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DATA PRODUCT INTEROPERABILITY IN S-100 NAVIGATION SYSTEMS

IHO Publication S-98

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Document History

Changes to this Specification are coordinated by the IHO S-100 Working Group. New editions will be made available via the IHO web site. Maintenance of the Specification shall conform to IHO Resolution 2/2007 (as amended).

Version Number	Date	Author	Purpose
0.1	31 Jul 2017	EM, RM	First draft.
0.2	12 Dec 2017	RM, EM	Changes from interoperability workshop and TSM5.
0.3	08 Jul 2018	EM, RM	Edits from March 2018 review comments Updates for conformance to S-100 Edition 4.0.0, ISO 19115-1, and 19115-3. Removed metadata items not used by S-98 from the metadata documentation tables.
1.0.0 RC1	13 mar 2019	RM	Applied S-100 WG4 decisions; updated metadata to conform to final version of S-100 Edition 4.0.0.
1.0.0 (Draft)	21 Mar 2019	JW	Editorial updates for HSSC1.
0.4	Jan 2020	RM	Revised after TSM7 decision to separate interoperability into an abstract specification (new S-100 Part) and implementation specification (S-98).

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S-98 – MAIN SPECIFICATION
ALL INTEROPERABILITY LEVELS

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1 Overview

Mariners and other users will receive different S-100-based data products, each providing one or more information layers, and will often need to view some of the information layers simultaneously on a S-100 compatible ECDIS as well as in other ship and shore-based scenarios. Other data layers such as radar overlays are also expected to be present. The smooth interoperation and harmonized user-friendly graphical presentations of these various products is therefore necessary. The rules for interoperation and harmonized graphical presentations of S-100 data products are contained in an *interoperability catalogue*, which is a type of meta-product that describes how specified products are to be used and displayed simultaneously.

This Specification describes the structure, usage, and rules for development of interoperability catalogues that can be used by systems to guide the simultaneous use and display of two or more S-100 based data products. It is an implementation of the abstract interoperability concepts described in S-100 Part 16.

This Specification defines four levels of interoperability, specified in Parts A-D of this document. The levels correspond to successively more complex interoperability rules and operations. However, Edition 1.0.0 specifies only Levels 1 and 2 in full. Levels 3 and 4 will be finalized at a later date after the implementation of Levels 1 and 2 has been tested further.

This Specification is structured as a multi-part document. The “Main” Part contains material that is common to all four levels of interoperability. Material specific to each of levels 1-4 is specified in Parts A-D respectively.

1.1 Introduction

This Specification defines the interoperability functions an S-100 compatible ECDIS should implement. It also defines the format of interoperability catalogues. Functionality beyond this Specification may be provided by S-100 compatible ECDIS, including functions allowing users to specify their own interoperability rules. This Specification is intended for ECDIS and Navigational Systems, however the same ideas may be reused elsewhere, but should then be defined as a separate Specification.

This version of the Specification describes interoperability for the S-100 based Product Specifications listed in Table 1-1 below. A catalogue conforming to this version of the Specification may potentially also include similar Product Specifications, such as S-123 (Marine Radio Services), but the ability to include such other Product Specifications must be evaluated on a case-by-case basis.

Table 1-1 - S-100 Product Specifications covered¹ by this version of S-98

Specification No.	Title
S-101	Electronic Navigational Chart (ENC) / <i>Cartes électroniques de navigation</i>
S-102	Bathymetric Surface / <i>Surface bathymétrique</i>
S-104	Water Level Information for Surface Navigation / <i>Information de hauteur d'eau pour la navigation de surface</i>
S-111	Surface currents / <i>Courants de surface</i>
S-129	Under Keel Clearance Management / <i>Gestion de dégagement sous la quille</i>

¹ Some examples in this document may mention data products other than those listed in Table 1.1. Mentioning other products must not be construed as including them in the list of products covered by this edition of S-98, or as an intention to cover them in a future edition of S-98.

1.2 References

- IEC 61174 Maritime navigation and radiocommunication equipment and systems – Electronic chart display and information system (ECDIS) – Operational and performance requirements, methods of testing and required test results. International Electrotechnical Commission (IEC), Edition 4.0, 2015.
- RFC 2141 URN Syntax. Internet Engineering Task Force (IETF), May 1997.
- S-52 Specifications for Chart Content and Display Aspects of ECDIS, Edition 6.1.1, June 2015.
- S-100 IHO Universal Hydrographic Data Model, Edition 5.0.0, [TBD].
- S-101 Electronic Navigational Chart (ENC) Product Specification.
- S-102 Bathymetric Surface Product Specification.
- S-104 Water Level Information for Surface Navigation Product Specification.
- S-111 Surface Currents Product Specification.
- S-122 Marine Protected Areas Product Specification. Draft 1.0.0, December 2018.
- S-123 Marine Radio Services Product Specification. Draft 1.0.0, December 2018.
- S-129 Under Keel Clearance Management Product Specification.
- IMO MSC.1/Circ.1512 Guideline on Software Quality Assurance and Human-Centred Design for e-Navigation.
- IMO MSC 232(82) Revised Performance Standards for Electronic Chart Display And Information Systems (ECDIS), IMO Resolution MSC.232(82), 2006.
- ISO 19115-1 ISO 19115-1:2014, Geographic information – Metadata – Part 1 - Fundamentals. As amended by Amendment 1, 2018.
- ISO 19115-3 ISO/TS 19115-3:2016, Geographic information - Metadata - XML schema implementation for fundamental concepts.
- XPath XML Path Language (XPath) 3.1 - W3C Recommendation 21 March 2017 (World-Wide Web Consortium – W3C). URL: <https://www.w3.org/TR/2017/REC-xpath-31-20170321/> (Retrieved 2017-12-08).

NOTE: Plain “S-100” in this document and its Parts, Annexes, or Appendices means S-100 Edition 5.0, any clarification.

1.3 Terms, definitions and abbreviations

1.3.1 Use of Language

Within this document:

- “Must” indicates a mandatory requirement.
- “Should” indicates an optional requirement, that is the recommended process to be followed, but is not mandatory.
- “May” means “allowed to” or “could possibly” and is not mandatory.

1.3.2 Terms and Definitions

Alarm

A high-priority **alert**. Condition requiring immediate attention and action by the bridge team, to maintain the safe navigation of the ship.

Alert

Announcement of abnormal situations and conditions requiring attention. Alerts are divided in four priorities: **emergency alarms**, **alarms**, **warnings**, and **cautions**. An alert provides information about a defined state

change in connection with information about how to announce this event in a defined way to the system and the operator.

Caution

Lowest priority of an **alert**. Awareness of a condition which does not warrant an **alarm** or **warning** condition, but still requires attention out of the ordinary consideration of the situation or of given information.

Data Coverage (feature)

A geographical area that describes the coverage and extent of spatial types. The meta feature **Data Coverage** encodes the area covered by data within the dataset.

Dataset

An identifiable collection of data.

NOTE: A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature contained within a larger dataset. A hardcopy map or chart may be considered a dataset.

Display Priority

Hierarchy to determine which **feature** is to be displayed when two features overlap. Priority 2 overwrites 1.

Electronic Chart Display and Information System (ECDIS)

A navigation information system which with adequate back-up arrangements can be accepted as complying with the up-to-date chart required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended, by displaying selected information from a **system electronic navigational chart** (SENC) with positional information from navigation sensors to assist the Mariner in route planning and route monitoring, and if required display additional navigation-related information.

Electronic Chart System (ECS)

Navigation information system that electronically displays vessel position and relevant nautical chart data and information from the ECS database on a display screen, but does not meet all IMO requirements for **ECDIS**, and does not satisfy SOLAS Chapter V requirement to carry a navigational chart.

Electronic Navigational Chart (ENC)

The **dataset**, standardized as to content, structure, and format, issued for use with **ECDIS** by or on the authority of a Government authorized Hydrographic Office or other relevant government institution, and conform to IHO standards. The ENC contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart which may be considered necessary for safe navigation.

Feature

Abstraction of real world phenomena.

NOTE: A feature may occur as a type or an instance. The terms “feature type” or “feature instance” should be used when only one is meant.

EXAMPLE: The feature instance named “Eiffel Tower” may be classified with other phenomena into a feature type “tower.”

Geometric Primitive

Geometric object representing a single, connected, homogeneous element of geometry.

NOTE: Geometric primitives are non-decomposed objects that present information about geometric configuration. They include points, curves and surfaces.

Human-Centred Design (HCD)

An approach to system design and development that aims to make interactive systems more usable by focussing on the use of the system; applying human factors, ergonomics and usability knowledge and techniques.

Indication

Visual indication giving information about the condition of a system or equipment.

Interoperability

The capability of controlling interactions, especially of visual appearance and information content, between two or more S-100 based data products displayed simultaneously on the same screen.

Minimum Display Scale

The smallest value of the ratio of the linear dimensions of **features** of a **dataset** presented in the display and the actual dimensions of the **features** represented (smallest scale) of the scale range of the **dataset**.

Maximum Display Scale

The larger value of the ratio of the linear dimensions of **features** of a **dataset** presented in the display and the actual dimensions of the **features** represented (largest scale) of the scale range of the dataset.

Navigation System

Navigation information system that electronically displays vessel position and relevant nautical chart data and information from a database on a display screen. **ECDIS** and **ECS** are two types of Navigation System.

Opaque Fill

The background is completely filled with the colour fill. (For example, depth area.) The point and line **SENC features** may be overwritten. The raw **radar** image is a special case of opaque fill which overwrites all other **features** except those with "priority over **radar**" (**OVERRADAR**).

OVERRADAR

A priority designation that instructs the display to put the object's presentation over **radar** information.

Pattern fill

A method of identifying areas by large, faintly coloured symbols well spaced out across the area. A pattern spacing algorithm ensures that the pattern symbols are visible without being so dense as to cause clutter. Used to ensure pattern symbols are always visible at any display scale.

RADAR

A method, system or technique of using beamed, reflected, and timed radio waves for detecting, locating, or tracking objects, and for measuring altitudes. The electronic equipment or apparatus used to generate, transmit, receive, and usually, to display radio scanning or locating waves; a radar set. The name 'radar' is derived from the words radio detecting and ranging.

Scale minimum (SCAMIN)

The smallest scale at which a **feature** is displayed (For example, a minor light, SCAMIN of 1:45,000, would not be displayed at a scale of 1:90,000).

System Electronic Navigational Chart (SENC)

In **ECDIS** means a database, in the manufacturer's internal **ECDIS** format, resulting from the loss-less transformation of the entire **ENC** contents and its updates. It is this database that is accessed by **ECDIS** for the display generation and other navigational functions, and is equivalent to an up-to-date paper chart. The **SENC** may also contain information added by the mariner and information from other sources.

Skin of the earth

A subset of the geographic (geo) **features** that must create a complete non-overlapping coverage of the area of data coverage of an **ENC dataset**.

Software Quality Assurance (SQA)

A set of processes that ensures software meets and complies with required quality specifications. Designated SQA processes align with a system design life cycle.

System

When used without a qualifying term, the combination of computer hardware, operating system, application software, and interfaces that constitute the platform on which S-100 and related data are processed for viewing or other use by a human end-user.

NOTE: “System” is often used with a qualifying term, for example “Electronic Chart Display and Information System”, “Electronic Charting System”, “operating system”, etc.

1.3.3 Abbreviations

ARPA	Automatic Radar Plotting Aid
AIS	Automatic Identification System
AIS ASM	AIS Application Specific Messages
CRS	Coordinate Reference System
DCEG	Data Classification and Encoding Guide
DQ	Data Quality
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
ENC	Electronic Navigational Chart
EPSG	European Petroleum Survey Group
FC	Feature Catalogue
HCD	Human-Centred Design
IEC	International Electrotechnical Commission
IC	Interoperability Catalogue
IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
GFM	General Feature Model
MPA	Marine Protected Area
MRN	Maritime Resource Name
OEM	Original Equipment Manufacturer
OGC	Open Geospatial Consortium
PC	Portrayal Catalogue
PDC	Pre-Defined Combination
PS	Product Specification

SENC	System Electronic Navigational Chart
SOLAS	Safety of Life at Sea (Convention)
SQA	Software Quality Assurance
UI	User Interface
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name
XML	eXtensible Markup Language
XSD	XML Schema Definition (a format for formally describing the elements in an XML document)
XSL	eXtensible Stylesheet Language
XSLT	XSL Transformations

1.4 General Data Product Description

Title:	Specification for Data Product Interoperability in S-100 Navigation Systems
Abstract:	An interoperability catalogue is a collection of rules that control visual and other interactions between S-100 based data products conforming to different product specifications. This interoperability catalogue is intended to be used by navigation systems where datasets conforming to two or more S-100 based product specifications are used and viewed simultaneously.
Acronym:	S-98
Content:	Catalogues conforming to this specification contain interoperability rules for S-100 based product specifications applicable to ECDIS systems, in conformance with the abstract specification of S-100 interoperability in Part 16 of S-100 5.0.x.
Spatial Extent:	Global coverage of maritime areas. East Bounding Longitude: 180° West Bounding Longitude: -180° North Bounding Latitude: 90° South Bounding Latitude: -90°
Purpose:	The purpose of an interoperability catalogue is to de-clutter displays; reduce information overload; resolve conflicts; and improve the overall quality and clarity of information presentation to mariners when multiple S-100 based data products are simultaneously displayed on-screen. This specification is intended to specify the format and semantics of interoperability catalogues for navigation systems, specifically ECDIS. Other applications may use the interoperability catalogue format and semantics specified in this publication.

1.5 Specification Metadata

Title:	S-98 Navigation System Interoperability Catalogue
S-100 Version:	5.0.x

S-98 Version: 0.4

Date: Xxx 2020

Language: English

Classification: Unclassified

Contact: International Hydrographic Bureau,
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Identifier: urn:mrn:iho:pub:spec:s98:0:4:0 (tentative)

Maintenance: Changes to the Specification S-98 are coordinated by the IHO S-100 Working Group (S-100WG), and must be made available via the IHO web site. Maintenance of the Specification must conform to IHO Resolution 2/2007, as amended.

1.6 IHO Specification Maintenance

1.6.1 Introduction

Changes to this Specification will be released by the IHO as a New Edition, revision, or clarification. This Specification will be periodically reviewed by IHO at intervals of no less than 5 years for confirmation or update. New Editions, revisions, and clarifications may be released more frequently as needed.

1.6.2 New Edition

New Editions of the Interoperability Catalogue Specification introduce significant changes. *New Editions* enable new concepts, such as the ability to support new functions or Product Specifications, or the introduction of new constructs or data types. *New Editions* are likely to have a significant impact on either existing users or future users of the Interoperability Catalogue specification.

1.6.3 Revisions

Revisions are defined as substantive semantic changes to the Interoperability Catalogue Specification. Typically, *revisions* will change the Interoperability Catalogue specification to correct factual errors; or introduce necessary changes that have become evident as a result of practical experience or changing circumstances. A *revision* must not be classified as a clarification. *Revisions* could have an impact on either existing users or future users of the Interoperability Catalogue Specification. All cumulative *clarifications* must be included with the release of approved *revisions*.

Changes in a revision are minor and ensure backward compatibility with the previous versions within the same Edition. Newer revisions, for example, introduce new feature or attribute combinations. Within the same Edition, a dataset processed with a catalogue of one version could always be processed with a later revision of the Interoperability Catalogue.

1.6.4 Clarification

Clarifications are non-substantive changes to the Interoperability Catalogue Specification. Typically, *clarifications*: remove ambiguity; correct grammatical and spelling errors; amend or update cross references; or insert improved graphics or improvements in spelling, punctuation and grammar. A *clarification* must not cause any substantive semantic change to the Interoperability Catalogue Specification.

Changes in a clarification are minor and ensure backward compatibility with the previous versions within the same Edition. Within the same Edition, a dataset processed with a catalogue of one clarification version could always be processed with a later clarification (or revision).

1.6.5 Version Numbers

The associated version control numbering to identify changes (n) to this Specification must be as follows:

New Editions denoted as **n**.0.0

Revisions denoted as n.**n**.0

Clarifications denoted as n.n.**n**

1.7 Implementation phases (informative)

Implementation of interoperability catalogues is envisaged to be done in two phases, with the simpler functionality implemented first and the more complex functionality postponed until further notice.

The functionality belonging to the first implementation phase is described in the Main component (this document) and Parts A and B.

The functionality belonging to the second implementation phase is described in the Main component (this document) and Parts C and D.

1.8 How to read and implement this specification

This Specification describes four levels of interoperability, with increasing power and complexity. The Main component (this document) contains specifications that are common to all four interoperability levels defined in S-98. Each of Parts A–D is an independent component that complements the common portions documented in the Main component of this Specification.

This Specification should be read and implemented as a combination of the Main component (this document) plus one of Parts A–D. Readers and implementors will also need to consult S-100 Part 16 for complete details about interoperability functionality, UML model, and XML schema, because S-98 is an implementation of the functionality, model, and schema described in S-100 Part 16.

Similarly, any document prescribing compliance requirements for interoperability for navigation systems should specify the “S-98 – Main” document plus exactly one of Parts A–D as normative references.

NOTE: While each successive level includes functionality and constructs of lower levels, S-98 Parts A–D are written so that implementors of higher levels do not need to consult Parts documenting lower levels.

2 Specification Scope

This product specification describes four types of catalogue products, corresponding to the Interoperability Level 1 – Level 4 scopes described in Table 2-1 below. Information common to all four types is contained in the “Core” scope.

Table 2-1 Specification scopes

scopeIdentification	level	levelName	description	extent (EX_Extent.description)
S98Core	MD_ScopeCode – 13 (software)	Core	Root (general) scope – information common to interoperability levels 1-4.	EX_Extent.description = “worldwide” EX_GeographicBoundingBox = [-180, +180, -90, +90]
S98L1		Interoperability Level 1	Interleaving of feature types	
S98L2		Interoperability Level 2	Type-based selectivity and feature class replacement; interleaving	
S98L3		Interoperability Level 3	Instance-based selectivity and feature hybridization; type selectivity; interleaving	
S98L4		Interoperability Level 4	Spatial operations; instance and type selectivity; hybridization; interleaving	

The scope descriptions are cumulative in that descriptions of higher levels subsume descriptions of lower levels, because S-98 is structured so that developers implementing higher levels do not need to consult a Part documenting a lower level.

The “Main” part of this Specification describes the “S98Core” scope (root scope) and applies to all interoperability catalogues conforming to this Specification. Information that pertains to particular interoperability levels is provided in Parts A–D of this Specification, corresponding to the scopes for Interoperability Levels 1–4 respectively.

2.1 Conformance levels

Compliance to a scope should be indicated using one or more of the following means, as appropriate to the referring context:

- 1) The governing documentary components of S-98 – the “S-98 Main” component and exactly one of Parts A–D (see clause 1.8).
- 2) The scope identification or level name of exactly one of Interoperability Levels 1–4, from Table 2-1.
- 3) An integer in the range 1–4, corresponding to one of Interoperability Levels 1–4.

An interoperability catalogue conforming to the S-100 interoperability XML schema (S-100 Part 16) uses the third option to indicate its conformance level.

3 Interoperability Catalogue Identification

This clause describes how to identify catalogues that conform to this specification. The information identifying the interoperability catalogue product must include the following items:

Title:	Level N ² S-100 Navigation System Interoperability Catalogue
Alternate Title:	Level N ² ECDIS Interoperability Catalogue
Abstract:	This S-100 Navigation System Interoperability Catalogue is created in accordance with the IHO Interoperability specification, and contains rules that govern interoperability of data where two or more S-100 based Product Specifications are used and viewed simultaneously in a navigation system.
Topic Category:	transportation
Geographic Description:	EX_GeographicBoundingBox westBoundLongitude: -180 eastBoundLongitude: 180 southBoundLatitude: -90 northBoundLatitude: 90
Spatial Resolution:	levelOfDetail: all scales
Purpose:	This interoperability catalogue is to be used by ECDIS or other navigational systems with interoperability function enabled, to govern the minimum means of how two or more S-100 based data products interact when viewed simultaneously.
Language:	English (Mandatory)
Classification:	Unclassified
Spatial Representation Type:	Nil
Point of Contact:	International Hydrographic Organization, 4 quai Antoine 1er, B.P. 445 MC 98011 MONACO CEDEX Telephone: +377 93 10 81 00 Fax: +377 93 10 81 40 Email: info@iho.int
Use Limitation:	This interoperability catalogue is primarily designed for ECDIS, but may be used in other navigation systems.

² N must be replaced by 1, 2, 3, or 4, corresponding to the highest interoperability level used in the catalogue.

4 Data Content and structure

4.1 Application Schema

The application schema for all scopes utilizes the ISO **CT_Catalogue** class defined in ISO 19139 (implemented in ISO 19115-3) as a super-type for header information.

The application schema for each level is described in the S-98 Part corresponding to that scope. The application schema for a level extends the application schema for lower levels. In other words:

- the application schema for level 2 extends the application schema for level 1;
- the application schema for level 3 extends the application schema for level 2;
- the application schema for level 4 extends the application schema for level 3.

This means that interoperability catalogues conforming to higher level application schemas include elements for lower levels. A level 3 interoperability catalogue, for example, is allowed to contain any element defined in levels 1 or 2.

4.1.1 List of covered data products

The specifications listed in Table 1.1 are considered in scope of an Interoperability Catalogue conforming to this edition of S-98. Other similar products such as S-123 (Marine Radio Services) may also be covered in an Interoperability Catalogue conforming to this edition of S-98, but the ability to include such other Product Specifications must be evaluated on a case-by-case basis.

The data products covered by Interoperability Catalogues conforming to this edition of S-98 (see Table 1-1) are listed in a “closed dictionary” identified by the following Maritime Resource Name (MRN):

```
urn:mrn:iho:prod:s98:1:0:0:products
```

This dictionary must be distributed as a support file as defined in S-100.

The initial edition of this dictionary file will include the products listed in Table 1-1 of this document. If a future decision is made to add other data products to this list, the dictionary file must be updated and distributed as an updated support file.

4.2 Interoperability Catalogue

4.2.1 Introduction

The Interoperability Catalogue specifies the relative display prioritization of feature types (and instances) defined in any of the data products within the scope of the Interoperability Catalogue.

An Interoperability Catalogue must be an XML document which conforms to the Interoperability Catalogue Schema defined in S-100 Part 16 which can be downloaded from the IHO website.

4.2.2 Use of S-100 types

4.2.2.1 Geographic feature types

The relative prioritization for display purposes of S-100 geographic feature types is at the core of the Interoperability Catalogue Specification. For the Interoperability Catalogue, S-100 feature types can be

considered as the “domain” of the Application Schema, just as feature concepts form the domain of an ordinary Product Specification.

Feature instances are not encoded in Interoperability Catalogues since an Interoperability Catalogue is a catalogue-based product that is functionally a collection of rules which adjust the display of information from feature datasets; an Interoperability Catalogue is not itself a feature-based data product.

References to feature types may appear as attribute values in Interoperability Catalogues. The reference will identify the product specification in which the feature type is defined. It may also identify the version of the Product Specification; if the version is not identified the reference is to the indicated feature type in all versions of the Product Specification.

A reference to a feature type must be interpreted as applying to all instances of the feature type in datasets conforming to the indicated Product Specification and version. (Additional conditions limiting applicability to subsets of feature instances may be encoded in other attributes.)

4.2.2.2 Meta feature types

The suppression, interleaving, and replacement operations in the Interoperability Catalogue do not affect meta features in individual Product Specifications. Display of meta features if requested by the mariner is as specified by individual Portrayal Catalogues.

4.2.2.3 Feature and Information associations

Feature and information associations are not directly used in an Interoperability Catalogue since an Interoperability Catalogue is a catalogue-like product.

Feature and information associations in covered products may be referenced by interoperability operations and rules.

4.2.2.4 Information Types

Information types are not prioritized by an Interoperability Catalogue nor are they used directly in an Interoperability Catalogue.

4.2.2.5 Attributes

The Interoperability Catalogue uses the following attribute types from the S-100 GFM.

Table 4-1 - Simple attribute types

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values.
Integer	A signed integer number. The representation of an integer is encapsulation and usage dependent.
CharacterString	An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets.
Date	A date provides values for year, month and day according to the Gregorian Calendar. Character encoding of a date is a string which must follow the calendar date format (complete representation, basic format) for date specified by ISO 8601:1988. EXAMPLE 19980918 (YYYYMMDD)

Time	<p>A time is given by an hour, minute and second. Character encoding of a time is a string that follows the local time (complete representation, basic format) format defined in ISO 8601:1988.</p> <p>EXAMPLE 183059</p> <p>If it is required to specify time with a reference to a time zone from UTC, this is done using the following format; 183059+0100; for one hour before UTC.</p> <p>If it is required to specify time according to UTC, it is done using the following format; 183059Z.</p>
Date and Time	<p>A DateTime is a combination of a date and a time type. Character encoding of a DateTime must follow ISO 8601:1988.</p> <p>EXAMPLE 19850412T101530</p>
S100_CodeList	Open enumeration or identifier of entry in a vocabulary.
S100_TruncatedDate	Truncated format for date.

Table 4-2 - Derived types

Derived type	Base type	Description
FeatureCode	CharacterString	Restricted to the camel case code of the feature type with optional suffixes or prefixes indicating a Product Specification and version.
FilterExpression	CharacterString	Restricted to the format for filter strings described in Clause 4.3.
URN	CharacterString	Restricted to the format for URN as defined by RFC 2141.

4.3 Filters

Attribute-value combination filters define conditions used to select features in covered products based on the values of the specified attributes. The filters are strings of the form <attr><op><value>, where:

- <attr> is the camel case code of the attribute;
- <op> is one of "=", "!=", "in", "notIn", "gt", "ge", "lt", "le", "null";
- <value> is a decimal number, integer, numeric code, or string, or a list of values. Strings must be enclosed in double quotes: "" with embedded double-quotes or \ characters preceded by a \ character.

The <attr>, <op>, and <value> components are separated by blank or tab characters.

Sub-attributes of complex attributes can be indicated in <attr> fields using a restricted subset of relative path expressions as specified in the W3C XPath specification (§ 3.3.1 XML Path Language (XPath) 3.1). The restrictions are:

- Paths are relative to the individual feature as the context node.
- Only the "child" axis is permitted and the optional "child::" prefix is not used.
- Predicates as described in the XPath specification are not used.

The effect is to allow <attr> fields to describe sub-attributes in terms of camel case codes separated by "/" characters. (It also allows a simple attribute to be designated by its camel case code alone as described above.)

EXAMPLE 1: The filter *categoryOfRadioStation = 20* selects features with **categoryOfRadioStation** attributes that have the value 20 (AIS Base station).

EXAMPLE 2: The filter *featureName/language* = “eng” selects features with **featureName** attributes that have a language sub-attribute having the value “eng”.

4.4 Interoperability Levels

This Specification defines four levels of interoperability. Only Levels 1 and 2 are fully described in this version of the Specification. Levels 3 and 4 are described for completeness but their specifications are only “informative” in this edition of the Specification and they **should not be included in production implementations of this version of the Interoperability Catalogue**.

4.4.1 Level 0 – Overlays – no explicit interoperability

In “Level 0” all interoperability processing is turned off. In this case, feature data is passed through unchanged to ordinary portrayal processing. Display plane information from the Interoperability Catalogue is also passed through since it specifies the layering which must be done by the display.

Interoperability Catalogues are not used. ENC is treated as the main product on the screen, and all other products are overlays. Information layer priority continues to conform to the relevant IMO and IEC performance standards.

Data product overlays may be portrayed using transparency so as not to obscure lower layers, but transparency values are generally not adjusted using rules based on data content or feature types. They may be adjusted using context information such as the number of stacked layers or light level mode.

Level 0 interoperability is effectively equivalent to what systems do today. It is also the default fall-back if a product not listed in the Interoperability Catalogue is loaded.

NOTE (informative): There is an implicit assumption here that Portrayal Catalogues assign features to only over/under-radar display planes. If display planes are given more complex semantics and continue to be defined in portrayal catalogues, Level 0 is likely to merge into Level 1.

Since there is are no interoperability operations or rules for “Level 0”, it does not have a distinct Part in this Specification.

4.4.2 Level 1 – Interleaving

In Level 1 processing, feature types from different products, including S-101, are interleaved as specified by display plane and drawing priority information contained in the Interoperability Catalogue. The output of interoperability processing is either the original feature data (processing option 1) or drawing instructions (processing option 2), accompanied by display plane and drawing priority information, which is passed through to the portrayal processor.

The ENC is still treated as the main product, but feature layers from other products may be interleaved with ENC feature layers to prevent ENC data from being obscured.

In other words, Level 1 interoperability allows only changes to the display planes and display orders specified in the portrayal catalogues of the covered products. There is no other interoperability-related processing of feature data at this level.

4.4.3 Level 2 – Type-based selectivity and feature class replacement

In Level 2 processing, Level 1 functionality is allowed as well as suppression of all features of a specified feature type in a specified product, with another feature type from a different product being displayed instead. Filtering by attribute values and geometry type is also possible. The output of interoperability processing is the same as Level 1 with certain feature types suppressed.

Feature types in other products may be determined to be superior to specific ENC feature types, in the sense that the features in the other product contain more details, have higher-resolution data values, etc., than the equivalent features in the ENC. In this level of interoperability, global suppression of equivalent ENC features in favour of the superior layer is allowed – all instances of the specified ENC feature type are suppressed and the superior feature layer is displayed.

Selected feature types from other products may be treated as being superior to or enhancing selected ENC feature instances. The features are selected using attribute-value combination filters (Clause 4.4) that use feature type and values of thematic attributes. The geometry of the superior feature instance must be spatially equal to that of the ENC feature instance (within specified tolerances).

The interoperability result is that the selected ENC feature instances are suppressed or replaced by the specified features from the other product. Only thematic attributes can be used in attribute-value filters.

NOTE: The criteria and process for determining what data is superior are yet to be determined.

Selection of replaced and replacement features in this level uses feature type (and data product) information. The only operation is replacement of instances as a whole, no combination of replaced and replacement information is done.

Level 2 also adds constructs allowing catalogues to partition interoperability rules and operations according to specified combinations of data products (“predefined combinations”). The rules and operations in each partition are applied only when the corresponding data products are part of the display.

Level 2 catalogues may also include Level 1 functionality for some features where appropriate.

4.4.4 Level 3 – Feature hybridization

As in Level 2, the ENC is treated as one of the components of the data stack, and selected feature instances from other products may be treated as being superior to or enhancing selected ENC feature instances. The feature instances are selected using selector expressions that use feature type and values of thematic attributes. The geometry of the superior/enhancing feature instance must be spatially equal to that of the ENC feature instance (within specified tolerances).

Level 3 extends interoperability functionality of Level 2 in that the ENC feature instance is either suppressed or replaced by the other feature instance (as in Level 2) or hybridized with it – that is, their attributes are combined in some way. In Level 3, only thematic attributes can be combined for the purposes of hybridization.

Hybridization may consist of adjustments to attributes of one of the ENC/other feature instances, such as re-calculation of values of numeric attribute, addition of listed values to an enumeration attribute. Hybridization may also result in an instance of a different feature type with an enhanced set of thematic attributes, some of which may be new attributes generated from attribute values of the original instances.

The interoperability product will include a hybrid Feature Catalogue and Portrayal Catalogue defining the feature types and portrayals for new hybrid features. Their structures will be the same as regular Feature and Portrayal Catalogues.

NOTE: Support for this level is not fully elaborated in this version of the Interoperability Catalogue Specification and it should therefore not be implemented in Interoperability Catalogues created from this Specification

4.4.5 Level 4 – Spatial operations

This level is the same as Level 3, but permitted spatial queries (to determine related subsets) and operations (to define the interoperation result) are explicitly defined using an adequate set of spatially-capable rules.

This means that the ENC and other-product feature(s) need not be spatially equal, they need only be related to one another by the spatial query. For hybridization, in addition to thematic attributes, feature geometry can also be combined using spatial operations.

NOTE 1: The spatial queries for determining related ENC/other-product features can be defined in terms of explicit rules such as positions within X m, or X mm at product scale for point features, 99% overlap for area features, or some other adequate explicit rule.

NOTE 2: Support for this level is not fully elaborated in this version of the Interoperability Catalogue Specification and it should therefore not be implemented in interoperability catalogues created from this specification.

4.4.6 Progression of interoperability levels

Higher levels of interoperability use progressively more of the Interoperability Catalogue model defined in S-100 Part 16. Figure 4.1 below shows the progressive use of the model from level 1 through level 4.

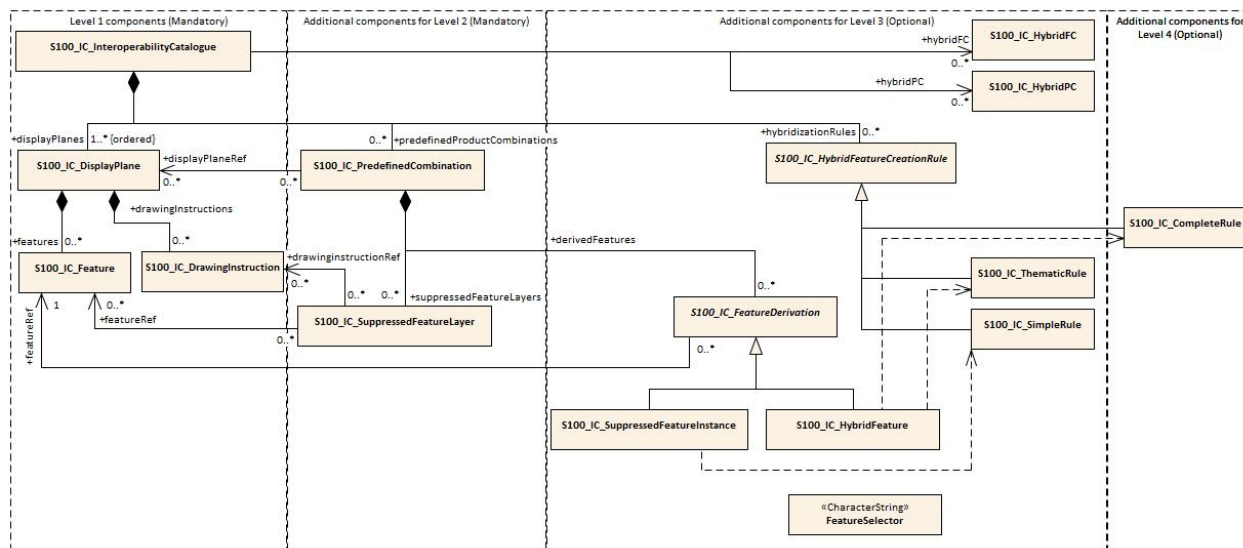


Figure 4.1. Progressive use of interoperability catalogue model

5 Coordinate Reference Systems (CRS)

The interoperability catalogue does not have a CRS of its own, and it is therefore expected that the interoperability-ready product's own CRS should be used by the viewing system to generate the portrayal. Product Specifications created for the primary use in ECDIS is strongly recommended to use EPSG:4326 (WGS84) for CRS.

6 Data Quality

Data quality allows users and user systems to assess fitness for use of the provided data. Data quality measures and the associated evaluation are reported as metadata of a data product. This metadata improves interoperability with other data products and provides usage by user groups that the data product was not originally intended for. The secondary users can make assessments of the data product usefulness in their application based on the reported data quality measures.

For S-98, two aspects of data quality need to be considered: the quality of the data displayed on the navigation screen and the quality of the catalogue itself.

6.1 Quality of displayed data

Data quality in the individual datasets should be kept available and accessible by user selection, either portrayed in the chart pane or accessible via pick report. Amalgamating data quality between products is outside the scope of this Specification and is not addressed in Interoperability Catalogues. See also Clause 10.7 for portrayal considerations.

Poor design of certain rules and operations in interoperability catalogues may adversely affect the quality of the displayed end result. Clause 8.11 in this document describes general considerations on maintaining data quality for various types of interoperability rules and operations. Level-dependent guidelines are included in Parts A-D as appropriate.

6.2 Quality of interoperability catalogues

The data quality measures recommended in S-97 (Part C) which are applicable to S-98 interoperability catalogues are indicated in Table 6-1 below. Measures not included in this table, or included but marked N/A, are not applicable.

Table 6-1 - Quality elements for S-98 interoperability catalogues

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for result ⁴
M1	Completeness / Commission	Excess data present in a dataset, as described by the scope.	numberOfExcessItems / This data quality measure indicates the number of items in the dataset, that should not have been present in the dataset.	dataset	dataset
M2	Completeness / Commission	Excess data present in a dataset, as described by the scope.	numberOfDuplicateFeatureInstances / This data quality measure indicates the total number of exact duplications of feature instances within the data.	dataset	dataset

³ For the IC evaluation scope, a "dataset" is an entire interoperability catalogue file, an "element" is an interoperability catalogue component corresponding to one of the classes in the model depicted in S-100 Part 16 Figure 16-3.

⁴ "Result" means the result of applying interoperability operations to covered data. "Resultant feature" means the apparent feature as it appears on the display after application of interoperability. "Resultant dataset" means the collection of resultant features. A "modified feature" is the feature or drawing instruction resulting from the application of an operation or rule which affects spatial or thematic attributes or their values, including combining or suppressing attributes or generating an instance of a feature defined in the HYBRID feature catalogue in Level 3 or 4. A "superseding feature" is a feature which suppresses a feature (instance or type) from another dataset, or whose priority is increased above that of a feature which would otherwise overlie it. A "superseded feature" is one that is suppressed or overlaid by a superseding feature.

