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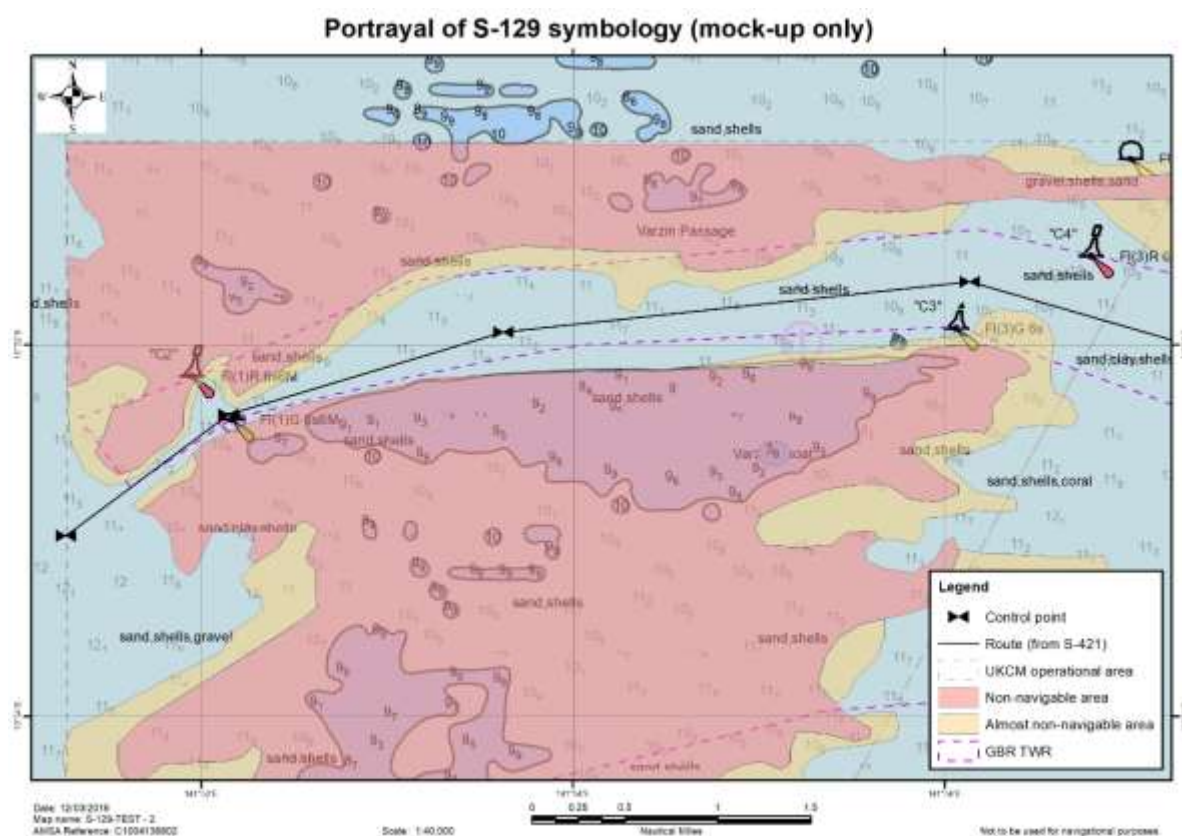
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1 Overview

1.1 Introduction

IHO's S-100 Working Group has prepared this document in response to a requirement to produce a dataset comprising Under Keel Clearance Management (UKCM) information that can be used as a Nautical Publication Information Overlay (NPIO) within an Electronic Chart Display and Information System (ECDIS). It is based on the IHO S-100 framework specification and the ISO 19100 series of standards.

S-129 is a vector Product Specification intended for encoding the extent and nature of UKCM information products for navigational purposes. Use of UKCM products conformant to this specification is not limited to navigation systems.



A Ship's master has an obligation under SOLAS regulation V/34 to plan their ship's passage from berth to berth. This Product Specification enables UKCM information to be provided to users of a UKCM service.

1.2 Initial voyage planning to navigate through a UKC operational area

A ship planning its voyage needs to determine the time periods when there are suitable tidal conditions for it to transit a UKCM operational area. A UKCM service provider completes calculations based on a range of possible arrival times to determine a pre-plan, which contains one or more time windows for a specified draught that a ship's master can choose from.

1.3 Refined voyage planning to navigate through a UKC operational area

A ship's master selects a time window to transit through a UKCM operational area and advises the UKCM service provider. A ship also sends the UKCM service provider updated information about its

particulars (for example stability and draught information). The UKCM service provider uses specialized ship and waterway specific modelling that includes predicted and observed environmental conditions (for example tide, wind, swell, tidal stream, etc.) to generate an actual plan for a ship.

An actual plan contains a route for the ship to take through the UKCM operational area and one or more control points. Control points are in effect waypoints and include time window information. An actual plan provides the ship with the necessary navigation information to safely pass through the UKCM operational area at a given time.

To facilitate logistics planning the actual plan can be shared with other parties, such as the ship's owners, management company, charterers, or the ship's agent at the relevant port. The ship's agent may contact relevant waterway authorities to make the necessary bookings, such as for a pilot or for a berth.

As the ship nears the UKCM operational area, the UKCM service provider checks the prevailing environmental conditions within the UKCM operational area and confirms the validity of the actual plan. The actual plan may alter due to changes in predicted weather forecasts, heights of tide, or the ship's particulars. The actual plan might be cancelled through replacement using an actual update when changes are required. This checking process allows the ship to manage its speed to meet the required time window to execute the actual plan.

The actual plan update contains details of the earliest and latest times at which the ship can safely commence navigating shallow areas in the UKCM operational area while maintaining the required UKC (note that waterway authorities specify a minimum UKC requirement for ships operating within a UKCM operational area). The actual plan update also includes any relevant non-navigable areas and almost non-navigable areas.

1.4 Voyage monitoring

When the ship embarks its pilot (if applicable) and enters the UKCM operational area, the actual update is able to be displayed on the ship's navigation system.

The pilot (if applicable) will generally be using a Portable Pilot Unit (PPU) that also shows the ship's UKC plan, including non-navigable and almost non-navigable areas which are also provided by the UKCM service provider. This same information displayed on a ship's navigation system helps a ship's crew support a pilot to navigate the ship through a UKCM operational area while maintaining at least the required UKC.

The UKCM service provider receives transmitted ship AIS data which allows them to send actual update datasets that contain updated non-navigable and almost non-navigable areas and, if necessary, new versions of the route and control points, based on the ship's speed and the current weather, tide and other met-ocean conditions.

The ship's crew and the pilot (if applicable) are able to monitor, in real-time or near real-time, areas that have been calculated as non-navigable and almost non-navigable on their on board navigation systems. The areas shown as almost non-navigable indicate to the ship's bridge team and the pilot (if applicable) the navigable areas that are close to becoming non-navigable at the time the ship would reach those locations.

If a Vessel Traffic Service (VTS) exists, it is able to monitor the ship's transit and support navigation in accordance with the actual plan and/or actual update.

After the ship has completed its cargo operations, and if the ship's draught is such that the local area UKCM system must be used to exit the port, then the UKCM service provider would similarly be used to assist the ship's safe departure from the port through the UKCM operational area.

2 References

2.1 Normative

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document.

IHO S-100	IHO Universal Hydrographic Data Model, Edition 4.0.0 – December 2018
IHO S-101	IHO Electronic Navigational Chart (ENC), Edition 1.0.0 – December 2018
IHO S-102	IHO Bathymetric Surface Product Specification, Edition 1.0.0 – April 2012
IHO S-104	IHO Water Level Information for Surface Navigation, Edition 0.0.6 – December 2018
IHO S-421	IEC Route Plan Exchange Format, Edition and date TBC
IHO S-52	IHO Specifications for Chart Content and Display Aspects of ECDIS, Edition 6.1.1 – October 2014 (with clarifications up to June 2015)
ISO 10646:2017	Information technology – Universal Coded Character Set (UCS) +Amd1 (2017) and Amd2 (2017)
ISO/IEC 15948	Information technology – Computer graphics and image processing – Portable Network Graphics (PNG): Functional specification
ISO 19101:2014	Geographic information – Reference model
ISO 19103:2015	Geographic information – Conceptual schema
ISO 19107:2003	Geographic information – Spatial schema
ISO 19108:2002	Geographic information – Temporal schema +Corr1 (2006)
ISO 19109:2005	Geographic information – Rules for application schema
ISO 19110:2016	Geographic information – Methodology for feature cataloguing
ISO 19111:2003	Geographic information – Spatial referencing by coordinates +Corr1 (2006)
ISO 19115-1:2014	Geographic information – Metadata Part 1: Fundamentals +Amd1 (2018)
ISO 19117:2012	Geographic information – Portrayal
ISO 19125-1:2004	Geographic information – Simple feature access – Part 1: Common Architecture
ISO 19136:2007	Geographic information – Geography Markup Language (GML)
ISO 19136-2:2015	Geographic information – Geography Markup Language (GML)
ISO/IEC 8211:1994	Information technology – Specification for a data descriptive file for information exchange

ISO 8601-1:2019	Date and time – Representation for information interchange – Part 1: Basic rules
ISO 8601-2:2019	Date and time – Representation for information interchange – Part 2: Extensions
ISO 639-2:1998	Codes for the representation of names of languages – Part 2: Alpha-3 code

3 Terms, Definitions and Abbreviations

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.

3.2 Terms and Definitions

The S-100 framework is based on the ISO 19100 series of geographic standards. The terms and definitions provided here are used to standardize the nomenclature found within that framework, whenever possible. They are taken from the references cited in Clause 2.1. Modifications have been made where necessary.

Actual Plan

An actual plan is specific to a ship and a UKCM operational area for a waterway, and contains a route defined by a set of geographical control points with time windows for each control point, and non-navigable and almost non-navigable areas.

Actual Update

An actual update is a replacement actual plan.

Almost non-navigable area

An area within a UKCM operational area where UKC for a specific ship is calculated to be approaching the UKC limit for the waterway (within a specified value range).

Control Point

A geographical position denoting a point along a specific ship’s route within a UKCM operational area where the ship must pass within a time range or time window (that is, start and end time) calculated by the UKCM service provider.

Coordinate

One of a sequence of n numbers designating the position of a point in n-dimensional space.

NOTE: In a coordinate reference system, the coordinate numbers are qualified by units.

Coordinate Reference System

Coordinate system that is related to an object by a datum.

NOTE: For geodetic and vertical datums, the object will be the Earth.

Feature

Abstraction of real-world phenomena.

NOTE 1: A feature may occur as a type or an instance. Feature type or feature instance must be used when only one is meant.

NOTE 2: In UML 2, a feature is a property, such as an operation or attribute, which is encapsulated as part of a list within a classifier, such as an interface, class, or data type.

[ISO 19101, ISO/TS 19103, ISO 19110]

Feature Attribute

Characteristic of a feature.

NOTE 1: A feature attribute may occur as a type or an instance. Feature attribute type or feature attribute instance is used when only one is meant.

NOTE 2: A feature attribute type has a name, a data type, and a domain associated to it. A feature attribute instance has an attribute value taken from the domain of the feature attribute type.

NOTE 3: In a feature catalogue, a feature attribute may include a value domain but does not specify attribute values for feature instances.

EXAMPLE 1: A feature attribute named *colour* may have an attribute value *green* which belongs to the data type *text*.

EXAMPLE 2: A feature attribute named *length* may have an attribute value *82.4* which belongs to the data type *real*.

Navigation Surface

A data object representing the bathymetry and associated uncertainty with the methods by which those objects can be manipulated, combined and used for a number of tasks, certified for safety of navigation.

Non-navigable Area

An area within a UKCM operational area where UKC for a specific ship is calculated to be less than the UKC limit for the waterway.

Pre-plan

A pre-plan is a set of tidal windows available for a ship to transit through a UKCM operational area at a specified draught.

Sea Surface

A two-dimensional (in the horizontal plane) field representing the air-sea interface, with high-frequency fluctuations such as wind waves and swell, but not astronomical tides, filtered out.

NOTE: This implies marine water, lakes, waterways, navigable rivers, etc.

EXAMPLE: sea surface, river surface, lake surface.

UKC Plan

There are three kinds of UKC plans: a pre plan, an actual plan and an actual plan update.

UKCM Operational Area

The geographic area in which a UKCM service is in operation and for which UKCM information can be provided.

UKCM Service

An aid to navigation which contributes to navigational safety and efficiency. It uses data modelling which may include detailed bathymetry, predicted and real-time environmental data and ship particulars and motion, to provide a ship-specific, real-time and/or forecast information for a given time and waterway.

3.3 Abbreviations

This Product Specification makes use of the following abbreviations:

AIS	Automatic Identification System
BAG	Bathymetric Attributed Grid
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigational Chart
GML	Geography Markup Language
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
ISO	International Organization for Standardization
UKC	Under Keel Clearance
UKCM	Under Keel Clearance Management
UML	Unified Modelling Language
UTC	Coordinated Universal Time

4 Specification Description

4.1 S-129 General Data Product Description

This clause contains general information regarding the data product.

Title:	UKCM Information Product Specification
Abstract:	UKCM services are generally used in conjunction with ENC (S-101) and routes (S-421) for aiding ships in safe passage through shallow waters. This S-129 UKCM Product Specification details the information typically provided by a UKCM service provider.
Content:	A conformant data product contains features associated with UKCM. The specific content is defined by the Feature Catalogue and the Application Schema.
Spatial Extent:	Description: Global coverage of maritime areas.
Purpose:	The data shall be produced for the purposes of UKCM.

4.2 Data Product Specification Metadata

NOTE This information uniquely identifies this Product Specification and provides information about its creation and maintenance. For further information on dataset metadata, see the metadata clause.

Title:	The International Hydrographic Organization Under Keel Clearance Management Information Product Specification
S-100 Version:	4.0.0
S-129 Version:	1.0.0
Date:	Xxxx 2019
Language:	English
Classification:	Unclassified
Contact:	International Hydrographic Organization, 4b quai Antoine 1er, B.P. 445 MC 98011 MONACO CEDEX Telephone: +377 93 10 81 00 Telefax: +377 93 10 81 40 Email: info@iho.int
URL:	www.iho.int
Identifier:	S-129
Maintenance:	Changes to the Product Specification S-129 are coordinated by the IHO S-100 Working Group (S-100WG), and must be made available via the IHO web site. Maintenance of the Product Specification must conform to IHO Technical Resolution 2/2007, as amended.

4.3 IHO Product Specification Maintenance

4.3.1 Introduction

Changes to S-129 will be released by the IHO as a New Edition, a revision, or as a document that includes clarification. These are described below.

4.3.2 New Editions

New Editions introduce significant changes. *New Editions* enable new concepts, such as the ability to support new functions or applications, 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 S-129. All cumulative *revisions* and *clarifications* must be included with the release of approved New Editions.

4.3.3 Revisions

Revisions are defined as substantive semantic changes. Typically, *revisions* will introduce changes 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 this specification. All cumulative *clarifications* must be included with the release of approved corrections 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 features and attributes. Within the same Edition, a dataset of one version could always be processed with a later version of the feature and portrayal catalogues.

In most cases, a new feature or portrayal catalogue will result in a revision of this specification.

4.3.4 Clarifications

Clarifications are non-substantive changes. 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 changes.

Changes in a clarification are minor and ensure backward compatibility with the previous versions within the same Edition. Within the same Edition, a dataset of one clarification version could always be processed with a later version of the feature and portrayal catalogues, and a portrayal catalogue can always rely on earlier versions of the feature catalogues.

4.3.5 Version Numbers

The associated version control numbering to identify changes (n) to S-129 must be as follows:

New Editions denoted as **n.0.0**

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

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

5 Specification Scope

This Product Specification describes one product and therefore requires only one scope.

Scope ID:	Under Keel Clearance Management datasets
Hierarchical level:	MD_ScopeCode – 005
Hierarchical level name:	Dataset
Level description:	Information applies to the datasets
Extent:	EX_Extent.description: Global coverage of maritime areas

6 Dataset Identification

This section describes how to identify datasets that conform to this Product Specification. An under keel clearance dataset that conforms to this Product Specification uses the following general information for distinction:

Title:	Under Keel Clearance Management
Abstract:	The dataset is a file containing under keel clearance data for a particular geographic region and set of times, along with the accompanying metadata describing the content, variables, applicable times and locations, and structure of the dataset. Under keel clearance management data includes depths assessed as being navigationally safe and windows within which these assessments are valid, based upon observed or mathematically-predicted values.
Acronym:	UKCM
Geographic Description:	EX_GeographicDescription: For example, official name of region

Spatial Resolution:	MD_Resolution>equivalentScale.denominator (integer) or MD_Resolution>levelOfDetail (CharacterString). For example “All scales”
Purpose:	Under keel clearance management data is intended to be used as a layer in an ENC
Language:	EN Additional values, if any, use CharacterString values from ISO 639-2
Classification:	Unclassified Additional values, if any, use CharacterString values from ISO 639-2
Point of Contact:	CI_Responsibility
Use Limitation:	Invalid over land

7 Data Content and Structure

7.1 Introduction

This section discusses:

- the application schema expressed in UML 2,0, shown in *Figure 7-2. S-129 Data Model*;
- the associated feature catalogue (included in Annex C);
- the dataset types, providing a full description of each feature type including its attributes, attribute values and relationships in the dataset;
- dataset loading and unloading; and
- the geometry.

