INTERNATIONAL FEDERATION OF SURVEYORS	INTERNATIONAL HYDROGRAPHIC ORGANIZATION	INTERNATIONAL CARTOGRAPHIC ASSOCIATION
		

STANDARDS OF COMPETENCE FOR NAUTICAL CARTOGRAPHERS AND MARINE GEOSPATIAL ANALYSTS

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

1. PREFACE

All components of the hydrographic surveying and marine cartography professions face the challenge of how best to ensure the maintenance of high standards and best practices based on minimum standards of competence worldwide.
To achieve these objectives, standards of competence have been developed by the International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC).
The IBSC is composed of members of known competence in the civil, governmental or educational sectors of hydrographic surveying and nautical cartography, selected to provide as wide as possible a spectrum of knowledge and experience in educational practices, hydrography, and nautical cartography, from different geographical areas. The members of the IBSC belong to three international organizations: International Federation of Surveyors (FIG), International Hydrographic Organization (IHO), and International Cartographic Association (ICA).
The latest edition of the standards of competence for nautical cartographers (S-8) and hydrographic surveyors (S-5) was published in June 2018.
Since May 2024, IBSC has been working to update these standards to keep pace with new technologies, methodologies, specifications, and the concept of data centricity, which prioritizes data as a highly valuable resource. In developing this new edition, the IBSC liaised with the hydrographic and cartographic community and received input from many stakeholders: Hydrographic offices, academies, universities, industries, private companies, professional associations, and individuals. The input was crucial in expressing the needs of the community and guiding the Board in updating the standards S-8/S-5, while remaining committed to its mandate.

For the purpose of this publication the words:
- **must**: indicates a mandatory requirement;
- **should**: indicates a recommended requirement;
- **may**: indicates an optional requirement

Changes to S-8 and S-5 standards will be released by the IHO as a New Edition, Revision, or Clarification as per the IHO Resolution 02/2007.
The associated version control numbering to identify changes (n) to the S-8 and S-5 Standards must be as follows:
- **New Editions** denoted as **n**.0.0
- **Revisions** denoted as n.**n**.0
- **Clarifications** denoted as n.n.**n**

2. INTRODUCTION

The IBSC can recognize two different categories of programmes: Category “A” and Category “B”. A Category “A” programme provides a comprehensive and broad-based knowledge in all aspects of the theory and practice of hydrography, nautical cartography and allied disciplines. A Category “B” programme provides a practical comprehension of hydrographic surveying, nautical cartography and related subjects.
Institutions and professional bodies must use the Standards when submitting their education/training programmes and competence schemes for IBSC Recognition.
In addition, even if they are not applying for Recognition, education and training providers should adopt the Standards for planning, scheduling and delivering their programmes.

Publication S-8 aims to provide a set of minimum competencies required for nautical cartographers in geospatial data analytics.
The intention is that a Category "A" individual with appropriate experience and education, would be a senior professional in their chosen field (government, industry, academia). Category "B" individuals with appropriate experience would be technical practitioners leading and delivering products and services to meet specifications and outcomes.

This document is structured to enable the student to acquire incrementally the knowledge required in order to be a competent cartographer in geospatial data analytics at the Category "A"/Category "B" level.
Each programme is made up of a series of lectures, tutorials, practical exercises, self-study/self-guided hours laboratories and project work in the cartographic field. More specifically, the sequence of the subjects is designed so that any new subject builds upon the content and the knowledge of the preparatory subjects.
The theoretical subjects are complemented with a final cartographic project (respectively called *Comprehensive Final Cartographic Project* (CFCP) for Category B programme and *Complex Multi-disciplinary Cartographic Project* (CMCP) for Category "A" programme) that includes all those items required to enable the student to solve efficiently and effectively, at different levels of knowledge, problems associated with the planning and production of modern nautical charts, S-57 ENCs, S-101 ENCs, and special purpose charts according to internationally adopted specifications.
Successful completion of the theoretical subjects and the final cartographic project will enable the student to obtain the appropriate Category "A" or Category "B" educational certification on Nautical Cartography in Geospatial Data Analytics.

3. DEFINITIONS

3.1 Subjects, topics and elements

The S8-B standard contains the following list of ***B**asic subjects and **E**ssential subjects*:

Topics and Elements:

- Each **Basic** or **Essential** *subject* comprises a list of *topics* which are denoted by Bx.y, Fx.y or Cx.y;
- Some of the *topics* contain *elements* which are denoted by Bx.y<c>, Fx.y<c> or Cx.y<c> .

For example, the *subject* E7 "Nautical Cartography" contains the *topic* E7.1 "The Nautical Chart" that has the *element* E7.1a "Evolution of nautical charts".

3.2 List of content and Learning outcomes

It is important to understand that each *topic* and/or *element* is associated with:

- a *content* list. 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*.
- one or more intended *learning outcomes* that a student should be able to achieve on completion of the programme.

A level of knowledge has been defined for each *topic/element*. It is indicated in italics in the left column, by a letter (*B*= Basic, *I*= Intermediate, *A*= Advanced) that complements the learning outcome description associated with each element.
All *learning outcomes* must be assessed. This may be done through one of, or a combination of, the following: examination, assessed exercise or presentation, laboratory report, prior to commencement of the final project.

3.3 Final Cartographic Project

The Programme must include a supervised and evaluated final Cartographic Project that reflects the level of knowledge outlined in the programme.
For students of S-8 Category "B" Programme, a *Comprehensive Final Cartographic Project* (CFCP) is required, which will include all those items expected to enable the student to compile and compose efficiently a modern nautical chart/ENC and special purpose charts according to internationally adopted specifications.

4. PROGRAMME PREPARATION AND SUBMISSION

The preparation of a programme submission to the IBSC must be in accordance with the document entitled "Guidelines for the implementation of the standards of competence for hydrographic surveyors and nautical cartographers" Ed.XX.XX XX. This document is available from the IHO website: https://iho.int/en/standards-and-specifications
The cross-reference table is a mandatory requirement for a programme submission and must be completed.
A template is specified and is available from the IHO website: https://iho.int/en/ibsc-templates

LIST OF ACRONYMS AND INITIALISMS USED IN THIS DOCUMENT

1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
AI	Artificial Intelligence – a form of Expert System
AIS	Automatic Identification System
B	Basic (level of knowledge)
B/W	Black and White
CATZOC	Category of Zones Of Confidence
CIE	International Commission on Illumination
CCP	Comprehensive Cartographic Project
CPU	Central Processing Unit
DBMS	DataBase Management System
DEM	Digital Elevation Model
DIGEST	Digital Geographic Exchange Standard
DXF	Digital Exchange Format
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
ENC	Electronic Navigation Chart
EPSG	European Petroleum Survey Group – part of IOGP
EROS	Earth Resources Observation and Science
ETRS89	European Terrestrial Reference System 1989
FAIR	Findable, Accessible, Interoperable, Reusable
FIG	International Federation of Surveyors
GeoTIFF	Geographic Tag Image File Format
GIS	Geographic Information System
GISc	Geographic Information Science
GML	Geographical Markup Language
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS80	Geodetic Reference System (1980)
GUI	Graphical User Interface
HLS	Hue, lightness/luminance, saturation
I	Intermediate (level of knowledge)
IALA	International Association of Lighthouse Authorities
IBSC	International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers
ICA	International Cartographic Association
IHO	International Hydrographic Organization
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
INT	International
IOGP	International Oil & Gas Producers
ISO	International Standards Organization
ITRF	International Terrestrial Reference Frame
JPEG	Joint Photographic Experts Group
LAN	Local Area Network
LiDAR	Light Detection And Ranging

