ii) Autonomous vehicles (iii) ROVs (iv) Surface vessel dynamic positioning (v) Engineering and installation (vi) Metrology	Identify appropriate acoustic positioning solutions for different applications, considering potential sources of error.
H1.6 Line keeping						
H1.6a Track guidance *(B)*					(i) Track guidance and route following information systems. (ii) Tolerances for track guidance in compliance with survey specifications and positioning system precision. (iii) Maintaining uniform sounding density in swath systems. (iv) The impact of the environment on the line keeping and data density (v) Options for accepting filed data when the navigation or line keeping is not optimal.	Specify the methods to be used in maintaining a survey vessel or remote survey system on a planned survey line or route and meeting sounding density specifications. Describe what may occur if the real-time navigation systems are interrupted during a survey. Explain how to compensate and mitigate for the effects of strong currents across a survey area/in a river estuary.

H2: UNDERWATER SENSORS and DATA PROCESSING						
H2.1 Underwater acoustics						
Element	**Hours**			**Course and content**	**Content**	**Learning outcomes**
	T	P	SG			
H2.1a Transducers and generation of acoustic waves *(I)*					(i) Piezoelectric principles (ii) Transducer arrays design, beam-forming, side lobes. (iii) Transducer Quality factor (iv) Plane and spherical waves in terms of wavelength, amplitude and frequency. (v) Absorption, spherical spreading (vi) Frequency, attenuation relationship to range (vii) Acoustic units, intensities and sound levels (viii) Signal to noise ratio (ix) Active Sonar Equation including sound source, causes of propagation loss in relation to water properties together with characteristics of the sea floor and targets, acoustic noise level and directivity (x) Continuous Wavelength (CW), Chirp transmission (xi) System parameters including bandwidth, pulse length, pulse repetition rate, gain, detection, threshold. (xii) Range resolution and spatial resolution. (xiii) Dynamic range, clipping and saturation (xiv) Sound speed profile and gradient (xv) Ray-tracing theory (xvi) Sound channel (xvii) Non horizontal sound speed layers	Analyse the effect of transducer design on beam characteristics and performance. Describe the design and use of multi-frequency, wide-bandwidth and parametric transducers. Differentiate between chirp and CW transmission, and characterize their relative performance. Determine source level from typically available sonar specification.
H2.1b Propagation of acoustic waves *(A)*						Explain how properties of the acoustic medium and source frequency affect the propagation of acoustic waves. Calculate propagation loss in practical situations, using medium property observations and available tables.
H2.1c Acoustic noise *(I)*						Identify the sources of noise and describe the effect of noise on echo sounding. Define the directivity index. Calculate the effect on sonar range of a variety of noise conditions and sonar directivity circumstances.
H2.1d Reflection, scattering and system performance. *(I)*						Define the characteristic impedance of an acoustic medium. Assess the effects of varying seafloor composition, texture, and slope on echo strength.
H2.1e Refraction and ray-tracing. *(A)*						Use the sound speed profile to compute the path of sound ray through the water column.
H2.2 Single beam systems						
H2.2a Single beam echo sounders principles *(I)*					(i) Single beam, split beam and dual beam concepts (ii) Beam footprint (iii) Specification of a single beam echo sounder. (iv) Bottom detection principles (matched filtering, thresholding) and range resolution. (v) Full echo envelope returns and bottom characterization	Explain the principles of operation of a single beam sounder detailing how acoustic parameters influence sounder returns.
H2.2b Single beam returns interpretation *(A)*						Interpret single beam returns including analysis of full echo envelopes and features of the sea bed and water column.