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for result ⁴
M3	Completeness / Omission	Data absent from the dataset, as described by the scope.	numberOfMissingItems / This data quality measure is an indicator that shows that a specific item is missing in the data.	dataset / element	dataset / feature
M4	Logical Consistency / Conceptual Consistency	Adherence to the rules of a conceptual schema.	numberOfInvalidSurfaceOverlaps / This data quality measure is a count of the total number of erroneous overlaps within the data. Which surfaces may overlap and which must not is application dependent. Not all overlapping surfaces are necessarily erroneous.	N/A	Superseding skin of the earth features with surface geometry.
M5	Logical Consistency / Format Consistency	Degree to which data is stored in accordance with the physical structure of the data set, as described by the scope	physicalStructureConflictsNumber / This data quality measure is a count of all items in the dataset that are stored in conflict with the physical structure of the dataset.	dataset	N/A
M6	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsUndershoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to undershoots.	N/A	Depth or safety contours generated from S-102 (+S-104) data.
M7	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsOvershoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to overshoots.	N/A	Depth or safety contours generated from S-102 (+S-104) data.
M8	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSlivers / This data quality measure is a count of all items in the dataset that are invalid sliver surfaces. A sliver is an unintended area that occurs when adjacent surfaces are not digitized properly. The borders of the adjacent surfaces may unintentionally gap or overlap to cause a topological error.	N/A	Superseding skin of the earth features with surface geometry.

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for result ⁴
M9	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSelfIntersects / This data quality measure is a count of all items in the dataset that illegally intersect with themselves.	N/A	Depth or safety contours generated from S-102 (+S-104) data.
M10	Temporal Quality / Temporal Consistency	Consistency with time.	temporalConsistencyStatement / Correctness of ordered events or sequences, if reported.	N/A	Superseding or modified features with time intervals, fixed/periodic date ranges, schedules, or other attributes of (or derived from) type Time, DateTime, or S100_TruncatedDate.
M11	Aggregation Measures / AggregationMeasures	In a data product specification, several requirements are set up for a product to conform to the specification.	DataProductSpecificationPassed / This data quality measure is a boolean indicating that all requirements in the referred data product specification are fulfilled.	dataset	N/A
M12	Aggregation Measures / AggregationMeasures	In a data product specification, several requirements are set up for a product to conform to the specification.	DataProductSpecificationFailRate / This data quality measure is a number indicating the number of data product specification requirements that are not fulfilled by the current product/dataset in relation to the total number of data product specification requirements.	dataset	N/A

6.2.1 Test methods

Test methods consist of executing the relevant tests from **Annex B (Validation Checks)** corresponding to the quality elements in Table 6-1 and counting the number of instances in the dataset which fail the checks for that quality element.

Note that in some cases “executing the relevant test” may involve comparing the result to the source material by visual means. For tests requiring visual comparison of encoded data to source material, sampling methods may be used (**or test datasets developed for S-98**) since the volume of data and number of datasets preclude checking all relevant data objects.

6.2.1.1 Accuracy computations

The recommendations in the respective product specifications for covered data products apply to the evaluation of positional accuracy for quality measures. In the absence of a recommendation in the appropriate specification, the recommendations in S-97 Part C apply.

For spatial primitives resulting from applying spatial operations to feature geometry in input products, the appropriate principles of error propagation should be applied. Since this need arises only for Level 4 interoperability catalogues, the relevant principles will be outlined in Part D of S-98.

6.2.2 Data quality testing and reporting

S-98 catalogues must be tested with the S-98 specific validation checks prior to release. Interoperability catalogue developers must review the check results and address any issues to ensure sufficient quality of the data products. **The checks are listed in Annex B.**

Production and certification processes for S-98 interoperability catalogues should include a standalone quality report which provides full information on the original results (with evaluation procedures and measures applied).

Quality reports accompanying S-98 exchange sets which are distributed to end users need include only the Data Quality Measure Aggregation results to indicate if the interoperability catalogue has passed the quality checks defined in this Product Specification. The format must be the standard quality report format defined in S-97 Part C.

7 Performance Standards for ECDIS

The IMO Performance Standard for ECDIS, including alerts and indications functionality, is unaffected. ECDIS that implement this specification will still be subject to the rules and limitations put in place by all applicable performance standards.

8 How to Make Product Specifications Interoperable

This clause provides guidelines for how to identify concepts that need to be factored into an Interoperability Catalogue, and suggestions for how to design rules to implement interoperability. Moreover, these guidelines can be useful in the development of Product Specifications that will be included in an Interoperability Catalogue destined for ECDIS.

The guidance in this clause can be used in all four levels of interoperability catalogues. Level-specific guidance, if any, is provided in the relevant Parts of this specification.

For portrayal considerations, see Clause 10.

8.1 Duplicated features

Perhaps the most significant issue to deal with when considering interoperability is how to deconflict duplicated features between layers. The following paragraphs deal with major categories of duplicate features.

NOTE: Level 1 and Level 2 interoperability modes only permit the creation of rules which apply to all instances of a feature class, or a subset of that feature class as determined by filter expressions. Suppressing or promotion of single feature instances requires interoperability Level 3 or 4 catalogues.

8.1.1 Duplicated features same model

Where there are equivalent models with same feature concept and attribute bindings, there still may be different attribute values due to issues with maintaining the same update sequence between different products. When considering this for the Interoperability Catalogue, priority should be given to the product that is most likely to be up to date with the latest information.

Developers of Product Specifications that are expected to be used in an ECDIS in interoperability mode should consider if the features within the specification are likely to be more frequently updated than those of the ENC or other products that may serve as a base layer or base layer combination for the product being developed. These considerations should be factored in when describing the production of the product and envisioned future use of the product.

8.1.2 Duplicated features, different models

Where the feature concept, attribute bindings, and values of selected attributes are mostly the same but there are minor differences in the different products, such as extra attribute bindings, the Interoperability Catalogue should consider which version of the feature is the higher value for the end user, and give that version priority. There may be different answers depending on the operational situation that the predefined combination tries to support, and this must be considered as part of constructing the Interoperability Catalogue.

EXAMPLE: Interoperability Catalogue developers compare the specifications and data samples of **Pilot Boarding Place** features from a “Piloting Information” data product and the Pilot Boarding Place features in S-101 and decide that features from the “Piloting Information” datasets have more value in approach and harbour entry scenarios.

Giving a version priority can be implemented in Level 1 (by adjusting display planes and display order) or in Level 2 (by suppressing a feature layer). As mentioned earlier, the answer may depend on the operational situation for which the interoperability catalogue is defined.

Developers of Product Specifications should consider how their data model is similar and/or different from other related Product Specifications and the justification for this; and make recommendations to the developers of the Interoperability Catalogue for how to best select between their version of the feature and related features.

8.1.3 Duplicate feature domains

Where feature concepts are different, but the information content is equivalent, considerations should include the update cycle of the information and when creating the Interoperability Catalogue priority should be given to the concept that is most likely to be updated most frequently. Other considerations should include any relations that the concept has to other feature concepts, and consequences of breaking these must be considered when choosing which concept to give the priority and which concept to suppress.

EXAMPLE: Developers investigate the update cycles of real-time current data products and discover that they are updated more frequently than S-101 **Current – Non-Gravitational** and **Tidal stream – Flood/Ebb** features, and features from the real-time current datasets are therefore preferred replacements for S-101 current features. Note that the question is decided not by comparing dates encoded in features, but on the basis of real-time data that is available on an ongoing basis vs. historical information gathered at a past date.

Product Specification developers should strive to maintain a data model that is as harmonized with related data models as possible. Due considerations should be taken before developing a concept that is different but functionally equal to similar concepts in other product specifications.

8.2 Geometry

The geometry of a feature is a significant element that must be considered when developing the Interoperability Catalogue. Similar to other feature attributes, decisions may have to be made to address issues such as selection of one feature over another, for example where types in one product is affected by small scale, while another by large scale, or if merging the two is a better approach.

Issues caused by spatial discrepancies between different products can stem from different causes. The possible solutions to geometry problems depend on the level of interoperability.

If one data product is considered more reliable, or more suitable in a display scale range, the solution may be to give preference to one product or another by either setting the display order (Level 1 – Part A of this specification) or suppressing a feature layer in one product (Level 2 – Part B of this specification). Adjustments to geometry are possible only in Interoperability Levels 3 and 4 (Parts C and D of this specification).

The following paragraphs give more details about options for deconflicting geometry between products with the help of an Interoperability Catalogue and provide pointers to the appropriate interoperability level for resolving conflicts. Level-specific guidance, if any, is addressed in the relevant Part of this specification.

8.2.1 Combined geometry

Where there is a feature in one dataset that effectively augments the geometry of a conceptually different feature in another dataset, Interoperability Catalogue developers need to specify a hybrid feature with portrayal that can correctly portray the combined information. This is possible only in interoperability Levels 3 and 4. Further guidance on addressing this problem in an Interoperability Catalogue is therefore provided in Parts C and D of this Specification.

EXAMPLE: A dredged area augmented with high definition bathymetry from survey of recent dredging operations giving more water and wider area than dredged area in ENC, combine to give a bigger (new boundary) dredged area than present in ENC.

Developers of Product Specifications that may result in hybrid features when interacting with specific other products, should cooperate with the developers of the related Product Specifications to correctly define the conditions for appropriate use of hybrid features, and communicate these specifications to the Interoperability Catalogue developers.

8.2.2 Spatial discrepancy, unrelated to scaled or cartographic smoothing

If the same feature instances in different data products are expected to have discrepant geometries, Interoperability Catalogue developers should establish the cause of the discrepancy. The cause will probably affect the solution implemented in the Interoperability Catalogue. For example, if one of the data products has more detailed information due to differences in the scopes of the Product Specifications, the Interoperability Catalogue developers should consider suppressing the feature class in the less-detailed product and preferring the same feature class in the product with greater detail. On the other hand, if the discrepancy is found to occur irregularly, it may be more appropriate to suppress the less-detailed instances and prefer the more-detailed instances, independently of the data products to which they belong.

EXAMPLE: ENC has Restricted Area features, while MPA has Marine Protected Area features which show greater details and several sub areas with sub categories.

Resolving this type of discrepancy may require interoperability level 2 or higher, since level 1 only allows changing of display plan and priority, which may cause “ghosting” in displays due to different geometry for nominally co-located features from different data products.

Developers of Product Specifications should examine the specification scope and consider if it is likely that resulting data products include information that will be better or worse than the same information in other products. For example, if information is only for contextual purposes, it is likely that better information is available in another product and in an interoperability ready ECDIS these contextual features should be suppressed in the presence of more accurate information. Such expectations should be communicated with the Interoperability Catalogue developers who can then add appropriate rules to the Interoperability Catalogue.

8.2.3 Spatial discrepancies, related to scale or cartographic smoothing

Where there is the expectation of differences of geometry for same feature instance in different products it is important to establish the cause, as this will likely impact the solution implemented in the Interoperability Catalogue. If the cause is related to scale or cartographic smoothing in one product over another due to issues such as different scopes (intended use) of the Specifications, the Interoperability Catalogue developers should consider suppressing the lesser detailed product and promoting the product with greater detail. If it is irregular occurrences of spatial discrepancies, it may be appropriate to suppress the instances where there are less detail and promote the more detailed instances.

EXAMPLE: ENC has approximate surface current instances using climatic data; Surface current gridded data has greater details and is daily updated.

Resolving this type of discrepancy may require interoperability level 2 or higher, since level 1 only allows changing of display plan and priority, which may cause “ghosting” in displays due to different spatial types, cartographic smoothing, or different coordinates at different scales for nominally co-located features from different data products.

Developers of Product Specifications should examine the Specification scope and consider if it is likely that resulting data products include information that will be better or worse than the same information in other products. For example, if information is only for contextual purposes or is reduced in detail due to scale, it may be that better information is available in another product and in an interoperability ready ECDIS these lesser detailed features should be suppressed in the presence of more accurate information. Such expectations should be communicated with the Interoperability Catalogue developers who can then add appropriate rules to the Interoperability Catalogue.

8.3 Display of text

For details about display of text, including placement, display selection and management of long text, see Clause 10.8. The Interoperability Catalogue does not address these issues in general terms.

Developers of Product Specifications should be aware that the instructions they place within the Product Specification generally carry through even when the product is used in ECDIS in interoperability mode. Moreover, text placement issues in interoperability mode are expected to occur at the border between two products which may result in text being partially obscured due to priority issues. OEMs have long experience with solving such issues from S-57 ECDIS; and advice should be sought with them in how to mitigate such issues. Additionally, Clause 10.8 invites OEMs to provide functionality that seek to address most of the issues that cause text to be partially obscured.

8.4 Skin-of-the-earth feature operations

Special care is needed when specifying interoperability for skin-of-the-earth features, to ensure that the result still qualifies as skin-of-the-earth. Consideration should also be given to the effect on alarms and indications.

8.4.1 Skin-of-the-earth feature replacement

As with other operations involving combining geometries, skin-of-the earth feature replacement is possible only in interoperability Levels 3 and 4. Further guidance on addressing this problem in an Interoperability Catalogue is therefore provided in Parts C and D of this Specification.

NOTE: This clause does not preclude Level 1 or 2 operations on skin-of-the-earth features, if necessary for specific, well-defined, application domains, e.g., berthing operations.

8.4.2 Skin-of-the-earth feature adjusting

In interoperability mode, skin-of-the-earth feature adjustment is a specialization of combined geometry, see Clause 8.2.1 for details. Also see Clauses 10.9 and 10.9.1 for portrayal considerations.

Additional considerations should be given to the attributes of the resulting skin-of-the-earth feature, as a combined feature may have altered geographical representation, attribute combinations or attribute values.

EXAMPLE: Shoaling in a channel in an ENC may be indicated by high definition bathymetry, and a shallower channel hybrid feature replaces the ENC feature, which also has an amended shape. Depth areas adjacent grow due to the shoaling.

8.5 Blended feature concepts

Blended feature concepts or blended portrayals can be produced by using transparency between related features; or creating a temporary blended feature; or blended portrayal (rule and/or symbol) of specific combinations of features from different products. See Clause 10.10 for portrayal considerations and example of use case. Blended features or blended portrayal are only possible in interoperability Levels 3 and 4. Such blended concepts will typically be created by using **S100_IC_PredefinedCombination** which link to a hybrid Portrayal Catalogue that includes the features to be combined and a suppression rule, for example by using **S100_IC_SuppressedFeatureLayer**, for the features that are to be replaced.

Developers of Product Specifications that are likely to be used in blended feature concepts by ECDIS in interoperability mode should communicate their intentions with developers of related Specifications so that awareness is created about the inter-dependencies of these types of relationships. Such communication is especially important when revisions to these Specifications are considered. Doing so will help manage risks to breaking the relationships as the related Product Specifications transition through their life cycle.

8.6 Hierarchy of data

In this context, hierarchy of data means the stacking of data products (layers) within a predefined combination.

In Level 1 interoperability, stacking of data is determined by the interoperability rules which specify the interleaving of display planes, display order and drawing order. Stacking of data products is limited to what can be achieved by interleaving display planes.

In Levels 2, 3, and 4, more control over stacking is possible due to the allowability of feature layer and feature suppression operations, as well as predefined combinations.

8.7 New datasets

New datasets that are added to an ECDIS with interoperability mode will be managed by any existing interoperability catalogue if the relevant data product is listed in it. Data producers should therefore perform sufficient tests to ensure new datasets perform as envisioned.

See Clause **Error! Reference source not found.** for additional information about new data products.

8.7.1 New datasets - coverages

New datasets may alter the available coverages of particular data that is used for interoperability views; and therefore any new dataset should be sufficiently tested to ensure performance is as envisioned.

8.7.2 New datasets - maximum and minimum display scales

New datasets may alter the available data in particular scales and/or scale bands, for example, by adding or removing data coverage. Considerations should therefore be given to harmonization of maximum and minimum display scales when a new dataset is provided.

8.7.3 New datasets - feature geometry

New datasets may alter the available feature geometry of available data that is used for interoperability views. Changes include extending or reducing size of areas, changing geometry type from area to point, point to area, area to line or line to area. Therefore, any new dataset should be sufficiently tested to ensure performance is as envisioned.

8.7.4 New datasets - types and attributes

New datasets may change type and attributes of instances in the ECDIS, for example a platform may be removed and an obstruction remain. These changes may impact the situational view created by the Interoperability Catalogue as changes to feature classes and attribute combinations may mean objects are no longer covered by conditions specific to a predefined combination, or new objects are new covered. Therefore, any new dataset should be sufficiently tested to ensure performance is as envisioned.

8.8 Dataset scales, loading and unloading

Developers of Product Specifications and producers of data should make every effort to harmonize effects of maximum and minimum display scales at loading/unloading time between related products to control over-scale indicators and datasets, in order to avoid situations where one overlay is in scale but not another.

8.9 Metadata

This edition of the Specification does not provide for comparing information that is not encoded as attributes of feature (or information type) instances. This means that metadata cannot be used in interleaving, filters, or rules unless it is encoded in feature attributes (for example “horizontal position uncertainty” attributes) or meta-features (for example **Quality of Bathymetric Data**). If Product Specification authors envisage a need to use metadata in interoperability, the Application Schema should be designed so as to make the relevant metadata available as feature attributes or meta-features.

8.10 Meta-features

Using information from meta-features in interoperability operations may involve spatial operations and thus require an Interoperability Catalogue to implement Level 3. If spatial operations are not required, meta-features can be treated like ordinary features (see however Clause 10.7 on portrayal of meta-features).

Note that product specifications may or may not define portrayal rules for meta-features.

8.11 Quality considerations

In choosing to prefer any data product, feature type, or feature instance to another (especially in the context of Clauses 8.1, 8.2, and 8.4), developers of interoperability catalogues must consider the effects on the

quality of the result. The general rule of thumb should be to avoid replacing a higher-quality product (or feature) with a lower-quality product (or feature). Interoperability catalogue developers should note that this decision should be made after assessing various factors affecting quality, including encoded uncertainty values as well as the age of data, rate of data degradation over time, and potentially also local knowledge.

9 Maintenance

This clause describes the potential sources for change to an Interoperability Catalogue, together with the processes that should be considered when implementing a change to the Interoperability Catalogue.

9.1 Maintenance and Update Frequency

Changes to this specification will be released by the IHO as a New Edition, revision or clarification. Details of what constitute a New Edition, revision or clarification are found in Clause 1.5.1. This Specification will be periodically reviewed by the IHO at intervals of no less than 5 years for confirmation or update. New Editions, revisions and clarifications may be released more frequently as needed.

9.2 Typical Sources of Change

Due to the nature of Interoperability Catalogues as a set of rules describing how a limited list of products are to interoperate within an ECDIS, the majority of all data sources for change will be from the listed supported products. Exceptions to this general practice will be when a new Product Specification is added to the list of supported products; along with changes to any relevant ECDIS related standards from IMO, IEC and IHO that could be a source for change to an Interoperability Catalogue.

9.3 Production Process

Interoperability Catalogues are created in an XML editor environment. It is generally expected that any off-the-shelf XML Editor can perform this task. The creation process of any new versions may benefit from starting from the previous version. Another alternative is to develop a dedicated Interoperability Catalogue Editor that can create and maintain the Interoperability Catalogue with dedicated functions for creating the various components, such as display planes and predefined combinations.

Due to the interconnected nature of the Product Specifications that are under the interoperability schema, a form of overarching change management is a necessity. Any revision or New Edition required in a Product Specification should be announced well in advance, giving the whole stakeholder community ample time to review the impact before it goes into effect. Any revisions and New Editions to a supported Product Specification may require a new version of the Interoperability Catalogue and the IHO body responsible for the maintenance of the Interoperability Catalogue needs to be informed and involved to assess any impacts. This includes updates to dataset metadata, as metadata changes such as Product Specification references may impact the link between the dataset and the Interoperability Catalogue.

9.4 Management of Feature Catalogue and Portrayal Catalogue updates

Changes to a supported Product Specification may have impacts on the Interoperability Catalogue. Revisions to the Feature Catalogue or Portrayal Catalogue are the most likely to require a revision of the Interoperability Catalogue in order to support the change. These types of changes will generally require a new version (n.n.0) of the Interoperability Catalogue to ensure support. It should be noted that revisions to a supported Feature Catalogue or Portrayal Catalogue may be ignored by previous versions of the Interoperability Catalogue and it is therefore necessary to consider this as part of the change management process, especially if the change is a matter of navigational safety. Major changes to Product Specifications, such as adding functionality or adding new Product Specifications to the supported list will result in a new edition (n.0.0) of an Interoperability Catalogue.

In cases of navigational safety, it may be necessary to issue a new edition of the Interoperability Catalogue in order to cancel previous versions and ensure all stakeholders and users are utilizing the most recent version.

Versions of the Interoperability Catalogue within the same edition are considered a compatible group. When a New Edition is issued, this compatibility is broken; and efforts should be undertaken to update all impacted systems as soon as possible.

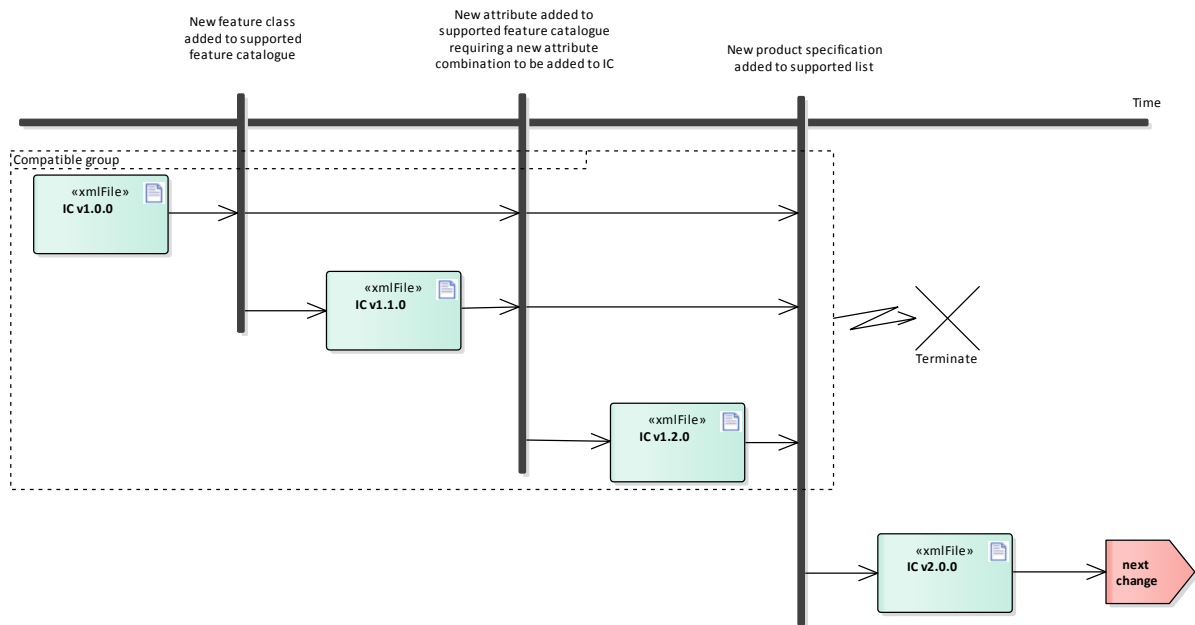


Figure 9.1 - Examples of how Feature Catalogue change may impact Interoperability Catalogue lifecycle

Several types of changes to supported Product Specifications may impact the Interoperability Catalogue in such a way that a new version is needed to maintain full support. These include:

- New feature added to a supported Product Specification that requires a new feature combination to be added to the Interoperability Catalogue;
- New attribute added to a feature in a supported Product Specification that requires a new attribute combination to be added to the Interoperability Catalogue;
- New Product Specification is added to the list of supported Product Specifications in the Interoperability Catalogue. This could also require new feature and attribute combinations to be added;
- Removal of feature or attribute from a supported Product Specification that are present in a feature or attribute combination within the Interoperability Catalogue;
- A correction to a supported Product Specification that triggers a version increment (n.n.0), which may break the link from the Interoperability Catalogue to the supported Product Specification;
- Matters of navigational safety as they arise.

New functions in either a supported Product Specification or the Interoperability Specification may require a new version of the Interoperability Catalogue.

9.5 Product Specification updates other than FC/PC

Updates to dataset metadata, such as Product Specification references, may impact the link between the dataset and the Interoperability Catalogue and therefore require a revision to the Interoperability Catalogue (n.n.0). Some changes to an interoperability-ready Product Specification may not require any changes to the Interoperability Specification or the Interoperability Catalogue. This includes amendments to the definitions of features, attributes or attribute values. It also includes minor changes to Product Specifications, such as clarifying language. Other changes may only require an update to the metadata of the Interoperability Specification and/or the Interoperability Catalogue, such as in case of supported Product Specification version references. Such minor changes to the Interoperability Specification and/or the Interoperability Catalogue may be collected and be applied at a later time when a more substantial revision is required.

9.6 Unpredictable Product Specification updates

Unpredictable changes to an interoperability-ready Product Specification, or its Feature Catalogues and Portrayal Catalogues, should be avoided. Great care should be taken in coordinating changes among all stakeholders to avoid any unforeseen consequences. Product Specifications that are under the ECDIS interoperability umbrella are interconnected and the responsible groups should therefore coordinate changes with other groups that issue interoperability-ready Product Specifications. Such coordination can be done, for example, by having an agreed fixed period between releases in which all pending changes are collected, implemented and issued in a coordinated fashion.

NOTE: If a situation arises where a product is not compatible with the Interoperability Catalogue, this product will only be available in interoperability mode Level 0. This means it may be displayed as an overlay that may obscure any data below the incompatible product, and the overlay may be obscured by any data with higher priority.

9.7 New data products

When a new product is added to an existing Interoperability Catalogue, a new version of the Interoperability Catalogue will be required. During the development of the new version, the Interoperability Catalogue developers should review existing predefined combinations for impact in addition to developing the new predefined combinations to manage the situational views that the new product is intended for.

An Interoperability Catalogue can be extended to include products not yet defined in the S-100 milieu, provided they comply with the same S-100 Edition as the other products in the Catalogue. As for any other new data product, such scenarios will require a New Edition of the Interoperability Catalogue.

9.8 Backward compatibility

Different versions of data products may be simultaneously active; the Interoperability Catalogue design allows for backward-compatible updates if and when the Interoperability Catalogue has to be updated, within the same major Edition. Figure 9.2 below shows an example of how the Interoperability Catalogue may evolve with change over time.

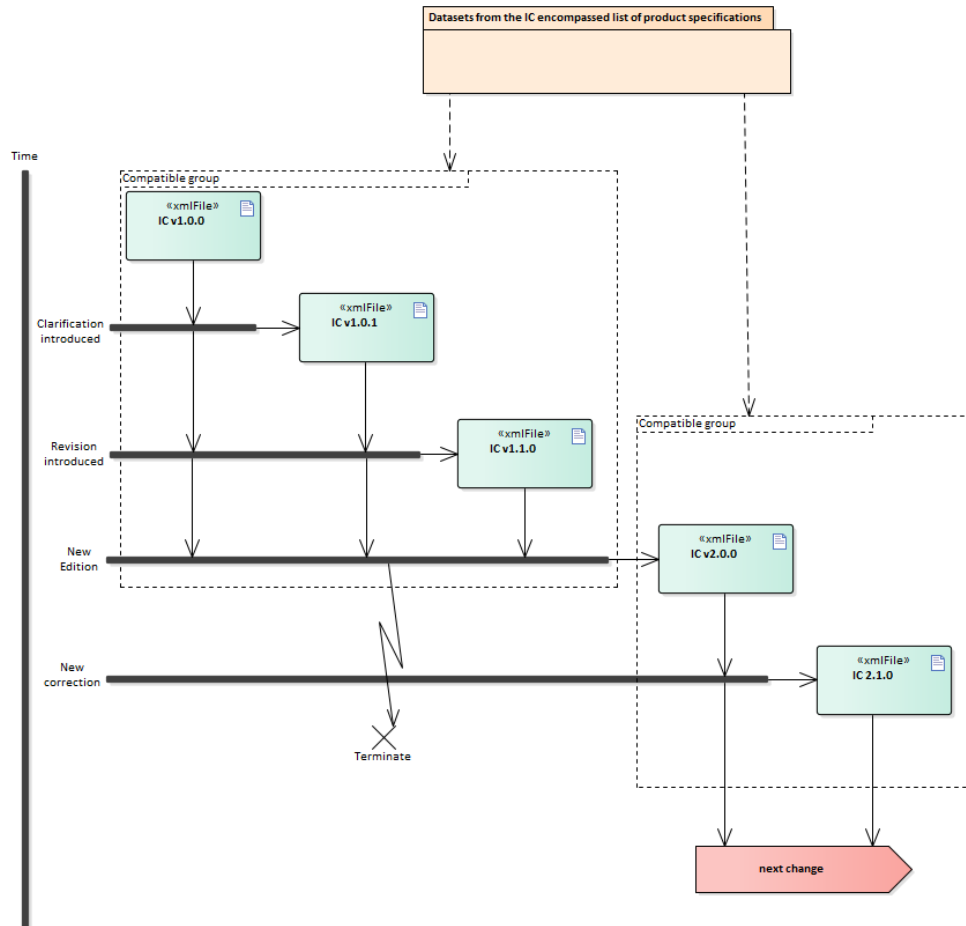


Figure 9.2 - Example life cycle of Interoperability Catalogue

10 Portrayal

This clause gives guidelines and instruction to portrayal considerations related to the use of the Interoperability Catalogue in an ECDIS. The Interoperability Catalogue must apply to the specific Product Specifications listed in the Interoperability Catalogue metadata, *interoperabilityCatalogueProducts* attribute under **S100_IC_CatalogueMetadata**.

There may be additional data products present in the S-100 ECDIS that are external to the Interoperability Catalogue; in such cases the Interoperability Catalogue should continue to function in presence of product not defined in the Catalogue. Data products that are outside of the interoperability scope must be treated in Interoperability Level 0 (see Clause 9.6).

10.1 Display of significant features

Significant features in a display plane should have the highest *displayPriority* value within the **S100_IC_DisplayPlane**. Care should also be given to assigning significant features with high drawing order values within the relevant **S100_IC_Feature** and **S100_IC_DrawingInstruction**. This ensures that less significant features in one data product are not displayed more prominently than more significant features in another product.

10.2 Display of significant features - switching to original

Users must be provided means to easily switch on and off the interoperability functionality and display only the ENC data.

10.3 Portrayal distinguishability - colour set-asides

Special consideration must be made when creating portrayal rules related to colour choices for a Product Specification that is on the list of ECDIS relevant Product Specifications. S-101 ENC portrayal follows the rules laid out in S-4, where it is stated that certain colours have specific meaning. For example, S-4 gives indications for magenta line meaning something non-physical, while black colour implies a physical item. See IHO S-4, Clauses B-141 to B-145 for additional details.

On ENC the light sectors marking intricate inshore channels in, for example, Scandinavian waters are shown in red, green, and yellow.

S-98 conforms to the principles for the use of colour set-asides as described in S-100 Part 16.

10.4 Day/night/dusk modes

It is required that every Product Specification that is included in the supported list has colours specified for day, dusk, and night modes. The system must utilize these colours depending on the mode the viewing system is set to.

10.5 Impacts on viewing groups

The viewing group is a concept to control the content of the display. It works as an on/off switch for any drawing instruction assigned to the corresponding viewing group. The concept can be seen as a filter on the list of drawing instructions [S-100 Part 9, Clause 9-11.1.3].

Interoperability Catalogue viewing groups take precedence over the applicable viewing groups for those feature instances in a supported Product Specification, and that are included in a **S100_IC_DrawingInstruction** or **S100_IC_Feature** instance.

10.6 Impacts on Portrayal Catalogues

Viewing systems must manage the visibility and display priority of data products, especially relative to radar/ARPA or AIS display. Moreover, systems must ensure significant features with over radar flag, in all products are distinguishable in the presence of radar/ARPA and AIS. Tracks and vessel position information are high priority but AIS ASM (application specific messages) may carry lower-priority information, including data described by an S-100 based Product Specification (for example meteorological and hydrographic information as described in S-104).

10.7 Meta-features

In general, the viewing system should allow display of meta features for only one product at a time. This is in order to minimize display clutter, user confusion, and the possibility of interpreting meta-features for one product as applying to a different product.

This means, for example, that data quality meta features for different on-screen products should not be displayed simultaneously, and that only the top most product data quality should be shown at any given time. This also applies in areas of the screen where the topmost product does not cover.

10.7.1 Data quality for individual products

This clause applies to the case where multiple products are on-screen and quality meta-features are enabled. Only one set of quality features should be displayed at any given time to avoid clutter and misreading the meaning of the quality metadata.

Interoperability Catalogues do not specify means of distinguishing data quality portrayals for individual products. Product Specifications must provide rules for display of data quality metadata (including data quality meta-feature information), which the ECDIS will use to portray data quality.

Means of distinguishing data quality portrayals for individual products is left to the Product Specification authors (in particular, Portrayal Catalogue authors) and OEMs, and can be handled by distinguishing portrayal rules or symbology for different products' data quality meta-features, such as colour coding or special line symbol. There should also be a clear on-screen message saying what data quality features are displayed in order to give users a firm indication of the layer to which the currently displayed quality metadata applies.

10.7.2 Portrayal of data quality for combinations

Interoperability Catalogues do not include combining data quality portrayals. The recommendation in Clause 10.7 about displaying only one set of meta-features is strengthened for data quality in particular. This specification recommends against simultaneous portrayal of data quality from different products.

Since ENC data is expected to be the base layer in most, if not all, combinations, the ENC data quality may not be shown if only top layer data quality is displayed. This would force users to turn off all other layers in order to see ENC data quality features on the graphic display. It is therefore recommended that OEMs include functions to let the user select which product's data quality should be displayed.

10.8 Display of text

Text is typically the last item drawn, before own ship. In general, rules for placement, display selection, and management of long text are defined in the individual product specification. The Interoperability Catalogue would, in general, only govern when a feature that text is generated from is displayed.

If the centre of the text bounding box falls outside of the dataset area, then it must not be drawn.

NOTE: OEMs may add functions for enhanced automatic text placement.

10.9 Skin-of-the-earth operations and portrayal

Skin-of-the-earth interoperability functionality depends on the interoperability level. Common among all the levels is that anything that replaces S-101 skin-of-the-earth features, will overwrite it by having a higher priority; that is, drawn later. Parts A-D describe the portrayal considerations related to skin-of-the-earth interoperability in levels 1-4.

10.10 Blended portrayals

When combining various layers, that may be of different compilation scale and coverage, it is likely that symbols and area patterns will end up at borders, or conflict with symbols and area patterns in other layers. It is important that symbols remain legible, and that OEMs use appropriate methods to avoid displaying partial symbols, or "grafting" part of lower-layer symbols onto symbols in upper layers.

For area fills the symbols of a pattern fill must be closer together for a small or narrow area, to ensure enough symbols are seen, and farther apart for a large area, to avoid clutter. An area pattern may be substituted by a single centred symbol if sufficient space is not available for a pattern to be shown.

10.11 Hierarchy of data

Hierarchy between different Product Specifications can be influenced by several factors such as intended use and navigational operation. It may not be possible to prescribe a fixed hierarchy list as a universal standard, and the Interoperability Catalogue model therefore offers a flexible approach. Within the Interoperability Catalogue the hierarchy of data between different S-100 based Product Specifications is determined using predefined combinations (which are allowed only in Level 2 and higher). The DisplayPlanes referenced within a PreDefinedCombination give the order of feature layers.

10.11.1 Interacting gridded information

If two or more gridded data types are to interact, the hierarchy between them should be established using predefined combinations as with other data types. Particular care has to be taken depending on how the presentation of the data is to be done when deciding which gridded data type has the highest priority, considering items such as will one gridded data type obscure the other.

For example, gridded bathymetry will likely obscure gridded surface currents and therefore the gridded surface currents should be given the highest priority between the two if they are to be displayed simultaneously.

10.12 Pick reports

[NOTE: The pick report functionality specification in S-98 is still under development, and the content of this section will change as this functionality is defined.]

Pick reports may be defined in the individual Product Specifications. The Interoperability Catalogue permits reuse of these specifications as it does not specify pick report design for the individual supported Product Specification. This Specification rather outlines the general principles that apply to pick reports when a system is used in interoperability mode. Future editions of S-98 should define either behaviour that works the same for every product, or some form of machine readable filters or styling rules to present content which can be customized by products and remain consistent with the pick report guidelines in S-52 or its applicable successor standard for S-100-based products.

10.12.1 Combined pick reports

In interoperability mode, pick reports should be combined into one pick report that contains information from all visible underlying products. Data should be organized to facilitate navigation through complex reports. Structures such as expandable tree controls, tabs or other GUI implementations could be used to help the user navigate the structure of report based on layers and features included. For example, a tree structure could be presented to the user, where the top most layer is the open branch, and the lower layers are closed branches, by default, but can be expanded by the user as required. Each branch should support the particulars of the product specification that is represented by that branch.

Means must be provided to distinguish which product a feature comes from, for example the product can be used as a “namespace prefix” for attributes or objects.

S-101: RestrictedAreaNavigational:...

S-122: RestrictedAreaNavigational:...

Pick reports may create a display that combines attributes from features from different products, and it should then be possible to distinguish where the attribute is from. For example, the method below may be used.

RestrictedAreaNavigational

S-101: restriction:...

S-122: restriction:...

NOTE 1: OEMs may include a common pick report style for all the visible data layers, but must provide means for easy access to Product Specification defined reporting styles.

NOTE 2: The scope of this recommendation and the definition of defaults and reporting styles are under development in S-98 Edition 1.0.0.

10.12.2 Prioritized pick reports

Pick report content should by default be prioritized in a manner consistent with how the layers are presented, with the highest priority content presented in precedence to lower priority content ("precedence" meaning before, etc., depending on the user interface structure and user expectations). OEMs may provide additional sorting methods as long as the user can easily link the information in the pick report to the respective layers.

10.12.3 Full information availability

Complete data from all products visible on the screen must be available to the ECDIS user, irrespective of all these products being in the scope of the Interoperability Catalogue or not.

Features that have been visually suppressed must not be included in the pick report.

10.13 User control over loaded set

Users must always have the option to load an additional product, or turn off one or more of the data products in a predefined combination. Portrayal must adjust to the loaded set as appropriate, for example if an additional product is loaded, it should be interleaved with layers from data products in the predefined combination according to the drawing priorities and drawing order in its Portrayal Catalogue.

The user interaction aspect of user control over loaded data products are discussed in Clause 15.3.