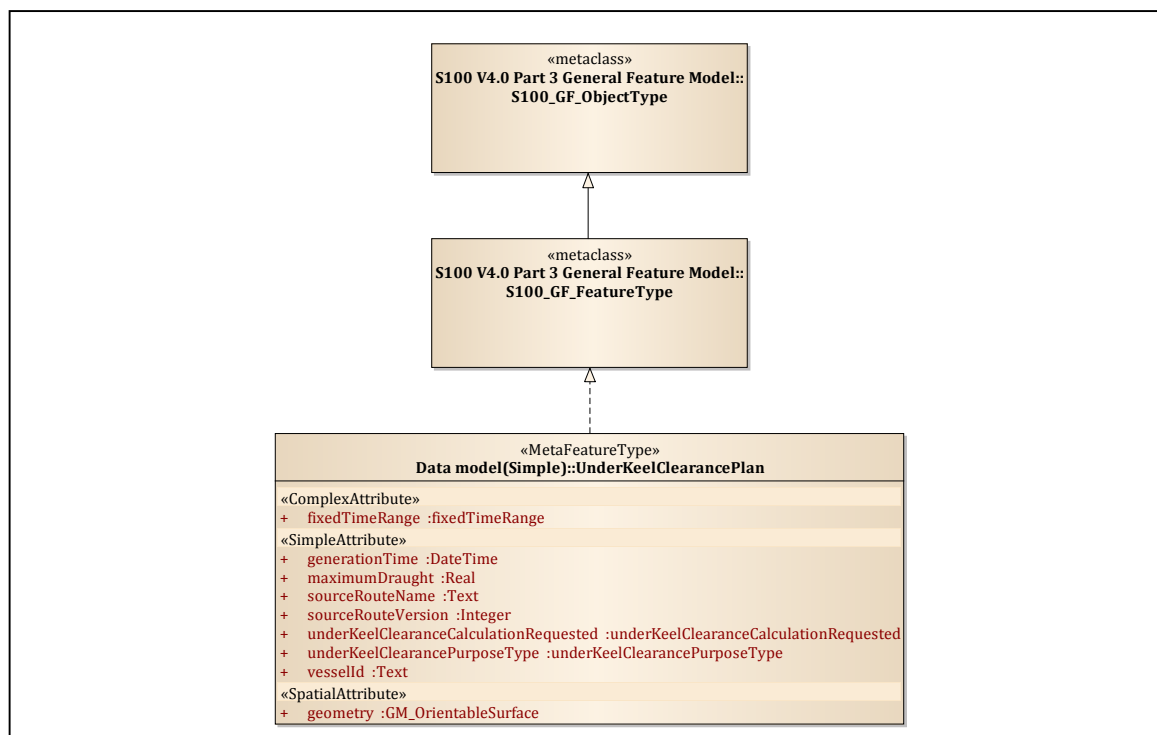


Figure 7-1 – Relationship between S-100 meta class and S-129 application schema

The S-129 features are based on the S-100 General Feature Model (GFM), and are a feature-based vector product. Figure 7-1 shows the relations between the S-129 Application Schema and the S-100 GFM.

All S-129 features are derived from the meta feature **UnderKeelClearancePlan** defined in the S-129 Application Schema and this **UnderKeelClearancePlan** realizes the GFM meta-classes **S100_GF_FeatureType**.

S-129 datasets are generally intended to be used with ENC, and optionally with S-102 bathymetric surface datasets. S-101 provides the background information, while S-129 datasets provide additional information related specifically to UKCM.

Dataset content will change over time during a ship's transit. Updating datasets is achieved by replacement. The attribute `ukcPurpose` captures the intended purpose of a dataset. The possible values are 'pre-plan', 'actual plan' and 'actual plan update'.

7.1.1 Dataset purposes

7.1.1.1 Pre-plan datasets

Pre-plan datasets are used in voyage pre-planning and will produce for a ship a set of tidal windows for an arrival port or waterway, for a specified draught, days or weeks in advance. In this case, it is likely that the UKCM service will simply compute tidal windows based on water level and current forecast models, other weather statistics and a standard assumed route.

7.1.1.2 Actual plan datasets

Actual plan datasets are produced closer to the arrival/departure (approx. 24 hours prior), and provide the mariner (crew and/or pilot) with a more detailed passage plan. This plan is generated from more frequent and/or precise weather forecasts/observations.

7.1.1.3 Actual plan update datasets

Actual plan update datasets include more up-to-date information and may be required every five to ten minutes. These datasets include the route, the almost non-navigable and non-navigable areas and the 'parent' UnderKeelClearancePlan feature. The dataset will be updated based on the latest weather conditions and (optionally) actual ship position, heading and speed (for example as received by a UKCM service provider via a ship's transmitted AIS signal).

7.1.2 Dataset use cases

UKCM datasets are updated by whole dataset replacement. Which data needs to be updated, and how frequently, depends on the purpose of UKC calculation (as indicated by the 'ukcPurpose' attribute). The following is a typical updating scenario, but variations may exist depending on local circumstances.

In the pre-planning use case, a ship requests a set of tidal windows for an arrival port or waterway, for a specified draught, days or weeks in advance. In this case, the UKCM service may compute a tidal window based on predicted tides, forecast navigable depths, including safety/manoeuvrability margins, ship maximum draught, speed and squat predictions, other forecast environmental conditions and a standard assumed route. In this scenario, the UKCM service could return a single dataset and generally no updates are required until approximately 24 hrs before the time when the ship enters the UKCM area.

Approximately 24 hrs before the time when a ship enters the UKCM area, the ship will need a more detailed UKC plan. This plan usually considers more up to date information and will typically need to be updated more frequently. In this case, the non-navigable and almost non-navigable areas, any tidal windows (via Control Points), and some metadata will have changed. Depending on the variability of the met-ocean conditions, the update frequency could vary between 10 and 60 minutes.

Immediately before entering the UKCM area and whilst underway, the use case changes again to become the actual plan and more up-to-date information is required, approximately every five to ten minutes. In this case, it is likely that the whole information in the dataset needs to be updated – including the route, the navigable and non-navigable areas and the 'parent' UnderKeelClearancePlan feature. The dataset will be updated based on latest observed and forecast conditions, and (optionally) actual ship position, heading and speed (for example as received in a UKCM service via AIS).

7.2 Application Schema

Figure 7-2 is the UML data model for the S-129.

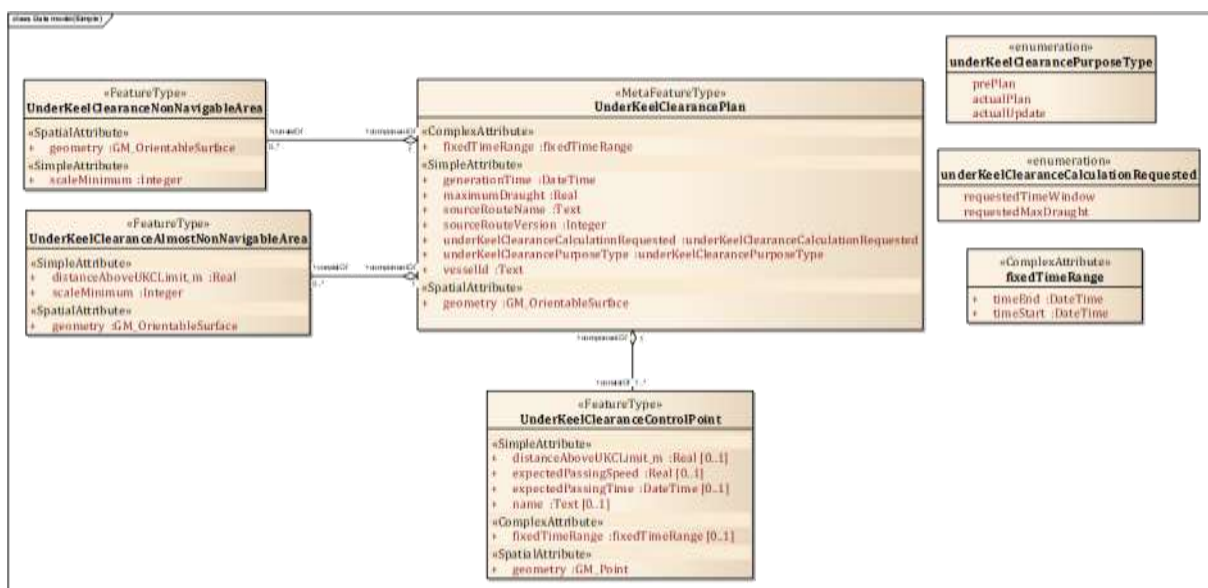


Figure 7-2. S-129 Data Model

7.2.1 Feature Types

7.2.1.1 UnderKeelClearancePlan

Role	Name	Description	Mult	dataType	Remarks
Class	UnderKeelClearancePlan	A UKC plan calculated for a particular ship and a particular passage		MetaFeatureType	
SimpleAttribute	generationTime	Time the plan was generated	[1]	DateTime	
SimpleAttribute	shipID	Unique identification of the ship used for the calculation	[1]	Text	
SimpleAttribute	sourceRouteName	Identification of the route used as a source for the calculation	[1]	Text	Using the value of S-421.Route.routeInfoName
SimpleAttribute	sourceRouteVersion	Identification of the route used as a source for the calculation	[1]	Integer	Using the value of S-421.RouteHistory.routeHistoryEditionNo
SimpleAttribute	maximumDraught	The maximum ship draught in meters, used as base for the calculation	[1]	Real	
SimpleAttribute	ukcPurpose	The purpose of the current calculation	[1]	underKeelClearancePurposeType	
SimpleAttribute	typeOfCalculation	The type of calculation	[1]	underKeelClearanceCalculationType	
SpatialAttribute	geometry	Boundaries of the Under Keel Clearance management area	[1]	GM_OrientableSurface	geometric object comes from Geometry class in S-100 standard
ComplexAttribute	fixedTimeRange	Time period	[1]	fixedTimeRange	

7.2.1.2 UnderKeelClearanceNonNavigableArea

Role	Name	Description	Mult	dataType	Remarks
Class	UnderKeelClearanceNonNavigableArea	An area of depth less than the calculated safe limit		FeatureType	The area has a time-dependent dimension
SimpleAttribute	scaleMinimum	Integer	[1]	Integer	
SpatialAttribute	geometry	Geometric object come from Geometry	[1]	GM_OrientableSurface	To be used to describe the UKCM service area

Role	Name	Description	Mult	dataType	Remarks
		class in S-100 standard			

7.2.1.3 UnderKeelClearanceAlmostNonNavigableArea

Role	Name	Description	Mult	dataType	Remarks
Class	UnderKeelClearanceAlmostNonNavigableArea	An area of depth less than the calculated safe limit		FeatureType	The area has a time-dependent dimension
SimpleAttribute	distanceAboveUKCLimit_m		[1]	Real	
SimpleAttribute	scaleMinimum	Integer	[1]	Integer	
SpatialAttribute	geometry	Geometric object come from Geometry class in S-100 standard	[1]	GM_OrientableSurface	To be used to describe the UKCM service area

7.2.1.4 UnderKeelClearanceControlPoint

Role	Name	Description	Mult	Data Type	Remarks
Class	UnderKeelClearanceControlPoint	Especially selected critical passage point or line		FeatureType	
SimpleAttribute	distanceAboveUKCLimit_m		[0..1]		
SimpleAttribute	name	string	[0..1]	Text	
SimpleAttribute	expectedPassingSpeed	float	[0..1]	Real	
SimpleAttribute	expectedPassingTime	dateTime	[0..1]	DateTime	
ComplexAttribute	fixedTimeRange		[0..1]	fixedTimeRange	

7.2.2 Feature Relationship

	Source	Mult	Target	Mult	Roles
Aggregation	UnderKeelClearanceNonNavigableArea	[1]	UnderKeelClearancePlan	[1..*]	Source role – consistOf Target role – componentOf
Aggregation	UnderKeelClearanceAlmostNonNavigableArea	[1]	UnderKeelClearancePlan	[0..*]	Source role – consistOf Target role – componentOf

	Source	Mult	Target	Mult	Roles
Aggregation	UnderKeelClearanceControlPoint	[1]	UnderKeelClearancePlan	[1..*]	Source role – consistOf Target role – componentOf

7.2.3 Complex Attribute

7.2.3.1 FixedTimeRange

Role	Name	Description	Multiplicity	Data Type	Remarks
ComplexAttribute	fixedTimeRange				
Attribute	TimeStart	dateTime	[1]	DateTime	
Attribute	TimeEnd	dateTime	[1]	DateTime	

7.2.4 Enumerations

Name	Description	Multiplicity	Data Type	Values
underKeelClearancePurposeType	Type of UKC plan	[1]	Enumeration	1: prePlan 2: actualPlan 3: actualUpdate
underKeelClearanceCalculationType	Indication of how the plan was calculated	[0..1]	Enumeration	1: timeWindow 2: maxDraught

8 Feature Catalogue

8.1 Introduction

According to ISO 19110, catalogues contain definitions and descriptions of the spatial object types, their attributes and associated components occurring in one or more spatial datasets, together with any operations that may be applied.

A Feature Catalogue (FC) refers to a description of an abstraction of reality that may be used to depict one or more geographic datasets. The FC for S-129 uses GML to describe the details of the application schema contained in Section 7.2 and is verified by the IHO's Feature Catalogue Builder (FCB).

The FC describes the features, information types, attributes, attribute values, associations and roles which may be in a UKCM dataset. The S-129 FC is described in XML which conforms to the S-100 XML Feature Catalogue Schema. The S-129 FC is described in

Feature Catalogue and can be downloaded from the IHO website (<http://s100.iho.int/S100/productspecs>).

8.2 Feature Types

Feature types contain descriptive attributes that characterize real-world entities. The word ‘feature’ may be used in one of two senses – feature type and feature instance. A feature type is a class and is defined in a Feature Catalogue. A feature instance is a single occurrence of the feature type and represented as an object in a dataset. A feature instance is located by a relationship to one or more spatial instances. In this specification, a feature instance may not exist without referencing a spatial instance.

8.2.1 Geographic

A Geographic (Geo) feature type carries the descriptive characteristics of a real-world entity. A Geo feature type forms the principle content of the dataset and is fully defined by its associated attributes and information types.

8.2.2 Meta

Meta features contain information about other features within a dataset. Information defined by meta features override the default metadata values defined by the dataset descriptive records. Meta attribution on individual features overrides attribution on meta features.

Meta features must be used to their maximum extent to reduce meta attribution on individual features.

8.2.3 Feature Relationship

A feature relationship links instances of one feature type with instances of the same or a different feature type. Although there are four types of defined feature relationships in S-100, S-129 uses only one of these – aggregation.

8.2.3.1 Aggregation

An aggregation is a relationship between two or more feature types where the aggregation feature is made up of component features.

EXAMPLE: A UKC plan feature may be composed of multiple UKC non-navigable area features to indicate unsafe areas.

8.2.4 Attributes

S-100 defines attributes as either simple or complex.

8.2.4.1 Simple attributes

S-129 uses five types of simple attributes, as listed in **Table 8-1**.

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values.
Real	A signed Real (floating point) number consisting of a mantissa and an exponent.
Integer	A signed integer number. The representation of an integer is encapsulation and usage dependent.
Character String	An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets.
Date and Time	A DateTime is a combination of a date and a time type. Character encoding of a DateTime must follow ISO 8601-1:2019 and ISO 8601-2:2019.

Table 8-1 – Attribute types**8.2.4.2 Complex attributes**

Complex attributes are aggregations of other attributes that are either simple or complex. The aggregation is defined by means of attribute bindings. S-129 includes only one complex attribute – fixedTimeRange – which has the simple attributes of timeStart and timeEnd.

**Figure 8-1 – S-129 Complex Attribute****8.3 Units of measure**

The following units of measure are used in the S-129 Product Specification:

- Ship draught in metres
- Ship length in metres
- Water depth in metres
- Direction in decimal degrees

9 Dataset Types

UKCM datasets consists of a UKC plan, control points and areas considered non-navigable and almost non-navigable. The datasets are generally intended for use with ENC, and (optionally) with S-102 bathymetric surface datasets. Dataset content will change over time during a ship's transit. Updating of datasets is achieved by replacement.

