

INTERNATIONAL STANDARD



**Maritime navigation and radiocommunication equipment and systems –
Data interfaces –
Part 1: S-421 route plan based on S-100**

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Part 1: S-421 route plan based on S-100**

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EQUIPMENT AND SYSTEMS – DATA INTERFACES –****Part 1: S-421 route plan based on S-100****FOREWORD**

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
80/997/FDIS	80/1000/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 63173 series, published under the general title *Maritime navigation and radiocommunication equipment and systems – Data interfaces*, can be found on the IEC website.

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- reconfirmed,
- withdrawn,
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INTRODUCTION

The voyage plan is a key element of a vessel's voyage and can be used to optimize safety and processes, as well as for the interaction of participants and stakeholders.

The core element of the voyage plan is the route.

The exchange of routes (whether it be between ship-to-ship, ship-to-shore or shore-to-shore) may improve

- situational awareness,
- reduction in the number of accidents and incidents (by proactively de-conflicting routes),
- resource utilization by knowing the intentions of other actors,
- secured passages by knowing the intentions of other actors,
- predictability of arrivals and departures by early information sharing,
- planning for involved actors leading to reduced idle time for resources, and
- just-in-time operations by enabling stakeholders and service providers to be efficiently organized for handling vessel movements, port resources, and hinterland connections.

This document has been registered with the IHO S-100 registry as product specification S-421. A S-100 product specification is a description of the features, attributes and relationships of an application and their mapping to a dataset. It is a complete description of all the elements required to define a particular geographic data product.

IHO S-97 describes readiness levels of product specifications to show a progression from an idea to regular use. S-421 is currently at the initial level 1 pending demonstration in a real-world environment.

S-100 uses camelCase for naming. CamelCase names are made up of words joined together without spaces and capitalised within the compound using a limited set of English letters. Feature and information types begin with uppercase A-Z and attributes and values begin with lowercase a-z.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – DATA INTERFACES –

Part 1: S-421 route plan based on S-100

1 Scope

This part of IEC 63173 specifies an S-100 compliant product specification for route plan intended for exchange of information. It specifies the content, structure, and metadata needed for creating fully S-100 compliant route plan information and its portrayal within an S-100-based application. The IHO manages all numbers for S-100 compliant product specifications and has assigned S-421 for this route plan IEC standard.

This document specifies only a data format for the route plan exchange. This document does not specify a data format of vessel monitoring and logging information. This information can be provided by other mechanisms or be specified in other standards.

The format of the route plan exchange includes some limited vessel static information. When more static information is required, it can be obtained by other methods such as AIS.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

S-100:2018, *IHO Universal Hydrographic Data Model* (edition 4.0.0)

3 Terms and definitions

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

active route

route which is currently monitored for the voyage which may contain the schedule information

3.2

actor

human or machine that takes part in the route plan exchange process

3.3

feature

abstraction of real-world phenomena

Note 1 to entry: A feature may occur as a type or an instance. A feature type or a feature instance should be used when only one is meant as described in S-100.

3.4 feature catalogue

catalogue containing definitions and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data as defined in S-100

3.5 planned route

candidate route for the active route of the voyage

Note 1 to entry: The schedule information may be set by the ship.

3.6 portrayal

presentation of information to humans as defined in S-100

Note 1 to entry: This document is restricted to the portrayal of geographic information.

3.7 portrayal catalogue

collections of defined portrayals for a feature catalogue as defined in S-100

Note 1 to entry: Content of the portrayal catalogue includes portrayal functions, symbols, and portrayal context parameters.

3.8 recommended route

route recommended by external actors (e.g. national authorities or commercial organizations) to own ship for the planned route of the voyage

3.9 recommended time

time set by external actors to own ship for the planned route of the voyage

3.10 reference route

route without any vessel-specific information that can assist in the creation of a route plan for a particular vessel

3.11 route information

all related route objects specified in this document

3.12 waypoint

reference point in physical space used for purposes of navigation

Note 1 to entry: It describes the geographical components of the route.

4 Abbreviated terms

ENC	electronic navigational chart
GML	geography markup language
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
ETA	estimated time of arrival

ETD estimated time of departure

EUT equipment under test

5 General description

5.1 General data product description

The data product of a route plan is described as specified in Table 1.

Table 1 – Informal description of the data product

Field	Description
Title	Route plan
Abstract	This data product describes real-world route plan and its related information.
Content	The product specification defines all requirements to which route plan data products shall conform. Specifically, it defines the data product content in terms of features and attributes within the feature catalogue. The display of features is defined by the symbols and rule sets contained in the portrayal catalogue
Spatial extent	Description: East bounding longitude: 180° West bounding longitude: –180° North bounding latitude: 90° South bounding latitude: –90°
Specific purpose	The purpose of a route plan dataset is to provide official route plan data to an S-100 based application for the safe and efficient passage and route of vessels to destinations.

5.2 Data product specification metadata

Table 2 uniquely identifies this document and provides information about its creation and maintenance. For further information on dataset metadata, see 11.4.

Table 2 – Data product specification metadata

Field	Description
Title	Route plan
S-100 version	4.0.0
Version	1.0
Language	English
Classification	Unclassified
Contact	International Electrotechnical Commission 3, rue de Varembé P.O. Box 131 CH – 1211 Geneva 20 – Switzerland Telephone: +41 22 919 02 11 Fax: + 41 22 919 03 00
URL	www.iec.ch
Identifier	S-421
Maintenance	Changes to the product specification S-421 coordinated by IEC TC 80

5.3 Product specification maintenance

This document for route plan complies with the maintenance schedule and policy in IEC.

5.4 Specification scopes

The product specification scope of the route plan is specified in Table 3.

Table 3 – Route plan product specification scope

Field	Description
Scope ID	Product
Level	006-series
Level name	Route plan

5.5 Dataset identification

The dataset identification information for this document is specified in Table 4.

Table 4 – Dataset identification

Field	Description
Title	Route plan
Alternate Title	Route plan exchange
Abstract	The route plan for the radiocommunication and navigational equipment and system shall be produced in accordance with the rules defined in this document. This document contains all the information necessary to enable users to produce a consistent route plan and to use that data efficiently in an application
Topic category	Transportation (ISO 19115 domain code 018)
Geographic description	Areas specific to marine navigation
Spatial resolution	Varies. The spatial resolution varies according to the application.
Purpose	Route plan exchange
Language	English (mandatory), other (optional)
Classification	Unclassified
Spatial representation type	Vector
Point of contact	Producing agency
Use limitation	Not to be used for navigation on land

6 Data content and structure

6.1 General

The route plan is a feature-based product. The content information is described in terms of a general feature model and a feature catalogue.

IMO has defined in MSC.232(83) minimum requirements for route planning in ECDIS. A route consists of both straight and curved segments. The route includes user selectable limits for checking navigational hazards. Further, a route includes user selectable cross track limits for automatic off-track alarms. In this document, curved segments are defined by radius-controlled turns in each waypoint. Also, the checking and cross track limit of starboard and port is defined in each waypoint.

IMO has defined voyage planning in A.893(21) and A.999(25). IMO voyage planning goes beyond this document and therefore this document does not use "voyage plan" for a route plan which contains some, but not all elements required for an IMO voyage plan.

This document uses the term "annotated route plan" for a plan which, in addition to route plan, contains some elements of the IMO voyage plan as georeferenced text or document (see Annex C).

The route plan contains elements intended for both mandatory and optional implementation. The optional elements to implement in this document do not describe all functionality which could be built around them. If a manufacturer wishes to implement at least some of the optional elements, he can provide a viewer or editor for these elements. This document specifies a standardized transfer format, and some use cases are described in Annex A.

6.2 Application schema

Route plan information conforms to the general feature model (GFM) from S-100, Part 3. The GFM is the conceptual model and the implementation is defined in the feature catalogue. The route plan information application schema is realized in the feature catalogue and the product specification only contains specific examples.

Figure 1 shows the route plan application schema which illustrates all objects and the associations among objects. The route plan is defined to be flexible and easily expandable. All objects in the schema have an attribute which has RouteExtensions data type. The mandatory and optional fields are specified with the descriptions of the attributes.

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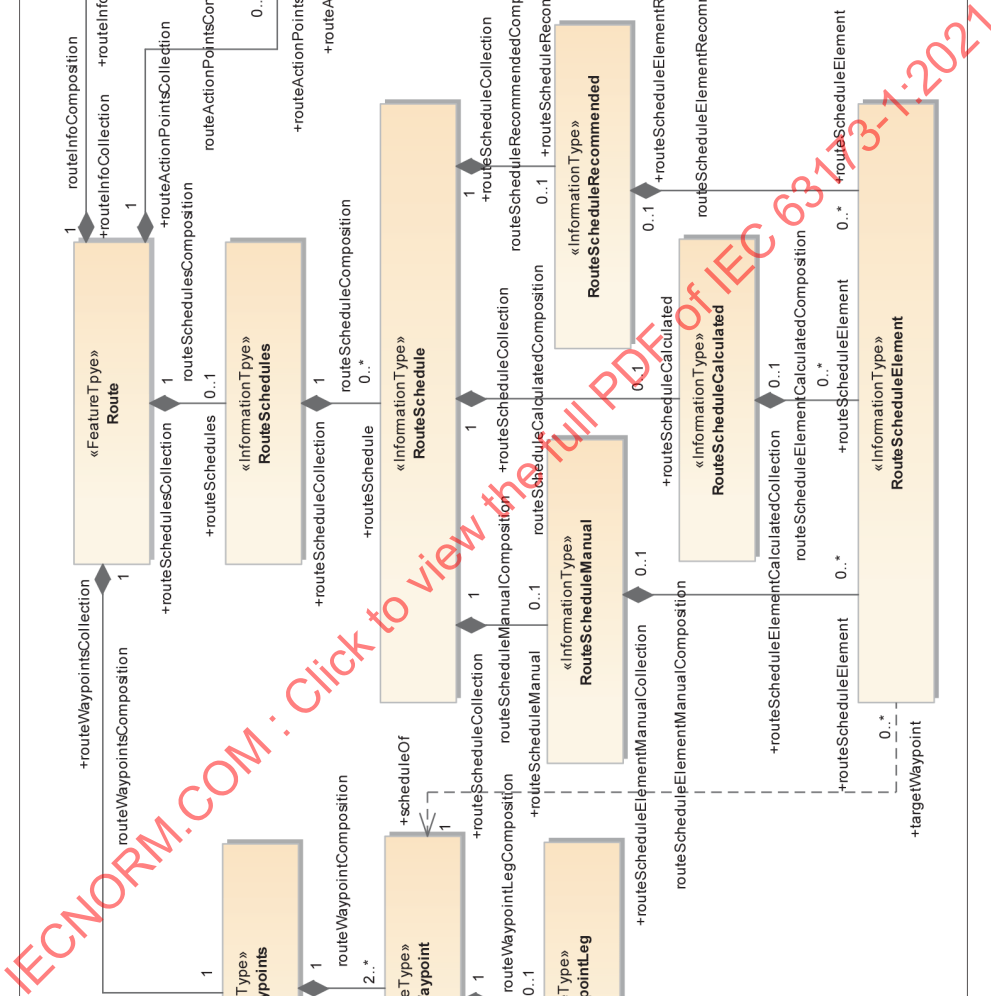


Figure 1 – Route plan application schema

6.3 Preservation of unknown content

Actors that either retransmit an unmodified route plan or modify and transmit an existing route shall ensure that any data that the actor does not require or understand is preserved. This data might include optional elements that the actor does not use, or RouteExtensions that have been added by other actors.

6.4 Geometry

The IHO S-100 model includes multiple geometries. This route plan exchange standard supports level 1 geometry which supports isolated and curve primitives from IHO (see Clauses 7-4.3.1 in S-100). In this document, each point represents a waypoint. The geometry of the route based on the waypoint is as described in 7.2.8.

6.5 Coordinate reference systems

The coordinate reference system used for this document is World Geodetic System 1984 (WGS 84).

The specification is given in Table 5.

Table 5 – Route plan coordinate reference systems

Field	Description
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 (all parts))	002 - publication
Responsible party	International Organisation of Oil and Gas Producers (OGP)
URL	http://www.iogp.org

7 Feature catalogue

7.1 General

The route plan feature catalogue describes the feature types, information types, attributes, attribute values, associations and roles which may be used in a route plan dataset.

The route plan feature catalogue is available in a machine-readable printed version which conforms to the S-100 XML feature catalogue schema and can be downloaded from the CIRM¹ website (<http://cirm.org/s-421>). It is also available in Annex D as a human readable version.

When there are conflicts in the texts, tables, data model (see Figure 1) or schema, the machine-readable files shall take precedence.

The "Implementation" column in the object attribute tables has two alternatives: mandatory and optional.

¹ Comité International Radio-Maritime, the International Association for Marine Electronic Companies, www.cirm.org

- Mandatory means that the attribute, when provided, shall always be implemented and shall always be possible to support, i.e. process and/or interpret, for example view, edit and associated functionality.

NOTE This is not the same as that the attribute is mandatory to exchange.

- Optional means that it is voluntary for the receiver to implement support for that attribute.

The multiplicity column in the tables describes the number of elements that can be provided. Even though mandatory is in the implementation column, the value in the multiplicity column may be zero to one or zero to many, i.e. the attribute can be omitted even if the value of implementation column is mandatory. For example, routeInfoValidityStart has Implementation mandatory but has multiplicity of 0..1. This is a requirement to support it but no requirement to provide it. The routeInfoStatus has multiplicity 1 and the attribute shall thus be supported and shall have a value.

Tables in Annex A specify the objects and attributes used for a specific use case. Fields in tables marked "mandatory" specify fields that shall contain a value when exchanged in the specific use case. All actors that support the use case shall implement and process all fields (mandatory and optional) that are specified in that use case.

7.2 Feature types

7.2.1 Geographic

Geographic (geo) feature types form the principal content of the dataset and are fully defined by their associated attributes and information types.

7.2.2 Meta

Meta features contain information about other features within a data set. Information defined by meta features override the default metadata values defined by the data set descriptive records.

7.2.3 Route

The Route object attributes are given in Table 6.

The version of route plan has a format X.Y. First value X of routeFormatVersion is updated when a significant change(s) is done in the route format structure. This includes

- 1) when the status of some recognizable element (e.g. XTD) is changed from Optional to Mandatory,
- 2) when new elements to the route format are added,
- 3) when some elements in the route format are deleted, and
- 4) where there are some changes to the XSD schema.

The second value Y of routeFormatVersion is updated when "typographical" changes are done, which do not affect the format itself. This includes

- 5) when there are additional explanations in the description of the format, and
- 6) when unrecognizable updates (i.e. add, delete and update) are made.

7.2.4 RouteActionPoints

The feature RouteActionPoints shall contain at least one RouteActionpoint object.

7.2.5 RouteActionPoint

The RouteActionPoint is intended to add elements of the associated voyage plan (see IMO A.893 (21)) into the basic route plan consisting of the waypoints and legs between the waypoints. The RouteActionPoint has the flexibility to use either point with radius, line with specified distance or area as a method to activate actions associated with waypoints or legs, or notes where a waypoint or leg cannot be used, for example to activate ship reporting when crossing a line or to act based on voyage planning when within a radius from a point (see Table 7, Table 8 and Table 9). Further examples of the use cases of RouteActionPoint are:

- instruction to report to a ship reporting system about entering the area using VHF (ship reporting);
- instruction to report to a ship reporting system via Website (ship reporting);
- instruction to report to entering into a VTS area (ship reporting);
- note about being too close to no-go area defined by the master (voyage plan);
- note about being aware of squat effect if the speed is more than 18 kn (voyage plan);
- note about being in area which require pilot (voyage plan);
- instruction to confirm pilot order (voyage plan);
- instruction to change used fuel to be compliant with a MARPOL area (voyage plan);
- instructions to reduce ballast water when sailing over a shallow area (voyage plan);
- instructions to perform check of position using line of position (LOP) method (voyage plan);
- instruction to select Radar and ECDIS setting suitable for area ahead (voyage plan).

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Table 6 – Route object attributes

Attribute Name	Description	Data type	Multiplicity	Implementation	Remarks
routeFormatVersion	The version of this route format	String	1	Mandatory	Describe when these numbers are changed, Format: X.Y X: Major version Y: Minor version
routeID	Unique route identifier	String	1	Mandatory	Unique identifier of the route
routeEditionNo	Route edition number	Integer	1	Mandatory	This number is increased by one whenever the route information has changed. Exceptions for not increasing the number of routeEditionNo are changes when only routeInfoDescription, routeWaypointLegIssue or routeInfoStatus attributes have been changed.
routeExtensions	Additional proprietary information for the route specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 7 – RouteActionPoints object attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
routeActionPointsExtensions	Additional proprietary information for the action points specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 8 – RouteActionPoint object attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
routeActionPointID	Identifier of the action point. The identifier shall be unique in the route.	Integer	1	Mandatory	Positive integer
routeActionPointName	Name of action point	String	0..1	Optional	
routeActionPointExternalReference	External reference information related to the action point	String	0..1	Optional	
geometry	Geographical position of the action point in degrees Examples : <geometry> <S100:pointProperty> <S100:Point gml:id="RTE.APT.1.PT" srsName="EPSG:4326"> <gml:pos>12.0 56.0</gml:pos> </S100:Point> </S100:pointProperty> </geometry>	GM_Point, GM_Curve, GM_Surface	1	Mandatory	For value range see IHO S-100 The minimum resolution is 0,000 1°
routeActionPointRadius	Distance from the action point within which action shall be taken.	Real	0..1	Mandatory for GM_Point	Unit: NM Positive real
routeActionPointTimeToAct	Time before or after the action point	Real	0..1	Mandatory	Unit: minutes Negative values: time before Positive values: time after
routeActionPointRequiredAction	The action required for this action	Enumeration	1	Mandatory	See Table 9
routeActionPointRequiredActionDescription	Human readable description of the action required for this action point	String	1	Mandatory	
routeActionPointExtensions	Additional proprietary information for the RouteActionPoint specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 9 – Definition of RouteActionPointRequiredAction

Enumeration value	Description	Remarks
1	User defined	Action is available in the field routeActionPointRequiredActionDescription
2	Report	Report from vessel to shore
3	UKCM	UKCM report
4	Note	Additional information related to the route
5 to 9	Reserved	Reserved for future use

Table 10 – RouteWaypoints object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeWaypointExtensions	Additional proprietary information for the waypoints specified by the manufacturer	RouteExtensions	0..*	Optional	

7.2.6 RouteWaypoints

The feature RouteWaypoints described in Table 10 shall contain two or more RouteWaypoint objects, when the value of the RouteInfoStatus is other than “Acknowledged”, “Terminated”, “Errors”, “Service started” or “Service ended” (see 7.3.6).

NOTE The listed cases (Terminated, Errors, Service started and Service ended) are events, and the RouteInfo object alone is sufficient to communicate the event.

The sailing order shall be determined by the appearance order of RouteWaypoint objects and shall be the same as the order of the references in RouteWaypoints object.

7.2.7 RouteWaypoint

The routeWaypointID (see Table 11) shall be unique within a route, i.e., there shall be no waypoints with the same ID within one route. The routeWaypointID field for a waypoint is not related to the order of waypoints. The waypoint identifiers permit references to the geometry (rather than the succession order) from other objects, for example from the RouteScheduleElement.

The routeWaypointTurnRadius attribute shall contain a non-negative number smaller or equal to 5 NM, since a larger value of this parameter is not practical, and the upper limit provides a higher “junk” detection probability. This field shall be accurate to at least one decimal place. This field presentation precision may vary from 0,1 NM to 0,01 NM. If turn radius is not decided, the value is zero (0,0), for example first waypoint, last waypoint and recommended waypoints from shore.

NOTE It is essential that this route has a strictly defined geometry, and the turn radius, in its waypoint, has a considerable effect on this geometry, and therefore is not indefinite.

The RouteWaypoint objects contain data related to the geometry of the route. The geometry shall contain the latitude and longitude values expressed in degrees. Coordinates shall be presented with at least five decimal places. These values may vary from 0,000 1° (with a precision in the order of 10 m) to 0,000 000 1° (with a precision in the order of 1 cm) depending on the application area.

Figure 2 and Figure 3 show examples of deleting and inserting waypoints and how routeWaypointID is used alongside how the waypoints in a route are presented to the end user.

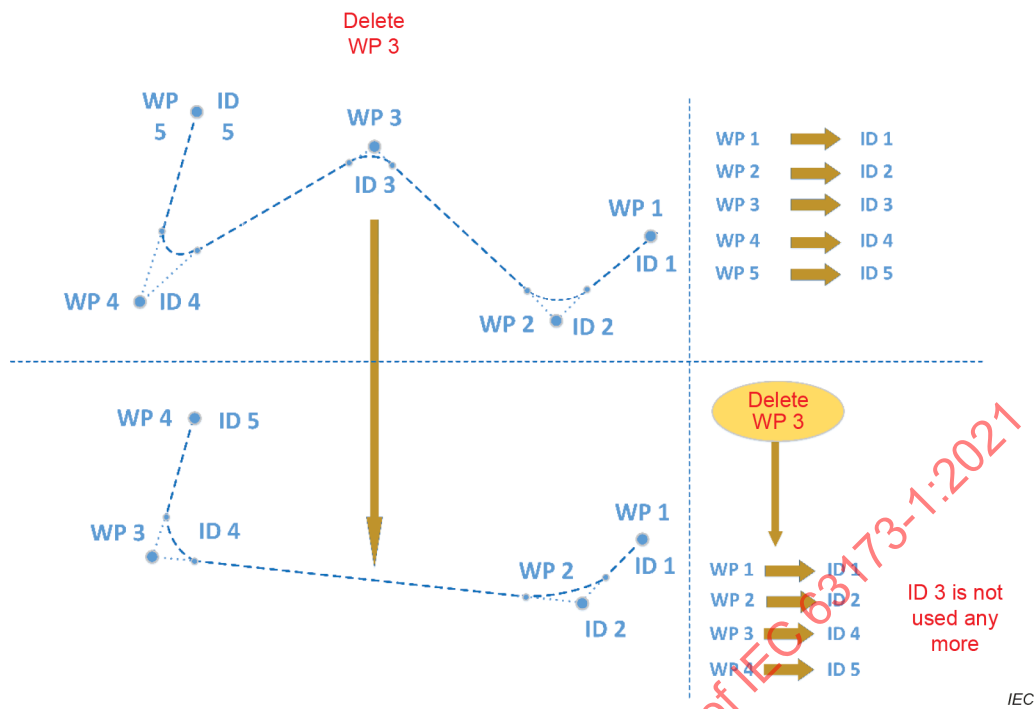


Figure 2 – RouteWaypointID usage examples: Delete

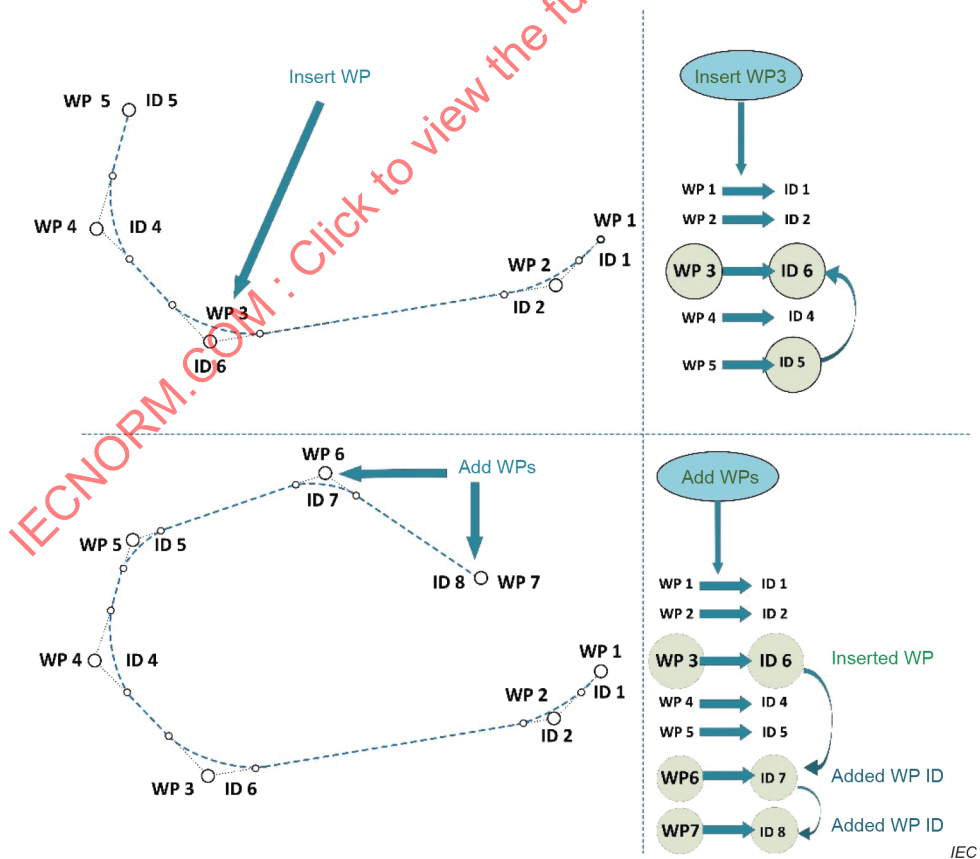


Figure 3 – RouteWaypointID usage examples: Insert

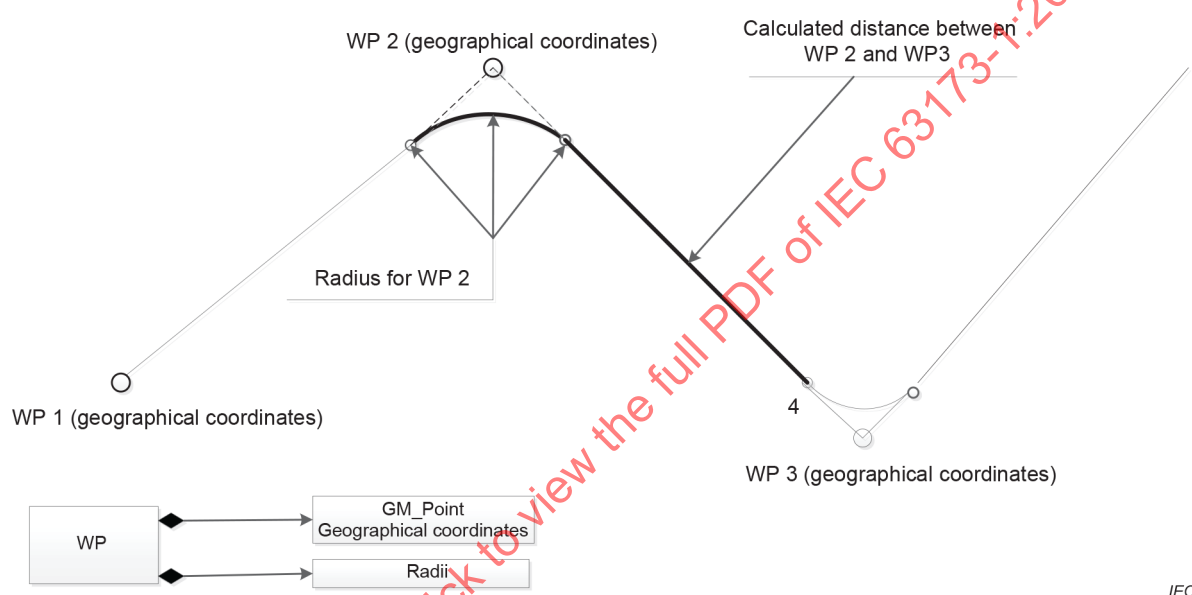
Table 11 – RouteWaypoint object attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
routeWaypointID	Identifier of the waypoint. The identifier shall be unique in the route.	Integer	1	Mandatory	Positive integer
routeWaypointName	Name of waypoint	String	0..1	Mandatory	
routeWaypointExternalReferenceID	External reference information related to the waypoint	String	0..1	Optional	
routeWaypointFixed	Indicator if the route waypoint is fixed or editable	Boolean	0..1	Mandatory	By default, all waypoints are editable unless set to fixed. FALSE: Editable. Deletion or update of the waypoints including waypoint position. TRUE: Fixed. No deletion or update of the waypoint position.
geometry	Geographical position of the waypoint in degrees Examples: <geometry> <S100:pointProperty> <S100:Point gml:id="RTE.WP.1.PT" srsName="EPSG:4326"> <gml:pos> 59 483136 22 609812 </gml:pos> </S100:Point> </S100:pointProperty> </geometry>	GM Point	1	Mandatory	For value range, see IHO S-100. The minimum resolution is 0,000 1°.
routeWaypointTurnRadius	Turn radius in nautical miles	Real	1	Mandatory	The value range is 0,0 NM to 5,0 NM The maximum resolution is 0,01 NM
routeWaypointExtensions	Additional proprietary information for the Route waypoints specified by the manufacturer	RouteExtensions	0..*	Optional	

7.2.8 RouteWaypointLeg

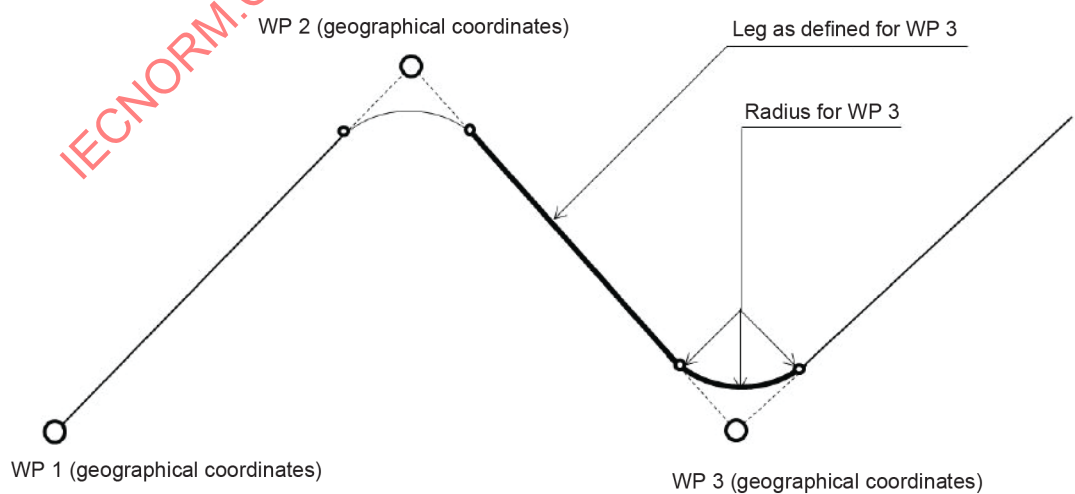
The RouteWaypointLeg object (see Figure 4 and Figure 5) is optional for a waypoint which contains related information from a waypoint. The order of the RouteWaypointLeg elements follows the order of the RouteWaypoint elements as defined in RouteWaypoints.