10.14 User control over interoperation level

Users must always have the option to select the interoperability levels they wish to use. Only predefined combinations that correspond to the levels chosen should then be available to the user. Alternatively, the user should be warned if picking a predefined combination that is not among the interoperability levels already selected.

The user interface aspects of user control over interoperation level are addressed in Clause 15.4.

11 Data Product Format (Encoding)

The format for S-98 interoperability catalogues conforms to the rules in S-100 Part 16.

Format Name: XML

Version: 1.0.0-YYYYMMDD

Character Set: UTF-8

Specification: S-100 5.0.x Part 16

The data format version is of the form <edition>.<revision>-<build> (or <edition>.<revision>.<clarification>-<build>). The <edition>.<revision> sequence will be the same as the corresponding components of the Interoperability Specification version. (The <clarification> component is optional, but if present will be the same as the clarification component.) The YYYYMMDD component is a build date for the XSD files which

constitute the machine-readable data format description. This format allows harmonization of the version numbering of the XSD files and this Specification. (Clarifications to the specification will generally not require changes to the XSD files, but if they do, a new set with <clarification> and new <build> date will be issued.)

The dictionary for the list of data products covered by S-98 is provided in a file named “098CCCCDICTIONARY.XML” (where CCCC is the producer code – see Clause 12.3.1) whose contents conform to the ISO 19115-3 format for “odelist” files. This file accompanies the S-98 XSD distribution.

EXAMPLE: For an Interoperability Catalogue issued by IHO, the dictionary file is named using the IHO producer code “AA00” in place of “CCCC”. The dictionary file is therefore named: 098AA00DICTIONARY.XML

The dictionary file must be included in every S-98 base exchange set as a support file, and documented in exchange set metadata as a support file. The recommended location for this file in an S-98 exchange set prepared by IHO is in a “resources” folder within the exchange set. Distributors are permitted to use alternate locations since the location of support files within exchange sets is discoverable from the discovery metadata for support files.

XML schemas and samples of interoperability catalogues for different levels are available from the IHO schema/sample distribution site (currently the S-100 GitHub page <<https://github.com/IHO-S100WG/S100-Schemas>>). The S-98 specific constraints on the S-100 generic schemas for interoperability catalogues are checked by means of Schematron rules, also available at the aforementioned IHO schema distribution site. The IHO dictionary file for S-98 products (clauses 4.1.1, 11, 12.3) is also available at the same site.

12 Data Product Delivery

12.1 Introduction

This clause specifies the encoding and delivery mechanisms for an Interoperability Catalogue. Data which conforms to this Specification must be delivered by means of an exchange set as specified in S-100 Part 4a.

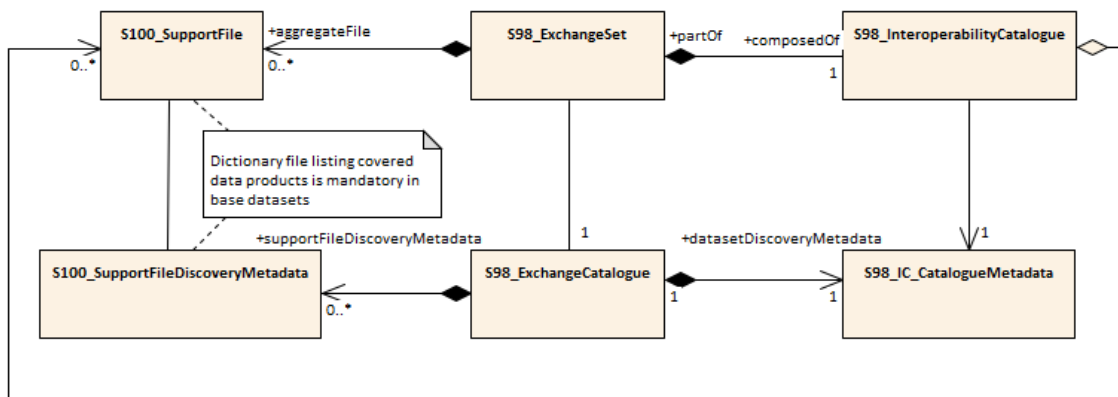


Figure 12.1 - Exchange Set structure for base catalogue set

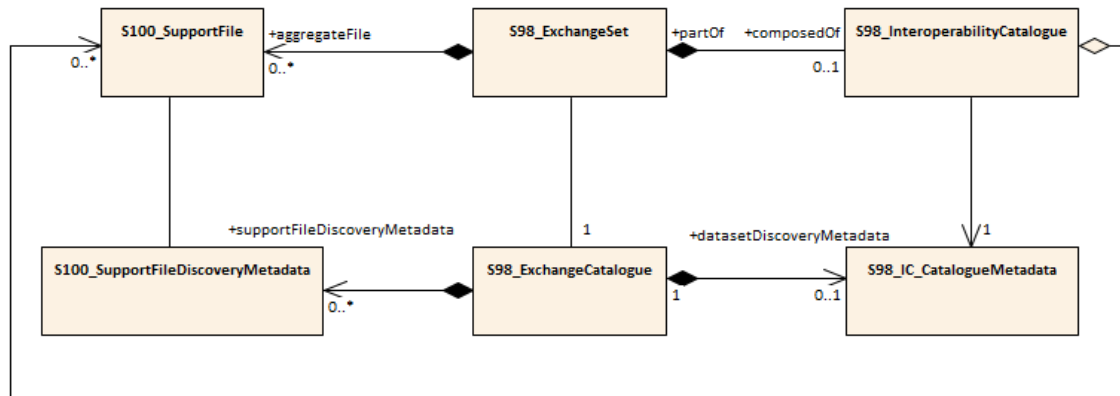


Figure 12.2 - Exchange Set structure for update catalogue set

Units of Delivery:	Exchange set
Transfer Size:	Unlimited
Medium Name:	Digital data delivery
Other Delivery Information:	

The Interoperability Catalogue exchange set has a single exchange catalogue which contains the discovery metadata for the Interoperability Catalogue and any associated support files.

A base set must have an Interoperability Catalogue present, while an update set must have at least one of an Interoperability Catalogue, a hybrid Feature Catalogue or a hybrid Portrayal Catalogue.

A base set must also include a support file in dictionary format listing the covered products. Clause 11 describes this file. Inclusion of this file in update sets is required if and only if it is being updated.

An exchange set may be encapsulated into a form suitable for transmission by a mapping called a transmission encoding. An encoding translates each of the elements of the exchange set into a logical form suitable for writing to media and for transmission online. An encoding may also define other elements in addition to the exchange set contents (that is, media identification, data extents etc...) and also may define commercial constructs such as encryption and compression methods.

If the data is transformed (for example for encryption or compression purposes) its content must not be changed.

12.1.1 Interoperability Catalogue in different formats

The Interoperability Catalogue may be substituted by equivalent catalogues or presentations developed by manufacturers or service providers, provided the minimum functions are maintained and the producer of the replacement Interoperability Catalogue can prove this through testing.

12.1.2 Extending the Interoperability Catalogue

The Interoperability Catalogue will be extensible with equivalent rules or presentations developed by manufacturers or service providers, provided the minimum functions are maintained and the producer of the augmented Interoperability Catalogue can prove this through testing.

12.1.3 Customization - OEM/integrator

OEM or service providers can provide their own versions in addition to the IHO catalogue, to facilitate custom product interoperations. These additional versions must not degrade or interfere with the functions of the official IHO Interoperability Catalogue.

12.2 Interoperability Catalogue product

Each Interoperability Catalogue product is by itself a whole unit. New versions – either clarification, correction, or New Edition – are updated by replacement with a newer version.

12.2.1 Interoperability Catalogue size

There is no size limit for Interoperability Catalogue products, however, compression is used to reduce the exchange set size.

12.2.2 Interoperability Catalogue exchange set compression

An Interoperability Catalogue exchange set must be compressed into a single archive using the ZIP algorithm with the DEFLATE compression method as specified in S-100 Part 15.

12.2.3 Interoperability Catalogue file naming

Interoperability Catalogues must follow the naming convention below, where the main part forms an identifier where:

098CCCCXXXXXX.XML

- The first three characters must be 098 – for S-98 Interoperability Catalogues.
- The next four characters must be the producer code according to the IHO Producer Code Register – for example, AA00 for the International Hydrographic Organization as the issuing organization.
- The eighth to thirteenth characters are for the version number to ensure the file name is globally unique. Version 1 would be 010000 [01.00.00].

The extension must always be .XML.

12.3 Support files

Interoperability catalogues at all levels require a “dictionary” file containing a list of the “standard” data products covered by the catalogue.

Interoperability Levels 3 and 4 may require support files in the form of hybrid Feature Catalogues and hybrid Portrayal Catalogues. Methods for managing these in Parts C and D.

12.3.1 Support file naming

098CCCCFFXXXXXXXXX.XML

Support file names must follow the naming convention below:

- The first three characters must be 098 – for S-98 Interoperability Catalogue support files.
- The next four characters must be the producer code according to the IHO Producer Code Register – for example, AA00 for the International Hydrographic Organization as the issuing organization.

- The eighth and ninth characters must be FC for Feature Catalogue or PC for Portrayal Catalogue. Other support files must not use “FC” or “PC” for these characters but may use any other two-character combination.
- The segment from the tenth to seventeenth characters is for a globally unique alpha numeric code. The following characters are allowed in the support file name, A to Z, 0 to 9 and the special character _ (underscore). Fewer than eight characters may be used in this segment.

The extension must always be .XML.

12.3.2 Support file management

When a support file is created or a subsequent version is issued it must carry its own issue date and be supported with a digital signature which authenticates it against the IHO’s public key included in the exchange set metadata.

The type of support file is indicated in the “purpose” field of the discovery metadata. Support files carrying the “deletion” flag may be removed from the ECDIS.

Support files should be stored in a separate folder within the exchange set.

12.4 Exchange Catalogue

The exchange catalogue acts as the table of contents for the exchange set. The catalogue file of the exchange set must be named CATALOG.XML. No other file in the exchange set may be named CATALOG.XML. The contents of the exchange catalogue are described in Clause 13 (Metadata).

The exchange catalogue format is described by an XSD file that extends the S-100 exchange catalogue schema. The exchange catalogue XSD file is available at the IHO schema distribution location (currently <https://github.com/IHO-S100WG>).

12.5 Encryption and authentication

12.5.1 Encryption method

Data Encryption is not mandatory, however if it is required then it must comply with the mechanisms provided in S-100 Part 15. Part 15 also allows dataset files to be compressed using the zip algorithm (see Clause 12.2.2) prior to encryption. Details are provided in S-100 Part 15.

12.5.2 Digital signature

S-98 Interoperability catalogues must be signed. The signature method, format, and location in the exchange set must conform to the method, format, and location described in S-100 Parts 15 and 4a.

IHO being the scheme administrator for authentication of S-100 products, an Interoperability Catalogue issued by IHO is therefore self-signed.

12.5.3 Authentication and integrity checks

To ensure the Interoperability Catalogue has been issued by the purported producer, and has not changed during transmission/delivery, authentication and integrity checks are performed as described in S-100 Part 15.

12.6 Updating the Interoperability Catalogue

Several versions of the Interoperability Catalogues may be active at a given time due to backward compatibility within each major edition. This compatibility is likely to be broken when a New Edition is released. See Clause 8.11 for more details on Interoperability Catalogue maintenance.

12.6.1 Updating the Interoperability Catalogue

Interoperability Catalogues may remain active after a new version has been issued. Systems receiving new versions within the same major edition should retain all versions. Store these in separate folders to avoid any issues, such as when the same support files have been reused between versions.

Due to issues with broken backwards compatibility, all previous versions of the Interoperability Catalogue should be cancelled when a New Edition is issued.

12.6.2 Cancelling a version of the Interoperability Catalogue

In order to cancel a version of the Interoperability Catalogue, a cancellation catalogue file is created for which the edition number must be set to 0. Interoperability Catalogue edition number is a field in exchange set metadata, class **S100_IC_CatalogueMetadata** (see Clause 13 on Metadata classes). The cancellation catalogue file may contain no data objects and any data objects present in it are ignored. The cancellation catalogue file may be part of an exchange set which contains a new version of the Interoperability Catalogue. This method is only used to cancel an Interoperability Catalogue. When a version of the Interoperability Catalogue is cancelled it must be removed from the system.

A cancellation applies only to Interoperability Catalogues meeting the following conditions:

- The issue date and time of the Interoperability Catalogue being cancelled precede the issue date and time of the cancellation itself. Issue date and time are fields in **S100_IC_CatalogueMetadata** (see Clause 13.3.2).
- The version date of the interoperability catalogue being cancelled precedes or coincides with the version date of the cancellation interoperability catalogue. Version date is a field in the interoperability catalogue header (see S-100 Part 16 Clause 16-4.4.2.1).

NOTE 1: The issue date in metadata may or may not be the same as the version date in the catalogue header.

NOTE 2: Verification and management of authority relationships is out of the scope of this Specification, and may have to be an external process (for example verification of signatures and verification that issuer and canceller are the same or successor organizations, or belong to the same or successor organizations).

12.6.3 Updating the Interoperability Catalogue support files

Support files are updated using the method detailed in Clause 12.3.2.

If changes occur to the support files of a version of the Interoperability Catalogue, then the *updateApplicationDate* in **S100_IC_CatalogueMetadata** must carry the date of the change.

12.6.3.1 New Edition of the support files

New Editions of the support files introduce significant changes. New Editions enable new concepts, such as the ability to support new functions, or the introduction of new constructs. New Editions are likely to have a significant impact on either existing users or future users of the Interoperability Catalogue Specification.

EXAMPLE: A new product is added to Interoperability Catalogue, and all support files should be updated to support the new product. This would require a New Edition of the support files.

12.6.3.2 Revisions to the support files

Revisions are defined as substantive semantic changes to the support files. Typically, revisions will change the support file to correct factual errors; introduce necessary changes that have become evident as a result of practical experience or changing circumstances. A revision must not be classified as a clarification. Revisions could have an impact on either existing users or future users of the Interoperability Catalogue Specification. All cumulative clarifications must be included with the release of approved revisions.

Changes in a revision are minor and ensure backward compatibility with the previous versions within the same Edition. Newer revisions, for example, introduce new feature or attribute combinations. Within the same Edition, a support file created for an Interoperability Catalogue of one version could always be processed with a later revision of the Interoperability Catalogue.

EXAMPLE: Adding a new hybrid feature will require a revision increment to the support file.

12.6.3.3 Clarification to the support files

Clarifications are non-substantive changes to the support file. Typically, clarifications: remove ambiguity; correct grammatical and spelling errors; amend or update cross references; insert improved graphics in spelling, punctuation and grammar. A clarification must not cause any substantive semantic change to the Interoperability Catalogue Specification.

Changes in a clarification are minor and ensure backward compatibility with the previous versions within the same Edition. Within the same Edition, a support file created for an Interoperability Catalogue of one version could always be processed with a later clarification (or revision) of the Interoperability Catalogue.

EXAMPLE: Correcting a spelling error in a definition will require a clarification increment to the support file.

12.6.3.4 Version Numbers

The associated version control numbering in the support file headers must follow the same structure as the Specification itself, see Clause 1.6.5. Support files need not follow the version number of the Interoperability Catalogue they belong to, as support files may be updated numerous times between versions of the Interoperability Catalogue.

Version numbers of support files may have a suffix that indicates a “build number” or date of creation or issue of the support file.

13 Metadata

13.1 Introduction

Discovery metadata for Interoperability Catalogues must be provided in XML format conforming to S-100 dataset discovery as specified in S-100 Part 4a, with the extensions described in this clause.

13.2 Language

Interoperability Catalogue metadata must be provided in the English language.

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13.3 Interoperability Catalogue Metadata elements

Each exchange set has a single CATALOG.XML file which contains meta information for the data and support files in the exchange set.

The exchange catalogue model is shown in Figure 13.1 and its contents are documented in the following sub-clauses.

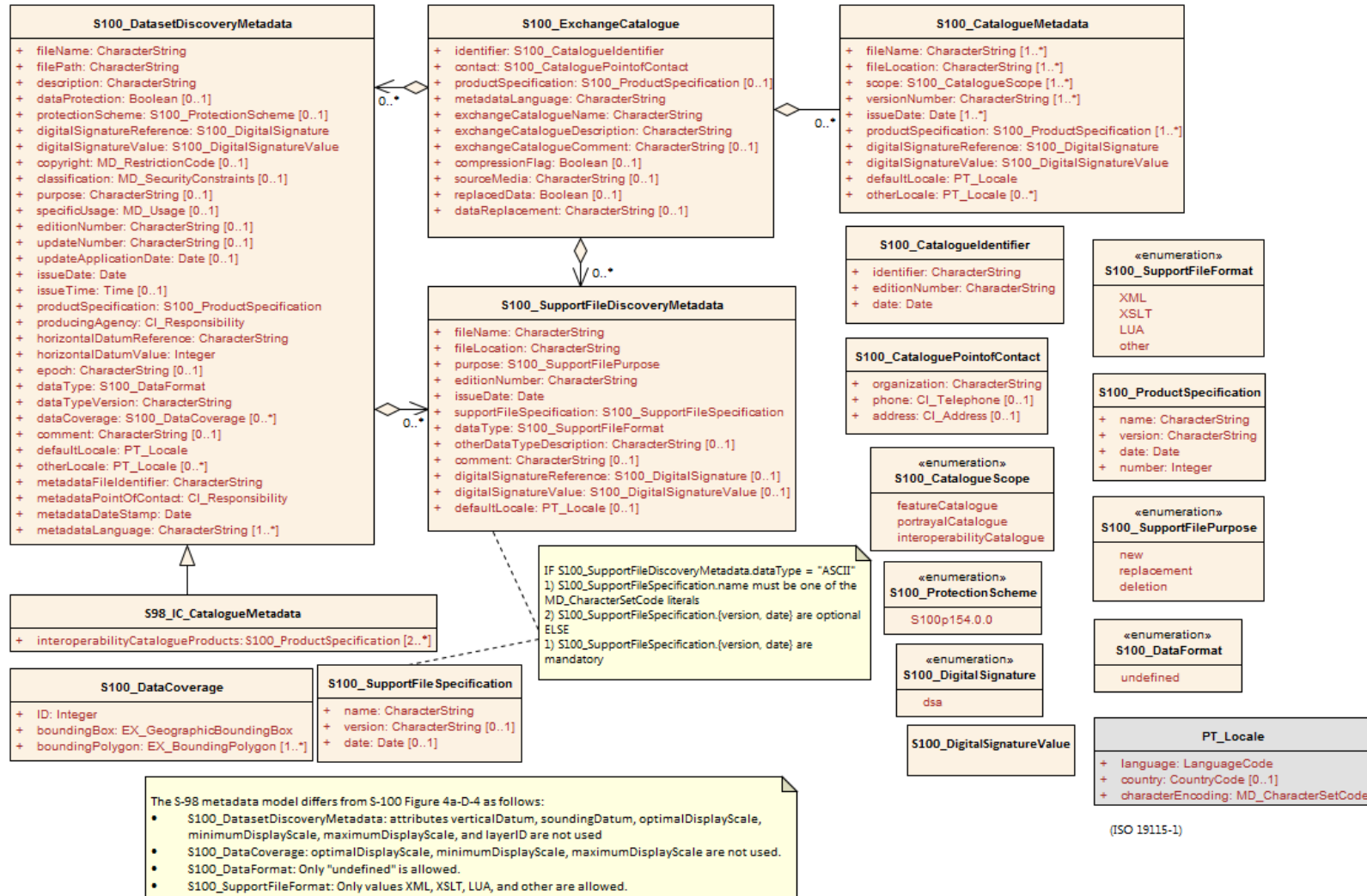


Figure 13.1 - S-98 Metadata classes, attributes, and relationships

13.3.1 S100_ExchangeCatalogue

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_ExchangeCatalogue	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-	-	-
Attribute	identifier	Uniquely identifies this exchange catalogue	1	S100_CatalogueIdentifier	
Attribute	contact	Details about the issuer of this exchange catalogue	1	S100_CataloguePointOfContact	
Attribute	productSpecification	Details about the product specifications used for the datasets contained in the exchange catalogue	0..1	S100_ProductSpecification	Conditional on all the datasets using the same product specification
Attribute	metadataLanguage	Details about the Language	1	CharacterString	
Attribute	exchangeCatalogueName	Catalogue filename	1	CharacterString	CATALOG.XML
Attribute	exchangeCatalogueDescription	Description of what the exchange catalogue contains	1	CharacterString	
Attribute	exchangeCatalogueComment	Any additional Information	0..1	CharacterString	
Attribute	compressionFlag	Is the data compressed	0..1	Boolean	Yes or No
Attribute	sourceMedia	Distribution media	0..1	CharacterString	
Attribute	replacedData	If a data file is cancelled is it replaced by another data file	0..1	Boolean	
Attribute	dataReplacement	Cell name	0..1	CharacterString	
Role	datasetDiscoveryMetadata	Exchange catalogues may include or reference discovery metadata for the datasets in the exchange set	0..*	Aggregation S100_DatasetDiscoveryMetadata	
Role	--	Metadata for catalogue	0..*	Aggregation S100_CatalogueMetadata	Metadata for the feature, portrayal, and interoperability catalogues, if any
Role	supportFileDiscoveryMetadata	Exchange catalogues may include or reference discovery metadata for the support files in the exchange set	0..*	Aggregation S100_SupportFileDiscoveryMetadata	Mandatory for base datasets, since the covered products dictionary is mandatory in base datasets.

13.3.1.1 S100_CatalogueIdentifier

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueIdentifier	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-	-	-
Attribute	identifier	Uniquely identifies this exchange catalogue	1	CharacterString	
Attribute	editionNumber	The edition number of this exchange catalogue	1	CharacterString	
Attribute	date	Creation date of the exchange catalogue	1	Date	

13.3.1.2 S100_CataloguePointofContact

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CataloguePointOfContact	Contact details of the issuer of this exchange catalogue	-	-	-
Attribute	organization	The organization distributing this exchange catalogue	1	CharacterString	This could be an individual producer, value added reseller, etc
Attribute	phone	The phone number of the organization	0..1	CI_Telephone	
Attribute	address	The address of the organization	0..1	CI_Address	

13.3.2 S98_IC_CatalogueMetadata

Role Name	Name	Description	Mult	Type	Remarks
Class	S98_IC_CatalogueMetadata	Catalogue metadata class for interoperability catalogues	-	-	Extension of S100_DatasetDiscoveryMetadata
Attribute	interoperabilityCatalogueProducts	List of supported product specifications	2..*	<sequence>S100_ProductSpecification	
Super class	S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the exchange catalogue	-	Class	Super class of S100_IC_CatalogueMetadata. The attributes verticalDatum and soundingDatum, optimalDisplayScale, minimumDisplayScale, maximumDisplayScale, and layerID are not used
Attribute	fileName	Dataset file name	1	CharacterString	

Role Name	Name	Description	Mult	Type	Remarks
Attribute	filePath	Full path from the exchange set root directory	1	CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<filename>
Attribute	description	Short description giving the area or location covered by the dataset	1	CharacterString	For example a harbour or port name, between two named locations etc
Attribute	dataProtection	Indicates if the data is encrypted	0..1	Boolean	0 indicates an unencrypted dataset 1 indicates an encrypted dataset
Attribute	protectionScheme	Specification or method used for data protection	0..1	S100_ProtectionScheme	
Attribute	digitalSignatureReference	Digital Signature of the file	1	S100_DigitalSignature	Specifies the algorithm used to compute digitalSignatureValue
Attribute	digitalSignatureValue	Value derived from the digital signature	1	S100_DigitalSignatureValue	The value resulting from application of digitalSignatureReference Implemented as the digital signature format specified in S-100 Part 15
Attribute	copyright	Indicates if the dataset is copyrighted	0..1	MD_LegalConstraints ->MD_RestrictionCode <copyright> (ISO 19115-1)	
Attribute	classification	Indicates the security classification of the dataset	0..1	Class MD_SecurityConstraints>MD_ClassificationCode (codelist)	1. unclassified 2. restricted 3. confidential 4. secret 5. top secret 6. sensitive but unclassified 7. for official use only 8. protected 9. limited distribution
Attribute	purpose	The purpose for which the dataset has been issued	0..1	MD_Identification>purpose CharacterString	For example new, new edition, update etc
Attribute	specificUsage	The use for which the dataset is intended	0..1	MD_USAGE>specificUsage> (character string) MD_USAGE>userContactInfo (CI_ResponsibleParty)	specificUsage = "Interoperability Catalogue for ECDIS"

Role Name	Name	Description	Mult	Type	Remarks
Attribute	editionNumber	The edition number of the dataset	0..1	CharacterString	When a data set is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each New Edition.
Attribute	issueDate	Date on which the data was made available by the data producer	1	Date	
Attribute	issueTime	Time of day at which the data was made available by the data producer	0..1	Time	The S-100 datatype Time
Attribute	updateNumber	Update number assigned to the dataset and increased by one for each subsequent update. Update number 0 is assigned to a new dataset.	0..1		Required if and only if this metadata is for an update to an interoperability catalogue.
Attribute	updateApplicationDate	This date is only used for the base cell files (i.e. new data sets, re-issue and new edition), not update cell files. All updates dated on or before this date must have been applied by the producer.	0..1		Required if and only if this metadata is for a base interoperability catalogue (i.e., new, re-issue, or new edition).
Attribute	productSpecification	The Product Specification used to create this dataset	1	S100_ProductSpecification	
Attribute	producingAgency	Agency responsible for producing the data	1	CI_Responsibility>CI_Organisation or CI_Responsibility>CI_Individual	
Attribute	dataType	The encoding format of the dataset	1	S100_DataFormat	Must be "undefined". See Clause 13.3.2.2
Attribute	dataTypeVersion	The version number of the dataType.	1	CharacterString	
Attribute	dataCoverage	Provides information about data coverages within the dataset	0..*	S100_DataCoverage	Interoperability Catalogues coverage is global
Attribute	comment	Any additional information	0..1	CharacterString	
Attribute	defaultLocale	Default language and character set used in the exchange catalogue	1	PT_Locale	
Attribute	otherLocale	Other languages and character sets used in the exchange catalogue	0..*	PT_Locale	
Attribute	metadataFileIdentifier	Identifier for metadata file	1	CharacterString	For example, for ISO 19115-3 metadata file
Attribute	metadataPointOfContact	Point of contact for metadata	1	CI_Responsibility>CI_Individual or CI_Responsibility>CI_Organisation	

Role Name	Name	Description	Mult	Type	Remarks
Attribute	metadataDateStamp	Date stamp for metadata	1	Date	May or may not be the issue date
Attribute	metadataLanguage	Language(s) in which the metadata is provided	1..*	CharacterString	
Role	--	Containment of, or reference to, discovery metadata for the support files referenced in the dataset	0..*	Aggregation S100_SupportFileDiscoveryMetad ata	

13.3.2.1 S100_DataCoverage

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_DataCoverage		-	-	Attributes for maximum, minimum, and optimum display scales are not used
Attribute	ID	Uniquely identifies the coverage	1	Integer	-
Attribute	boundingBox	The extent of the dataset limits	1	EX_GeographicBoundingBox	Set to global coverage for the initial implementation of Interoperability Catalogues
Attribute	boundingPolygon	A polygon which defines the actual data limit	1..*	EX_BoundingPolygon	Set to global coverage for the initial implementation of Interoperability Catalogues

13.3.2.2 S100_DataFormat

Role Name	Name	Description	Code	Remarks
Enumeration	S100_DataFormat	The encoding format	-	Only the "undefined" format is permitted
Value	undefined	The encoding is defined in the Product Specification	-	Use this for Interoperability Catalogues

13.3.2.3 S100_ProductSpecification

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_ProductSpecification	The Product Specification contains the information needed to build the specified product	-	-	-

Role Name	Name	Description	Mult	Type	Remarks
Attribute	name	The name of the Product Specification used to create the datasets	1	CharacterString	S-98
Attribute	version	The version number of the Product Specification	1	CharacterString	
Attribute	date	The version date of the Product Specification	1	Date	
Attribute	number	The number (registry index) used to lookup the product in the Product Specification Register of the IHO GI Registry	1	Integer	From the Product Specification Register, in the IHO Geospatial Information (GI) Registry

13.3.3 S100_SupportFileDiscoveryMetadata

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_SupportFileDiscoveryMetadata	Metadata about the individual support files in the exchange catalogue	-	-	-
Attribute	fileName	Name of the support file	1	CharacterString	
Attribute	fileLocation	Full location from the exchange set root directory	1	CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<fileLocation>/<file name>
Attribute	purpose	The purpose for which the dataset has been issued	1	S100_SupportFilePurpose	For example new, re-issue, new edition, update etc
Attribute	editionNumber	The edition number of the dataset	1	CharacterString	When a data set is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each new edition
Attribute	issueDate	Date on which the data was made available by the data producer	1	Date	
Attribute	supportFileSpecification	The specification used to create this file	1	S100_SupportFileSpecification	
Attribute	dataType	The format of the support file	1	S100_SupportFileFormat	
Attribute	otherDataTypeDescription	Support file format other than those listed	0..1	CharacterString	
Attribute	dataTypeVersion	The version number of the dataType.	1	CharacterString	
Attribute	comment		0..1	CharacterString	

Role Name	Name	Description	Mult	Type	Remarks
Attribute	digitalSignatureReference	Digital Signature of the file	0..1	CharacterString	Reference to the appropriate digital signature algorithm
Attribute	digitalSignatureValue	Value derived from the digital signature	0..1	S100_DigitalSignatureValue	The value resulting from application of digitalSignatureReference. Implemented as the digital signature format specified in Part 15
Attribute	defaultLocale	Default language and character set used in the exchange catalogue	0..1	PT_Locale	A support file is expected to use only one locale, because other files can be created for other languages

13.3.3.1 S100_SupportFileFormat

Role Name	Name	Description	Code	Remarks
Enumeration	S100_SupportFileFormat	The format used in the support file	-	S-100 support file formats other than those listed here are not allowed
Value	XML		-	Feature Catalogue and Portrayal Catalogue are in XML
Value	XSLT		-	For example filters, rules
Value	LUA	A Lua script file	-	
Value	other		-	For example symbols, etc.

13.3.3.2 S100_SupportFilePurpose

Role Name	Name	Description	Code	Remarks
Enumeration	S100_SupportFilePurpose	The reason for inclusion of the support file in this exchange set	-	-
Value	new	A file which is new	-	Signifies a new file
Value	replacement	A file which replaces an existing file	-	Signifies a replacement for a file of the same name
Value	deletion	Deletes an existing file	-	Signifies deletion of a file of that name

13.3.3.3 S100_SupportFileSpecification

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_SupportFileSpecification	The Standard or Specification to which a support file conforms	-	-	-

Role Name	Name	Description	Mult	Type	Remarks
Attribute	name	The name of the Specification used to create the support file	1	CharacterString	
Attribute	version	The version number of the Specification	0..1	CharacterString	
Attribute	date	The version date of the Specification	0..1	Date	

13.3.4 S100_CatalogueMetadata

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_Catalogue	Class for S-100 catalogue metadata.	-	-	-
Attribute	filename	The name for the catalogue	1..*	CharacterString	
Attribute	fileLocation	Full location from the exchange set root director	1..*	CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<fileLocation>/<file name>
Attribute	scope	Subject domain of the catalogue	1..*	S100_CatalogueScope	
Attribute	versionNumber	The version number of the Product Specification	1..*	CharacterString	
Attribute	issueDate	The version date of the Product Specification	1..*	Date	
Attribute	productSpecification	The Product Specification used to create this file	1..*	S100_ProductSpecification	
Attribute	digitalSignatureReference	Digital signature of the file	1	S100_DigitalSignature	Reference to the appropriate digital signature algorithm
Attribute	digitalSignatureValue	Value derived from the digital signature	1	S100_DigitalSignatureValue	The value resulting from application of digitalSignatureReference. Implemented as the digital signature format specified in Part 15
Attribute	defaultLocale	Default language and character set used in the exchange catalogue	1	PT_Locale	
Attribute	otherLocale	Other languages and character sets used in the exchange catalogue	0..*	PT_Locale	

13.3.4.1 S100_CatalogueScope

Role Name	Name	Description	Code	Remarks
Enumeration	S100_CatalogueScope	The scope of the catalogue	-	-
Value	featureCatalogue	S-100 Feature Catalogue	-	Only Interoperability Catalogues implementing Level 3 or 4 may be accompanied by a Feature Catalogue
Value	portrayalCatalogue	S-100 Portrayal Catalogue	-	
Value	interoperabilityCatalogue	S-100 interoperability information	-	Use this for Interoperability Catalogues

13.3.4.2 S100_DigitalSignature

Role Name	Name	Description	Code	Remarks
Enumeration	S100_DigitalSignature	Algorithm used to compute the digital signature	-	-
Value	dsa	Digital Signature Algorithm	-	See S-100 Part 15

13.3.4.3 S100_DigitalSignatureValue

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_DigitalSignatureValue	Signed Public Key plus the digital signature	-	-	Data type for digital signature value

13.3.4.4 PT_Locale

Role Name	Name	Description	Mult	Type	Remarks
Class	PT_Locale	Description of a locale	-	-	From ISO 19115-1
Attribute	language	Designation of the locale language	1	LanguageCode	ISO 639-2 3-letter language codes
Attribute	country	Designation of the specific country of the locale language	0..1	CountryCode	ISO 3166-2 2-letter country codes
Attribute	characterEncoding	Designation of the character set to be used to encode the textual value of the locale	1	MD_CharacterSetCode	Use (the "Name" from the) IANA Character Set register: http://www.iana.org/assignments/character-sets . (ISO 19115-1 B.3.14) For example UTF-8

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14 Processing Model

14.1 Overview of processing

Interoperability processing can either precede or follow portrayal processing (except rendering, which converts feature data into graphics and is necessarily the step just before actual display). A mixed processing model, where interoperability processing is done both before and after portrayal processing, is also possible.

- Option 1 - Interoperability before regular portrayal processing: Feature data from S-101 and other S-100-based datasets is an input to the interoperability processor, along with the Interoperability Catalogue and context parameters. The interoperability processor filters and interleaves feature data according to the Interoperability Catalogue and interoperability level selected by the user and passes the resultant feature data to the portrayal processor, which uses the Portrayal Catalogue for individual products to generate drawing instructions for the display processor.
- Option 2- Interoperability after regular portrayal processing: Feature data from S-101 and other S-100-based datasets flows to the portrayal processor. The portrayal processor transforms them into drawing instructions. The drawing instructions flow to the interoperability processor. The interoperability processor filters and interleaves the drawing instructions according to the Interoperability Catalogue and interoperability level selected by the user and passes the resultant drawing instructions to the display processor.

Both processing options are shown in Figure 14.1 below. This figure extends S-100 Figures 9-2 (Part 9) and 9a-1 (Part 9a) with interoperability concepts. Details of the processing model depend on the interoperability level and are provided in Parts A-D.

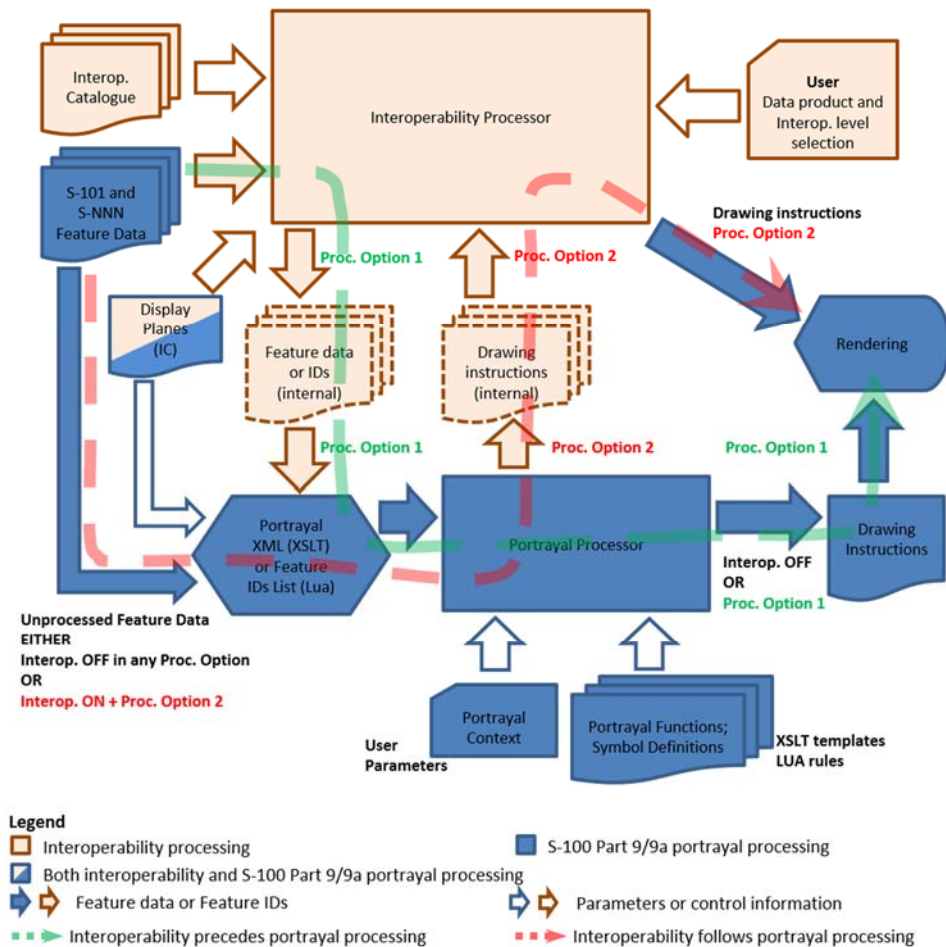


Figure 14.1 – Overview of interoperability processing

In all levels of processing except Level 0 (interoperability off), and Level 1 (which does not include predefined combinations) data products to be loaded are selected by the system according to the list in the predefined combination selected by the mariner selection from among those listed in the catalogue. (In level 1 they are selected by the mariner.) The mariner may also select additional data products from the optional load set.