MatLab	Mathematics Laboratory software
ML	Machine Learning – a type of Expert System
MSDIs	Marine Spatial Data Infrastructures
OGC	Open Geospatial Consortium
P	Practicals (fieldwork and/or laboratories)
QA	Quality Assurance
QC	Quality Control
RADAR	RAdio Detection And Ranging
RAM	Random Access Memory
RENC	Regional ENC Coordinating Centre
RGB	Red, Green, Blue
RHC	Regional Hydrographic Commissions
RIP	Raster Image Processing
RMSE	Root Mean Square Error
S-4	IHO Publication S-4 *Regulations for International (INT) Charts and Chart Specifications of the IHO*
S-11	IHO Publication S-11 *INTernational Chart Web Catalog*
S-52	IHO Publication S-*52 Specifications for Chart Content and Display Aspects of ECDIS*
S-57	IHO Publication S-57 IHO *Transfer Standard for Digital Hydrographic Data*
S-58	IHO Publication S-58 *ENC Validation Checks*
S-65	IHO Publication S-65 *ENCs: Production, Maintenance and Distribution Guidance*
S-67	IHO Publication S-65 Mariners guide to accuracy of Electronic Navigational Charts (ENC)
S-99	IHO Publication S-99 *Operational Procedures for the Organization and Management of the S-100 Geospatial Information Registry*
S-100	IHO Publication S-100 *IHO Universal Hydrographic Data Model*
S-101	IHO Publication S-101 *ENC Product Specification*
S-102	IHO Publication S-102 *Bathymetric Surface Product Specification*
SDI	Spatial Data Infrastructure
SDTS	Spatial Data Transfer Standard
SENC	System Electronic Navigation Chart
SG	Self-guided exercises (or student's personal independent work)
SOLAS	Safety of Life at Sea
SSDM	Seabed Survey Data Model
SVG	Scalable Vector Graphics
T	Theoretical (theory through lectures)
TIN	Triangulated Irregular Network
UKOOA	UK Offshore Operators Association
UNCLOS	United Nations Convention on the Law of the Sea
UTM	Universal Transverse Mercator
WEND	Worldwide Electronic Navigational Chart Database
WGS84	World Geodetic System (1984)
WWW	World Wide Web
XML	eXtensible Markup Language
ZOC	Zones of Confidence

S-8B STANDARDS

CONTENT
AND
INTENDED LEARNING OUTCOMES

1. **BASIC SUBJECTS**

B1: Mathematics, Statistics, Theory of Errors		
Topic/Element	**Content**	**Learning outcomes**
B1.1 Coordinate geometry *(I)*	(i) Coordinate systems (ii) Linear and quadratic functions (iii) Functions in plane geometry for lines and planes. (iv) Geometry of the ellipse	Describe and use coordinate systems. Describe and use equations for lines and planes. Calculate distances between points, the intersection between lines and planes and the distance from a point to a plane. Compute lengths and coordinates on an ellipse
B1. 2 Linear Algebra *(I)*	(i) Vector and affine spaces, vector and inner products, norms (ii) Linear equations, determinants (iii) Analytical geometry, line and plane equations (iv) Linear operators, matrix representation, composition, inverse, transpose (v) Translations, rotations, coordinate transformations.	Describe and apply 2D and 3D transformations involved in mapping. Solve linear equations using matrix methods.
B1.3 Trigonometry *(B)*	(i) Basic trigonometry (ii) Spherical trigonometry (Sphere, great circle, rhumb lines, sphere angles, spherical triangles, and spherical excess).	Describe the use of plane and spherical trigonometry in cartography problems.
B1.4 Statistics and sources of uncertainties *(I)*	(i) Statistics of samples, populations and measurements (ii) Sources of uncertainties and their classification (iii) Random variables, mean, variance, standard deviation (iv) Level of confidence (v) Covariance and correlation (vi) Estimation of mean, variance, covariance (vii) Normal distribution.	Describe and classify possible sources of error because of utilization of a chart (i.e. measurement, digitization). Estimate and interpret the mean, variance, covariance, and standard deviation from data sets.

B1.5 Least squares *(I)*	(i) Least squares principle (ii) Solution of problems using least squares estimation (iii) Definition and use of Root Mean Square Error (RMSE)	Perform least square calculations using available applications and interpret results.
B1.6 1D and 2D Interpolation *(I)*	(i) 1D and 2D spatial interpolation	Describe and apply 1D and 2D spatial interpolation methods.
B2: Information and Communication Technology		
Topic/Element	**Content**	**Learning outcomes**
B2.1 Computer systems *(B)*	(i) Computer Systems and peripherals. (ii) Communication board, serial links, communication ports buffers, Ethernet links, data transmission rates (iii) Client server (architecture, software and communication) (iii) Communication protocols (iv) Operating systems (v) Device drivers (vi) Input/output devices (scanners, digitizers, printers, plotters) and associated technical characteristics/specifications (vii) Data storage: device types, the cloud, network-based storage advantages, limitations. (viii) Cloud computing: Overview ● Essential characteristics, ● Cloud infrastructure concepts	Describe the different components of a computer system and the alternative ways of communication between systems and peripheral devices. Describe the role of a device driver and its relation to data transfer. List technical specifications for input/output devices used in cartographic operations. Describe the most used data storage devices and the cloud. Compare and contrast data storage options in the context of spatial data requirements. Describe the characteristics of a cloud computing environment, its advantages/ limitations
B2.2 Programming basics *(I)*	(i) Basic operations of a computer program or script (ii) File types (binary, text, XML) (iii) Algorithms (loops, conditional instructions) (iv) Programming languages (e.g. Visual Basic, Visual C++, Python, Java, Lua, XSLT) (v) Scientific computation environments (e.g. Matlab) (vi) Application to data exchange, file and format conversion.	Develop software programs or scripts for simple data format conversion and/or basic algorithmic computation. Perform simple computations using common application environments.
B2.3 Databases and DataBase Management Systems (DBMSs)	(i) DataBase Management Systems and query languages (ii) Overview of Geospatial Data, types of Geospatial Data (iii) Relational databases.	Describe and design a simple geospatial database. Create/populate a geospatial database and query its content.