H2.2c Single beam survey system *(A)*					(i) Components of a single beam echo sounder system to include: positioning system, motion sensor, acquisition system, source of reference level (i.e. tide gauge, GNSS) (ii) Acoustic parameters of single beam echo-sounders (iii) Reduction of soundings to the specified datum	Specify survey system to perform a single beam survey in accordance with application requirements. Select appropriate range, scale, frequency and pulse for specific applications in relation to spatial resolution, bottom penetration, depth of water and water column analysis.
H2.2d Processing of single beam data *(I, A)*					(i) Systematic effects in system components: • Single Beam Echo-Sounders • IMU/INS • Sound speed profilers and other peripheral sensors (ii) Single beam echo sounders data processing workflows	Specify processing workflow for single beam data. *(I)* Integrate and merge data of various sources and of various types in preparation for product generation. *(A)*
H2.3 Sonar imagery systems						
H2.3a Side-scan sonar systems *(A)*					(i) Principles, components and geometry of side scan sonar systems (ii) Range, beam angle (iii) Resolution in relation to beam width, sampling rate angle of incidence and pulse length.	Evaluate, select and configure side-scan sonar in alignment with survey operational needs.
H2.3c Synthetic Aperture Sonar *(I)*					(i) Principles of synthetic aperture imaging	Discuss and compare the use of SAS with that of more conventional sonar imaging systems.
					(i)	
H2.4 Swath echo sounder systems						
H2.4a Multibeam echo sounders *(A, I)*					(i) Principles and geometry of multibeam sonar systems (ii) Combination of transducer elements into transmit and receive arrays. (iii) Beam stabilization and beam steering (iv) Amplitude and phase bottom detection (v) Variations in beam spacing and footprint size (vi) Backscatter recording modes (e.g., beam average, side scan time series, beam time series) (vii) Backscatter and seabed classification (viii) Water column data (ix) Power, gain, pulse length	Explain the basic principles of multibeam sonar transmit and receive beam forming and beam steering. *(I)* Explain the effect of aperture size and element spacing on array performance. *(I)* Analyse the techniques of amplitude and phase methods of bottom detection and relate them to depth uncertainty. *(A)*
H2.4b Multibeam system parameters *(A)*						Tune acoustic parameters on-line for depth *and* backscatter. Determine the beam footprint size and sounding spacing across the swath and assess the limitations and likelihood of detecting objects on the seafloor

					(x) Multiple signal returns, aliasing of muliple signals in the water.	under varying surveying conditions. Explain the use of water column returns and differentiate from bottom detection.
H2.4c Multibeam systems *(A)*					(i) positioning system, telemetry, motion and attitude sensors, (ii) acquisition system, (iii) source of reference level (i.e. tide gauge, GNSS), (iv) Sound Speed measurements	Specify survey system to perform a multi-beam survey in accordance with application requirements.
H2.4d Multibeam data processing *(A)*					(i) Multibeam data elements: (ii) Beam and travel-time data (iii) IMU/INS (iv) Positioning data (v) Time stamping (vi) Offsets between sensor reference points (vii) Sound speed profile (viii) Data file formats	Describe how and where data elements are combined to produce geo-referenced soundings. Integrate and merge data elements in preparation for data processing.
H2.4e Interferometric Sonar *(A)*					(i) Principles and geometry of interferometric (phase measurement) sonar systems (ii) Sounding determination principles (iii) Mounting methods and towing (iv) Transducers arrangement (v) Sounding filtering and binning techniques	Analyze the principles and geometry of interferometry and phase differencing bathymetric sonars and the arrangement of transducer arrays. Explain the need for filtering phase measurement data for depth, object detection and backscatter. Explain the effect of aperture size and transducer geometry on array performance. Assess the relative merits of multibeam and phase differencing systems for specific mapping applications in water depths from very shallow to full ocean depths.
H2.5 Backscatter						
H2.5a Backscatter from side scan, interferometric swath sonars and multibeam echo sounders *(A)*					(i) Relationship between backscatter content and characteristics of the seabed, water column properties and acoustic signal parameters (ii) Generation of backscatter information within acoustic systems (iii) Principle of backscatter compensation for absorption, incidence angle, gain and power (i) Mosaicing	Specify and configure a side scan sonar and a swath echo sounder for backscatter acquisition under varying environmental conditions and for specific application. Monitor and assess quality on-line and apply appropriate compensation. Apply backscatter principles to produce a compensated backscatter mosaic.

<table>
<tr><th colspan="7">H3 LiDAR and REMOTE SENSING</th></tr>
<tr><th colspan="7">H3.1 LiDAR</th></tr>
<tr><th rowspan="2">Element</th><th colspan="3">Hours</th><th rowspan="2">Module and content</th><th rowspan="2">Content</th><th rowspan="2">Learning outcomes</th></tr>
<tr><th></th><th>P</th><th>SG</th></tr>
<tr><td>H3.1a Airborne LiDAR systems