Feature data from products not listed in the Interoperability Catalogue are passed through to portrayal processing as described in S-100 Part 9/9a (stage *Portrayal Processing*) without any intermediate stages in interoperability processing, and displayed by ordinary S-100 portrayal processing according to their individual Portrayal Catalogues.

Details of the processing model for each level are discussed in the relevant Part of this Specification.

15 User Interaction Constraints and Expectations

15.1 Interoperation requirements for Product Specifications

Responsible parties for Product Specifications that are included in the Interoperability Catalogue should consider the impact on the Interoperability Catalogue and associated Product Specifications throughout the lifecycle of the Product Specification. The general principles of Software Quality Assurance (SQA) as found in section 4 of the Annex to MSC.1/Circ.1512 should be applied.

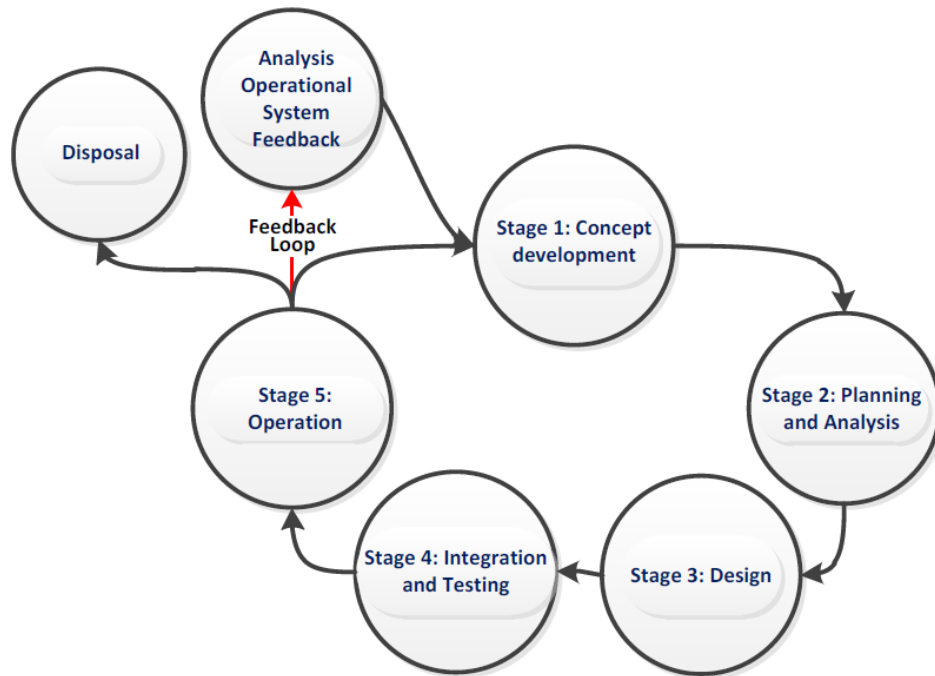


Figure 15.2 - Generic life cycle (from MSC.1/Circ.1512)

Figure 15.2 shows a typical generic life cycle with the stages recommended as a minimum for the management of the development of Product Specifications that are used with the Interoperability Catalogue:

- Analysis of operational system feedback;
- Stage 1: Concept development;
- Stage 2: Planning and analysis;
- Stage 3: Design;
- Stage 4: Integration and testing;
- Stage 5: Operation; and
- Disposal.

15.2 Support different levels of interoperation

The S-98 Interoperability Catalogue provides support for a fixed set of levels of interoperation, as defined in this document. The progression of levels is from lower to higher levels of implementation complexity and visual integration of products.

15.3 User control over loaded set

Users may load an additional product, or turn off one or more of the data products in a predefined combination.

Data from such additional products which are not mentioned in the Interoperability Catalogue are treated by the ECDIS according to the priorities and viewing groups encoded in the product's own Portrayal Catalogue (for example interleaved with layers from products controlled by the Interoperability Catalogue according to their relative drawing orders and display priorities).

Turning off a data product is treated as if the relevant datasets are not available on the system at all. For example, interoperability rules that are made inapplicable due to one of the data products in their conditions

being turned off are ignored. Conversely, loading a dataset covered by an interoperability catalogue (with interoperability turned on) should apply the interoperability catalogue to the combination of the newly loaded dataset and datasets which are already loaded.

15.4 User control over interoperation level

The system should allow the user to change the interoperation level and/or pick a predefined combination by means of simple operations. Any options offered to the user must be valid in context; for example, if the user interface offers the user a choice of predefined combinations at an interoperability level, the listed combinations should be only those defined at that level in the Interoperability Catalogue.

The system should minimise demands for user interaction when changing interoperability level or predefined combinations, subject to constraints imposed by the platform and interface. Some implications of this guidance are:

- 1) When the interoperability level alone is changed and the Interoperability Catalogue contains a predefined combination of the new level that lists the currently displayed product set, the system should apply the rules of the new level to the product set immediately. Alternative predefined combinations for the level may be offered in an unobtrusive way.

EXAMPLE: S-125 and S-101 data are both on-screen when Level 1 is changed to Level 2, and the catalogue includes a “Level 2 S125+S201” predefined combination. Interleaving of S-101 and S-125 features (Level 1) immediately changes to suppression of S-101 navigation aids by S-125 navigation aid features (Level 2). Optionally, a panel on the side of the graphic may display the predefined combinations defined at the new level in the Interoperability Catalogue.

- 2) When the predefined combination alone is changed and the Interoperability Catalogue contains the new predefined combination at the current level, the system should apply the rules of the current level to the new predefined combination.

EXAMPLE: The system is in Level 2 and the S125+S101 predefined combination is changed to S125+S101+S122. The system suppresses S-101 Restricted Area features of type “nature reserve” in favour of Marine Protected Areas from S-122 (assuming the Interoperability Catalogue contains such a rule).

- 3) When the Interoperability Catalogue does not contain a predefined combination at the new level, the user interface should provide an indication of this to the user (though not necessarily by disabling the choice or blocking the transition). Strategies for dealing with this situation are left to interface designers. For example, systems may offer to use the closest fit in the Interoperability Catalogue with any residual on-screen products as ordinary overlays.

15.5 Priority overrides for user-specified settings

Where user action amends a setting, which then conflicts with a system setting, the user setting should override the system setting.

EXAMPLE: Feature display priority set by a user should override display priority set in the Interoperability Catalogue or Portrayal Catalogue.

16 Data Encoding Guide

The data encoding guidance for S-98 Interoperability Catalogues conforms to the guidance in S-100 Part 16.

17 Normative Implementation Guidance

17.1 Reduce demand on user attention - display adjustment

Provide for the use of decluttering techniques by implementations, such as minimizing overlaps of both symbols and text, minimization of the number of colours on the display.

17.2 Reduce demands on user attention - avoid text overload

Provide for text to be shown separately from graphic display. Provide for limiting the amount of text shown both in-graphic, over-graphic, and in a separate auxiliary display.

Generally, in-line text is shorter than text from a support file, though some specifications (for example S-101) allow as many as 300 characters.

Generally speaking Interoperability Catalogue developers should review what individual Data Classification and Encoding Guides say and what Portrayal Catalogues do with text attributes, since the Product Specification developers can be expected to know which attributes can be expected to contain long text and which contain short text.

17.3 Support for novice users

Allow implementations to have "novice" modes or user interface controls, which provide shortcuts for inexperienced users.

17.4 Reduce demands on user attention - planning and monitoring modes

Planning mode can be allowed to provide more powerful information search or processing functionality at the expense of more user attention.

Route monitoring mode must support the ECDIS showing the information required for monitoring while allowing bridge officers to focus on other tasks.

17.5 Interoperability and data coverage

The interoperability rules and interleaving operations described in an Interoperability Catalogue apply only in areas where the products referenced in the rule or interleaving operation have data coverage at the current display scale on the navigation system.

If data coverage for some of the products covered by an interoperability catalogue is absent in an area, the rules and interleaving operations referring to products which do have data coverage in the area in question will continue to apply in that area. Rules and interleaving operations referring to products which do not have data coverage in the area will not apply in the area in question.

Implementations should be capable of indicating parts of the display screen where (a) interoperability is partially applicable because some of the data products in a predefined combination do not have data coverage while others do have coverage; (b) interoperability is not applicable at all because the data products in the selected predefined combination do not have coverage (or the only coverage is that of the base S-101 layer).

NOTE (informative): Depiction and symbols for such distinguished parts of the screen is a matter for ECDIS Performance Standards but an off-graphic message on the ECDIS, or an adaptation of overscale warning symbology may be suitable.

17.6 Other significant information

The inclusion in Interoperability Catalogues of data products whose interoperability has not been discussed with the relevant Product Specification development team is recommended against.

There should be a dialogue between interoperability teams and Product Specification teams, so that new changes to Product Specifications are ensured to be covered by Interoperability Catalogues.

Feature Catalogue and Portrayal Catalogue development teams are stakeholders for hybrid catalogues.

Product Specifications that are in scope of the Interoperability Catalogue should have at least ten display priority steps between display groups, in order to allow more flexibility in interleaving with other products.

17.7 Alarm and indication functionality

The rules and requirements in the applicable IMO and IEC performance standards for navigation systems (MSC 232(82) and IEC 61174), as amended, continue to apply when interoperability is active on the screen. Examples of these rules and requirements are:

- requirements for which features should trigger alarms, and under what circumstances;
- the requirement to use the largest scale data available for alarms or indications of crossing the ship's safety contour, entering a prohibited area, or other alarms or indications described in the standards.

When S-98 interoperability is active, conditions which cause alarms and indications should be treated as follows:

- 1) Conditions from a feature that is not displayed due to reduction in its drawing priority by interoperability should continue to function as specified by the relevant performance standards for off-screen features or features hidden by overlays⁵.
- 2) Conditions from a feature that is not displayed because the feature type or instance is suppressed by an interoperability rule or operation should continue to be generated and processed according to the applicable performance standards, but their display should be tagged with an indicator that it was generated from a suppressed feature.
- 3) A feature that is generated by a hybridization rule in the interoperability catalogue should be treated according to the highest level treatment prescribed for the input features. For example, if one of the input products to the rule triggers an alarm and the other does not, the result should be an alarm on the resultant hybrid feature.
- 4) Conditions from a hybrid feature (item (3) above) should be treated as if they were from a normal data product and the relevant feature types from the input product(s) treated as suppressed feature types as described in item (2).
- 5) The system should combine "spatially stacked" trigger conditions from the same or different products while processing the condition, so that multiple alarms are not unnecessarily generated⁶.
- 6) The system should provide for user action to show or hide the alarm or indication from a suppressed feature or feature with lower drawing priority, both collectively and individually (that is, for all instances of a feature type and for particular feature instances).

⁵ This means alarms or indications should be generated, displayed, etc., as the standards prescribe for a feature of that type which is currently off-screen or hidden. For example, MSC 232(82) (Annex) § 11.4.2 prescribes that automatic route monitoring functions should continue when the ship is not on the display.

⁶ The combined effect of items 3, 4, and 5 is that an alarm on a hybrid feature in Level 3 interoperability will be accompanied by a tagged alarm on at least one of its input features.

- 7) Conditions from a safety contour generated from S-102 data (with or without S-104 data) should be treated as conditions from a hybrid feature, with the contour from the S-101 data treated as a suppressed feature.
- 8) The system should provide for user action to highlight the geometry of a suppressed feature, feature of lower drawing priority, or input feature to a hybrid feature, via user action. The user action should preferably be on the user interface element displaying the individual alarm or indication.

Conditions in areas outside the coverage of interoperating data products should continue to be generated and treated as specified by the governing standards.

17.8 Interoperability in the presence of legacy data formats

The interoperability aspects of dealing with cases where S-57 and S-101 + S-1xx data are both on the navigation screen are not addressed in this draft, pending determination of the path forward with respect to dual-fuel ECDIS. The same applies to interoperability with raster ENC's.

17.9 Interoperability with partial data coverage

The interoperability aspects, if any, of dealing with cases where S-1xx and S-101 coverages are different are not addressed in this draft.

17.10 Phased implementation

Implementation of interoperability is planned in two phases.

1. Phase 1: Levels 1 and 2 constructs.
2. Phase 2: Levels 3 and 4 constructs.

For this version of the Specification, only implementation of Phase 1 is envisaged. Implementation of Phase 2 is placed on hold until further notice.

18 Interoperability Catalogue Schema Documentation

Detailed documentation for the XML schema is provided in S-100 Part 16 Appendix 16-A.

19 Feature Catalogue

Levels 1 and 2 do not define feature catalogues. Levels 3 and 4 use an S-98 hybrid Feature Catalogue, which must be specified by developers of Level 3 or 4 catalogues which generate hybrid features (see Parts C and D).

20 Portrayal Catalogue

Levels 1 and 2 do not define portrayal catalogues. Levels 3 and 4 use an S-98 hybrid Portrayal Catalogue, which must be specified by developers of Level 3 or 4 catalogues which generate hybrid features (see Parts C and D).

S-98 – PART A

LEVEL 1 INTEROPERABILITY

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1 Introduction

S-98 Part A contains information that applies to interoperability catalogues which use interoperability rules and operations of at most Level 1 interoperability.

Interoperability catalogues conforming to this Part must comply with both the following components of S-98:

- 1) S-98 Main Specification, which describes requirements applying to all S-98 interoperability catalogues and S-98 exchange sets;
- 2) S-98 Part A (this Part), which defines the subset of the interoperability model and catalogue encoding that are specific to Level 1 interoperability.

The hypothetical processing model for implementations is described in general terms in the “S-98 – Main” document and elaborated in clause 7 of this Part.

In Level 1 processing, feature types from different products, including S-101, are interleaved as specified by display plane and drawing priority information contained in the Interoperability Catalogue. The ENC is still treated as the main product, but feature layers from other products may be interleaved with ENC feature layers to prevent ENC data from being obscured. There is no other interoperability-related processing of feature data at this level.

The output of interoperability processing is either the original feature data (processing option 1) or drawing instructions (processing option 2), accompanied by display plane and drawing priority information, which is passed through to the portrayal processor. Clause 7 elaborates on these options.

1.1 How to read this Part

Clause 2 of this Part contains scope identification information corresponding to the contents of this Part, which applies specifically to Interoperability catalogues designated as Level 1.

For Clauses 3–10, the content of the clause or sub-clause extends or elaborates on the content under the same or similar clause head or sub-head in S-98 – Main.

The numbering of Clauses 3-10 may differ from that of corresponding clauses in S-98 – Main, because for some there is no additional level-specific information needed. If a clause or sub-clause in S-98 – Main has no corresponding clause or sub-clause in this Part, there is no level-specific information on that topic.

2 Specification Scope for Part A

S-98 Part A describes the portions of S-98 which correspond to the following scope defined in S-98 – Main (Clause 2):

Scope Identification: S98L1

Level: MD_ScopeCode – 13 (software)

Level Name: Interoperability Level 1

Description: Interleaving of feature types

Extent: EX_Extent.description = “worldwide”; EX_GeographicBoundingBox = [-180, +180, -90, +90]

3 Data Content and structure

3.1 Application Schema

3.1.1 Overview of application schema

The application schema for Interoperability Level 1 is depicted in Figure 3.1 below. This application schema is a subset of the full application schema in S-100 Part 16. It consists of the following components:

- 1) Catalogue header information.
- 2) Display plane ordering information.
- 3) Display plane content in the form of either features or drawing instructions.

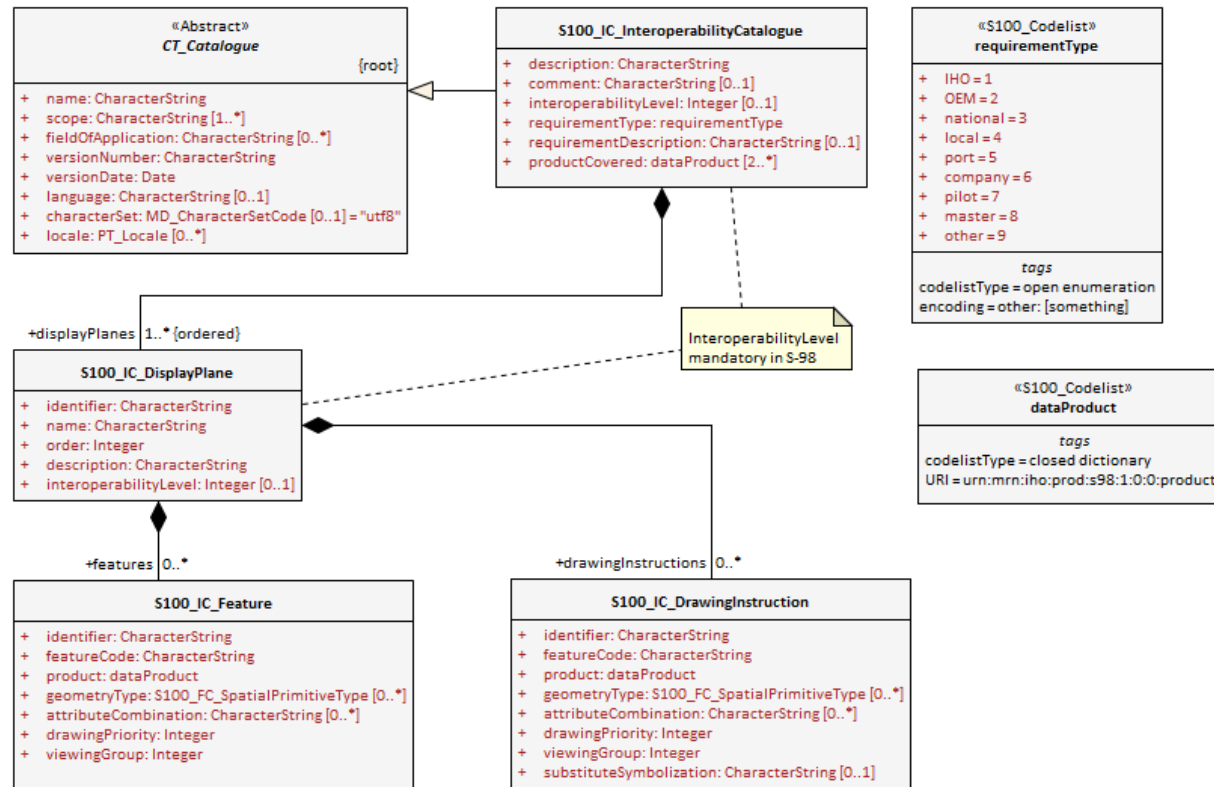


Figure 3.1 – Level 1 interoperability catalogue

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3.1.2 Operations in Pre-Defined Combinations

Operations in predefined combinations are possible only in Levels 2, 3, and 4 (Parts B, C, D).

3.1.3 Enhanced selection of feature instances

Enhanced selection of feature instances is possible only in Levels 3, and 4 (Parts C and D).

3.1.4 Interoperability levels

The *interoperabilityLevel* attribute in **S100_IC_InteroperabilityCatalogue** specifies the highest level of interoperability implemented in that XML interoperability catalogue file. The *interoperabilityLevel* attribute in **S100_IC_DisplayPlane** specifies the level to which that display plane pertains.

3.1.5 Hybridization rules

Hybridization rules are allowed only in Levels 3 and 4 (Parts C and D).

3.1.6 Hybrid feature and portrayal catalogues

Hybrid Feature and Portrayal Catalogues are allowed only in Levels 3 and 4 (Parts C and D).

3.1.7 Progression of interoperability levels

The only progression of interoperability levels is from no interoperability (in which case interoperability catalogues are not involved and there is no interoperability schema) to Level 1 interoperability.

3.2 Interoperability Catalogue

3.2.1 Conceptual Types for Level 1 Interoperability

The following clauses summarize the conceptual elements used in Level 1 Interoperability Catalogues. Details about these conceptual types are provided in S-100 Part 16.

3.2.1.1 Display Plane (S100_IC_DisplayPlane)

A display plane element in the interoperability catalogue acts as a container for display information for specified feature classes, which enables the interleaving of feature layers during portrayal by indicating the display plane, priority, and drawing order of the features assigned to a display plane.

A feature type may be referenced in more than one **S100_IC_DisplayPlane**, but the entries in different display planes must be distinguished by different attribute-value combinations or spatial primitives so that the actual instances of features are partitioned unambiguously between different display planes.

The portrayal of feature types not mentioned in any **S100_IC_DisplayPlane** component is undefined until ordinary portrayal processing takes place.

3.2.1.2 Feature type display information (S100_IC_Feature)

The **S100_IC_Feature** element describes the display parameters for all features of a specific feature type in a specific product and thereby determines the order of drawing the feature type relative to other feature types in the same display plane. It also specifies the viewing group to which the feature is assigned. Its applicability can be optionally restricted to a subset of instances of the feature type by additional attributes that specify the type of spatial primitive and indicate specific values of thematic attributes.

3.2.1.3 Drawing instruction (S100_IC_DrawingInstruction)

Drawing instructions in the Interoperability Catalogue play a similar role to feature type display information (**S100_IC_FeatureType**) but with drawing instructions instead of feature objects. The **S100_IC_DrawingInstruction** element in Interoperability Catalogues is similar in operation to the layering and priority aspects of the **DrawingInstruction** element in Portrayal Catalogues (see S-100 Part 9 - Portrayal). Where there is a conflict with a Portrayal Catalogue drawing instruction, the drawing instruction in the Interoperability Catalogue supersedes the drawing instruction in the Portrayal Catalogue.

The **S100_IC_DrawingInstruction** element contains an additional attribute that allows substitution of symbolization instructions generated by portrayal processing.

3.2.1.3.1 Comparison and use of S100_IC_Feature and S100_IC_DrawingInstruction

S100_IC_Feature and **S100_IC_DrawingInstruction** elements in Interoperability Catalogues operate in essentially the same way as far as assignment of drawing order, priority, and display planes is concerned. They differ in that **S100_IC_DrawingInstruction** provides an optional attribute to substitute the symbolization elements of the drawing instruction.

S100_IC_Feature should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions.

S100_IC_DrawingInstruction should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions. It should also be used in all catalogues where substitution of symbolization is necessary.

3.2.2 Use of S-100 types

The S-100 types used by S-98 Level 1 interoperability catalogues are described in the S-98 – Main component of this Specification. For Level 1 interoperability catalogues, the following additional information applies.

- Interoperability Catalogues of Level 1 do not use feature and information associations in feature filters.

3.3 UML model documentation

The UML model documentation is provided in **S-100 Part 16**. This clause documents details specific to the use of the UML model for the interoperability level described in this Part of S-98.

Only the model elements used in this level (and included in the level's application schema) are listed. The constraints and considerations listed in the UML documentation tables in S-100 Part 16 apply. Any S-98 general or level-specific considerations are described under the element name in the list below.

- 1) **S100_IC_DisplayPlane**: No level-specific constraints or notes

Attribute *interoperabilityLevel*: Mandatory in S-98 catalogues at all levels. The only value allowed for Level 1 interoperability catalogues is 1.

- 2) **S100_IC_DrawingInstruction**:

NOTE for implementers: Even if the Presentation schema in S-100 Part 9 is used, implementers may need to provide specific code to validate the content of the *substituteSymbolization* attribute instead of depending on normal XML schema validation. The content of this attribute is not prescribed by this specification and may be a fragment of XML, or interpretable code or rules, etc., in a non-XML syntax. It may be enclosed in a `<![CDATA[...]]>` section so that XML validators treat it as character data instead of XML.

3) **S100_IC_Feature**: No level-specific constraints or notes

4) **S100_IC_InteroperabilityCatalogue**:

Attribute *productCovered*: Must use values defined in the dictionary identified by MRN: urn:mrn:iho:prod:s98:1:0:0:products

Attribute *interoperabilityLevel*: Mandatory. The only value allowed for level 1 interoperability catalogues is 1.

5) **Codelist dataProduct**: No level-specific constraints or notes. The data type for all levels is described below.

Codelist Type: closed dictionary

MRN: urn:mrn:iho:prod:s98:1:0:0:products

6) **Codelist requirementType**: No level-specific constraints or notes.

For all interoperability levels, the following subset of the standard values listed in S-100 Part 16 are permitted to be used in S-98 interoperability catalogues:

Table 3-1 - Allowed values for requirementType

Value	Description	Code
IHO	Original IHO Interoperability Catalogue	1
OEM	Prepared according to requirements specified by OEM or systems integrator	2
national	Prepared according to requirements specified by a national government, group of national governments (for example the European Union), or governmental agency such as a national shipping authority or the Coast Guard.	3
local	Prepared according to requirements specified by a sub-national governmental authority such as a state, province, or county	4
port	Prepared according to requirements specified by a harbormaster's office or port authority	5
company	Prepared according to requirements specified by the owner, charterer, or operator	6
pilot	Prepared according to requirements specified by a pilot	7
master	Prepared according to requirements specified by the vessel's master	8

Extra values ("other: ...") as defined in S-100 § 3-6.7 are also permitted.

4 Level-specific data quality considerations

4.1 Quality of displayed data

There are no level-specific extensions to Clause 6.1 of the "S98 – Main" document.

Clause 5.11 provides guidance for maintaining data quality for level-specific rules and operations.

4.2 Quality of interoperability catalogues

The quality measures recommended in S-97 (Part C) which are applicable to Level 1 S-98 interoperability catalogues are those listed in Table 6-1 of the “S-98 – Main” document. There are no additional level-specific measures for Level 1.

4.2.1 Test methods

There are no level-specific extensions to Clause 6.2.1 of the “S-98 – Main” document.

4.2.2 Data quality testing

There are no level-specific extensions to Clause 6.2.2 of the “S-98 – Main” document.

5 Level-specific Guidance on Making Product Specifications Interoperable

The guidelines in this clause supplement and extend guidance common to all levels on making product specifications interoperable, which is given in clause 8 of the “S-98 – Main” document.

5.1 Duplicated features

There is no level-specific guidance for determining duplicated features. However, when interoperability catalogues are developed to resolve duplicated features, keep in mind the following level-dependent considerations:

Level 1 interoperability catalogues can allow only changes to the display planes and display orders specified in the products’ portrayal catalogues, as determined by display plane and drawing priority information. This means that features which are not covered by features with higher drawing priority or in a upper display plane will still be visible.

5.1.1 Duplicated features same model

See the guidance in the “S-98 – Main” component of this specification.

5.1.2 Duplicated features, different models

See the guidance in the “S-98 – Main” component of this specification.

5.1.3 Duplicate feature domains

See the guidance in the “S-98 – Main” component of this specification.

5.2 Geometry

5.2.1 Combined geometry

Combined geometry is possible only in interoperability levels 3 and 4 (Parts C and D of this specification).

5.2.2 Spatial discrepancy, unrelated to scaled or cartographic smoothing

Resolution of this type of spatial discrepancy is possible only in Levels, 2, 3, and 4 (Parts B, C, and D of this specification).

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.2.3 Spatial discrepancies, related to scale or cartographic smoothing

Resolution of this type of spatial discrepancy is possible only in Levels, 2, 3, and 4 (Parts B, C, and D of this specification).

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.3 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also clause 10.8 of the “S-98 – Main” component.

5.4 Skin-of-the-earth feature operations

5.4.1 Skin-of-the earth feature replacement

Level 1 Interoperability Catalogues permit the following:

- Interleaving of display planes so that upper planes overwrite lower planes (Level 1 functionality). This can be used to shift feature layers to lower or higher planes to overwrite layers whose replacement is desired.

See clause 5.9 for portrayal considerations.

5.4.2 Skin-of-the earth feature adjusting

Adjustment of the geometry of skin-of-the-earth features is possible only in Level 4 (Part D).

5.5 Blended feature concepts

Blended features or blended portrayal are only possible in interoperability Levels 3 and 4 (Parts C and D).

5.6 Hierarchy of data

5.6.1 Hierarchy by stacking of display planes

In Level 1 interoperability catalogues, hierarchy can be set only to the extent that display planes can be interleaved by the interoperability rules.

5.6.2 Predefined combinations

Predefined combinations can be defined only in Level 2, 3, or 4 interoperability catalogues (Parts B, C, and D).

5.7 New datasets

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.8 Dataset scales, loading, and unloading

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.9 Metadata

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.10 Meta-features

Any spatial operations on meta-features require an Interoperability Catalogue to implement at least Level 4.

There is no other level-specific guidance for meta-features. Common guidance is provided in the “S-98 – Main” component of this specification.

5.11 Quality considerations

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6 Portrayal

This clause gives guidelines and instruction to portrayal considerations related to the use of the Interoperability Catalogue in an ECDIS. The Interoperability Catalogue must apply to the specific Product Specifications listed in the Interoperability Catalogue metadata, *interoperabilityCatalogueProducts* attribute under **S100_IC_CatalogueMetadata**.

There may be additional data products present in the S-100 ECDIS that are external to the Interoperability Catalogue; in such cases the Interoperability Catalogue should continue to function in presence of product not defined in the Catalogue. Data products that are outside of the interoperability scope must be treated in Interoperability Level 0 (see clause 9.6 of “S-98 – Main”).

6.1 Display of significant features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.2 Display of significant features - switching to original

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.3 Portrayal distinguishability - colour set-asides

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also S-100 Part 16 for specific guidance on colour set-asides.

6.4 Day/night/dusk modes

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.5 Impacts on viewing groups

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.6 Impacts on Portrayal Catalogues

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.7 Meta-features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.8 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.9 Skin-of-the-earth operations and portrayal

6.9.1 Skin-of-the-earth feature replacement and portrayal

For all levels, anything that replaces S-101 skin-of-the-earth features, will overwrite it by having a higher priority; that is, be drawn later. The major difference between the levels is in the overwriting.

Interoperability operations in Level 1 overwrites skin-of-the-earth features and everything else (by interleaving display planes so that upper planes overwrite lower planes).

Gridded data will generally go over ENC and obscure ENC features, either all (interoperability Level 0) or specific features (interoperability Level 1) depending on interoperability level chosen, the predefined combinations or display plane of the features that are interacting.

EXAMPLE: High definition gridded bathymetry replaces (overwrite) depth area and depth contours, but soundings, aids to navigation, and obstructions are over the high definition bathymetry (interoperability Level 1).

NOTE: Safety contour comes from ENC and is generated by the viewer system. This safety contour is an IMO requirement (IMO Performance Standard 5.8 (MSC.232(82))) for ECDIS and should be presented with highest priority when turned on by the user. OEMs are permitted to add additional safety contour functions, for example; generated from combining high definition gridded bathymetry (S-102) and S-104 input.

6.9.2 Skin-of-the-earth feature adjusting and portrayal

This clause covers the possibility of the skin-of-the-earth features geometry and/or attribute values being dynamically adjusted based on the corresponding features in other data layers.

Changes to the location or extent of symbols displayed on the screen due to a feature in another dataset are only possible in interoperability Levels 3 and 4 (Parts C and D).

6.10 Blended portrayals

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.11 Hierarchy of data

As noted in the “S-98 – Main” component of this specification, hierarchy of data can be controlled by predefined combinations (Level 2 and higher). Level 1 catalogues offer only a very limited means of controlling hierarchy by means of display plane ordering. There is no level-specific guidance for portrayal in connection with this issue.

6.11.1 Interacting gridded information

There is no level-specific guidance for portrayal in connection with this issue.

6.12 Pick reports

[NOTE: The pick report functionality specification in S-98 is still under development, and the content of this section will change as this functionality is defined.]

Clause 10.12 of “S-98 – Main” applies. There is no additional level-specific guidance for Level 1.

7 Processing Model

Figure 7.1 below shows the processing steps and input to each step from parts of the Interoperability Catalogue, for the “Interoperability before portrayal” processing option. Figure 7.1 shows the steps and inputs for the “Interoperability after portrayal” processing option. In both cases, the flow depends on the interoperability level selected by the mariner.

In Level 0 processing, interoperability is turned off and all data products loaded are passed through to S-100 Portrayal Processing to be portrayed as overlays to ENC data according to their individual Portrayal Catalogues.

In Level 1 processing, the only interoperability processing is interleaving of feature layers by means of display plane information, and Interleave Feature Layers is the only interoperability processing before feature data is passed to S-100 Portrayal Processing. The only input from the Interoperability Catalogue is display plane and drawing order information from **S100_IC_DisplayPlane** elements in the catalogue.

Figures 7.2 and Figure 7.3 depict two possible implementations, with the input to interoperability processing being either feature data or drawing instructions generated from feature data by (part of) portrayal processing.

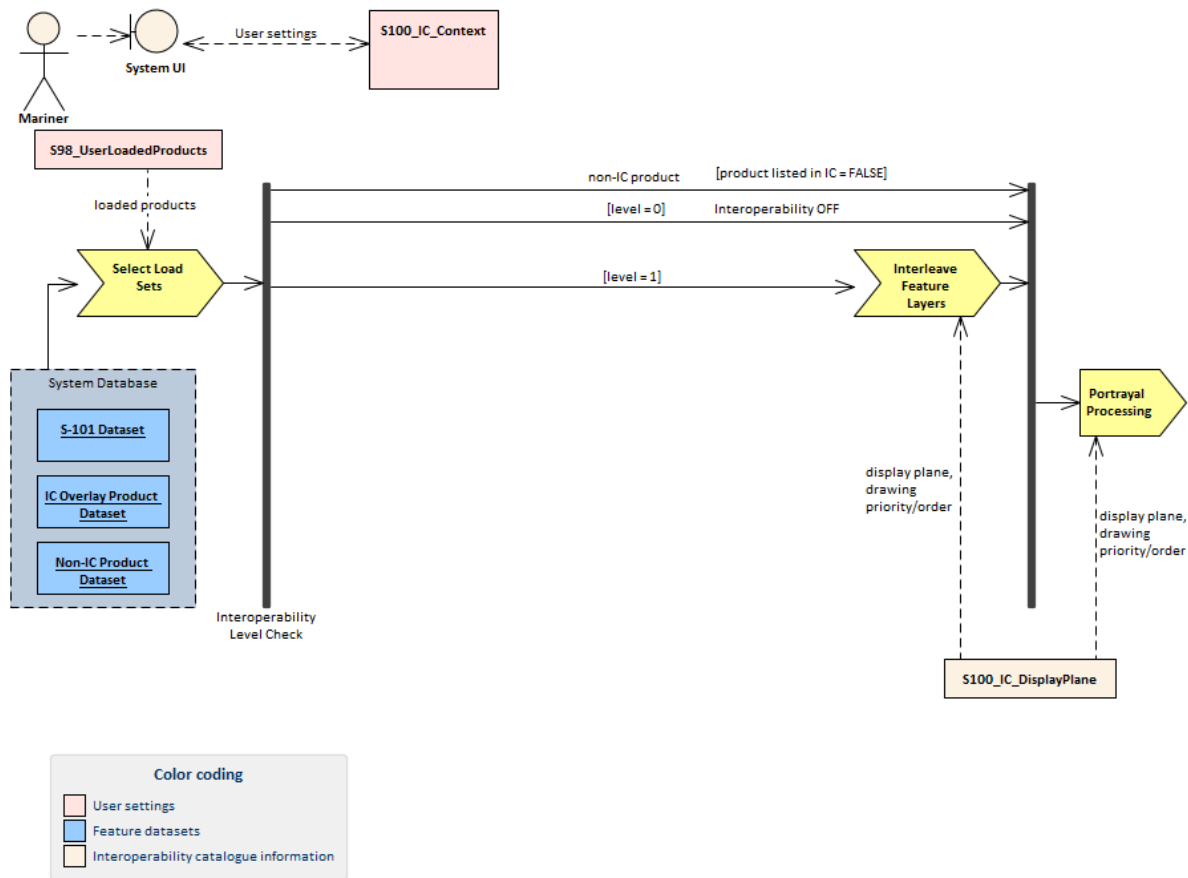


Figure 7.2 - Interoperability processing flow (portrayal processing after interoperability)

For implementations that pass drawing instructions instead of features to interoperability processing, the flow is similar except that portrayal processing takes place before interoperability processing.

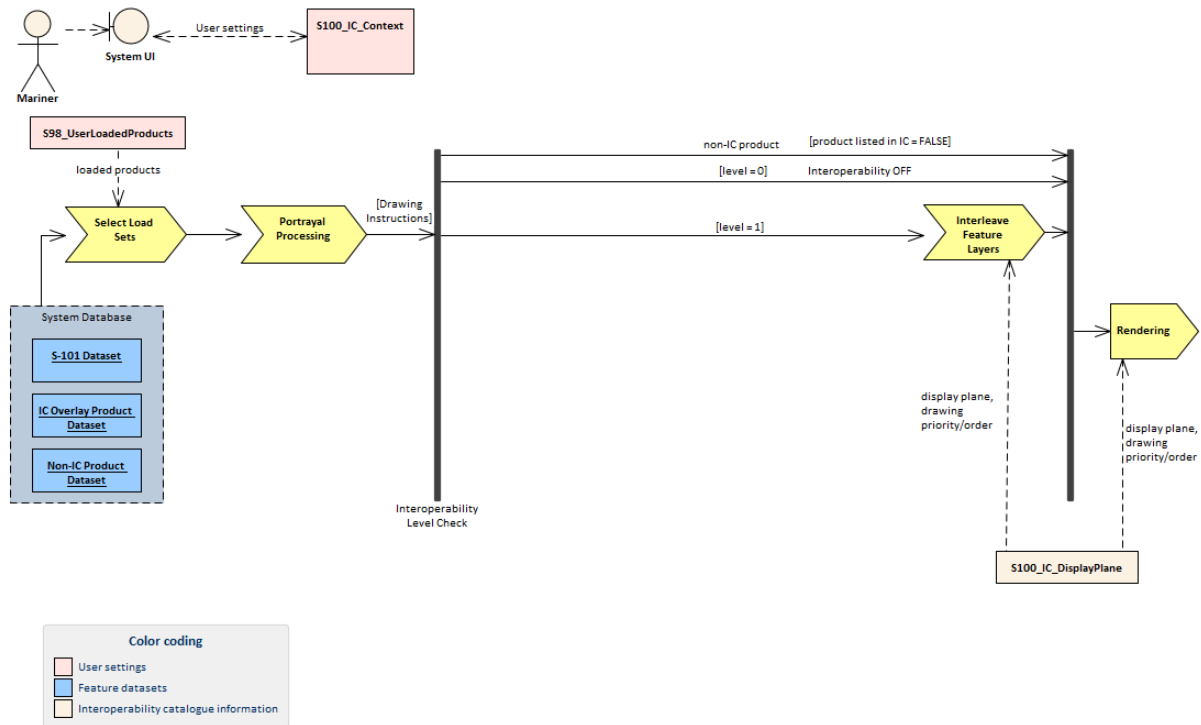


Figure 7.3 - Interoperability processing (drawing instructions generated before interoperability processing)

Table 6.1 - Stages in Level 1 interoperability processing

Stage	Description	Level	IC information	Context information	Remarks
Select Load Sets	Select data products to be loaded	All	User adds data products to display individually	None	-
Portrayal Processing	Ordinary S-100 portrayal processing	All	display planes		Except final display processing / rendering
Interleave Feature Layers	Assign display plane and drawing order to feature data	1	S100_IC_DisplayPlane		
Rendering	Display processing	All	S100_IC_DisplayPlane		

8 Normative Implementation Guidance

There is no level-specific normative implementation guidance in this edition of S-98. See the Main component of this Specification for implementation guidance that applies to all levels.