Each route leg is formed within the framework of the set geometry (great circle or rhumb line) on the terrestrial ellipsoid. The routeWaypointLegGeometryType element is mandatory. Each route waypoint leg is formed as the shortest of all the possible segments within the framework of the set geometry in two waypoints. It shall be in the range $-180^\circ \leq \text{lon} \leq 180^\circ$ and $-90^\circ \leq \text{lat} \leq 90^\circ$. With this restriction, each point on the terrestrial surface (except for the poles, which can be corrected by setting zero longitudes only for them) can be uniquely correlated with a lat/lon pair. Moreover, introduction of this restriction permits, as in the case of the turn radius, easy detection of the "junk" longitude values.



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Figure 4 – RouteWaypointLegDistance between WP2 and WP3

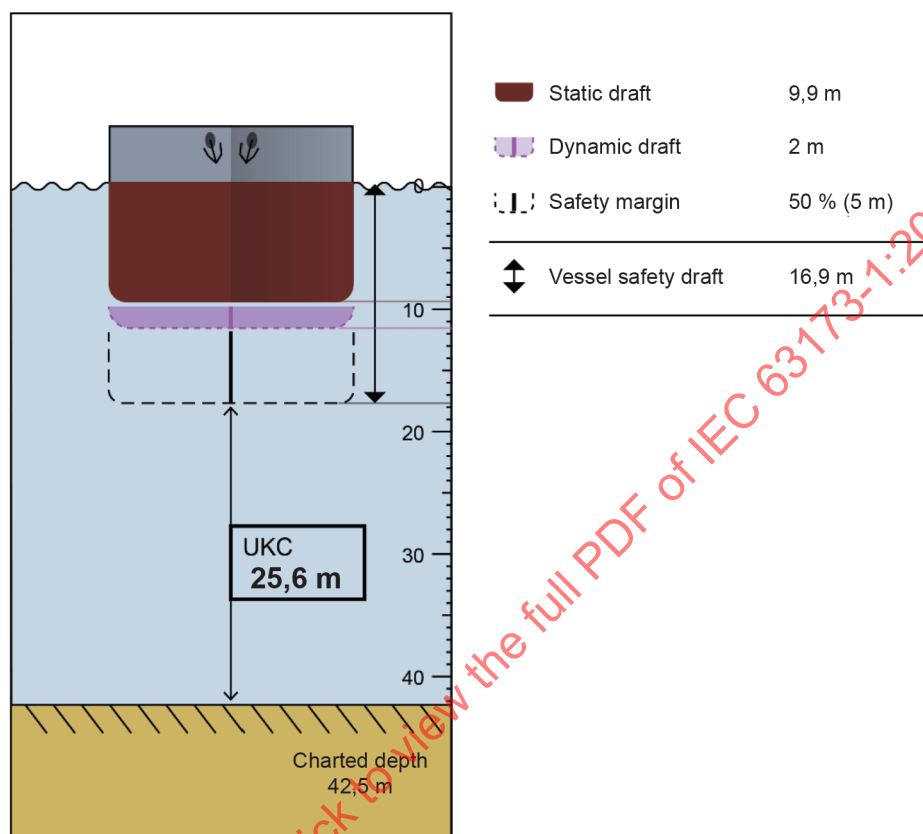


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Figure 5 – RouteWaypointLeg parameters belonging to WP3

The routeWaypointLegStarboardXTDL and routeWaypointLegPortXTDL are optional attributes.

The under-keel clearance (see Figure 6) is a vertical distance between the deepest underwater point of the ship's hull accounting for the water level, dynamic draft, safety margin; and charted depth. That clearance shall be sufficient to allow the ship's floatability in the most adverse hydrographical and meteorological conditions.



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Figure 6 – Under-keel clearance example

The static draft is the draft of the vessel when not making way or subject to sea and swell influences, i.e. the maximum draft the vessel has loaded to.

The dynamic draft is the draft of the vessel when making way and subject to squat, sea and swell state and increase of draft due to heel when turning.

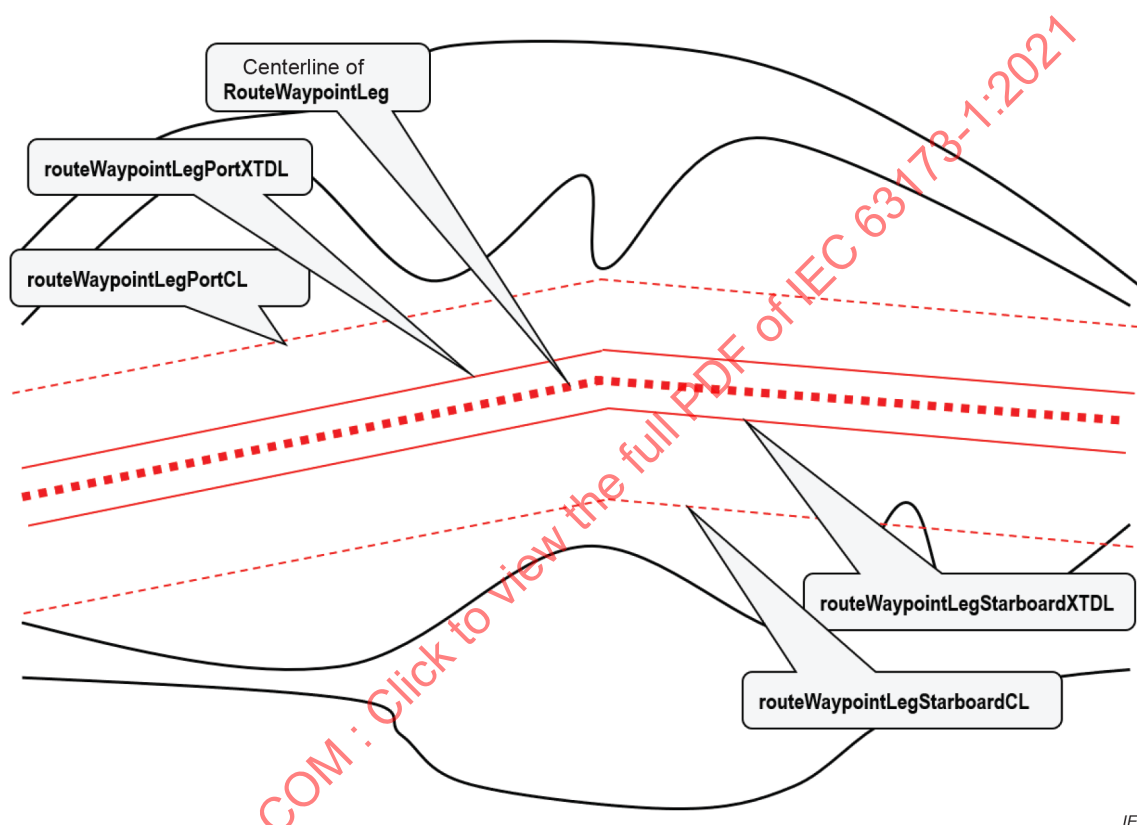
The safety margin is the draft component including uncertainties such as:

- the accuracy of the hydrographic data (references to reliability are often included on charts CATZOC);
- the vessel's size and handling characteristics;
- changes in the predicted tidal height, caused by wind speed and direction and high or low barometric pressure;
- the nature and stability of the seabed, i.e. sand waves, siltation, pipelines, obstructions etc.

Vessel safety draft is the sum of the static draft, dynamic draft and safety margin.

The waypoint leg area (see Table 12) is the area within a perpendicular distance from the center line of the leg as specified by `routeWaypointLegStarboardCL` and `routeWaypointLegPortCL`. In the case of crossing the 180° meridian, there might be multiple instances of the waypoint leg area. This can be derived from the route plan.

The waypoint leg area is related to the requirement of IMO MSC 232/A.11.3.5 for the user defined distance to check prohibited areas, areas with special conditions or navigational hazards. A smaller area within a perpendicular distance of the center line of the leg as specified by `routeWaypointLegStarboardXTDL` and `routeWaypointLegPortXTDL` is related to the requirement of IMO MSC 232/A.11.4.5 for an alarm when the user specified cross track limit for deviation from the planned route is exceeded. See Figure 7. The waypoint leg centerline is the center line of the leg.



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Figure 7 – RouteWaypointLeg limits example

Table 12 – RouteWaypointLeg object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeWaypointLegStarboardXTDL	Starboard cross track distance limit. Used during the route monitoring onboard.	Integer	0..1	Optional	Unit: metre The value range is 1 m to 10 000 m. The resolution is 1 m.
routeWaypointLegPortXTDL	Port cross track distance limit. Used during the route monitoring onboard.	Integer	0..1	Optional	Unit: metre The value range is 1 m to 10 000 m. The resolution is 1 m.
routeWaypointLegStarboardCL	Starboard cross track distance check limit Used to check route plan against the safety contour, areas with special condition and navigational hazards.	Integer	0..1	Optional	Unit: metre The value range is 1 m to 10 000 m. The resolution is 1 m.
routeWaypointLegPortCL	Port cross track distance check limit. Used to check route plan against the safety contour, areas with special condition and navigational hazards.	Integer	0..1	Optional	Unit: metre The value range is 1 m to 10 000 m. The resolution is 1 m.
routeWaypointLegSafetyContour	Planned safety contour	Real	0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegSafetyDepth	Planned safety depth	Real	0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegGeometryType	Geometry type of leg	Enum	1	Mandatory	Default value is 1 = loxodrome. 1: loxodrome (= rhumb line), 2: orthodrome (= great circle)
routeWaypointLegSOGMin	Regulatory lowest speed over ground	Real	0..1	Optional	Unit: knots, speed over ground
routeWaypointLegSOGMax	Regulatory highest speed over ground	Real	0..1	Optional	Unit: knots, speed over ground
routeWaypointLegSTWMax	Maximum safe speed through water	Real	0..1	Optional	Unit: knots, speed through water
routeWaypointLegSTWMin	Minimum safe speed through water	Real	0..1	Optional	Unit: knots, speed through water

Attribute name	Description	Data type		Multiplicity	Implementation	Remarks
routeWaypointLegDraft	Planned static draft, maximum	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegDraftForward	Planned static draft forward	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegDraftAft	Planned static draft Aft	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegDraftMax	Maximum draft of the route waypoint leg for all vessels	Real		0..1	Optional	Unit : metre The resolution is 0,01 m.
routeWaypointLegAirDraftMax	Maximum air draft of the route waypoint leg for all vessels	Real		0..1	Optional	Unit : metre The resolution is 0,01 m.
routeWaypointLegBeamMax	Maximum vessel beam of the route waypoint leg for all vessels	Real		0..1	Optional	Unit : metre The resolution is 0,01 m.
routeWaypointLegLengthMax	Maximum vessel length of the route waypoint leg for all vessels	Real		0..1	Optional	Unit : metre The resolution is 0,01 m.
routeWaypointLegStaticUKC	Minimum static UKC on the leg	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegDynamicUKC	Minimum dynamic UKC on the leg	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegSafetyMargin	Draft component including uncertainties	Real		0..1	Optional	Unit: metre The resolution is 0,1 m.
routeWaypointLegNote	Note for the route waypoint leg	String		0..1	Optional	
routeWaypointLegIssue	Safety issue for the route waypoint leg	String		0..1	Optional	
routeWaypointLegExtensions	Additional proprietary information for the route RouteWaypointLegs specified by the manufacturer	RouteExtensions		0..*	Optional	

7.3 Information types

7.3.1 General

Information types are identifiable pieces of information in a dataset that can be shared between other features. They have attributes but have no relationship to any geometry. Information types may reference other information types.

7.3.2 RouteSchedules

The feature RouteSchedules described in Table 13 shall contain zero or one RouteSchedule object.

The three main elements of a schedule are: ETA, ETD, and speed. These schedule elements can be set manually by the operator or calculated by machine. See Table 13 to Table 16.

Each schedule element is associated with a routeWaypointID. When a RouteScheduleManual is used, the schedule element is set by the operator. When a RouteScheduleCalculated is used, all schedule element values except manual elements are set by machine. The schedule elements of passed waypoints may be omitted.

If the route geometry changes, all the calculated elements for schedules shall be reset, as the calculation results basically depend on the geometry.

7.3.3 RouteSchedule

The schedules contain three distinguishable parts: manual schedule (RouteScheduleManual), calculated schedule (RouteScheduleCalculated), and recommended schedule (RouteScheduleRecommended). The manual schedule is used to indicate manually entered values which are the basis for the schedule calculation/estimation. The main goal for the ship is to navigate safely to meet the manual schedule.

The RouteScheduleManual contains a list of RouteScheduleElement objects that describe time preferences and calculation restrictions for each leg or waypoint of the route. A waypoint shall have only one associated RouteScheduleElement within a RouteScheduleManual.

NOTE The manually entered values are normally one or several of 1) manually entered planned time of departure from berth, 2) manually entered planned time of arrival to PBG (pilot boarding ground) and/or berth, 3) manually entered planned speed on certain legs, 4) speed constrained by SOGMin/Max on a leg (the regulatory constraints), and the preferred service speed window depending on cargo and weather.

If an external party has entered manual values, the calculated schedule shall be removed or cleared to indicate that it is invalid. Also, if waypoints have been changed, the calculated schedule may be invalid and shall be removed or cleared as a signal to the ship to re-calculate the schedule. Only one active manual schedule is allowed in a route plan.

RouteScheduleRecommended object is used by, from the ship perspective, external actors to recommend or request a new time, for example a port can use the ETD or ETA in the recommended schedule to request/recommend a new time for departure or arrival.

RouteScheduleCalculated object contains a sequence of RouteScheduleElement objects that store calculations results according to user's preferences available from the RouteScheduleManual or RouteScheduleRecommended object. A waypoint shall have only one associated RouteScheduleElement within a RouteScheduleCalculated object.

The calculated schedule contains manually entered values and calculated estimations on waypoints between the manually set times. Hence, the calculated schedule is more complete with times on each waypoint. It is calculated based on manually entered values and regulatory speeds on legs. The calculated schedule is set by the ship, but can also be calculated onshore by for example a route optimization provider.

If the receiving application uses route information only for display or information purposes, it shall use the RouteScheduleElementCalculated object since this has all the schedule elements.

Table 13 – RouteSchedules object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeSchedulesExtensions	Additional proprietary information for the route schedules specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 14 – RouteScheduleManual object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeScheduleManualExtensions	Additional proprietary information for the route schedule manual specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 15 – RouteScheduleCalculated object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeScheduleCalculatedExtensions	Additional proprietary information for the route schedule calculated and specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 16 – RouteScheduleRecommended object attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
routeScheduleRecommendedExtensions	Additional proprietary information for the route schedule recommended and specified by the manufacturer	RouteExtensions	0..*	Optional	

Table 17 – RouteSchedule object attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
routeScheduleID	Identifier of the schedule. This identifier is unique in the route	Integer	1	Mandatory	positive integer
routeScheduleName	Name of schedule	String	0..1	Optional	Human readable text
routeScheduleExtensions	Additional proprietary information for the route schedule specified by the manufacturer	RouteExtensions	0..*	Optional	

7.3.4 RouteScheduleManual/RouteScheduleCalculated/RouteScheduleRecommended

The RouteScheduleCalculated shall contain both parameters consistent with the manually set values (presented in RouteScheduleManual or RouteScheduleRecommended), and the calculated values.

Consistency means equal value intervals for the routeScheduleElementETA, routeScheduleElementETD (with some reservations for this parameter which will be referred to below) and equality of the rest of parameters, as it is essentially dependent on the specific routeScheduleElementETA, routeScheduleElementETD values rather than on their intervals.

The schedule is considered complete if:

- 1) its RouteScheduleCalculated element contains ETD parameter values for all the waypoints except the last one, and the ETA and speed parameter values for all the waypoints except the first one;
- 2) the RouteScheduleManual element is not in contradiction with the RouteScheduleCalculated element, and the data for RouteScheduleManual is sufficient for recalculating the schedule.

7.3.5 RouteScheduleElement

The routeScheduleID (see Table 17) is intended for machine processing. The routeScheduleName is intended for the human operator. A unique routeScheduleID shall be set for each RouteSchedule object. The routeScheduleName attribute is optional, and there may be several schedules with the same name within the framework of one route.

NOTE 1 The routeScheduleName attribute is intended mainly for making it easier for an operator handling several schedules for one and the same route, to find the necessary schedule and distinguish the schedules from one another.

NOTE 2 It is helpful to use a globally unique identifier (GUID) for a routeScheduleID in the routeSchedule, to avoid problems associated with the merging of two versions of the same route from different sources, since the GUID guarantees that the schedules would not intersect, and that one could be certain about which schedules are common.

When all/any of the following attributes are changed,

- routeScheduleElementETA;
- routeScheduleElementETD (see Table 18);
- routeScheduleElementPlanSOG;

there is a need to set intervals appropriately by filling in the following attributes:

- routeScheduleElementETDWindowBefore;
- routeScheduleElementETDWindowAfter;
- routeScheduleElementETAWindowBefore;
- routeScheduleElementETAWindowAfter.

All the fields describing a certain time interval (routeScheduleElementETAWindowAfter, routeScheduleElementETDWindowAfter, routeScheduleElementETAWindowBefore, routeScheduleElementETDWindowBefore) shall have the integer format with minutes. When the interval length is more than 24 h, and comes to for example 37 h 27 min, this shall be expressed as 2247.

7.3.6 RouteInfo

The routeInfoName (see Table 19) attribute is mandatory, intended for human reading purposes, and shall not be empty or consist of space symbols only.

When a route plan is exchanged in any given status, the validity period can be defined with a start and stop, or eventually only one of them. The attributes `routeInfoValidityStart/routeInfoValidityEnd` shall be understood by the receiving party that the route shall be used only within the given period. For a reference route (see Clause A.11), this implies that the use of the route for passage planning shall not be possible outside the given time window. For a recommended route for example, giving a recommended ETA, the validity period implies that the receiver shall not be able to base passage planning on the received route after this time window, and eventually shall request a new recommendation (see Clause A.10). For a service replying with an under keel clearance management (see Clause A.6) condition, the validity period shall be understood as the period during which the affected ship has to reply that the recommended route is to be used, and given the status of "used for monitoring". This understanding shall apply to any use of these two attributes.

The `routeInfoAuthor` attribute may specify not only the name with initials, but also the organizational position in human readable format. This attribute is not mandatory but important to support understanding by the receivers of a route.

The `routeInfoEditionTime` is mandatory and is the time when the given route was created or updated.

The `routeInfoStatus` field is mandatory. The `routeInfoStatus` shall be used to give the status of the route in order to support the various scenarios, for example route optimization and route cross check. The intention of the "Terminated" status is to inform receivers of a route plan that the route has been completed or stopped/cancelled; for example if a route is cancelled, possible previous receivers need to be made aware about this, whether or not they are given access rights to the route that "replaces" the cancelled one. Figure 8 describes typical transitions of `routeInfoStatus` values for a ship. The route planning typically starts with an initial route or when a ship receives reference routes (`routeInfoStatus=1` (Initial)). Some attributes in an initial route may be added or modified. When a route plan is ready to use, it changes state to "Planned" (`routeInfoStatus=2`).

The planned route may be sent to shore for processing; received routes are normally updated in the planned route. At any time, the ship may receive a recommended route (`routeInfoStatus=3`), an acknowledged route (`routeInfoStatus=4`) or a route issues (`routeInfoStatus=9`).

When route is loaded into ECDIS for monitoring, it changes status to "Used for monitoring" (`routeInfoStatus=5`).

If route is not finalised when unloaded, the route changes to status "Planned" (`routeInfoStatus=2`). When route is unloaded from ECDIS and the complete route plan is finalised or cancelled, the route changes status to "Terminated" (`routeInfoStatus=6`).

Figure 9 describes typical transitions of `routeInfoStatus` values for a shore side service.

Shore is waiting for a route from a ship, or a route request from a ship. If a received route is planned or used for monitoring, processing is required. After the processing, the response is sent back to the ship with either a recommended route, an acknowledged route, a route issue, an incomplete route or a route error.

When the shore receives a terminated route, it ends all processing related with the route plan. When the shore receives the route request with an initial route or when it needs to send a reference route, it provides a reference route to the ship.

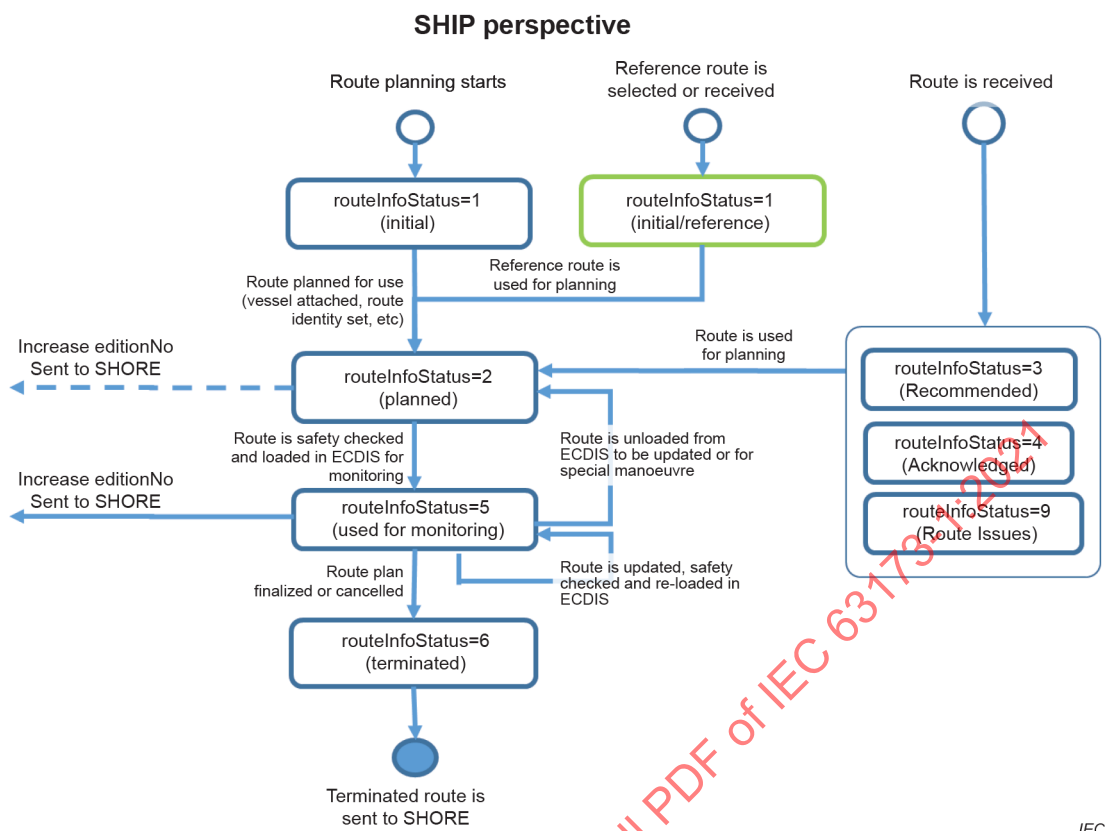


Figure 8 – State diagram for route status from ship perspective

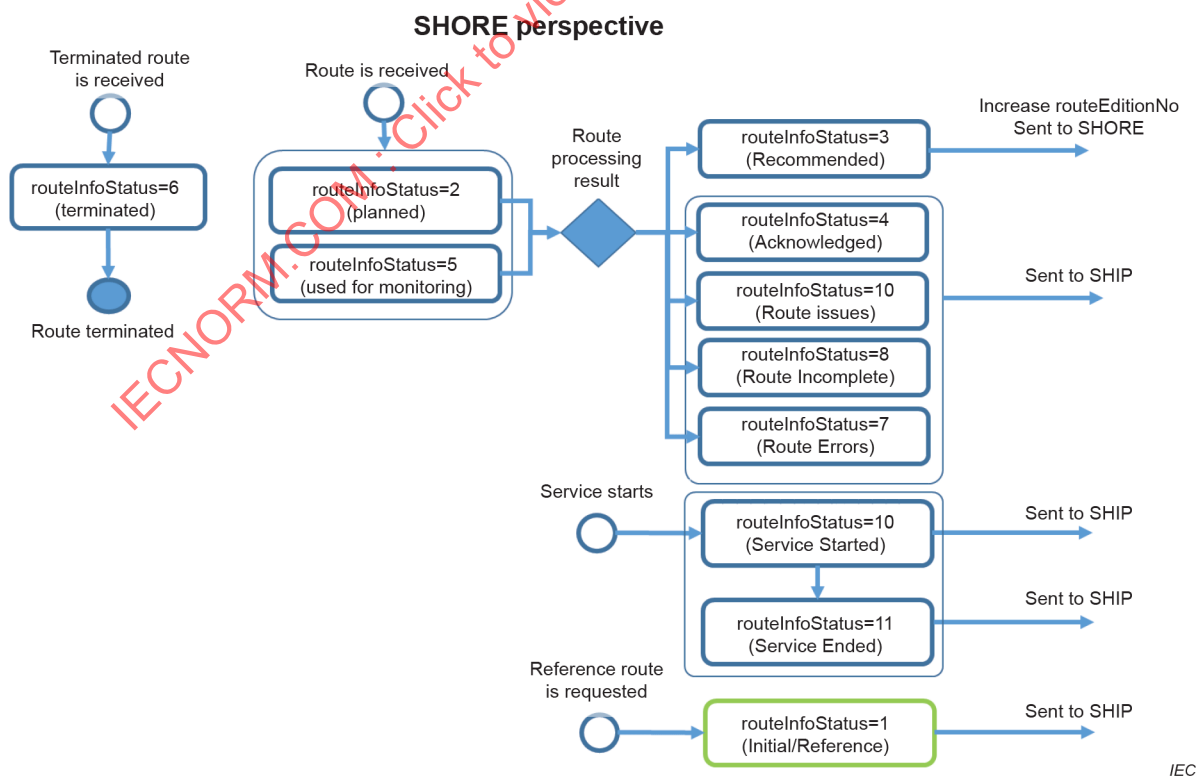


Figure 9 – State diagram of route status from shore perspective

Table 18 – RouteScheduleElement object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeWaypointID	Waypoint identifier of the schedule	Integer	1	Mandatory	
routeScheduleElementPlanSOG	Planned speed over ground	Real	0..1	Mandatory	Unit: knots, speed over ground
routeScheduleElementETD	Planned or recommended time of departure represented by estimated time of departure (ETD by schedule or by SOG)	DateTime	0..1	Mandatory	
routeScheduleElementETA	Planned or recommended time of arrival represented by estimated time of arrival (ETA by Schedule or by SOG)	DateTime	0..1	Mandatory	
routeScheduleElementETDWindowBefore	Describes the period of time before planned or recommended time of departure	integer	0..1	Optional	UNIT: minutes minutes to ETD
routeScheduleElementETDWindowAfter	Describes the period of time after planned or recommended time of departure	Integer	0..1	Optional	UNIT: minutes minutes after ETD
routeScheduleElementETAWindowBefore	Describes the period of time before planned or recommended time of arrival	integer	0..1	Optional	UNIT: minutes minutes to ETA
routeScheduleElementETAWindowAfter	Describes the period of time after planned or recommended time of arrival	Integer	0..1	Optional	UNIT: minutes minutes after ETA
routeScheduleElementNote	Notes for the route schedule element	String	0..1	Optional	
routeScheduleElementExtensions	Additional proprietary information for the route schedule element specified by the manufacturer	RouteExtensions	0..1	Optional	