(I)	(iv) Importance of Data Management and Metadata, Overview of Metadata Standards (ISO 19115, Dublin Core, etc.) (v) Tools for Creating and Editing Metadata Records, Conducting Metadata Searches (vi) User Roles and permissions (vii) Open source geospatial software and Database management, e.g., QGIS, PostgreSQL.	Identify and differentiate between various types of geospatial data. Explain the importance of metadata and data management in geospatial contexts. Understand and apply metadata standards in geospatial data management. Create and edit comprehensive metadata records. Classify roles and permissions to secure geospatial data Use open-source software to create, populate, modify, and query a database.
B2.5 Web and network communications *(B)*	(i) Networks (LANs) (ii) Network and cloud storage, file sharing (iii) Internet (iv) Network integrity (v) Communication protocols.	Describe the different network communication configurations and associated protocols used in data transfer/exchange applications.
B3: Earth Sciences		
Topic/Element	**Content**	**Learning outcomes**
B3.1 Marine geomorphology and marine geographic features *(B)*	(i) Marine Geomorphology ● concepts ● features ● processes.	Describe and identify marine geographic features, such as coastline, bays, inlets, capes, oceans, seas, channels, etc. Describe processes of deposition and erosion in coastal, fluvial, and glacial environments
B3.2 Marine geophysics *(B)*	(i) Gravity (ii) Magnetics (iii) Seismic profiles.	Describe the data acquired by gravity, magnetic, and seismic surveys. Describe the geophysical properties of undersea features.
B3.3 Ocean properties and dynamics *(B)*	(i) Seawater properties (ii) Ocean Dynamics • nature • motion • tides • currents.	List the main properties of seawater. Describe ocean dynamics in terms of currents and tidal variations.
B3.4 Seafloor characteristics *(B)*	(i) Sediment types (ii) Submerged aquatic vegetation (iii) Corals (iv) Outcropping rocks.	Distinguish common seafloor characteristics.

2. **ESSENTIAL SUBJECTS**

<table>
<tr><th colspan="3">E1: General Geodesy</th></tr>
<tr><th>Topic/Element</th><th>Content</th><th>Learning outcomes</th></tr>
<tr><td>E1.1 Introduction to Geodesy

(I)</td><td rowspan="4">(i) Shape and size of the Earth as a geoid, spheroid, and sphere
(ii) Definition of the authalic sphere as a model of the Earth
(iii) Definition of latitude and longitude on the ellipsoid and the sphere
(iv) Local geodetic reference frames
(v) Terrestrial reference systems and reference frames
(vi) Datums and datum transformation techniques
(vii) Vertical datums
(viii) Modern Coordinate Reference Systems (CRS) and Geodetic Datums [GRS80, WGS84, ETRS89, ITRF]
(ix) The EPSG Geodetic Parameter Catalogue and its use
(x) Computations on the sphere
(xi) Computations on the ellipsoid.
(xii) Vertical datums and associated transformations.</td><td>Describe the figure of the Earth as a geoid, a spheroid and a sphere.
Describe the geometry of lines on the sphere and the ellipsoid.
Analyze the characteristics of loxodrome and orthodrome and compute positions on these lines using appropriate applications.</td></tr>
<tr><td>E1.2 Coordinate systems, frames, and datums

(I)</td><td>Define and specify geodetic reference systems (GRSs) and associated reference frames.</td></tr>
<tr><td>E1.3 Geodetic transformations and associated computations

(I)</td><td>Describe and apply transformation methods between:
a. CRSs and
b. Horizontal and vertical datums
using available software.</td></tr>
<tr><td>E1.4 Spherical and ellipsoidal computations

(I)</td><td>Perform grid, spherical, and ellipsoidal computations on the spherical and ellipsoidal surfaces using available software.</td></tr>
<tr><th colspan="3">E2: General Cartography</th></tr>
<tr><th>Topic/Element</th><th>Content</th><th>Learning outcomes</th></tr>
<tr><td>E2.1 Elements of Cartography

(I)</td><td>(i) Definition of a map and a nautical chart
(ii) Characteristics of maps, charts, and Electronic Navigational Charts (ENCs)
(iii) The concept of scale
(iv) Categorization of maps/charts in relation to scale and purpose
(v) Cartographic design
(vi) Representing the figure of the Earth on a flat surface
(vii) Abstract representation and generalization
(viii) Symbolization
(ix) Static & dynamic maps/charts.</td><td>Describe and detail the fundamental cartographic elements and associated characteristics of maps, nautical charts, and Electronic Navigational Charts.
Describe the importance of cartographic design, symbolization and dynamic portrayal.</td></tr>
</table>

E2.2a Map projections *(I)*	(i) Map/chart projections, their properties and associated distortions (ii) Categories of map/chart projections (cylindrical, conical, azimuthal) (iii) Properties of map/chart projections (conformal, equivalent, equidistant) (iv) Methodology for the selection of a cartographic projection (v) Projection formulae and planimetric coordinates (vi) Projection systems (vii) Worldwide cartographic systems such as Universal Transverse Mercator - UTM, Gauss-Krüger - GK, and Universal Polar Stereographic - UPS.	Describe the properties and distortions in different categories of projections used for maps and charts. Explain the procedure for selecting a specific projection and apply appropriate projection formulae. Describe projection systems with emphasis on the UTM projection system. Analyze and classify the projections used for nautical charts and Electronic Navigational Charts -_ENCs
E2.2b Study of map distortions *(I)*	(i) Definition of Scale Factor (ii) Tissot's theorem (iii) Principal directions (iv) Tissot's indicatrix (v) Distortions in distances, areas and angles associated with specific map projections (Mercator, Transverse Mercator, Lambert conformal conic). (vi) Selection of the appropriate cartographic projection	Describe the scale factor and its properties. Identify the prevailing properties of a projection using Tissot's indicatrix. Compute bearings, distances and areas on projections used in nautical cartography. Evaluate distortions and apply the process for the selection of the appropriate projection and associated parameters for specific use.
E2.3 Abstract representation and generalization *(I)*	(i) Rationale for abstract representation and generalization (ii) Model, semantic, and cartographic generalization (iii) Elements of generalization (iv) Controls of generalization (v) Rules for semantic generalization (vi) Cartographic generalization of point, line, and area features (vii) Cartographic generalization algorithms and associated parameters (viii) Guidelines and methodologies for automated generalization process	Explain the rationale for abstract representation and generalization. Distinguish between model, semantic, and cartographic generalization. Classify and detail the processes of generalization. Rationalize the selection of generalization algorithms. Perform generalization of point, line, and polygon features using: ● appropriate generalization rules and processes using algorithms and associated parameters' values ● manual processes.
E2.4 Relief representation	(i) Rationale for terrain and sea bottom representation	Explain the reasons underpinning terrain and sea bottom representation.

(I)	(ii) Methods for terrain and sea bottom representation (contouring, zoning, shading, etc.) (iii) Relative and absolute accuracy in contouring (iv) Digital representation of the relief – Digital Elevation Models [DEM] and methods of interpolation (Inverse distance, TIN, GRID, Kriging….). (v) Extraction of DEM by-products (contours, slope, aspect, volume….).	Describe in detail and compare common methods used for terrain and sea bottom representation. Select and apply the appropriate interpolation method for a specific purpose and assess the results. Extract by-products from a created DEM.
E2.5 Scales of measurement of cartographic and geospatial variables *(B)*	(i) Scales of cartographic data measurement: ● Nominal scale ● Ordinal scale ● Interval scale.	Categorize cartographic and geospatial variables according to their scale of measurement.
E2.6 Symbolization (*I)*	(i) Rationale for symbolization (ii) Concepts of symbolization (iii) Graphical elements of symbols (point, line, area) (iv) Visual variables (shape, size, orientation, colour, pattern, etc.) (v) Basic rules of symbol design and use i) Symbol libraries, their content, and use.	Explain the rationale for symbolization. Identify and describe visual variables. Use visual variables with respect to the scale of cartographic data measurement. Distinguish types of symbols and their use Explain the need for and use of symbol libraries.
E2.7 Colour (*B)*	(i) Rationale for the use of colour (ii) The nature of colour (spectral colours vs. reflected colours) (iii) The dimensions of colour (iv) Systems of colour modeling/ specification (CIE, Munsell) (v) Electronic display colour models (RGB, HLS…) (vi) Choosing colours for maps/charts (vii) Colour conventions (viii) Patterns (B/W–colour) (ix) Colour for computer graphics (screens, plotters, printers) (x) Colour for printing.	Explain the rationale, role, and importance of colour and its use in mapping and charting. Outline the principal colour conventions for maps and charts and their features. Differentiate colour for various computer graphics and printing applications.