9 Feature Catalogue

Level 1 does not define feature catalogues.

10 Portrayal Catalogue

Level 1 does not define portrayal catalogues.

S-98 – PART B

LEVEL 2 INTEROPERABILITY

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1 Introduction

S-98 Part B contains information that applies to interoperability catalogues which use interoperability rules and operations of at most Level 2 interoperability.

Interoperability catalogues conforming to this Part must comply with both the following components of S-98:

- 1) S-98 Main Specification, which describes requirements applying to all S-98 interoperability catalogues and S-98 exchange sets;
- 2) S-98 Part B (this Part), which defines the subset of the interoperability model and catalogue encoding that are specific to Level 2 interoperability.

The hypothetical processing model for implementations is described in general terms in the “S-98 - Main” document and elaborated in clause 7 of this Part.

Level 2 interoperability includes the following capabilities:

- Level 1 interoperability, in which feature types from different products, including S-101, are interleaved as specified by display plane and drawing priority information contained in the Interoperability Catalogue.
- In addition, Level 2 allows suppression of all features of a specified feature type in a specified product, with another feature type from a different product being displayed instead. Filtering by attribute values and geometry type is also possible.
- Level 2 also adds constructs allowing catalogues to partition interoperability rules and operations according to specified combinations of data products (“predefined combinations”). The rules and operations in each partition are applied only when the corresponding data products are part of the display.

The output of interoperability processing is either the original feature data (processing option 1) or drawing instructions (processing option 2), accompanied by display plane and drawing priority information, which is passed through to the portrayal processor. Clause 7 elaborates on these options.

1.1 How to read this Part

Clause 2 of this Part contains scope identification information corresponding to the contents of this Part, which applies specifically to Interoperability catalogues designated as Level 2.

For Clauses 3–10, the content of the clause or sub-clause extends or elaborates on the content under the same or similar clause head or sub-head in S-98 – Main.

The numbering of Clauses 3-10 may differ from that of corresponding clauses in S-98 – Main, because for some there is no additional level-specific information needed. If a clause or sub-clause in S-98 – Main has no corresponding clause or sub-clause in this Part, there is no level-specific information on that topic.

Part B includes Part A content (pertaining to Level 1), adapted as necessary for Level 2. Reference to Part A should therefore not be needed.

2 Specification Scope for Part B

S-98 Part B describes the portions of S-98 which correspond to the following scope defined in S-98 – Main (Clause 2):

Scope Identification: S98L2

Level: MD_ScopeCode – 13 (software)

Level Name: Interoperability Level 2

Description: Type-based selectivity and feature class replacement; interleaving

Extent: EX_Extent.description = “worldwide”; EX_GeographicBoundingBox = [-180, +180, -90, +90]

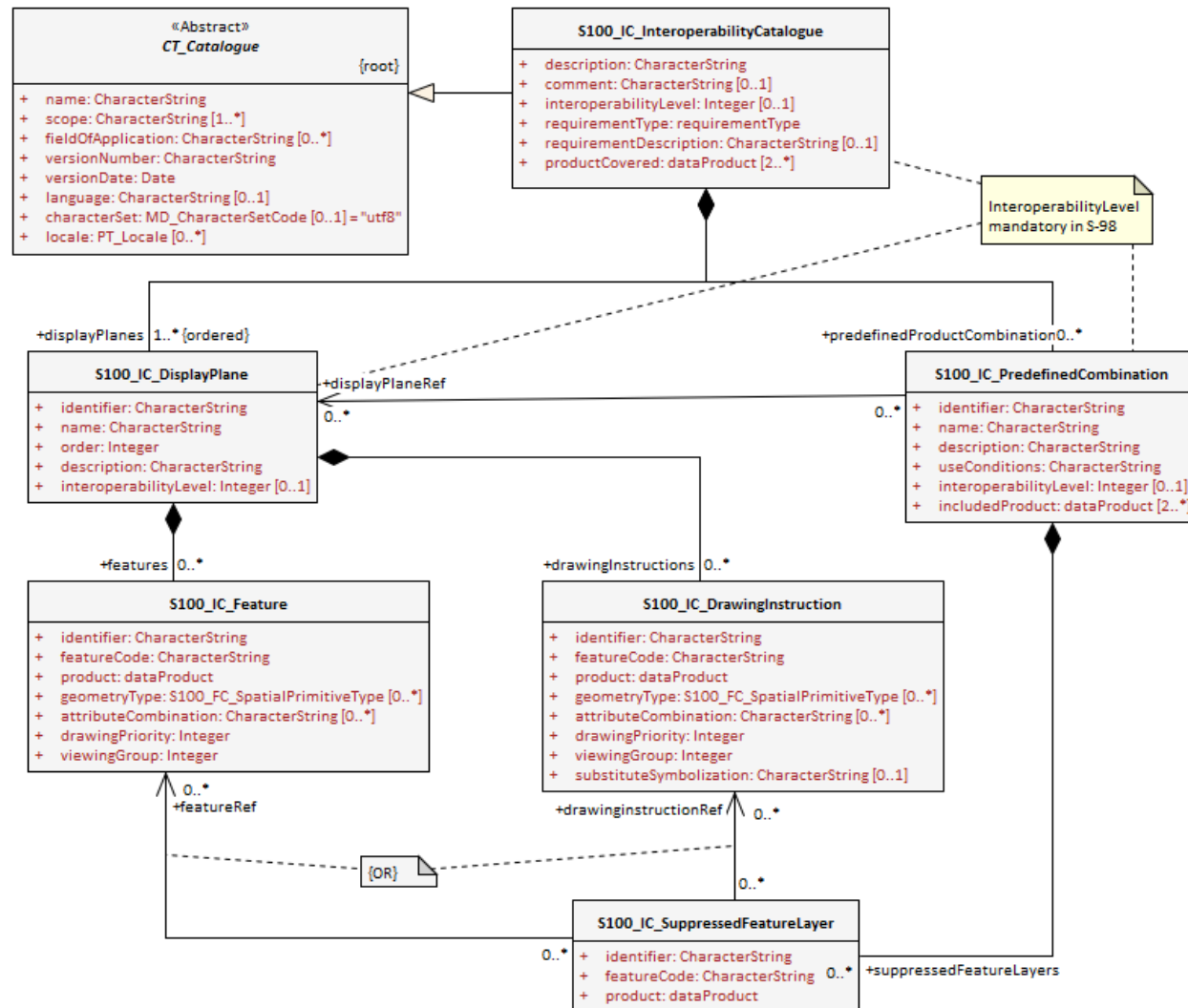
3 Data Content and structure

3.1 Application Schema

3.1.1 Overview of application schema

The application schema for Interoperability Level 2 is depicted in Figure 3.1 below. This application schema is a subset of the full application schema in S-100 Part 16. It consists of the following components:

- 1) Catalogue header information.
- 2) Display plane ordering information.
- 3) Display planes content in the form of either features or drawing instructions.
- 4) Specification of rules indicating which feature layers to suppress.
- 5) Specification of data product combinations and method of referencing collections of interoperability rules and operations to specific combinations.
- 6) Specification of rules indicating which feature instances to suppress.



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3.1.2 Operations in Pre-Defined Combinations

Level 2 introduces predefined combinations, whereby the scope of specified interoperability operations can be restricted so the operations are executed only when a specified set of data products is active on the user display. Display plane and feature ordering (Level 1 operations) can be thus restricted by associating a specific set of products (listed in **S100_IC_PredefinedCombination** elements) to **S100_IC_DisplayPlane** elements.

Level 2 interoperability also allows replacement of a feature layer from one product by a feature layer from another product. These layers are specified by **S100_IC_SuppressedFeatureLayer** elements. Replacement operations are restricted to occur only when specific combinations of data products are present on the user display because the **S100_IC_SuppressedFeatureLayer** elements in interoperability catalogues are always contained within **S100_IC_PredefinedCombination** elements.

3.1.3 Enhanced selection of feature instances

Enhanced selection of feature instances is possible only in Levels 3 and 4 (Parts C and D).

3.1.4 Interoperability levels

The *interoperabilityLevel* attribute in **S100_IC_InteroperabilityCatalogue** specifies the highest level of interoperability implemented in that XML interoperability catalogue file. The *interoperabilityLevel* attribute in **S100_IC_DisplayPlane** specifies the level to which that display plane pertains.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements are permitted to also include operations of a lower level of interoperability.

3.1.5 Hybridization rules

Hybridization rules are allowed only in Levels 3 and 4 (Parts C and D).

3.1.6 Hybrid feature and portrayal catalogues

Hybrid Feature and Portrayal Catalogues are allowed only in Levels 3 and 4 (Parts C and D).

3.1.7 Progression of interoperability levels

Figure 3.2 below shows the components of the model subset used by this level compared to lower levels.

Level 2 adds predefined combinations and feature suppression elements to Level 1.

Interoperability catalogues at any level can also use lower-level functionality.

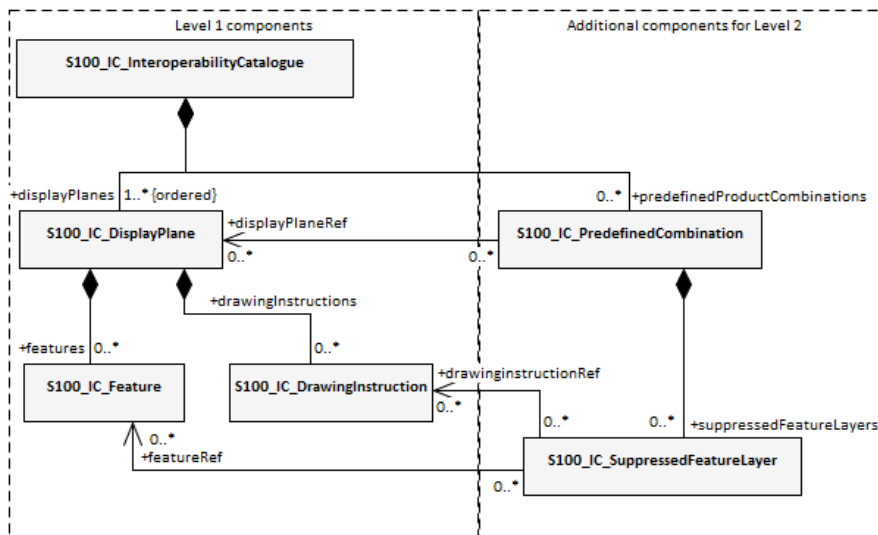


Figure 3.2 - Progressive use of Interoperability Catalogue model

3.2 Interoperability Catalogue

3.2.1 Conceptual Types for Level 2 Interoperability

The following clauses summarize the conceptual elements used in Level 2 Interoperability Catalogues. Details about these conceptual types are provided in S-100 Part 16.

3.2.1.1 Display Plane (S100_IC_DisplayPlane)

A display plane element in the interoperability catalogue acts as a container for display information for specified feature classes, which enables the interleaving of feature layers during portrayal by indicating the display plane, priority, and drawing order of the features assigned to a display plane.

A feature type may be referenced in more than one **S100_IC_DisplayPlane**, but the entries in different display planes must be distinguished by different attribute-value combinations or spatial primitives so that the actual instances of features are partitioned unambiguously between different display planes.

The portrayal of feature types not mentioned in any **S100_IC_DisplayPlane** component is undefined until ordinary portrayal processing takes place.

3.2.1.2 Feature type display information (S100_IC_Feature)

The **S100_IC_Feature** element describes the display parameters for all features of a specific feature type in a specific product and thereby determines the order of drawing the feature type relative to other feature types in the same display plane. It also specifies the viewing group to which the feature is assigned. Its applicability can be optionally restricted to a subset of instances of the feature type by additional attributes that specify the type of spatial primitive and indicate specific values of thematic attributes.

3.2.1.3 Feature layer (S100_IC_SuppressedFeatureLayer)

Each instance of this element identifies a feature type in a specific data product which is supposed to be suppressed in the presence of another specified feature type from another product.

3.2.1.4 Drawing instruction (**S100_IC_DrawingInstruction**)

Drawing instructions in the Interoperability Catalogue play a similar role to feature type display information (**S100_IC_FeatureType**) but with drawing instructions instead of feature objects. The **S100_IC_DrawingInstruction** element in Interoperability Catalogues is similar in operation to the layering and priority aspects of the **DrawingInstruction** element in Portrayal Catalogues (see S-100 Part 9 - Portrayal). Where there is a conflict with a Portrayal Catalogue drawing instruction, the drawing instruction in the Interoperability Catalogue supersedes the drawing instruction in the Portrayal Catalogue.

The **S100_IC_DrawingInstruction** element contains an additional attribute that allows substitution of symbolization instructions generated by portrayal processing.

3.2.1.4.1 Comparison and use of **S100_IC_Feature** and **S100_IC_DrawingInstruction**

S100_IC_Feature and **S100_IC_DrawingInstruction** elements in Interoperability Catalogues operate in essentially the same way as far as assignment of drawing order, priority, and display planes is concerned. They differ in that **S100_IC_DrawingInstruction** provides an optional attribute to substitute the symbolization elements of the drawing instruction.

S100_IC_Feature should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions.

S100_IC_DrawingInstruction should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions. It should also be used in all catalogues where substitution of symbolization is necessary.

3.2.1.5 Predefined combination (**S100_IC_PredefinedCombination**)

A predefined combination element defines a collection of data products for which a common set of interoperability operations have been defined in the Interoperability Catalogue. Instances of predefined combinations are also characterized by interoperability level, which allows the encoding of different sets of operations depending on how tightly integrated the user desires the products to be on the resultant display.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements with a specified level attribute are permitted to also include operations of a lower level of interoperability.

Predefined combinations can be linked to **S100_IC_DisplayPlane** elements by means of references in the **S100_IC_PredefinedCombination** elements.

3.2.2 Use of S-100 types

The S-100 types used by S-98 Level 2 interoperability catalogues are described in the S-98 – Main component of this Specification. For Level 2 interoperability catalogues, the following additional information applies.

- Interoperability Catalogues of Level 2 do not use feature and information associations in feature filters.

3.3 UML model documentation

The UML model documentation is provided in **S-100 Part 16**. This clause documents details specific to the use of the UML model for the interoperability level described in this Part of S-98.

Only the model elements used in this level (and included in the level's application schema) are listed. The constraints and considerations listed in the UML documentation tables in S-100 Part 16 apply. Any S-98 general or level-specific considerations are described under the element name in the list below.

- 1) **S100_IC_DisplayPlane:** No level-specific constraints or notes

Attribute *interoperabilityLevel*: Mandatory. The only values allowed for Level 2 interoperability catalogues are 1 and 2.

- 2) **S100_IC_DrawingInstruction:**

NOTE for implementers: Even if the Presentation schema in S-100 Part 9 is used, implementers may need to provide specific code to validate the content of the *substituteSymbolization* attribute instead of depending on normal XML schema validation. The content of this attribute is not prescribed by this specification and may be a fragment of XML, or interpretable code or rules, etc., in a non-XML syntax. It may be enclosed in a `<![CDATA[...]]>` section so that XML validators treat it as character data instead of XML.

- 3) **S100_IC_Feature:** No level-specific constraints or notes

- 4) **S100_IC_InteroperabilityCatalogue:**

Attribute *productCovered*: Must use values defined in the dictionary identified by MRN: urn:mrn:iho:prod:s98:1:0:0:products

Attribute *interoperabilityLevel*: Mandatory in S-98 catalogues at all levels. The only value allowed for Level 2 interoperability catalogues is 2.

- 5) **S100_IC_PredefinedCombination:**

Attribute *interoperabilityLevel*: Mandatory in S-98 interoperability catalogue; allowed values: 1, 2.

- 6) **S100_IC_SuppressedFeatureLayer:** No level-specific constraints or notes

- 7) **Codelist dataProduct:** No level-specific constraints or notes. The data type for all levels is described below.

Codelist Type: closed dictionary

MRN: urn:mrn:iho:prod:s98:1:0:0:products

- 8) **Codelist requirementType:** No level-specific constraints or notes.

For all interoperability levels, the following subset of the standard values listed in S-100 Part 16 are permitted to be used in S-98 interoperability catalogues:

Table 3-1 - Allowed values for requirementType

Value	Description	Code
IHO	Original IHO Interoperability Catalogue	1
OEM	Prepared according to requirements specified by OEM or systems integrator	2
national	Prepared according to requirements specified by a national government, group of national governments (for example the European Union), or governmental agency such as a national shipping authority or the Coast Guard.	3
local	Prepared according to requirements specified by a sub-national governmental authority such as a state, province, or county	4
port	Prepared according to requirements specified by a harbormaster's office or port authority	5

Value	Description	Code
company	Prepared according to requirements specified by the owner, charterer, or operator	6
pilot	Prepared according to requirements specified by a pilot	7
master	Prepared according to requirements specified by the vessel's master	8

Extra values (“other: ...”) as defined in S-100 § 3-6.7 are also permitted.

9) S100_IC_PredefinedCombination

Role *derivedFeatures*: Not allowed in Level 2 interoperability catalogues.

4 Level-specific data quality considerations

4.1 Quality of displayed data

There are no level-specific extensions to Clause 6.1 of the “S98 – Main” document.

Clause 5.11 provides guidance for maintaining data quality for level-specific rules and operations.

4.2 Quality of interoperability catalogues

The quality measures recommended in S-97 (Part C) which are applicable to Level 2 S-98 interoperability catalogues are those listed in Table 6-1 of the “S-98 – Main” document. There are no additional level-specific measures for Level 2.

4.2.1 Test methods

There are no level-specific extensions to Clause 6.2.1 of the “S-98 – Main” document.

4.2.2 Data quality testing

There are no level-specific extensions to Clause 6.2.2 of the “S-98 – Main” document.

5 Level-specific Guidance on Making Product Specifications Interoperable

The guidelines in this clause supplement and extend guidance common to all levels on making product specifications interoperable, which is given in clause 8 of the “S-98 – Main” document.

5.1 Duplicated features

There is no level-specific guidance for determining duplicated features. However, when interoperability catalogues are developed to resolve duplicated features, keep in mind the following level-dependent considerations:

Level 2 interoperability catalogues offer the following interoperability functionality:

- Interleaving changes - changes to the display planes and display orders specified in the products' portrayal catalogues, as determined by display plane and drawing priority information. This means

that features which are not covered by features with higher drawing priority or in a upper display plane will still be visible. This is the same functionality as Level 1.

- Type-based suppression of features from one product by features from another product. The difference from interleaving changes is that type-based suppression will suppress even features which are not covered by features from the second product. Note that this applies only in areas where there is data coverage by both products; it does not apply in areas where only one product has data coverage. This functionality is added in Level 2.

5.1.1 Duplicated features same model

See the guidance in the “S-98 – Main” component of this specification, and keep in mind the differences between Level 1 and Level 2 interoperability solutions described earlier in Clause 5.1 of this Part.

S100_IC_SuppressedFeatureLayer elements only have feature code and product as attributes for suppression, this means that all instances of a listed feature class will be suppressed. This is important to remember when creating rules that promote alternative instances. **S100_IC_Feature** and **S100_IC_DrawingInstruction** can have attribute combinations and spatial primitives to select the alternative instances. There is therefore, a risk that unless sufficient attention to details is given, important instances may be omitted.

EXAMPLE: If **Restricted Area Navigational** in ENC is suppressed, and **Restricted Area Navigational** with attribute **category of restricted area = 4 (nature reserve)** in Marine Protected Area dataset is promoted in its place, there is a chance that only instances with that combination will be visible, and all others suppressed.

5.1.2 Duplicated features, different models

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Level 1 and Level 2 interoperability solutions described in Clause 5.1 of this Part. There is no other level-specific guidance for this scenario.

5.1.3 Duplicate feature domains

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Level 1 and Level 2 interoperability solutions described in Clause 5.1 of this Part. There is no other level-specific guidance for this scenario.

5.2 Geometry

5.2.1 Combined geometry

Combined geometry is possible only in interoperability levels 3 and 4 (Parts C and D of this specification).

5.2.2 Spatial discrepancy, unrelated to scaled or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.2.3 Spatial discrepancies, related to scale or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.3 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also clause 10.8 of the “S-98 – Main” component.

5.4 Skin-of-the-earth feature operations

5.4.1 Skin-of-the earth feature replacement

Level 2 Interoperability Catalogues permit any of the following:

- Interleaving of display planes so that upper planes overwrite lower planes (Level 1 functionality). This can be used to shift feature layers to lower or higher planes to overwrite layers whose replacement is desired.
- Suppression of feature layers in which case the features in the suppressed layer are not processed for portrayal but features over/under the suppressed features will be displayed as determined by their display planes and drawing priorities (Level 2 functionality).

See clause 6.9 for portrayal considerations.

5.4.2 Skin-of-the earth feature adjusting

Adjustment of the geometry of skin-of-the-earth features is possible only in Level 4 (Part D).

5.5 Blended feature concepts

Blended features or blended portrayal are only possible in interoperability Levels 3 and 4 (Parts C and D).

5.6 Hierarchy of data

5.6.1 Hierarchy by stacking of display planes

In Level 2 interoperability catalogues, hierarchy can be set by interleaving of display planes or feature layer suppression operations.

5.6.2 Predefined combinations

Predefined combinations can be defined in Level 2 interoperability catalogues. Interoperability rules can be made contingent on the presence of particular combinations of data products on the display. Predefined combinations are generally created with a particular type of operational view in mind, and therefore the hierarchy of data may vary between predefined combinations. Typically, the ENC will be the base layer; that is, the lowest layer in a predefined combination.

Predefined combinations are used to define the hierarchy of data between different S-100 based specifications. An instance of **S100_IC_PredefinedCombination** is associated to **S100_IC_DisplayPlane** instances to give the hierarchy of the data products that are intended to be used. The attribute *order* within the **S100_IC_DisplayPlane** gives the order in which the layers are drawn.

5.7 New datasets

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.8 Dataset scales, loading, and unloading

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.9 Metadata

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.10 Meta-features

Any spatial operations on meta-features require an Interoperability Catalogue to implement at least Level 4.

There is no other level-specific guidance for meta-features. Common guidance is provided in the “S-98 – Main” component of this specification.

5.11 Quality considerations

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6 Portrayal

This clause gives guidelines and instruction to portrayal considerations related to the use of the Interoperability Catalogue in an ECDIS. The Interoperability Catalogue must apply to the specific Product Specifications listed in the Interoperability Catalogue metadata, *interoperabilityCatalogueProducts* attribute under **S100_IC_CatalogueMetadata**.

There may be additional data products present in the S-100 ECDIS that are external to the Interoperability Catalogue; in such cases the Interoperability Catalogue should continue to function in presence of product not defined in the Catalogue. Data products that are outside of the interoperability scope must be treated in Interoperability Level 0 (see clause 9.6 in “S-98 – Main”).

6.1 Display of significant features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.2 Display of significant features - switching to original

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.3 Portrayal distinguishability - colour set-asides

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also S-100 Part 16 for specific guidance on colour set-asides.

6.4 Day/night/dusk modes

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.5 Impacts on viewing groups

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.6 Impacts on Portrayal Catalogues

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.7 Meta-features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.8 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.9 Skin-of-the-earth operations and portrayal

6.9.1 Skin-of-the-earth feature replacement and portrayal

For all levels, anything that replaces S-101 skin-of-the-earth features, will overwrite it by having a higher priority; that is, be drawn later. The major difference between the levels is in the overwriting.

Interoperability operations in Level 2 can overwrite skin-of-the-earth features and everything else (by interleaving display planes so that upper planes overwrite lower planes). They can also suppress feature layers, in which case features over/under the suppressed features will be displayed as determined by their display planes and drawing priorities.

Gridded data will generally go over ENC and obscure ENC features, either all (interoperability Level 0) or specific features (interoperability Levels 1 or 2) depending on interoperability level chosen, the predefined combinations or display plane of the features that are interacting.

EXAMPLE 1: High definition gridded bathymetry replaces (overwrite) depth area and depth contours, but soundings, aids to navigation, and obstructions are over the high definition bathymetry (interoperability Level 1).

EXAMPLE 2: Surface current gridded data goes over ENC and replaces all surface current features (interoperability Level 2).

NOTE: Safety contour comes from ENC and is generated by the viewer system. This safety contour is an IMO requirement (IMO Performance Standard 5.8 (MSC.232(82))) for ECDIS and should be presented with highest priority when turned on by the user. OEMs are permitted to add additional safety contour functions, for example; generated from combining high definition gridded bathymetry (S-102) and S-104 input.

6.9.2 Skin-of-the-earth feature adjusting and portrayal

Adjustment of the geometry of skin-of-the-earth features is possible only in Level 4 (Part D).

6.10 Blended portrayals

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.11 Hierarchy of data

As noted in the Main component of this specification, hierarchy of data can be controlled by predefined combinations. There is no level-specific guidance for portrayal in connection with this issue.

6.11.1 Interacting gridded information

There is no level-specific guidance for portrayal in connection with this issue.

6.12 Pick reports

[NOTE: The pick report functionality specification in S-98 is still under development, and the content of this section will change as this functionality is defined.]

7 Processing Model

Figure 7.1 below shows the processing steps and input to each step from parts of the Interoperability Catalogue, for the “Interoperability before portrayal” processing option. Figure 7.1 shows the steps and inputs for the “Interoperability after portrayal” processing option. In both cases, the flow depends on the interoperability level selected by the mariner.

In Level 0 processing, interoperability is turned off and all data products loaded are passed through to S-100 Portrayal Processing to be portrayed as overlays to ENC data according to their individual Portrayal Catalogues.

In Level 1 processing, the only interoperability processing is interleaving of feature layers by means of display plane information, and Interleave Feature Layers is the only interoperability processing before feature data is passed to S-100 Portrayal Processing. The only input from the Interoperability Catalogue is display plane and drawing order information from **S100_IC_DisplayPlane** elements in the catalogue.

In Level 2 processing, feature type suppression operations (stage *Suppress Feature Types*) precede interleaving operations.

Figures 7.2 and 7.3 depict two possible implementations, with the input to interoperability processing being either feature data or drawing instructions generated from feature data by (part of) portrayal processing.

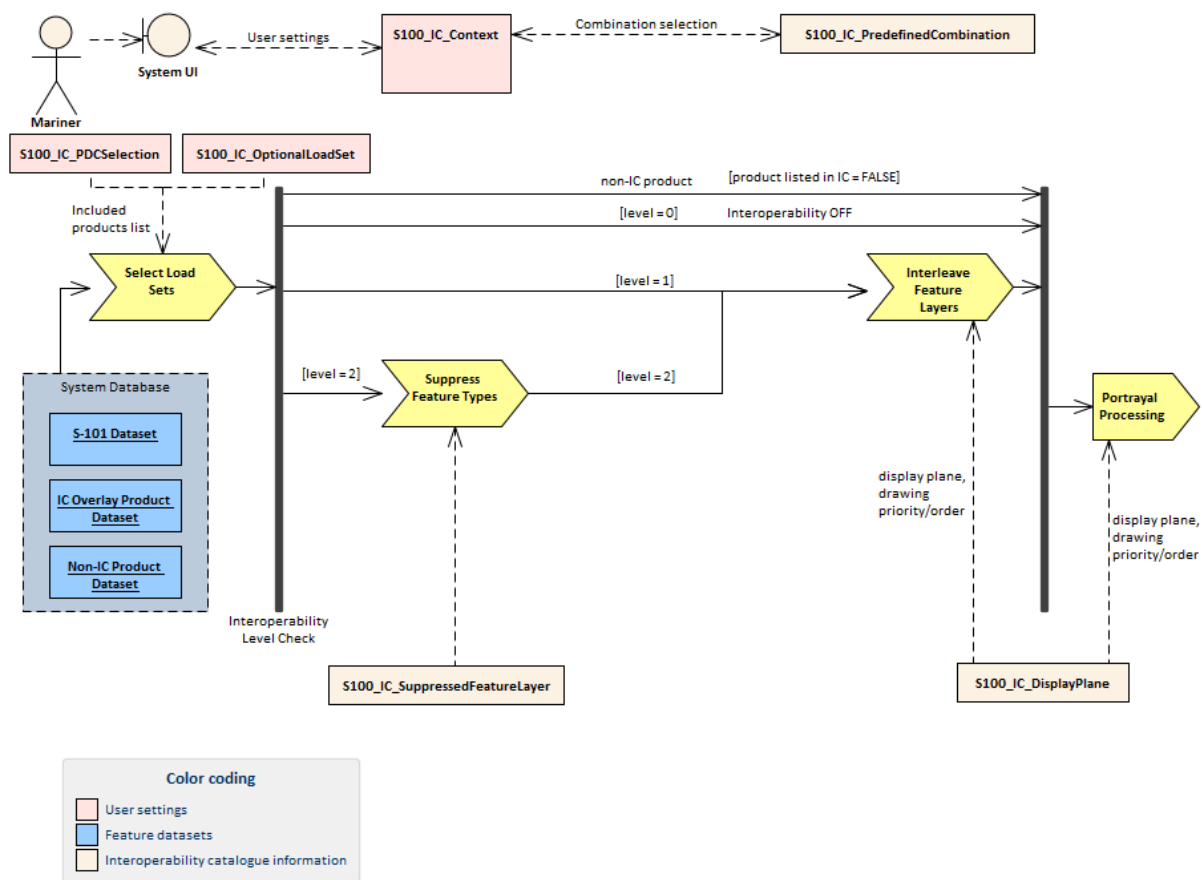


Figure 7.2 - Interoperability processing flow (portrayal processing after interoperability)

For implementations that pass drawing instructions instead of features to interoperability processing, the flow is similar except that portrayal processing takes place before interoperability processing.

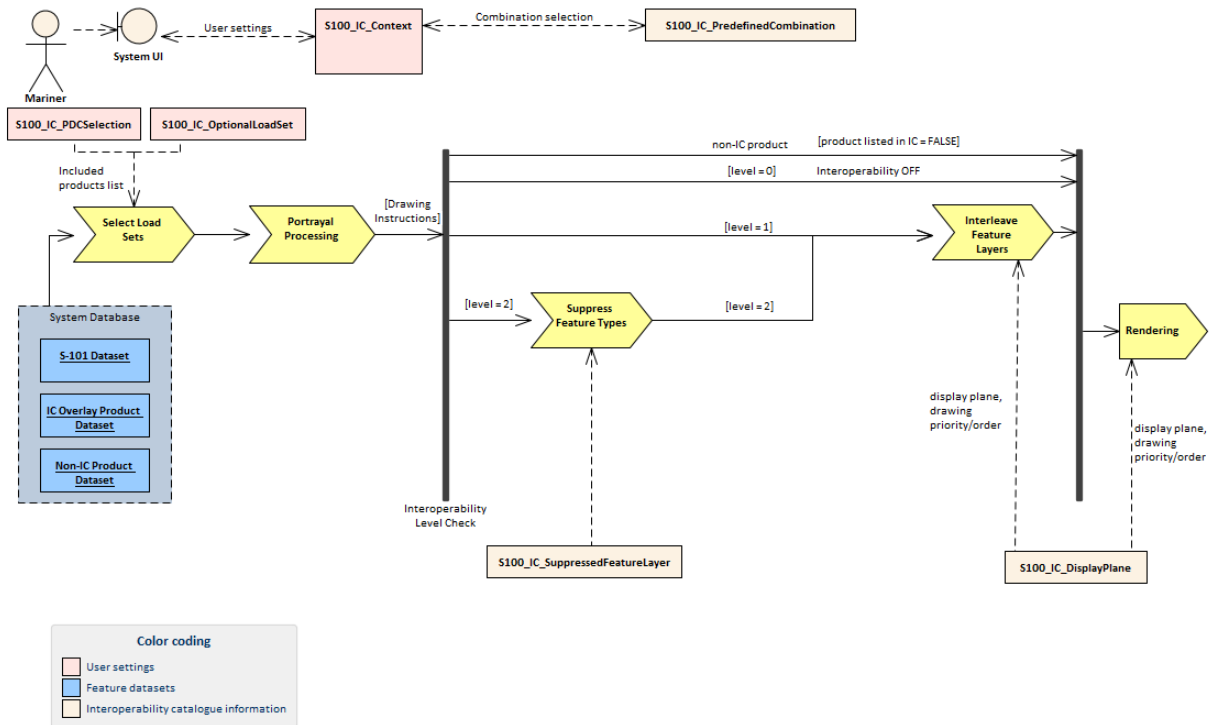


Figure 7.3 - Interoperability processing (drawing instructions generated before interoperability processing)

Table 7.1 - Stages in Levels 2 interoperability processing

Stage	Description	Level	IC information	Context information	Remarks
Select Load Sets	Select data products to be loaded	All	Level 1: User adds data products to display individually Level 2: Included product list from S100_IC_PredefinedCombination.includedProduct	Level 1: None Level 2: User-selected predefined combination	Information & functionality depends on whether user selects Level 1 or 2.
Portrayal Processing	Ordinary S-100 portrayal processing	All	display planes		Except final display processing / rendering
Interleave Feature Layers	Assign display plane and drawing order to feature data	1, 2	S100_IC_DisplayPlane		
Suppress Feature Types	Suppress all instances of a specified feature type in a product	2	S100_IC_SuppressedFeatureLayer		
Rendering	Display processing	All	S100_IC_DisplayPlane		

8 Normative Implementation Guidance

There is no level-specific normative implementation guidance in this edition of S-98. See the Main component of this Specification for implementation guidance that applies to all levels.

9 Feature Catalogue

Level 2 does not define feature catalogues.

10 Portrayal Catalogue

Level 2 does not define portrayal catalogues.

S-98 – PART C

LEVEL 3 INTEROPERABILITY

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1 Introduction

S-98 Part A contains information that applies to interoperability catalogues which use interoperability rules and operations of at most Level 1 interoperability.

Interoperability catalogues conforming to this Part must comply with both the following components of S-98:

- 1) S-98 Main Specification, which describes requirements applying to all S-98 interoperability catalogues and S-98 exchange sets;
- 2) S-98 Part A (this Part), which defines the subset of the interoperability model and catalogue encoding that are specific to Level 1 interoperability.

The hypothetical processing model for implementations is described in general terms in the “S-98 - Main” document and elaborated in clause 7 of this Part.

Level 3 interoperability includes the following capabilities:

- Level 1 interoperability, in which feature types from different products, including S-101, are interleaved as specified by display plane and drawing priority information contained in the Interoperability Catalogue.
- Level 2 type suppression functionality, which allows suppression of all features of a specified feature type in a specified product, with another feature type from a different product being displayed instead. Filtering by attribute values and geometry type is also possible.
- Level 2 constructs allowing catalogues to partition interoperability rules and operations according to specified combinations of data products (“predefined combinations”). The rules and operations in each partition are applied only when the corresponding data products are part of the display.
- Additional interoperability functionality introduced in Level 3 for allowing suppression of selected feature instances and combination or conversion of feature types from input products into different feature types for display and alert processing purposes. In Level 3, combination/conversion operations are limited to thematic attributes.

The output of interoperability processing is either the original feature data (processing option 1) or drawing instructions (processing option 2), accompanied by display plane and drawing priority information, which is passed through to the portrayal processor. Clause 7 elaborates on these options.

1.1 How to read this Part

Clause 2 of this Part contains scope identification information corresponding to the contents of this Part, which applies specifically to Interoperability catalogues designated as Level 3.

For Clauses 3–10, the content of the clause or sub-clause extends or elaborates on the content under the same or similar clause head or sub-head in S-98 – Main.

The numbering of Clauses 3-10 may differ from that of corresponding clauses in S-98 – Main, because for some there is no additional level-specific information needed. If a clause or sub-clause in S-98 – Main has no corresponding clause or sub-clause in this Part, there is no level-specific information on that topic.