Table 19 – RouteInfo object attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeInfoName	Name of the route	String	1	Mandatory	Human readable text
routeInfoAuthor	Author of the route	String	0..1	Mandatory	Human readable text
routeInfoEditionTime	Time this edition of route plan is edited	DateTime	0..1	Mandatory	In UTC time, for example 2019-06-26T14:22:02Z
routeInfoDescription	Additional information for the status of the route, i.e. specific error message and/or cause of the route change and/or any other detail to consider before further use of this route plan and/or the purpose of sending a route plan and/or why this route is recommended.	String	0..1	Mandatory	Human readable text
routeInfoStatus	Enumerated status value of the route	Enum	1	Mandatory	See Table 20
routeInfoValidityStart	Start of validity of route plan	DateTime	0..1	Mandatory	
routeInfoValidityEnd	End of validity of route plan	DateTime	0..1	Mandatory	
routeInfoDeparturePortID1	Primary identifier for departure port given by UN/LOCODE	String	0..1	Optional	UN/LOCODE as found from UNECE's code list
routeInfoDeparturePortID2	Secondary identifier for departure port given by free text string	String	0..1	Optional	Free text, e.g. location name, berth name, other identifier
routeInfoDeparturePortCall	Reference to port call identifier in departing port	String	0..1	Optional	
routeInfoArrivalPortID1	Primary identifier for arrival port given by UN/LOCODE	String	0..1	Optional	UN/LOCODE as found from UNECE's code list
routeInfoArrivalPortID2	Secondary identifier for arrival port given by free text string	String	0..1	Optional	Free text, e.g. location name, berth name, other identifier
routeInfoArrivalPortCall	Reference to port call identifier in arriving port	String	0..1	Optional	
routeInfoReferencePrevRoute	Reference previous route	String	0..1	Optional	
routeInfoReferenceNextRoute	Reference next route	String	0..1	Optional	
routeInfoVesselType	Type of ship	Integer	0..1	Optional	See Table 21

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeInfoVesselName	Ship's name	String	0..1	Optional	Any one of these attributes is used for the alternatives for the identification of the vessel
routeInfoVesselMMSI	Ship's MMSI	String	0..1	Mandatory	MMSI is used for vessel identification.
routeInfoVesselCallsign	Ship's call sign	String	0..1	Optional	These attributes complement the identification of the vessel.
routeInfoVesselIMO	Ship's IMO number	String	0..1	Optional	
routeInfoVesselVoyage	Unique voyage identifier A voyage may have more than one destination and departure locations, but a route plan refers to only one destination and one departure location	String	0..1	Optional	
routeInfoVesselHeight	Vessel height measured from the keel to the masthead	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoVesselLength	Vessel length overall (LOA)	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoVesselBeam	Vessel beam	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoDraftMax	Maximum vessel draft	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoAirDraftMax	Maximum vessel air draft	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoBeamMax	Maximum vessel beam	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoLengthMax	Maximum vessel length	Real	0..1	Optional	Unit : metres Resolution is 0,01 m
routeInfoExtensions	Additional proprietary information for the route info specified by the manufacturer	RouteExtensions	0..1	Optional	

Table 20 – Definition of RouteInfoStatus

routeInfoStatus	Human readable text	Description of use case	Actors
1	Initial	Initial route or a reference route if meant for more than one specific route plan	Ship or shore - Ship: Initial route which is created in the route database on the ship (route plan is not loaded into monitoring) or external system onboard. If route is to be stored and used for more than one route plan, the route shall be addressed as a reference route. - Service provider (shore): reference routes given from a national authority or from a company. This includes a company making common reference routes for their own vessels, or from a service providing routes such as a VTS-service, pilot routes for given areas, routes for winter ice navigation and other appropriate services.
2	Planned	Route and schedule prepared by crew	Ship only Route with one or several schedules, calculated and stored in the route database on the ship (route plan is not loaded into monitoring)
3	Recommended	Route and schedule recommended by 3 rd party service provider	Shore only Recommended route with one or several schedules, calculated by any 3rd party service provider (weather optimization, auto-routing, route checked, traffic management, etc.) and delivered to the ship or fleet operator.
4	Acknowledged	Checked and acknowledged route from any 3 rd party service provider or from a ship	Ship or shore - Service provider: Acknowledged route verified by 3rd party service provider. Route has been checked and approved for a given voyage for example by a VTS. The responsibility to choose a safe route for monitoring is nevertheless the captain's responsibility. - Ship: Acknowledged route from ship to shore, for instance a ship acknowledge to perform a specific search and rescue.
5	Used for monitoring	Loaded for monitoring	Ship only Route with or without schedule is loaded for monitoring in the system on board. This is used only for the active route.
6	Terminated	Route completed or cancelled	Ship only Route plan has been completed or stopped/cancelled, or end of route monitoring
7	Errors	The received route information is invalid according to schema validation or application level context check	Ship, shore

routeInfoStatus	Human readable text	Description of use case	Actors
8	Incomplete	Some fields of received route information are missing for this specific use case	Ship, shore
9	Route issues	Route checked by 3 rd party and the comments are available in routeWaypointLegIssue and/or routeInfoDescription attributes	- Shore: Service provider has added routeWaypointLegIssue and/or routeInfoDescription attributes. Route has been checked and disapproved for a given voyage for example by a VTS. The route will then often hold issues on one or more legs (RouteWaypointLegIssue) that should be addressed before resending to the given service, VTS or other. - Ship: After import of the route, inform the user about route check issues and provide textual contents of the routeWaypointLegIssue and/or routeInfoDescription attributes for reading.
10	Service started	This status is used for routes sent to a ship confirming a shore based service has started for the given route	Shore only
11	Service ended	This status is used for routes sent to a ship confirming a shore based service has been ended for the given route.	Shore only

Table 21 – Type of ship

Identifier no.	Special craft
50	Pilot vessel
51	Search and rescue vessel
52	Tugs
53	Port tenders
54	Vessel with anti-pollution facilities and equipment
55	Law enforcement vessels
56	Spare – for assignments to local vessels
57	Spare – for assignments to local vessels
58	Medical transports (as defined in the 1949 Geneva Conventions and Additional Protocols)
59	Ships and aircraft of States not parties to an armed conflict

Other ships			
First digit	Second digit	First digit	Second digit
1 – Reserved for future use	0 – All ships of this type	-	0 – Fishing
2 – WIG	1 – Carrying DG, HS, or MP, IMO hazard or pollutant category X(2)		1 – Towing
3 – See right column	2 – Carrying DG, HS, or MP, IMO hazard or pollutant category Y(2)	3 – Vessel	2 – Towing and length of the tow exceeds 200 m or breadth exceeds 25 m
4 – HSC	3 – Carrying DG, HS, or MP, IMO hazard or pollutant category Z(2)		3 – Engaged in dredging or underwater operations
5 – See above	4 – Carrying DG, HS, or MP, IMO hazard or pollutant category OS(2)		4 – Engaged in diving operations
	5 – Reserved for future use		5 – Engaged in military operations
6 – Passenger ships	6 – Reserved for future use	-	6 – Sailing
7 – Cargo ships	7 – Reserved for future use	-	7 – Pleasure craft
8 – Tanker(s)	8 – Reserved for future use	-	8 – Reserved for future use
9 – Other types of ship	9 – No additional information	-	9 – Reserved for future use

7.4 Association roles of feature catalogue

An association role describes the nature of the relationships. First is the relationship from one feature type to another feature type in a feature association. Second is the relationship from one object (feature or information type) to one information type in an information association. Each association has exactly two roles. Either or both may be a default. This document defines all roles which is used for feature associations and information associations. If there is any conflict in the association roles in Table 22 and Figure 1, Figure 1 has precedence.

Table 22 – Roles of the route plan

Role name	Definition	Code	Mult	Remarks
RouteInfoSet	A pointer to the aggregate in a whole-part relationship	routeInfoSet	1	
RouteInfo	A pointer to the class	routeInfo	1	
RouteWaypointsSet	A pointer to the aggregate in a whole-part relationship	routeWaypointsSet	1	
RouteWaypoints	A pointer to the class	routeWaypoints	0..1	
RouteWaypointSet	A pointer to the aggregate in a whole-part relationship.	routeWaypointSet	1	
RouteWaypoint	A pointer to the class	routeWaypoint	2..*	
RouteWaypointLegSet	A pointer to the aggregate in a whole-part relationship	routeWaypointLegSet	1	
RouteWaypointLeg	A pointer to the class	routeWaypointLeg	0..1	
Route Schedules Set	A pointer to the aggregate in a whole-part relationship	routeSchedulesSet	1	
Route Schedules	A pointer to the class	routeSchedules	0..1	
Route Schedule Set	A pointer to the aggregate in a whole-part relationship	routeScheduleSet	1	
Route Schedule	A pointer to the class	routeSchedule	0..*	
RouteScheduleManual Set	A pointer to the member class in a whole-part relationship	routeScheduleManualSet	1	
RouteScheduleManual	A pointer to the class	routeScheduleManual	0..1	
RouteScheduleCalculatedSet	A pointer to the member class in a whole-part relationship	routeScheduleCalculatedSet	1	
RouteScheduleCalculated	A pointer to the class	routeScheduleCalculated	0..1	
RouteScheduleRecommendSet	A pointer to the member class in a whole-part relationship	routeScheduleRecommendSet	1	
RouteScheduleRecommend	A pointer to the class	routeScheduleRecommend	0..1	
RouteScheduleElementManualSet	A pointer to the member class in a whole-part relationship	routeScheduleElementManualSet	0..1	
RouteScheduleElementCalculatedSet	A pointer to the member class in a whole-part relationship	routeScheduleElementCalculatedSet	0..1	
RouteScheduleElementRecommendSet	A pointer to the member class in a whole-part relationship	routeScheduleElementRecommendSet	0..1	
RouteScheduleElement	A pointer to the class	routeScheduleElement	1..*	
RouteActionPointsSet	A pointer to the aggregate in a whole-part relationship	routeActionPointsSet	1	
RouteActionPoints	A pointer to the class	routeActionPoints	0..1	
RouteActionPointSet	A pointer to the aggregate in a whole-part relationship	routeActionPointSet	1	
RouteActionPoint	A pointer to the class	routeActionPoint	0..*	

7.5 Associations of feature catalogue

7.5.1 General

Associations are named relationships between objects (feature or information types). There are two types of associations: feature associations for relationships between two feature types, and information associations for relationships between objects (feature or information type) and an information type. If there is any conflict in the associations and Figure 1, Figure 1 has precedence.

7.5.2 Feature association

A feature association is the description of the relationship between two instances of feature types. It can be characterized by thematic attributes and has normally two roles. The roles describe the ends of the relationship since such relationship is usually not symmetric (see Table 23).

Table 23 – Feature association for route plan

Role name	Definition	Code	Role	Role
RouteWaypointsComposition	Association of between feature types	routeWaypointsComposition	routeWaypointsSet	routeWaypoints
RouteWaypointComposition	Association of between feature types	routeWaypointComposition	routeWaypointSet	routeWaypoint
RouteWaypointLegComposition	Association of between feature types	routeWaypointLegComposition	routeWaypointLegSet	routeWaypointLeg
RouteActionPointComposition	Association of between feature types	routeActionPointComposition	routeActionPointSet	routeActionPoint
RouteActionPointComposition	Association of between feature types	routeActionPointComposition	routeActionPointSet	routeActionPoint

7.5.3 Information association

An information association is the description between an arbitrary object (feature or information type) and an information type that supplies additional information for that object (feature or information type). The relationship can be characterized by thematic attributes and a role (see Table 24).

Table 24 – Information association for route plan

Role name	Definition	Code	Role	Role
RouteInfoComposition	Association of between feature and information type	routeInfoComposition	routeInfoSet	routeInfo
RouteSchedulesComposition	Association of between information types	routeSchedulesComposition	routeSchedulesSet	routeSchedules
RouteScheduleComposition	Association of between information types	routeScheduleComposition	routeSchedulesSet	routeSchedule
RouteScheduleManualComposition	Association of between information types	routeScheduleManualComposition	routeScheduleManualSet	routeScheduleManual
RouteScheduleCalculatedComposition	Association of between information types	routeScheduleCalculatedComposition	routeScheduleCalculatedSet	routeScheduleCalculated
RouteScheduleRecommendComposition	Association of between information types	routeScheduleRecommendComposition	routeScheduleRecommendSet	routeScheduleRecommend
RouteScheduleElementManualComposition	Association of between information types	routeScheduleElementManualComposition	routeScheduleElementManualSet	routeScheduleElement
RouteScheduleElementCalculatedComposition	Association of between information types	routeScheduleElementCalculatedComposition	routeScheduleElementCalculatedSet	routeScheduleElement
RouteScheduleElementRecommendComposition	Association of between information types	routeScheduleElementRecommendComposition	routeScheduleElementRecommendSet	routeScheduleElement

7.6 Attributes

7.6.1 General

This document defines attributes as simple and complex. Types for thematic attribute types and spatial types (see 7.2) are used for attributes of feature types and are used for information types in this document (see 7.3).

7.6.2 Simple attribute types

This document uses eight types of simple attributes as defined in Table 25.

Table 25 – Simple attribute types

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values
Boolean	A value representing binary logic. The value can be either True or False. The default state for Boolean type attributes (i.e. where the attribute is not populated for the feature) is False.
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.
CharacterString	An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets
Date	A date provides values for year, month and day according to the Gregorian calendar. Character encoding of a date is a string which follows the calendar date format. EXAMPLE 19980918 (YYYYMMDD)
Time	A time is given by an hour, minute and second in the 24-hour clock system. Character encoding of a time shall be a complete representation of the basic format. Complete representation means that hours, minutes and seconds shall be used. Basic format means that separating characters are omitted. Time is preferably expressed as universal time coordinated (UTC). EXAMPLE 183059Z Time may be expressed as a local time with a given offset to UTC. EXAMPLE 183059+0100 Time may be expressed as a local time without a specified offset to UTC. EXAMPLE 183059 The complete representation of the time of 27 min and 46 s past 15 h locally in Geneva (in winter one hour ahead of UTC), and in New York (in winter five hours behind UTC), together with the indication of the difference between the time scale of local time and UTC, are used as examples. Geneva: 152746+0100 New York: 152746-0500 The service hours for a service that is available all year in an area where daylight saving hour affects the offset to UTC could be expressed as local time without specified offset. Opening: 074500 Closing: 161500
DateTime	A DateTime is a combination of a date and a time type. EXAMPLE: 19850412T101530

7.6.3 Complex attributes

Complex attributes are aggregations of other attributes that are either simple or complex. The aggregation is defined by means of attribute bindings.

RouteExtensions (see Table 26) is best associated with additional fields for the proprietary purpose in the route plan.

Table 26 – RouteExtensions attributes

Attribute name	Description	Data type	Multiplicity	Implementation	Remarks
routeExtensionsManufacturerId	Unique vendor identifier for the Route extensions	CharacterString	1	Mandatory	
routeExtensionsName	Route extension name	CharacterString	0..1	Optional	
routeExtensionsVersion	RouteExtension version	CharacterString	0..1	Optional	
routeExtensionsNote	Route Extension Note	Character String	1..*	Optional	

7.6.4 Spatial attribute types

Only feature type class RouteWaypoint and RouteActionPoint have a spatial attribute type. RouteWaypoint defines GM_Point as a spatial attribute type. RouteActionPoint has one of three kinds of spatial attribute types for example, GM_Point, GM_Curve and GM_Surface. All spatial attribute types this document needs in this document are GM_Point, GM_Curve, GM_Surface (see Table 27).

Table 27 – Spatial attributes

Attribute Name	Description	Data Type	Multiplicity	Implementation	Remarks
geometry	Geographical position of the action point in degrees	GM_Point, GM_Curve, GM_Surface	1	Mandatory	For value range see IHO S-100 The minimum resolution is 0,000 1°

7.7 Binding

7.7.1 General

Bindings consist of attribute bindings, feature bindings and information bindings. The following use cases for attribute bindings exist:

- 1) defining the attributes for feature type;
- 2) defining the attributes for information types;
- 3) defining the attributes for feature association;
- 4) defining the attributes for information associations;
- 5) defining the aggregation of attributes for a complex attribute.

Number 1), 2), 5) are done through the definition of feature class type and information class type. Number 3) and 4) are accomplished by an association role, the feature associations and the information associations. Binding specifies the target attribute and the multiplicity of the attribute. The multiplicity indicates how many instances are mandatory (1..n) or optional (0..n). If there is any conflict in the bindings and Figure 1, then Figure 1 has precedence.

7.7.2 Feature binding

Feature binding describes the association between two feature types. Both the feature association and the association role are specified with the target feature type. Furthermore, the multiplicity and the role type are defined. The latter describes the nature of the role (see Table 28).

Table 28 – Feature binding for the route plan

Class	Mult	Role type	Feature type	Role	Association
Route	0..1	composition	RouteWaypoints	routeWaypoints	routeWaypointsComposition
	0..1	composition	RouteActionPoints	routeActionPoints	routeActionPointsComposition
RouteWaypoints	1	composition	Route	routeWaypointsSet	routeWaypointsComposition
	2..*	composition	RouteWaypoint	routeWaypoint	routeWaypointComposition
RouteWaypoint	1	composition	RouteWaypoints	routeWaypointSet	routeWaypointComposition
	0..1	composition	RouteWaypointLeg	routeWaypointLeg	routeWaypointLegComposition
RouteWaypointLeg	1	composition	RouteWaypoint	routeWaypointLegSet	routeWaypointLegComposition
RouteActionPoints	1	composition	Route	routeActionPointsSet	routeActionPointsComposition
	1..*	composition	RouteActionPoint	routeActionPoint	routeActionPointComposition
RouteActionPoints	1	composition	RouteActionPoints	routeActionPointSet	routeActionPointComposition

7.7.3 Information binding

Information bindings describe which information type can be associated to which feature or information types. In addition to the target information type, the multiplicity of this binding is also defined (see Table 29).

Table 29 – Information binding for the route plan

Class	Mult	Role type	Role	Association	Information type
Route	1	composition	routeInfo	routeInfoComposition	RouteInfo
	0..1	composition	routeSchedules	routeSchedulesComposition	RouteSchedules
RouteSchedules	0..*	composition	routeSchedule	routeScheduleComposition	RouteSchedule
RouteSchedule	1	composition	routeScheduleSet	routeScheduleComposition	RouteSchedule
	0..1	composition	routeScheduleManual	routeScheduleManualComposition	RouteScheduleManual
	0..1	composition	routeScheduleCalculated	routeScheduleCalculatedComposition	RouteScheduleCalculated
RouteScheduleManual	1	composition	routeScheduleManualSet	routeScheduleComposition	RouteSchedule
	1..*	composition	routeScheduleElementManual	routeScheduleElementManualComposition	RouteScheduleElement
RouteScheduleCalculated	1	composition	routeScheduleCalculatedSet	routeScheduleComposition	RouteSchedule
	1..*	composition	routeScheduleElementCalculated	routeScheduleElementCalculatedComposition	RouteScheduleElement
RouteScheduleRecommended	1	composition	routeScheduleCalculatedSet	routeScheduleComposition	RouteSchedule
	1..*	composition	routeScheduleElementCalculated	routeScheduleElementRecommendedComposition	RouteScheduleElement
RouteScheduleElement	0..1	composition	routeScheduleElementManual	routeScheduleManualComposition	RouteScheduleManual
	0..1	composition	routeScheduleElementCalculated	routeScheduleCalculatedComposition	RouteScheduleCalculated

8 Data type and structure of transmission format

In the IHO S-100 model, a dataset is one or more files containing specified information. In the IHO S-100 model, encoding means format of a file. This document uses the GML encoding option as defined in IHO S-100.

9 Maintenance

9.1 Feature and portrayal catalogue management

9.1.1 Feature catalogue management

For each new version of the S-421 product specification, a new feature catalogue will be released. The end user system shall be able to manage datasets and their corresponding feature catalogue that are created using different versions of the S-421 product specification.

9.1.2 Portrayal catalogue management

For each new version of the S-421 product specification, a new portrayal catalogue will be released. Only the applicable end user system shall be able to manage their corresponding portrayal catalogue that are created using different versions of the S-421 product specification.

9.2 Data source

Data producers shall use all available and applicable sources, as evaluated against a robust data assessment process, to maintain and update S-421 datasets as required.

9.3 Production process

Data producers should follow their established production processes for maintaining and updating datasets. Data shall be maintained against the S-421 data classification and encoding guide.

10 Portrayal

10.1 General

S-421 portrayal is compliant with the portrayal model as defined in S-100. The portrayal catalogue defines symbology and the portrayal rules for each geo-referenced feature object and attribute combination in the feature catalogue.

Portrayal is fully compliant with the symbol shapes and other rules as defined in IEC 62288. The portrayal catalogue is a machine-readable method to implement symbol shapes as defined in IEC 62288.

10.2 Portrayal catalogue

The portrayal catalogue defines symbology and the portrayal rules for each feature attribute combination contained in the feature catalogue as described in Table 30.

Table 30 – Information binding for the route plan portrayal catalogue

Item name	Description	M/O	Cardinality	Type
S421_PortrayalCatalogue	Catalogue containing the mechanisms to portray S-421 route plan	M	1	CI_Citation (ISO 19115)
Key M: Mandatory O: Optional				

The portrayal catalogue contains the mechanisms for the system to portray information found in this document. The portrayal catalogue contains the following types of mechanisms and structures:

- product input schema;
- set of portrayal rules;
- set of drawing instructions;
- set of symbols, line styles and colours.

The portrayal catalogue model is defined in S-100, Part 9.

The S-421 portrayal catalogue is available as an XML file and can be downloaded from the CIRM website (<http://cirm.org/s-421>). The portrayal catalogue conforms to the S-100 XML portrayal catalogue schema as follows:

Root ---- (contains the catalogue named “portrayal_catalogue.xml”)

|

|-- Pixmaps (contains XML files describing pixmaps)

|

|-- ColorProfiles (contains XML files with colour profiles and CSS2 style sheets)

|

|-- Symbols (contains SVG files with symbols)

|

|-- LineStyles (contains XML files with line styles)

|

|-- AreaFills (contains XML files area fills)

|

|-- Fonts (contains TrueType font files)

|

|-- Rules (contains XSLT files with templates)

11 Data product delivery

11.1 General

Route plans can be exchanged in one of three formats:

- a) a single XML file (11.2);
- b) a compressed data container (11.3);
- c) an S-100-compliant exchange set (11.4).

Equipment that can import route plans shall be able to read all three of these formats. Equipment that can export route plans shall be able to write single XML files and compressed data containers, and may optionally support writing S-100-compliant exchange sets. The manufacturer shall state which import and export formats are supported in the user manual.

11.2 Single XML file

When using this delivery mechanism, the route plan is stored as a single XML file with the extension .s421. This file shall conform to the schema specified in this document (see Clause D.1), and shall be encoded in UTF-8.

11.3 Compressed data container

Equipment may optionally deliver route plans in a compressed data container. Data containers are standard ZIP archive files with the extension .s421p. The contents of this data container shall consist of an XML file (see 11.2).

11.4 S-100-compliant exchange set

11.4.1 General

Route plan information may be encoded in an S-100-compliant exchange set as shown in Figure 10.

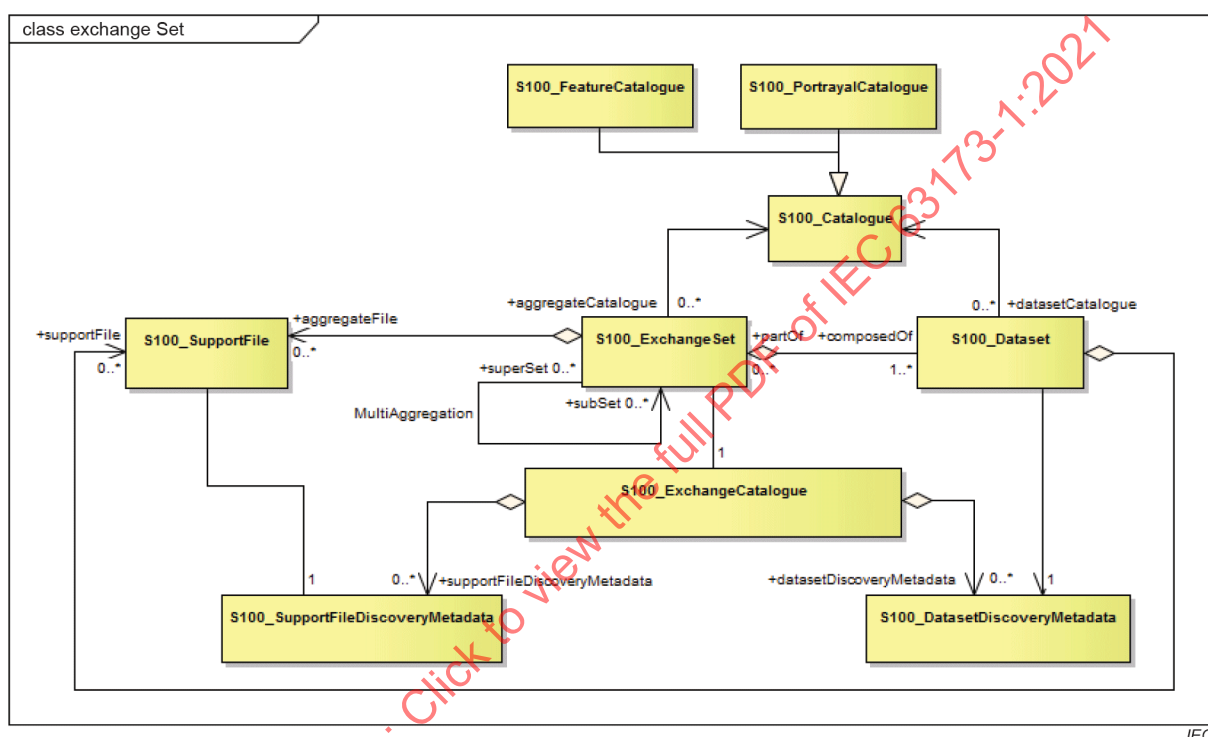


Figure 10 – S-100 exchange set structure

11.4.2 Exchange set

Route plan datasets are grouped into exchange sets. Each exchange set consists of one or more route plan datasets with an associated XML metadata file and a single exchange catalogue XML file containing metadata.

- Units of delivery: exchange set.
- Transfer size: unlimited.
- Medium name: digital data delivery.
- Other delivery information: n/a.

Each exchange set has a single exchange catalogue which contains the discovery metadata for each dataset.

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

This document defines the encoding which shall be used for transmission of data between parties.

11.4.3 Dataset

11.4.3.1 Dataset types

Four types of dataset files are supported by IHO S-100. In this document, only the new dataset and the new edition of a dataset type are used. In this document, incremental updates and re-issues are not used.

11.4.3.2 Data encoding

The S-421 data classification and encoding guide (see Annex B) describes how data describing the real world is captured using the types defined in the S-421 feature catalogue.

Each attribute with a value shall be identified uniquely within the dataset (see Annex E). This identifier (gml:id) values shall be used as the reference for the object from another object in the same dataset or another dataset.

11.4.3.3 Dataset file naming

All dataset files shall have unique file identifiers in a system. The dataset file metadata that accompanies the file will inform the user of the name and purpose of the file (new, replacement and deletion).

11.4.3.4 Dataset size

Datasets shall not exceed 10 MB.

11.4.4 Exchange catalogue

The exchange catalogue acts as the table of contents for the exchange set. The catalogue file of the exchange set shall be named CATALOG.nnn. The value of nnn is "001" in this first edition of this standard. No other file in the exchange set may be named CATALOG. The contents of the exchange catalogue are described in 11.4.7.

11.4.5 Digital signature

The digital signature may be added as described in S-100:2018, 15-8. The digital signature may be included in the dataset metadata (see 11.4.7.3) which is exchanged together with the S-421 dataset.

The private and public key pair shall be generated by a PKI system endorsed by IHO, if provided.

11.4.6 Encryption

This is not described in this document.

NOTE The services using the route plan can provide the encryption (see IHO S-100:2018, Part 15).

11.4.7.1 Application

This document is intended for developers and implementers of metadata applications, and provides a basic understanding of the principles and the overall requirements for standardisation of geographic information as described in IHO S-100.

For information exchange, there is metadata about the route plan contained in the catalogue.

The mandatory and optional metadata needed for the route plan is as follows.

Figure 11 and Figure 12 outline the overall concept of a route plan exchange set for the interchange of route plan. Figure 11 depicts the realization of the classes which form the foundation of the exchange set. The overall structure of route plan metadata for exchange sets is modelled in Figure 12 and Figure 13. Example of more detailed information about the various classes is shown in Figure 14 and a textual description is in Table 31. The actual information is available in IHO S-100.