10 Dataset Loading and Unloading

S-129 datasets are typically intended to be overlays to ENC and always displayed with ENC data in the background. Systems that support the display of S-129 datasets should provide the user with simple functions to turn the display of S-129 datasets on and off.

All S-129 datasets are scale independent and will therefore be usable across the entire scale range of underlying chart data for the UKCM area. The various feature instances within the dataset may include scaleMinimum attributes, but these do not change the resolution or validity of the data, only whether the data should be visible at a particular display scale.

Optionally, S-129 datasets can be viewed as overlays to a combination of ENC and S-102 datasets. The same requirements to allow the user to easily toggle the S-129 dataset on/off persist.

11 Geometry

Geometry in S-129 datasets conforms to S-100 Geometry level 3a constrained to 2-dimensional geometry.

12 Coordinate Reference Systems (CRS)

12.1 Introduction

The location of a feature in the S-100 standard is defined by means of coordinates, which relate a feature to a position.

Horizontal coordinate reference system:	EPSG:4326 (WGS84)
Projection:	None
Temporal reference system:	Gregorian calendar
Coordinate reference system registry:	EPSG Geodetic Parameter Registry
Date type (according to ISO 19115):	002 – publication
Responsible party:	International Association of Oil and Gas Producers (IOGP)
URL:	http://www.iogp.org

12.2 Horizontal Reference System

In S-129 datasets the horizontal CRS must be the ellipsoidal (geodetic) system EPSG: 4326 (WGS84). The full reference to EPSG: 4326 can be found at <http://www.epsg-registry.org/>

12.3 Vertical Reference System

The vertical coordinate is directed upward from its origin (that is, away from the Earth's centre) – the vertical datum – and has units of metres. That is, a positive value for the level relative to the vertical datum means that the level is above the vertical datum. This is consistent with the bathymetric CRS in S-102 Edition 1.0.0. The vertical datum is not an ellipsoid but is one of the following: (a) the sea surface (defined in clause 3.2), (b) a vertical, sounding, or chart datum (MSL, LAT, etc.), or (c) the sea floor.

12.4 Temporal Reference System

The temporal reference system is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with ISO 19108:2002, Temporal Schema clause 5.4.4. All date and time variables must follow the format specified in ISO 8601-1:2019 and ISO 8601-2:2019.

- A date variable will have the following 8-character format: `yyyymmdd`.
- A time variable will have the following 7-character format: `hhmmssZ`.
- A date-time variable will have the following 16-character format: `yyyymmddThhmmssZ`.

13 Data Quality

13.1 Introduction

Areas where UKCM services are in place are typically covered by very high definition and up-to-date bathymetry, and have available predicted and observed (that is, real time) met-ocean data.

Bathymetric, tidal and other met-ocean data used to generate products in compliance with this Product Specification are provided by official sources using quality assured processes outside the scope of this Product Specification. This information is, therefore, assumed to be of high quality and guaranteed by the processes employed by the relevant authorities.

Quality of UKCM products used for navigation depends on the combined quality of many inputs including observed and forecast data (for example bathymetry, tide, water levels, currents, tidal streams etc.) and ship positional data. Quality information relevant to the many data inputs used by a UKCM service is difficult to produce as a meaningful metric of UKCM product quality able to be understood by the mariner.

Data validity is time-limited and is another reason why it is not practical to provide a meaningful measure of data quality for UKCM products.

UKCM products are generated containing margins that account for uncertainty to guarantee the safety of individual ships for stated periods of validity.

14 Data Capture and Classification

The S-129 Data Classification and Encoding Guide (DCEG) gives guidance for how to encode UKCM datasets for the various stages of a journey to and through a UKCM area. The document can be found in Annex A.

15 Maintenance

Dataset maintenance is dependent on local conditions and the policies of the UKCM service provider. Typically, a ship would be sent several UKCM information products during a transit of a UKCM area in order to ensure the ship has correct and up-to-date UKCM information.

15.1 Maintenance and Update Frequency

In the pre-planning use case the UKCM service may simply compute a tidal window based on predicted tide, forecast navigable depths (including safety/manoeuvrability margins) ship maximum draught, speed and squat predictions, other forecast environmental conditions and standard assumed route. In this pre-planning scenario, the UKCM service could only return a single dataset and generally no updates would be required until approximately 24 hours before the time when the ship enters the UKCM area.

About 24 hours before the time when the ship enters the UKCM area the ship will need a more detailed passage plan, which will be updated more frequently. Depending on the variability of the observed and forecast conditions in the UKCM area, the update frequency might range between 10 minutes to 60 minutes.

As the ship is approaching the UKCM area, more up-to-date information will be required and UKCM product datasets may be updated as frequently as every five to ten minutes.

15.2 Data Source

Data sources used when creating UKCM product datasets can vary with each UKCM area. Source information can include high definition bathymetric data, observed or forecast water level, current, tidal stream, and observed or forecast climatic data. This information is combined into a model that contains ship details such as draughts, speed and position to create UKCM product datasets that are individually tailored for each ship.

15.3 Production Process

The production process of UKCM product datasets will vary depending on the environmental sensors used in each UKCM area, and may also vary depending on the stage of a ship's passage.

16 Portrayal

The Portrayal Catalogue (PC) in Annex D defines how S-129 datasets are to be portrayed. The PC specifies the symbols and portrayal rules needed to display S-129 features.

The PC contains portrayal functions to map the features to symbols, symbol definitions, colour definitions, portrayal parameters and portrayal management concepts such as viewing groups.

17 Data Product Format (Encoding)

The GML encoding of S-129 datasets is based on the S-100 profile of GML 3.2.1. This is described in S-100 Edition 4.0.0 Part 10b.

Detailed documentation of the S-129 encoding schema is provided in Annex B of this document.

Format Name: GML

Version: 3.2.1

Character Set: UTF-8

Specification: S-100 4.0.0 profile of GML 3.2.1

17.1 Encoding of Latitude and Longitude

Values of latitude and longitude must be expressed with a precision of 9 decimal places. Coordinates must be encoded as decimals in the format described below. The encoding is indicated by multiplication factor fields defined in the S-100 GML schema dataset identification record.

17.1.1 Encoding of coordinates as decimals

Values should be coded as decimal numbers with 7 or fewer digits after the decimal. The normative encoding is in degrees, with an accuracy of 10^{-7} degrees (that is, 7 digits after the decimal point). The decimal point must be indicated by the "." character.

Trailing zeroes after the decimal point (and the decimal point itself if appropriate) may be omitted at producer discretion, but the accuracy must still be as indicated (for example 10^{-7} degrees for coordinates of default accuracy).

Latitude and longitude multiplication factors held in the Dataset Structure Information field under [coordMultFactorX] and [coordMultFactorY] must be set to a value corresponding to the encoding (for example {1} for coordinates encoded in decimal degrees).

EXAMPLE: A longitude = 42.0000 is converted into $X = \text{longitude} * \text{coordMultFactorX} = 42.0000 * 1 = 42.000000000$.

17.2 Numeric Attribute Encoding

Floating point and integer attribute values must not contain leading zeros. Floating point attribute values must not contain non-significant trailing zeros.

17.3 Text Attribute Values

Character strings must be encoded using the character set defined in ISO 10646-1, in Unicode Transformation Format-8 (UTF-8).

17.4 Mandatory Attribute Values

There are four reasons why attribute values may be considered mandatory:

- They determine whether a feature is in the display base.
- Certain features make no logical sense without specific attributes.

- Some attributes are necessary to determine which symbol is to be displayed.
- Some attributes are required for safety of navigation.

All mandatory attributes are identified in the Feature Catalogue and summarised in Annex A – Data Classification and Encoding Guide.

17.5 Unknown Attribute Values

When a mandatory attribute code or tag is present but the attribute value is missing, it means that the producer wishes to indicate that this attribute value is unknown. Missing mandatory attributes must be “nilled” with a GML *nilReason* attribute giving the reason for omission.

Optional attributes must be omitted altogether if the value is unknown or missing. They must not be “nilled.”

17.6 Structure of dataset files

17.6.1 Sequence of objects

The order of data objects in each dataset file is described below:

- i. Dataset identification information
- ii. Dataset structure information
- iii. Spatial records for by-reference geometries
 - iii.1. Point
 - iii.2. Multi point
 - iii.3. Curve
 - iii.4. Composite curve
 - iii.5. Surface
- iv. Information objects
- v. Feature objects (Geometry may be encoded inline or by reference)
 - v.1. Meta features
 - v.2. Geo features
- vi. S-129 Collection objects

17.7 Object identifiers

The name of feature records must provide a unique world-wide identifier of feature records. The name of the record is the combination of the subfields **agency**, **featureObjectIdentifier** and **featureIdentificationSubdivision** elements of the **featureObjectIdentifier** element of the object.

Features, information types, collection objects, meta features, and geometries (inline or external) are all required by the schema to have a **gml:id** attribute with a value that is unique within the dataset. The **gml:id** values must be used as the reference for the object from another object in the same dataset or another dataset.

17.8 Dataset validation

Fields may be repeated or omitted as permitted by the XML schemas and the validation tests. Since XML schema cannot encode rules for conditional presence or attributes, these rules can be checked by Schematron rules or other validation code.

17.9 Data overlap

S-129 datasets must not overlap temporally, but may spatially overlap other S-129 datasets.

17.10 Data quality

One or more QualityOfNonbathymetricData feature must cover the dataset.

18 Data Product Delivery

18.1 Introduction

This clause specifies the encoding and delivery mechanisms for an S-129 dataset. Data which conforms to this Product Specification must be delivered by means of an exchange set.

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

Other Delivery Information:

Each dataset must be contained in a separate, uniquely identified file on the transfer medium.

Each exchange set has a single exchange catalogue, which contains the discovery metadata for each dataset and references to any support files.

Support files contain supplementary information which is linked to the features and information types by attributes. The attributes containing these links are described in the Application Schema and Feature Catalogue.

An exchange set may be encapsulated in 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. An encoding may also define other elements in addition to the exchange set contents (for example media identification, data extents, etc.) and also may define commercial constructs such as encryption and compression methods.

Depending on the required level of detail, particularly when non-navigable and almost non-navigable areas are included, S-129 files can be constructed accordingly to maximise efficiency of transmission.

Further, S-129 files can be compressed using guidance provided in S-100 Part 15 in cases where files would otherwise take too long to transmit.

It is anticipated that uncompressed S-129 files for an area of 36 by 10 nautical miles, may range in size between 0.7MB and 2.5MB, depending on the complexity and extent of the no-go areas. Compressed versions of such files can reduce file sizes to between 28KB and 93KB respectively.

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

This Product Specification defines the transmission encoding which must be used as a default for transmission of data.

The exchange set elements are as follows:

Mandatory Elements:

1. New dataset and new edition of a dataset (base dataset): Each new edition of a dataset must have the same name as the dataset that it replaces. A new edition can also contain data that has previously been produced for the same UKCM operational area. The encoding structure is included in Annex B.
2. Cancellation: A dataset shall be considered cancelled when a newer edition has been received or the validTimeEnd of the UnderKeelClearancePlan is exceeded.

18.2.2 Dataset size

There is no recommended maximum file size for UKCM datasets. Future testing may result in a recommended file size limit.

18.2.3 Dataset file naming

Dataset files shall be named:

129XXXXYYYYYYYY.GML

The file name forms a unique identifier where:

- the first three characters are fixed to 129, and identify the dataset as a S-129 dataset.
- the fourth to seventh characters indicate the issuing agency (mandatory) in accordance with IHO S-62.
- the eighth to fifteenth characters are optional and may be used in any way by the producer to provide the unique file name. It is not required to use all characters. The following characters are allowed in the dataset name: A to Z, 0 to 9 and the special character _ (underscore).
- GML – the character sequence “GML” or “gml”.

18.3 Support Files

The only support file type allowed for S-129 is an optional file describing the route which was used to calculate the S-129 dataset. Changes to the route during transit should be kept to a minimum, and the file should be included only when it is changed. The specific route file is identified within the S-129 dataset by the following simple attributes:

- SourceRouteName
- SourceRouteVersion

File Types	Extensions	Comment
XML		
	RTZ	An XML file format for Route Exchange as specified in edition 4 of IEC 61174 Annex S.
		An XML file format for Route Exchange as specified in S-421 when published.

Table 18-1 – Support file format

Note: The route file exchange format specified in IEC61174 Annex S is currently (2019) being developed into the S-100 based Product Specification S-421. S-421 will provide guidelines for using the Route Plan with S-129 in an ECDIS or other navigation system.

18.3.1 Support File Naming

Files shall be named as follows:

129XXXXYYYYYYYY.EEE

The file name forms a unique identifier where:

- the first three characters are fixed as 129, and identify the dataset as a S-129 based dataset.
- the fourth to seventh characters indicate the issuing agency (mandatory) in accordance with IHO S-62.
- the eighth to fifteenth characters are optional and may be used in any way by the producer to provide the unique file name. It is not required to use all characters. The following characters are allowed in the dataset name: A to Z, 0 to 9 and the special character_ (underscore).
- EEE – support file extension (note – must conform to the file format).

19 Metadata

19.1 Introduction

The S-129 UKCM metadata description is based on the S-100 metadata document section, which is a profile of the ISO 19115 standard. These documents provide a structure for describing digital geographic data, and define metadata elements, a common set of metadata terminology, definitions and extension procedures.

Two metadata packages are described in this Product Specification: dataset metadata; and, exchange set metadata.

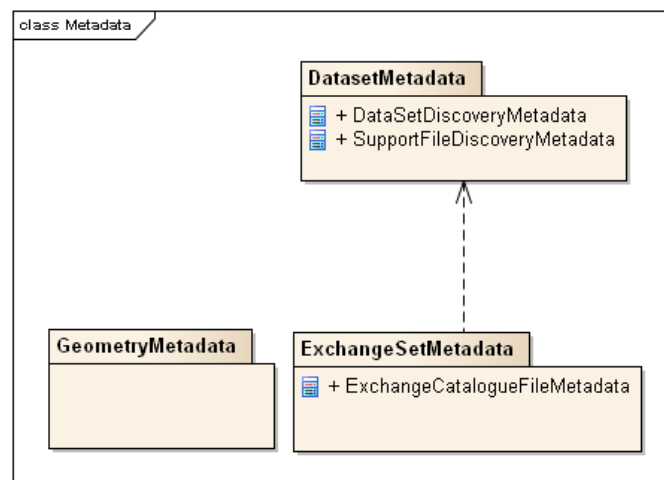


Figure 199-1 – Metadata packages

NOTE 1: Types with CI_, EX_, and MD_ prefixes are from packages defined in ISO 19115 and adapted by S-100. Types with S100_ prefix are from packages defined in S-100.

NOTE 2: When a dataset is terminated, the 'purpose' metadata field is set to 3 (terminated), and the 'editionNumber' metadata field is set to 0. All other metadata fields must be blank.

NOTE 3: The implication of only updating by new edition is that, if a support file is terminated a new edition of the dataset is required.

19.2 Use of S-421 to provide routes in UKC plans

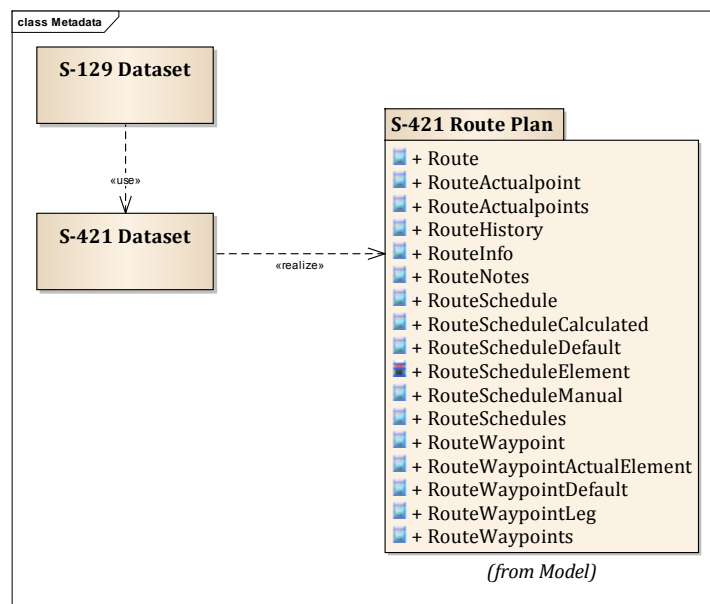


Figure 19-2 – relationship between S-129 and S-421

To provide a UKCM service, and a UKC route plan in particular, S-421 is used to generate a ship's route through the UKCM area. Figure 19-2 shows the relationship between S-129 and S-421.