2 Specification Scope for Part A

S-98 Part A describes the portions of S-98 which correspond to the following scope defined in S-98 – Main (Clause 2):

Scope Identification: S98L3

Level: MD_ScopeCode – 13

Level Name: Interoperability Level 3

Description: Instance-based selectivity and feature hybridization; type selectivity; interleaving

Extent: EX_Extent.description = “worldwide”; EX_GeographicBoundingBox = [-180, +180, -90, +90]

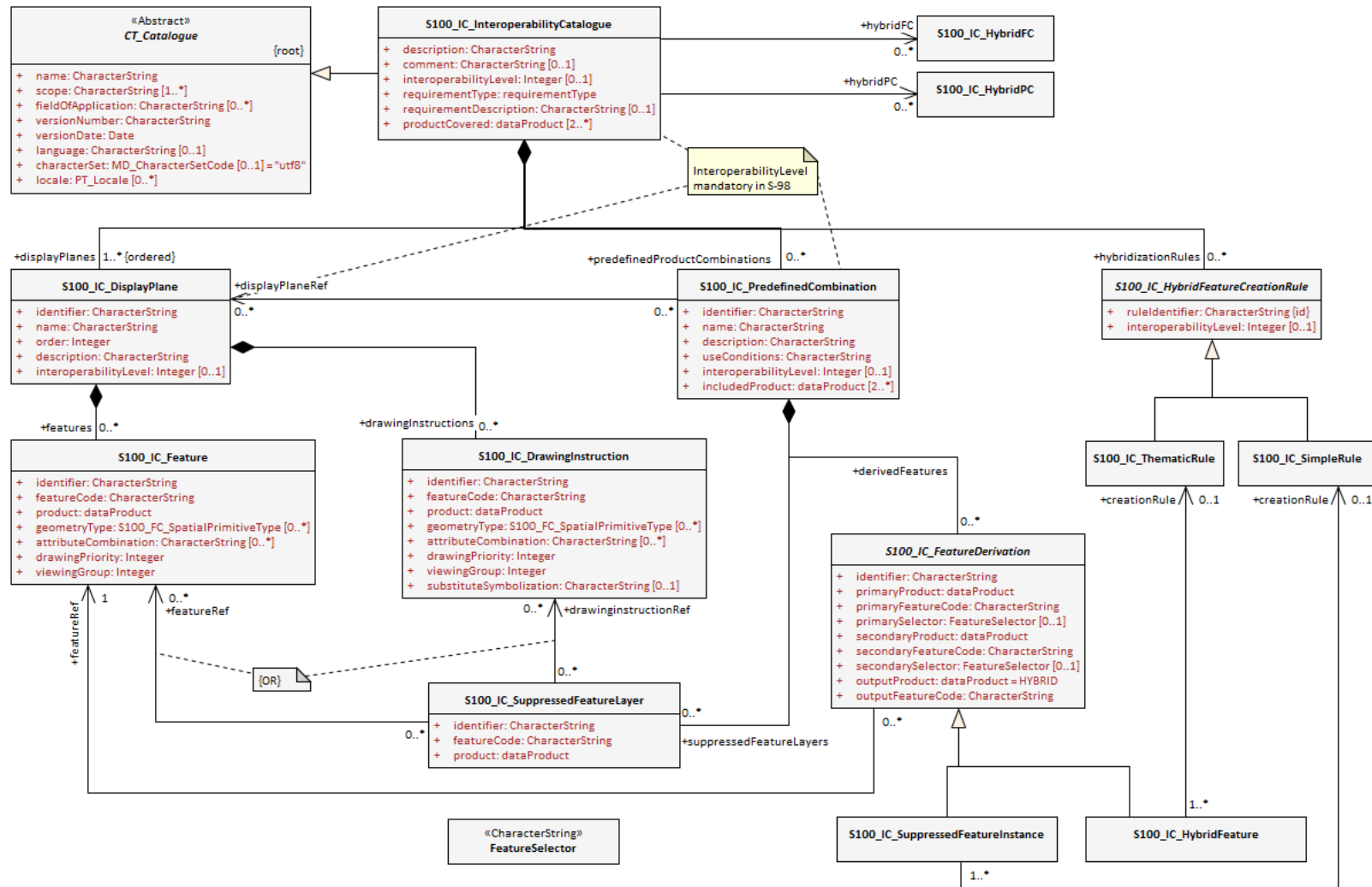
3 Data Content and structure

3.1 Application Schema

3.1.1 Overview of application schema

The application schema for Interoperability Level 3 is depicted in Figure 3.1 below. This application schema is a subset of the full application schema in S-100 Part 16. It consists of the following components:

- 1) Catalogue header information.
- 2) Display plane ordering information.
- 3) Display planes content in the form of either features or drawing instructions.
- 4) Specification of rules indicating which feature layers to suppress.
- 5) Specification of data product combinations and method of referencing collections of interoperability rules and operations to specific combinations.
- 6) Specification of rules indicating which feature instances to suppress.
- 7) Rules for combining feature data into new features based on thematic attributes.
- 8) Operations involving only thematic attributes, for combining selected instances of feature types from different data products, or conversion of feature data into new feature data.
- 9) Feature and Portrayal Catalogues for the new features generated according to the abovementioned combination or conversion operations.



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3.1.2 Operations in Pre-Defined Combinations

Level 3 allows predefined combinations, whereby the scope of specified interoperability operations can be restricted so the operations are executed only when a specified set of data products is active on the user display. Display plane and feature ordering (Level 1 operations) can be thus restricted by associating a specific set of products (listed in **S100_IC_PredefinedCombination** elements) to **S100_IC_DisplayPlane** elements.

Level 3 interoperability also allows replacement of a feature layer from one product by a feature layer from another product. These layers are specified by **S100_IC_SuppressedFeatureLayer** elements. Replacement operations are restricted to occur only when specific combinations of data products are present on the user display because the **S100_IC_SuppressedFeatureLayer** elements in interoperability catalogues are always contained within **S100_IC_PredefinedCombination** elements.

Level 3 also allows more complex operations, including conversion of input feature instances into new features (hybridization) as described by **S100_IC_HybridFeature** elements. The replacement and hybridization rules are described in Clause 3.1.5. The additional operations allowed in Level 3 are:

- 1) Operations on selected instances of a feature type.
- 2) Conversion of input feature data into new feature data involving only thematic attributes.

3.1.3 Enhanced selection of feature instances

S100_IC_SuppressedFeatureInstance and **S100_IC_HybridFeature** elements specify the feature types on which they operate by indicating the product and feature types of two products. Selection of feature instances is done by evaluating a filter expression (type **FeatureSelector**, a string expression conforming to the specified [TBD] format) with the feature instance as input parameter. A **FeatureSelector** is a more expressive form of the attribute-value combination filter described in Clause 4.3 (S-98 – Main) that can include spatial operations and more complex expressions on thematic attributes.

[NOTE: If a scripting language for selection is developed it will belong in this level – the TBD in the previous sentence would be the specification of the scripting language, and equally importantly, their call/function signatures and restrictions on what the scripts are allowed to do.]

For Level 3 interoperability, spatial equality is an implied criterion in determining each input instance set of feature instances to be converted to new feature data uses spatial equality as an implicit criterion for set membership; that is, only coincident instances (to a system-determined tolerance) are combined, and the geometry of the output is the same as the geometry of any instance in the input set.

3.1.4 Interoperability levels

The *interoperabilityLevel* attribute in **S100_IC_InteroperabilityCatalogue** specifies the highest level of interoperability implemented in that XML interoperability catalogue file. The *interoperabilityLevel* attribute in **S100_IC_DisplayPlane** specifies the level to which that display plane pertains.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements are permitted to also include operations of a lower level of interoperability.

The *interoperabilityLevel* attribute in **S100_HybridFeatureCreationRule** specifies the interoperability level to which that rule applies. In Level 3 catalogues the value must be 3.

3.1.5 Hybridization rules

Hybridization rules define how a set of feature instances is combined to create a hybrid feature type. In the simplest form of hybridization, the hybrid feature would bind all the attributes of the input types to a single output feature type (this assumes that there are no collisions¹ between the thematic attributes of the input types.) More complex hybridization rules can handle collisions, for example by defining a preference order for colliding attributes, including all the values if the input types bind the same enumerated attribute, or adding uncertainty metadata if numeric attribute values are different.

The hybridization rules require two feature instances as input and produce a single feature instance as output. The formal specification and rule language for hybridization will be described in a subsequent version of this Specification.

3.1.5.1 Simple hybridization rule

Simple rules treat thematic attributes uniformly, for example by binding the attributes of both primary and secondary input instances to the output instance, or preferring the attribute bindings of the primary instance to those of the secondary instance in case of a difference in the values of common attributes. Location/extent spatial attributes of all input instances must be spatially equal and are passed through unchanged.

3.1.5.2 Thematic hybridization rule

Thematic rules treat thematic attributes on an individual basis, for example, use specified attributes from the primary input instance and specified attributes from the secondary input instance. Combination operations on attribute values may be specified (for example, `OutputFeature.depthValue = maximum(ProductA.FeatureX.depthValue, ProductB.FeatureY.depthValue)`). Location/extent spatial attributes of all input instances must be spatially equal (as defined in IHO S-58) and are passed through unchanged.

3.1.6 Hybrid feature and portrayal catalogues

Hybrid Feature and Portrayal Catalogues are physically separate files from the main Interoperability Catalogue, but the main Catalogue links to them by encoding the names of the hybrid catalogue files which are used by the feature creation rules defined in it. The hybrid Feature and Portrayal Catalogues conform to the structures required by S-100 Parts 5 and 9 respectively.

3.1.7 Progression of interoperability levels

Figure 3.2 below shows the components of the model subset used by this level compared to lower levels.

Level 2 adds predefined combinations and feature suppression elements to Level 1.

Level 3 adds elements related to thematic hybridization to Level 2 functionality.

Interoperability catalogues at any level can also use lower-level functionality.

¹ Attributes which describe the same characteristic of substantially the same phenomenon. These attributes will generally have the same name. Developers of interoperability catalogues can detect collisions by comparing application schemas and feature catalogues.

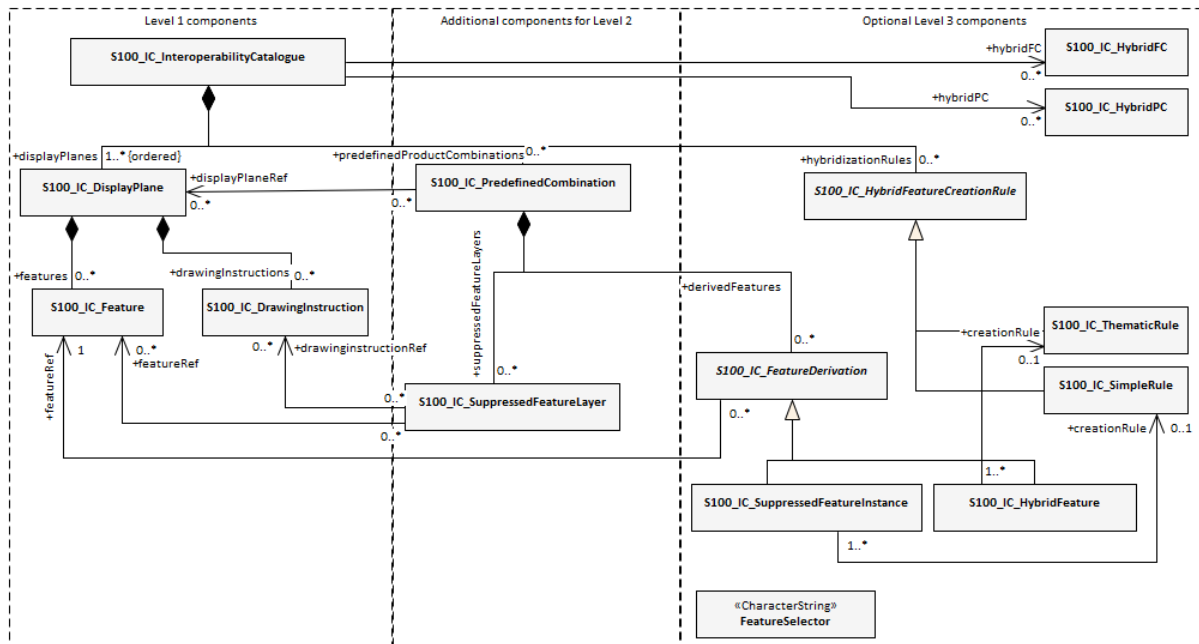


Figure 3-2 - Progressive use of Interoperability Catalogue model

3.2 Interoperability Catalogue

3.2.1 Conceptual Types for Level 3 Interoperability

The following clauses summarize the conceptual elements used in Level 3 Interoperability Catalogues. Details about these conceptual types are provided in S-100 Part 16.

3.2.1.1 Display Plane (S100_IC_DisplayPlane)

A display plane element in the interoperability catalogue acts as a container for display information for specified feature classes, which enables the interleaving of feature layers during portrayal by indicating the display plane, priority, and drawing order of the features assigned to a display plane.

A feature type may be referenced in more than one **S100_IC_DisplayPlane**, but the entries in different display planes must be distinguished by different attribute-value combinations or spatial primitives so that the actual instances of features are partitioned unambiguously between different display planes.

The portrayal of feature types not mentioned in any **S100_IC_DisplayPlane** component is undefined until ordinary portrayal processing takes place.

3.2.1.2 Feature type display information (S100_IC_Feature)

The **S100_IC_Feature** element describes the display parameters for all features of a specific feature type in a specific product and thereby determines the order of drawing the feature type relative to other feature types in the same display plane. It also specifies the viewing group to which the feature is assigned. Its applicability can be optionally restricted to a subset of instances of the feature type by additional attributes that specify the type of spatial primitive and indicate specific values of thematic attributes.

3.2.1.3 Feature layer (**S100_IC_SuppressedFeatureLayer**)

Each instance of this element identifies a feature type in a specific data product which is supposed to be suppressed in the presence of another specified feature type from another product.

3.2.1.4 Drawing instruction (**S100_IC_DrawingInstruction**)

Drawing instructions in the Interoperability Catalogue play a similar role to feature type display information (**S100_IC_FeatureType**) but with drawing instructions instead of feature objects. The **S100_IC_DrawingInstruction** element in Interoperability Catalogues is similar in operation to the layering and priority aspects of the **DrawingInstruction** element in Portrayal Catalogues (see S-100 Part 9 - Portrayal). Where there is a conflict with a Portrayal Catalogue drawing instruction, the drawing instruction in the Interoperability Catalogue supersedes the drawing instruction in the Portrayal Catalogue.

The **S100_IC_DrawingInstruction** element contains an additional attribute that allows substitution of symbolization instructions generated by portrayal processing.

3.2.1.4.1 Comparison and use of **S100_IC_Feature** and **S100_IC_DrawingInstruction**

S100_IC_Feature and **S100_IC_DrawingInstruction** elements in Interoperability Catalogues operate in essentially the same way as far as assignment of drawing order, priority, and display planes is concerned. They differ in that **S100_IC_DrawingInstruction** provides an optional attribute to substitute the symbolization elements of the drawing instruction.

S100_IC_Feature should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions.

S100_IC_DrawingInstruction should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions. It should also be used in all catalogues where substitution of symbolization is necessary.

3.2.1.5 Predefined combination (**S100_IC_PredefinedCombination**)

A predefined combination element defines a collection of data products for which a common set of interoperability operations have been defined in the Interoperability Catalogue. Instances of predefined combinations are also characterized by interoperability level, which allows the encoding of different sets of operations depending on how tightly integrated the user desires the products to be on the resultant display.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements with a specified level attribute are permitted to also include operations of a lower level of interoperability.

Predefined combinations can be linked to **S100_IC_DisplayPlane** elements by means of references in the **S100_IC_PredefinedCombination** elements.

3.2.1.6 Suppressed feature Instance (**S100_SuppressedFeatureInstance**)

This element allows interoperability catalogues to indicate when specific feature instances in a data product must be suppressed by specific feature instances in another product. Its functionality is similar to **S100_SuppressedFeatureLayer** except that it can use somewhat more expressive selection/replacement rules (by virtue of its dependency on **S100_SimpleRule**) and it applies to feature instances instead of feature types or subsets of feature types.

3.2.1.7 Feature hybridization (S100_HybridFeature)

This element allows selected feature types or instances to be combined into a new feature for display purposes.

3.2.1.8 Feature creation or replacement rule (S100_SimpleRule, S100_ThematicRule)

Feature creation and replacement is advanced functionality whose implementation is not required for this version of the Interoperability Catalogue.

Feature creation and replacement rules create new feature types by combining characteristics of specified feature types from the input data products. A feature creation/replacement rule basically transforms a collection of feature instances in the input stream into one or more different feature instances in the output stream. The created feature differs from all the input features, for example by adding properties of one feature to properties of another feature.

3.2.2 Use of S-100 types

The S-100 types used by S-98 Level 3 interoperability catalogues are described in the S-98 – Main component of this Specification. For Level 3 interoperability catalogues, the following additional information applies.

- Interoperability Catalogues of Level 3 do not use feature and information associations in feature filters defined by *attributeCombination* attributes in **S100_S100_IC_Feature** or **S100_IC_DrawingInstruction** elements. This is the same as the Level 1 and 2 functionality for these elements.
- Interoperability Catalogues of Level 3 are allowed to use feature and information associations in feature selector expressions encoded in the *primarySelector* and *secondarySelector* attributes of **S100_IC_DerivedFeature** or in **S100_SimpleRule** or **S100_ThematicRule** elements.

3.3 UML model documentation

The UML model documentation is provided in **S-100 Part 16**. This clause documents details specific to the use of the UML model for the interoperability level described in this Part of S-98.

Only the model elements used in this level (and included in the level's application schema) are listed. The constraints and considerations listed in the UML documentation tables in S-100 Part 16 apply. Any S-98 general or level-specific considerations are described under the element name in the list below.

- 1) **S100_IC_DisplayPlane**: No level-specific constraints or notes
Attribute *interoperabilityLevel*: Mandatory. The only values allowed for Level 3 interoperability catalogues are 1, 2, and 3.
- 2) **S100_IC_DrawingInstruction**:
NOTE for implementers: Even if the Presentation schema in S-100 Part 9 is used, implementers may need to provide specific code to validate the content of the *substituteSymbolization* attribute instead of depending on normal XML schema validation. The content of this attribute is not prescribed by this specification and may be a fragment of XML, or interpretable code or rules, etc., in a non-XML syntax. It may be enclosed in a `<![CDATA[...]]>` section so that XML validators treat it as character data instead of XML.
- 3) **S100_IC_Feature**: No level-specific constraints or notes
- 4) **S100_IC_InteroperabilityCatalogue**:

Attribute *productCovered*: Must use values defined in the dictionary identified by MRN: urn:mrn:iho:prod:s98:1:0:0:products

Attribute *interoperabilityLevel*: Mandatory in S-98 catalogues at all levels. The only value allowed for Level 3 interoperability catalogues is 3.

Role *hybridFC*: Required if and only if there are any feature hybridization rules in the catalogue.

Role *hybridPC*: Required if and only if there are any feature hybridization rules in the catalogue.

Role *hybridizationRules*: Required if and only if there are any instances of S100_IC_SimpleRule, S100_IC_ThematicRule, or S100_IC_CompleteRule in the catalogue.

5) **S100_IC_PredefinedCombination**:

Attribute *interoperabilityLevel*: Mandatory in S-98 interoperability catalogue; allowed values: 1, 2, 3.

6) **S100_IC_SuppressedFeatureLayer**: No level-specific constraints or notes

7) **Codelist dataProduct**: No level-specific constraints or notes. The data type for all levels is described below.

Codelist Type: closed dictionary

MRN: urn:mrn:iho:prod:s98:1:0:0:products

8) **Codelist requirementType**: No level-specific constraints or notes.

For all interoperability levels, the following subset of the standard values listed in S-100 Part 16 are permitted to be used in S-98 interoperability catalogues:

Table 3-1 - Allowed values for requirementType

Value	Description	Code
IHO	Original IHO Interoperability Catalogue	1
OEM	Prepared according to requirements specified by OEM or systems integrator	2
national	Prepared according to requirements specified by a national government, group of national governments (for example the European Union), or governmental agency such as a national shipping authority or the Coast Guard.	3
local	Prepared according to requirements specified by a sub-national governmental authority such as a state, province, or county	4
port	Prepared according to requirements specified by a harbormaster's office or port authority	5
company	Prepared according to requirements specified by the owner, charterer, or operator	6
pilot	Prepared according to requirements specified by a pilot	7
master	Prepared according to requirements specified by the vessel's master	8

Extra values ("other: ...") as defined in S-100 § 3-6.7 are also permitted.

9) **S100_IC_FeatureDerivation**:

The resulting derived feature does not need to have any hybrid characteristics, that is, one restricted area replaced with another restricted area will use regular PC/FC of the primary product. However

if the result feature needs to be supported by any custom FC or PC elements they must be defined under hybrid FC and hybrid PC accordingly.

A rule for creating the feature must be described in the rules section of the interoperability catalogue.

Attribute *primarySelector*: If omitted, all instances of the type are included.

In L3 processing, may contain only thematic attributes and the primary and secondary instance geometries must be spatially equal.

L3 Example: CATICE = 5

Attribute *secondarySelector*: If omitted, all instances of the type are included.

In L3 processing, may contain only thematic attributes and the primary and secondary instance geometries must be spatially equal.

L3 Example: CATICE = 5

NOTE: **S100_IC_FeatureDerivation** is an abstract super-class for different types of feature hybridization operations.

- 10) **S100_IC_HybridFC**: No level-specific constraints or notes.
- 11) **S100_IC_HybridFeature**: No level-specific constraints or notes.
- 12) **S100_IC_HybridFeatureCreationRule**: No level-specific constraints or notes.

Attribute *interoperabilityLevel*: Mandatory in S-98.

NOTE 1: **S100_IC_HybridFeatureCreationRule** is an abstract super-class for different types of hybridization rules. This functionality needs to be worked out but OGC Filter seems to be the ideal option for defining data filtering logic.

NOTE 2: Overall, the output from execution of **S100_IC_HybridFeatureCreationRule** is a set of hybrid features for which predefined FC, PC and display plane definitions already exist so such feature will be suitable for passing to the portrayal engine for processing just like any other S-100 features.

- 13) **S100_HybridPC**: No level-specific constraints or notes.

14) **S100_IC_PredefinedCombination**

Role *derivedFeatures*: Required if and only if there are any instances of **S100_SuppressedFeatureInstance** or subclasses of the abstract class **S100_IC_HybridFeature** in the catalogue.

- 15) **S100_IC_SimpleRule**: No level-specific constraints or notes.
- 16) **S100_IC_SuppressedFeatureInstance**: No level-specific constraints or notes.
- 17) **S100_IC_ThematicRule**: No level-specific constraints or notes.
- 18) **FeatureSelector**: No level-specific constraints or notes.

4 Level-specific data quality considerations

4.1 Quality of displayed data

There are no level-specific extensions to Clause 6.1 of the “S98 – Main” document.

Clause 5.11 provides guidance for maintaining data quality for level-specific rules and operations.

4.2 Quality of interoperability catalogues

The quality measures recommended in S-97 (Part C) which are applicable to Level 3 S-98 interoperability catalogues are those listed in Table 6-1 of the “S-98 – Main” document plus those listed in Table 4-1 below.

Table 4-1 - Quality elements for Level 3 S-98 interoperability catalogues

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ² for IC	Evaluation scope for resultant ³ features
C1	Completeness / Omission	Data absent from the dataset, as described by the scope.	numberOfMissingItems / This data quality measure is an indicator that shows that a specific item is missing in the data.	Hybrid FC / PC	Features produced by hybridization rules.
C2	Logical Consistency / Domain Consistency	Adherence of the values to the value domains.	numberOfNonconformantItems / This data quality measure is a count of all items in the dataset that are not in conformance with their value domain.	(See S-98 – Main)	Features produced by hybridization rules.
C3	Thematic Accuracy / Thematic Classification Correctness	Comparison of the classes assigned to features or their attributes to a universe of discourse.	<p>miscalculationRate / This data quality measure indicates the number of incorrectly classified features in relation to the number of features that are supposed to be there. [Adapted from ISO 19157]</p> <p>This is a RATE which is a ratio, and is expressed as a REAL number representing the rational fraction corresponding to the numerator and denominator of the ratio.</p> <p>For example, if there are 1 items that are classified incorrectly and there are 100 of the items in the dataset then the ratio is 1/100 and the reported rate = 0.01.</p>	Hybrid FC / PC	Features produced by hybridization rules.

4.2.1 Test methods

The provisions of Clause 6.2.1 of the “S-98 – Main” document apply.

² For the IC evaluation scope, a “dataset” is an entire interoperability catalogue file, an “element” is an interoperability catalogue component corresponding to one of the classes in the model depicted in S-100 Part 16 Figure 16-3.

³ “Resultant” means the result of applying interoperability operations to covered data. “Resultant feature” means the apparent feature as it appears on the display after application of interoperability. “Resultant dataset” means the collection of resultant features. A “modified resultant feature” is the feature or drawing instruction resulting from the application of an operation or rule which affects spatial or thematic attributes or their values, including combining or suppressing attributes or generating an instance of a feature defined in the HYBRID feature catalogue in Level 3 or 4. A “superseding feature” is a feature which suppresses a feature (instance or type) from another dataset, or whose priority is increased by an interoperability rule or operation (which would make it visible in preference to a feature which would otherwise overlie it). A “superseded feature” is one that is suppressed or overlaid by a superseding feature.

The level-specific tests in Table 4-1 should be evaluated only with features produced by hybridization rules.

Evaluation of quality elements C1-C3 in Table 4-1 consists of verifying that the FC and PC corresponding to the output product(s) specified in hybridization operations define a feature type and portrayal rule respectively for any feature type produced by a hybridization operation and that the attribute bindings and values are consistent.

4.2.2 Data quality testing

The provisions of Clause 6.2.2 of the “S-98 – Main” document apply. Evaluation methods for quality element C1-C3 in Table 4-1 should include either a complete static analysis of hybridization rules compared to feature and portrayal catalogues (either with or without automated support) or full test case coverage.

5 Level-specific Guidance on Making Product Specifications Interoperable

The guidelines in this clause supplement and extend guidance common to all levels on making product specifications interoperable, which is given in clause 8 of the “S-98 – Main” document.

5.1 Duplicated features

There is no level-specific guidance for determining duplicated features. However, when interoperability catalogues are developed to resolve duplicated features, keep in mind the following level-dependent considerations:

Level 3 interoperability catalogues offer the following interoperability functionality:

- Interleaving changes - changes to the display planes and display orders specified in the products' portrayal catalogues, as determined by display plane and drawing priority information. This means that features which are not covered by features with higher drawing priority or in a upper display plane will still be visible. This is the same functionality as Level 1.
- Type-based suppression of features from one product by features from another product. The difference from interleaving changes is that type-based suppression will suppress even features which are not covered by features from the second product. Note that this applies only in areas where there is data coverage by both products; it does not apply in areas where only one product has data coverage. This is the same functionality added by Level 2 to Level 1.
- Suppression of feature instances matching specified conditions and their replacement by other feature instances. This functionality is added in Level 3.

5.1.1 Duplicated features same model

See the guidance in the “S-98 – Main” component of this specification, and keep in mind the differences between Level 1, 2, and 3 interoperability solutions described earlier in Clause 5.1 of this Part.

S100_IC_SuppressedFeatureLayer elements only have feature code and product as attributes for suppression, this means that all instances of a listed feature class will be suppressed. This is important to remember when creating rules that promote alternative instances. **S100_IC_Feature** and **S100_IC_DrawingInstruction** can have attribute combinations and spatial primitives to select the alternative instances. There is therefore, a risk that unless sufficient attention to details is given, important instances may be omitted.

EXAMPLE: If **Restricted Area Navigational** in ENC is suppressed, and **Restricted Area Navigational** with attribute **category of restricted area = 4 (nature reserve)** in Marine Protected Area dataset is promoted in its place, there is a chance that only instances with that combination will be visible, and all others suppressed.

S100_SuppressedFeatureInstance elements can suppress instances selectively, as defined by conditions specified in the *primarySelector* attribute or referenced **S100_SimpleRule** element. While the **S100_HybridFeature** element is intended mainly for feature hybridization, it can also be used to suppress duplicated features, since it inherits the same attributes as **S100_SuppressedFeatureInstance** from their common abstract super-class **S100_FeatureDerivation**. However, if the intention is merely to suppress a feature, **S100_SuppressedFeatureInstance** should be used.

5.1.2 Duplicated features, different models

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Level 1 and Level 2 interoperability solutions described in Clause 5.1 of this Part. There is no other level-specific guidance for this scenario.

5.1.3 Duplicate feature domains

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Levels 1, 2, and 3 interoperability solutions described in Clause 5.1 of this Part. There is no other level-specific guidance for this scenario.

5.2 Geometry

5.2.1 Combined geometry

See the corresponding clause in the Main part of this Specification for guidance for developers of Product Specifications that may result in hybrid features when interacting with specific other products.

NOTE: The hybrid feature concept is only for interoperability Levels 3 and 4. Thematic hybridization/fusion is possible in both Levels 3 and 4. Spatial hybridization/fusion is only available for interoperability Level 4. Both are out of scope for initial implementations of this Interoperability Specification.

5.2.2 Spatial discrepancy, unrelated to scaled or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.2.3 Spatial discrepancies, related to scale or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.3 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also clause 10.8 of the “S-98 – Main” component.

5.4 Skin-of-the-earth feature operations

5.4.1 Skin of the earth feature replacement

Level 3 Interoperability Catalogues permit any of the following:

- Interleaving of display planes so that upper planes overwrite lower planes (Level 1 functionality). This can be used to shift feature layers to lower or higher planes to overwrite layers whose replacement is desired.
- Suppression of feature layers in which case the features in the suppressed layer are not processed for portrayal but features over/under the suppressed features will be displayed as determined by their display planes and drawing priorities (Level 2 functionality).
- Suppression of feature instances, which is like suppression of feature layers but applies to feature instances selected by selector expression or simple rule (additional functionality in Level 3).
- Merging of features from different products creating hybrid features (additional functionality in Level 3).

See clause 6.9 for portrayal considerations.

5.4.2 Skin-of-the earth feature adjusting

Adjustment of attribute values is possible in Level 3 catalogues by means of hybridization rules.

For example, the values of depth and under keel clearance attributes may be adjusted by combining bathymetry and/or water level information with ENC data.

Adjustment of the geometry of skin-of-the-earth features is possible only in Level 4 (Part D).

5.5 Blended feature concepts

Blended feature concepts or blended portrayals can be produced by using transparency between related features; or creating a temporary blended feature; or blended portrayal (rule and/or symbol) of specific combinations of features from different products. See clause 10 in the “S-98 – Main” document for portrayal considerations and example of use case.

Blended features or portrayal will typically be created by using **S100_IC_PredefinedCombination** which link to a hybrid Portrayal Catalogue that includes the features to be combined and a suppression rule, for example by using **S-100_IC_SuppressedFeatureLayer**, for the features that are to be replaced.

An example where a blended concept could be used is where winds blowing from the west cause fairways to some west coast ports of Finland to get layered ice (wind pushes ice layers on top of each other until there is ice from the sea bottom up to the surface). When an ice-breaker makes a path through some ice remains between the sea bottom and the keel of the ice-breaker. Ice thickness in such a place could be up to 11 m while the ice-breaker draught is around 7-8 meters. In such cases a simultaneous display of both ice coverage and underlying depth area is required. Other depth area features such as spot soundings, rocks, wrecks, etc., are also still important.

Developers of Product Specifications that are likely to be used in blended feature concepts by ECDIS in interoperability mode should communicate their intentions with developers of related Specifications so that awareness is created about the inter-dependencies of these types of relationships. Such communication is especially important when revisions to these Specifications are considered. Doing so will help manage risks to breaking the relationships as the related Product Specifications transition through their life cycle.

5.6 Hierarchy of data

5.6.1 Hierarchy by stacking of display planes

In Level 3 interoperability catalogues, hierarchy can be set by interleaving of display planes or feature layer suppression operations.

5.6.2 Predefined combinations

Predefined combinations can be defined in Level 3 interoperability catalogues. Interoperability rules can be made contingent on the presence of particular combinations of data products on the display. Predefined combinations are generally created with a particular type of operational view in mind, and therefore the hierarchy of data may vary between predefined combinations. Typically, the ENC will be the base layer; that is, the lowest layer in a predefined combination.

Predefined combinations are used to define the hierarchy of data between different S-100 based specifications. An instance of **S100_IC_PredefinedCombination** is associated to **S100_IC_DisplayPlane** instances to give the hierarchy of the data products that are intended to be used. The attribute *order* within the **S100_IC_DisplayPlane** gives the order in which the layers are drawn.

5.7 New datasets

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.8 Dataset scales, loading, and unloading

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.9 Metadata

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.10 Meta-features

Any spatial operations on meta-features require an Interoperability Catalogue to implement at least Level 4.

There is no other level-specific guidance for meta-features. Common guidance is provided in the “S-98 – Main” component of this specification.

5.11 Quality considerations

The guidance in the “S-98 – Main” component of this specification applies.

Developers of interoperability catalogues should note that the caution about not replacing products of higher data quality with products of lower data quality is extended to the attribute level for feature hybridization – for example, vertical measure attributes of lower data quality should not replace vertical measures of higher quality, taking into account not just the encoded uncertainties but the totality of circumstances surrounding data quality assessment of a particular product, dataset, or feature.

6 Portrayal

This clause gives guidelines and instruction to portrayal considerations related to the use of the Interoperability Catalogue in an ECDIS. The Interoperability Catalogue must apply to the specific Product Specifications listed in the Interoperability Catalogue metadata, *interoperabilityCatalogueProducts* attribute under **S100_IC_CatalogueMetadata**.

There may be additional data products present in the S-100 ECDIS that are external to the Interoperability Catalogue; in such cases the Interoperability Catalogue should continue to function in presence of product

not defined in the Catalogue. Data products that are outside of the interoperability scope must be treated in Interoperability Level 0 (see clause 9.6 in “S-98 – Main”).

6.1 Display of significant features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.2 Display of significant features - switching to original

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.3 Portrayal distinguishability - colour set-asides

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also S-100 Part 16 for specific guidance on colour set-asides.

6.4 Day/night/dusk modes

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.5 Impacts on viewing groups

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.6 Impacts on Portrayal Catalogues

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.7 Meta-features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.8 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.9 Skin-of-the-earth operations and portrayal

6.9.1 Skin-of-the-earth feature replacement and portrayal

For all levels, anything that replaces S-101 skin-of-the-earth features, will overwrite it by having a higher priority; that is, be drawn later.

For suppressed feature layers the suppressed features do not reach the rendering stage and case features from layers over/under the suppressed features will be displayed as determined by their display planes and drawing priorities, after any modifications encoded in the Interoperability catalogue.

Suppressed feature instances are treated similarly to suppressed feature layers for portrayal purposes, except that only selected instances are suppressed. Instances that are not suppressed will be portrayed as determined by the applicable display order and drawing priority, modified as prescribed by any applicable Interoperability Catalogue rules or operations.

Gridded data will generally go over ENC and obscure ENC features, either all (interoperability Level 0) or specific features (interoperability Levels 1 or 2) depending on interoperability level chosen, the predefined combinations or display plane of the features that are interacting.

EXAMPLE 1: High definition gridded bathymetry replaces (overwrite) depth area and depth contours, but soundings, aids to navigation, and obstructions are over the high definition bathymetry (interoperability Level 1).

EXAMPLE 2: Surface current gridded data goes over ENC and replaces all surface current features (interoperability Level 2).

NOTE: Safety contour comes from ENC and is generated by the viewer system. This safety contour is an IMO requirement (IMO Performance Standard 5.8 (MSC.232(82))) for ECDIS and should be presented with highest priority when turned on by the user. OEMs are permitted to add additional safety contour functions, for example; generated from combining high definition gridded bathymetry (S-102) and S-104 input.

6.9.2 Skin-of-the-earth feature adjusting and portrayal

Adjusted features are portrayed according to the portrayal catalogue for the product named as the output product in the hybridization rule in the Interoperability Catalogue. If the output product is specified as "HYBRID", the Hybrid Portrayal Catalogue must be used.

6.10 Blended portrayals

There is no level-specific guidance for this issue. Common guidance is provided in the "S-98 – Main" component of this specification.

6.11 Hierarchy of data

As noted in the Main component of this specification, hierarchy of data can be controlled by predefined combinations (Level 2 and higher). Level 1 catalogues offer only a very limited means of controlling hierarchy by means of display plane ordering. There is no level-specific guidance for portrayal in connection with this issue.

6.11.1 Interacting gridded information

There is no level-specific guidance for portrayal in connection with this issue.

6.12 Pick reports

[NOTE: The pick report functionality specification in S-98 is still under development, and the content of this section will change as this functionality is defined.]

In interoperability Level 3, hybrid features must be present in the pick report and marked as hybrid features.

7 Processing Model

Figure 7.1 below shows the processing steps and input to each step from parts of the Interoperability Catalogue, for the "Interoperability before portrayal" processing option. Figure 7.2 shows the processing

steps and input to each step for the for the “Interoperability after portrayal” processing option. In each case, the flow depends on the interoperability level selected by the mariner.

As in Level 2 interoperability, data products to be loaded are selected as specified in the predefined combination selected by the mariner. The mariner may also select additional data products from the optional load set.

In Level 3 processing, operations for suppressing feature instances (Suppress Feature Instances) are added, as are operations for hybridization of thematic attributes (Combine Thematic Attributes). Additional processing to adjust feature and information associations for remaining features may be needed and this is done in the “Combine Associations” stage. The order of processing steps is **Suppress Feature Types -> Suppress Feature Instances -> Combine Thematic Attributes -> Interleave Feature Layers**. It is depicted in Figure 7.2.

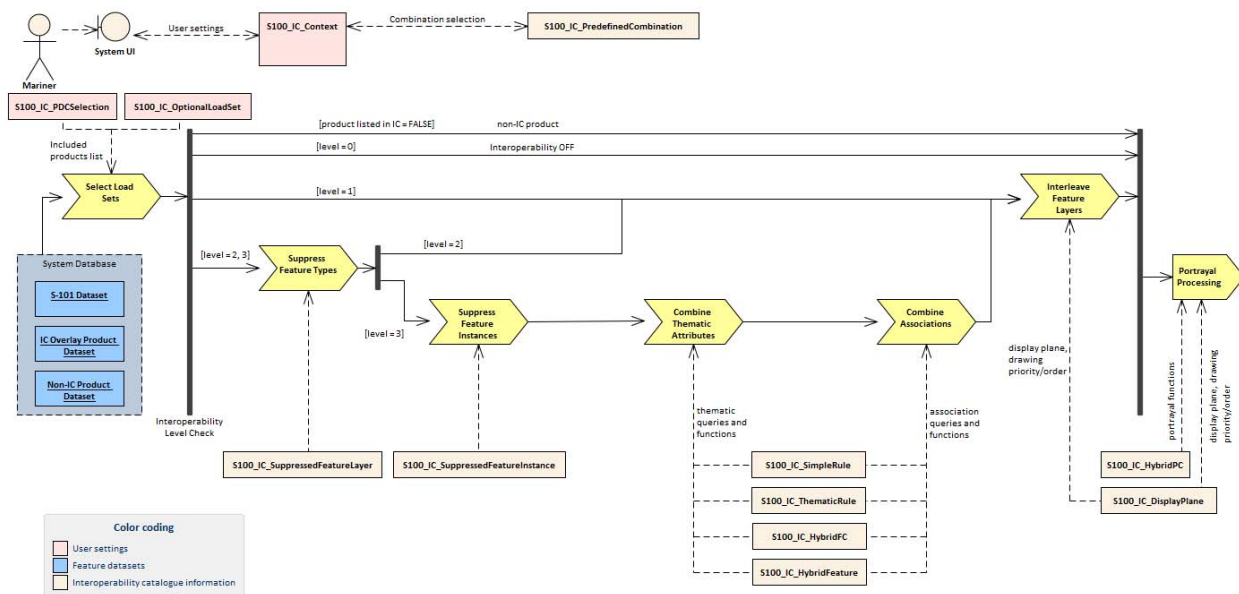


Figure 7-1 - Processing for Level 3 interoperability (interoperability precedes portrayal)

The processing flow for the other implementation option (drawing instructions precede interoperability) is similar with an additional step (*Portrayal Processing*) moved to immediately follow loading of data.