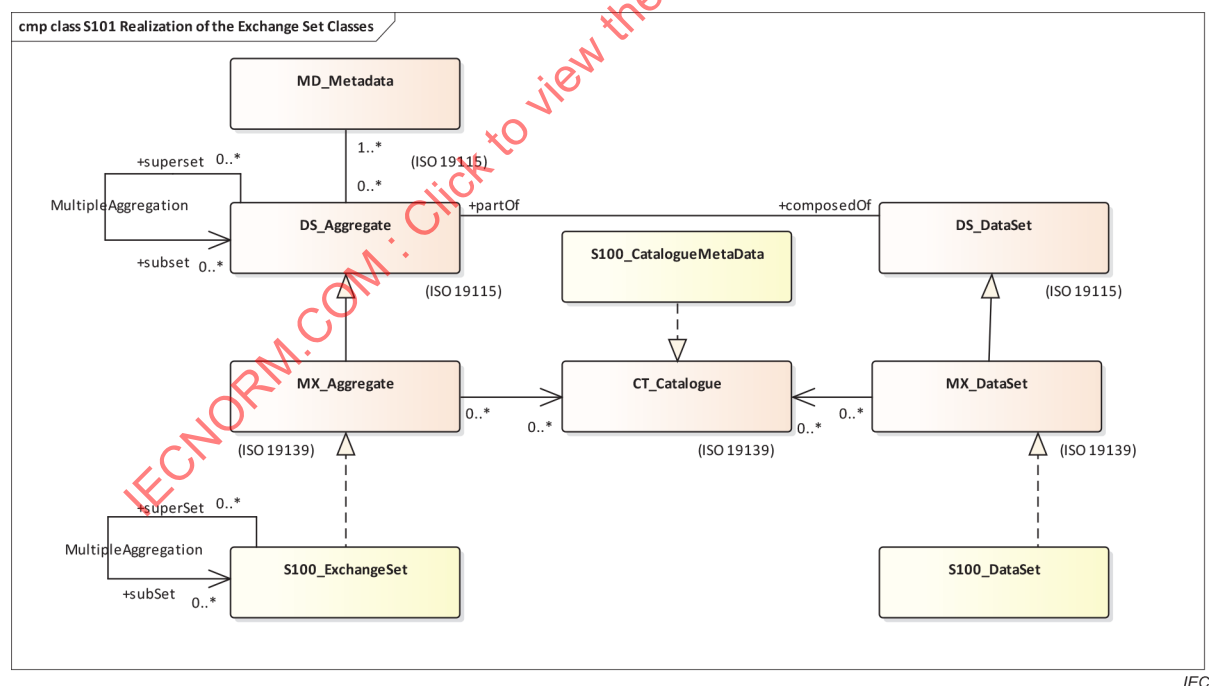


Figure 11 – Realization of the exchange set classes

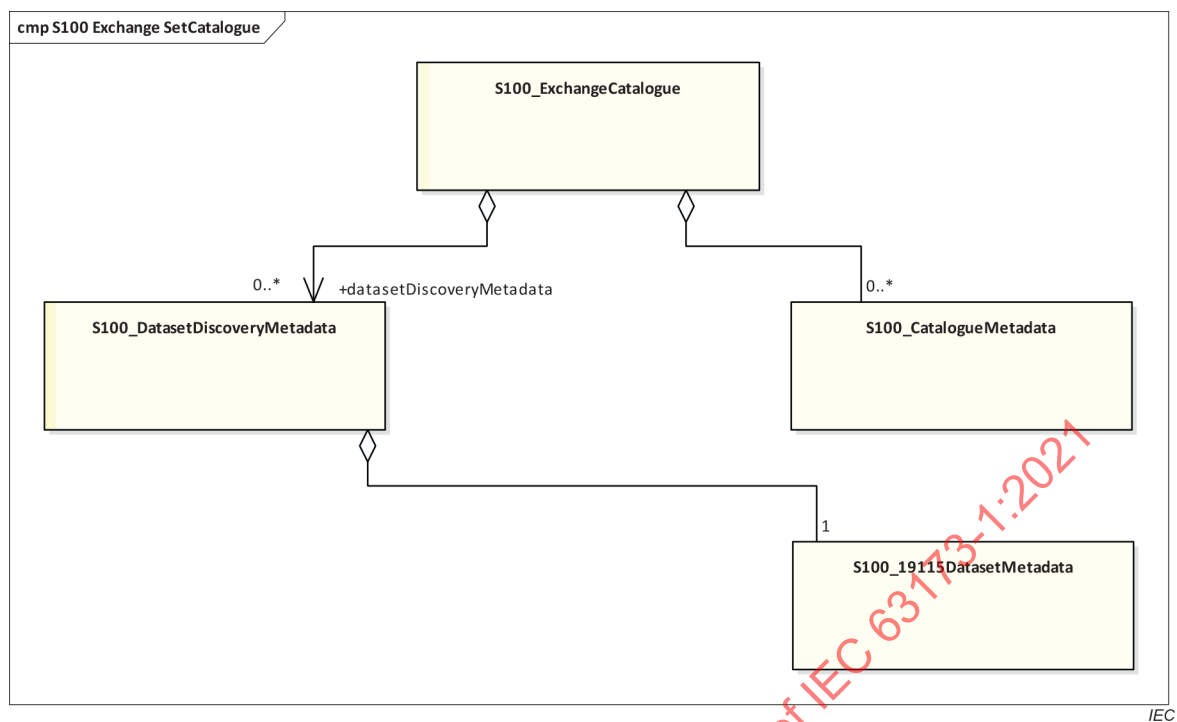


Figure 12 – Route exchange set catalogue

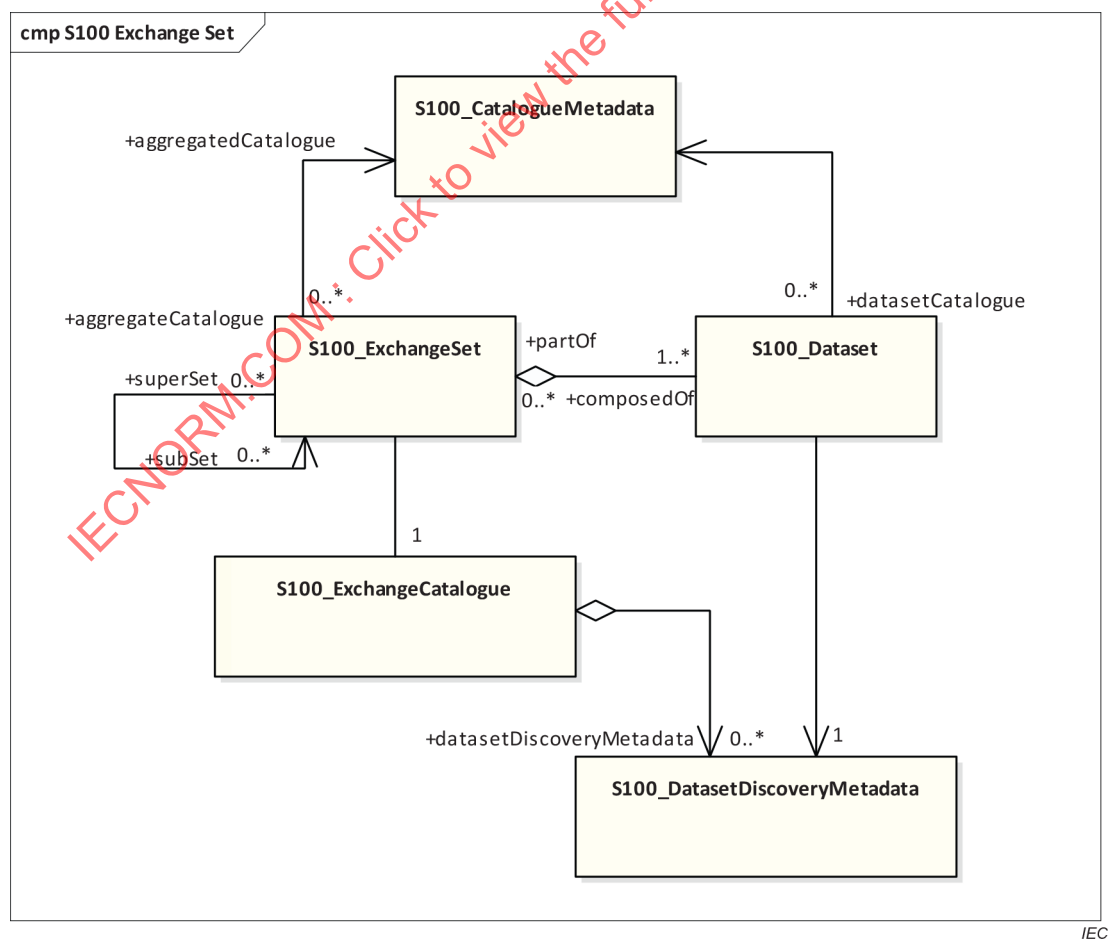
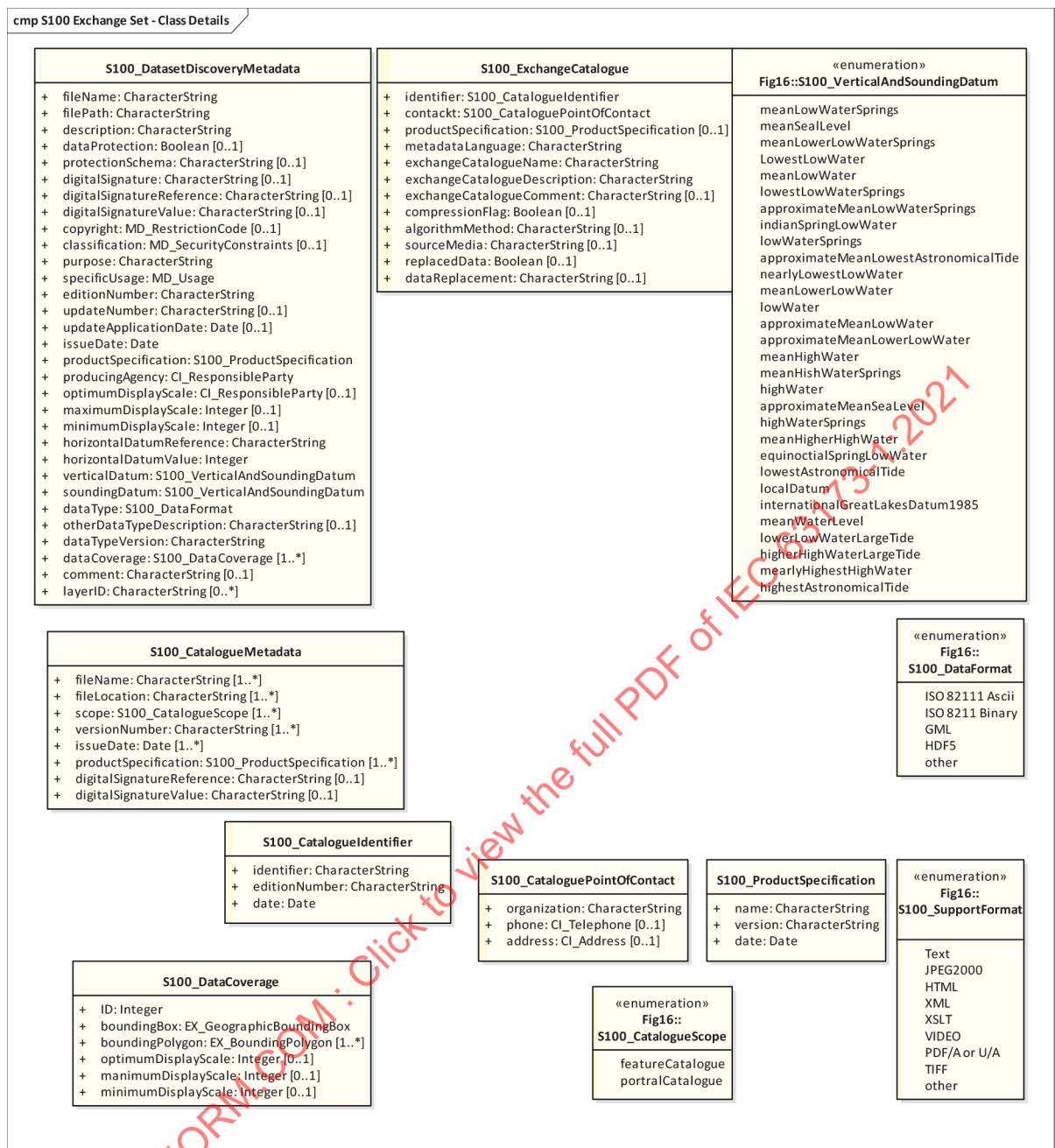


Figure 13 – Route exchange set



IEC

Figure 14 – Route exchange set – Example of class details

11.4.7.3 Dataset metadata

Table 31 defines the mandatory and optional metadata needed for S-421. In some cases, the metadata may be repeated in a national language. If this is the case, it is noted in the Remarks column.

Table 31 – Dataset metadata

Name	Multiplicity	Value	Type	Remarks
metadataFileIdentifier	1		CharacterString	
metadataPointOfContact	1		CI_ResponsibleParty	
metadataDateStamp	1		Date	
metadataLanguage	1	English	CharacterString	All data sets conforming to S-101 PS use the English language
fileName	1		CharacterString	Dataset file name
description	1		CharacterString	Short description of the area covered by dataset harbour or port name, between two named locations etc. NATIONAL LANGUAGE enabled
dataProtection	1		Boolean	True = Encrypted False = Unencrypted A value of True indicates the presence of encryption. Otherwise, the value shall be False
protectionScheme	0..1		CharacterString	E.g. S-63
digitalSignature	1		CharacterString	
classification	1	{1} to {5}	Class MD_SecurityConstraints>MD_ClassificationCode (codelist)	1. unclassified 2. restricted 3. confidential 4. secret 5. top secret
purpose	1	{1} to {5}	CharacterString MD_Identification>purpose (character string)	1. new dataset 2. new edition

12 Test methods and expected results

12.1 General

A simulator or test arrangements with the following characteristics is required:

- capable of importing and exporting route plan compliant data;
- capable of examining content of route plan (i.e. GML-encoded XML file);
- capable of editing the import and exported route plan file.

Confirm by inspection of the documented evidence that the user manual specifies:

- the versions of the S-421 schema supported;
- the optional attributes of the S-421 schema supported;
- which formats are supported for import and export (see 11.1);
- the types of schedules supported;
- portrayal catalogue;
- the manufacturer extensions supported.

Route related tests are subdivided into two: generic tests specified in Clause 12 and use case specific tests specified in Annex A.

12.2 Test data

12.2.1 Test material

Test material is provided in machine readable form at <http://cirm.org/s-421>. This data is provided in each of the three formats specified in this document: single XML files (11.2), compressed data containers (11.3) and S-100-compliant exchange sets (11.4).

Test data is defined for the mandatory and optional tests. The mandatory test is for the test of the mandatory implementation and optional test is for the test of the optional implementations.

Ready to use test material is available for the minimum generic test (RTE-TEST-GMIN.s421), basic generic test (RTE-TEST-GBASIC.s421) and full generic test (RTE-TEST-GFULL.s421). Test material for other test cases can be created by editing the provided test material, for example:

- optional attributes can be removed from the generic test material;
- value of attribute can be changed to be appropriate for the test;
- incomplete route plan can be created by removing mandatory attributes;
- incomplete route plan can be created by referencing a non-existent GML object, such as reference from routeScheduleElement to a non-existent routeWaypoint;
- incomplete route plan can be created by setting a routeInfoValidityEnd before routeInfoValidityStart, or ETD before ETA on a routeScheduleElement;
- invalid route plan: application level context check error can be created by duplicating an attribute;
- invalid route plan: application level context check error can be created by editing a part of geometry;
- invalid route plan: application level context check error can be created by changing the number of decimals (for example as less or more than allowed range);
- invalid route plan: application level context check error can be created by changing the geometry for meridional difference of over 180°;
- invalid route plan: application level context check error can be created by changing waypoint ID reference to a non existing waypoint;
- invalid route plan: schema validation error can be created by removing field start or end markings of the XML encoding;
- invalid route plan: schema validation error can be created by changing the value of an attribute as not compliant with attribute specification (for example: value out of legal range, different data type, such as characters instead of numeric value);
- invalid route plan: schema validation error can be created by removing a required field.

12.2.2 Minimum generic test data

Minimum generic test data includes only the proper data available for required objects (Route, RouteInfo and RouteWaypoint object only) by schema and related mandatory attributes, and no optional objects or attributes. This data is to test the minimum requirement of the route plan. All equipment shall support at least this minimum test data in all 3 delivery options (see 11.2, 11.3 and 11.4).

Valid route plan for minimum generic test cases includes:

- typical route plan including only Route, RouteInfo and RouteWaypoints objects and its mandatory attributes;

- editing of attributes of “routeWaypoint” objects to create separate test cases:
 - “routeWaypointFixed” to be changed between true (fixed = not editable) or false (editable);
 - “geometry”, i.e. geographical position to be changed to another geographical position;
 - “routeWaypointTurnRadius” to be changed to smaller and larger value of radius;
- deletion of “routeWaypoint” object as separate test cases in the beginning, middle or end of the route;
- adding a new “routeWaypoint” object as separate test cases in the beginning, middle or end of the route.

Invalid route plan test cases require editing (see 12.2.1) of the valid route plan test data for the following cases:

- invalid route plan according to schema;
- invalid route plan including invalid route version format;
- invalid route plan including duplicated route identifier;
- invalid route plan including invalid routeInfoEditionTime value
- invalid route plan including invalid routeInfoStatus enumeration;
- invalid route plan including invalid routeInfoValidityStart and routeInfoValidityEnd value;
- invalid route plan including dual waypoint ID;
- invalid route plan including invalid position resolution in route waypoint geometry;
- invalid route plan including invalid geometry type in route waypoint geometry;
- invalid route plan including invalid data with waypoint turn radius larger than 5 NM;
- invalid route plan including invalid data with wrong precision in route waypoint turn radius.

NOTE The minimum required objects do not include the attributes whose multiplicity are zero to one and zero to many.

12.2.3 Basic generic test data

Basic generic test data includes only all mandatory attributes for all objects in route plan. This test data is used for the basic test for the route plan objects which require any modifications of the content of the test data. Every route plan within the test data includes at least 10 waypoints from shore to ship (as GML-encoded XML file).

Valid route plan data set for a basic generic test includes separate test data for following cases in addition to minimum generic test data:

- typical route plan with all mandatory attributes in the objects available from shore to ship and ship to shore (GML-encoded XML file);
- waypoints which are a mix of fixed and editable and no values for routeWaypointFixed attributes;
- schedule with manual and calculated, and recommended.

Invalid route plan cases require editing (see 12.2.1) of the valid route plan test data for following cases:

- invalid route plan according to schema;
- invalid route plan including invalid vessel MMSI format;
- invalid route plan including dual action point ID;
- invalid route plan including invalid geometry type in route action point geometry;
- invalid route plan including invalid geometry resolution value in route action point geometry;

- invalid route plan including invalid action point radius value of in route action point geometry if GM_Point is used;
- invalid route plan including action point radius value of in route action point geometry unless GM_Point is used;
- invalid route plan including invalid action point required action enumeration value;
- invalid route plan including invalid data with larger than 5 NM in route waypoint turn radius;
- invalid route plan including invalid data with wrong resolution in route waypoint turn radius;
- invalid route plan including invalid geometry type in route waypoint leg;
- invalid route plan including two waypoints where the meridional difference between two waypoints are 180°;
- invalid route plan including dual route schedule ID;
- invalid route plan including invalid waypoint ID reference in schedule element;
- invalid route plan including invalid planned SOG minimum and SOG maximum values;
- invalid route plan including invalid ETD/ETA data values;
- invalid route plan including invalid ETD window before/after data values;
- invalid route plan including invalid ETA window before/after data values.

12.2.4 Full generic test data

Full generic test data includes all optional objects and attributes as well as mandatory objects and attributes. This test data is used for any test which require any modifications of the content of the test data. Every route plan within the test data includes at least 10 waypoints from shore to ship (as GML-encoded XML file).

Valid route plan data set for a full generic test includes separate test data for the following cases in addition to basic generic test data:

- typical route plan with all mandatory and optional objects/attributes available from shore to ship and ship to shore (GML-encoded XML file).

Invalid route plan cases require editing (see 12.2.1) of the valid route plan test data for following cases:

- invalid route plan according to schema;
- invalid route plan including invalid primary departure and arrival port identifier with UNLOCODE value;
- invalid route plan including invalid vessel type;
- invalid route plan including invalid vessel call sign format;
- invalid route plan including invalid vessel IMO number format;
- invalid route plan including invalid vessel height, length and beam resolution values;
- invalid route plan including invalid route maximum draft, maximum air draft, maximum beam and maximum length resolution values;
- invalid route plan including invalid data or data resolution in starboard cross track distance limit;
- invalid route plan including invalid data or data resolution in port cross track distance limit;
- invalid route plan including invalid data or data resolution in starboard cross track distance check limit;
- invalid route plan including invalid data or data resolution in port cross track distance check limit;
- invalid route plan including invalid data resolution in safety contour;

- invalid route plan including invalid data resolution in safety depth;
- invalid route plan including invalid data resolution in static draft;
- invalid route plan including invalid data resolution in static draft forward;
- invalid route plan including invalid data resolution in leg draft after;
- invalid route plan including invalid data resolution in minimum static UKC;
- invalid route plan including invalid data resolution in minimum dynamic UKC;
- invalid route plan including invalid data resolution in safety margin;
- invalid route plan including invalid data resolution in maximum draft of the route waypoint leg;
- invalid route plan including invalid data resolution in maximum air draft of the route waypoint leg;
- invalid route plan including invalid data resolution in maximum vessel beam of the route waypoint leg;
- invalid route plan including invalid data resolution in maximum vessel length of the route waypoint leg.

12.3 Route plan test

12.3.1 General

Route plan tests consist of minimum generic route plan test (see 12.3.2), basic generic route plan test (see 12.3.3) and full generic route plan test (see 12.3.4 and use case specific tests (see Annex A). The target of minimum generic route plan tests is to test compliance with this document for the absolute minimum mandatory set of fully implemented objects and attributes. The target of full generic route plans tests is to test that the EUT is able to manage the situation as required by this document when any object or attribute available in this document is present. The target of use case specific tests is to test compliance with a specific use case.

12.3.2 Minimum generic route plan test

12.3.2.1 Import route plan test for proper minimum route

Use the simulator or test arrangements as the source to import a proper route plan from the minimum generic test material (RTE-TEST-GMIN.s421).

- a) Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that presentation of route information complies as specified in this document.
- b) Change some attribute values and confirm by observation that the route imports without error, that the route is identified as a new edition of the previously imported route and that all parts of the route are correctly available for viewing by the EUT.
- c) Delete any object(s) and attribute(s) to cause the route to be below the minimum required by this document and confirm by observation that the route import terminates with an indication about the route not meeting the minimum acceptable content of a route.

12.3.2.2 Import route plan test for invalid route

Use the simulator or test arrangement as the means to edit and import an invalid route plan from the minimum generic test material (RTE-TEST-GMIN.s421) for the following cases.

- a) Invalid route version format. Confirm by observation that the route import terminates with an indication about an error of "invalid route version format".
- b) Duplicated route ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated route id".
- c) Invalid time value in routeInfoEditionTime. Confirm by observation that the route import terminates with an indication about an error of "invalid route info edition time".

- d) Invalid enumeration value in routeInfoStatus. Confirm by observation that the route import terminates with an indication about an error of "invalid route info status enumeration value".
- e) Invalid time value in routeInfoValidityStart. Confirm by observation that the route import terminates with an indication about an error of "invalid route info validity start time".
- f) Invalid time value in routeInfoValidityEnd. Confirm by observation that the route import terminates with an indication about an error of "invalid route info validity end time".
- g) Dual waypoint ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated waypoint id".
- h) Invalid generic route plan including route waypoint geometry type. Confirm by observation that the route import terminates with an indication about an error of "invalid waypoint geometry type".
- i) Invalid generic route plan including route waypoint geometry position resolution. Confirm by observation that the route import terminates with an indication about an error of "invalid waypoint geometry position resolution".
- j) Invalid data with larger than 5 NM in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about "an error in value of turn radius".
- k) Invalid data with wrong precision in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about "an error in value of turn radius".
- l) Invalid generic route plan according to schema. Confirm by observation that the route import terminates with an indication about error in the route plan.

12.3.2.3 Export route plan test for minimum route

12.3.2.3.1 Test against schema

Use the EUT to create a route consisting of only the minimum element available in the EUT. Export the route. Use the generic schema and a schema validation tool, and confirm by observation that the exported route plan passes a schema check.

If the EUT supports manufacturer's extensions, use the manufacturer's documentation describing the routeExtension information in the route and routeInfo. Export the route. Use a tool to view the content of the route and confirm by observation that the routeExtension information is provided correctly as supported in EUT.

12.3.2.3.2 Tests related to Route and RouteInfo

Use the EUT to create three different routes. Export the routes. Use a tool to view the content of the route and confirm by observation that each route plan has same route format version and unique combination of route ID and route Edition Number. Use a tool to view the content of the route and confirm by observation that route name, route status and at least one ship identification information is provided by the EUT.

Use the EUT to amend one of the routes. Export the amended route. Use a tool to view the content of the route and confirm by observation that the route edition number has been increased by one and route info status description, if applicable, has been provided in human readable text whenever the route plan is changed.

If the EUT supports route plan exchange with more than one entity, use the EUT to create such entities, export the entities and use a tool to confirm by observation that route edition number is managed independently for each entity.

12.3.3 Basic generic route plan test

12.3.3.1 Import route plan test for proper basic route

Use the simulator or test arrangements as the source to import a proper route plan from the basic generic test material (RTE-TEST-GBASIC.s421).

- a) Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that presentation of route information complies as specified in this document.
- b) Change some attribute values and confirm by observation that the route imports without error, that the route is identified as a new edition of the previously imported route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
- c) Delete any object(s) and attribute(s) to cause the route to be below the minimum required by this document and confirm by observation that the route import terminates with an indication about the route not meeting the minimum acceptable content of a route.
- d) Change the order of waypoints and confirm by observation that the route waypoints are presented correctly as specified in this document.
- e) Delete some waypoints and confirm by observation that the route import terminates with an indication about the route not meeting the minimum acceptable content of a route.
- f) Include extensions to the route plan and confirm by observation that the route imports without error and that all parts of the route which are not part of extensions are correctly available for viewing by the EUT.

12.3.3.2 Import route plan test for invalid route

12.3.3.2.1 Test related to Route and RouteInfo

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the basic generic test material (RTE-TEST-GBASIC.s421) for the following cases.

- a) Invalid route version format. Confirm by observation that the route import terminates with an indication about an error of "invalid route version format".
- b) Duplicated route ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated route id".
- c) Invalid time value in routeInfoEditionTime. Confirm by observation that the route import terminates with an indication about an error of "invalid route info edition time".
- d) Invalid enumeration value in routeInfoStatus. Confirm by observation that the route import terminates with an indication about an error of "invalid route info status enumeration value".
- e) Invalid time value in routeInfoValidityStart. Confirm by observation that the route import terminates with an indication about an error of "invalid route info validity start time".
- f) Invalid time value in routeInfoValidityEnd. Confirm by observation that the route import terminates with an indication about an error of "invalid route info validity end time".
- g) Invalid MMSI format. Confirm by observation that the route import terminates with an indication about an error of "invalid vessel MMSI format".

12.3.3.2.2 Tests related to route action point

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the basic generic test material (RTE-TEST-GBASIC.s421) for the following cases.

- a) Dual action point id. Confirm by observation that the route import terminates with an indication about an error of "duplicated action point id".
- b) Invalid action point geometry value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point geometry value".
- c) Invalid action point geometry resolution value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point geometry resolution value".
- d) Invalid route action point radius value for GM_Point in route action point position value. Confirm by observation that the route import terminates with an indication about an error of "invalid use of route action point radius".

- e) Invalid action point required action enumeration value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point required action enumeration value".

12.3.3.2.3 Test related to route waypoint and leg

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the basic generic test material (RTE-TEST-GBASIC.s421) for the following cases.

- a) Dual waypoint ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated waypoint id".
- b) Invalid route waypoint geometry position resolution. Confirm by observation that the route import terminates with an indication about an error in "invalid waypoint geometry position resolution".
- c) Invalid data with larger than 5 NM in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about an error of "out of range in turn radius values".
- d) Invalid resolution in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution value of turn radius".
- e) Invalid geometry type in waypoint leg. Confirm by observation that the route import terminates with an indication about an error of "invalid waypoint leg geometry type".
- f) Two waypoints where the meridional difference between two waypoints are 180°. Confirm by observation that the route import terminates with an indication about an error of "invalid the meridional difference between two waypoints".

12.3.3.2.4 Tests related to route schedules

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the basic generic test material (RTE-TEST-GBASIC.s421) for the following cases.

- a) Dual schedule id. Confirm by observation that the route import terminates with an indication about an error of "duplicated schedule id".
- b) Schedule referencing non-existent waypoints. Confirm by observation that the route import terminates with an indication about an error of "Invalid schedule referencing with non-existing waypoints".
- c) Invalid planned SOG value. Confirm by observation that the route import terminates with an indication about an error of "Invalid planned SOG value".
- d) Invalid ETA value. Confirm by observation that the route import terminates with an indication about an error of "Invalid ETA value".
- e) Invalid ETD value. Confirm by observation that the route import terminates with an indication about an error of "Invalid ETD value".

12.3.3.3 Export route plan test

12.3.3.3.1 Test against schema

Use the schema and a schema validation tool, and confirm by observation that the exported route plan passes the schema check.

12.3.3.3.2 Tests related to Route and RouteInfo

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create three different routes. Export the routes. Use a tool to view the content of the route and confirm by observation that each route plan has the same route format version and unique combination of route ID and route edition number. Use a tool to view the content of the route and confirm by observation that route name, route status, route validation time (start and end time) and at least one ship identification information is provided by the EUT.