19.3 Language

The language used for the metadata is English.

19.4 Dataset metadata

Dataset metadata is intended to describe information about a dataset. It facilitates the management and exploitation of data and is an important requirement for understanding the characteristics of a dataset. Whereas dataset metadata is usually fairly comprehensive, there is also a requirement for a constrained subset of metadata elements that are usually required for discovery purposes. Discovery metadata are often used for building web catalogues, and can help users determine whether a product or service is fit for purpose and where they can be obtained.

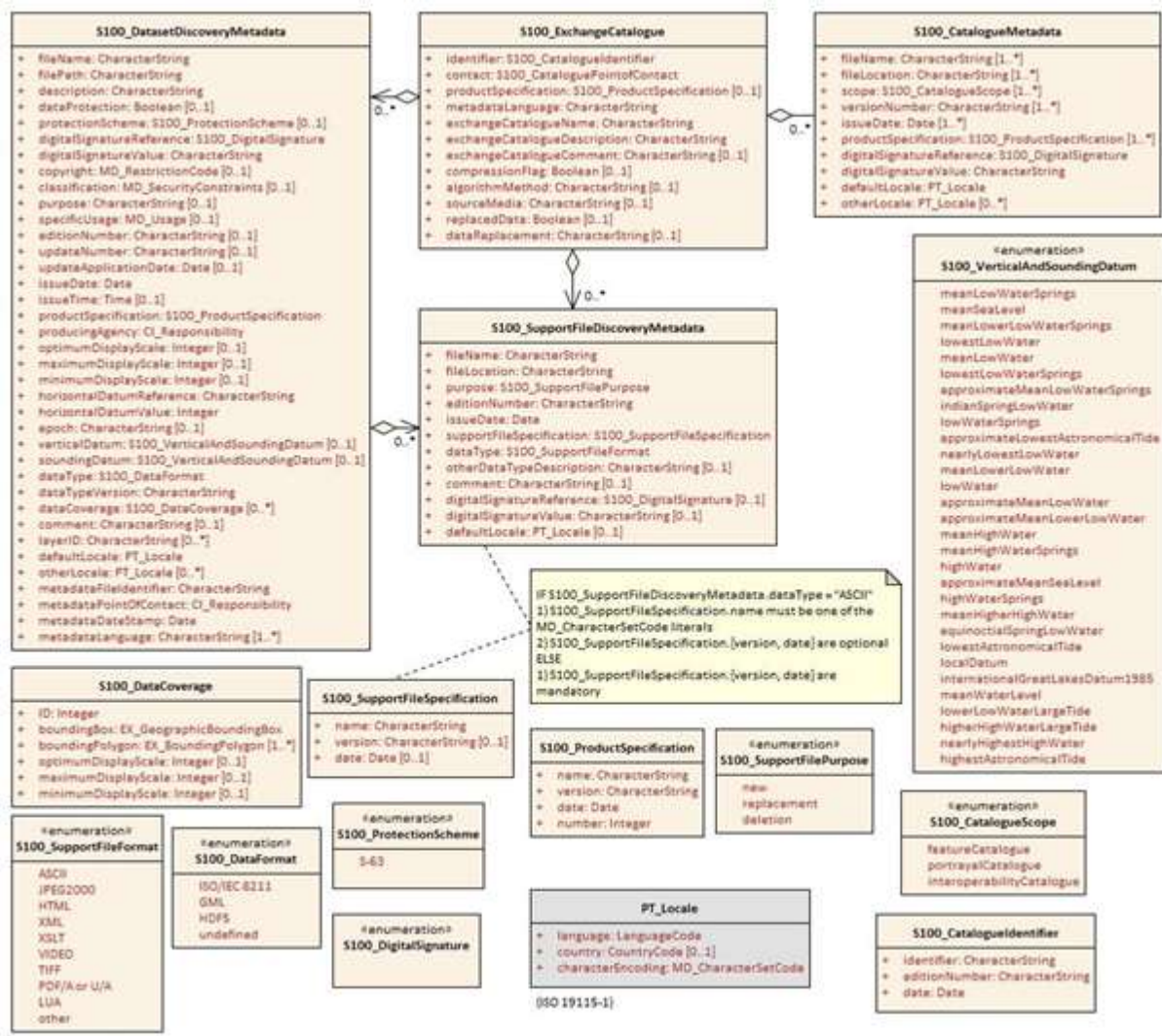


Figure 199-3 – S-129 Exchange catalogue and discovery metadata

NOTE 1: Types with CI, EX, and MD prefixes are from packages defined in ISO 19115-1 and 19115-3 and adapted by S-100. Types with S100 prefix are from packages defined in S-100.

NOTE 2: When a dataset is terminated, the purpose metadata field is set to 3 (terminated), and the editionNumber metadata field is set to 0. All inapplicable but mandatory metadata fields must be nulled.

19.5 S100_ExchangeCatalogue

19.5.1 Elements of the exchange set

Each exchange set has a single S100_ExchangeCatalogue, which contains meta information for the data and support files in the exchange set.

19.5.2 S100_ExchangeSet

An S-100 Exchange Set is an aggregation of all the various elements required to support the interchange of geospatial data and metadata. The MultiAggregation association introduces the concept of using subsets which could be domain oriented, for example, packaged by scale, producer, region etc.

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_ExchangeSet	Aggregation of the elements comprising an exchange set for the transfer of data	-	-	-
Role	aggregateFile	Collection of support files in the exchange set	0..*	-	
Role	partOf	Collection of datasets which are part of the exchange set	0..*	-	
Role	aggregateCatalogue	Collection of catalogues	0..*	-	
Role	superSet	The master container exchange set which can contain a subSet of exchange sets	0..*		
Role	subSet	Exchange set which is part of the superSet	0..*		

19.5.3 S100_ExchangeCatalogue

Each exchange set has a single S100_ExchangeCatalogue which contains meta information for the data and support files in the exchange set.

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	

Role Name	Name	Description	Mult	Type	Remarks
Attribute	S100_SupportFileSpecification	The specification used to create this file	1	S100_SupportFileSpecification	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	algorithmMethod	Type of compression algorithm	0..1	CharacterString	For example. RAR or ZIP
Attribute	sourceMedia	Distribution media	0..1	CharacterString	
Attribute	replacedData	If a dataset is cancelled is it replaced by another dataset	0..1	Boolean	Yes or No
Attribute	dataReplacement	Description of dataset to be replaced (e.g. 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	

19.5.4 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	Truncated Date	

19.5.5 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	

19.5.6 S100_Dataset

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_Dataset		-	-	-
Role	composedOf	An exchange set is composed of 0 or more datasets	0..*	-	
Role	datasetCatalogue	Catalogue which is related to this dataset	0..*	-	

19.6 S100_DatasetDiscoveryMetadata

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the exchange catalogue	-	-	-
Attribute	fileName	Dataset file name	1	CharacterString	
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	For example S-63
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
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	1	MD_Identification>purpose CharacterString	Pre plan, actual plan, or actual update.

Role Name	Name	Description	Mult	Type	Remarks
Attribute	specificUsage	The use for which the dataset is intended	1	MD_USAGE>specificUsage (character string) MD_USAGE>userContactInfo (CI_Responsibility)	For navigation through <name of UKCM area> by <ship name>.
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	1	Time	The S-100 datatype Time
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	See Tables 4a-2 and 4a-3
Attribute	optimumDisplayScale	The scale with which the data is optimally displayed	0..1	Integer	Example: A scale of 1:25000 is encoded as 25000
Attribute	maximumDisplayScale	The maximum scale with which the data is displayed	0..1	Integer	
Attribute	minimumDisplayScale	The minimum scale with which the data is displayed	0..1	Integer	
Attribute	horizontalDatumReference	Reference to the register from which the horizontal datum value is taken	1	characterString	EPSG
Attribute	horizontalDatumValue	Horizontal Datum of the entire dataset	1	Integer	4326
Attribute	epoch	Code denoting the epoch of the geodetic datum used by the CRS.	0..1	CharacterString	For example, G1762 for the 2013-10-16 realization of the geodetic datum for WGS84
Attribute	verticalDatum	Vertical Datum of the entire dataset	0..1	S100_VerticalAndSoundingDatum	
Attribute	soundingDatum	Sounding Datum of the entire dataset	0..1	S100_VerticalAndSoundingDatum	
Attribute	dataType	The encoding format of the dataset	1	S100_DataFormat	Must be GML
Attribute	dataTypeVersion	The version number of the dataType.	1	CharacterString	3,2,1 S-100 4.0.0 Profile
Attribute	dataCoverage	Provides information about data coverages within the dataset	1..*	S100_DataCoverage	
Attribute	comment	Any additional information	0..1	CharacterString	

Role Name	Name	Description	Mult	Type	Remarks
Attribute	layerID	Identifies other layers with which this dataset is intended to be used or portrayed	0..*	CharacterString	In navigation system, S-129 datasets must be used with ENC.
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	
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_SupportFileDiscoveryMetadata	

19.6.1 S100_DataCoverage

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_DataCoverage		-	-	-
Attribute	ID	Uniquely identifies the coverage	1	Integer	-
Attribute	boundingBox	The extent of the dataset limits	1	EX_GeographicBoundingBox	-
Attribute	boundingPolygon	A polygon which defines the actual data limit	1..*	EX_BoundingPolygon	-

19.6.2 S100_DigitalSignature

Role Name	Name	Description	Mult	Type	Remarks
Enumeration	S100_DigitalSignature	Algorithm used to compute the digital signature	-	-	-
Value	(TBD)	Digital Signature Algorithm	-	-	

19.6.3 S100_VerticalAndSoundingDatum

Role Name	Name	Description	Code	Remarks
Enumeration	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	-
Value	meanLowWaterSprings		1	(MLWS)
Value	meanLowerLowWaterSprings		2	
Value	meanSeaLevel		3	(MSL)
Value	lowestLowWater		4	
Value	meanLowWater		5	(MLW)
Value	lowestLowWaterSprings		6	
Value	approximateMeanLowWaterSprings		7	
Value	indianSpringLowWater		8	
Value	lowWaterSprings		9	
Value	approximateLowestAstronomicalTide		10	
Value	nearlyLowestLowWater		11	
Value	meanLowerLowWater		12	(MLLW)
Value	lowWater		13	(LW)
Value	approximateMeanLowWater		14	
Value	approximateMeanLowerLowWater		15	
Value	meanHighWater		16	(MHW)
Value	meanHighWaterSprings		17	(MHWS)
Value	highWater		18	(HW)
Value	approximateMeanSeaLevel		19	
Value	highWaterSprings		20	
Value	meanHigherHighWater		21	(MHHW)
Value	equinoctialSpringLowWater		22	
Value	lowestAstronomicalTide		23	(LAT)
Value	localDatum		24	
Value	internationalGreatLakesDatum1985		25	

Role Name	Name	Description	Code	Remarks
Value	meanWaterLevel		26	
Value	lowerLowWaterLargeTide		27	
Value	higherHighWaterLargeTide		28	
Value	nearlyHighestHighWater		29	
Value	highestAstronomicalTide		30	(HAT)

Note: The numeric codes are the codes specified in the IHO GI Registry for the equivalent listed values of the IHO Hydro domain attribute *Vertical datum*, since the registry does not at present (March 2019) contain entries for exchange set metadata and dataset metadata attributes.

19.6.4 S100_DataFormat

Role Name	Name	Description	Code	Remarks
Enumeration	S100_DataFormat	The encoding format	-	Only value permitted in S-129 is GML, therefore the rest are removed.
Value	GML	The GML data format as defined in Part 10b		-
LUA	S100_DataFormat	LUA script file for transformation processing		-

19.6.5 S100_ProductSpecification

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_ProductSpecification	The Product Specification contains the information needed to build the specified product	-	-	-
Attribute	name	The name of the product specification used to create the datasets	1	CharacterString	129
Attribute	version	The version number of the product specification	1	CharacterString	1.0.0
Attribute	date	The version date of the product specification	1	Date	CCYYMMDD
Attribute	number	The number (registry index) used to lookup the product in the product specification GI registry	1	Integer	From the Product Specification Register in the IHO Geospatial Information Registry

19.6.6 S100_ProtectionScheme

Role Name	Name	Description	Code	Remarks
Enumeration	S100_ProtectionScheme	Data protection schemes	-	-
Value	S-63	IHO S-63		

19.6.7 S100_SupportFile

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_SupportFile		-	-	-
Role	aggregateFile	Collection of support files	0..*	-	
Role	supportFile	File which has information about a dataset	0..*	-	

19.7 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>/<filePath>/<filename>
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 dataset is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each new edition. Edition number remains the same for a re-issue
Attribute	issueDate	Date on which the data was made available by the data producer	1	Date	
Attribute	productSpecification	The product specification used to create this file	1	S100_ProductSpecification	

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	
Attribute	digitalSignatureReference	Digital Signature of the file	0..1	S100_DigitalSignature	Reference to the appropriate digital signature algorithm
Attribute	digitalSignatureValue	Value derived from the digital signature	0..1	S100_DigitalSignatureValue	
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

19.7.1 S100_SupportFileFormat

Role Name	Name	Description	Code	Remarks
Enumeration	S100_SupportFileFormat	The format used in the support file	-	-
Value	ASCII			
Value	JPEG2000			
Value	HTML			
Value	XML			
Value	XSLT			
Value	VIDEO			
Value	TIFF			
Value	PDF/A or UA			Product Specification developers should take careful consideration in using PDF as a support file format. It is recommended that PDF never be used in products that will be used on a navigation system as it may impair night vision
Value	LUA	LUA script file for transformation processing		
Value	other			

19.7.2 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

19.7.3 S100_SupportFileSpecification

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_SupportFileSpecification	The standard or specification to which a support file conforms.	-	-	-
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	

19.8 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>/<filePath>/<filename>
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	
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	

19.8.1 S100_CatalogueScope

Role Name	Name	Description	Code	Remarks
Enumeration	S100_CatalogueScope	The scope of the catalogue	-	-
Value	featureCatalogue	S-100 feature catalogue		
Value	portrayalCatalogue	S-100 portrayal catalogue		
Value	interoperabilityCatalogue	S-100 interoperability information		

Annex A. Data Classification and Encoding Guide

A.1 UnderKeelClearancePlan

IHO Definition: UKC plans are specific to a ship and a UKCM operational area. There are three kinds of plan: a pre-plan, an actual plan and an actual update.				
S-129 Metadata Feature: UnderKeelClearancePlan				
Super Type:				
Primitive: noGeometry				
<i>Real World</i>	<i>Paper Chart Symbol</i>		<i>ECDIS Symbol</i>	
S-129 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
Generation Time			DT	0, 1
Vessel ID			TE	0, 1
Source Route Name			TE	0, 1
Source Route Version			TE	0, 1
Maximum Draught			RE	0, 1
UnderKeelClearance Purpose Type		1: prePlan 2: actualPlan 3: actualUpdate	EN	0, 1
UnderKeelClearance Calculation Requested		1: timeWindow 2: maxDraught	EN	0, 1
Fixed Time Range			C	0, 1
Time Start			(S) DT	0, 1
Time End			(S) DT	0, 1
Introductory remarks. There are three kinds of UKC plans: <ul style="list-style-type: none"> a pre-plan is a set of tidal windows available for a ship to transit through a UKCM operational area, at a specified draught an actual plan is specific to a ship and a UKCM operational area for a waterway, and contains a route defined by a set of geographical control points with time windows for each control point, and non-navigable and almost non-navigable areas, and an actual update is a replacement actual plan. 				

A.2 UnderKeelClearanceNonNavigableArea

IHO Definition: An area within a UKCM operational area where UKC for a specific ship is calculated to be less than the UKC limit for the waterway.				
S-129 Geo Feature: UnderKeelClearanceNonNavigableArea				
Super Type:				
Primitive: surface				
<i>Real World</i>	<i>Paper Chart Symbol</i>		<i>ECDIS Symbol</i>	
S-129 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
Scale Minimum			IN	0, 1
Introductory remarks. Non-navigable areas are spatial information which are included in actual plans and actual updates.				

A.3 UnderKeelClearanceAlmostNonNavigableArea

IHO Definition: An area within a UKCM operational area where UKC for a specific ship is calculated to be approaching the UKC limit for the waterway (within a specified value range).				
S-129 Geo Feature: UnderKeelClearanceAlmostNonNavigableArea				
Super Type:				
Primitive: surface				
<i>Real World</i>	<i>Paper Chart Symbol</i>		<i>ECDIS Symbol</i>	
S-128 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
Scale Minimum			IN	0, 1
Distance Above UKC Limit			RE	0, 1
Introductory remarks. Almost non-navigable areas are spatial information which are included in actual plans and actual updates.				