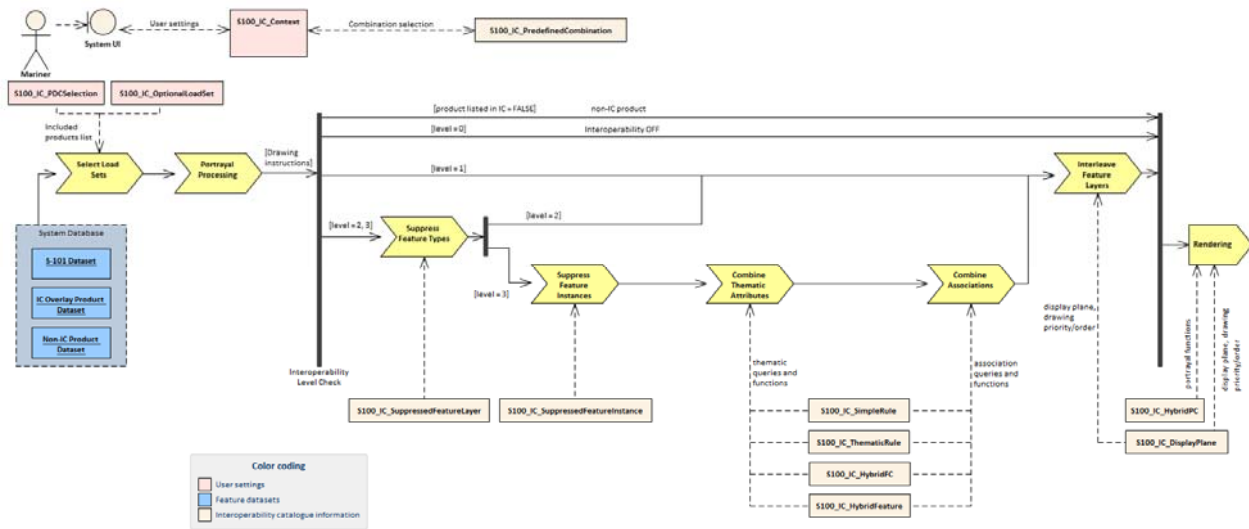


Figure 7-2 – Processing for Level 3 interoperability (Interoperability follows portrayal processing)

Table 7.2 - Stages in Level 3 interoperability processing

Stage	Description	Level	IC information	Context information	Remarks
Select Load Sets	Select data products to be loaded	All	Level 1: User adds data products to display individually Level 2: Included product list from S100_IC_PrefdefinedCombination. includedProduct Level 3: included product list from S100_IC_PrefdefinedCombination. includedProduct	Level 1: None Levels 2, 3: User-selected predefined combination.	Information & functionality depends on user-selected level setting.
Portrayal Processing	Ordinary S-100 portrayal processing	All	Levels 1,2: display planes Level 3: Hybrid PC, display planes		Except final display processing / rendering
Interleave Feature Layers	Assign display plane and drawing order to feature data	1, 2, 3	S100_IC_DisplayPlane		
Suppress Feature Types	Suppress all instances of a specified feature type in a product	2,3	S100_IC_Suppressed FeatureLayer		

Stage	Description	Level	IC information	Context information	Remarks
Suppress Feature Instances	Suppress selected instances of a specified feature type in a product	3	S100_IC_SuppressedFeatureInstance		Applies feature selector expressions encoded in <i>primarySelector</i> and <i>secondarySelector</i> attributes.
Combine Thematic Attributes	Select instances for hybridization and generate thematic attributes of a derived feature	3	S100_IC_SimpleRule, S100_IC_ThematicRule, S100_IC_HybridFeature, S100_IC_HybridFC		
Combine Associations	Adjust associations	3	S100_IC_SimpleRule, S100_IC_ThematicRule, S100_IC_HybridFeature, S100_IC_HybridFC		
Rendering	Display processing	All	S100_IC_DisplayPlane		

8 Normative Implementation Guidance

There is no level-specific normative implementation guidance in this edition of S-98. See the Main component of this Specification for implementation guidance that applies to all levels.

9 Feature Catalogue

Level 3 Interoperability Catalogues use a conditionally mandatory S-98 hybrid Feature Catalogue, which must be defined by Interoperability Catalogue developers if the Interoperability Catalogue contains hybridization rules which generate feature types which do not conform to the feature catalogue for one of the input data products.

10 Portrayal Catalogue

Level 3 Interoperability Catalogues use a conditionally mandatory S-98 hybrid Portrayal Catalogue, which must be defined by Interoperability Catalogue developers if the Interoperability catalogue contains hybridization rules which generate feature types which do not conform to the feature catalogue for one of the input data products.

S-98 – PART D

LEVEL 4 INTEROPERABILITY

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1 Introduction

S-98 Part A contains information that applies to interoperability catalogues which use interoperability rules and operations of at most Level 4 interoperability.

Interoperability catalogues conforming to this Part must comply with both the following components of S-98:

- 1) S-98 Main Specification, which describes requirements applying to all S-98 interoperability catalogues and S-98 exchange sets;
- 2) S-98 Part D (this Part), which defines the subset of the interoperability model and catalogue encoding that are specific to Level 4 interoperability.

The hypothetical processing model for implementations is described in general terms in the “S-98 - Main” document and elaborated in clause 7 of this Part.

Level 4 interoperability includes the following capabilities:

- Level 1 interoperability, in which feature types from different products, including S-101, are interleaved as specified by display plane and drawing priority information contained in the Interoperability Catalogue.
- Level 2 type suppression functionality, which allows suppression of all features of a specified feature type in a specified product, with another feature type from a different product being displayed instead. Filtering by attribute values and geometry type is also possible.
- Level 2 constructs allowing catalogues to partition interoperability rules and operations according to specified combinations of data products (“predefined combinations”). The rules and operations in each partition are applied only when the corresponding data products are part of the display.
- Level 3 interoperability functionality for allowing suppression of selected feature instances and combination or conversion of feature types from input products into different feature types for display and alert processing purposes. In Level 3, combination/conversion operations are limited to thematic attributes.
- Enhanced feature combination/conversion functionality introduced in Level 4, allowing query, combination, and conversion operations on spatial attributes as well as thematic attributes.

The output of interoperability processing is either the original feature data (processing option 1) or drawing instructions (processing option 2), accompanied by display plane and drawing priority information, which is passed through to the portrayal processor. Clause 7 elaborates on these options.

1.1 How to read this Part

Clause 2 of this Part contains scope identification information corresponding to the contents of this Part, which applies specifically to Interoperability catalogues designated as Level 1.

For Clauses 3–10, the content of the clause or sub-clause extends or elaborates on the content under the same or similar clause head or sub-head in S-98 – Main.

The numbering of Clauses 3-10 may differ from that of corresponding clauses in S-98 – Main, because for some there is no additional level-specific information needed. If a clause or sub-clause in S-98 – Main has no corresponding clause or sub-clause in this Part, there is no level-specific information on that topic.

2 Specification Scope for Part D

S-98 Part D describes the portions of S-98 which correspond to the following scope defined in S-98 – Main (Clause 2):

Scope Identification: S98L4

Level: MD_ScopeCode – 13

Level Name: Interoperability Level 4

Description: Spatial operations; instance and type selectivity; hybridization; interleaving

Extent: EX_Extent.description = "worldwide"; EX_GeographicBoundingBox = [-180, +180, -90, +90]

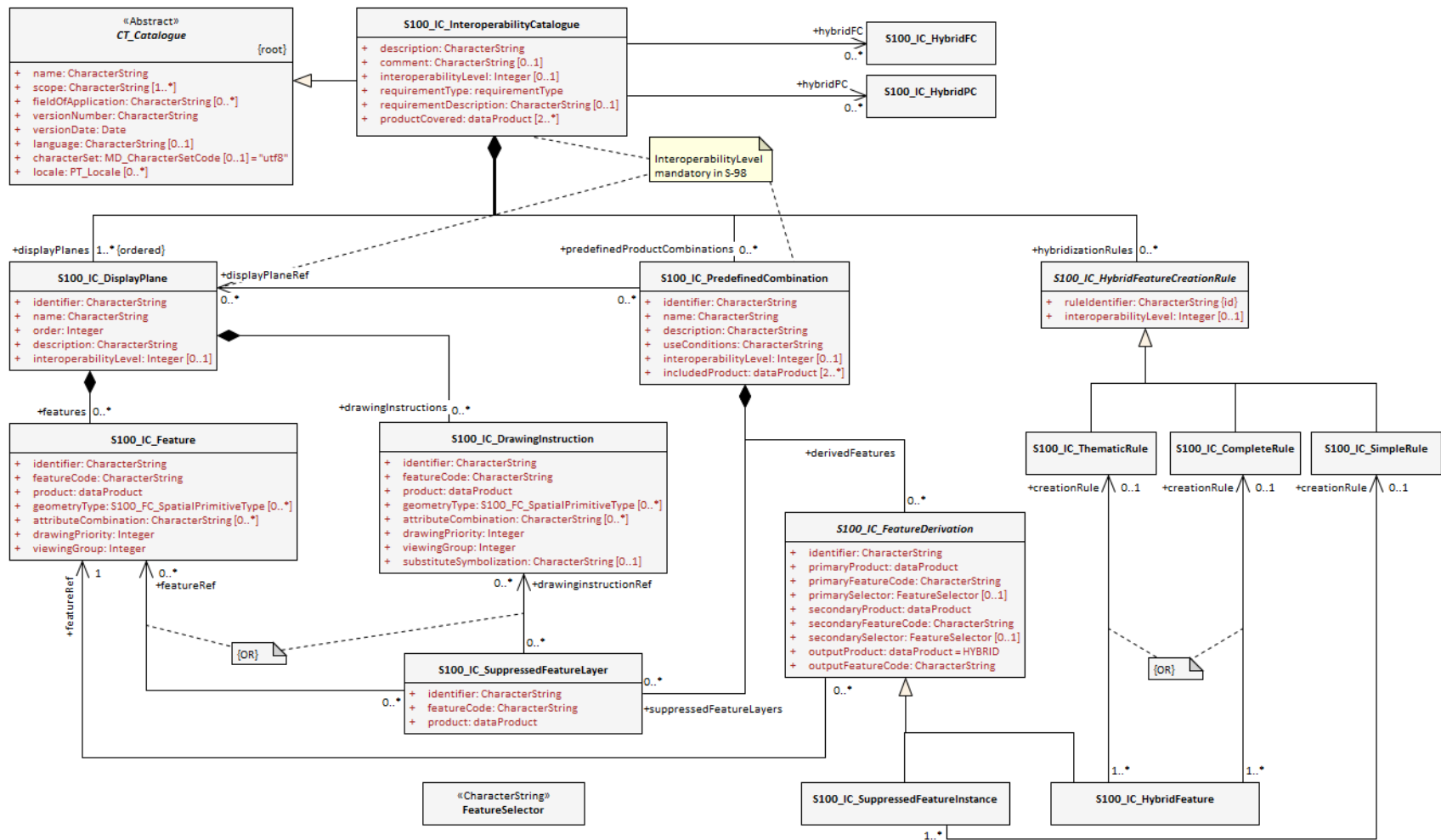
3 Data Content and structure

3.1 Application Schema

3.1.1 Overview of application schema

The application schema for Interoperability Level 4 is depicted in Figure 3.1 below. This application schema is a subset of the full application schema in S-100 Part 16. It consists of the following components:

- 1) Catalogue header information.
- 2) Display plane ordering information.
- 3) Display planes content in the form of either features or drawing instructions.
- 4) Specification of rules indicating which feature layers to suppress.
- 5) Specification of data product combinations and method of referencing collections of interoperability rules and operations to specific combinations.
- 6) Specification of rules indicating which feature instances to suppress.
- 7) Rules for combining feature data into new features based on thematic attributes.
- 8) Operations involving only thematic attributes, for combining selected instances of feature types from different data products, or conversion of feature data into new feature data.
- 9) Feature and Portrayal Catalogues for the new features generated according to the abovementioned combination or conversion operations.
- 10) Operations involving querying, combining, or performing other spatial operations on feature geometry (in combination with the previously mentioned operations on thematic attributes), for combining or converting feature data into new features.



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3.1.2 Operations in Pre-Defined Combinations

Level 4 allows predefined combinations, whereby the scope of specified interoperability operations can be restricted so the operations are executed only when a specified set of data products is active on the user display. Display plane and feature ordering (Level 1 operations) can be thus restricted by associating a specific set of products (listed in **S100_IC_PredefinedCombination** elements) to **S100_IC_DisplayPlane** elements.

Level 4 interoperability also allows replacement of a feature layer from one product by a feature layer from another product. These layers are specified by **S100_IC_SuppressedFeatureLayer** elements. Replacement operations are restricted to occur only when specific combinations of data products are present on the user display because the **S100_IC_SuppressedFeatureLayer** elements in interoperability catalogues are always contained within **S100_IC_PredefinedCombination** elements.

The simplest operations on feature instances are replacement of selected instances from one product by selected instances from another product. These are described by **S100_IC_SuppressedFeatureInstance** elements.

Level 4 also allows more complex operations, including conversion of input feature instances into new features (hybridization) as described by **S100_IC_HybridFeature** elements. The replacement and hybridization rules are described in Clause 3.1.5. The operations allowed in Level 4 are:

- 1) Operations on selected instances of a feature type (Level 3 interoperability).
- 2) Conversion of input feature data into new feature data involving only thematic attributes (Level 3 interoperability).
- 3) Conversion of input feature data into new feature data involving spatial as well as thematic attributes (enhanced functionality introduced in Level 4).

3.1.3 Enhanced selection of feature instances

S100_IC_SuppressedFeatureInstance and **S100_IC_HybridFeature** elements specify the feature types on which they operate by indicating the product and feature types of two products. Selection of feature instances is done by evaluating a filter expression (type **FeatureSelector**, a string expression conforming to the specified [TBD] format) with the feature instance as input parameter. A **FeatureSelector** is a more expressive form of the attribute-value combination filter described in Clause 4.3 (S-98 – Main) that can include spatial operations and more complex expressions on thematic attributes.

[NOTE: If a scripting language for selection is developed it will belong in this level – the TBD in the previous sentence would be the specification of the scripting language, and equally importantly, their call/function signatures and restrictions on what the scripts are allowed to do.]

If spatial attributes are not mentioned in filtering or selection conditions, spatial equality is an implied criterion in determining each input instance set of feature instances to be converted to new feature data uses spatial equality as an implicit criterion for set membership; that is, only coincident instances (to a system-determined tolerance) are combined, and the geometry of the output is the same as the geometry of any instance in the input set.

For Level 4 interoperability, the Levels 1-3 restriction on the use of spatial attributes is relaxed and complex spatial operations are permitted but there is an implicit assumption that the members of the input instance set are meaningfully related spatially (for example 95% common area). The precise criteria for meaningful

spatial relationships depend on the nature of the data products and other particular circumstances, and must, for this edition of S-98, be defined by the developers of a particular interoperability catalogue¹.

In Level 4 interoperability, the spatial attributes of the output instance may be generated by applying spatial operators for example spatial union, intersection, etc.) to the spatial attributes of the input instance set. The allowed spatial operations are the methods for testing spatial relations described in IHO S-58, Section 2 extended with additional operations (to be determined when Level 4 is elaborated¹).

3.1.4 Interoperability levels

The *interoperabilityLevel* attribute in **S100_IC_InteroperabilityCatalogue** specifies the highest level of interoperability implemented in that XML interoperability catalogue file. The *interoperabilityLevel* attribute in **S100_IC_DisplayPlane** specifies the level to which that display plane pertains.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements are permitted to also include operations of a lower level of interoperability.

The *interoperabilityLevel* attribute in **S100_HybridFeatureCreationRule** specifies the interoperability level to which that rule applies.

3.1.5 Hybridization rules

Hybridization rules define how a set of feature instances is combined to create a hybrid feature type. In the simplest form of hybridization, the hybrid feature would bind all the attributes of the input types to a single output feature type (this assumes that there are no collisions² between the thematic attributes of the input types.) More complex hybridization rules can handle collisions, for example by defining a preference order for colliding attributes, including all the values if the input types bind the same enumerated attribute, or adding uncertainty metadata if numeric attribute values are different.

The hybridization rules require two feature instances as input and produce a single feature instance as output. The formal specification and rule language for hybridization will be described in a subsequent version of this Specification.

3.1.5.1 Simple hybridization rule

Simple rules treat thematic attributes uniformly, for example by binding the attributes of both primary and secondary input instances to the output instance, or preferring the attribute bindings of the primary instance to those of the secondary instance in case of a difference in the values of common attributes. Location/extent spatial attributes of all input instances must be spatially equal and are passed through unchanged.

3.1.5.2 Thematic hybridization rule

Thematic rules treat thematic attributes on an individual basis, for example, use specified attributes from the primary input instance and specified attributes from the secondary input instance. Combination operations on attribute values may be specified (for example, `OutputFeature.depthValue = maximum(ProductA.FeatureX.depthValue, ProductB.FeatureY.depthValue)`). Location/extent spatial

¹ Later editions of S-98 may include concrete criteria and additional spatial operations, ideally after exploratory Level 4 implementations have resulted in agreement on which spatial operations are useful for practical interoperability.

² Attributes which describe the same characteristic of substantially the same phenomenon. Such attributes will generally have the same name. Developers of interoperability catalogues can detect collisions by comparing application schemas and feature catalogues.

3.2 Interoperability Catalogue

3.2.1 Conceptual Types for Level 4 Interoperability

The following clauses summarize the conceptual elements used in Level 4 Interoperability Catalogues. Details about these conceptual types are provided in S-100 Part 16.

3.2.1.1 Display Plane (**S100_IC_DisplayPlane**)

A display plane element in the interoperability catalogue acts as a container for display information for specified feature classes, which enables the interleaving of feature layers during portrayal by indicating the display plane, priority, and drawing order of the features assigned to a display plane.

A feature type may be referenced in more than one **S100_IC_DisplayPlane**, but the entries in different display planes must be distinguished by different attribute-value combinations or spatial primitives so that the actual instances of features are partitioned unambiguously between different display planes.

The portrayal of feature types not mentioned in any **S100_IC_DisplayPlane** component is undefined until ordinary portrayal processing takes place.

3.2.1.2 Feature type display information (**S100_IC_Feature**)

The **S100_IC_Feature** element describes the display parameters for all features of a specific feature type in a specific product and thereby determines the order of drawing the feature type relative to other feature types in the same display plane. It also specifies the viewing group to which the feature is assigned. Its applicability can be optionally restricted to a subset of instances of the feature type by additional attributes that specify the type of spatial primitive and indicate specific values of thematic attributes.

3.2.1.3 Feature layer (**S100_IC_SuppressedFeatureLayer**)

Each instance of this element identifies a feature type in a specific data product which is supposed to be suppressed in the presence of another specified feature type from another product.

3.2.1.4 Drawing instruction (**S100_IC_DrawingInstruction**)

Drawing instructions in the Interoperability Catalogue play a similar role to feature type display information (**S100_IC_FeatureType**) but with drawing instructions instead of feature objects. The **S100_IC_DrawingInstruction** element in Interoperability Catalogues is similar in operation to the layering and priority aspects of the **DrawingInstruction** element in Portrayal Catalogues (see S-100 Part 9 - Portrayal). Where there is a conflict with a Portrayal Catalogue drawing instruction, the drawing instruction in the Interoperability Catalogue supersedes the drawing instruction in the Portrayal Catalogue.

The **S100_IC_DrawingInstruction** element contains an additional attribute that allows substitution of symbolization instructions generated by portrayal processing.

3.2.1.4.1 Comparison and use of **S100_IC_Feature** and **S100_IC_DrawingInstruction**

S100_IC_Feature and **S100_IC_DrawingInstruction** elements in Interoperability Catalogues operate in essentially the same way as far as assignment of drawing order, priority, and display planes is concerned. They differ in that **S100_IC_DrawingInstruction** provides an optional attribute to substitute the symbolization elements of the drawing instruction.

S100_IC_Feature should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions.

S100_IC_DrawingInstruction should be used for Interoperability Catalogues that are designed for systems where interoperability processing precedes the generation of drawing instructions. It should also be used in all catalogues where substitution of symbolization is necessary.

3.2.1.5 Predefined combination (S100_IC_PredefinedCombination)

A predefined combination element defines a collection of data products for which a common set of interoperability operations have been defined in the Interoperability Catalogue. Instances of predefined combinations are also characterized by interoperability level, which allows the encoding of different sets of operations depending on how tightly integrated the user desires the products to be on the resultant display.

The *interoperabilityLevel* attribute in each **S100_IC_PredefinedCombination** element specifies the highest level of interoperability operations that are encoded in the element. **S100_IC_PredefinedCombination** elements with a specified level attribute are permitted to also include operations of a lower level of interoperability.

Predefined combinations can be linked to **S100_IC_DisplayPlane** elements by means of references in the **S100_IC_PredefinedCombination** elements.

3.2.1.6 Suppressed feature Instance (S100_SuppressedFeatureInstance)

This element allows interoperability catalogues to indicate when specific feature instances in a data product must be suppressed by specific feature instances in another product. Its functionality is similar to **S100_SuppressedFeatureLayer** except that it can use somewhat more expressive selection/replacement rules (by virtue of its dependency on **S100_SimpleRule**) and it applies to feature instances instead of feature types or subsets of feature types.

3.2.1.7 Feature hybridization (S100_HybridFeature)

This element allows selected feature types or instances to be combined into a new feature for display purposes.

3.2.1.8 Feature creation or replacement rule (S100_SimpleRule, S100_ThematicRule, S100_CompleteRule)

Feature creation and replacement is advanced functionality whose implementation is not required for this version of the Interoperability Catalogue.

Feature creation and replacement rules create new feature types by combining characteristics of specified feature types from the input data products. A feature creation/replacement rule basically transforms a collection of feature instances in the input stream into one or more different feature instances in the output stream. The created feature differs from all the input features, for example by adding properties of one feature to properties of another feature.

3.2.2 Use of S-100 types

The S-100 types used by S-98 Level 4 interoperability catalogues are described in the S-98 – Main component of this Specification. For Level 4 interoperability catalogues, the following additional information applies.

- Interoperability Catalogues of Level 4 do not use feature and information associations in feature filters defined by *attributeCombination* attributes in **S100_S100_IC_Feature** or **S100_IC_DrawingInstruction** elements. This is the same as the Level 1, 2, and 3 functionality for these elements.

- Interoperability Catalogues of Level 4 are allowed to use feature and information associations in feature selector expressions encoded in the *primarySelector* and *secondarySelector* attributes of **S100_IC_DerivedFeature** or in **S100_SimpleRule**, **S100_ThematicRule**, or **S100_CompleteRule** elements.

3.3 UML model documentation

The UML model documentation is provided in **S-100 Part 16**. This clause documents details specific to the use of the UML model for the interoperability level described in this Part of S-98.

Only the model elements used in this level (and included in the level's application schema) are listed. The constraints and considerations listed in the UML documentation tables in S-100 Part 16 apply. Any S-98 general or level-specific considerations are described under the element name in the list below.

- 1) **S100_IC_DisplayPlane**: No level-specific constraints or notes

Attribute *interoperabilityLevel*: Mandatory. The only values allowed for Level 4 interoperability catalogues are 1, 2, 3, and 4.

- 2) **S100_IC_DrawingInstruction**:

NOTE for implementers: Even if the Presentation schema in S-100 Part 9 is used, implementers may need to provide specific code to validate the content of the *substituteSymbolization* attribute instead of depending on normal XML schema validation. The content of this attribute is not prescribed by this specification and may be a fragment of XML, or interpretable code or rules, etc., in a non-XML syntax. It may be enclosed in a `<![CDATA[...]]>` section so that XML validators treat it as character data instead of XML.

- 3) **S100_IC_Feature**: No level-specific constraints or notes

- 4) **S100_IC_InteroperabilityCatalogue**:

Attribute *productCovered*: Must use values defined in the dictionary identified by MRN: urn:mrn:iho:prod:s98:1:0:0:products

Attribute *interoperabilityLevel*: Mandatory in S-98 catalogues at all levels. The only value allowed for Level 4 interoperability catalogues is 4.

Role *hybridFC*: Required if and only if there are any feature hybridization rules in the catalogue.

Role *hybridPC*: Required if and only if there are any feature hybridization rules in the catalogue.

Role *hybridizationRules*: Required if and only if there are any instances of **S100_IC_SimpleRule**, **S100_IC_ThematicRule**, or **S100_IC_CompleteRule** in the catalogue.

- 5) **S100_IC_PredefinedCombination**:

Attribute *interoperabilityLevel*: Mandatory in S-98 interoperability catalogue; allowed values: 1, 2, 3, 4.

- 6) **S100_IC_SuppressedFeatureLayer**: No level-specific constraints or notes

- 7) **Codelist dataProduct**: No level-specific constraints or notes. The data type for all levels is described below.

Codelist Type: closed dictionary

MRN: urn:mrn:iho:prod:s98:1:0:0:products

- 8) **Codelist requirementType**: No level-specific constraints or notes.

For all interoperability levels, the following subset of the standard values listed in S-100 Part 16 are permitted to be used in S-98 interoperability catalogues:

Table 3-1 - Allowed values for requirementType

Value	Description	Code
IHO	Original IHO Interoperability Catalogue	1
OEM	Prepared according to requirements specified by OEM or systems integrator	2
national	Prepared according to requirements specified by a national government, group of national governments (for example the European Union), or governmental agency such as a national shipping authority or the Coast Guard.	3
local	Prepared according to requirements specified by a sub-national governmental authority such as a state, province, or county	4
port	Prepared according to requirements specified by a harbormaster's office or port authority	5
company	Prepared according to requirements specified by the owner, charterer, or operator	6
pilot	Prepared according to requirements specified by a pilot	7
master	Prepared according to requirements specified by the vessel's master	8

Extra values ("other: ...") as defined in S-100 § 3-6.7 are also permitted.

9) S100_IC_FeatureDerivation:

The resulting derived feature does not need to have any hybrid characteristics, that is, one restricted area replaced with another restricted area will use regular PC/FC of the primary product. However if the result feature needs to be supported by any custom FC or PC elements they must be defined under hybrid FC and hybrid PC accordingly.

A rule for creating the feature must be described in the rules section of the interoperability catalogue.

Attribute primarySelector: If omitted, all instances of the type are included.

In L3 processing, may contain only thematic attributes and the primary and secondary instance geometries must be spatially equal.

L3 Example: CATICE = 5

In L4 processing, expressions may also contain spatial attributes.

L4 Example: CATICE = 5 AND WITHIN(<primary>, <secondary>)

Attribute secondarySelector: If omitted, all instances of the type are included.

In L3 processing, may contain only thematic attributes and the primary and secondary instance geometries must be spatially equal.

L3 Example: CATICE = 5

In L4 processing, expressions may also contain spatial attributes.

L4 Example: CATICE = 5 AND WITHIN(<secondary>, <primary>)

NOTE: **S100_IC_FeatureDerivation** is an abstract super-class for different types of feature hybridization operations.

10) S100_IC_HybridFC: No level-specific constraints or notes.

11) S100_IC_HybridFeature: No level-specific constraints or notes.

- 12) **S100_IC_HybridFeatureCreationRule**: No level-specific constraints or notes.

Attribute *interoperabilityLevel*: Mandatory for all levels in S-98.

NOTE 1: **S100_IC_HybridFeatureCreationRule** is an abstract super-class for different types of hybridization rules. This functionality needs to be worked out but OGC Filter seems to be the ideal option for defining data filtering logic.

NOTE 2: Overall, the output from execution of **S100_IC_HybridFeatureCreationRule** is a set of hybrid features for which predefined FC, PC and display plane definitions already exist so such feature will be suitable for passing to the portrayal engine for processing just like any other S-100 features.

- 13) **S100_HybridPC**: No level-specific constraints or notes.

14) S100_IC_PredefinedCombination

Role *derivedFeatures*: Required if and only if there are any instances of S100_SuppressedFeatureInstance or subclasses of the abstract class S100_IC_HybridFeature in the catalogue.

- 15) **S100_IC_SimpleRule**: No level-specific constraints or notes.

- 16) **S100_IC_SuppressedFeatureInstance**: No level-specific constraints or notes.

- 17) **S100_IC_ThematicRule**: No level-specific constraints or notes.

- 18) **FeatureSelector**: No level-specific constraints or notes.

- 19) **S100_CompleteRule**: No level-specific constraints or notes.

4 Level-specific data quality considerations

4.1 Quality of displayed data

There are no level-specific extensions to Clause 6.1 of the “S98 – Main” document.

Clause 5.11 provides guidance for maintaining data quality for level-specific rules and operations.

4.2 Quality of interoperability catalogues

The quality measures recommended in S-97 (Part C) which are applicable to Level 4 S-98 interoperability catalogues are those listed in Table 6-1 of the “S-98 – Main” document plus those listed in Table 4-1 below.

S-98 also includes the quality measure “Relative Internal Positional Accuracy” (S-100 Part 4c App. 4c-C) as a measure of the accuracy of any spatial operations during interoperability processing which may generate spatial primitives for display purposes from input products.

Table 4-1 - Quality elements for Level X S-98 interoperability catalogues

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for resultant ⁴ features
D1	Completeness / Omission	Data absent from the dataset, as described by the scope.	numberOfMissingItems / This data quality measure is an indicator that shows that a specific item is missing in the data.	Hybrid FC / PC	Features produced by hybridization rules.
D2	Logical Consistency / Domain Consistency	Adherence of the values to the value domains.	numberOfNonconformantItems / This data quality measure is a count of all items in the dataset that are not in conformance with their value domain.	(See S-98 – Main)	Features produced by hybridization rules.
D3	Thematic Accuracy / Thematic Classification Correctness	Comparison of the classes assigned to features or their attributes to a universe of discourse.	<p>miscalculationRate / This data quality measure indicates the number of incorrectly classified features in relation to the number of features that are supposed to be there. [Adapted from ISO 19157]</p> <p>This is a RATE which is a ratio, and is expressed as a REAL number representing the rational fraction corresponding to the numerator and denominator of the ratio.</p> <p>For example, if there are 1 items that are classified incorrectly and there are 100 of the items in the dataset then the ratio is 1/100 and the reported rate = 0.01.</p>	Hybrid FC / PC	Features produced by hybridization rules.
D4	Logical Consistency / Conceptual Consistency	Adherence to the rules of a conceptual schema.	numberOfInvalidSurfaceOverlaps / This data quality measure is a count of the total number of erroneous overlaps within the data. Which surfaces may overlap and which must not is application dependent. Not all overlapping surfaces are necessarily erroneous.	N/A	Features produced by hybridization rules with spatial operations on surface spatial primitives.

³ For the IC evaluation scope, a “dataset” is an entire interoperability catalogue file, an “element” is an interoperability catalogue component corresponding to one of the classes in the model depicted in S-100 Part 16 Figure 16-3.

⁴ “Resultant” means the result of applying interoperability operations to covered data. “Resultant feature” means the apparent feature as it appears on the display after application of interoperability. “Resultant dataset” means the collection of resultant features. A “modified resultant feature” is the feature or drawing instruction resulting from the application of an operation or rule which affects spatial or thematic attributes or their values, including combining or suppressing attributes or generating an instance of a feature defined in the HYBRID feature catalogue in Level 3 or 4. A “superseding feature” is a feature which suppresses a feature (instance or type) from another dataset, or whose priority is increased by an interoperability rule or operation (which would make it visible in preference to a feature which would otherwise overlie it). A “superseded feature” is one that is suppressed or overlaid by a superseding feature.

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for resultant ⁴ features
D5	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	rateOfFaultyPointCurveConnections / This data quality measure indicates the number of faulty link-node connections in relation to the number of supposed link-node connections. This data quality measure gives the erroneous point-curve connections in relation to the total number of point-curve connections.	N/A	Features produced by hybridization rules with spatial operations on curve spatial primitives.
D6	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsUndershoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to undershoots.	N/A	Features produced by hybridization rules with spatial operations on curve spatial primitives.
D7	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsOvershoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to overshoots.	N/A	Features produced by hybridization rules with spatial operations on curve spatial primitives.
D8	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSlivers / This data quality measure is a count of all items in the dataset that are invalid sliver surfaces. A sliver is an unintended area that occurs when adjacent surfaces are not digitized properly. The borders of the adjacent surfaces may unintentionally gap or overlap to cause a topological error.	N/A	Features produced by hybridization rules with spatial operations on surface spatial primitives.
D9	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSelfIntersects / This data quality measure is a count of all items in the dataset that illegally intersect with themselves.	N/A	Features produced by hybridization rules with spatial operations on surface spatial primitives.
D10	Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as	numberOfInvalidSelfOverlap / This data quality measure is a count of all items in the dataset that illegally self-overlap.	N/A	Features produced by hybridization rules with spatial operations on

No.	Data quality element and sub element	Definition	DQ measure / description	Evaluation scope ³ for IC	Evaluation scope for resultant ⁴ features
		described by the scope.			surface or curve spatial primitives.
D1 1	Positional Accuracy / Absolute or External Accuracy	Closeness of reported coordinative values to values accepted as or being true.	Root Mean Square Error / Standard deviation, where the true value is not estimated from the observations but known a priori.	N/A	Modified or superseding features that have coordinate values associated.
D1 2	Positional Accuracy / Vertical Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	linearMapAccuracy2Sigma / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	N/A	Modified or superseding features with attributes indicating vertical data measures.
D1 3	Positional Accuracy / Horizontal Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	linearMapAccuracy2Sigma / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	N/A	Modified or superseding features that have horizontal coordinate values associated.
D1 4	Positional Accuracy / Gridded Data Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	Root mean square error of planimetry / Radius of a circle around the given point, in which the true value lies with probability P.	N/A	Modified or superseding features of gridded spatial types.
D1 5	Positional Accuracy / Relative Internal Position Accuracy	Closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true	relativeHorizontalError / An evaluation of the random errors in the horizontal position of one feature to another in the same data set or on the same map/chart.	N/A	Features produced by hybridization rules with spatial operations.
D1 6	Positional Accuracy / Relative Internal Position Accuracy	Closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true	relativeVerticalError / An evaluation of the random errors of one relief feature to another in the same data set or on the same map/chart. It is a function of the random errors in the two elevations with respect to a common vertical datum.	N/A	Features produced by hybridization rules with spatial operations.

4.2.1 Test methods

The provisions of Clause 6.2.1 of the “S-98 – Main” document apply.

The tests in Table 4 1 should be evaluated only with features produced by hybridization rules.

Evaluation of quality elements D1-D3 in Table 4 1 consists of verifying that the FC and PC corresponding to the output product(s) specified in hybridization operations define a feature type and portrayal rule respectively for any feature type produced by a hybridization operation and that the attribute bindings and values are consistent.

4.2.2 Data quality testing

The provisions of Clause 6.2.2 of the “S-98 – Main” document apply. Evaluation methods for quality element D1-D3 in Table 4 1 should include either a complete static analysis of hybridization rules compared to feature and portrayal catalogues (either with or without automated support) or full test case coverage. Evaluation methods for quality elements D4-D16 may use test datasets.

5 Level-specific Guidance on Making Product Specifications Interoperable

The guidelines in this clause supplement and extend guidance common to all levels on making product specifications interoperable, which is given in clause 8 of the “S-98 – Main” document.

5.1 Duplicated features

There is no level-specific guidance for determining duplicated features. However, when interoperability catalogues are developed to resolve duplicated features, keep in mind the following level-dependent considerations.

Level 4 interoperability catalogues offer the same interoperability functionality for resolving duplicated features as Level 3:

- Interleaving changes - changes to the display planes and display orders specified in the products' portrayal catalogues, as determined by display plane and drawing priority information. This means that features which are not covered by features with higher drawing priority or in a upper display plane will still be visible. This is the same functionality as Level 1.
- Type-based suppression of features from one product by features from another product. The difference from interleaving changes is that type-based suppression will suppress even features which are not covered by features from the second product. Note that this applies only in areas where there is data coverage by both products; it does not apply in areas where only one product has data coverage. This is the same functionality added by Level 2 to Level 1.
- Suppression of feature instances matching specified conditions and their replacement by other feature instances. This is the same functionality as Level 3.

5.1.1 Duplicated features same model

Level 4 offers the same interoperability functionality for resolving this as Level 3. See the guidance in the “S-98 – Main” component of this specification, and keep in mind the differences between Level 1, 2, and 3 interoperability solutions described earlier in Clause 5.1 of this Part.

S100_IC_SuppressedFeatureLayer elements only have feature code and product as attributes for suppression, this means that all instances of a listed feature class will be suppressed. This is important to

remember when creating rules that promote alternative instances. **S100_IC_Feature** and **S100_IC_DrawingInstruction** can have attribute combinations and spatial primitives to select the alternative instances. There is therefore, a risk that unless sufficient attention to details is given, important instances may be omitted.