E2.8 Map/chart lettering, toponymy and labeling *(I)*	(i) Rationale of toponymy (ii) Lettering and its functionality (iii) Lettering style, size, and colour (iv) Relationship between toponyms and the use of lettering (v) Naming conventions (vi) Positioning guidelines for toponyms of point, line, and area features (vii) Placement of toponyms with respect to the scale/graticule. (viii) Automatic placement of toponyms and text	Explain the rationale and the functionality of toponymic display. Describe and demonstrate appropriate use of lettering in relation to the inherent characteristics of cartographic features. Describe and apply placement rules for toponyms and associated features on maps/charts at various scales. Use software for automatic placement of toponyms and text.
E2.9 Cartographic design *(I)*	(i) Principles of good and efficient cartographic design (ii) Design requirements for different map/chart categories and scales (iii) Scale selection (iv) Graphic organization (map/chart layout) (v) Visual balance (vi) Types of data (point, linear, areal, 3D) (vii) Representation (of reality) (viii) Visual hierarchy (ix) Presentation (x) Use of colour/figure-ground/contrast.	Describe and apply the principles and characteristics underpinning good cartographic design. Identify selected maps/charts in terms of the principles of good cartographic design (with proper justification).
E2.10 Map/chart compilation and composition *(I)*	(i) The cartographic compilation and composition process (ii) Compilation planning and scheduling (iii) Source data and map/chart scale (iv) Map/Chart data quality elements ● Accuracy (positional, thematic, temporal) ● Resolution (spatial, temporal) ● Consistency (logical, domain) ● Currency ● Completeness ● Clarity (v) Data quality standards (vi) Assessment of appropriateness of source data for map or chart compilation (vii) Source data homogenization (viii) Quality control process	Describe and apply the logical process of cartographic compilation and composition identifying discrete stages. Differentiate between the appropriate compilation processes for maps and nautical charts of different themes and scales. Specify the advantages and disadvantages of analog and digital compilation processes. Describe and apply cartographic data quality assessment processes. Develop a digital compilation worksheet covering a defined region and utilize it for map/chart composition and symbolization.

	within a quality management system (ix) Digital compilation worksheet.	
E3: Hydrography and Nautical Products		
Topic/Element	**Content**	**Learning outcomes**
E3.1 Hydrography, nautical cartography, and navigation *(I)*	(i) Rationale for hydrographic and other surveys (ii) Relationship between hydrography, nautical cartography, and navigation (iii) Hydrographic and other data for map/chart purposes.	Define hydrography, nautical cartography, and types of navigation, explaining their relationship. Identify hydrographic and other data for map/chart purposes.
E3.2 Navigational hazards and aids to navigation *(B)*	(i) Navigational hazards (ii) Types of buoys and beacons (iii) The IALA system (iv) Automatic Identification Systems (AISs).	Identify and describe navigational hazards. Describe the principal fixed and floating aids to navigation and their significance for nautical charting. Describe AIS and its use.
E3.2a Nautical data sources *(B)*	(i) Hydrographic surveys and reports (ii) Maritime Safety Information e.g. Notices to Mariners - NtM (iii) Shoreline surveys (iv) Navigational hazards (v) Aids to navigation updates (vi) Geographic names (including undersea features) (vii) Overhead obstruction clearances (viii) Offshore installations (ix) Regulatory publications	Describe the components of different nautical data source deliverables. Outline the AtoN update process. List the authoritative sources for various chart features. Describe the monitoring and update process through international regulatory publications.
E3.3 Navigational publications *(I)*	(i) Notices to Mariners (ii) Sailing directions (iii) Light and radio lists (iv) Tides and current tables.	Describe and use content derived from nautical publications in a charting context.
E3.4 Hydrographic surveys *(I)*	(i) Types and scales of hydrographic surveys (ii) Hydrographic survey operations (former and modern methods). (iii) Special-purpose surveys and reports (iv) Data sources, formats, accuracy, and applications.	Differentiate the types and purpose of various hydrographic surveys. Analyze and select hydrographic surveys and associated data are essential to ensure nautical charting integrity.
E3.5 Positioning *(B)*	(i) Evolution of technology in positioning (ii) Satellite (GNSS,...) radio and other systems for positioning (iii) Relative accuracy of commonly available systems. (iv) Error sources in positioning	Describe different methods and systems used for positioning with respect to their accuracy. Describe the principal characteristics of Global Navigation Satellite Systems (GNSS).

		Differentiate data for positional consistency in relation to the positional method employed.
E3.6 Depth measurement *(B)*	(i) Evolution of technology and methodologies for depth measurement (ii) Hydrographic vs. bathymetric data measurement. (iii) Error sources in depth measurements.	Describe different methods and associated accuracies used in depth measurement. Describe the suitability of different depth measurement methods to achieve specific surveying and charting objectives. Differentiate data for depth measurement uncertainty in relation to the measurement methods employed.
E3.7 Hydrographic data management *(I)*	(i) Management of hydrographic data in the chart compilation process ii) Databases for hydrographic data.	Specify hydrographic data management processes in the chart compilation procedure. Specify the content and use of a hydrographic source database.
E4: Data for Nautical and Special Purpose Charting		
Topic/Element	**Content**	**Learning outcomes**
E4.1 Coastline and topographic data *(I)*	(i) Data sources appropriate for inclusion in nautical charting for coastline and topography (ii) Categories and corresponding definitions of coastline (iii) Relevance of scale for selecting appropriate data sources (iv) Principles of selection and depiction of topography (v) Principles of selection and depiction of bathymetry (vi) Bathymetric data quality (vii) The concept and use of CATZOC. (viii) Bathymetric data products, e.g., GEBCO, crowd-sourced bathymetry data (refer to IHO Publication B-12).	Classify different categories of coastline and their depiction. Harmonize topographic data from various data sources for depiction on charts with regard to scale.
E4.2 Bathymetric data *(I)*		Analyze bathymetric data sources for use in nautical and special-purpose charts. Define and use CATZOC. Evaluate and harmonize hydrographic/ bathymetric data from various data sources and utilize them for depiction on charts with regard to scale/purpose.
E4.3 Encoding and portrayal of nautical data *(I)*	(i) Natural features (skin of the earth) (ii) Hazards to navigation (iii) Aids to navigation (iv) Routeing measures (v) Regulated areas (vi) Administrative areas (vii) Offshore installations	Use selected data sources for hazards and aids to navigation. Apply specifications to encode nautical data features according to documented standards. Apply the relationship between feature attribution and portrayal on ENC and automated chart products.
E4.4 Sailing directions and nautical publications	(i) Identification of textual and administrative data suitable for graphic presentation (boundaries, environmental areas, traffic routing etc.)	Analyze the relationship between nautical charts and textual data sources and their use (sailing directions and other nautical publications including reports, lists and tabular data).