A.4 UnderKeelClearanceControlPoint

IHO Definition: A geographical position denoting a point along a specific ship's route within a UKCM operational area where the ship must pass within a time range or time window (for example start and end time) calculated by the UKCM service provider.

S-129 Geo Feature: UnderKeelClearanceControlPoint

Super Type:

Primitive: point

Real World

Paper Chart Symbol

ECDIS Symbol

S-129 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
Name			TE	0, 1
Expected Passing Time			DT	0, 1
Expected Passing Speed			RE	0, 1
Fixed Time Range			C	0, 1
Time Start			(S) DT	0, 1
Time End			(S) DT	0, 1

Introductory remarks. Control points are included in actual plans and actual updates.

A.5 Associations/Aggregations/Compositions

Remarks: 1. Aggregation relations between features of S-129 UKCM data model.			
Role Type	Role	Features	Multiplicity
Aggregation	componentOf	UnderKeelClearancePlan- UnderKeelClearanceControlPoint	1
	consistOf	UnderKeelClearanceControlPoint- UnderKeelClearancePlan-	1..*
Aggregation	componentOf	UnderKeelClearancePlan- UnderKeelClearanceNonNavigatbleArea	1
	consistOf	UnderKeelClearanceNonNavigatbleArea- UnderKeelClearancePlan-	1..*
Aggregation	componentOf	UnderKeelClearancePlan- UnderKeelClearanceAlmostNonNavigatbleArea	1
	consistOf	UnderKeelClearanceAlmostNonNavigatbleArea - UnderKeelClearancePlan-	1..*

Annex B. Schema documentation for S129.xsd

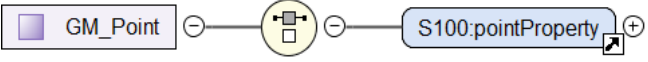
B.1 Schema(s)

B.1.1 Main schema S129.xsd

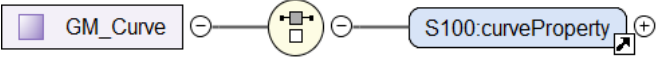
Namespace	http://www.iho.int/S124/gml/cs0/0.1
Properties	attribute form default: unqualified
	element form default: unqualified
	version: 0.1-20180531

B.2 Complex Type(s)

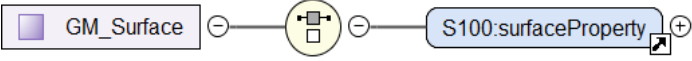
B.2.1 Complex Type —GM_Point

Namespace	http://www.iho.int/S124/gml/cs0/0.1
Diagram	
Used by	Element UnderKeelClearanceControlPointType/geometry
Model	pointProperty
Children	pointProperty

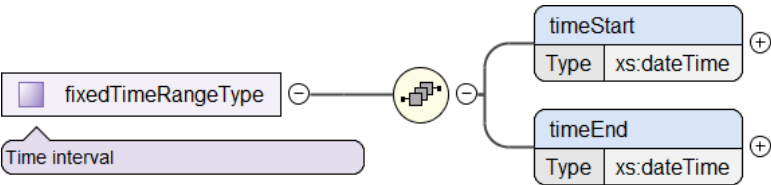
B.2.2 Complex Type —GM_Curve

Namespace	http://www.iho.int/S124/gml/cs0/0.1
Diagram	
Model	curveProperty
Children	curveProperty

B.2.3 Complex Type —GM_Surface

Namespace	http://www.iho.int/S124/gml/cs0/0.1
Diagram	
Used by	Elements UnderKeelClearanceAlmostNonNavigableAreaType/geometry, UnderKeelClearanceNonNavigableAreaType/geometry, UnderKeelClearancePlanType/geometry
Model	surfaceProperty
Children	surfaceProperty

B.2.4 Complex Type —fixedTimeRangeType

Namespace	http://www.iho.int/S124/gml/cs0/0.1
Annotations	Time interval
Diagram	

Used by	Elements	UnderKeelClearanceControlPointType/fixedTimeRange, UnderKeelClearancePlanType/fixed-
Model	timeStart , timeEnd	
Children	timeEnd, timeStart	

B.2.5 Complex Type — FeatureType

Namespace	http://www.iho.int/S124/gml/cs0/0.1		
Annotations	Generalized feature type which carries all the common attributes		
Diagram	<p>The diagram illustrates the UML structure of the FeatureType complex type. It is an abstract base type that generalizes gml:AbstractFeatureType, which itself generalizes gml:AbstractGMLType. gml:AbstractGMLType includes a mandatory attribute gml:id and a complex content model with gml:boundedBy and a choice of featureObjectIdentifier, informationAssociation (0..∞), featureAssociation (0..∞), and invFeatureAssociation (0..∞). Annotations explain that gml:id is mandatory for XML representation and that gml:boundedBy describes the minimum bounding box. A note states that the basic feature model is given by gml:AbstractFeatureType and that the content model for gml:AbstractFeatureType adds two elements.</p>		
Type	extension of AbstractFeatureType		
Type hierarchy	<div>1. gml:AbstractGMLType</div> <div>1. gml:AbstractFeatureType</div> <div>1. AbstractFeatureType</div> <div>1. FeatureType</div>		
Properties	abstract:	true	
Used by	Element	FeatureType	
	Complex Types	UnderKeelClearanceAlmostNonNavigableAreaType, UnderKeelClearanceControlPointType, UnderKeelClearanceNonNavigableAreaType, UnderKeelClearancePlanType	
Model	gml:boundedBy{0,1} , featureObjectIdentifier{0,1} , informationAssociation* , featureAssociation* , invFeatureAssociation*		
Children	featureAssociation, featureObjectIdentifier, gml:boundedBy, informationAssociation, invFeatureAssociation		
Attributes	QName	Type	Use
	gml:id	ID	required
		The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.	

B.2.6 Complex Type — UnderKeelClearancePlanType

Namespace	http://www.iho.int/S124/gml/cs0/0.1	
Annotations	A UKC plan calculated for a particular vessel, for a particular passage.	
Diagram		
Type	extension of FeatureType	

Type hierarchy	1. gml:AbstractGMLType 1. gml:AbstractFeatureType 1. AbstractFeatureType 1. FeatureType 1. UnderKeelClearancePlanType		
Used by	Element UnderKeelClearancePlan		
Model	gml:boundedBy{0,1} , featureObjectIdentifier{0,1} , informationAssociation* , featureAssociation* , invFeatureAssociation* , fixedTimeRange , generationTime , vesselID , sourceRouteName , sourceRouteVersion , maximumDraught , underKeelClearancePurposeType , underKeelClearanceCalculationType , geometry , consitOf+		
Children	consitOf, featureAssociation, featureObjectIdentifier, fixedTimeRange, generationTime, geometry, gml:boundedBy, informationAssociation, invFeatureAssociation, maximumDraught, sourceRouteName, sourceRouteVersion, underKeelClearanceCalculationType, underKeelClearancePurposeType, vesselID		
Attributes	QName	Type	Use
	gml:id	ID	required
		The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.	

B.2.7 Complex Type — UnderKeelClearanceNonNavigableAreaType

Namespace	http://www.iho.int/S124/gml/cs0/0.1
Annotations	An area of depth less than the calculated safe limit.
Diagram	<p>The diagram illustrates the structure of the <code>UnderKeelClearanceNonNavigableAreaType</code> complex type. It is an extension of <code>FeatureType</code>. The base type <code>FeatureType</code> is an abstract type that extends <code>S100AbstractFeatureType</code>, which in turn extends <code>gml:AbstractFeatureType</code>. <code>gml:AbstractFeatureType</code> is an abstract type that extends <code>gml:AbstractGMLType</code>. The <code>gml:AbstractGMLType</code> type has an attribute <code>gml:id</code> and a property <code>gml:boundedBy</code>. The <code>UnderKeelClearanceNonNavigableAreaType</code> type has a base type of <code>FeatureType</code> and contains the following elements:</p> <ul style="list-style-type: none"> <code>gml:boundedBy</code>: A property that describes the minimum bounding box or rectangle that encloses the entire feature. <code>featureObjectIdentifier</code>: A property that identifies the feature. <code>informationAssociation</code>: A property that associates the feature with information. <code>featureAssociation</code>: A property that associates the feature with other features. <code>invFeatureAssociation</code>: A property that associates the feature with other features. <code>scaleMinimum</code>: A property of type <code>xs:int</code> that specifies the minimum scale. <code>geometry</code>: A property of type <code>GM_Surface</code> that specifies the geometry of the feature. <code>componentOf</code>: A property of type <code>gml:ReferenceType</code> that specifies the component of the feature. <p>The diagram also includes a note: "The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory." and another note: "This property describes the minimum bounding box or rectangle that encloses the entire feature.".</p>
Type	extension of FeatureType
Type hierarchy	<ol style="list-style-type: none"> 1. gml:AbstractGMLType <ol style="list-style-type: none"> 1. gml:AbstractFeatureType <ol style="list-style-type: none"> 1. AbstractFeatureType <ol style="list-style-type: none"> 1. FeatureType <ol style="list-style-type: none"> 1. UnderKeelClearanceNonNavigableAreaType
Used by	Element UnderKeelClearanceNonNavigableArea
Model	<code>gml:boundedBy{0,1}</code> , <code>featureObjectIdentifier{0,1}</code> , <code>informationAssociation*</code> , <code>featureAssociation*</code> , <code>invFeatureAssociation*</code> , <code>scaleMinimum</code> , <code>geometry</code> , <code>componentOf</code>
Children	<code>componentOf</code> , <code>featureAssociation</code> , <code>featureObjectIdentifier</code> , <code>geometry</code> , <code>gml:boundedBy</code> , <code>informationAssociation</code> , <code>invFeatureAssociation</code> , <code>scaleMinimum</code>

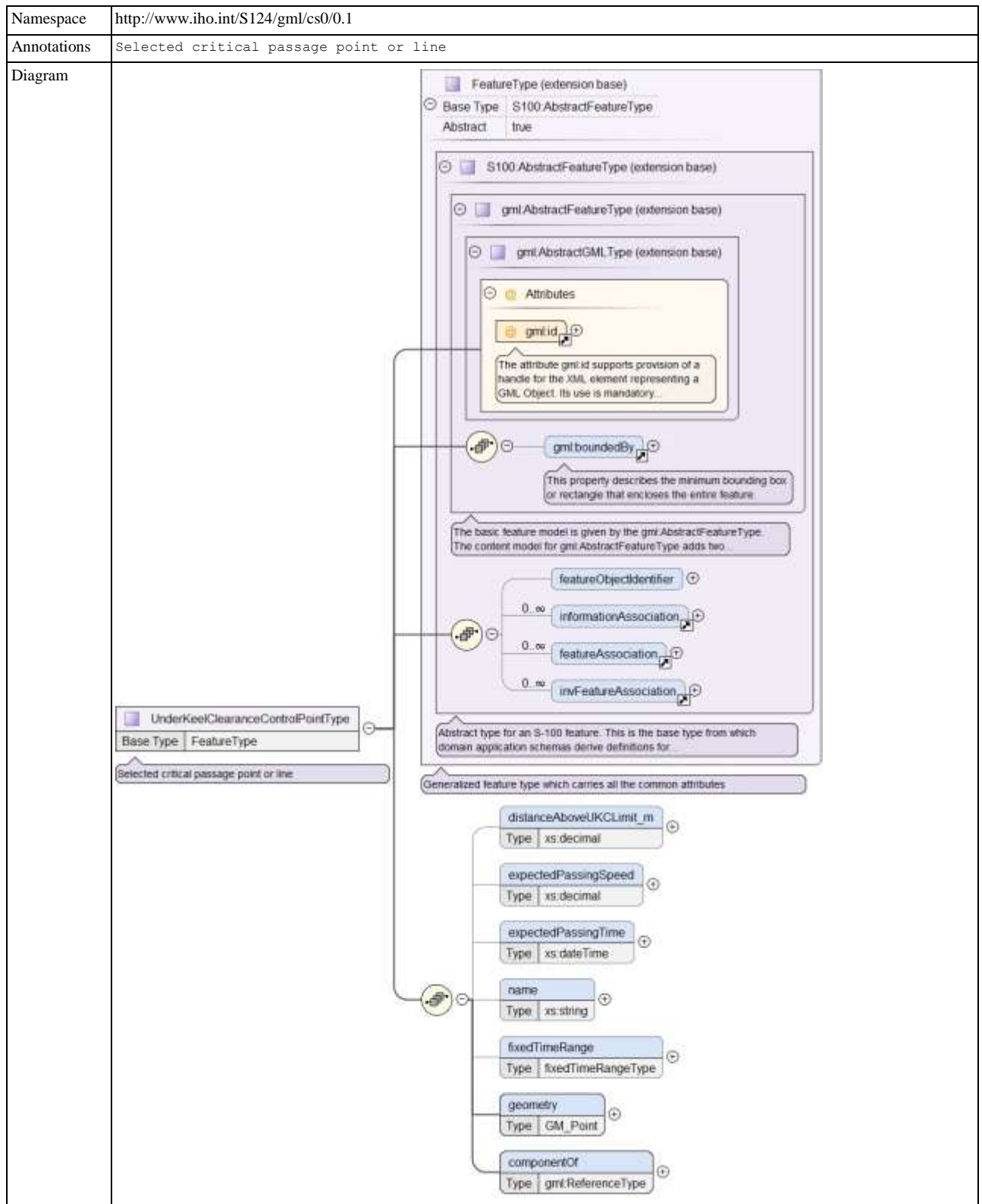
Attributes	QName	Type	Use
	gml:id	ID	
			The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.

B.2.8 Complex Type—UnderKeelClearanceAlmostNonNavigableAreaType

Namespace	http://www.iho.int/S124/gml/cs0/0.1		
Annotations	An area of depth almost less than the calculated safe limit, as established for the waterway.		
Diagram	<p>The diagram illustrates the class hierarchy and content model for the UnderKeelClearanceAlmostNonNavigableAreaType. It shows the following structure:</p> <ul style="list-style-type: none"> FeatureType (extension base) is the root, marked as Base Type and Abstract. S100 AbstractFeatureType (extension base) extends FeatureType. gml AbstractFeatureType (extension base) extends S100 AbstractFeatureType. gml AbstractGMLType (extension base) extends gml AbstractFeatureType. UnderKeelClearanceAlmostNonNavigableAreaType (Base Type: FeatureType) extends gml AbstractGMLType. <p>The content model for gml AbstractGMLType includes the following elements:</p> <ul style="list-style-type: none"> gml:id (Attribute): The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory. gml:boundedBy (Attribute): This property describes the minimum bounding box or rectangle that encloses the entire feature. featureObjectIdentifier (Element): 0..∞ occurrences. informationAssociation (Element): 0..∞ occurrences. featureAssociation (Element): 0..∞ occurrences. intFeatureAssociation (Element): 0..∞ occurrences. <p>The content model for UnderKeelClearanceAlmostNonNavigableAreaType includes the following elements:</p> <ul style="list-style-type: none"> distanceAboveUKCLimit_m (Element): Type xs:decimal. scaleMinimum (Element): Type xs:int. geometry (Element): Type GM_Surface. componentOf (Element): Type gml:ReferenceType. 		
Type	extension of FeatureType		
Type hierarchy	<ol style="list-style-type: none"> 1. gml:AbstractGMLType <ol style="list-style-type: none"> 1. gml:AbstractFeatureType <ol style="list-style-type: none"> 1. AbstractFeatureType <ol style="list-style-type: none"> 1. FeatureType <ol style="list-style-type: none"> 1. UnderKeelClearanceAlmostNonNavigableAreaType 		
Used by	Element	UnderKeelClearanceAlmostNonNavigableArea	

Model	gml:boundedBy{0,1} , featureObjectIdentifier{0,1} , informationAssociation* , featureAssociation* , invFeatureAssociation* , distanceAboveUKCLimit_m , scaleMinimum , geometry , componentOf		
Children	componentOf, distanceAboveUKCLimit_m, featureAssociation, featureObjectIdentifier, geometry, gml:boundedBy, informationAssociation, invFeatureAssociation, scaleMinimum		
Attributes	QName	Type	Use
	gml:id	ID	required
	QName	The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.	