- b) Use the EUT to amend one of the routes. Export the amended route. Use a tool to view the content of the route and confirm by observation that the route edition number has been increased by one and route info status description, if applicable, has been provided in human readable text whenever the route plan is changed.
- c) If the EUT supports route plan exchange with more than one entity, use the EUT to create such entities, export the entities and use a tool to confirm by observation that route edition number is managed independently for each entity.
- d) Use the EUT to create routes with route author if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the route author information has been provided in human readable text. Confirm by observation that the route edition time, if applicable, has been provided in UTC time format whenever the route plan is changed.
- e) Use the EUT to create routes with vessel MMSI number if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel MMSI number, if applicable, has been provided in vessel MMSI format.

12.3.3.3.3 Tests related to route action point

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create a route with three different action points. Export the routes. Use a tool to view the content of the route action point and confirm by observation that each action point has a unique action point identifier, time to act, and a proper action code (see Table 9) and its description in human readable text. Use a tool to view the content of the route and its action point, and confirm by observation that action point and action code information is provided by the EUT.
- b) Use the EUT to create a route with three different action point positions if applicable. Export the routes. Use a tool to view the content of the route action point and confirm by observation that each action point has a value with minimum resolution of 0,000 1° and a proper geometry presentation as one of the following as defined in this document: point, curve or surface. Confirm by observation that the radius is provided if the point is applied for the action point.
- c) If provided, confirm by observation that the action point name is provided.

12.3.3.3.4 Tests related to route waypoints and leg

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create a route with only one waypoint. Export the route. Confirm by observation that the route export terminates with an indication about invalid number of waypoints.
- b) Use the EUT to create a route with 10 different waypoints. Export the route. Use a tool to view the content of the route waypoint and confirm by observation that each waypoint has a unique identifier.
- c) Use the EUT to change the order of waypoints of the route in previous test. Export the route. Use a tool to view the content of the route waypoint and confirm by observation that the order of waypoints is same as the order of waypoint objects and that the route waypoint ID is not changed. Confirm by observation that the order of waypoint leg, if applicable, has been provided in the same way as the order of its waypoint objects.
- d) Use the simulator or test arrangements to change any information for waypoints. Confirm by observation that by default waypoints are editable. Use the simulator or test arrangements to change a waypoint as "fixed". Import the route. Confirm by observation that the fixed waypoint is not editable while all other waypoints are editable. Export the route. Confirm by observation that the values of the fixed waypoint are not changed.
- e) Use the EUT to create a route with a route waypoint position value. Export the route. Use a tool to view the content of the route and confirm by observation that waypoint position is provided as a point with minimum resolution 0,000 1°.

- f) Use the EUT to create a route with route waypoint turn radius. Export the route. Use a tool to view the content of the route and confirm by observation that turn radius is provided with values in range from 0,0 NM to 5,0 NM and with minimum resolution of 0,1 NM.
- g) Use the EUT to create a route with route waypoint leg if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that geometry type of waypoint leg (see Table 12) has been provided and presented properly if applicable.

12.3.3.3.5 Tests related to schedules

Use the simulator or test arrangements for the following cases.

- a) Use the simulator or test arrangements to change the planned speed (i.e. the planned speed and ETA/ETD values of the route do not match). Import the route to the EUT. Export the route after the EUT generates calculated schedules. Confirm by observation that the calculated schedule information is re-calculated.
- b) Use the simulator or test arrangements to add or to delete the manual schedule. Import the route. Export the route after the EUT generates calculated schedules. Confirm by observation that the calculated schedule information is provided including all manual schedule elements, if applicable.
- c) Use the EUT to create a route schedule with 10 different schedule elements. Confirm by observation that each route schedule has a unique identifier. Modify the route with addition and deletion of some schedule elements. Export the route and confirm by observation that each route schedule element has a unique identifier.

12.3.4 Full generic route plan test

12.3.4.1 Import route plan test

Use the simulator or test arrangements as the source to import a proper route plan from the full generic test material (RTE-TEST-GFULL.s421).

- a) Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
- b) Change some attribute values and confirm by observation that the route imports without error, that the route is identified as a new edition of the previously imported route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information complies with the portrayal catalogue as specified in this document.
- c) Delete any object(s) and/or attribute(s) to cause the route to be below the minimum required by this document and confirm by observation that the route import terminates with an indication about the route not meeting the minimum acceptable content of a route.

12.3.4.2 Import route plan test for invalid route

12.3.4.2.1 Test related to Route and RouteInfo

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the full generic test material (RTE-TEST-GFULL.s421) for the following cases.

- a) Invalid primary arrival port identifier format. Confirm by observation that the route import terminates with an indication about an error of "invalid primary arrival port identifier format" if applicable.
- b) Invalid primary departure port identifier format. Confirm by observation that the route import terminates with an indication about an error of "invalid primary departure port identifier format" if applicable.
- c) Invalid vessel type value. Confirm by observation that the route import terminates with an indication about an error of "invalid vessel type value" if applicable.
- d) Invalid call sign format. Confirm by observation that the route import terminates with an indication about an error of "invalid vessel call sign format" if applicable.

- e) Invalid IMO number format. Confirm by observation that the route import terminates with an indication about an error of "invalid vessel IMO number format" if applicable.
- f) Invalid vessel height, length or beam. Confirm by observation that the route import terminates with an indication about an error of "invalid vessel height, length or beam" if applicable.
- g) Invalid route maximum draft, maximum air draft, maximum beam and maximum length. Confirm by observation that the route import terminates with an indication about an error or "invalid route height, length or beam" if applicable.
- h) Invalid route waypoint leg maximum draft, maximum air draft, maximum beam and maximum length. Confirm by observation that the route import terminates with an indication about an error of "invalid route waypoint leg height, length or beam" if applicable.

12.3.4.2.2 Tests related to route action point

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the full generic test material (RTE-TEST-GFULL.s421) for the following cases.

- a) Dual action point ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated action point id".
- b) Invalid action point geometry value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point geometry value".
- c) Invalid action point geometry resolution value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point geometry resolution value".
- d) Invalid route action point radius value for GM Point in route action point position value. Confirm by observation that the route import terminates with an indication about an error of "invalid use of route action point radius".
- e) Invalid action point required action enumeration value. Confirm by observation that the route import terminates with an indication about an error of "invalid action point required action enumeration value".

12.3.4.2.3 Test related to route waypoint and leg

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the full generic test material (RTE-TEST-GFULL.s421) for the following cases.

- a) Dual waypoint ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated waypoint id".
- b) Invalid route waypoint geometry position resolution. Confirm by observation that the route import terminates with an indication about an error of "invalid waypoint position resolution".
- c) Invalid data with larger than 5 NM in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about an error of "out of range in turn radius values".
- d) Invalid resolution in route waypoint turn radius. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution value of turn radius".
- e) Invalid geometry type in waypoint leg. Confirm by observation that the route import terminates with an indication about an error of "invalid geometry type".
- f) Two waypoints where the meridional difference between two waypoints are 180°. Confirm by observation that the route import terminates with an indication about an error of "invalid the meridional difference between two waypoints".
- g) Invalid value of starboard cross track distance limit. Confirm by observation that the route import terminates with an indication about an error of "out of range value of starboard cross track distance limit".
- h) Invalid resolution value of starboard cross track distance limit. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of starboard cross track distance limit".

- i) Invalid value of port cross track distance limit. Confirm by observation that the route import terminates with an indication about an error of "out of range value of port cross track distance limit".
- j) Invalid resolution value of port cross track distance limit. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of port cross track distance limit".
- k) Invalid value of starboard cross track distance check limit. Confirm by observation that the route import terminates with an indication about an error of "out of range value of starboard cross track distance check limit".
- l) Invalid resolution value of starboard cross track distance check limit. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of starboard cross track distance check limit".
- m) Invalid value of port cross track distance check limit. Confirm by observation that the route import terminates with an indication about an error of "out of range value of port cross track distance check limit".
- n) Invalid resolution value of port cross track distance limit. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of port cross track distance check limit".
- o) Invalid resolution value of safety contour. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of safety contour".
- p) Invalid resolution value of safety depth. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of safety depth".
- q) Invalid resolution value of leg draft. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg draft".
- r) Invalid resolution value of leg draft forward. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg draft forward".
- s) Invalid resolution value of leg draft after. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg draft after".
- t) Invalid resolution value of leg draft max. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg draft max".
- u) Invalid resolution value of leg air draft max. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg air draft max".
- v) Invalid resolution value of leg beam max. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg beam max".
- w) Invalid resolution value of leg length max. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of leg length max".
- x) Invalid resolution value of static UKC. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of static UKC".
- y) Invalid resolution value of dynamic UKC. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of dynamic UKC".
- z) Invalid resolution value of safety margin. Confirm by observation that the route import terminates with an indication about an error of "invalid resolution of safety margin".
- aa) Invalid SOG minimum and maximum data values. Confirm by observation that the route import terminates with an indication about an error of "invalid data of SOG minimum and maximum".

12.3.4.2.4 Tests related to route schedules

Use the simulator or test arrangements as the means to edit and import an invalid route plan from the full generic test material (RTE-TEST-GFULL.s421) for the following cases.

- a) Dual schedule ID. Confirm by observation that the route import terminates with an indication about an error of "duplicated schedule id".

- b) Schedule referencing non-existent waypoints. Confirm by observation that the route import terminates with an indication about an error of "schedule referencing non-existing waypoints".
- c) Invalid planned SOG value. Confirm by observation that the route import terminates with an indication about an error of "Invalid planned SOG value".
- d) Invalid ETA value. Confirm by observation that the route import terminates with an indication about an error of "Invalid ETA value".
- e) Invalid ETD value. Confirm by observation that the route import terminates with an indication about an error of "Invalid ETD value".
- f) Invalid ETD window before/after values. Confirm by observation that the route import terminates with an indication about an error of "invalid ETD window values".
- g) Invalid ETA window before/after values. Confirm by observation that the route import terminates with an indication about an error of "invalid ETA window values".
- h) Invalid generic route plan according to schema. Confirm by observation that the route import terminates with an indication about an error in schema of the route.

12.3.4.3 Export route plan test

12.3.4.3.1 Test against schema

Use the generic schema and a schema validation tool, and confirm by observation that the exported route plan passes the schema check.

12.3.4.3.2 Tests related to Route and RouteInfo

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create three different routes. Export the routes. Use a tool to view the content of the route and confirm by observation that each route plan has same route format version and unique combination of route ID and route edition number. Use a tool to view the content of the route and confirm by observation that route name, route status, route validation time (start and end time) and at least one ship identification information is provided by the EUT.
- b) Use the EUT to amend one of the routes. Export the amended route. Use a tool to view the content of the route and confirm by observation that the route edition number has been increased by one and route info status description, if applicable, has been provided in human readable text whenever the route plan is changed.
- c) If the EUT supports the route plan exchange with more than one entity, use the EUT to create such entities, export the entities and use a tool to confirm by observation that route edition number is managed independently for each entity.
- d) Use the EUT to create routes with route author if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the route author information has been provided in human readable text. Confirm by observation that the route edition time, if applicable, has been provided in UTC time format whenever the route plan is changed.
- e) Use the EUT to create routes with arrival port information if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the primary port identifier is provided in UNLOCODE format and the secondary identifier is text string if available.
- f) Use the EUT to create routes with departure port information if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the primary port identifier is provided in UNLOCODE format and the secondary identifier is text string if available.
- g) Use the EUT to create routes with arrival/departure port call if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the port call information is provided in the text string.

- h) Use the EUT to create routes with previous/next route reference if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the previous/next route reference is provided in the text string. Use the EUT to create routes with vessel type if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel type if applicable, has been provided in accordance with Table 21.
- i) Use the EUT to create routes with route draft max if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that draft max is provided.
- j) Use the EUT to create routes with route air draft max if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that air draft max is provided.
- k) Use the EUT to create routes with route beam max if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that route beam max is provided.
- l) Use the EUT to create routes with route length max if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that route length max is provided.
- m) Use the EUT to create routes with vessel MMSI number if applicable. Use a tool to view the content of the route and confirm by observation that the vessel MMSI number, if applicable, has been provided in vessel MMSI format.
- n) Use the EUT to create routes with vessel name if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel name, if applicable, has been provided correctly.
- o) Use the EUT to create routes with vessel call sign if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel call sign number, if applicable, has been provided in vessel call sign format.
- p) Use the EUT to create routes with vessel IMO number if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel IMO number, if applicable, has been provided in vessel IMO format.
- q) Use the EUT to create routes with vessel height, length and beam if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the vessel height, length and beam, if applicable, has been provided with a resolution of 0,01 m.
- r) Use the EUT to create routes with the source route identifier, source edition number, reference route information, and vessel voyage identifier if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that the source route identifier, source edition number, reference route information, and vessel voyage identifier has been provided in string format.
- s) Check the documentation describing the routeExtension information in the route and routeInfo, and use the EUT to edit the routeExtension. Export the route and confirm by observation that the routeExtension information is provided and processed correctly for the routeExtension information supported in EUT.
- t) Confirm by observation that the presentation of route information complies with the portrayal catalogue as specified in this document.

12.3.4.3.3 Tests related to route action point

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create a route with three different action points. Export the routes. Use a tool to view the content of the route action point and confirm by observation that each action point has a unique action point identifier, time to act, and a proper action code (see Table 8) and its description in human readable text. Use a tool to view the content of the route and its action point, and confirm by observation that action point and action code information is provided by the EUT. Confirm by observation that the order of action is the same as the order of action point objects.
- b) Use the EUT to create a route with three different action point positions if applicable. Export the routes. Use a tool to view the content of the route action point and confirm by

observation that each action point has the value with minimum resolution of 0,000 1° and a proper geometry presentation as defined in the portrayal catalogue of: point, curve or surface. Confirm by observation that the radius is provided if the point is applied for the action point.

- c) Use the EUT to create a route with action point name if applicable. Export the route. Use a tool to view the content of the route action point and confirm by observation that action point name has been provided in string format.
- d) Use the EUT to create a route with external reference information if applicable. Export the route. Use a tool to view the content of the route action point and confirm by observation that external reference information has been provided in string format.
- e) Check the documentation describing the routeExtension information in the routeActionPoints and routeActionPoint, and use the EUT to edit the routeExtension. Export the route and confirm by observation that the routeExtension information is provided and processed correctly for the routeExtension information supported in EUT.
- f) If provided, confirm by observation that the action point name is provided.

12.3.4.3.4 Tests related to route waypoints and leg

Use the simulator or test arrangements for the following cases.

- a) Use the EUT to create a route with only one waypoint. Export the route. Confirm by observation that the route export terminates with an indication about invalid number of waypoints.
- b) Use the EUT to create a route with 10 different waypoints. Export the route. Use a tool to view the content of the route waypoint and confirm by observation that each waypoint has a unique identifier.
- c) Use the EUT to change the order of waypoints of the route in previous test. Export the route. Use a tool to view the content of the route waypoint and confirm by observation that the sailing order of waypoint is same as the order of waypoint objects and that the route waypoint ID is not changed. Confirm by observation that the order of waypoint leg, if applicable, has been provided in the same order of its waypoint objects.
- d) Use the simulator or test arrangements to change any information for waypoints. Confirm by observation that by default waypoints are editable. Use the simulator or test arrangements to change a waypoint as "fixed". Import the route. Confirm by observation that the fixed waypoint is not editable while all other waypoints are editable. Export the route. Confirm by observation that the values of fixed waypoint are not changed.
- e) Use the EUT to create a route with route way point position value. Export the route. Use a tool to view the content of the route and confirm by observation that waypoint position is provided as a point with minimum resolution 0,000 1°.
- f) Use the EUT to create a route with route waypoint turn radius. Export the route. Use a tool to view the content of the route and confirm by observation that turn radius is provided with values in the range from 0,0 NM to 5,0 NM and with minimum resolution of 0,1 NM.
- g) Use the EUT to create a route with route waypoint name and external reference identifier if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that route waypoint name and external reference identifier, if applicable, is provided in string format.
- h) Use the EUT to create a route with route waypoint leg if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that geometry type of waypoint leg (see Table 12) has been provided and presented properly if applicable.
- i) Use the EUT to create a route with starboard cross track distance limit, port cross track distance limit, starboard cross track distance check limit and port starboard cross track distance check limit for the route waypoint leg if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that starboard cross track distance limit, port cross track distance limit, starboard cross track distance check limit and port starboard cross track distance check limit have a value in the range from 1 m to 1 000 m with the resolution of 1 m.

- j) Use the EUT to create a route with safety contour, safety depth, static draft, static draft forward, static draft aft, draft max, air draft max, beam max, length max, static UKC, dynamic UKC and safety margin for the route waypoint leg if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that safety contour, safety depth, static draft, static draft forward, static draft aft, static UKC, dynamic UKC and safety margin is provided with a resolution of 0,1 m. Confirm by observation that the vessel safety draft is calculated correctly.
- k) Use the EUT to create a route with maximum draft, maximum air draft, maximum vessel beam and maximum vessel length for the route waypoint leg if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that maximum draft, maximum air draft, maximum vessel beam and maximum vessel length is provided with a resolution of 0,01 m. Confirm by observation that the vessel safety draft is calculated correctly.
- l) Use the EUT to create a route in which the lowest regulatory speed is higher than the highest regulatory speed. Export the route. Confirm by observation that the route export terminates with an indication about invalid regulatory speed.
- m) Check the documentation describing the routeExtension information in the routeWaypoints, routeWaypoint and routeWaypointLeg, and use the EUT to edit the routeExtension. Export the route and confirm by observation that the routeExtension information is provided and processed correctly for the routeExtension information supported in EUT.

12.3.4.3.5 Tests related to schedules

Use the simulator or test arrangements for the following cases.

- a) Use the simulator or test arrangements to change the planned speed (i.e. the planned speed and ETA/ETD values of the route do not match). Import the route to the EUT. Export the route after the EUT generates calculated schedules. Confirm by observation that the calculated schedule information is re-calculated.
- b) Use the simulator or test arrangements to add or to delete the manual schedule. Import the route. Export the route after the EUT generates calculated schedules. Confirm by observation that the calculated schedule information is provided including all manual schedule elements, if applicable.
- c) Use the simulator or test arrangements to change the geometry type of waypoint leg. Import the route. Export the route. Confirm by observation that the calculated schedule elements are re-calculated.
- d) Use the EUT to create a route with ETA window before/after and ETD window before/after, if applicable. Export the route. Use a tool to view the content of the route and confirm by observation that ETA window before/after and ETD window before/after is provided correctly.
- e) Use the EUT to create a route schedule with 10 different schedule elements. Confirm by observation that each route schedule has a unique identifier. Modify the route with addition and deletion of some schedule elements. Export the route and confirm by observation that each route schedule has a unique identifier.
- f) Check the documentation describing the routeExtension information in the routeSchedules, RouteScheduleManual, RouteScheduleCalculated and routeScheduleRecommended, and use the EUT to edit the routeExtension. Export the route and confirm by observation that the routeExtension information is provided and processed correctly for the routeExtension information supported in EUT.

Annex A (normative)

Examples of use cases for route

A.1 General

Annex A contains multiple use cases for route plan. Manufacturers can choose which use case or cases to implement and manufacturers shall declare the implemented use case or cases in the user manual. For compliance with this document, at least one use case shall be implemented.

Each scenario specifies its mandatory and optional objects/attributes. All other objects/attributes not specified in each scenario including routeExtensions may be supported.

The test of each scenario consists of onboard and shore system tests. When a test applies to only one system, a simulation arrangement for the other system shall be provided. The manufacturer shall provide documents that describe the objects and attributes that the EUT supports as mandatory or optional. The test data for each scenario can be prepared from the full generic test data set (see RTE-TEST-GFULL.s421 in <http://cirm.org/s-421>) with some modification.

A.2 Route cross check

A.2.1 Description

The purpose of route cross check is to include updated regional area information that could affect a ship's route plan. The intended route plan from a ship is sent to a shore-based service provider (for example VTS center) for cross-checking. The cross-checking may be done before the vessel's departure or before arrival at a certain geographical area. The check is initiated by sending a route either automatically by onboard system such as ECDIS (for example monitored route) or manually.

The route cross check involves two actors as shown in Figure A.1:

- 1) ship, where crew members suggest waypoints to the shore center and get advice on adjustments back;
- 2) shore center, which provides a route cross checking service by comparing the routes from the ship with the knowledge of the shore center such as traffic separation or current water level.

When a ship's route is sent to shore-side actors, shore-side actors will review the intended route and verify if the route is in accordance with all general and local area information and regulations. Additionally, necessary changes can be sent as a recommended route from shore-side actors to the ship, which also reduces voice communication and misunderstandings – often a contributing factor to accidents. Examples of cross-checking parameters include, but are not limited to, under keel clearance (UKC), air draft, ship particulars in relation to fairway restrictions, tidal water restrictions, cargo properties, no-go areas, maritime safety information (MSI) and compliance with mandatory routing. No optimization services as such are included in the route cross-checking. The route cross-check may not include the schedule information, for example where the tidal information is not critical for safe navigation.

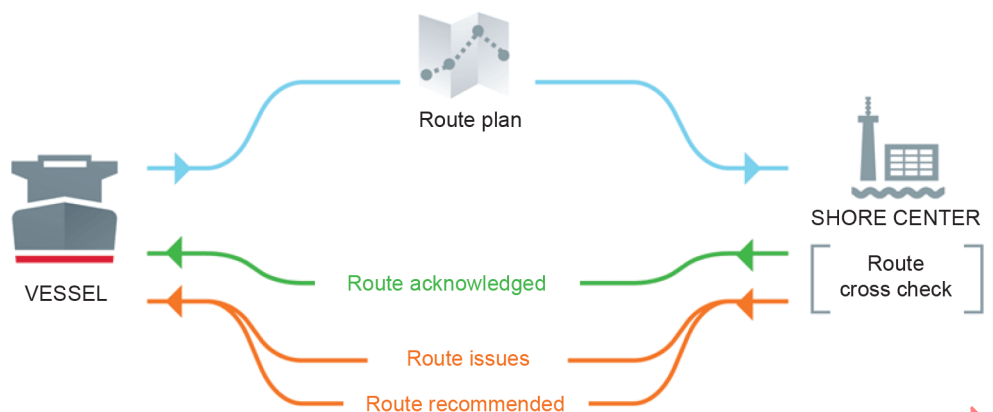


Figure A.1 – Route cross check example

A.2.2 Information exchange diagram

The sequence diagram in Figure A.2 describes how the information is exchanged between the ship and shore center. This diagram explains the interaction with the shore center.

All messages are formatted as a route plan. The different meanings of the messages are as follows.

- 1) Send a planned route from the ship to the shore-side actor for the route cross check with waypoints. The planned route contains route ID, edition number and waypoints.
- 2) The response from the shore-side actor shall be a route with RouteInfoStatus= Recommended, Acknowledged, Route Issues or Error in RouteInfoStatus. "Acknowledged" means that the planned route is acknowledged and no changes are made. "Route Issues" means that there are issues related to the planned route and that description of these issues are available in routeWaypointLegIssue attributes, for example route plan over too shallow area, non-compliant with local regulations, etc. When a new route is issued, it contains recommended routes from the shore-side actor on how the route can be changed to improve safety. This does not require the update of the route edition number.

If the schedule information needs to be provided, the recommended route shall include the validity period of the route and ETD/ETA information of waypoints together.

- 3) The ship can iterate a suggestion in steps 1) and 2) as many times as desired with updated edition number. When satisfied, the ship provides a final route plan.

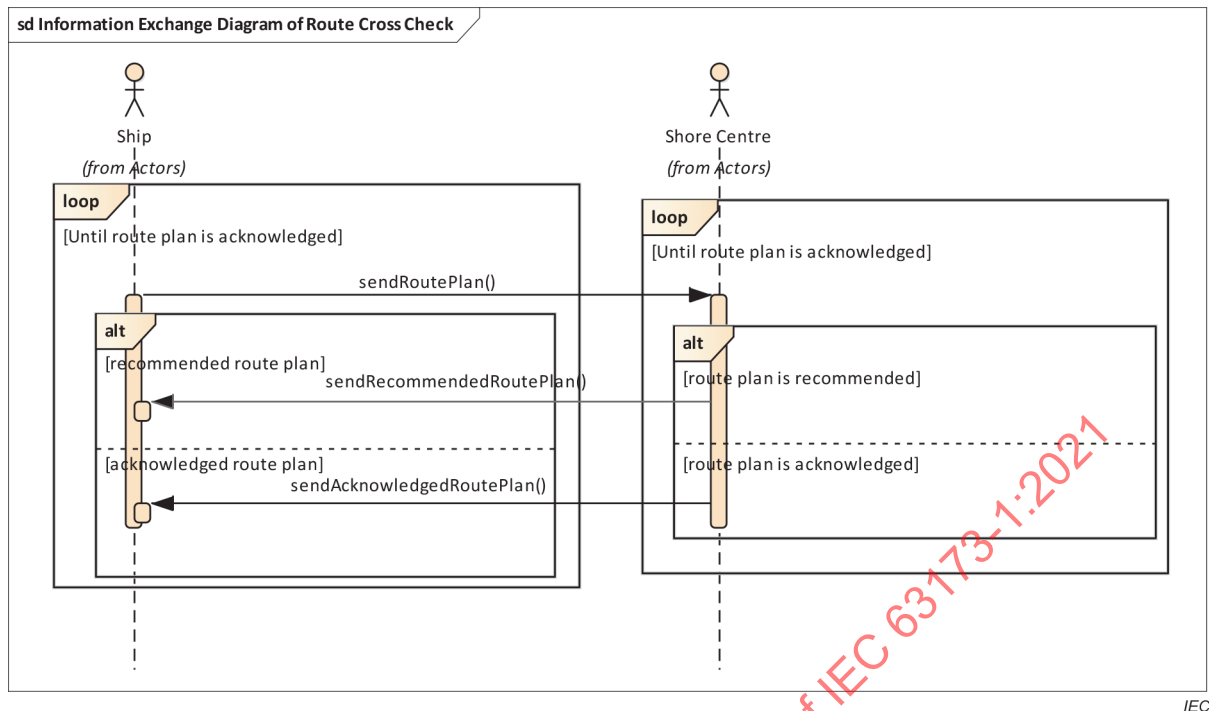


Figure A.2 – Interaction diagram

A.2.3 State transition diagram

From the point of the view of the ship, the route will transition through the states shown in Figure A.3. The states are defined as:

- Route is ready – the route is ready but not cross checked yet.;
- Route cross check is requested – a state which sends a route cross check is sent to the shore-side actor and waits for the response;
- Route is recommended (by the shore) – a state which a route is recommended by the shore-side actor;
- Route is approved (by the master) – a state which a route is approved by the master.

From the point of the view of the shore center, the route will transition through the states shown in Figure A.4. The states are defined as:

- Waiting – a state which the shore center waits for any request from ships for the route cross check;
- Route is cross-checking – a state when the route cross-check is requested from a ship and the route is checking;
- Route is responded – a state when the route was replied with acknowledged or with a recommend new route.

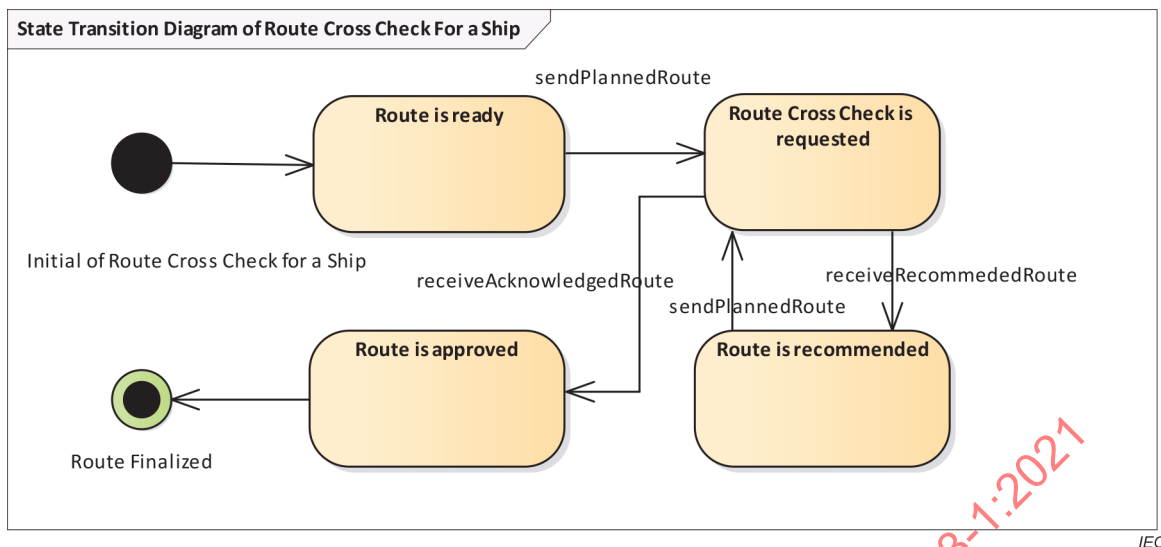


Figure A.3 – State transition diagram for the route plan onboard

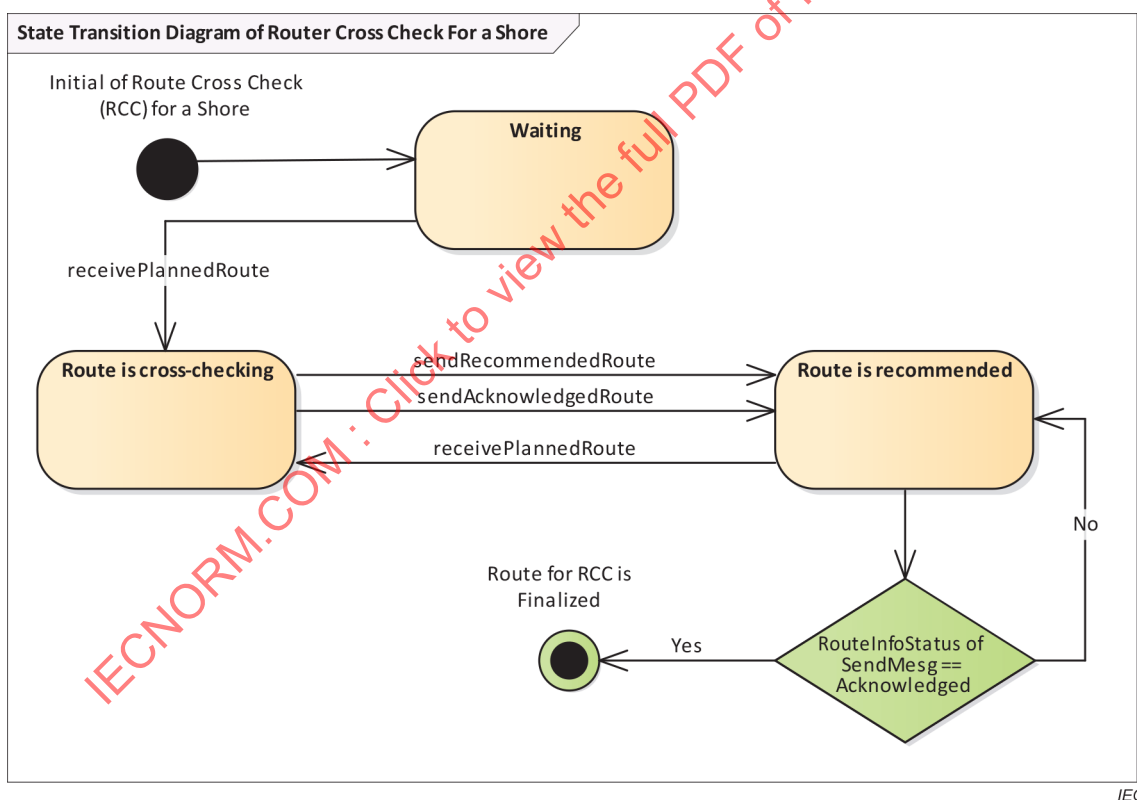


Figure A.4 – State transition diagram for the route plan onshore

A.2.4 Required objects and attributes and their usage

Table A.1 describes the objects and attributes required except routeExtensions and their meaning in this service scenario.