(I)	(ii) Symbiotic relationship between textual and graphic data. (iii) E-publications.	Assess available administrative data for consistency in its graphical depiction and/or textual promulgation.
E4.5 Source data adjustment (*B)*	(i) Chart datums: horizontal and vertical (ii) Principles of horizontal and vertical datums (iii) Methodologies for adjusting data against various datums (iv) Adjusting data by using software.	Define horizontal and vertical datums. Identify horizontal and vertical datums commonly used in cartographic data sources. Compute horizontal and vertical adjustments of data referred to various datums using software applications.
E4.6 Oceanographic information *(B)*	(i) Identification of appropriate oceanographic data sources (ii) Depiction of oceanographic information (iii) Tidal and current information.	Describe the sources and characteristics of oceanographic data. Differentiate oceanographic data for its depiction on nautical charts. Depict/display tidal and current information on nautical charts and special purpose charts.
E4.7 Magnetic data *(B)*	(i) Magnetic variation and anomalies, computation and appropriateness for charting. (ii) Magnetic data sources utilization, computations, encoding practices and portrayal	Explain "magnetic variation". Compute magnetic variation for specified positions/areas and time using appropriate software. Encode and portray magnetic anomalies.
E4.8 Metadata *(I)*	(i) Metadata for digital data and chart products. (ii) FAIR data principles.	Explain the purpose and importance of creating and using metadata according to appropriate standards. Compile and utilize metadata. Explain the rationale for data sharing and the use of FAIR data principles.
E4.9 Quality Management System(s) for chart production *(I)*	(i) Nautical chart production processes and their content (ii) Quality Management System(s) (iii) Quality Control (QC) and Quality Assurance (QA) processes for the compilation and production of nautical and special-purpose charts (iv) Data quality implications relevant to scales, density, accuracy, time, different datums, technologies, etc.	Analyze nautical chart production processes and their content. Select and apply QC processes to nautical chart and special-purpose chart production. Identify and describe the implications on data quality arising from the variability of source data types. Apply automated quality validation checks in chart production.
E4.10 Data for special-purpose charting *(B)*	(i) Requirement, use, and design of special-purpose charts (ii) Data types: ● Subsurface ● Imagery ● Geotechnical ● Environmental ● Engineering and assets	Describe special-purpose charts and their uses. Identify and list data types for particular special-purpose charts.

E5: Photogrammetry and Remote Sensing		
Topic/Element	**Content**	**Learning outcomes**
E5.1 Photogrammetry and Remote Sensing application to charting *(B)*	(i) Development of Photogrammetry and Remote Sensing: brief history and context (ii) Introduction to equipment types: sensors and formats of aerial photographs and remotely sensed images (iii) Basics of photogrammetric and remote sensing geometry in the context of adjustment and application for charting: ● Image scale, relief and radial displacement ● Theory and implementation of spatial rectification (iv) Positional control including use of aerial GPS. (v) Satellite-derived bathymetry (SDB)	Describe basic geometrical principles applicable to aerial photography and imaging. Describe the use of photogrammetric and remotely sensed data sources to define topographic features for charting. List remotely sensed techniques applicable to depth measurement. Describe rectification and control methods. Describe data acquisition from SDB
E5.2 Sensor data sources *(B)*	(i) Characteristics of commonly available photogrammetric and satellite sensors (such as EROS; IKONOS; SPOT; Landsat; WorldView, GeoEye-1, QuickBird panchromatic, Sentinel, …) and associated data (ii) Pansharpening techniques	Identify the characteristics of commonly available photogrammetric and satellite sensor data sources. Describe the merging of high-resolution panchromatic and lower-resolution multispectral imagery to create a single high-resolution colour image. Compare and contrast the use of various imagery for charting.
E5.3 Geometric modeling *(B)*	(i) Utilization of different imagery: panchromatic, multi-spectral bands; colour, laser, and altimetry (ii) Image geo-referencing (iii) Ortho-image production and utilization. (iv) Establishment of the requirements for mapping/charting (v) Satellite Remote Sensing and Imagery Processing Software (vi) Identification of different levels of detail (vii) Procedures for data extraction and automated feature	Describe the process of preparing photogrammetric and remotely sensed imagery for feature extraction. Explain the approach to be taken for effective feature extraction suitable for charting.
E5.4 Data management, processing, and analysis *(B)*		Define the steps involved in the Remote Sensing processing Software Describe geo-reference procedures for photogrammetric and remotely sensed imagery. Identify changes to existing nautical charting content with regard to more recent imagery sources. Describe methods for data and automated feature extraction

E5.5 Shoreline delineation, feature extraction, and satellite bathymetry *(I)*	extraction. (viii) Methods of Change Detection	Perform shoreline extraction concerning the state of the tide at the time of imagery. Determine intertidal areas. Utilize remotely sensed images for bathymetry Extract hydrographic features: reefs, rocks, hazards, seabed features. Use specific applications for automated feature extraction.
E5.6 Airborne topographic and bathymetric LiDAR systems and data products *(B)*	(i) Airborne, topographic, and bathymetric LiDAR systems and their capabilities (ii) Modeling land and seabed topography (iii) Water surface mapping techniques (iv) Environmental mapping techniques (v) Temporal mapping techniques (vi) Determining change using LIDAR (airborne and terrestrial) data. (vii) Calibration of topographic and bathymetric LIDAR data after sea-truthing	Describe commonly available LiDAR systems and list their capabilities and uses. Describe the capabilities of LiDAR systems for determining coastal features and changes over time. Identify how such techniques are applicable to charting. Choose topographic and bathymetric LIDAR data after calibration
E6: Geospatial Information and Processing		
Topic/Element	**Content**	**Learning outcomes**
E6.1 Overview of Geospatial Information Science and systems *(I)*	(i) Geospatial Information Science and data (ii) Geographic Information Systems [GIS] and applications (iii) Graphical User Interface (GUI).	Define Geospatial Information Science and its role in spatial data processing and utilization. Elaborate on the characteristics and the functionality of a GIS with emphasis in the charting process.
E6.2 Geospatial data modeling *(I)*	(i) Vector data models (ii) Raster data models (iii) Representation of point, line and area data in vector and raster models (iv) Geospatial data structures (v) Industry standard data model (e.g. SSDM) (vi) Spatial resolution and Scale (vii) Model suitability criteria (viii) Topology: definition, levels, and topological relationships. (ix) Open data formats: XML, GML, SVG, and their use.	Analyze the inherent characteristics of vector and raster data models. Select and apply vector and raster models for the encoding of spatial data, taking into account the spatial resolution required for a specific application and scale. Define and encode topological relationships in spatial data files using available software tools. Select an open data format to encode and portray geospatial data.
E6.3 Geospatial data input and editing *(I)*	(i) Feature and attribute data encoding and standards (ii) Data entry (iii) Manual, semi-automatic, and automatic digitization	Use a GIS environment to encode and edit geospatial data derived from manual, semi-automatic, and automatic digitization.