B.2.9 Complex Type — UnderKeelClearanceControlPointType



Type	extension of FeatureType		
Type hierarchy	1. gml:AbstractGMLType <div>1. gml:AbstractFeatureType</div> <div>1. AbstractFeatureType</div> <div>1. FeatureType</div> <div>1. UnderKeelClearanceControlPointType</div>		
Used by	Element UnderKeelClearanceControlPoint		
Model	gml:boundedBy{0,1} , featureObjectIdentifier{0,1} , informationAssociation* , featureAssociation* , invFeatureAssociation* , distanceAboveUKCLimit_m{0,1} , expectedPassingSpeed{0,1} , expectedPassingTime{0,1} , name{0,1} , fixedTimeRange{0,1} , geometry , componentOf		
Children	componentOf, distanceAboveUKCLimit_m, expectedPassingSpeed, expectedPassingTime, featureAssociation, featureObjectIdentifier, fixedTimeRange, geometry, gml:boundedBy, informationAssociation, invFeatureAssociation, name		
Attributes	QName	Type	Use required
	gml:id	ID	
			The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.

B.2.10 Complex Type—InformationTypeType

Namespace	http://www.iho.int/S124/gml/cs0/0.1		
Annotations	Generalized information type which carry all the common attributes		
Diagram			
Type	extension of AbstractInformationType		
Type hierarchy	1. gml:AbstractGMLType 1. AbstractInformationType 1. InformationTypeType		
Properties	abstract:	true	
Used by	Element	InformationType	
Model	informationAssociation*, invInformationAssociation*		
Children	informationAssociation, invInformationAssociation		
Attributes	QName	Type	Use
	gml:id	ID	required

		The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.
--	--	---

B.2.11 Complex Type — DatasetType

Namespace	http://www.ih0.int/S124/gml/cs0/0.1
Annotations	Dataset element for dataset as "GML document"
Diagram	<p>The diagram illustrates the structure of the DatasetType complex type. It is an extension of gml:AbstractFeatureType. The gml:AbstractFeatureType base type includes an attribute gml:id (XML type ID) and a property gml:boundedBy (describing the minimum bounding box). The DatasetType itself is annotated as a "Dataset element for dataset as 'GML document'". It contains several components:</p> <ul style="list-style-type: none"> DatasetIdentificationInformation: Type S100 DataSetIdentificationType, labeled "Dataset identification information". DatasetStructureInformation: Type S100 DataSetStructureInformationType, labeled "Dataset structure information". S100 Geometry: A group of all S-100 curve types, including Point, MultiPoint, Curve, CompositeCurve, OrientableCurve (noted as the same as GML orientable curve), Surface, and Polygon (noted as S100 version of polygon type). A note states: "Allows spatial objects to be located outside feature objects (for references, and compatibility with ISO 9211 encoding)". MemberType: Two member elements of type MemberType. The first is intended for S100 information types (extension of GML practice, not addressed by ISO 19136). The second is intended for technical GML 3.2 requirements for making the dataset a "GML document" and clause 21.3 of the OGC GML.
Type	extension of gml:AbstractFeatureType
Type hierarchy	<ol style="list-style-type: none"> 1. gml:AbstractGMLType <ol style="list-style-type: none"> 1. gml:AbstractFeatureType <ol style="list-style-type: none"> 1. DatasetType

Used by	Element DataSet		
Model	gml:boundedBy{0,1} , DatasetIdentificationInformation{0,1} , DatasetStructureInformation{0,1} , (Point MultiPoint Curve CompositeCurve OrientableCurve Surface Polygon) , (imember* member*)		
Children	CompositeCurve, Curve, DatasetIdentificationInformation, DatasetStructureInformation, MultiPoint, OrientableCurve, Point, Polygon, Surface, gml:boundedBy, imember, member		
Attributes	QName	Type	Use
	gml:id	ID	required
	The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.		

B.2.12 Complex Type —IMemberType

Namespace	http://www.ihp.int/S124/gml/cs0/0.1				
Annotations	dataset member S-100 information types				
Diagram	<p>The diagram illustrates the IMemberType complex type. It is an extension of gml:AbstractFeatureMemberType. IMemberType contains two attribute groups: gml:OwnershipAttributeGroup and gml:AssociationAttributeGroup. A note explains that encoding a GML property inline vs. by-reference does not imply anything about ownership. Another note states that to create a collection of GML features, a property type shall be derived by extension from IMemberType. A table for InformationType shows Type as InformationTypeType and Abstract as true.</p>				
Type	extension of gml:AbstractFeatureMemberType				
Type hierarchy	1. gml:AbstractFeatureMemberType 1. IMemberType				
Used by	Element DataSetType/imember				
Model	InformationType				
Children	InformationType				
Attributes	QName	Type	Fixed	Default	Use
	nilReason	gml:NilReasonType	false		optional
	owns	boolean			optional
	xlink:actuate	xlink:actuateType			optional
	xlink:arcrole	xlink:arcroleType			optional
	xlink:href	xlink:hrefType			optional
	xlink:role	xlink:roleType			optional
	xlink:show	xlink:showType			optional

	QName	Type	Fixed	Default	Use	
	xlink:title	xlink:titleAttrType	simple		optional	
	xlink:type	xlink:typeType			optional	

B.2.13 Complex Type—MemberType

Namespace	http://www.iho.int/S124/gml/cs0/0.1					
Annotations	dataset member					
Diagram						
Type	extension of gml:AbstractFeatureMemberType					
Type hierarchy	1. gml:AbstractFeatureMemberType 1. MemberType					
Used by	Element DatasetType/member					
Model	gml:AbstractFeature					
Children	gml:AbstractFeature					
Attributes	QName	Type	Fixed	Default	Use	
	nilReason	gml:nilReasonType	simple	false	optional	
	owns	boolean			optional	
	xlink:actuate	xlink:actuateType			optional	
	xlink:arcrole	xlink:arcroleType			optional	
	xlink:href	xlink:hrefType			optional	
	xlink:role	xlink:roleType			optional	
	xlink:show	xlink:showType			optional	
	xlink:title	xlink:titleAttrType			optional	
	xlink:type	xlink:typeType			optional	

B.2.14 Complex Type —GenericFeatureType

Namespace	http://www.iho.int/S124/gml/cs0/0.1		
Diagram			
Type	extension of AbstractFeatureType		
Type hierarchy	<ol style="list-style-type: none"> 1. gml:AbstractGMLType <ol style="list-style-type: none"> 1. gml:AbstractFeatureType <ol style="list-style-type: none"> 1. AbstractFeatureType <ol style="list-style-type: none"> 1. GenericFeatureType 		
Model	gml:boundedBy{0,1}, featureObjectIdentifier{0,1}, informationAssociation*, featureAssociation*, invFeatureAssociation*, ANY element from LOCAL namespace 'No Namespace'		
Children	featureAssociation, featureObjectIdentifier, gml:boundedBy, informationAssociation, invFeatureAssociation		
Attributes	QName	Type	Use
	gml:id	ID	required
	The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.		

B.3 Simple Type(s)

B.3.1 Simple Type — underKeelClearancePurposeTypeType

Namespace	http://www.iho.int/S124/gml/cs0/0.1	
Annotations	The relevant phase of a UKC passage plan	
Diagram		
Type	restriction of xs:string	
Facets	enumeration	pre plan An indicative UKC plan that identifies potential sailing windows for a nominated vessel draught, days, weeks or months prior to the planned passage through the UKCM region.
	enumeration	actual plan A detailed UKC plan that identifies sailing windows non-navigable and almost non-navigable areas, integrating live weather data, hours or days prior to transiting the UKCM region.
	enumeration	actual update A near real-time, detailed, UKC plan that identifies sailing windows and non-navigable and almost non-navigable areas, using live weather, vessel position and traffic data, while the vessel is transiting the UKCM region.
Used by	Element	UnderKeelClearancePlanType/underKeelClearancePurposeType

B.3.2 Simple Type — underKeelClearanceCalculationTypeType

Namespace	http://www.iho.int/S124/gml/cs0/0.1	
Annotations	Indication of the aim of the UKC plan: to find the maximum safe vessel draught for transiting the UKCM region, or to find sailing windows for a nominated vessel draught	
Diagram		
Type	restriction of xs:string	
Facets	enumeration	time window The available time window(s) for a given draught.
	enumeration	max draught The maximum draught for a given time window.
Used by	Element	UnderKeelClearancePlanType/underKeelClearanceCalculationType

Annex C. Feature Catalogue

The Feature catalogue (FC) is a document that describes the content of a data model which is an abstraction of reality that may be used to depict geographic datasets. The FC for S-129 describes the details of Application Schema in clause 7.2 of this Product Specification with GML and it is verified by the FCB (Feature Catalogue Builder) published by KHOA on behalf of IHO.

C.1 Catalogue header information

Name: Feature Catalogue for S-129

Scope: Dynamic under keel clearance management information

Field of Application: Under keel clearance management

Version Number:

Version date: 2018-10-19

Producer information:

Individual name:

Organisation name: International Hydrographic Organization

Position Name:

Contact Information:

Phone:

Address:

deliveryPoint	city	administrativeArea	postalCode	country	electronicMailAddress
International Hydrographic Organization, 4 quai Antoine 1er, B.P. 445			MC 98011 MONACO CEDEX		

Online resource information:

Hours of Service:

Contact Instructions:

Role: user

Classification: unclassified

C.2 Definition Sources

No definition sources in catalogue.

C.3 Simple Attributes

C.3.1 Generation Time

Name: Generation Time

Definition:

Code: 'generationTime'

Remarks:

Aliases: (none)

Value Type: dateTime

C.3.2 Vessel ID

Name: Vessel ID

Definition:

Code: 'vesselID'

Remarks:

Aliases: (none)

Value Type: text

C.3.3 Source Route Name

Name: Source Route Name

Definition:

Code: 'sourceRouteName'

Remarks:

Aliases: (none)

Value Type: text

C.3.4 Source Route Version

Name: Source Route Version

Definition:

Code: 'sourceRouteVersion'

Remarks:

Aliases: (none)

Value Type: text

C.3.5 Maximum Draught

Name: Maximum Draught

Definition:

Code: 'maximumDraught'

Remarks:

Aliases:

Value Type: real

C.3.6 Distance Above UKC Limit

Name: Distance Above UKC Limit

Definition:

Code: 'distanceAboveUKCLimit_m'

Remarks:

Aliases:

Value Type: real

C.3.7 Scale Minimum

Name: Scale Minimum

Definition:

Code: 'scaleMinimum'

Remarks:

Aliases:

Value Type: integer

C.3.8 Expected Passing Time

Name: Expected Passing Time

Definition:

Code: 'expectedPassingTime'

Remarks:

Aliases:

Value Type: dateTime

C.3.9 Expected Passing Speed

Name: Expected Passing Speed

Definition:

Code: 'expectedPassingSpeed'

Remarks:

Aliases:

Value Type: real

C.4 Enumerations

C.4.1 UnderKeelClearance Purpose Type

Name: UnderKeelClearance Purpose Type

Definition:

Code: 'UnderKeelClearancePurposeType'

Remarks:

Aliases: (none)

Value Type: Enumeration

Listed Values

Label	Definition	Code	Remarks
'prePlan' Aliases: (none)	a pre-plan is a set of tidal windows available for a ship to transit through a UKCM operational area, at a specified draught	1	
'actualPlan' Aliases: (none)	an actual plan is specific to a ship and a UKCM operational area for a waterway, and contains a route defined by a set of geographical control points with time windows for each control point, and non-navigable and almost non-navigable areas	2	
'actualUpdate' Aliases: (none)	an actual update is a replacement actual plan	3	

C.4.2 UnderKeelClearance Calculation Request

Name: UnderKeelClearance Calculation Request

Definition:

Code: 'UnderKeelClearanceCalculationRequest'

Remarks:

Aliases: (none)

Value Type: Enumeration

Listed Values

Label	Definition	Code	Remarks
'timeWindow' Aliases: (none)	The available time window(s) for a given draught.	1	
'maxDraught' Aliases: (none)	The maximum draught for a given time window.	2	

C.5 Complex Attributes

C.5.1 Fixed Time Range

Name: Fixed Time Range

Definition:

Code: 'fixedTimeRange'

Remarks:

Aliases: (none)

Sub-Attributes

Sub-attribute	Type	Mult.	Permitted Values	sequential
timeStart	dateTime			false
timeEnd	dateTime			false

C.6 Roles

C.6.1 Associations

Association(name): (none)

Definition: Association between 'UnderKeelClearancePlanNonNavigable' class and 'UnderKeelClearancePlan' class

Role type: Aggregation

Code: <S100FC:featureBinding> ~ </S100FC:featureBinding>

Multiplicity: 0..* / 1

Role: 'consistOf / componentOf'

Feature type: UnderKeelClearancePlanNonNavigable / UnderKeelClearancePlan

Remarks: It must be in all feature types that they have connection. The featuretype attribute is target feature.

Association(name): (none)

Definition: Association between 'UnderKeelClearanceAlmostNonNavigableArea' class and 'UnderKeelClearancePlan' class

Role type: Aggregation

Code: <S100FC:featureBinding> ~ </S100FC:featureBinding>

Multiplicity: 0..* / 1

Role: 'consistOf / componentOf'

Feature type: UnderKeelClearanceAlmostNonNavigableArea / UnderKeelClearancePlan

Remarks: It must be in all feature types that they have connection. The featuretype attribute is target feature.

Association(name): (none)

Definition: Association between 'UnderKeelClearanceControlPoint' class and 'UnderKeelClearancePlan' class

Role type: Aggregation

Code: <S100FC:featureBinding> ~ </S100FC:featureBinding>

Multiplicity: 0..* / 1

Role: 'consistOf / componentOf'

Feature type: UnderKeelClearanceControlPoint / UnderKeelClearancePlan

Remarks: It must be in all feature types that they have connection. The featuretype attribute is target feature.

C.6.2 Component of

Name: Component of

Definition: A pointer to the aggregate in a whole-part relationship.

Code: 'componentOf'

Remarks: Definition may need to be discussed with S-101 team and GI registry manager

Aliases: (none)

C.6.3 Consists of

Name: Consists of

Definition: A pointer to a part in a whole-part relationship

Code: 'consistsOf'

Remarks: Definition may need to be discussed with S-101 team and GI registry manager

Aliases: (none)

C.7 Feature Types

C.7.1 UnderKeelClearancePlan

Name: UnderKeelClearancePlan

Abstract type: true

Definition: This feature is MetaFeature of UKCM information

Code: 'UKCP'

Remarks:

Aliases: (none)

Supertype: MetaFeatureType

Feature use type: meta

Permitted primitives: noGeometry

Attribute Bindings

Attribute	Type	Mult.	Permitted Values	Sequential
generationTime	Simple			false
vesselID	Simple			false
sourceRouteName	Simple			false
sourceRouteVersion	Simple			false
maximumDraught	Simple			false
UnderKeelClearancePurposeType	Enumeration		1: prePlan 2: actualPlan 3: actualUpdate	false
UnderKeelClearanceCalculationRequested	Enumeration		1: timeWindow 2: maxDraught	false
fixedTimeRange	Complex			false

C.7.2 UnderKeelClearanceNonNavigableArea

Name: UnderKeelClearanceNonNavigableArea

Abstract type: false

Definition: Non Navigation Area.

Code: 'UnderKeelClearanceNonNavigableArea'

Remarks:

Aliases: (none)

Supertype: FeatureType

Feature use type: geographic

Permitted primitives: surface

Attribute Bindings

Attribute	Type	Mult.	Permitted Values	Sequential
scaleMinimum	Simple			false

C.7.3 UnderKeelClearanceAlmostNonNavigableArea

Name: UnderKeelClearanceAlmostNonNavigableArea

Abstract type: false

Definition: Almost Non-Navigable Area.

Code: 'UnderKeelClearanceAlmostNonNavigableArea'

Remarks:

Aliases: (none)

Supertype: FeatureType

Feature use type: geographic

Permitted primitives: surface

Attribute Bindings

Attribute	Type	Mult.	Permitted Values	Sequential
scaleMinimum	Simple			false
distanceAboveUKCLimit_m	Simple			false

C.7.4 UnderKeelClearanceControlPoint

Name: UnderKeelClearanceControlPoint

Abstract type: false

Definition: UnderKeelClearance ControlPoint

Code: 'UnderKeelClearanceControlPoint'

Remarks:

Aliases: (none)

Supertype: FeatureType

Feature use type: geographic

Permitted primitives: point

Attribute Bindings

Attribute	Type	Mult.	Permitted Values	Sequential
Name	Simple	0..1		false
distanceAboveUKCLimit_m	Simple	0..1		false
expectedPassingTime	Simple	0..1		false
expectedPassingSpeed	Simple	0..1		false
fixedTimeRange	Complex	0..1		false

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Annex D. Portrayal Catalogue

The Portrayal Catalogue (PC) provides those portrayal functions for S-129 UKCM with GML as a machine readable form to display the features of the data model. This PC is verified by the PCB (Portrayal Catalogue Builder) published by KHOA on behalf of IHO.