Table A.1 – Objects and attributes used by route cross check

Object name	Attribute name	Description of use	Comment
Route	routeID	Unique identifier of the route.	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Start from 1 for each new route Set by the vessel, increased by one if vessel requests a new schedule for the same route Exception for the case when shore creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
	routeInfoName	Set by the vessel	Only for human reading purposes From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoAuthor	Author of the route	From ship (optional) To ship (mandatory)
	routeInfoEditionTime	Time when this edition of route plan is edited	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	Additional information of the route status in human readable text	From ship (optional) To ship (optional)
	routeInfoStatus	Set both by vessel and shore-server	From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Start of validity period	This may be an empty value when the validity is not applied. From ship (optional) To ship (optional)
	routeInfoValidityEnd	Stop of validity period	This may be an empty value when the validity is not applied. From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
	routeInfoArrivalPortID1	Primary arrival port identifier for this route given by UN/LOCODE	Next arrival port in UN/LOCODE format From ship (optional) To ship (optional)
	routeInfoArrivalPortID2	Secondary arrival port for this route given by free text string	From ship (optional) To ship (optional)
	routeInfoVesselType	Ship's vessel type	From ship (optional) To ship (optional)
	RouteInfoVesselName	Ship's name	From ship (optional) To ship (optional)
	routeInfoVesselMMSI	Set by the vessel	To facilitate shore-based monitoring using AIS data From ship (mandatory) To ship (optional)
	routeInfoVesselHeight	Vessel height measured from the keel to the masthead	From ship (mandatory) To ship (N/A)
	routeInfoVesselLength	Vessel length overall (LOA)	From ship (optional) To ship (N/A)
	routeInfoVesselBeam	Vessel beam	From ship (optional) To ship (N/A)
	routeInfoDraftMax	Maximum draft of the route	From ship (N/A) To ship (optional)
	routeInfoAirDraftMax	Maximum air draft of the route	From ship (N/A) To ship (optional)
	routeInfoBeamMax	Maximum vessel beam of the route	From ship (N/A) To ship (optional)
	routeInfoLengthMax	Maximum vessel length of the route	From ship (N/A) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeWaypointID	Reference number used to connect schedule and waypoint together	From ship (mandatory) To ship (mandatory)
	Geometry	The position of the route. The request from the ship includes the planned waypoint position. The reply from the shore includes the recommended waypoint position.	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Turn radius in nautical miles	From ship (mandatory) To ship (mandatory)
RouteWaypointLeg	routeWaypointLegStarboardXTDL	Starboard cross track distance limit	From ship (mandatory) To ship (optional)
	routeWaypointLegPortXTDL	Port cross track distance limit	From ship (mandatory) To ship (optional)
	routeWaypointLegStarboardCL	Starboard cross track distance check limit	From ship (optional) To ship (optional)
	routeWaypointLegPortCL	Port cross track distance check limit	From ship (optional) To ship (optional)
	routeWaypointLegGeometryType	Geometry type of leg	From ship (mandatory) To ship (mandatory)
	routeWaypointLegSOGMin	Regulatory lowest speed over ground	From ship (optional) To ship (optional)
	routeWaypointLegSOGMax	Regulatory highest speed over ground	From ship (optional) To ship (optional)
	routeWaypointLegDraft	Planned static draft, maximum	From ship (mandatory) To ship (optional)
	routeWaypointLegDraftForward	Planned static draft Forward	From ship (optional) To ship (optional)
	routeWaypointLegDraftAft	Planned static draft aft	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteScheduleManual/ RouteScheduleElement Or RouteScheduleCalculated/ RouteScheduleElement (not applicable for case to ship, optional for case from ship)	routeWaypointLegDraftMax	Maximum draft of the route leg	From ship (N/A) To ship (optional)
	routeWaypointLegAirDraftMax	Maximum air draft of the route leg	From ship (N/A) To ship (optional)
	routeWaypointLegBeamMax	Maximum vessel beam of the route leg	From ship (N/A) To ship (optional)
	routeWaypointLegLengthMax	Maximum vessel length of the route leg	From ship (N/A) To ship (optional)
	routeWaypointLegIssue	Information about safety issues which require action can be exchanged to the ship	From ship (N/A) To ship (optional)
	routeWaypointLegNote	Information about the route issues can be exchanged to the ship	From ship (optional) To ship (optional)
	routeWaypointID	Refer the waypoint ID for this route	From ship (mandatory)
	routeScheduleElementETD	Planned Time of departure. This is set by vessel to the shore center	From ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before planned time	From ship (optional)
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after planned time	From ship (optional)
	routeScheduleElementETA	Planned time of arrival	From ship (mandatory)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before planned time	From ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after planned time	From ship (optional)

Object name	Attribute name	Description of use	Comment
RouteScheduleRecommended/ RouteScheduleElement (not applicable for case from ship, optional for case to ship)	routeWaypointID	Refer the waypoint ID for this route	To ship (mandatory)
	routeScheduleElementETD	Recommended Time of departure. This is set by vessel to the shore center	To ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before recommended time	To ship (optional)
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after recommended time	To ship (optional)
	routeScheduleElementETA	Recommended time of arrival	To ship (mandatory)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before recommended time	To ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after recommended time	To ship (optional)

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A.2.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.1.

The test data for this scenario shall be prepared from the full generic test data according to Table A.2.

Table A.2 – Test procedures for route cross check

Step	Applicable for onboard EUT	Applicable for shore EUT
Basic route cross check		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route with RouteInfoStatus = Planned from Table A.1 to the shore. Export the route. Use a tool to view content of the exported route and confirm by observation that all mandatory elements from Table A.1 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.1, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.1 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1 and that RouteWaypoint objects and the value of "routeEditionNo" are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1 and that the value of "routeEditionNo" has been increased by one compared to that imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.1. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.1. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.1.
Route cross check with leg		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route plus leg information with RouteInfoStatus = Planned from Table A.1 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.1 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.1, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements and optional leg information from Table A.1 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly and the route cross check process is ended or continued as step 1.	Confirm by observation that, based on an imported route, it is possible to create a recommended route with new leg information (including leg notes) with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.
	Confirm by observation that, when a route with RouteInfoStatus = Route Issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the route cross check process is ended or continued as step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.1. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that a route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.

Step	Applicable for onboard EUT	Applicable for shore EUT
Route cross-check with schedules		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route plus schedule information with RouteInfoStatus = Planned from Table A.1 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.1 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.1, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements and optional schedule information from Table A.1 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly and the route cross check process is ended or continued as step 1.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new schedule information (if applicable) with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of issues (routeInfoDescription and routeWaypointLegIssue) and that the route cross-check process is ended or continued as step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.1. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that a route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.1.

A.3 Flow management

A.3.1 Description

This scenario continues from the basic scenario of the route cross-checking by adding other forecasted traffic. This scenario requires availability of a schedule. This scenario covers the case where a VTS or other shore authorities establish a service for route exchange between the ship and shore-side actors that have an interest in the ships transit or arrival times. There are a number of possible reasons for implementing such a service.

- It can be useful to organize the ship traffic to avoid potential traffic congestion, for example to avoid that large ships meet in depth restricted narrows. In this case, mainly intermediate waypoints are of interest and the service should be available to transiting as well as arriving ships. Here, one may change waypoint positions as well as arrival times;
- If the ship is planning an arrival in a port, the service can help to better predict and optimize arrival time, for example by reducing waiting time for port services (encouraging just in time arrival) or for any other traffic optimization purpose. In this case, it is the final arrival time that is of the most interest.

Both cases involve two actors:

- 1) ship, where crew members plan waypoints and times to the shore center and get advice on adjustments back;
- 2) shore center, which has tools to predict future traffic situations and/or availability of port services and which can use these tools to optimize traffic in the area, to some local criteria.

Figure A.5 illustrates a ship transmitting a planned route through waypoints 1 and 2 (WPT1, WPT2) and receives a recommended route via waypoints WPT0a, WPT0b and WPT0c, to avoid a dredging operation in the area. All waypoints consist of a position and a planned transit time, so that both route and speed can be optimized. This is an example of the first service type.

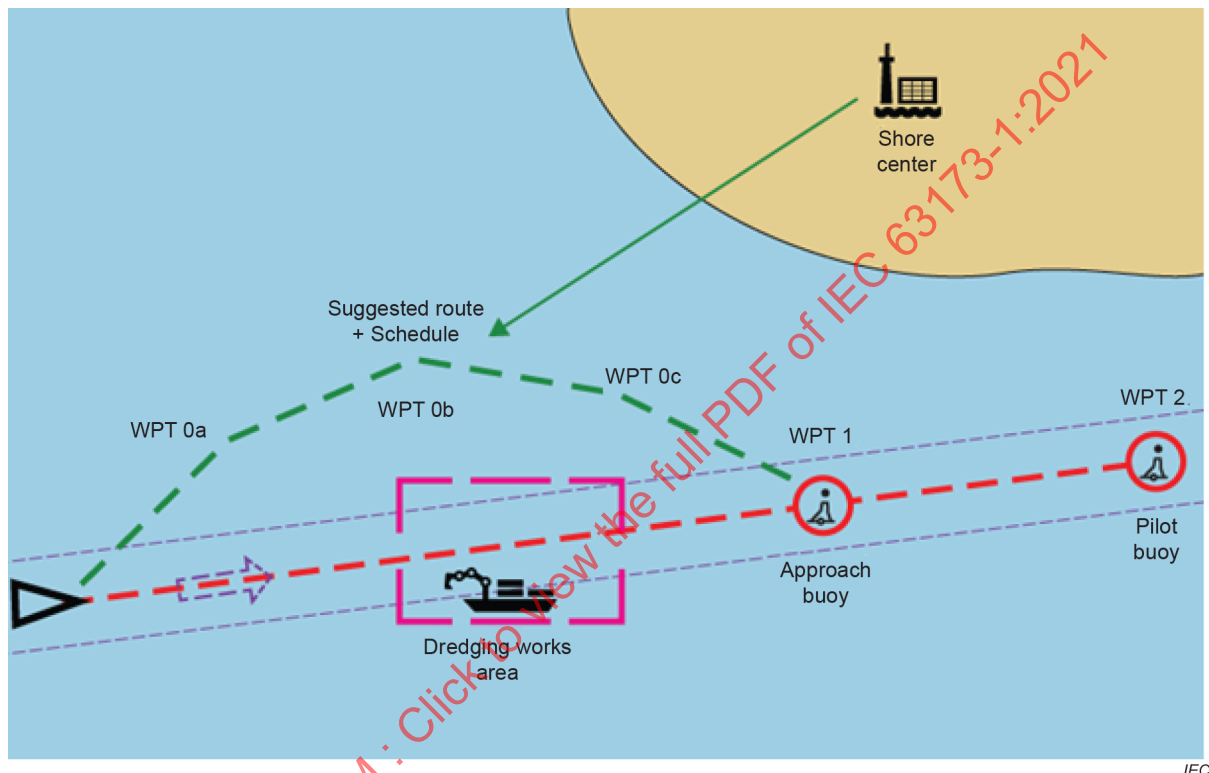


Figure A.5 – Flow management example

The principle for this process is that the ship's master has the final say in the matter and can override any suggestion from shore. This means that provisions shall be available to lock certain points or times and to exchange explanations (routeInfoDescription) of why optimization is suggested or not accepted.

A.3.2 Information exchange diagram

The sequence diagram in Figure A.6 describes the interaction between the ship and shore center.

All information exchanges are formatted as a route plan. The block enclosed in "loop" is optional and can be repeated several times, if needed. The different exchanges are as follows.

- 1) A planned route from the ship is sent to the shore-side actor. This contains planned waypoints and corresponding schedule. Some points may be locked in position or set by time; this may for example apply to final arrival time.

- 2) The response from the shore-side actor is acknowledged or recommended for a new route. If the waypoints are changed, it contains recommended routes from the shore-side actor on how the route can be changed to improve safety, traffic efficiency or to minimize waiting times. It also needs to contain explanations for why the changes have been proposed.
- 3) The ship can iterate a suggestion in steps 1) and 2) as many times as desired with the updated edition number. When satisfied, the ship provides a final route plan.

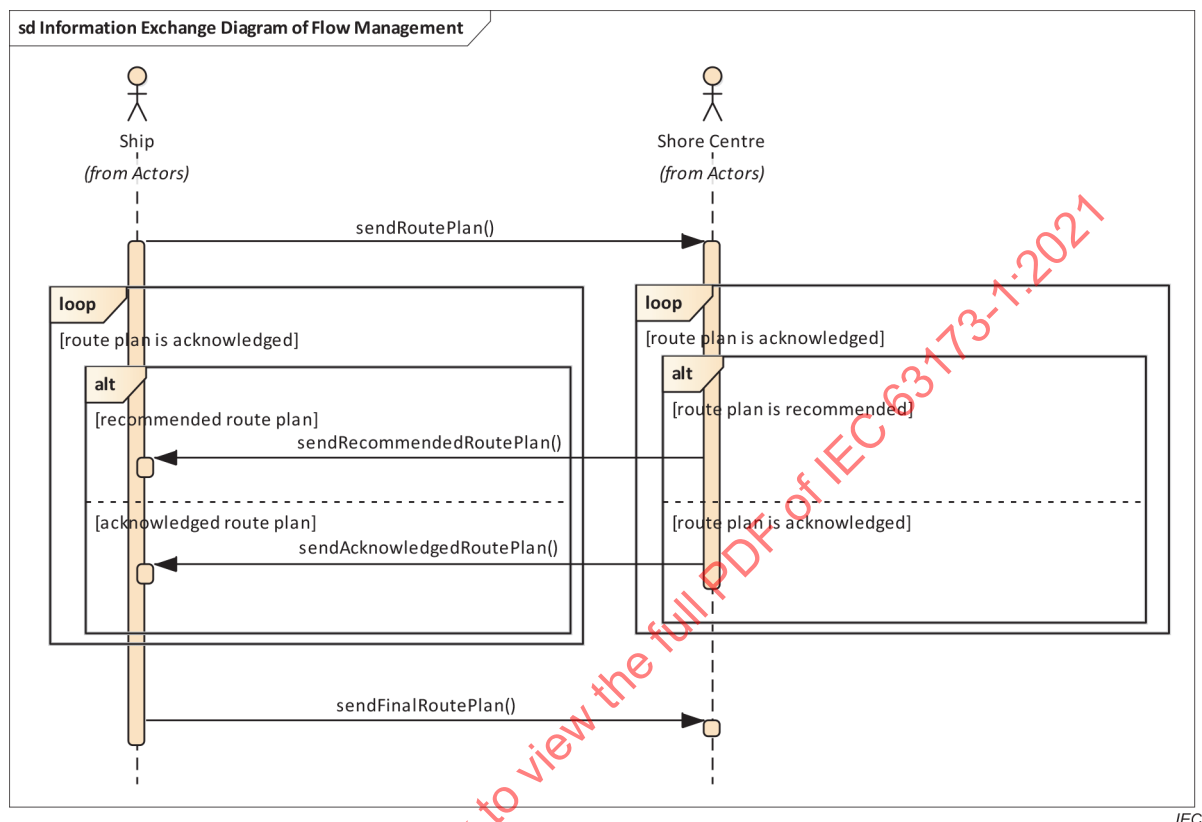


Figure A.6 – Data interaction diagram

A.3.3 State transition diagram

From the point of the view of the ship, the route will transition through the states shown in Figure A.7. The states are defined as:

- Route is ready – the route is ready but schedule is not checked yet;
- Route schedule is requested – a state which sends a route with schedule is sent to the shore-side actor and waits for the response;
- Route is recommended – a state which a route is recommended by the shore-side actor;
- Route is approved – a state which a route is approved by the master.

From the point of the view of the shore center, the route will transition through the states shown in Figure A.8. The states are defined as:

- Waiting – a state which waits for any request from ships for the route with schedule;
- Route schedule is being checked – a state when the route schedule is requested from a ship and the route is checking;
- Route is responded to – a state when the route was replied with acknowledged or with a recommend new route.

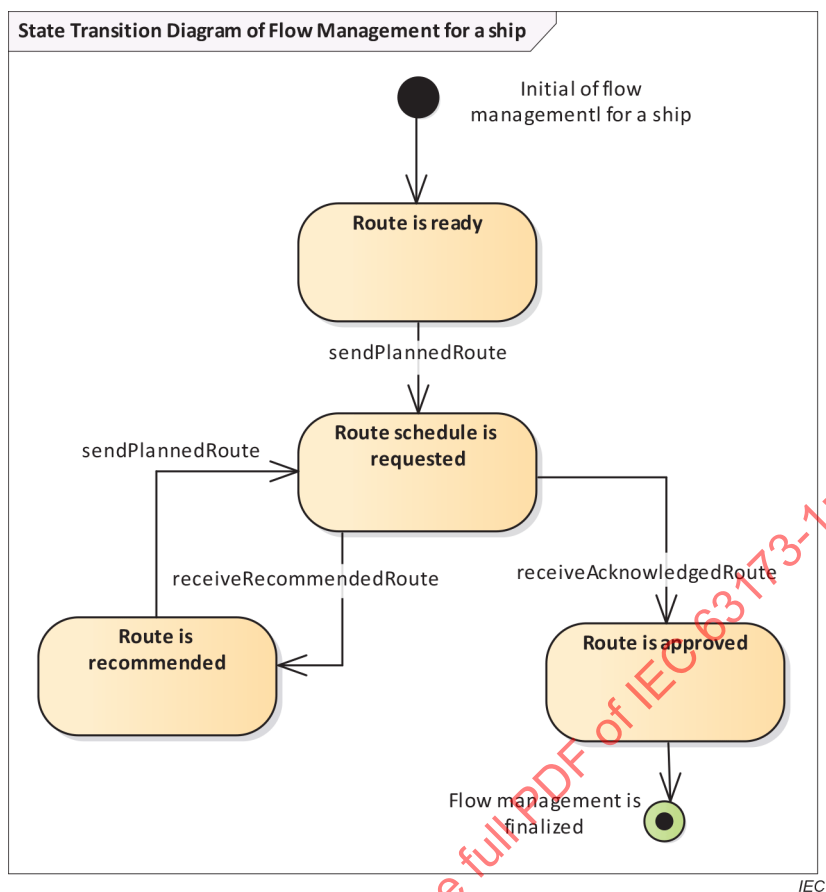


Figure A.7 – State transition diagram for the route plan onboard

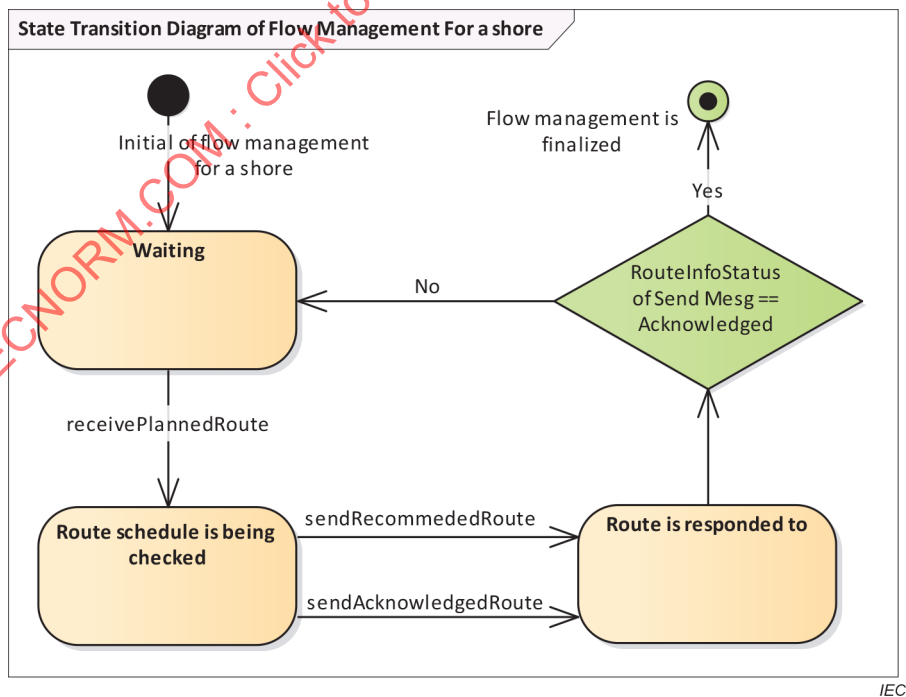


Figure A.8 – State transition diagram for the route plan onshore

A.3.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes given in Table A.3 are used and have a special meaning in this profile.

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Table A.3 – Objects and attributes used by flow management

Object name	Attribute name	Description of use	Comment
Route	routeID	Route identifier	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Start from 1 for each new route Set by the vessel, increased by one if vessel requests a new schedule for the same route Exception for the case when shore creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoEditionTime	Time when this edition of route plan is edited	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	Additional information of the route status in human readable text	From ship (optional) To ship (optional)
	routeInfoStatus	Set both by vessel and shore-server	From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Start of validity period	From ship (optional) To ship (optional)
	routeInfoValidityEnd	Stop of validity period	From ship (optional) To ship (optional)
	routeInfoVesselType	Ship's vessel type	From ship (optional) To ship (N/A)
	RouteInfoVesselName	Vessel name	From ship (optional) To ship (optional)
	routeInfoVesselMMSI	Set by the vessel	To facilitate shore-based monitoring using AIS data From ship (mandatory) To ship (mandatory)
	RouteInfoVesselIMO	Vessel IMO number	From ship (optional) To ship (optional)
	routeInfoVesselHeight	Vessel height measured from the keel to the masthead	From ship (optional) To ship (N/A)

Object name	Attribute name	Description of use	Comment
RouteScheduleManual/ RouteScheduleElement or RouteScheduleCalculated/ RouteScheduleElement	routeWaypointLegIssue	Safety issue for the route waypoint leg	From ship (optional) To Ship (optional)
	routeWaypointLegNote	Note for the route waypoint leg	From ship (optional) To ship (optional)
	routeWaypointID	Refer the waypoint ID for this route	From ship (mandatory)
	routeScheduleElementETD	Planned Time of departure. This is set by vessel to the shore center	From ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before planned time	From ship (optional)
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after planned time	From ship (optional)
	routeScheduleElementETA	Planned time of arrival	From ship (mandatory)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before planned time	From ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after planned time	From ship (optional)
	routeWaypointID	Refer the waypoint ID for this route	To ship (mandatory)
RouteScheduleRecommended/ RouteScheduleElement	routeScheduleElementETD	Recommended Time of departure. This is set by vessel to the shore center	To ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before recommended time	To ship (optional)
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after recommended time	To ship (optional)
	routeScheduleElementETA	Recommended time of arrival	To ship (mandatory)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before recommended time	To ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after recommended time	To ship (optional)

A.3.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.3.

The test data for this scenario shall be prepared from the full generic test data according to Table A.4.

Table A.4 – Test procedures for flow management

Step	Applicable for onboard EUT	Applicable for shore EUT
Basic flow management		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route with RouteInfoStatus = Planned from Table A.3 to the shore. Export the route. Use a tool to view content of the exported route and confirm by observation that all mandatory elements from Table A.3 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.3, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.3 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that based on an imported route it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.3 and that RouteWaypoint objects and the value of "routeEditionNo" are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.3 and that the value of "routeEditionNo" has been increased by one compared to that imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.3. Import the route to EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.3.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.3. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.3.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.3.
Flow management with leg		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route with RouteInfoStatus = Planned from Table A.3 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.3 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.3, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.3 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that an acknowledged route is processed correctly and the route cross check process is ended.	Confirm by observation that an acknowledged route with RouteInfoStatus = Acknowledged is exported to the ship.
	Confirm by observation that a recommended route is imported and processed correctly and that the route cross check process is ended or continued as step 1.	Confirm by observation that a recommended route with new leg information (including leg notes) with RouteInfoStatus = Recommended is exported to the ship when it imports a route with route issues or invalid leg information. Confirm by observation that the exported file is generated in accordance with Table A.3 (contents check).
	Confirm by observation that when a Route issues route is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeWaypointLegIssue) and that route cross check process is ended or continued as step 1.	Confirm by observation that an acknowledged route with RouteInfoStatus = Route Issues is exported to the ship.

A.4 Enhanced monitoring

A.4.1 Description

This is a service in which a vessel shares a monitored route as shown in Figure A.9. This service shall be done after the route cross check service is performed. This monitored route could be used by all interested parties which are allowed to have access the ships route plan. Such parties could include VTS, fleet manager, insurance company, costal surveillance, etc.

This service can be used to monitor that the vessel stays within the planned corridor as defined in the route plan or in the shore center system. The shore center can receive updates of the vessel position through, for example, AIS and compare these vessel positions against the route plan for the vessel. The shore center is able to detect if the planned schedule is not kept or if the ship deviates from the planned route geometry. The shore center can also use the route plan information to foresee possible dangerous situations. The shore center may contact the vessel by different means. This is not specified in this document.

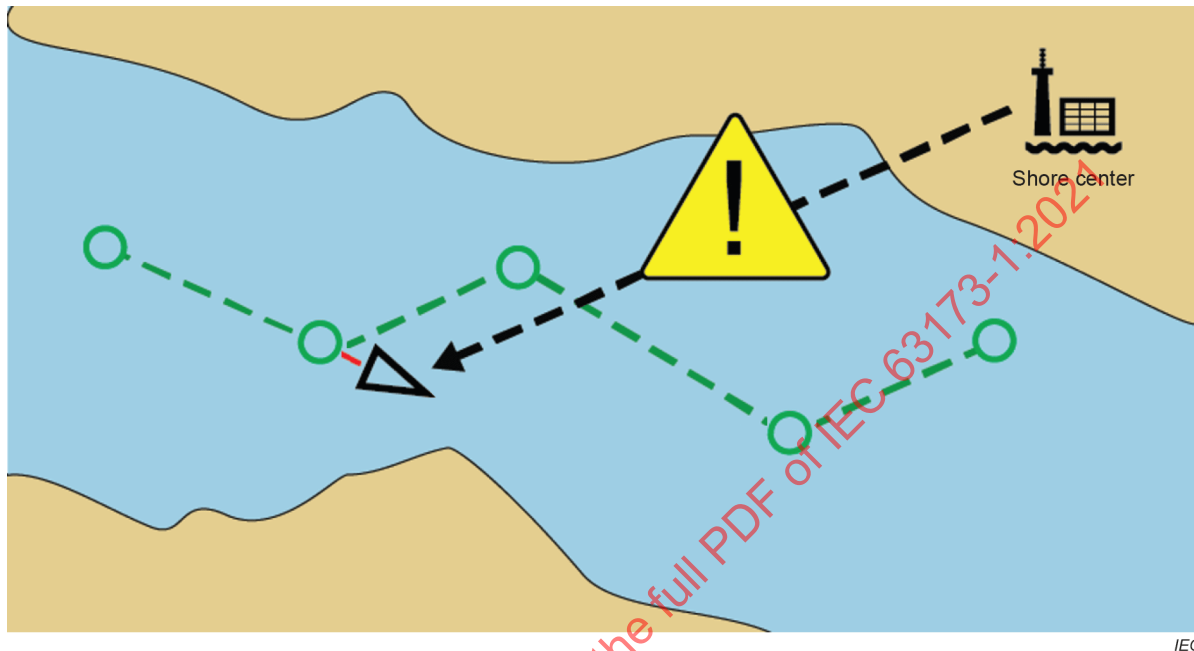


Figure A.9 – Enhanced monitoring example

A.4.2 Information exchange diagram

These sequence diagram in Figure A.10 describes the interaction between the ship and shore center.