(A)</td><td></td><td></td><td></td><td></td><td rowspan="3">(i) Wavelength, water penetration, ground detection and laser safety.
(ii) Scanning frequency and pattern in relation to power, coverage and spatial density.
(iii) Influence of sea surface roughness, water column turbidity on the beam pattern and penetration.
(iv) Sea bed optical characteristics and bottom detection.
(v) Influence of seabed on reflectance
(vi) Relationship between full waveform signature and seabed characteristics.
(vii) Secchi disc and Secchi depth
(viii) Impact of structure and canopy on topographic LiDAR
(ix) Optical characteristics of coastal terrain.
(x) Influence of geometry and waveform on feature detection.
(xi) Integration of components including time stamping, attitude compensation, sensor offsets and networking.
(xii) Sources and levels of uncertainty associated with LiDAR data and products.
(xiii) Combined bathymetric and topographic LiDAR systems
(xiv) Vessel-based LiDAR</td><td>Determine the applicability of topographic and bathymetric LiDAR to specific mapping applications.
Specify the appropriate LiDAR technology for given applications and identify supporting survey operations required to conduct the survey and process data.</td></tr>
<tr><td>H3.1b Airborne LiDAR data products

(I, A)</td><td></td><td></td><td></td><td></td><td>Identify potential sources of error in combined topographic and bathymetric LiDAR data and apply corrective processing techniques as appropriate. (I)

Evaluate results (x,y,z) of specific bathymetric LiDAR surveys for compliance with hydrographic requirements. (I)

Explain how to incorporate information from full waveform analysis in the production of LiDAR mapping products. (A)</td></tr>
<tr><td>H3.1c Terrestrial LiDAR

(B)</td><td></td><td></td><td></td><td></td><td>Determine situations where terrestrial and vessel-based LiDAR data can be used to complement other coastal and offshore spatial data.

Explain the need for calibration and validation of vessel-based LiDAR and describe how data from such system will be integrated with other data streams.</td></tr>
<tr><th colspan="7">H3.2 Remote Sensing</th></tr>
<tr><td>H3.2a Remotely sensed bathymetry

(I)</td><td></td><td></td><td></td><td></td><td>(i) Multispectral imagery and water penetration in relation to wavelength
(ii) Optical properties of sea water.
(iii) Model based and empirical inversion methods for determining bathymetry.</td><td>Explain and compare the methods that enable depth to be determined from wavelength together with optical properties of both the water and the seabed.</td></tr>
</table>

					(iv) Atmospheric corrections. (v) Spatial resolution and accuracy in position and depth. (vi) Reflectance properties of the sea floor.	
H3.2b Satellite altimetry *(B)*					(i) Missions and sensors (ii) Products	Describe the principles and limitations of satellite altimetry products including sea-surface topography and derived bathymetry
H3.2c Optical methods of shoreline delineation *(I)*					(i) Colour imagery and multispectral imagery. (ii) Reflectance of multispectral imagery in relation to wavelength and terrain characteristics. (iii) Use of imagery in shoreline mapping and identification of other topographic features. (iv) Uncertainty associated with map features derived from imagery. (v) Geometrical properties of satellite images and aerial photographs	Describe geometrical properties of images and principles of orthorectification. Explain how imagery can be used in planning survey operations and in supporting hydrographic products. Compare image based methods with those of LiDAR for shoreline delineation

H4: SURVEY OPERATIONS AND APPLICATIONS						
H4.1 Hydrographic survey projects						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
H4.1a Hydrographic survey requirements *(A)*					(i) IHO S-44 and other survey quality standards. (ii) Underkeel clearance (iii) Procedures and installations required to conduct hydrographic surveys of specific types, for example: • Nautical charting survey • Boundary delimitation survey • Ports, harbor and waterways surveys. • Engineering works and dredging surveys • Coastal engineering surveys • Inland surveys • Erosion and land-sea interface monitoring • Oceanographic surveys • Deep sea and ROVs /AUVs surveys • Seismic, gravity and geomagnetic surveys • Pipeline route, pipeline installation, inspection and cable laying surveys • Wreck and debris surveys.	Establish procedures required to achieve quality standards in hydrographic surveys. Specify the type of survey system and equipment needs together with associated parameters and procedures for various components of the overall survey operation. Evaluate the impact of local physical and environmental factors on survey results.
H4.1b Hydrographic survey project management *(A)*					(i) Hydrographic instructions and tenders. (ii) Estimating and drafting survey work plans and schedules (iii) Risk assessment in survey operations associated with the proposed work plan. (iv) Assessment and reporting of work progress against the work plan (v) Health and safety compliance (vi) Environmental impact of survey activities (vii) Emergency Response Situations and Plan	Prepare hydrographic specifications, instructions and tenders associated with survey objectives. Estimate the resources, scheduling and timing associated with hydrographic projects and prepare project plans including health and safety requirements, environmental issues and emergency response. Define, assign and distribute the roles and responsibilities of individuals within a survey team. Prepare progress reports and submit interim project deliverables.