D.1 Catalogue header information

Name: Portrayal Catalogue for S-129

Scope: Dynamic under keel clearance management information

Field of Application: Under keel clearance management

Version Number:

Version date: 2018-10-19

Producer information:

Individual name:

Organisation name: International Hydrographic Organization

Position Name:

Contact Information:

Phone:

Address:

deliveryPoint	city	administrativeArea	postalCode	country	electronicMailAddress
International Hydrographic Organization, 4 quai Antoine 1er, B.P. 445			MC 98011 MONACO CEDEX		

Online resource information:

Hours of Service:

Contact Instructions:

Role: user

Classification: unclassified

D.2 Definition Sources

No definition sources in catalogue.

D.3 Color Profiles

D.3.1 UKC color profile

Name: UKC color profile

Description: Color profile for UKC information

ID: UKCColorProfile

Language: en (English)

Remarks:

File Name: colorProfile.xml

File Type: ColorProfile

File Format: XML

D.4 Symbols

D.4.1 Control Point

Name: Control Point

Description: Control Point in UKC

ID: CP

Language: en (English)

Remarks:

File Name: CP.svg

File Type: Symbol

File Format: SVG

D.5 Line styles

(No description)

D.6 Area Fills

D.6.1 Almost Non-Navigable Area

Name: Almost Non-Navigable Area

Description:

ID: ANARemarks

File Name: ANA.xml

File Type: AreaFill

File Format: XML

D.6.2 Non Navigable Area

Name: Non Navigable Area

Description:

ID: ANA

Remarks:

File Name: NNA.xml

File Type: AreaFill

File Format: XML

D.7 Fonts

(No description)

D.8 Viewing Group

(No description)

D.9 Rules

D.9.1 Main rule set

Name: Main rule set

Description:

ID: main

Remarks:

File Name: main.xsl

File Type: Rule

File Format: XSLT

Rule Type: TopLevelTemplate

D.9.2 Control Point

Name: Control Point

Description:

ID: controlpoint

Remarks:

File Name: ControlPoint.xsl

File Type: Rule

File Format: XSLT

Rule Type: SubTemplate

D.9.3 Information Box

Name: Information Box

Description:

ID: InformationBox

Remarks:

File Name: InformationBox.xsl

File Type: Rule

File Format: XSLT

Rule Type: SubTemplate

D.9.4 Almost Non Navigable Area

Name: Almost Non Navigable Area

Description:

ID: AlmostNonNavigableArea

Remarks:

File Name: AlmostNonNavigableArea.xsl

File Type: Rule

File Format: XSLT

Rule Type: SubTemplate

D.9.5 Non Navigable Area

Name: Non Navigable Area

Description:

ID: NonNavigableArea

Remarks:

File Name: NonNavigableArea.xsl

File Type: Rule

File Format: XSLT

Rule Type: SubTemplate

Annex E. Data Validation Checks

E.1.1 References

IHO S-58 ENC VALIDATION CHECKS Edition 6.0.0 – 2016

E.1.2 Abbreviations

PS – Product Specification

DCEG – Data Classification and Encoding Guide

E.1.3 Production validation checks for S-129 Under Keel Clearance Management

The following checks are intended for production systems designed to produce S-129 UKCM datasets. The checks can be administered at any time during the production phase. All checks should be considered as warnings, even though more severe classifications are available. Given the status of the development and lack of experience with system use of S-129 datasets, it is considered premature to classify any checks as error or critical error at this time. All operators and spatial expressions are defined in Annex F.

E.1.4 Check Classification

C	Critical Error	An error which would make an ENC unusable in ECDIS through not loading or causing an ECDIS to crash or presenting data which is unsafe for navigation.
E	Error	An error which may degrade the quality of the ENC through appearance or usability but which will not pose a significant danger when used to support navigation.
W	Warning	An error which may be duplication or an inconsistency which will not noticeably degrade the usability of an ENC in ECDIS.

E.1.5 Check application

B	Base	Apply check to new dataset, new edition, and post-update dataset (after updates have been applied to the base).
U	Update	Apply check to update datasets in isolation.
S	Post-update	Apply check only to a post-update dataset (i.e. subsequent to application of all available updates).

Checks do not apply to dataset terminations or cancellations, except where the check description explicitly states it applies in case of a termination or cancellation.

E.1.6 Checks relating to UKCM Product Specification

No	Check description	Check message	Check solution	Conformity to:	Apply to
1	If any mandatory attributes are not Present.	Mandatory attributes are not encoded.	Populate mandatory attributes.	DCEG and PS 7.2 Application Schema	B
2	If any mandatory attributes are present but the attribute value is unknown.	Mandatory attributes are encoded, but attribute value is unknown.	The reason for omission must be given by populating a GML nilReason attribute.	PS 7.2 Application Schema	B
3	For each feature object with an attribute of type Float or Integer where the value contains zeroes before the first numerical digit or after the last numerical digit.	Values have been padded with non-significant zeroes. E.g. For a signal period of 2.5 sec, the value of SIGPER must be 2.5 and not 02.500.	Remove non-significant zeroes.	PS 7.2 Application Schema	B
4	For each association between features instances, features instances and information instances, and between information instances that is not defined in the feature catalogue.	Wrong association used.	Use correct association type.	Logical consistency	B
5	For each role name on associations that is not defined in the feature catalogue.	Wrong role used.	Use correct role name.	Logical consistency	B
6	For each association that is not defined in the feature catalogue.	Unknown association is used.	Use association that is defined in the feature catalogue.	Logical consistency	B
7	For each role name that is not defined in the feature catalogue.	Unknown role name is used.	Use role name that is defined in the feature catalogue.	Logical consistency	B

No	Check description	Check message	Check solution	Conformity to:	Apply to
8	For each association ensure associated classes are only those permitted by the feature catalogue.	Class is associated in an illegal association.	Ensure correct association is used between classes.	Logical consistency	B
9	For each role name ensure it is only used with permitted associations.	Role name is used on an illegal association.	Ensure correct role names are used on the association.	Logical consistency	B
10	Ensure dataset conformance to the GML schema.	Dataset does not conform to the GML schema.	Ensure conformance to the GML schema.	Annex B. Schema documentation	B
11	If the file names in an exchange set are not in accordance with the Product Specification.	File names are not in accordance with the Product Specification.	Amend file names.	Logical consistency	B
12	For each feature instance, which does not have a valid feature class label/code as defined by the feature catalogue.	Object has invalid feature class code.	Amend object class code.	Logical consistency	B
13	For each attribute, which does not have a valid attribute label/code as defined by the feature catalogue.	Attribute has invalid attribute label/code.	Amend attribute label/code.	Logical consistency	B
14	For each feature object, which contains attributes outside the list of permissible attributes for the feature class (as defined in the feature catalogue).	Attribute not permitted on feature class.	Remove attribute.	Logical consistency	B
15	If the order of the data in a dataset is not correct.	Incorrect data order.	Amend data order.	Logical consistency	B

No	Check description	Check message	Check solution	Conformity to:	Apply to
16	For each attribute instance where the total number of instances exceed the permitted number of instances.	Too many instances of attribute.	Ensure correct attribute encoding.	Logical consistency	B
17	For each instance of a file referenced in the data, and if not present in the exchange set.	File referenced in the dataset is not present in the exchange set.	Add file to exchange set or remove reference to file.	Logical consistency	B
18	For each dataset discovery metadata file that does not correspond to the dataset discovery metadata content table.	Dataset discovery metadata file that does not correspond to the dataset discovery metadata content table.	Ensure correct encoding of the discovery metadata file.	Logical consistency	B
19	For each cancellation (termination) of a dataset that does not exist on the system or has already been cancelled.	Terminated dataset is not present.	Ignore the update.	Logical consistency	B, U
20	For each cancellation (termination) of a dataset where the update exchange set contains a corresponding dataset file.	Cancellations cannot contain data objects.	Remove the dataset file from the exchange set or correct the metadata.	Logical consistency	B, U
21	If any optional attributes are present but the attribute value is unknown or missing.	Optional attributes are encoded, but attribute value is unknown or missing.	Remove optional attributes when value is unknown or missing.	Logical consistency	B
22	For datasets not named according to dataset file naming convention.	Dataset file name is not according to file naming convention.	Rename according to naming convention.	Logical consistency	B

No	Check description	Check message	Check solution	Conformity to:	Apply to
23	For each feature instance of type FixedTimeRange where timeStart is encoded later than timeEnd.	Feature has timeStart encoded later than timeEnd.	Ensure values of FixedTimeRange subattributes timeEnd and timeStart are logical.	PS 7.2 Application Schema	B
24	For each feature instance where FixedTimeRange subattribute timeStart is notNull AND timeEnd is Null OR not Present.	Feature has timeStart without a value of timeEnd.	Populate timeEnd or remove timeStart.	PS 7.2 Application Schema	B
25	For each feature instance where FixedTimeRange subattribute timeEND is notNull AND timeStart is Null OR not Present.	Object has timeEnd without a value of timeStart.	Populate timeStart or remove timeEnd.	PS 7.2 Application Schema	B
26	For the Date Time attributes generationTime, expectedPassingTime, Timestart and TimeEnd where encoding is not according to format.	Attributes are not encoded according to attribute type format.	Encode according to attribute type format.	PS 7.2 Application Schema	B
27	For each UnderKeelClearancePlan without any UnderKeelClearanceControlPoint associated with it.	An UnderKeelClearancePlan must consist of minimum 1 UnderKeelClearanceControlPoint association.	Associate UnderKeelClearancePlan with UnderKeelClearanceControlPoint association.	PS 7.2 Application Schema	B

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Annex F. Geometry

F.1 Introduction

F.1.1 ISO 19125-1:2004 geometry

This section defines ISO 19125-2004 geometric terms used in this Annex.

F.1.1.1 Definitions for ISO 19125-1:2004 geometry

These definitions are for the primitives defined by ISO 19125-1:2004 which are single point, single Line and single area geometry objects:

1. *Polygon* – A Polygon has a geometric dimension of 2. It consists of a boundary and its interior, not just a boundary on its own. It is a simple planar surface defined by 1 exterior boundary and 0 or more interior boundaries. The geometry used by an S-57 Area feature is equivalent to a Polygon.
2. *Polygon boundary* – A Polygon boundary has a geometric dimension of 1 and is equivalent to the outer and inner rings used by an S-57 Area feature.
3. *LineString* – A LineString is a Curve with linear interpolation between Points. A LineString has a geometric dimension of 1. It is composed of one or more segments – each segment is defined by a pair of points. The geometry used by an S-57 Line feature is equivalent to a LineString.
4. *Line* – An ISO 19125-1:2004 line is a LineString with exactly 2 points. Note that the geometry used by an S-57 Line feature is equivalent to a LineString, not a line in ISO 19125-1:2004 terms. In this document the term Line refers to an S-57 Line feature or a LineString which can have more than two points.
5. *Point* – Points have a geometric dimension of 0. The geometry used by an S-57 Point feature is equivalent to an ISO 19125-1:2004 point.
6. *Reciprocal* – inversely related or opposite

The following table matches 19125-1:2004 geometric terms to S-57 terms:

ISO 19125-1:2004	S-57
Polygon	Area feature geometry OR Area
Polygon boundary	outer and inner rings
LineString	Line feature geometry OR Line
Point	Point feature geometry OR Point

F.1.1.2 Definition of symbols used in ISO 19125-1:2004

I = interior of a geometric object

E = exterior of a geometric object

B = boundary of a geometric object

\cap = the set theoretic intersection

U = the set theoretic union

\wedge = AND

$\dot{\cup}$ = OR

\neq = not equal

\emptyset = the empty or null set

a = first geometry, interior and boundary (the topological definition)

b = second geometry, interior and boundary (the topological definition)

dim = geometric dimension – 2 for Polygons, 1 for LineStrings and 0 for Points

Dim(x) returns the maximum dimension (-1, 0, 1, or 2) of the geometric objects in x, with a numeric value of -1 corresponding to dim (\emptyset).

Note:

1. Neither interior nor exterior include the boundary (i.e. I, E and B are mutually exclusive).
2. The boundary of a Polygon includes its set of outer and inner rings.
3. The boundary of a LineString is its end points except for a closed LineString, which has no boundary; the rest of the LineString is its interior.
4. A Point does not have a boundary.

F.1.2 ISO 19125-1:2004 geometric operator relationships

In ISO 19125-1:2004 (see Reference [1]), the dimensionally extended nine-intersection model (DE-9IM) defines 5 mutually exclusive geometric relationships between two objects (Polygons, LineStrings and/or Points). One and only one relationship will be true for any two given objects (see Reference [2]):

1. WITHIN
2. CROSSES
3. TOUCHES
4. DISJOINT
5. OVERLAPS

There are others that help further define the relationship:

1. CONTAINS
 - the reciprocal of WITHIN
 - within is the primary operator; however, if **a** is not within **b** then **a** may contain **b** so CONTAINS may be the unique relationship between the objects.
2. EQUAL
 - a special case of WITHIN / CONTAINS.
3. INTERSECTS
 - reciprocal of DISJOINT
 - have at least one point in common

4. COVERS and is COVERED_BY
 - reciprocal operators
 - extends CONTAINS and WITHIN respectively
5. COINCIDENT

Note that COVERS, COVERED_BY and COINCIDENT relational operators are not described in the ISO 19125-1:2004 document.

The formulas given in this annex (for example, $a.\text{Disjoint}(b) \Leftrightarrow a \cap b = \emptyset$) are the generalized ones given for ISO 19125-1, not the more specific DE-9IM formulas (i.e. DE-9IM predicates). The generalized formulas use topologically closed notation (i.e. geometry includes the interior and boundary unless otherwise stated), whereas the DE-9IM formulas refer to the interior and boundary of geometry separately. Note that different versions of documents describing 19125-1 give different generalized formulas – this annex is using the formulas that are the most consistent with the DE-9IM predicates. If a generalized formula appears to contradict a DE-9IM predicate as defined in ISO 19125-1:2004, the DE-9IM predicate takes precedence. Software is expected to be consistent with DE-9IM predicates.

F.1.3 How the relationships apply to S-57 Features

Geometric relationships will be tested on an entire S-57 feature object as a single geometric entity. Note that S-57 Point, Line and Area feature geometry is equivalent in ISO 19125-1:2004 terms to Point, LineString and Polygon geometry respectively.

A Line feature in S-57 may be made up of several individual edges. The geometric relationship operators used with a Line feature will consider the sequence of edges as a single geometry (LineString).

A test on an Area feature will operate on the entire Polygon.

In an S-57 file a Line or Area feature may be split into pieces as a result of a cutting operation from a data source. In that case each feature record in the dataset is treated as a separate LineString or Polygon when testing geometric relationships.

If a test intends to operate only on a feature's specific components – Polygon boundary (all rings), Polygon outer ring, Polygon inner rings, edges, vertexes or nodes then it must make this explicit in the description of the test. When a specific linear portion is specified in a test (Polygon boundary, edge) then it is treated as a LineString while individual vertexes or points will be treated as points.

For example, a test to look for cases where object class A OVERLAPS object class B would operate on the entire geometry. While a test to see if boundary of Area object class A OVERLAPS an edge of Line class B will be comparing Area boundaries to edges using Line to Line comparisons.

F.2 Geometric Operator Definitions

ISO 19125-1 definitions referenced in this section, refer to section 6.1.14.3 entitled “Named spatial relationship predicates based on the DE-9IM” in the ISO 19125-1:2004 document.

In the diagrams within this annex LineString corresponds to the S-57 Line geometric primitive.

F.2.1 EQUALS

Geometric object **a** is spatially equal to geometric object **b**.

The two geometric objects are the same. This is a special case of WITHIN.



Figure F-1 – Examples of the EQUALS relationship

Note: ISO 19107:2003 describes equality more formally as:

Two different GM_Objects are equal if they return the same Boolean value for the operation GM_Object::contains for every tested DirectPosition within the valid range of the coordinate reference system associated to the object.

NOTE – Since an infinite set of direct positions cannot be tested, the internal implementation of equal must test for equivalence between two, possibly quite different, representations. This test may be limited to the resolution of the coordinate system or the accuracy of the data. Application schemas may define a tolerance that returns true if the two GM_Objects have the same dimension and each direct position in this GM_Object is within a tolerance distance of a direct position in the passed GM_Object and vice versa.

For the purposes of S-129, a GM_Object is any spatial object as described in F.1.1.1 (Polygons, LineStrings, and Points). A spatial object is always equal to itself, that is, **a EQUALS a** is always true.

F.2.2 DISJOINT

Geometric object **a** and geometric object **b** do not intersect.

The two geometric objects have no common points.

The ISO 19125-1 definition of DISJOINT is:

$$\mathbf{a.Disjoint(b)} \Leftrightarrow \mathbf{a} \cap \mathbf{b} = \emptyset$$

This translates to: **a** is disjoint from **b** if the intersection of **a** and **b** is the empty set.