EXAMPLE: If **Restricted Area Navigational** in ENC is suppressed, and **Restricted Area Navigational** with attribute **category of restricted area = 4 (nature reserve)** in Marine Protected Area dataset is promoted in its place, there is a chance that only instances with that combination will be visible, and all others suppressed.

S100_SuppressedFeatureInstance elements can suppress instances selectively, as defined by conditions specified in the *primarySelector* attribute or referenced **S100_SimpleRule** element. While the **S100_HybridFeature** element is intended mainly for feature hybridization, it can also be used to suppress duplicated features, since it inherits the same attributes as **S100_SuppressedFeatureInstance** from their common abstract super-class **S100_FeatureDerivation**. However, if the intention is merely to suppress a feature, **S100_SuppressedFeatureInstance** should be used.

5.1.2 Duplicated features, different models

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Level 1 and Level 2 interoperability solutions described in Clause 5.1 of this Part. There is no other level-specific guidance for this scenario.

5.1.3 Duplicate feature domains

See the guidance in the “S-98 – Main” component of this specification and keep in mind the differences between Level 1 and Level 2 interoperability solutions described in 4.1 of this Part. There is no other level-specific guidance for this scenario.

5.2 Geometry

5.2.1 Combined geometry

See the corresponding clause in the Main part of this Specification for guidance for developers of Product Specifications that may result in hybrid features when interacting with specific other products.

NOTE: The hybrid feature concept is only for interoperability Levels 3 and 4. Thematic hybridization/fusion is possible in both Levels 3 and 4. Spatial hybridization/fusion is only available for interoperability Level 4. Both are out of scope for initial implementations of this Interoperability Specification.

5.2.2 Spatial discrepancy, unrelated to scaled or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.2.3 Spatial discrepancies, related to scale or cartographic smoothing

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.3 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also clause 10.8 of the “S-98 – Main” component.

5.4 Skin-of-the-earth feature operations

5.4.1 Skin-of-the earth feature replacement

Level 4 Interoperability Catalogues permit any of the following:

- Interleaving of display planes so that upper planes overwrite lower planes (Level 1 functionality). This can be used to shift feature layers to lower or higher planes to overwrite layers whose replacement is desired.
- Suppression of feature layers in which case the features in the suppressed layer are not processed for portrayal but features over/under the suppressed features will be displayed as determined by their display planes and drawing priorities (Level 2 functionality).
- Suppression of feature instances, which is like suppression of feature layers but applies to feature instances selected by selector expression or simple rule (Level 3 functionality).
- Merging of features from different products creating hybrid features (Level 3 functionality).
- Spatial operations for feature selection or creation of feature geometry for hybrid features from the geometry of the input features (additional functionality in Level 4).

See clause 6.9 for portrayal considerations.

5.4.2 Skin-of-the earth feature adjusting

Adjustment of thematic attribute values is possible in Level 4 catalogues by means of hybridization rules.

For example, the values of depth and under keel clearance attributes may be adjusted by combining bathymetry and/or water level information with ENC data.

In interoperability Level 4, skin-of-the-earth feature spatial attribute adjustment is a specialization of combined geometry, see clause 5.2.1 for details. Also see clause 6.9 for portrayal considerations. Additional considerations should be given to the attributes of the resulting skin-of-the-earth feature, as a combined feature may have altered geographical representation, attribute combinations or attribute values.

EXAMPLE: Shoaling in a channel in an ENC may be indicated by high definition bathymetry, and a shallower channel hybrid feature replaces the ENC feature, which also has an amended shape. Depth areas adjacent grow due to the shoaling.

5.5 Blended feature concepts

Blended feature concepts or blended portrayals can be produced by using transparency between related features; or creating a temporary blended feature; or blended portrayal (rule and/or symbol) of specific combinations of features from different products. See clause 10 in the “S-98 – Main” document for portrayal considerations and example of use case.

Blended features or portrayal will typically be created by using **S100_IC_PredefinedCombination** which link to a hybrid Portrayal Catalogue that includes the features to be combined and a suppression rule, for example by using **S-100_IC_SuppressedFeatureLayer**, for the features that are to be replaced.

An example where a blended concept could be used is where winds blowing from the west cause fairways to some west coast ports of Finland to get layered ice (wind pushes ice layers on top of each other until there is ice from the sea bottom up to the surface). When an ice-breaker makes a path through some ice remains between the sea bottom and the keel of the ice-breaker. Ice thickness in such a place could be up to 11 m while the ice-breaker draught is around 7-8 meters. In such cases a simultaneous display of both

ice coverage and underlying depth area is required. Other depth area features such as spot soundings, rocks, wrecks, etc., are also still important.

Developers of Product Specifications that are likely to be used in blended feature concepts by ECDIS in interoperability mode should communicate their intentions with developers of related Specifications so that awareness is created about the inter-dependencies of these types of relationships. Such communication is especially important when revisions to these Specifications are considered. Doing so will help manage risks to breaking the relationships as the related Product Specifications transition through their life cycle.

5.6 Hierarchy of data

5.6.1 Hierarchy by stacking of display planes

In Level 4 interoperability catalogues, hierarchy can be set by interleaving of display planes or feature layer suppression operations.

5.6.2 Predefined combinations

Predefined combinations can be defined in Level 4 interoperability catalogues. Interoperability rules can be made contingent on the presence of particular combinations of data products on the display. Predefined combinations are generally created with a particular type of operational view in mind, and therefore the hierarchy of data may vary between predefined combinations. Typically, the ENC will be the base layer; that is, the lowest layer in a predefined combination.

Predefined combinations are used to define the hierarchy of data between different S-100 based specifications. An instance of **S100_IC_PredefinedCombination** is associated to **S100_IC_DisplayPlane** instances to give the hierarchy of the data products that are intended to be used. The attribute *order* within the **S100_IC_DisplayPlane** gives the order in which the layers are drawn.

5.7 New datasets

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.8 Dataset scales, loading, and unloading

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.9 Metadata

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

5.10 Meta-features

Any spatial operations on meta-features require an Interoperability Catalogue to implement at least Level 4.

There is no other level-specific guidance for meta-features. Common guidance is provided in the “S-98 – Main” component of this specification.

5.11 Quality considerations

The guidance in the “S-98 – Main” component of this specification applies.

Developers of interoperability catalogues should note that the caution about not replacing products of higher data quality with products of lower data quality is extended to the attribute level for feature hybridization – for example, vertical measure attributes of lower data quality should not replace vertical measures of higher quality, taking into account not just the encoded uncertainties but the totality of circumstances surrounding data quality assessment of a particular product, dataset, or feature.

If spatial operations are encoded in an interoperability catalogue, developers should, while developing the corresponding hybridization rule, assess the effect on data quality of applying the appropriate principles of error propagation to the resultant spatial primitives. This assessment will need to take into account the nature of the operation (replacement, intersection, etc.). The assessment may change the uncertainty of the result relative to the input feature data, so developers may have to determine whether the quality of the result is sufficient to justify the rule.

6 Portrayal

This clause gives guidelines and instruction to portrayal considerations related to the use of the Interoperability Catalogue in an ECDIS. The Interoperability Catalogue must apply to the specific Product Specifications listed in the Interoperability Catalogue metadata, *interoperabilityCatalogueProducts* attribute under **S100_IC_CatalogueMetadata**.

There may be additional data products present in the S-100 ECDIS that are external to the Interoperability Catalogue; in such cases the Interoperability Catalogue should continue to function in presence of product not defined in the Catalogue. Data products that are outside of the interoperability scope must be treated in Interoperability Level 0 (see clause 9.6 in “S-98 – Main”).

6.1 Display of significant features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.2 Display of significant features - switching to original

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.3 Portrayal distinguishability - colour set-asides

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification. See also S-100 Part 16 for specific guidance on colour set-asides.

6.4 Day/night/dusk modes

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.5 Impacts on viewing groups

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.6 Impacts on Portrayal Catalogues

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.7 Meta-features

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.8 Display of text

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.9 Skin-of-the-earth operations and portrayal

6.9.1 Skin-of-the-earth feature replacement and portrayal

For all levels, anything that replaces S-101 skin-of-the-earth features, will overwrite it by having a higher priority; that is, be drawn later. The major difference between the levels is in the overwriting.

For suppressed feature layers the suppressed features do not reach the rendering stage and case features from layers over/under the suppressed features will be displayed as determined by their display planes and drawing priorities, after any modifications encoded in the Interoperability catalogue.

Suppressed feature instances are treated similarly to suppressed feature layers for portrayal purposes, except that only selected instances are suppressed. Instances that are not suppressed will be portrayed as determined by the applicable display order and drawing priority, modified as prescribed by any applicable Interoperability Catalogue rules or operations.

Gridded data will generally go over ENC and obscure ENC features, either all (interoperability Level 0) or specific features (interoperability Levels 1 or 2) depending on interoperability level chosen, the predefined combinations or display plane of the features that are interacting.

EXAMPLE 1: High definition gridded bathymetry replaces (overwrite) depth area and depth contours, but soundings, aids to navigation, and obstructions are over the high definition bathymetry (interoperability Level 1).

EXAMPLE 2: Surface current gridded data goes over ENC and replaces all surface current features (interoperability Level 2).

NOTE: Safety contour comes from ENC and is generated by the viewer system. This safety contour is an IMO requirement (IMO Performance Standard 5.8 (MSC.232(82))) for ECDIS and should be presented with highest priority when turned on by the user. OEMs are permitted to add additional safety contour functions, for example; generated from combining high definition gridded bathymetry (S-102) and S-104 input.

6.9.2 Skin-of-the-earth feature adjusting and portrayal

This clause covers the possibility of the skin-of-the-earth features geometry and/or attribute values being dynamically adjusted based on the corresponding features in other data layers.

Adjusted features are portrayed according to the portrayal catalogue for the product named as the output product in the hybridization rule in the Interoperability Catalogue. If the output product is specified as “HYBRID”, the Hybrid Portrayal Catalogue must be used.

Changes to the location or extent of symbols displayed on the screen due to a feature in another dataset are possible in interoperability Level 4. These changes effectively augment the geometry and/or attributes of a conceptually different feature in another dataset (though the nominal value remains unchanged). For example, surface or sea-floor ice may effectively change the geometry of safety contours, by reducing the

extent of safe water or affecting depths and under keel clearance in ways that depend on vessel characteristics and icebreaker activity.

6.10 Blended portrayals

There is no level-specific guidance for this issue. Common guidance is provided in the “S-98 – Main” component of this specification.

6.11 Hierarchy of data

As noted in the Main component of this specification, hierarchy of data can be controlled by predefined combinations (Level 2 and higher). Level 1 catalogues offer only a very limited means of controlling hierarchy by means of display plane ordering. There is no level-specific guidance for portrayal in connection with this issue.

6.11.1 Interacting gridded information

There is no level-specific guidance for portrayal in connection with this issue.

6.12 Pick reports

[NOTE: The pick report functionality specification in S-98 is still under development, and the content of this section will change as this functionality is defined.]

In interoperability Level 4, hybrid features must be present in the pick report and marked as hybrid features.

7 Processing Model

Figure 7.1 below shows the processing steps and input to each step from parts of the Interoperability Catalogue, for the “Interoperability before portrayal” processing option. Figure 7.2 shows the processing steps and input to each step for the for the “Interoperability after portrayal” processing option. In each case, the flow depends on the interoperability level selected by the mariner.

As in Level 2 or 3 interoperability, data products to be loaded are selected as specified in the predefined combination selected by the mariner. The mariner may also select additional data products from the optional load set.

In Level 3 processing, operations for suppressing feature instances (Suppress Feature Instances) are added, as are operations for hybridization of thematic attributes (Combine Thematic Attributes). Additional processing to adjust feature and information associations for remaining features may be needed and this is done in the “Combine Associations” stage. The order of processing steps is **Suppress Feature Types ->Suppress Feature Instances ->Combine Thematic Attributes ->Interleave Feature Layers**. It is depicted in Figure 7.1.

In Level 4 processing, any additional processing needed to generate spatial primitives for the output hybridized feature is done in the Combine Spatial Attributes stage between suppression of feature instances and combination of thematic attributes. The processing flow is **Suppress Feature Types ->Suppress Feature Instances ->Combine Spatial Attributes ->Combine Thematic Attributes ->Interleave Feature Layers**. It is also depicted in Figure 7.2.

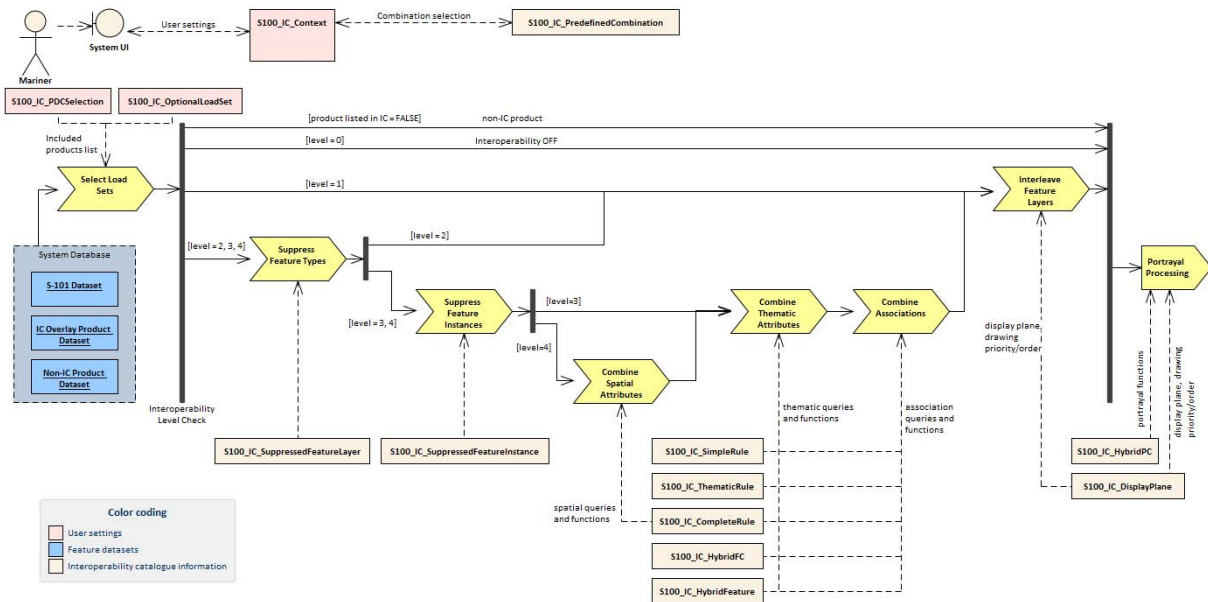


Figure 7-1 - - Processing for Level 4 interoperability (interoperability precedes portrayal)

The processing flow for the other implementation option (drawing instructions precede interoperability) is similar with an additional step (*Portrayal Processing*) moved to immediately follow loading of data.

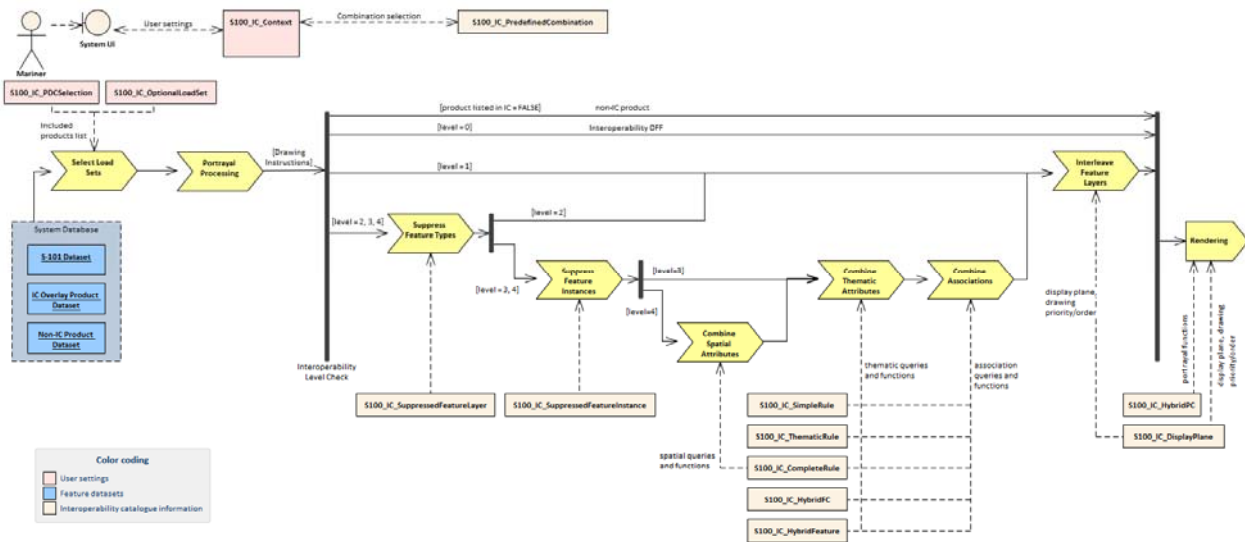


Figure 7-2 - Processing for Level 4 interoperability (portrayal processing precedes interoperability)

Table 7.2 - Stages in Level 4 interoperability processing

Stage	Description	Level	IC information	Context information	Remarks
Select Load Sets	Select data products to be loaded	All	Level 1: User adds data products to display individually Level 2: Included product list from S100_IC_PredefinedCombination.includedProduct Levels 3, 4: included product list from S100_IC_PredefinedCombination.includedProduct	Level 1: None Levels 2, 3, 4: User-selected predefined combination.	Information & functionality depends on user-selected level setting.
Portrayal Processing	Ordinary S-100 portrayal processing	All	Levels 1, 2: display planes Levels 3, 4: Hybrid PC, display planes		Except final display processing / rendering
Interleave Feature Layers	Assign display plane and drawing order to feature data	1, 2, 3, 4	S100_IC_DisplayPlane		
Suppress Feature Types	Suppress all instances of a specified feature type in a product	2,3,4	S100_IC_SuppressedFeatureLayer		
Suppress Feature Instances	Suppress selected instances of a specified feature type in a product	3,4	S100_IC_SuppressedFeatureInstance		Applies feature selector expressions encoded in primarySelector and secondarySelector attributes.
Combine Thematic Attributes	Select instances for hybridization and generate thematic attributes of a derived feature	3,4	S100_IC_SimpleRule, S100_IC_ThematicRule, S100_IC_CompleteRule, S100_IC_HybridFeature, S100_IC_HybridFC		Selection step skipped if preceded by Combine Spatial Attributes (L4 processing)
Combine Associations	Adjust associations	3, 4	S100_IC_SimpleRule, S100_IC_ThematicRule, S100_IC_CompleteRule, S100_IC_HybridFeature, S100_IC_HybridFC		

Stage	Description	Level	IC information	Context information	Remarks
Combine Spatial Attributes	Select instances for hybridization and generate spatial attributes of hybrid feature	4	S100_IC_CompleteRule		Complete rules incorporate thematic as well as spatial queries and functions.
Rendering	Display processing	All	S100_IC_DisplayPlane		

8 Normative Implementation Guidance

There is no level-specific normative implementation guidance in this edition of S-98. See the Main component of this Specification for implementation guidance that applies to all levels.

9 Feature Catalogue

Level 4 Interoperability Catalogues use a conditionally mandatory S-98 hybrid Feature Catalogue, which must be defined by Interoperability Catalogue developers if the Interoperability Catalogue contains hybridization rules which generate feature types which do not conform to the feature catalogue for one of the input data products.

10 Portrayal Catalogue

Level 4 Interoperability Catalogues use a conditionally mandatory S-98 hybrid Portrayal Catalogue, which must be defined by Interoperability Catalogue developers if the Interoperability catalogue contains hybridization rules which generate feature types which do not conform to the feature catalogue for one of the input data products.

S-98 - Annex A

(Informative)

OPERATIONAL CONTEXTS, SCENARIOS, AND USE CASES

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1 Introduction

This Annex contains descriptions of operational contexts, use scenarios, and use cases for S-98 interoperability.

Section 4 in this Annex outlines the broad types of operational contexts, limited for the present to shipboard activities. Section 5 describes which products are likely to be needed for broad categories of activities within different operational contexts. Section 6 “drills down” to operational tasks and describes which S-100 products are likely to be needed for different tasks. Section 7 describes selected hypothetical use cases in which interoperability is likely to play a role.

The contexts, activities, scenarios, and use cases in this Annex are illustrative and should not be regarded as definitive prescriptions for the implementation or use of S-98 Interoperability Catalogues in ECDIS, ECS, INS, or other systems.

2 References

IMO A.893(21) Guidelines for voyage planning, IMO resolution A893(21) (25 November 1999).

IMO MSC.232(82) Adoption of the revised performance standards for electronic chart display and information systems (ECDIS), IMO Resolution MSC.232(82), (5 December 2006).

ICS 2016 Bridge procedures guide, (5th edition), International Chamber of Shipping, London (2016).

3 Terms, definitions, and abbreviations

3.1 Use of language

The usages specified in S-98 1.3.1 (Use of language) apply to this Annex.

3.2 Terms and definitions

Alarm

A high-priority **alert**. Condition requiring immediate attention and action by the bridge team, to maintain the safe navigation of the ship.

Alert

Announcement of abnormal situations and conditions requiring attention. Alerts are divided in four priorities: **emergency alarms**, **alarms**, **warnings**, and **cautions**. An alert provides information about a defined state change in connection with information about how to announce this event in a defined way to the system and the operator.

Caution

Lowest priority of an **alert**. Awareness of a condition which does not warrant an **alarm** or **warning** condition, but still requires attention out of the ordinary consideration of the situation or of given information.

3.3 Abbreviations

OOW	Officer Of the Watch
AML	Additional Military Layer
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Charting System
FC	Feature Catalogue
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System
IHO	International Hydrographic Organization/Organisation Hydrographique Internationale
IMO	International Maritime Organization
INS	Integrated Navigation System
MSC	Maritime Safety Committee (IMO)

MSI	Marine Safety Information
PC	Portrayal Catalogue
PPU	Portable Pilot Unit
PS	S-100-based Product Specification
UKC	Under-keel Clearance
UKCM	Under-keel Clearance Management
VTS	Vessel Traffic Service

4 Operational contexts

In the e-navigation concept [ref.], two scopes are defined: the ship side and shore side services. The S-100 concept meets the need for a Common Maritime Data Structure (CMDs). The proposed approach only focuses on the ship side. In the literature (regulation, navigation guide, study on e-navigation), navigation is defined according to two functionalities: voyage planning and execution of voyage plan and others officer of watch (OOW) tasks, often summarized as “route monitoring”. The role of the future ECDIS on the bridge has to be defined regarding these two functionalities in accordance with IMO regulations. Identification of use cases on bridge is needed to answer which S-100 products are expected for ECDIS and for other bridge equipment. We are in the case of human navigation, but the approach is not in conflict with the emerging autonomous ship navigation.

According to the bridge procedures guide of the International Chamber of Shipping [ICS 2016], the four stages to achieve a safe passage plan are:



Figure UC-1 - Passage planning stages (from [ICS 2016])

These four steps can be summarized in two use cases: the voyage planning and the monitoring / execution of voyage planning, as defined in IMO regulations.

4.1 Voyage planning

This activity is usually performed in a relatively quiet area, on the back end of the bridge, on a chart table. It is done ahead of departure or can be conducted during long ocean passage. The officer of watch gathers the information needed for the voyage plan from berth to berth: it is various in formats, relevance and frequency of updating. He is normally available to spend a reasonable amount of time to understand information at his disposal to prepare his route: sorting, analysis, selection of a travel planning scenario. It may require reading literature, if the information is not directly understood; he has the possibility to read it again, to analyze and to do a cross-reference between different information. With S-100 products, most of the information becomes georeferenced-information. Cross-reference process is more efficient.

ECDIS in route planning mode is the regulated system for designing and checking the planned route. The OOW needs the following information:

Ocean routes:

- Climatological and oceanographic seasonal conditions, ocean currents, ice limits, load lines.
- Meteorological information.
- Services for weathers routeing.
- Environmental protection measures.
- Ship' routeing and reporting system, VTS.
- Navigational warnings.
- Volume of traffic likely to be encountered.
- Landfall conspicuous landmarks.
- MSI services and communications.
- Regulatory areas: Emission control areas.

Coastal routes:

- Charted features and other features for safe distance.
- Available depth of water including tidal water level information.
- UKC requirements and other limiting conditions.
- Currents, tidal currents.
- Landmarks and AtoNs, availability of visual and radar fixing opportunities.
- Recommended routes and channel information, local conditions and restrictions on navigation, traffic likely to be encountered.
- Navigational warnings.
- Pilotage requirements and services, procedures (a pilotage plan is required).
- Port requirements, port facilities, procedures for port entry.
- Reporting et communication procedures.
- Details of the prospective berth and anchorages.
- Meteorological information.
- Environmental protection measures.
- Ship' routeing and reporting system, VTS.
- MSI services and communications.

Berthing / pilotage

- Arrival intentions including embarkation time, arrangements for cargo discharge and bunkering.
- Communications should be established with Pilot, port VTS and port authorities as appropriate.
- Pilotage plan subject of Master/pilot information exchange (MPX).
- Updates on local conditions such as weather, depth of water, tides and tidal streams, traffic conditions.
- Information on berthing arrangements including the use, characteristics and number of tugs, mooring boats, mooring arrangements and other external facilities.

IMO A.893(21) contains guidelines for voyage planning.

4.2 Route monitoring

This task is performed at the front of bridge, as the OOW needs to have a control view of the environment, specially, when the ship is approaching harbor and entering coastal waters. The OOW normally executes the voyage planning previously defined. The voyage plan is normally stored and can be followed on an ECDIS (route monitoring mode) integrated in an INS (Integrated Navigation System). The need of synthetic, unambiguous and clear information is essential, as its decision-making needs to be rapid in the face of any events that may occur (anti-collision, anti-grounding). It is necessary to reduce the number of manipulations to be carried out on the system (ECDIS) and reduce its mental workload as much as possible.

A part of the monitoring can be done with the help of the ECDIS, including monitoring of the following:

- The ship's current position and proximity of dangers to navigation.
- The intended track (passage plan), course and speed, cross-track deviation.
- The traffic situation and the traffic density to be encountered.
- The vessel reporting requirements, completed or due.
- The environmental requirements.
- Weather conditions to be encountered including sea state and visibility.
- Navigational hazards uncharted which may be encountered.

The OOW should:

- Follow the passage plan and monitor the progress of the ship.
- Make a full appraisal of the risk of collision with other vessels.
- Identify navigational hazards such as wrecks, floating objects, ice and uncharted hazards.
- Determine the risk of grounding or stranding (UKC).
- Detect and respond as appropriate to any significant change in the weather, visibility or sea state.
- Identify navigational marks.
- Perform position fixing of the ship by all appropriate means.
- Take action to avoid collision.
- Amend the passage plan -
 - Permanently (the passage planning phase is repeated). Examples of causes are weather routing developments, change of destination, or search and rescue response.
 - For a deviation from the current plan. Examples of causes are COLREG issues, variations of weather conditions, advice received from VTS, navigational warnings, detected hazards.
- Monitor GMDSS watchkeeping (radio, emergency, MSI, routine and general communications).

5 Product collections for operational contexts

Since different operating contexts e.g., passage planning, route monitoring, etc., will involve loading different collections of data products, and since they are likely to be more or less the same for the same class of end-user, it may be useful to specify pre-defined collections or "base collections" of products which can be loaded by the user under specific conditions or for specific tasks. An ECDIS would allow the user to select from a list of pre-defined product combinations instead of loading and unloading individual data products. SOLAS V or other external requirements should be taken into consideration.

It is envisaged that the ECDIS will allow end-users to adapt the collections or customize them by changing the load sets, selecting portrayals, changing context parameters and user settings, etc.

Customized collections can be saved – thereby allowing operators, masters, and bridge officers to add to the library of pre-defined collections available on the ECDIS. Either initial or customized collections can be reloaded at a later time. Users can also load additional data products, real-time information (e.g., radar, AIS) or unload one or more of the default products after a pre-defined collection is loaded.

The classifications and loading in Table UC-1 are intended for illustrating interoperability use cases and not a prescription for ECDIS or requirements of performance standards.

N: not loaded

Y: Loaded

O: Optional (loaded or unloaded at user option)

C: Customized subset of features, e.g. a subset selected by feature type, attribute value, or creation time

“Other products” are products that are not covered by S-98 (see Table 1-1 in “S-98 – Main”).

Table UC-1 - Operational contexts and data products

Collection Purpose	Product						Remarks
	S-101 ENC	S-102 Bathymetric Surface	S-111 Surface Currents	S-104 Water Level Information	S-129 Underkeel Clearance Management	Other products: S-411 (Sea Ice); S-412 (Weather and wave hazards); S-413 (Weather and wave conditions); S-124 (Navigational warnings)	
Voyage and route planning							
Voyage planning	Y	N	N	N	Y	S-411 (O) S-412 (C) S-413 (C) S-124 (Y)	The voyage plan defines the start and end of the voyage and the intended transit time considering the ship's parameters. S-411, S-412, S-413, S-124 areas may be bypassed depending on their status and active time.
Route planning, ocean or offshore voyage	Y	N	Y	N	Y	S-411 (O) S-412 (C) S-413 (C) S-124 (Y)	Depth and current data may affect time of harbour entry. S-412, S-413 as relevant to track.
Route planning, coastal voyage	Y	Y	Y	O	Y	S-411 (C) S-412 (C) S-413 (C) S-124 (C)	S-411, S-412, S-413, S-124 – as relevant to vessel track.
Route monitoring							
Route monitoring, ocean	Y	N	O	N	N	radar, ARPA, AIS S-411 (Y) S-412 (Y) S-413 (Y) S-124 (C)	S-124 – as relevant to track

Route monitoring, coastal	Y	N	Y	N	Y	radar, ARPA, AIS S-411 (Y) S-412 (Y) S-413 (Y) S-124 (C)	S-124 – as relevant to track
Route monitoring, congested waterways (e.g. TSS)	Y	N	Y	N	N	radar, ARPA, AIS S-411 (Y) S-412 (O) S-413 (O) S-124 (Y)	
Route monitoring shallow waterways	Y	Y	Y	Y	Y	radar, ARPA, AIS, UKCM S-412 (C) S-413 (C) S-124 (Y)	S-412, S-413 – as relevant to track
Route monitoring, port approach/departure (Piloting)	Y	Y	Y	Y	Y	radar, ARPA, AIS S-411 (O) S-412 (C) S-413 (C) S-124 (Y)	S-412, S-413 – as relevant to track Also on PPU
Other operations							
Berthing	Y	Y	N	Y	N	specialized products	Assumes S-129 datasets are not available within harbours. Also on mobile or special display or specialized apps.
Harbour movement	Y	Y	Y	Y	N	specialized products	Assumes S-129 datasets are not available within harbours. Also PPU
Transit of bridge	Y	Y	C	C	O	S-124 (C); specialized products	Also on mobile or other display, or specialized apps.

6 Operational activities and products

This section summarizes shipboard activities and the data products likely to be needed for each.

At present this section addresses only activities in the route monitoring context.

6.1 Route monitoring activities

Table UC-2 summarizes the tasks related to route monitoring activity, the information needed by the OOW, and the related S-100 products.

Table UC-2 - Route monitoring activities and products

Activities of OOW for route monitoring	Information	S-100 products
Follow the passage plan and monitor the progress of the Ship	Route, GNSS, chart, voyage plan	S-101
Make a full appraisal of the risk of collision with other vessels	GNSS, AIS, radar	(none)
Identify navigational hazards such as wrecks, floating objects, ice and uncharted hazards;	Chart, navigational warning, sea ice observations	S-101 S-124 S-411
Determine the risk of grounding or stranding (UKC);	Chart, high density bathymetry, UKC, voyage plan	S-101 S-102 S-104 S-129
Detect and respond as appropriate to any significant change in the weather, visibility or sea state	Weather forecasts	S-412
Identify navigational marks	Chart, voyage plan	S-101
Position fixing of the ship by all appropriate means	Chart, radar	S-101
Take action to avoid collision	GNSS, chart, voyage plan	S-101
Amend the passage plan permanently (the passage planning phase is repeated) - Causes : weather routing developments, change of destination, SAR response deviation, COLREG, variations of weather conditions, advice received from VTS, NWs, detected hazards.	Chart, SAR information, weather forecast, nav. warnings, VTS information	S-101 S-111, S-104, S-124, S-411, S-412, S-413
GMDSS watchkeeping (radio, emergency, MSI, routine and general comm)	Chart, voyage plan	S-101

7 Use cases

7.1 Bathymetry replaces soundings

Goal: Given an overlay certified as a suitable replacement, replace the corresponding ENC features with features from the overlay.

Actors: OOW; ECDIS

Description: S-102 (Bathymetry surface) gridded data is displayed over an ENC. The S-102 data is certified as allowable replacement for appropriate ENC features. Depth areas, dredged areas and soundings with multi-point geometry are replaced with bathy surface features. Depth contours are re-computed based on S-102. Alerts trigger when the safety contour is crossed. Contours are computed on gridded data using an algorithm to be determined by the S-102 group.

7.2 Suppression of parts of underlying ENC data

Goal: ENC data is hidden when data intended to suppress ENC data is loaded

Actors: OOW; ECDIS

S-111, S-411 and S-412 will have similar operations where parts of the underlying ENC data may be suppressed while the product is on the screen.

S-111 is coverage data while S-411 and S-412 are vector data so this has 2 variant sub-cases (described below). The actors are as mentioned above for both.

7.2.1 Sub-case: Suppression of ENC information with coverage data - S-101 and S-111

Description: S-111 (Surface Currents) coverage features suppress any S-101 current features (“Current – non-gravitational”, “Tidal stream – flood/ebb”). S-101 WaterTurbulence features are retained since they are not covered by S-111.

7.2.2 Sub-case: Suppression of ENC data with vector data - S-101 and S-411 and S-412

Description: Ice area features from S-411 (Sea Ice) suppress any overlapping S-101 IceArea features. S-412 (Weather and Wave Hazards) has IceEdge and LimitOfKnownIce features – they can suppress S-411 ice features via rule-based interoperability operations depending on factors such as which data is more recent.

7.3 Bridge with air gap and wind information

Goal: The navigator can filter out information by user-defined areas, time, and thematic attributes.

Actors: OOW (or barge skipper, or river pilot); ECDIS

Description: Bridge with wind and air gap broadcasting, navigator reviews data two hours before crossing and makes the go/no-go decision. In the “go” scenario, the navigator might have the air gap data until the bridge is 5min away and remove the information but keep the wind information visible for the whole bridge crossing. This scenario implies the ability to show partial information in a very specific area for any length the navigator deems necessary.

If hypothetically S-412 has both wind and water level information in the same feature type. So “partial information” would mean writing an interoperability catalogue rule for filtering down to the attribute level, by space, and time

7.4 Passage / route planning

Goal: The system can be configured to display different types of information needed to plan the route for a voyage

Actors: Passage planner (OOW, navigation officer, mate, planner in shipping company office); ECDIS.

Description: ENC, UKCM, navigational warnings, and bathymetric surface data are used in a back-of-bridge scenario to plan the route for a voyage. The planner may turn on or off different viewing groups or sets of features from different data products so as to provide information about particular aspects of the planning problem without adding clutter by including irrelevant feature types or attributes.

7.5 Route monitoring

Goal: The system can be configured to display different types of information needed to monitor the vessel's route.

Actors: OOW; ECDIS

Description: This is the classic “ECDIS” situation. During route monitoring in different circumstances, what are the combinations of information the bridge officers want to see on the ECDIS? All the datasets? Subsets of feature types from some datasets? Sub-cases are defined in the subsections below. (Actors for the sub-cases are mentioned where they may be different from the base case.)

7.5.1 Sub-case: Ocean passage

Products needed on the display are S-101, S-111 (if available for ocean currents), S-124 for NAVAREA warnings, S-411 (if available, for icebergs); S-412 and S-413 for weather and waves.

7.5.2 Sub-case: Coastal route monitoring

Products needed on the display are S-101, S-102 (depths and safety contour – the latter computed from data), S-111 (currents), S-124 (warnings about nav aids, hazardous conditions, etc. – coastal warnings), S-411 (ice), S-412 and S-413 (weather and wave hazards and conditions)

7.5.3 Sub-case: Navigation in harbour approaches

Products needed are S-101, S-102 (depths and safety contour), S-111 (currents), S-124 (local warnings), S-411 (ice), S-412 and S-413 (weather and wave hazards and conditions)

7.6 Entering or departing harbour

Actors: OOW; pilot; tug operator; ECDIS; PPU

Products needed are S-101 for harbour and berth information, S-104 for water levels, S-102 for bathymetry, S-129 for underkeel clearance – all only if sufficiently large scale data (or scale-independent data) is available and only in a relatively small area.

7.7 Operations within harbours

Actors: OOW; harbour pilot; tug operator; harbourmaster's office; ECDIS

Products needed are S-101, S-102, S-111, S-104, S-124, other data products specific to the harbour, such as a terminal map. Will probably have additional information too, specific to the berth and other inputs e.g., sensors for distance measurements. In fact, berthing might not use an ECDIS at all (see section 7.10).

7.8 Operations in narrow channels

Actors: OOW; pilot or river pilot; ECDIS

Products needed are S-101, S-102, S-104, other data products specific to the channel.

7.9 Operations in congested waters

Actors: OOW; deep sea pilot; VTS controller; ECDIS; VTS display

Products needed on the display are S-101, S-102, S-104, other data products specific to the waterway if any.

7.10 Berthing

Actors: OOW; pilot; terminal operator; tug operator; ECDIS; PPU; or custom application

A large vessel approaching a berth, possibly assisted by tugs and S-101 for harbour and berth information, S-104 for water levels, S-102 for bathymetry – all only if sufficiently large scale data is available and only in a relatively small area. Will probably have additional information too, specific to the berth and other inputs e.g., sensors for distance measurements. In fact, berthing might not use an ECDIS at all, but other specialized equipment that uses only a subset of S-101 information (possibly in a specialized berthing chart) plus water level and depth data plus specialized sensors and may be partially guided from shore.