H4.2 Hydrographic survey operations						
H4.2a Survey planning *(A)*					(i) Components of survey planning including on-board equipment, platform's dynamic positioning, remote installations, data from satellites and telemetry links. (ii) Planning of survey operation considering general depth, bottom character, water column variability, weather, currents, tides, coastal features and vessel/flight safety. (iii) Logistical considerations for survey operations (iv) Maintaining safe working conditions.	Plan survey lines and schedule to accommodate environmental and topographic conditions for the vessel or aircraft and for towed, remote and autonomous vehicles.
H4.2b Single Beam operations *(A)*					(i) Transducer mounting (ii) Calibration techniques and requirements (iii) Line spacing, orientation and line planning (iv) Causes and effects of motion artefacts and water properties artefact on data (v) Integration with ancillary systems (vi) Compensation for vessel motion, attitude, dynamic draft (vii) Feature development (viii) Data logging parameters	Specify survey procedures and quality assurance practices to perform a single beam survey in accordance with application requirements. Select appropriate range, scale, frequency and pulse repetition rate for specific application in relations to spatial resolution, bottom penetration, depth of water, and water column analysis.
H4.2 c Multibeam and Interferometric operations *(A)*					(i) Selection of platform and deployment (hull mount, pole mount, AUV, ROV) (ii) Swath coverage and resolution (iii) Object detection (iv) Sound speed profile (v) Survey speed in relation to system parameters (vi) Causes and effects of motion artefacts and water property artefacts on data (vii) Swath planning (viii) Calibration methods and procedures	Specify survey procedures and quality assurance practices to perform a multibeam or interferometric survey in accordance with application requirements. Identify deficiencies in multibeam echo sounder or interferometric sonar data, relate issues encountered to system or operational factors and respond appropriately.

					(ix) Ancillary sensors and integration (x) On-line monitoring of data being acquired (xi) Uncertainty models	
H4.2d Magnetic surveys *(I)*					(i) Operating principles and sensitivity characteristics of magnetometers and gradiometers (ii) Deployment of magnetometers and gradiometers and planning of magnetic surveys (iii) Objectives of magnetic surveys in the detection of objects such as pipelines, cables, ordnance, debris, wrecks. (iv) Display and interpretation of magnetometer and gradiometer data.	Describe the capabilities and limitations of magnetometers and gradiometers in conducting object detection surveys.
H4.2e Airborne LiDAR surveys *(I)*					(i) Calibration techniques and requirements (ii) Flight line spacing, ground speed, orientation and aircraft turning characteristics (iii) Environmental factors affecting data coverage (i.e., sunlight, clouds, rain, smoke, sea conditions, etc.)	Specify survey procedures and quality assurance practices to perform a LiDAR survey in accordance with application requirements. Specify LiDAR coverage and data density requirements for a survey. Assess LiDAR survey data (xyz point cloud and resultant depth grid) for adequacy and quality of overlap with adjacent acoustic survey data. Consider operational and environmental conditions in planning LiDAR surveys.
H4.2f Side scan sonar operations *(A)*					(i) Selection of platform and deployment (tow, hull mount, AUV) (ii) Elevation above the seafloor. (iii) Swath coverage (iv) Survey speed in relation to sonar system parameters (v) Towfish positioning (vi) Target aspect (vii) Effects of motion and water properties on images	Design and conduct a side scan sonar survey as part of an integrated data acquisition system in compliance with survey objectives. Explain and identify the effects of stratification of the water column and develop mitigating strategies for surveying in a variety of environmental conditions.