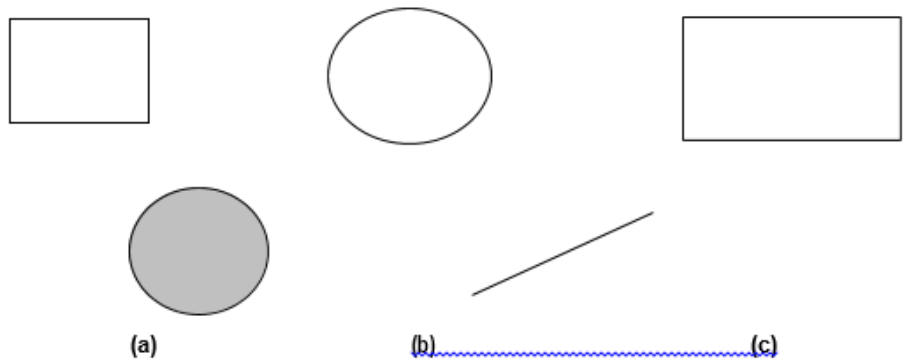


Figure F-2 – Examples of the DISJOINT relationship

F.2.3 TOUCHES

Geometric object **a** intersects with geometric object **b** but they do not share interior points.

Only the boundary of one geometry intersects with the boundary or interior of another geometry.

The only thing the geometric objects have in common is contained in the union of their boundaries.

The ISO 19125-1 definition of TOUCHES is:

$$\mathbf{a.Touch(b)} \Leftrightarrow (\mathbf{I(a)} \cap \mathbf{I(b)} = \emptyset) \wedge (\mathbf{a} \cap \mathbf{b}) \neq \emptyset$$

This translates to: **a** touches **b** if the intersection of the interior of **a** and the interior of **b** is the empty set

AND the intersection of **a** and **b** is not the empty set.

Note: This operator applies to the Area/Area, Line/Line, Line/Area, Point/Area and Point/Line relationships. It does not apply to a Point/Point relationship since points do not have a boundary.

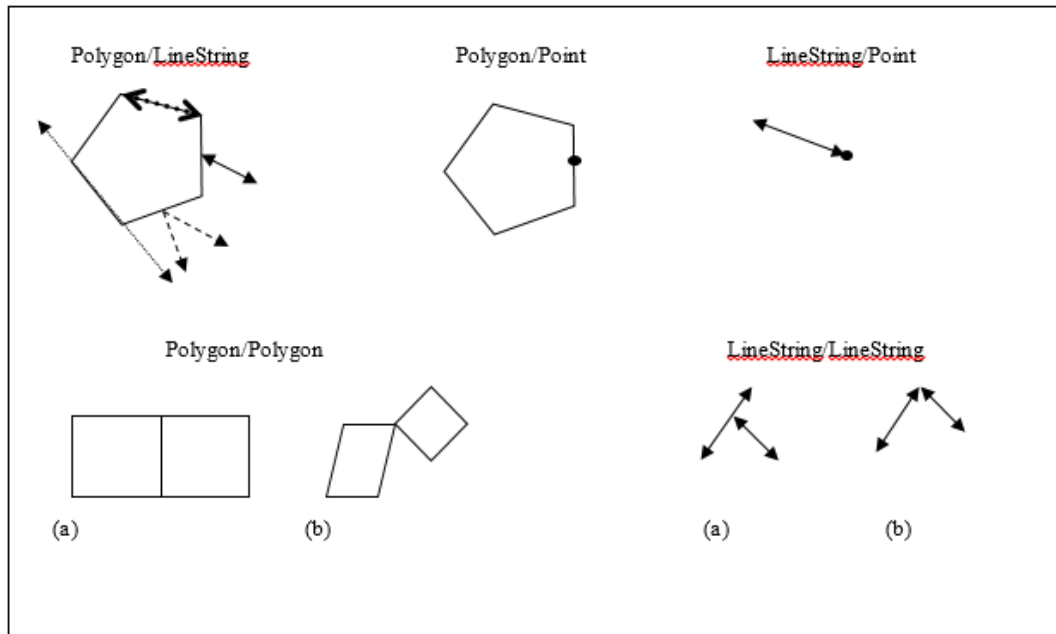


Figure F-3 – Examples of the TOUCHES relationship

Note the Polygon touches Polygon example (a) is also a case where the Polygon boundaries are COINCIDENT. In the Polygon/LineString example two of the LineStrings that share a linear portion of the Polygon boundary are also COINCIDENT with the Polygon boundary.

F.2.4 WITHIN

Geometric object **a** is completely contained in geometric object **b**.

WITHIN includes EQUALS.

The definition of WITHIN is:

$$\mathbf{a}.\text{Within}(\mathbf{b}) \Leftrightarrow (\mathbf{a} \cap \mathbf{b} = \mathbf{a}) \wedge (I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset)$$

This translates to: **a** is within **b** if the intersection of **a** and **b** equals **a** AND the intersection of the interior of **a** and the interior of **b** is not the empty set.

Note that this formula matches the one given in the **OpenGIS Simple Features Specification for SQL, Revision 1.1 (OpenGIS Project Document 99-049, Release Date: May 5, 1999)** which is the precursor to ISO 19125-1.

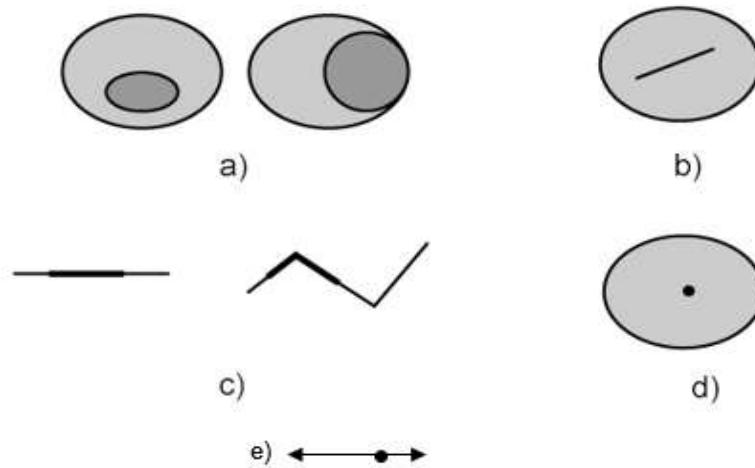


Figure F-4 – Examples of the WITHIN relationship — Polygon/Polygon (a), Polygon/LineString (b), LineString/LineString (c), Polygon/Point (d), and LineString/Point (e)

Note that a Line that completely falls on a Polygon boundary is not WITHIN the Polygon, it TOUCHES it. In that case it would also be COINCIDENT with the Polygon boundary and COVERED_BY the Polygon.

F.2.5 OVERLAPS

The intersection of two geometric objects with the same dimension results in an object of the same dimension but is different from both of them.

For two Polygons or two LineStrings, part of each geometry, but not all, is shared with the other.

The OVERLAPS relationship is defined for Area/Area and Line/Line relationships. Points are either equal or disjoint.

Note that this does not include lines that cross.

The ISO 19125-1 definition of OVERLAPS is:

$$\mathbf{a.Overlaps(b)} \Leftrightarrow (\dim(I(\mathbf{a})) = \dim(I(\mathbf{b})) = \dim(I(\mathbf{a}) \cap I(\mathbf{b}))) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{a}) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{b})$$

This translates to: **a OVERLAPS b** if the geometric dimension of:

1. the interior of **a**
2. the interior of **b**
3. the intersection of the interiors of **a** and **b**

are all equal AND the intersection of **a** and **b** does not equal either **a** or **b**.

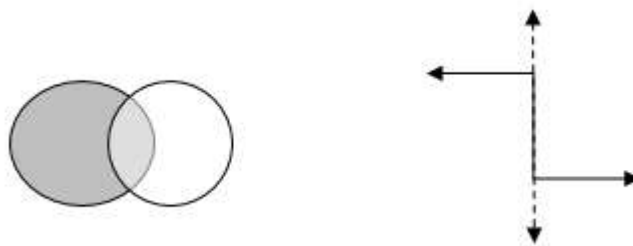


Figure F-6 – Examples of the OVERLAPS relationship

Note Lines that OVERLAP are also COINCIDENT.

F.2.6 CROSSES

The intersection of geometric object **a** and geometric object **b** returns geometry with a dimension less than the largest dimension between **a** and **b** but is not the same as geometric object **a** or **b**.

Two LineStrings cross each other if they meet on an interior point. A LineString crosses a Polygon if the LineString is partly inside the Polygon and partly outside.

The definition of CROSSES is:

$$\mathbf{a.Cross(b)} \Leftrightarrow (I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset) \wedge (dim(I(\mathbf{a}) \cap I(\mathbf{b})) < \max(dim(I(\mathbf{a})), dim(I(\mathbf{b})))) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{a}) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{b})$$

This translates to: **a** crosses **b** if the intersection of the interiors of **a** and **b** is not the empty set AND the dimension of the result of the intersection of the interiors of **a** and **b** is less than the largest dimension between the interiors of **a** and **b** AND the intersection of **a** and **b** does not equal either **a** or **b**.

Note that “ $(I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset) \wedge$ ” was added to the beginning of the ISO 19125-1 formula so that it would not be true for disjoint geometry.

The CROSSES operator only applies Line/Line and Line/Area relationships.

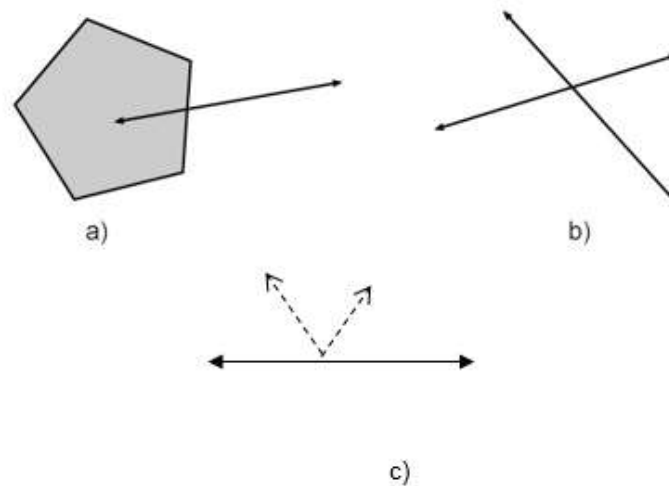


Figure F-7 – Examples of the CROSSES relationship

Note that example c) shows one solid line and one dashed line – their interiors intersect. If any Line were split into two separate Line features at the intersection point then the relationship would be TOUCHES because a boundary would be involved.

F.2.7 INTERSECTS

is the reciprocal of DISJOINT.

The two geometric objects cross, overlap or touch, or one is within (or is contained by) the other. They have at least one common point.

F.2.8 CONTAINS

is the reciprocal of WITHIN.

*Given two geometric objects, **a** and **b**, if **a** is within **b** then **b** must contain **a**.*

F.2.9 COVERED_BY

(not a standard ISO 19125-1 operator)

No point of geometry **a** is outside geometry **b**.

The definition of COVERED_BY is:

$$\mathbf{a. \text{ COVERED_BY } (b) \Leftrightarrow (a \cap b = a)}$$

This translates to: **a** is COVERED_BY **b** if the intersection of **a** and **b** equals **a**.

The following expressions are equivalent to **a** is COVERED_BY **b**:

1. Polygon (**a**) is COVERED_BY Polygon (**b**): Polygon **a** is WITHIN a polygon **b** (WITHIN includes EQUALS)
2. Point (**a**) is COVERED_BY Polygon (**b**): Point **a** is WITHIN or TOUCHES polygon **b**
3. Line (**a**) is COVERED_BY Polygon (**b**): Line **a** is WITHIN polygon **b** or WITHIN the boundary of Polygon **b**
4. Line (**a**) is COVERED_BY Line (**b**): Line **a** is WITHIN Line **b** (WITHIN includes EQUALS)
5. Point (**a**) is COVERED_BY Line (**b**): Point **a** is WITHIN or TOUCHES Line **b**
6. Point (**a**) is COVERED_BY Point (**b**): Point **a** EQUALS Point **b**

Note that the figure below on the left is an example of Lines that are COVERED_BY a polygon.

The figure on the right is NOT an example of a Line that is covered by a Polygon – it is an example of a Line that TOUCHES a Polygon. In both cases the Lines are COINCIDENT with the Polygon boundary.

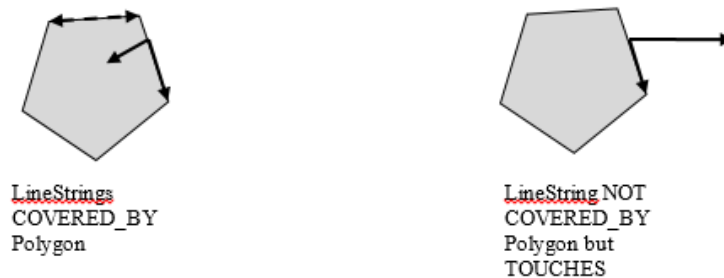


Figure F-8 – COVERED_BY relationship

F.2.10 COVERS

(not a standard ISO 19125-1 operator)

COVERS is the reciprocal of COVERED_BY.

*Given two geometric objects, **a** and **b**, if **a** is COVERED_BY **b** then **b** must cover **a**. COINCIDENT*

(not an ISO 19125-1 operator)

F.2.11 COINCIDENT

Two geometric Lines OVERLAP or one geometric Line is WITHIN the other. Note that EQUAL Lines are also COINCIDENT by this definition.

The intersection of two geometric Lines results in one or more Lines.

This operator is only to be used to compare a Line with another Line. Note that normally the boundary of a Polygon is not the same as a Line but for this operation the boundary of a Polygon, exterior and interior rings, is treated as Lines for the COINCIDENT test.

The following expressions are equivalent to **a** is COINCIDENT with **b**:

1. Polygon (**a**) is COINCIDENT with Polygon (**b**): The boundary of Polygon **a** OVERLAPS or is WITHIN the boundary of Polygon **b**.
2. Line (**a**) is COINCIDENT WITH Polygon (**b**): Line **a** OVERLAPS or is WITHIN the boundary of Polygon **b**.
3. Line (**a**) is COINCIDENT WITH Line (**b**): Line **a** OVERLAPS or is WITHIN Line **b**

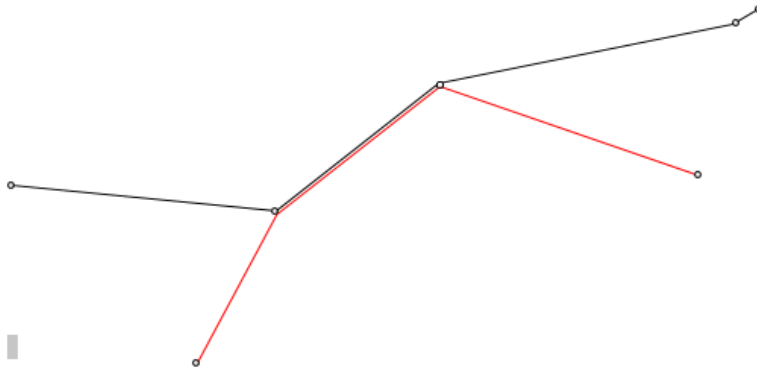


Figure F-9 – Example of COINCIDENT relationship (line geometry)

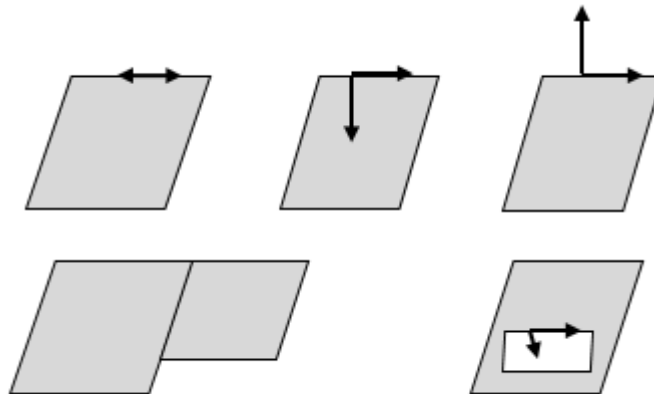


Figure F-10 – Example of COINCIDENT relationship (polygon boundary)

Above are other examples of objects COINCIDENT with the boundary of a Polygon. LineStrings following a portion of a Polygon boundary or Polygons sharing a boundaryportion.

Note that by definition a Line can be COINCIDENT with an interior boundary of a Polygon.

Note that other relationships may also be true such as COVERED_BY or TOUCHES since COINCIDENT is not mutually exclusi

F.3 Bibliography

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