	(iv) Scanning (v) Data editing.	Apply the appropriate scanning parameters with respect to a specific application and scale, and utilize the resulting file.
E6.4 Geospatial data transformations *(I)*	(i) Affine transformation (ii) Projection transformations (iii) Nature of problems associated with geospatial data transformations.	Describe and apply the most used spatial data transformations using appropriate software. Evaluate the results of spatial data transformations.
E6.5 Raster to Vector Conversion *(I)*	(i) Raster to Vector and Vector to Raster conversions and associated algorithms.	Apply raster to vector and vector to raster conversions using appropriate software and assess the results.
E6.6 Geospatial and cartographic databases *(I)*	(i) Geospatial vs. cartographic databases (ii) Geospatial/Cartographic database design (iii) Geospatial/Cartographic database integrity (iv) Geospatial/Cartographic database operations. (v) Adding and managing layers (vi) Open-source geospatial databases and standards.	Describe different types of geospatial data and their representation in a DBMS environment. Describe a geospatial database on a conceptual, logical, and physical level. For a given design, build and populate a spatial database in a DBMS and use it to support cartographic composition. Add and manage layers within geospatial datasets.
E6.7 Geospatial data analysis and modeling *(B)*	(i) Single and multiple layer operations in a GIS environment (ii) Geospatial data analysis, modeling and tools. (iii) Pre-trained machine learning tools for data processing (iv) Introduction to Digital Twins	Describe the functionality of a GIS/SDI in geospatial data analysis and modeling. Describe the methodology for the integration of available data sets to design a digital twin model Geospatial processing with pre-trained machine learning tools
E6.8 Raster data compression *(B)*	(i) Raster data compression methods, e.g.: ● Run-length encoding ● Freeman chain codes ● Quad tree encoding	Describe the various raster data compression methods in terms of space saving and resolution.
E6.9 Geospatial data transfer standards and formats *(B)*	(i) Geospatial data transfer standards and formats (S-57, S-100, DXF, SDTS, Geotiff, GML, KML DIGEST) (ii) Geospatial data transfer process.	Explain the rationale underpinning geospatial data transfer. Describe a typical process for transferring geospatial data between different hardware and software environments.

E6.10a Spatial Data Infrastructures (SDIs) *(B)*	(i) Spatial Data Infrastructures (SDIs): overview, benefits and hierarchy (ii) Quantitative and qualitative benefits (iii) Open data and authoritative data in SDIs (iv) FAIR data principles	Describe the demand for structured geospatial data from commerce, government, industry, academia and citizens. Describe the economic, social, scientific, and environmental benefits of SDIs Describe different types of SDI at different organization level
E6.10b Marine Spatial Data Infrastructures (MSDIs) *(B)*	(i) Marine Spatial Data Infrastructures for the Marine Environment (MSDIs) (ii) Interoperability as a vital aspect for the development of MSDIs (refer to IHO Publication C-17), (iii) Tools and technologies used in building the physical components of MSDIs ● Geographic Information Systems ● Database Management Systems ● Web Services and APIs ● Data Visualization Tools ● Metadata Standards and Catalogs ● Satellite Remote Sensing and Imagery Processing Software ● Data Conversion and Transformation Tools ● Geospatial analysis techniques in MSDIs ● Geospatial Analytic, Modeling Software and use of Expert Systems ● Cloud Computing Services ● Data Quality Assurance and Validation Tools ● Open-Source Software ● Cybersecurity and Data Protection Tools ● Geospatial database (iv) Types of marine data of an MSDI: ● Hydrographic Data ● Bathymetric Data ● Oceanographic Data ● Fisheries Data ● Meteorological data ● Geology Data ● Environmental and ecological Data ● Vessel tracking Data	Describe the structure and the content of a MSDI. Describe the need for efficient collaboration between the various spatial stakeholders Describe interoperability as an enabler for seamless operation of data systems and services in a MSDI Describe and differentiate the technologies and tools used in building MSDIs Describe the types of marine data relevant in an MSDI Describe the use of Expert Systems (AI and ML) to support MSDI.

	● Maritime boundaries data ● Remote sensing data ● International, national and regional boundaries and limits. ● Any other marine spatial information.	
E6.10c Spatial analysis techniques used with MSDIs *(B)*	(i) Spatial analysis techniques commonly used with MSDIs: ●· Buffer analysis ●· Overlay analysis ●· Distance analysis ●· Spatial Join ●· Hotspot analysis ●· Network analysis ●· Density analysis ●· Multicriteria decision analysis ●· Statistical analysis ●· Time series analysis ●Expert Systems (AI and ML) and tools.	Describe the techniques used with MSDIs on vector and raster data Describe the use of Expert Systems in geospatial data analysis tasks.
E6.11 Web services *(B)*	(i) Web services for geospatial data ● Web feature services ● Web map services ● Web coverage services ● Web processing services (ii)Map and chart compilation, composition and publication on the web.	Compare web services with traditional processes for delivery, storage and portrayal of spatial data. Describe Web services and associated data for map/chart composition and publication
E6.12 Visualization with mobile devices *(B)*	(i) Map and chart functions on mobile devices (ii) Security of data (iii) Tracking and visualizing routes and locations (iv) Mobile services, products, and updates (v) Mobile Networks, 4G, 5G, Iridium (vi) Limitations and benefits of mobile devices for navigation	Understand the limits of Mobile Devices for nautical use. Describe the different delivery mechanisms and their characteristics.

E6A Data Analytics for Marine Cartography		
Topic/Element	**Content**	**Learning outcomes**
E6A.1 Introduction to Data Analytics in Marine Sciences (B)	(i) Uses and benefits of data analytics in marine cartography. (ii) Introduction to real-time and large-volume data in marine environments. (iii) Basic concepts of spatial and spatiotemporal data.	Identify the role of data analytics in producing marine maps. Recognize the importance of spatial and temporal components in marine data. Use well-structured marine datasets for basic digital analysis. Utilizing existing software.
E6A.2 Applied Machine Learning for Marine Cartography (B)	(i) Data normalization and scaling: preparing data for analysis. (ii) Supervised vs. unsupervised learning: basic differences and examples. (iii) Basic regression models for marine geographic data. (iv) Simple evaluation of models: accuracy and basic validation techniques. (v) Introduction to open-source libraries	Apply basic classification and clustering algorithms to marine datasets. Use pre-trained regression models to predict marine variables. Comment on the accuracy and reliability of basic models. Describe standard ML libraries for marine geospatial data.
E6A.3 Deep Learning for Feature Detection (B)	(i) Basic understanding of Convolutional Neural Networks (CNNs). (ii) Pattern detection with CNNs in satellite imagery. (iii) Practical applications of deep learning to vector and raster data.	Basic pre-trained deep learning models for geospatial data. Use basic CNNs for feature detection and classification. Apply pre-trained models to extract features from marine raster and vector maps.
E7 Nautical Cartography		
E7.1 The Nautical Chart		
Topic/Element	**Content**	**Learning outcomes**
E7.1a Evolution of nautical charts *(I)*	(i) Paper (national and INT) charts (ii) ENCs (ECDIS) (iii) ECS. (iv) Nautical charts and ENCs derived from encoded data through automated/semi-automated processes	Outline the evolution of nautical charts and chart systems.
E7.1b Nautical charts and ENCs *(I)*	(i) Planning/scheming (ii) Navigation (iii) Types of charts (iv) Chart reading.	Classify the various types of nautical charts and ENCs and their content according to their primary use
E7.1c Nautical chart and ENC design *(I)*	(i) Design principles for nautical charts and ENCs (ii) Characteristics (iii) Content (iv) Terminology (v) Symbolization.	Analyze present-day characteristics and design principles of nautical charts and ENCs. Describe the impact of technology on nautical charts and ENC design and production.