					(viii) Layback calculations	
H4.2f Side-scan sonar data interpretation *(A)*					(i) Side scan sonar backscatter and sea floor reflection. (ii) Side scan images and mosaicking (iii) Sources of distortion and artefacts from water column properties, motion (iv) Determination of height, size and position of seafloor features (v) Sonar signature of wrecks, pipelines, gas, fish and fresh water, etc.	Interpret side scan sonar imagery through assessment of individual and overlapping swaths to identify potential sonar targets for further investigation. Interpret side scan sonar imagery to assess differences in seafloor composition and topography.
H4.3 Seabed characterization						
H4.3a Classification from acoustic data *(I)*					(i) SBES full echo envelope (ii) Sub-bottom profiler full echo-envelope (iii) Side scan sonar images (iv) Synthetic aperture sonars images (v) Side scan sonar and swath echo sounders backscatter information (vi) Ground-truthing	Explain the concept of incidence angle dependence and describe the signal processing steps required to obtain corrected backscatter data for seafloor characterization. Explain the techniques available and their limitations for observing, interpreting and classifying differences in seabed characteristics from acoustic sensors.
H4.3b Classification from optical data *(B)*					(i) Hyperspectral and multispectral sensors images (ii) Underwater cameras (iii) LiDAR (iv) Ground-truthing	Explain the techniques available and their limitations for observing and interpreting differences in seabed and inter-tidal zone characteristics from optical sensors.
H4.3c Seabed sampling *(I)*					(i) Grabs (ii) Corers (iii) Use in ground-truthing	Plan a sampling campaign to classify the seabed as part of a survey. Use remotely sensed information to select sampling sites.
H4.3e Seabed characterization *(I)*					(i) Classification standards (ii) Classification methods	Consider the combination of remotely sensed information with seabed samples in a seafloor characterization survey. Apply classification standards to seabed characterization results.

H5 WATER LEVELS AND FLOW

H5.1 Principles of Water Levels

Element	**Hours** T	P	SG	**Module and content**	**Content**	**Learning outcomes**
H5.1a Tide theory *(I)*					(i) Tide generating forces, the equilibrium and real tides. (ii) Tide constituents and different types of tide. (iii) Amphidromic points and co-tidal and co-range lines. (iv) Geomorphological and basin influences on tidal characteristics	Characterize features of the tide in terms of tide raising forces and local hydrographic features.
H5.1b Non-tidal water level variations *(I)*					(i) Changes in water level caused by: atmospheric pressure, wind, seiches, ocean temperature and precipitation. (ii) Water level variations occurring in inland waters. (iii) Water level variations in estuaries, wet lands and rivers	Evaluate the effect of non-tidal influences on water levels in the conduct of a hydrographic survey.

H5.2 Water level measurements

H5.2a Water level gauges *(A)*					(i) Principles of operation of various types of water level gauges including pressure (vented and unvented), GNSS buoys, float, radar, acoustic sensors and tide poles.	Select appropriate type of water level gauge technology according to survey project operations. Install, level to a vertical reference, and calibrate a water level gauge while evaluating sources of errors and applying appropriate corrections.
H5.2b Tidal measurement *(A)*					(ii) Installing gauges, establishment and levelling of associated survey marks (iii) Determination of tide correctors from water level observations	Evaluate and select appropriate sites for water level monitoring. Select water level gauge parameters for logging data, data communication, data download and for network operation with appropriate quality control measures.
H5.2c Uncertainty in water level *(I)*					(iv) Networks of water level gauges (v) Use of satellite altimetry in determining water levels (vi) Uncertainties associated with water level measurement devices (vii) Uncertainties associated with duration of observations.	Assess and quantify the contribution of water level observations to uncertainties in survey measurements. Assess the uncertainty in water level observations due to duration of observations and distance from water level gauge.