All information exchanges are formatted as a route plan. The different exchanges are as follows.

- 1) The monitored route plan from the ship is sent to the shore center. This contains waypoints and may contain leg xtdl values for the width of the corridor and schedule. The exchange is repeated if changes are made in monitored route on vessel.
- 2) The shore center confirms when enhanced monitoring is started/ongoing by sending the route back to the ship with RouteinfoStatus = Service started. When enhanced monitoring is ended, the shore center sends the route to the ship with RouteinfoStatus = Service ended. The state of the service may be indicated onboard ship.
- 3) If the shore center detects that the schedule is not kept or that the ship deviates from the route geometry, it sends a route to the vessel, with either RouteinfoStatus = Route issues or RouteinfoStatus = Recommended, if a recommendation has been made. The routeInfoDescription attribute may be used to indicate the level of emergency: For example "Information:", "Warning:", and "Instruction:".
- 4) When a ship no longer needs an enhanced monitoring service, it sends RouteinfoStatus = Terminated to the shore center to stop the service.

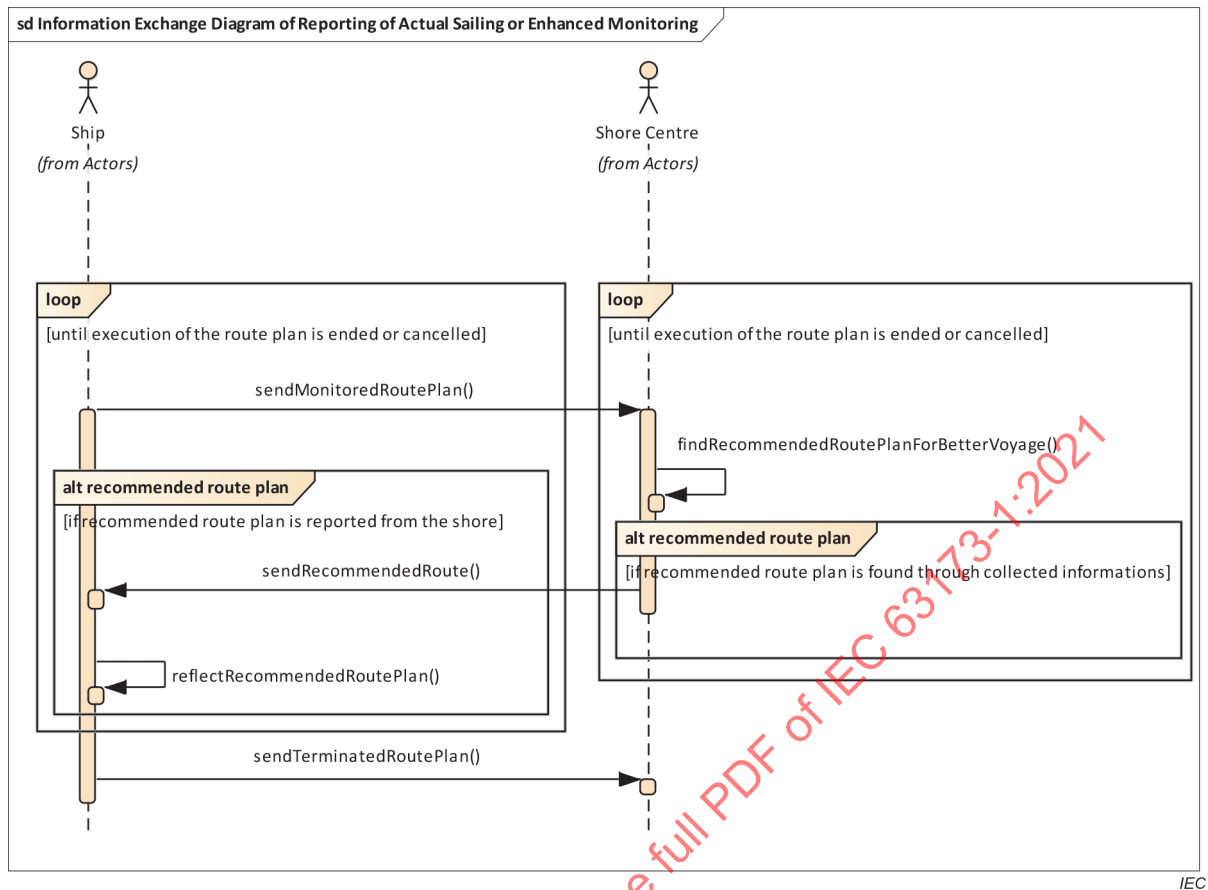


Figure A.10 – Information exchange diagram

A.4.3 State transition diagram

From the point of the view of the ship, the route will transit through the states shown in Figure A.11 and Figure A.12. On shore, additional states may be needed to fully describe all states.

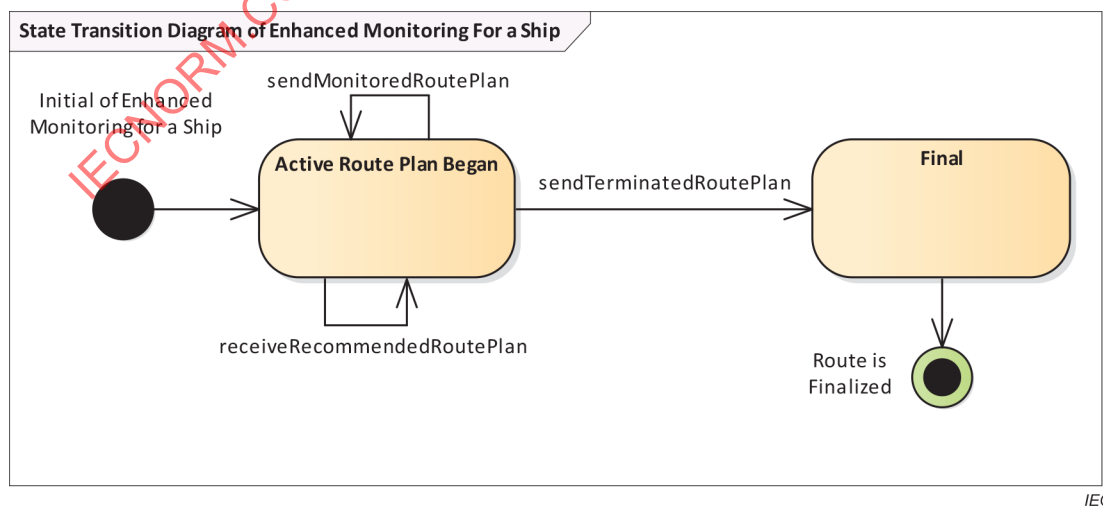


Figure A.11 – State transition diagram for the route plan onboard

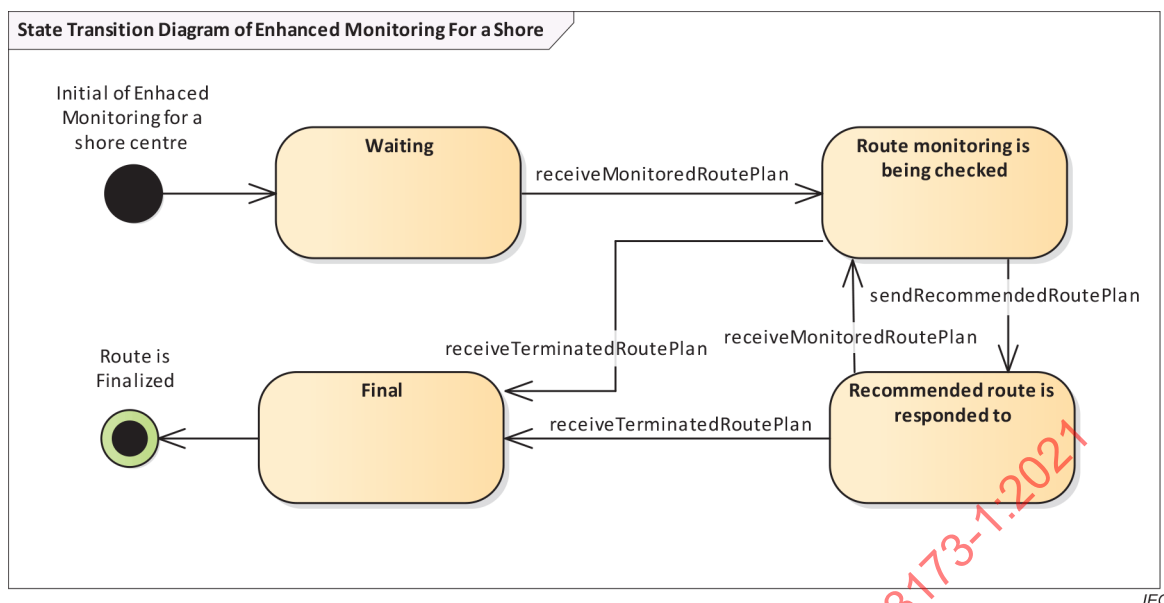


Figure A.12 – State transition diagram for the route plan onshore

The states and transitions are:

- Active plan began: This state is the start of this service. The complete plan including all fields is sent from the vessel to shore;
- Final: This happens when ship leaves the monitored area, or the route is finished or cancelled.

A.4.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes of Table A.5 are used and have a special meaning in this profile.

Table A.5 – Objects and attributes used by enhanced monitoring

Object name	Attribute name	Description of use	Comment
Route	routeID	Unique identifier of the route plan from A to B	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Start from 1 for each new route. Set by the vessel, increased by one for every change in the route plan. Exception for the case when shore creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoName	Only for human reading purposes	From ship (mandatory) To ship (mandatory)
	routeInfoEditionTime	Time for update of route plan	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	May be used to indicate the level of emergency when a route plan is sent to the ship during enhanced monitoring.	From ship (optional) To ship (optional)
	routeInfoStatus	Status on the route	From ship (mandatory) To ship (mandatory)
	routeInfoVesselName	Optional for display	From ship (optional) To ship (optional)
	routeInfoVesselMMSI	Facilitate shore-based monitoring using AIS data	From ship (mandatory) To ship (optional)
	routeInfoVesselCallsign	Optional for contact information	From ship (optional) To ship (optional)
	routeInfoVesselIMO	Optional	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeWaypointID	Links waypoint with schedule element	From ship (mandatory) To ship (mandatory)
	geometry	Geographical representation	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Geographical representation	From ship (mandatory) To ship (mandatory)
	routeWaypointLegStarboardXTDL	Used to detect deviation from route	From ship (optional) To ship (optional)
RouteWaypointLeg (optional)	routeWaypointLegPortXTDL	Used to detect deviation from route	From ship (optional) To ship (optional)
	routeWaypointLegStarboardCL	Used to detect deviation from route	From ship (optional) To ship (optional)
	routeWaypointLegPortCL	Used to detect deviation from route	From ship (optional) To ship (optional)
	routeWaypointLegGeometryType	Mandatory for correct graphical representation of route	From ship (mandatory) To ship (mandatory)
ManualSchedule/. RouteScheduleElement	routeWaypointID	Links the schedule element to one waypoint	From ship (mandatory) To ship (optional)
	routeScheduleElementPlanSOG	Manually set speed on leg to waypoint	From ship (optional) To ship (optional)
	routeScheduleElementETA	Manually set time of arrival to certain waypoint(s)	From ship (mandatory) To ship (optional)
	routeScheduleElementETD	Manually set time of departure from certain waypoint(s)	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
CalculatedSchedule. RouteScheduleElement	routeWaypointID	Links the schedule element to a waypoint	From ship (mandatory)
	routeScheduleElementPlanSOG	Calculated speed to waypoint	From ship (optional)
	routeScheduleElementETA	Calculated time of arrival to each waypoint	From ship (mandatory)
	routeScheduleElementETD	Calculated time of departure from waypoint, if different than arrival time, e.g. stay at anchor	From ship (optional)

A.4.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.5.

The test data for this scenario shall be prepared from the full generic test data according to Table A.6.

Table A.6 – Test procedures for enhanced monitoring

Step	Applicable for onboard EUT as client of the enhanced monitoring service	Applicable for shore EUT which provides the enhanced monitoring service
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route from Table A.5 to request the enhanced monitoring service. (routeInfoStatus = Monitored). Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.5 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.5, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.5 and which holds routeInfoStatus = Monitored. Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use a simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.5 and confirm by observation that the route imports with an indication about incomplete route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route from Table A.5 to request the enhanced monitoring service to be ended (routeInfoStatus = Terminated). Export the route. Use a tool to view content of the exported route and confirm by observation that all mandatory elements from Table A.5 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.5, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.5 and which holds routeInfoStatus = Terminated. Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use a simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.5 and confirm by observation that the route imports with an indication about incomplete route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
3	Confirm by observation that, when a route with RouteInfoStatus = Service started is imported, it is processed correctly. Confirm that the user is able to read the included information (routeInfoDescription).	Use a simulator or test arrangements as the source to export a route with all mandatory elements from Table A.5 and which holds routeInfoStatus = Service started. Confirm by observation that the route exports without error and that all parts of the route are correctly available and that RouteWaypoint objects and value of routeEditionNo are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Service ended is imported, it is processed correctly. Confirm the user is able to read the included information (routeInfoDescription).	Use a simulator or test arrangements as the source to export a route with all mandatory elements from Table A.5 and which holds routeInfoStatus = Service ended. Confirm by observation that the route exports without error and that all parts of the route are correctly available and that RouteWaypoint objects and value of "routeEditionNo" are as imported from the vessel

Step	Applicable for onboard EUT as client of the enhanced monitoring service	Applicable for shore EUT which provides the enhanced monitoring service
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, it is processed correctly. Confirm that the user is able to read the included information (routeInfoDescription and routeWaypointLegIssue).	Use a simulator or test arrangements as the source to export a route with all mandatory elements from Table A.5 and which holds routeinfoStatus = Route issues. Confirm by observation that the route exports without error and that all parts of the route are correctly available.
4	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly. Confirm that the user is able to read the included information (routeInfoDescription), and the user can validate the route and bring the route into routeInfoStatus = Monitored.	Use a simulator or test arrangements as the source to export a route with all mandatory elements from Table A.5 and which holds routeinfoStatus = Recommended. Confirm by observation that the route exports without error and that all parts of the route are correctly available.
5.	Confirm by observation that, when a route with RouteInfoStatus = Incomplete route is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.5. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.5.
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to the user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.5.

A.5 Ice navigation

A.5.1 Description

Typically, organizations responsible for traffic in sea ice try to improve efficiency of both icebreakers and vessels sailing in areas with sea ice. Often the assistance is given as recommended routes through the ice-covered areas.

NOTE Other information can be provided to assist safe navigation in sea ice. Wind forecasts can tell where open ice-free paths can occur within otherwise ice-covered areas. Satellite photos and analysis of these into spatial data on ice coverage can be of good use for the navigator, and textual information on ice status can also assist safe navigation. Provision of this other information is not part of this document.

The ice navigation service can be a part of an ice breaking service or as an independent information service only.

A textual description (routeInfoDescription) may provide information about a convoy, for instance position in convoy, or preparations needed for the convoy.

A validity period (routeInfoValidityStart, routeInfoValidityEnd) may be provided if the ice navigation service can specify for how long the route can be used.

The recommended route may be transmitted directly to the ship's navigation system. Introducing route exchange will give both icebreaker services and assisted ships better information in more automated procedures reducing workload and risk for misunderstandings as shown in Figure A.13. This scenario may be provided without reference to a particular ship.

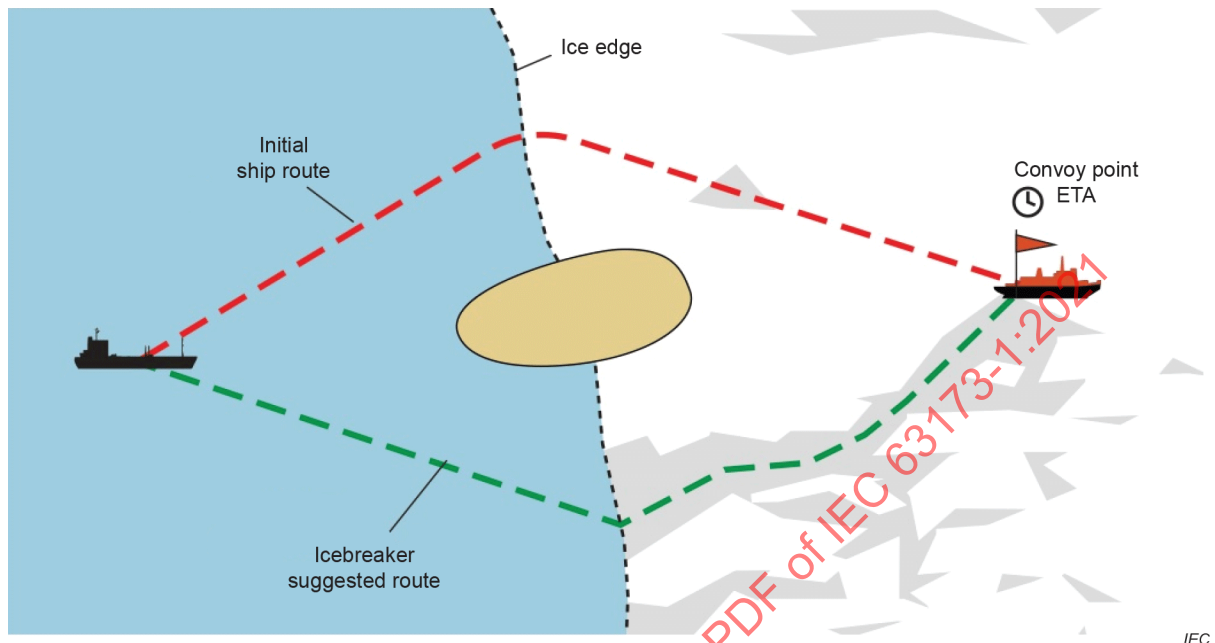


Figure A.13 – Ice navigation example

A.5.2 Information exchange diagram

The sequence diagram in Figure A.14 describes a nominal sequence of information exchange.

- 1) The ship sends a route plan to the ice navigation service. The route plan includes routeID, routeEditionNo, ship identifier (MMSI), waypoints and optionally schedule(s). The values that ship considers fixed are put into manual schedule, such as time of arrival to certain waypoint(s) (e.g. pilot boarding ground (PBG), berth), time of departure (for example from berth) and speed window. The leg to each waypoint may contain the draft of the ship (max. or separate for forward and aft).
- 2) The ice navigation service provider assesses the received route plan and may either provide:
 - a) a general or tailored recommended route from a given point through the area, or
 - b) a general or tailored recommended route from a given point to the point from which an icebreaker assistance is planned to start.

Often the recommended route does not cover the full distance (i.e. full length of the route sent by the ship to the next port) but a subset available from the ice navigation service provider. As the weather, for example wind, may alter the ice coverage situation, the vessel may need to repeat the process several times for longer routes.

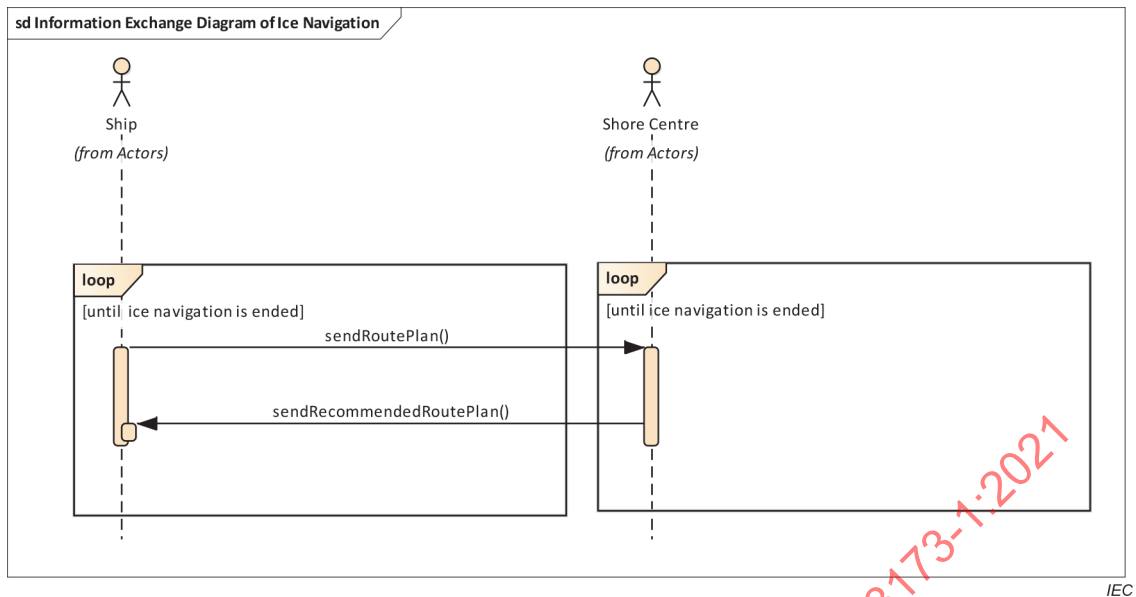


Figure A.14 – Interaction diagram on request

A.5.3 State transition diagram ship side

The system requires the following sending and receiving functions (see Figure A.15).

- Ready: ice navigation service for a ship side is ready.
- Send Planned Route: status after the ship has sent the planned route.
- Receive Recommended Route: when the vessel receives a recommended route from the shore, the ship enters into this state.

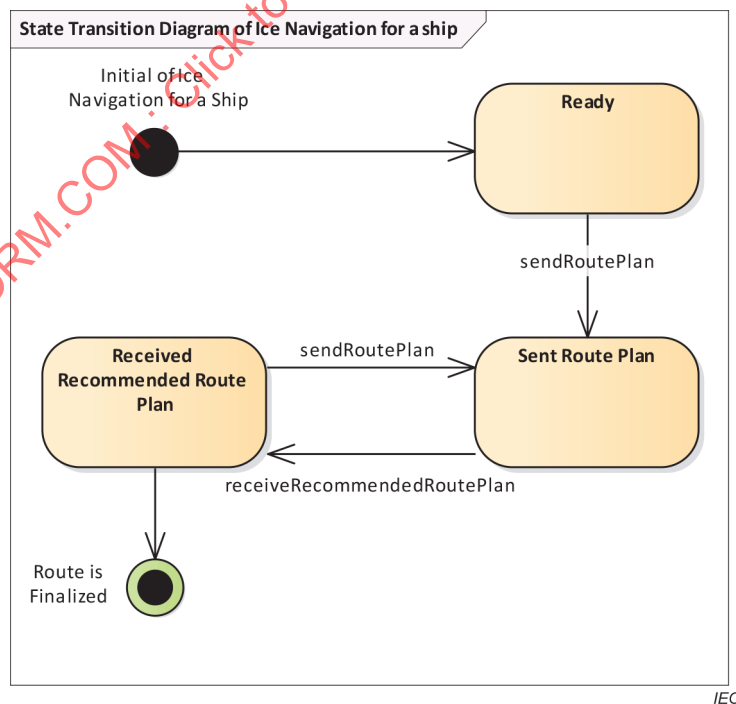


Figure A.15 – State transition diagram for a ship

A.5.4 Shore side

The system requires the following sending and receiving functions (see Figure A.16).

- Ready: the ice navigation service provider shore side waits for the requests of ice navigation support from ships.
- Receive Planned Route: after receiving of the planned route, the ice navigation service provider enters into this state.
- Create Route Plan: the ice navigation service provider creates a recommended route for the ship.
- Send Recommended Route: after creation of the new route plan, the shore sends the recommended route to the ship.

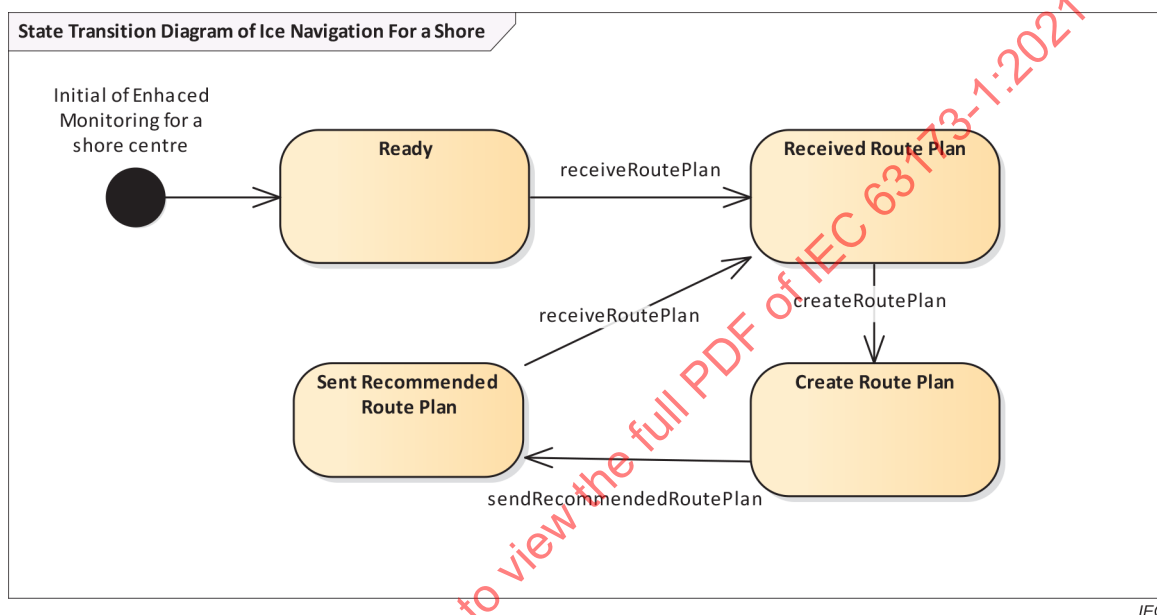


Figure A.16 – State transition diagram for a shore

A.5.5 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the attributes of Table A.7 are used and have a special meaning in this profile.

The static information of the vessel such as service max., service min., max. speed and wind area may be necessary for the ice navigation. This information may be exchanged by other methods not with this object model.

Table A.7 – Objects and attributes used by ice navigation

Object name	Attribute name	Description of use	Comment
Route	routeID	Mandatory identifier on the route plan. Unique for complete route between A to B	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Mandatory edition of the route plan. Increased by 1 for every change.	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoDescription	Additional information for the route info status in human readable text	From ship (optional) To ship (mandatory)
	routeInfoStatus	Status on route	From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Start of validity period	From ship (optional) To ship (optional)
	routeInfoValidityEnd	End of validity period	From ship (optional) To ship (optional)
	routeInfoArrivalPortID1	Primary arrival port identifier for this route as UN/LOCODE	From ship (mandatory) To ship (not applicable) Mandatory here means either arrival port or departure port shall be given.
	routeInfoArrivalPortID2	Secondary arrival port identifier in text string	From ship (optional) To ship (optional)
	routeInfoDeparturePortID1	Primary departure port identifier for this route as UN/LOCODE	From ship (mandatory) To ship (not applicable) Mandatory here means either arrival port or departure port shall be given.
	routeInfoDeparturePortID2	Secondary departure port identifier in text string	From ship (optional) To ship (optional)
	routeInfoVesselName	Set by vessel	From ship (optional) To ship (not applicable)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeInfoVesselMMSI	Set by the vessel	From ship (optional) To ship (not applicable)
	routeInfoVesselIMO	Vessel IMO number	From ship (optional) To ship (not applicable)
	geometry	Mandatory position on waypoint	From ship (mandatory) To ship (mandatory)
RouteWaypointLeg	routeWaypointTurnRadius	Mandatory radius on waypoint	From ship (mandatory) To ship (optional)
	routeWaypointFixed	Input to optimization to not change the position of the waypoint(s)	From ship (mandatory) To ship (mandatory)
	routeWaypointLegStarboardCL	Enables to check that the planned route does not go over too shallow areas	From ship (optional) To ship (optional)
	routeWaypointLegPortCL	Enables to check that the planned route does not go over too shallow areas	From ship (optional) To ship (optional)
	routeWaypointLegSafetyDepth	Enables to check that the planned route does not go over too shallow areas	From ship (optional) To ship (not applicable)
	routeWaypointLegGeometryType	Geometry type on leg; orthodrome or loxodrome	From ship (mandatory) To ship (mandatory)
	routeWaypointLegDraft	Enables to check that the planned route does not go over too shallow areas	From ship (optional) To ship (not applicable)
	routeWaypointLegDraftForward	Enables to check that the planned route does not go over too shallow areas, see also routeWaypointLegDraft	From ship (optional) To ship (not applicable)
	routeWaypointLegDraftAft	Enables to check that the planned route does not go over too shallow areas, see also routeWaypointLegDraft	From ship (optional) To ship (not applicable)
	routeWaypointLegSafetyMargin	Enables to check that the planned route does not go over too shallow areas, see also routeWaypointLegDraft	From ship (optional) To ship (not applicable)

A.5.6 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.7.