E7.1d Nautical chart reference framework *(I)*	(i) Chart graticule (ii) Chart grid.	Calculate and prepare the chart graticule and chart grid using appropriate software according to specifications.
E7.2 International Organizations and Nautical Charting products		
Topic/Element	**Content**	**Learning outcomes**
E7.2a Role and structure of the IHO *(B)*	(i) IHO roles and structure (ii) General Assembly (iii) Regional Hydrographic Commissions (iv) Committees and Working Groups (v) IMO and the SOLAS convention (vi) IALA guidelines and recommendations.	Describe the roles of IHO, IMO and IALA with respect to the development and use of nautical charts and ENCs for safe navigation.
E7.2b Role of the IMO *(B)*		
E7.2c Role of the IALA *(B)*		
E7.3 Nautical chart compilation and production		
Topic/Element	**Content**	**Learning outcomes**
E7.3a Planning and scheming *(B)*	(i) Geographical area and scale (ii) Chart scheming (iii) Overlapping and nesting principles.	Refer to the planning processes adopted internationally for the scheming and production of (official) nautical charts and ENCs.
E7.3b Data sources *(I)*	(i) Metadata considerations (ii) Source data selection and evaluation (iii) Source data homogenization (iv) Source data registration.	Analyze methods applied for the appropriate selection, evaluation and homogenization of source data including crowd source data.
E7.3c Content, Encoding and Symbology (*I*)	(i) Coastlines ● Natural ● Constructed ● Approximate (ii) Bathymetry ● Soundings ● Sounding pattern selection ● Principles ● Automated techniques ● Channel depiction (iii) Bathymetric contours (iv) Dangers to navigation ● Rocks ● Wrecks ● Reefs ● Shoals ● Offshore constructions ● Submarine pipelines and cables ● Obstructions ● Sea floor descriptions	Identify the various categories of features portrayed on nautical charts and ENCs and use them in their production. Explain the rationale underpinning the symbology for each feature and/or data category and apply them in nautical chart production. Define and select critical and controlling depths.

	(v) Topography ● Depiction using seaward view principle ● Natural features ● Landmarks ● Constructed features ● Conspicuous objects (vi) Boundaries and limits ● Dredged areas ● Controlled areas ● Controlled routes ● Baselines ● International boundaries and maritime zones (vii) Navigation aids ● Lights, beacons, buoys, marks ● Light sectors ● Leads ● Radio beacons ● Radar reflectors ● Recommended tracks ● Recommended routes (viii) Source data diagrams – depiction (ix) ZOC (x) Titles and chart notes (xi) Graphic scales. (xii) Design principles for nautical charts and ENCs	
E7.3d Chart compilation and composition *(I)*	(i) The chart compilation and composition processes. • Element selection • Database extraction • Synthesis and homogenization • Conflict resolution • Validation. (ii) AI in chart compilation and composition	Describe and perform the processes required for chart compilation and composition from a geospatial database using standalone software systems or integrated cartographic production systems. Describe the use of AI tools in chart compilation and composition.
E7.3e IHO Standards and Chart Specifications *(I)*	(i) IHO standards and chart specifications (ii) INT chart specifications (iii) INT 1 (iv) INT 2 (v) INT 3 (vi) IHO S-4 (vii) IHO S-11 (viii) IHO S-57 (ix) IHO S-58 (x) IHO S-65 (xi) IHO S-100 overview (xii) Feature attribution	Describe the processes of the IHO Member States for the development of international charts and ENCs standards and schemes. Identify, describe, and use the international standards and specifications for nautical charts and ENCs.

	(xiii) Text (Styles as symbols) (xiv) Notes, legends.	
E7.3f Updating *(I)*	(i) Procedures for updating nautical charts (ii) Notices to mariners (iii) New editions and reprints	Specify the requirement for updating nautical charts Perform a complete chart updating task, including editing, updating, and publishing.
E7.3g Mapping on demand *(B)*	(i) Customized mapping from existing databases. (ii) Printing up-to-date official nautical charts from an existing catalog.	Explain the concept of mapping and printing on demand.
E7.4 Map/chart production systems		
Topic/Element	**Content**	**Learning outcomes**
E7.4a Commercial Systems *(I)*	(i) Commercial systems for map/chart production (ii) Graphics and image processing software in cartographic applications (iii) Open standards and public domain systems (iv) Open Geospatial Consortium (OGC).	Identify common commercial systems and analyze their functionality. Use a commercial system for map/chart composition and production. Identify and use commercial graphics and image processing systems.
E7.4b Public domain systems (*B)*		Describe the concept of public domain systems as applied to map/chart production. Identify some public domain geospatial standards, their content, and the organizations developing them.
E7.4c Map/chart production systems evaluation *(B)*		Identify the benefits and/or limitations of the use of commercial and/or public domain systems, including those employing AI-based methodologies for data analytics
E7.5 Electronic chart production		
Topic/Element	**Content**	**Learning outcomes**
E7.5a Introduction to Electronic Navigational Charts (ENCs) *(I)*	(i) Definition of ENC, SENC, and ECDIS (ii) IMO carriage requirements (iii) ENC as product (iv) Production conventions ● Issuance ● Numbering ● Cell structure ● Updating ● Official status ● Security protection ● SENC	Define and differentiate between ENC and SENC Describe ECDIS and its characteristics Analyze the product characteristics of ENCs.
E7.5b ENC production and IHO Standards (*I)*	(i) IHO S-57 ● Contents including appendices ● Data model ● Topology (ii) Object Catalogue	Identify and analyze the international standards and specifications relating to ENCs Describe the rationale underpinning the development of S-100 Analyze the S-57 and S-100 data models

	● Object, attribute, and master/slave classes ● Spatial objects ● Feature objects ● Relationships ● Special cases (iii) IHO S-52 ● Presentation Library (iv) IHO S-65 ● ENC production ● Quality control ● Quality assurance ● Quality management systems (v) Designing workflow (vi) IHO S-58 ● Validation process ● Spatial accuracy ● Feature completeness ● Logical consistency ● ECDIS display consistency ● Software validation tools ● False warnings ● Errors and warnings (vii) ENC distribution system ● IHO S-63 ● IHO WEND principles and RENCS (viii) IHO S-99 (ix) IHO S-100 data model ● S-100 Registry and Registers ● S-101 ENC product specification ● S-102 Bathymetry surface product specification. (x) S-57 ENC to S-101 Conversion	including their differences. Describe the content of the Presentation Library. Describe the S-101 Standard for ENC production.
E7.5c ENC production, distribution, and IHO Standards (*I*)		Explain the general principles underpinning electronic chart data visualization. Use of the object catalogue for ENC Describe recommended production procedures for ENCs and utilize a software environment to produce an ENC. Implement the paper and ENC synchronization process Identify best practices for the QC/QA of an ENC including gaps and overlaps of adjacent cells. Use software applications to produce an ENC. Describe the ENC distribution system. Describe how to adapt S-57 ENC to optimize the automated conversion to S-101 ENC. Apply and assess automated conversion processes. Production of S-101 cells Load and test the ENC on an ECDIS simulator.

E7.6 Rasterized products		
Topic/Element	**Content**	**Learning outcomes**
E7.6 Raster charts (*B*)	(i) The rasterization process (ii) Scanning processes (iii) Advantages and limitations of rasterized chart products (iv) Raster data structures (v) Raster chart formats (vi) Raster chart products (vii) Raster chart images and tiles (viii) Raster chart images – use within GIS and other environments.	Describe the characteristics, advantages, and limitations of rasterized chart products. Describe rasterizing processes. Describe the use of rasterized chart images within navigation systems.