					(viii) Uncertainties associated with spatial separation of water level measurements.	
H5.3 Tide modelling						
H5.3a Harmonic analysis *(I)*					(i) Harmonic constituents from astronomical periods (ii) Harmonic coefficients and residuals. (iii) Water level time series observations (iv) Fourier series and Fourier analysis (v) Tide tables and tide prediction	Compute standard harmonic constituents from astronomical periods. Derive harmonic coefficients and residuals from times series observations using Fourier analysis. Describe the computation of tide tables from harmonic coefficients. Compare the tidal characteristics and residuals of two tide stations using harmonic analysis.
H5.3b Ocean water level *(B)*					(i) Earth tide (ii) Harmonic astronomic component (iii) Oceanographic components (iv) Meteorological component. (v) Satellite altimetry	Describe ocean water level models and observation methods.
H5.4 Ellipsoid separation models and vertical datums						
H5.4a Separation models *(I)*					(i) Single-point and regional models (ii) Principle of Separation surface construction (iii) Ellipsoid to Chart Datum separation models (iv) Tidally defined vertical datums components, including LAT, HAT, MSL, etc… (v) Chart Datum and sounding datum (vi) Geoid as a reference surface (vii) Datums in oceans coastal waters, estuaries, rivers and lakes (viii) Interpolation of datums between water level stations (ix) Reduction of survey data to a datum	Explain the relationship between geoid, ellipsoid, and chart datum. Apply relevant offsets to convert between datums
H5.4b Vertical Datums *(A)*						Select, establish, interpolate and transfer a vertical datum in various environments.
H5.4c Sounding reduction *(A)*						Reduce ellipsoidal referenced survey data to a water level datum using an appropriate separation model with an appreciation for associated uncertainty. Apply tide correctors to reduce survey soundings to a chart datum.
H5.5 Currents						

<table>
<tr><td>H5.5a Tidally induced currents
(B)</td><td></td><td></td><td></td><td></td><td rowspan="2">(i) The relationship between currents and tides
(ii) Rectilinear and rotary tidal currents
(iii) current meters,
(iv) acoustic current profilers
(v) Drogues
(vi) Surface current radar observation
(vii) Static and mobile current measurements
(viii) Current surveys
(ix) Portraying current data</td><td>Explain the forces behind tidally induced currents and describe temporal variations.
Differentiate between tidal and non-tidal current.</td></tr>
<tr><td>H5.5b Current measurement, portrayal and surveys

(I)</td><td></td><td></td><td></td><td></td><td>Select, use techniques and instruments for current measurement.

Plan current surveys.

Use appropriate methods for processing and displaying current data.</td></tr>
</table>

H6 HYDROGRAPHIC DATA ACQUISITION AND PROCESSING

H6.1 Real-time data acquisition and control

Element	Hours			Module and content	Content	Learning outcomes
	T	P	S G			
H6.1a Hydrographic Data acquisition *(A)*					(i) Integration of data from various sensors in accordance with survey specifications to include equipment such as: • Echo-sounder (SBES, MBES) • Terrestrial and airborne LiDAR • Sound velocity profiler, surface velocity probe • Side-scan sonar • Surface positioning system • IMU / INS • Subsea positioning system (USBL) • ROVs and AUVs (ii) Data acquisition system and software (iii) Time-tagging (iv) Data visualisation (v) Data quality control methods (vi) Types and sources of errors (vii) System errors identification methods	Define, configure and validate a complex survey suite for different types of surveys in accordance with technical specification. Specify and configure communication interfaces between survey devices and system components.
H6.1b Real-time data monitoring *(A)*						Evaluate performance of an integrated survey system against survey specifications using quality control methods and address deficiencies using troubleshooting methods. Identify type and sources of system errors and undertake system analysis.
E6.1c Survey data storage and transfer *(A)*					(i) Content of files in different formats used to record data in survey planning, data acquisition and products. (ii) Multiple data types (iii) Storage requirements (iv) Proprietary vs. standard data format (v) Metadata (vi) Organisation of survey databases.	Export survey data to databases and analysis tools taking account of different data formats. Employ data storage strategies to facilitate survey data flow. Populate and maintain metadata associated with different data types and products.

H6.2 Bathymetric data filtering and estimation

Element	T	P	S G	Module and content	Content	Learning outcomes
H6.2 a Filtering and estimation of single beam data *(A)*					(i) Data cleaning techniques (manual and automated) (ii) Identification of outliers (iii) Identification and classification of systematic errors	Identify and remove outliers and validate data cleaning and other decisions made in processing single beam data. Interpret and resolve systematic errors detected during data processing

					(iv) Total propagated uncertainty - horizontal (v) Total propagated uncertainty - vertical (vi) Comparing crossing data between survey lines (vii) Comparing overlapping data between platforms (viii) Assessing coverage in relation with contour lines and features	Perform time series analysis of data from multiple sensors to detect artefacts and other errors that may exist in a survey dataset. Specify additional coverage and associated survey parameters to resolve shortcomings in survey data.
H6.2b Filtering and estimation of multibeam data *(A)*					(i) Data cleaning techniques (manual and automated) (ii) Identification of outliers (iii) Identification and classification of systematic errors (iv) Total propagated uncertainty - horizontal (v) Total propagated uncertainty - vertical (vi) Comparing crossing and adjacent data between survey lines (vii) Comparing overlapping data between platforms	Identify and remove outliers and validate data cleaning and other decisions made in processing multibeam data. Interpret and resolve systematic errors detected during data processing Perform time series analysis of data from multiple sensors to detect artefacts and other errors that may exist in a survey dataset. Assess processed data for coverage and quality, and specify remedial surveys.
H6.2c Spatial data quality control *(A)*					(i) A posteriori and a priori total propagated uncertainty (horizontal and vertical) (ii) Primary and secondary survey sensors used for quality control (iii) Relative and absolute uncertainties	Differentiate between relative and absolute uncertainties. Estimate and compare uncertainties through the use of different spatial and temporal datasets. Define procedures used to assess and accept or reject data.
H6.2d Spatial data interpolation *(I, A)*					(i) 1D polynomial interpolation (ii) Interpolating splines, B-Splines, multi-dimensional splines (iii) Spatial interpolation by inverse distance and Kriging (iv) Grids and TIN construction from spatial data (v) Contouring techniques	Choose an appropriate interpolation method and compute a surface from sparse survey measurements. *(I)* Select appropriate spatial data processing methods to create digital terrain models or gridded surfaces and contouring. *(A)*
H6.2e Spatial data representation *(I, A)*					(i) Point Clouds (ii) Surface models (iii) Raster and vector data (iv) Spatial resolution	Apply estimation procedures to survey measurements to represent data according to survey product requirements. *(I)*

					(v) Data resolution (vi) Horizontal scale and vertical exaggeration (vii) Volume computations (viii) Profiles	Select optimal parameters for data representation. *(A)*

H7 MANAGEMENT OF HYDROGRAPHIC DATA						
H7.1 Data organisation and presentation						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
H7.1a Databases *(I)*					(i) Relational databases (ii) Spatial databases (iii) Databases to hold different types of feature and geographical information	Explain the concepts of relational and spatial databases. Conceptualise, develop, and populate a spatial database to represent hydrographic survey elements and define relationships between those elements.
H7.1b Marine GIS basics *(B)*					(i) Features and feature types of point, line and polygon with marine examples. (ii) Marine and coastal data bases (iii) Datums and projections (iv) Vertical datums (v) Survey metadata (vi) Base maps and images	Identify the data types that might be used to represent features from the marine environment considering the attribute that might be associated with such features. Create a GIS project using marine spatial data. Perform spatial processing on marine data sets including datum and projection transformations.
H7.2 Marine data sources and dissemination						
H7.2a MSDI *(B)*					(i) Basic concept of MSDI (ii) Importance and role of data standards (iii) The value and benefit of good metadata (iv) Data exchange and sharing (v)	Describe the role of hydrographic data in Marine Spatial Data Infrastructures.
H7.2b Open access marine data *(B)*					(i) Open access databases including GEBCO (ii) Marine data portals (iii) Data reliability from web sources (iv) Crowd-sourced data	Distinguish between types and sources of data as a measure of reliability and utility.
H7.3 Spatial data integration and deliverables						
H7.3a Spatial data integration *(I)*					(i) Tools and method for integration and comparison of hybrid data sets (ii) Co-registration of hybrid data sets	Integrate data from multiple sources and sensor types in the conduct of a multi-sensor survey.
H7.3b Spatial data visualisation *(A)*					(i) Use of colour schemes (ii) Shading and illumination (iii) Vertical exaggeration (iv) Standards	Evaluate and select the best visualization method to highlight features of interest and quality-control a hydrographic data set.
H7.3c Deliverables *(A)*					(i) Products provided directly from source data such as sounding data files and metadata.	Describe hydrographic deliverables and produce paper products as well as digital products in accordance with specifications and standards.

					(ii) Feature databases such as wrecks, rocks and obstructions (iii) Data required for sailing directions, light lists, radio aids to navigation, port guides and notices to mariners. (iv) Digital and paper products derived from source data for various survey types and usage such as GIS and CAD files and/or geo-referenced images. (v) Reports on quality control, procedures, results and conclusions detailing processes adopted within survey operations and data processing. (vi) Standards including: • IHO S-100, and product standards such as S-102. • Standard Seabed Data Model (SSDM).	Prepare a report on a hydrographic survey.