E8: Legal aspects (Relating to nautical cartography)		
Topic/Element	**Content**	**Learning outcomes**
E8.1 Liability and responsibility (*B)*	(i) The IMO SOLAS convention (ii) The status of an official nautical chart ● General status under IMO carriage requirements ● Legal document ● Status post maritime incident (iii) The role of national hydrographic agencies (iv) Potential legal issues: ● Duty of care ● Product liability ● Defectiveness ● Fitness for purpose. ● Defectiveness (v) Professional responsibilities (vi) Best practices (vii) Role of professional associations.	Describe the role and responsibilities of national hydrographic agencies as required under the Safety of Life at Sea Convention Describe the organizational structure, departmental responsibilities and duties involved in the production of nautical charts and ENCs. Describe the status of the nautical chart and the ENC at both an operational and legal entity. Outline the role and responsibilities of the nautical cartographer. Describe potential issues of legal liability relating to nautical charts and ENCs.
E8.2 Intellectual property and copyright *(B)*	(i) Definition (ii) Protection (iii) Permission/License and fees (iv) Disclaimers (v) Penalties.	Define intellectual property and copyright in the framework of nautical charting. Explain how copyright issues are managed within different map and chart production agencies.
E8.3 Law of the Sea (*B)*	(i) The United Nations Convention on the Law of the Sea (UNCLOS): ● General provisions ● Base points ● Baselines - normal (including bay closing lines); straight and archipelagic ● Internal waters ● Territorial sea ● Contiguous zones ● Exclusive Economic Zone ● Continental Shelf and Extended Continental Shelf. (ii) Status of the nautical chart for portrayal of boundaries and maritime zones (iii) Delimitation of boundaries and maritime zones.	Describe the types of lines and areas defined under UNCLOS and their delimitation. Explain the status of the official nautical chart as a reference in relation to the depiction of boundaries and maritime zones.

E9: Special Purpose Charting		
E9.1 Industrial and Engineering Survey Chart Production		
Topic/Element	**Content**	**Learning outcomes**
E9.1a Introduction to industrial and engineering surveys and their cartographic representation *(B)*	(i) Types of Industrial and Engineering Surveys. (ii) Data from remotely operated and autonomous vehicles. (iii) Additional sensors. (iv) Use of Expert Systems in data analytics (including ML and AI) for industrial and engineering surveys. (v) General requirements and forms for cartographic presentation. (vi) Applicable standards (e.g., IOGP; UKOOA; IMCA; …).	Differentiate the representation of industrial and engineering survey data from nautical charting data. Describe specific requirements and standards for engineering survey charts Describe the use of Expert Systems in industrial and engineering data analytics
E9.1b Route surveys charting *(B)*	(i) Rationale of charts and graphics for route surveys (ii) Forms of presentation for route survey data (iii) Vertical exaggeration in DEMs and profiles.	Describe specific requirements and guidelines for route survey charts.
E9.1c Dredging surveys charting *(B)*	(i) Rationale of charts and graphics for dredging surveys (ii) Forms of presentation for dredging survey data (iii) Presentation techniques for volumetrics.	Describe specific requirements for the charting of dredging surveys.
E9.1d Shallow geophysical site surveys charting *(B)*	(i) Rationale of charts and graphics for Geophysical Site surveys. (ii) Use of Data Analytics and Expert Systems. (iii) Forms of presentation for Geophysical Site survey data. (iv) Presentation techniques for Geophysical Site survey data, including the depiction of multiple layers.	Describe specific requirements and guidelines for shallow geophysical survey charts.
E9.1e Still photographs and video surveys charting *(B)*	(i) Rationale for the use of still photographs and video surveys (ii) Photographic and video formats (iii) Video eventing (iv) Relating video surveys to other relevant charts and graphics. (v) Use of Data Analytics and Expert Systems. (vi) Positional considerations.	Describe specific requirements and standards for photographic and/or video survey charts.

E9.1f Geo-technical surveys charting *(B)*	(i) Rationale of charts and graphics for geotechnical data (ii) Forms of presentation for geotechnical data, including written reporting. (iii) Use of Data Analytics and Expert Systems.	Describe specific requirements and guidelines for charting engineering and foundation survey data.
E9.1g Environmental surveys charting *(B)*	(i) Rationale of charts and graphics for environmental data (ii) Forms of presentation for environmental data.	Describe specific requirements and guidelines for charting environmental surveys.
E10: Map/Chart Reproduction		
Topic/Element	**Content**	**Learning outcomes**
E10.1 Output options and formats *(B)*	(i) Soft copies, Hard copies. (ii) Page description language (PostScript)	Explain the differences and use of available output options.
E10.2 Raster processing techniques *(B)*	(i) Raster Image Processing (RIP). (ii) Parameters associated with the product	Explain raster processing techniques (e.g., resolution change, overlay, etc.). Describe raster product parameters.
E10.3 Output devices *(B)*	(i) Electrostatic printers/plotters (ii) Ink-jet printers/plotters (iii) Laser printers/plotters (iv) Thermal printers (v) Image setters.	Describe the technical characteristics of the various output devices used in cartographic production.
E10.4 Colour management *(B)*	(i) Standards for colour (ii) Matching colour profiles (iii) Gamut mapping.	Explain the need for the use of colour standards and the creation of colour profiles. Describe the gamut mapping process.
E10.5 Colour separation *(B)*	(i) Colour separation (ii) Image Setters (iii) Compositing separations	Explain the need for colour separation. Describe the colour separation process in a digital environment.

CFCP - COMPREHENSIVE FINAL CARTOGRAPHIC PROJECT

Programmes must include a supervised and evaluated *Comprehensive Final Cartographic Project* (CFCP) with a minimum aggregate period of **at least four weeks**; see "GUIDELINES FOR THE IMPLEMENTATION OF THE STANDARDS OF COMPETENCE FOR HYDROGRAPHIC SURVEYORS AND NAUTICAL CARTOGRAPHERS".

Notes:

a. The Comprehensive Final Cartographic Project does not include practical exercises, which form a part of the course modules' syllabi and are designed to complement the theory component. See "GUIDELINES FOR THE IMPLEMENTATION OF THE STANDARDS OF COMPETENCE FOR HYDROGRAPHIC SURVEYORS AND NAUTICAL CARTOGRAPHERS".
b. The Comprehensive Final Cartographic Project must contain all those items that will enable the student to compile and compose a modern nautical chart, ENCs, and special-purpose charts according to international specifications.
c. The Comprehensive Final Cartographic Project must be divided in phases, representing the distinct processes involved in cartographic composition and production, e.g., planning, preparation, acquisition & processing, composition, deliverables (paper charts, ENCs, special purpose charts), and reports.
d. Each phase will be further divided into tasks that will:
    - result in specific outcome(s)
    - require specific equipment, software, data sources, etc.
    - be carried out in a specific number of hours and
    - be related to specific S-B elements.

THE TABLE -AS SPECIFIED IN THE GUIDELINES- MUST BE COMPLETED AND SUBMITTED IN ADDITION TO A DETAILED AND COMPREHENSIVE NARRATIVE DESCRIPTION OF THE COMPREHENSIVE FINAL CARTOGRAPHIC PROJECT MODULE FOLLOWING THE GUIDELINES.