H8 LEGAL ASPECTS						
H8.1 Product liability						
Element	**Hours**			**Module and content**	**Content**	**Learning outcomes**
	T	P	SG			
H8.1a Responsibilities of the hydrographic surveyor *(B, I)*					(i) Nautical charts. (ii) Notice to mariners. (iii) Survey notes and reports. (iv) Fundamentals of professional liability relating to surveying (v) Professional ethics relating to commercial and government projects (vi) Legal issues and liability associated with hydrographic equipment and products.	Detail the role and responsibilities of the hydrographic surveyor as required under industrial standards and national/international legislation/conventions. (B) Identify the sources of ethical guidance and discuss ethical considerations when dealing in a professional capacity with client and contracts. (I) Discuss the potential liability of the hydrographic surveyor in common hydrographic endeavors. (I)
H8.1b Contracts *(I)*					(i) Invitation to tender and survey work specifications (ii) Response to tender (iii) Contractual obligations and insurance (iv) Survey work and deliverables	Develop the technical content of an invitation to tender. Analyze the risk and develop the technical content of a response that would include details and cost of necessary resources. Interpret contractual obligations in terms of survey planning, execution and deliverables.
(v) H8.2 Maritime zones						
H8.2a Delimitations *(B)*					(i) Historical development of 1982 UNCLOS Baselines – normal (including closing lines); straight and archipelagic (ii) Base points (iii) Baselines (iv) Internal waters. (v) Territorial seas. (vi) Contiguous zones. (vii) Exclusive Economic Zone (viii) Extended continental shelf. (ix) High seas	Define the types of baselines under UNCLOS and how the territorial sea limit and other limits are projected from them, including the use of low tide elevations. Conduct and document surveys with appreciation for the type of baselines and the implication of the baselines. Describe the legal operational constraints that apply within maritime zones.
E8.2b Impact of surveys *(I)*					(i) Vessel speed restrictions and permanent and temporary threshold shifts (hearing) and harassment levels for marine mammals. (ii) Limitation of use of physical techniques such	Specify appropriate procedures and limitations for use of surveying equipment in compliance with environmental laws and marine protected area regulations.

					as bottom sampling and moorings in environmentally sensitive areas. (iii) Respect for cultural traditions in relation to use of the environment (iv) Marine protected areas	

CMFP: COMPLEX MULTIDISCIPLINARY FIELD PROJECT

Submissions should include the following information to demonstrate that a programme provides for a minimum aggregate period of **at least four weeks**, supervised and evaluated Complex Multidisciplinary Field Project (Section. 4.2 of the "GUIDELINES FOR THE IMPLEMENTATION OF THE STANDARDS OF COMPETENCE FOR HYDROGRAPHIC SURVEYORS").

The Complex Multidisciplinary Field Project for Category A level shall comprise a comprehensive field survey incorporating different aspects of hydrography in a complex environment with varying sea-floor and oceanographic conditions.

Students should undertake:

- Survey specification and planning;
- Hydrographic and oceanographic measurements using a comprehensive suite of instruments;
- Data processing, quality control and quality assurance ;
- Preparation of different type of product deliverables and reports.

Note: The Complex Multidisciplinary Field Project does not include the practical exercises that form a part of the course modules syllabi and are designed to complement the theory component (Section 4.1 of the "GUIDELINES FOR THE IMPLEMENTATION OF THE STANDARDS OF COMPETENCE FOR HYDROGRAPHIC SURVEYORS").

THE FOLLOWING TABLE **MUST** BE COMPLETED AND SUBMITTED IN ADDITION TO A DETAILED AND COMPREHENSIVE NARRATIVE DESCRIPTION OF THE FINAL FIELD PROJECT MODULE:

- Learning outcomes, content and assessment must be described in order to reflect the different activities and objectives of the final project.
- For each task, the number of Theory and Practical contact hours and Self Guidance hours must be provided.
- A reference of activities and tasks of the comprehensive final field project to the related Essential subject must be provided.

Note: Hours referenced in the following table are also to be included in the cross-reference table under appropriate elements.

CMFP: Complex Multidisciplinary Field Project							
Tasks:	Hours			Module modules reference	Related Foundational or Hydrographic science subject:	Content	Learning outcomes:
	T	P	SG				
Planning							
Preparation							

Acquisition							
Processing							
Deliverables							
Reports							
Total							