The test data for this scenario shall be prepared with the full generic test data according to Table A.8.

Table A.8 – Test procedures for ice navigation

Step	Applicable for onboard EUT as client of ice navigation service provider	Applicable for EUT which provides ice navigation service (either on shore or onboard)
From onboard to ice navigation service provider		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route from Table A.7 for an ice navigation request to an ice navigation service provider. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.7 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.7, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.7 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use a simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.7 and confirm by observation that the route imports with an indication about incomplete route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.7.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.7. Import the route to EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.7.
	Confirm by observation that when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.7. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.7.

Step	Applicable for onboard EUT as client of ice navigation service provider	Applicable for EUT which provides ice navigation service (either on shore or onboard)
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.7.

A.6 Under keel clearance management

A.6.1 Description

In certain sea areas, a shore based UKCM service could be available to allow sailing through shallow areas with more draft than would be allowed to sail without the UKCM service.

NOTE For example, Australia has for the Torres Strait mandatory participation for UKCM for vessel having more draft than 8 m.

The UKCM service is based in a shore-based server which has deep knowledge of the bathymetry, water levels and environmental conditions such as wind and waves. Based on this knowledge, the shore-based UKCM server can forecast the safest draft with associated vessel speed and time windows for the vessel to pass "action points". The deep knowledge required to forecast uses so large an amount of data that it is not feasible to transfer it onboard in order to facilitate local onboard decisions. The UKCM service is a combination of the use of generic route plan exchange (this document, S-421) and specific UKCM overlay (IHO S-129). Further, the UKCM shore-server may be used to schedule safe passage of multiple vessels (i.e. to avoid too many vessels in narrow depth limited parts of the total route through the UKCM service area).

Use of the UKCM service requires that the vessel is a registered client of the UKCM service as the precise forecast requires knowledge of the hydrodynamics of the hull of the vessel. The result of the UKCM service is applicable only for the named vessel for the time slotted passage through the UKCM area.

Use of UKCM service has a long history, but before this document, the real time usage during sailing through the UKCM area has been limited to portable pilot units (PPUs). This document facilitates sharing of situation awareness between the pilot with his PPU and the crew of the vessel monitoring the sailing using the onboard ECDIS.

Before sailing, the vessel requests a passage through the UKCM area by sending her route plan as a S-421 file to the UKCM shore-server. The key planning value is the requested draft and the requested time and date (as specified by ETD and ETA for waypoints). The UKCM shore-server responds by one or multiple alternative route plans which are amended for possible time slots to sail with the requested draft. The time slot information is embedded into the recommended schedules for each waypoint. The planned sailing speed is crucial for UKCM as faster or slower speed cause different squat (i.e. the real draft of the vessel is a function of the vessel speed and amount of water between bottom of the sea and hull of the vessel).

During the actual sailing, the function of the separate IHO S-129 is to provide an overlay chart of go/no-go areas (i.e. to graphically display area available for safe sailing) and control points with their time window values. The function of this document (S-421) is to facilitate graphical display, monitoring and even track control based on the route plan provided by the UKCM shore-server. Key elements of S-421 for this use case are waypoints and legs with ETD, ETA and planned speeds. During actual sailing, the UKCM shore server will receive updates of the vessel position through the AIS base stations.

NOTE For example, the UKCM system in Torres Strait, Australia, updates S-129 and S-421 information every 15 min when the vessel sails through the UKCM area.

Figure A.17 to Figure A.19 illustrate UKCM.

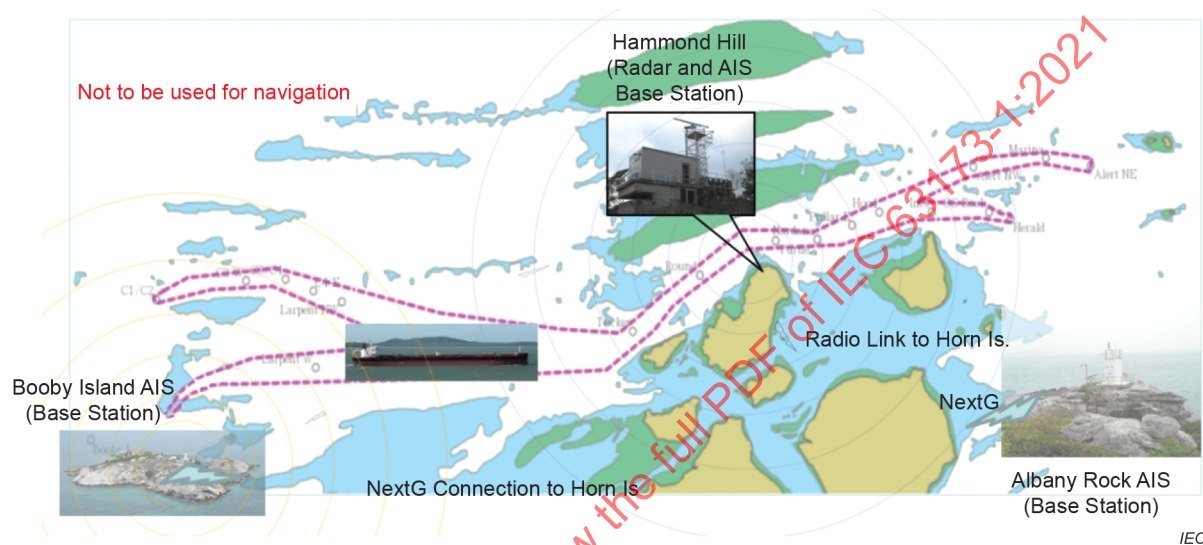


Figure A.17 – Example of UKCM area



Figure A.18 – Example of portrayal of S-421 part of UKCM

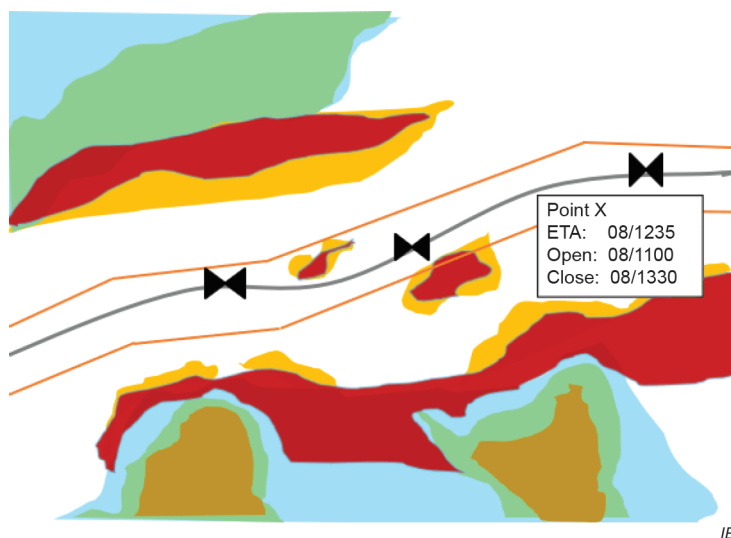


Figure A.19 – Example of portrayal of S-129 overlay part of UKCM

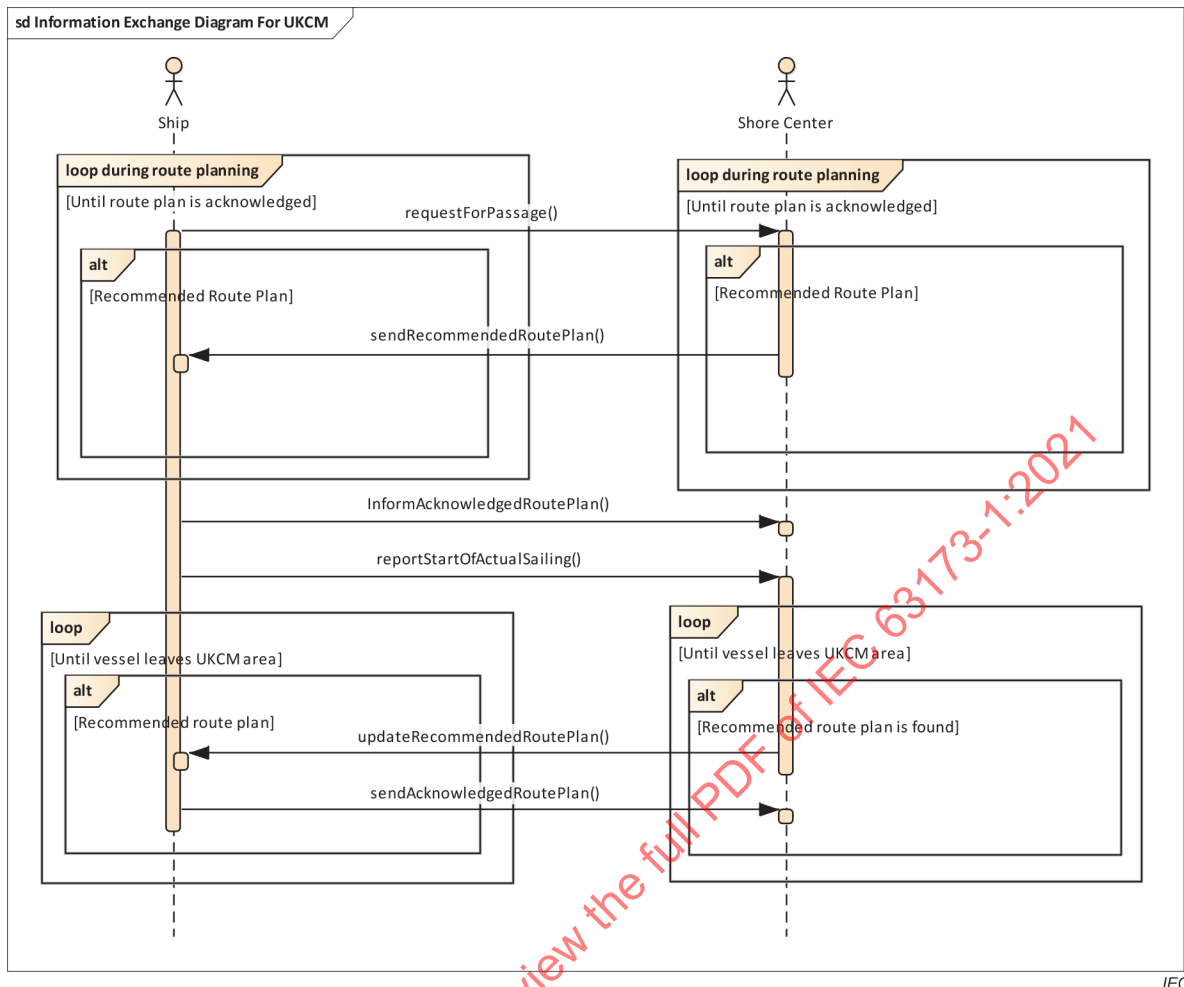
A.6.2 Information exchange diagram

The information exchange diagram in Figure A.20 describes the interaction between the vessel and UKCM shore center. There are two separate phases – planning before sailing and actual sailing.

All information exchange is formatted as a S-421 route plan file. The embedded metadata of S-421 facilitates the transfer of the purpose, planning or actual, between the vessel and the UKCM shore-server.

The different meanings of the information exchange during planning before sailing are:

- 1) a planned route from the vessel to the UKCM shore-server. This contains waypoints, legs, draft, planned speeds and corresponding ETD & ETA times;
- 2) the answer from the UKCM shore-server: "Acknowledged" for the recommended route, or "Recommended" for new route(s). The UKCM shore server may provide amended waypoints, legs, planned speeds and corresponding recommended schedules as appropriate for safe sailing with the requested draft with the updated routeEditionNo. When multiple routes are provided, they have a different routeID;
- 3) the vessel may accept one of the routes as the final route plan or vessel may repeat steps 1) and 2) above until an acceptable result is available.



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Figure A.20 – Information exchange diagram

The different meanings of the information exchange during sailing through UKCM area are as follows.

- 1) UKCM shore server receives AIS target reports from the vessel through AIS base stations. UKCM shore-server updates the S-421 route plan (and S-129 UKCM overlay) for the progress of the vessel and for any change in environmental conditions. This update contains waypoints, legs, draft, recommended speeds and corresponding recommended schedules adjusted for real-time observations and forecasts known by the UKCM shore server. This update will happen at a time interval specified by the UKCM shore server.
- 2) The vessel confirms the route to the UKCM shore-server by sending the same route information received from the UKCM shore-server with "planned".
- 3) The route is acknowledged by the UKCM shore-server by sending "Acknowledged" with the same route information.

A.6.3 State transition diagram

A.6.3.1 General

From the point of the view of the vessel, the route will transit through the states shown in Figure A.21 and Figure A.22.

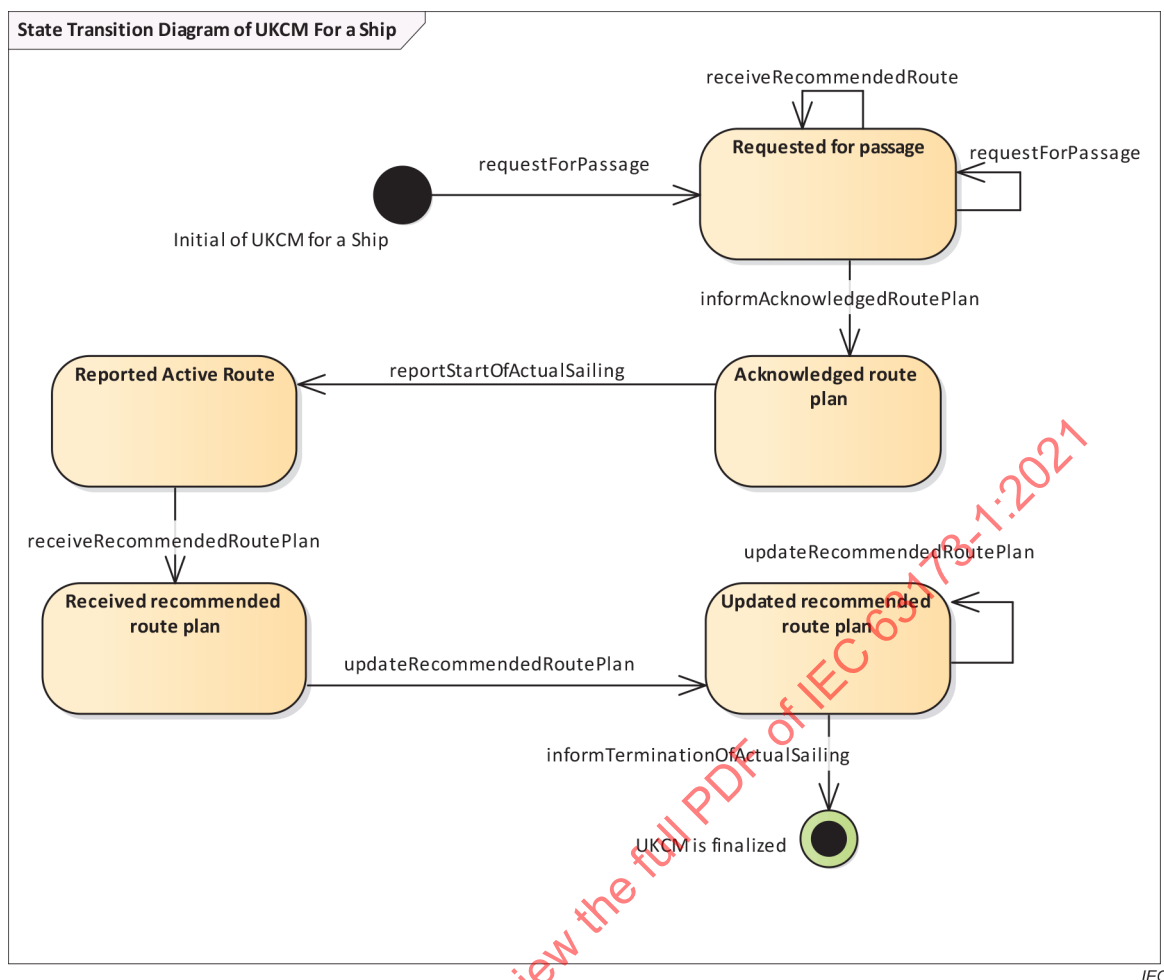


Figure A.21 – State transition diagram of UKCM for a ship

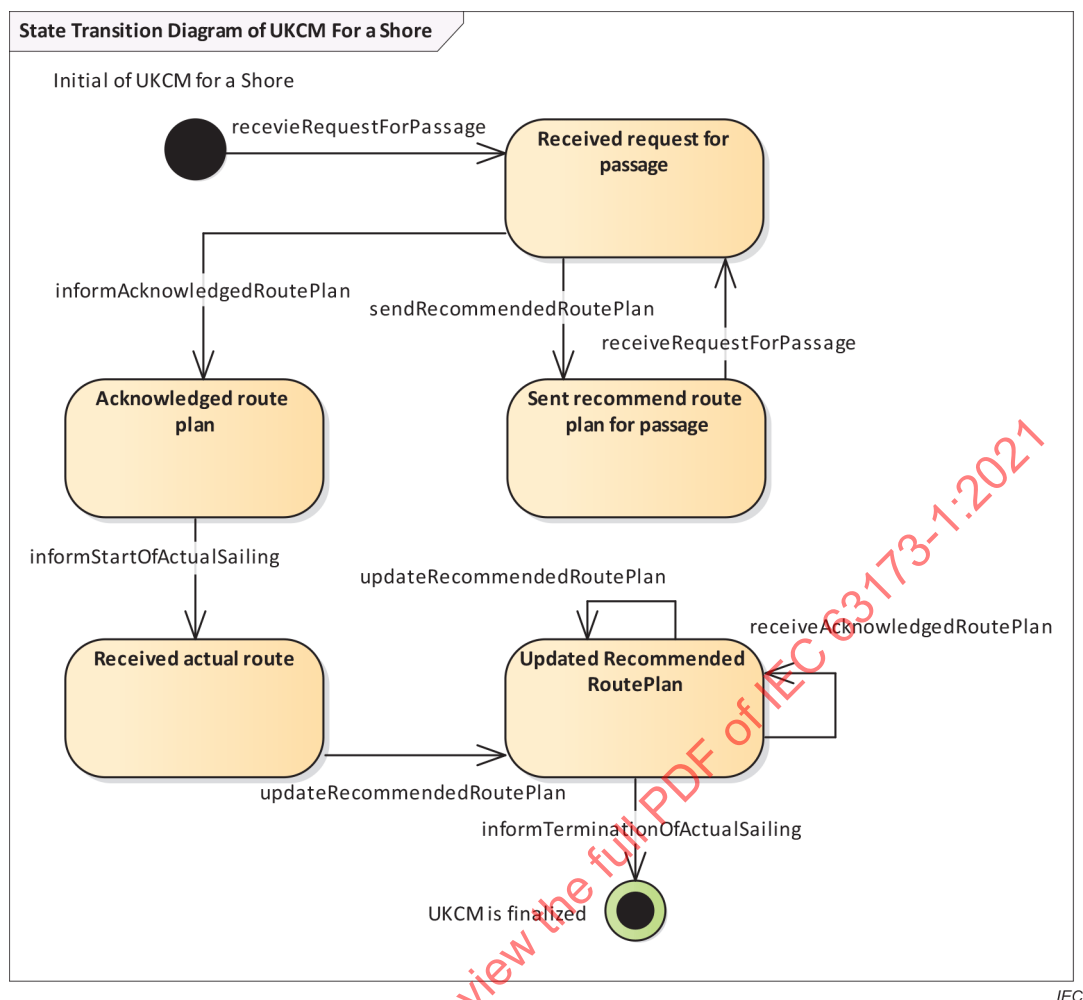


Figure A.22 – State transition diagram of UKCM for a shore

A.6.3.2 Ship side

The system requires the following sending and receiving functions.

- Requested for passage: send a request for passage through UKCM area to UKCM shore server. This may happen days, weeks or even months before actual sailing.
- Acknowledged route plan (before sailing): inform UKCM shore-server about the recommended plan selected by the vessel for sailing. This may happen days, weeks or even months before actual sailing.
- Reported active route (at start of UKCM area): inform UKCM shore-server about start of actual sailing in UKCM area based on the agreed plan.
- Received the recommended route (at start of UKCM area): accept recommended routes from UKCM shore-server and introduce them for the crew for decision making before sailing.
- Updated recommended route plan (during sailing through UKCM area): accept updated recommended route plan from UKCM shore-server and use it to replace the previous active route from the UKCM shore-server. The condition to replace is that routeInfoVesselVoyage and routeEditionNo are equal to the route currently in use and that routeUpdateNo is higher than in the route currently in use.

A.6.3.3 Shore side

The system requires the following sending and receiving functions from/to UKCM shore-server.

- Received request for passage (before sailing): receive a request for passage through UKCM from a vessel.
- Sent Recommend route for the passage (before sailing): calculate and forecast recommended route(s) based on request received from the vessel.
- Updated Recommended route (during sailing through UKCM area): after reception of active route at beginning of UKCM area, start periodical calculation and forecasting of the UKCM for the vessel. This process continues until the vessel leaves the UKCM area.
- Acknowledged Route (before sailing): accept announcement of the vessel about the selected route plan. Store the request and update the client database.
- Received Actual Route (at start of UKCM area): accept announcement of the vessel about start of sailing through UKCM area. Update the client database. Initiate periodical sending of updated route to the vessel. Initiate monitoring of the vessel based on AIS data.

A.6.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes given in Table A.9 are used and have a special meaning in this profile.

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Table A.9 – Objects and attributes used by UKCM

Object name	Attribute name	Description of use	Comment
Route	routeEditionNo	Start from 1 for each new route. Set by the vessel, increased by one if vessel request new schedule for the same route Exception is the case when UKCM shore-server creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
	routeID	Unique route identifier	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoName	Set by the vessel	Only for human reading purposes MtoM functionality is based on routeInfoVesselVoyage From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Start of validity period	From ship (not applicable) To ship (mandatory)
	routeInfoValidityEnd	End of validity period	From ship (not applicable) To ship (mandatory)
	routeInfoArrivalPortID1	Primary arrival port identifier for this route	Next arrival port in UN/LOCODE format From ship (optional) To ship (not applicable)
	routeInfoArrivalPortID2	Secondary arrival port identifier for this route	From ship (optional) To ship (not applicable)
	routeInfoVesselMMSI	Set by the vessel	Facilitate shore-based monitoring using AIS data From ship (mandatory) To ship (mandatory)

Object name	Attribute name	Description of use	Comment
	routeInfoVesselVoyage	Set by the first-time creator of a new route	Normally set by the vessel Exception is alternative route plans replied by the UKCM shore-server From ship (optional) To ship (optional)
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeWaypointID	Identifier of the waypoints.	From ship (mandatory) To ship (mandatory)
	geometry	Geographical position of the waypoint in degrees	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Turn radius in nautical miles	From ship (mandatory) To ship (mandatory)
	routeWaypointLegGeometryType	Geometry type of leg	From ship (mandatory) To ship (mandatory)
RouteWaypointLeg	routeWaypointLegSTWMax	Max. STW as set by UKCM shore server.	Squat effect (i.e. vessel sails deeper) depends on STW and this is fundamental safety parameter in this use case of UKCM From ship (not applicable) To ship (mandatory)
	routeWaypointID	Used to link schedule element to one of the waypoints of the route	From ship (mandatory) To ship (mandatory)
RouteScheduleManual/ RouteScheduleElement or RouteScheduleCalculated/ RouteScheduleElement	routeScheduleElementETA	Planned time of arrival requested by the vessel at WOL	Mandatory for the schedule element of the first waypoint. Other schedule elements could be without this (i.e. vessel sets time when she wants to sail and UKCM shore-server creates corresponding "recommended" times) From ship (mandatory for first waypoint)

Object name	Attribute name	Description of use	Comment
RouteScheduleRecommended/ RouteScheduleElement	routeWaypointID	Used to link schedule element to one of the waypoints of the route	From ship (mandatory) To ship (mandatory)
	routeScheduleElementETA	Recommended time of arrival assigned by UKCM shore-server	Set by UKCM shore-server for each schedule element To ship (mandatory)
	routeScheduleElementETAWindowBefore	Beginning of time window set by UKCM shore server	To ship (mandatory)
	routeScheduleElementETAWindowAfter	End of time window set by UKCM shore server	To ship (mandatory)

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A.6.5 Test methods and expected results

A.6.5.1 General test

The test consists of onboard and shore system tests. When the EUT applies only one system, a simulation arrangement for the other system shall be provided.

Confirm by inspection that the manufacturer's documents that describe objects and attributes which the EUT supports that the EUT supports all mandatory and optional objects/attributes described in Table A.9.

Confirm by observation that EUT complies with the test requirements as described in 12.3 for the supported objects and attributes.

A.6.5.2 Service specific test

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.9.

The test data for this scenario shall be prepared with the full generic test data according to Table A.10.

Table A.10 – Test procedures for UKCM

Step	Applicable for onboard EUT	Applicable for shore EUT
Before sailing, planned route from onboard to shore		
1	Use the EUT and create a route of 5 waypoints, which contain at least all minimum elements of a route from Table A.9 for UKCM request to shore. Set routeInfoStatus = Initial. Use the EUT and export the route. Use a tool to view contents of the route and confirm by observation that all mandatory elements from Table A.9 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.9, if available, are correctly encoded in the exported route.	Use the simulator or test arrangements as the source to import a route with all mandatory elements from Table A.9 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use the simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.9 and confirm by observation that the route imports with an indication about incomplete route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use the simulator or test arrangements as the source to import a route with invalid content and confirm by observation that the route import terminates with an indication about invalid content of the route.
2	Confirm by observation that, when a route with RouteInfoStatus = Recommended route is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.9.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.9. Import the route to EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.9.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject of editing or the process may terminate. If a new or edited monitored route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.9. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.9.
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to the user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.9.
Before sailing, planned route from shore to onboard		
1		Use the EUT and create a route of 5 waypoints, which contain at least all minimum elements of a route from Table A.9 for UKCM response to ship. Set routeInfoStatus = Recommended. Use the EUT and export the route. Use a tool to view the content of the route and confirm by observation that all mandatory elements from Table A.9 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.9, if available, are correctly encoded in the exported route.
Start of actual sailing		
1	Use the EUT and create the acknowledged route to sail of 5 waypoints, which contains at least all minimum elements of a route from Table A.9 for UKCM request to shore. Set routeInfoStatus = Planned for the route. Use the EUT and export the route. Use a tool to view content of the route and confirm by observation that all mandatory elements from Table A.9 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.9, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.9 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.

Step	Applicable for onboard EUT	Applicable for shore EUT
2	Confirm by observation that, when a route with Recommended route is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.9.
	Use the EUT to create "start of actual sailing" based on the route from the previous step. Set routeInfoStatus = Used for monitoring. Use the EUT and export the route. Use a tool to view the content of the route and confirm by observation that all mandatory elements from Table A.9 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.9, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with routeInfoStatus = Used for monitoring and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
	Confirm by observation that, when a route with RouteInfoStatus = Service started is imported, there is an indication about the start of the UKCM service to the user.	Use the EUT to create start of service event to the ship. Set routeInfoStatus = Service started. Use the EUT and export the route. Use a tool to view the content of the route and confirm by observation that at least RouteInfo object is available and that all elements available are correctly encoded in the exported route as specified in Table A.9.
Loop during actual sailing		
1	Confirm by observation that a route with routeInfoStatus = Recommended is imported and processed correctly.	Use the EUT and create a route of 5 waypoints, which contain at least all mandatory elements from Table A.9 of a route for UKCM as a response from shore to ship. Set routeInfoStatus = Recommended. Use the EUT and export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.9.
End of actual sailing		
1	Use the EUT to create "end of actual sailing" based on the route from the previous step. Set routeInfoStatus = Terminated. Use the EUT and export the route. Use a tool to view the contents of the route and confirm by observation that all mandatory elements from Table A.9 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.9, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with routeInfoStatus = Terminated and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of the route information is as specified in this document.
2	Confirm by observation that when a route with RouteInfoStatus = Service ended is imported, there is an indication about the start of the UKCM service to the user.	Use the EUT to create a start of service event to the ship. Set routeInfoStatus = Service ended. Use the EUT and export the route. Use a tool to view the content of the route and confirm by observation that at least RouteInfo object is available and that all elements available are correctly encoded in the exported route as specified in Table A.9.

A.7 Fleet route planning

A.7.1 Description

Fleet route planning is a tool which can enable a company to optimise its fleet operations by providing a means to view, plan and direct the routes for the vessels in its fleet.

Fleet route planning involves two actors.

- 1) A company, typically a shipping company, which has an overview of the route plans of the vessels in its fleet and can use these to ensure that these route plans are safe and efficient, and meet the operational and commercial objectives of the company, and to direct the ship accordingly.
- 2) A ship, which can advise the company of its current intentions and receive revised route orders from the company.

In accordance with the operational procedure determined by the company, the ship will transmit its planned route to the company, who will use it in conjunction with the routes from the other ships in the fleet to determine the safest and most efficient use of the fleet in terms of port calls, routes taken, ship speeds etc. When fleet route planning is initiated by the company, this process will be omitted.

If the company determines that the planned route of a ship no longer meets the safety, operational or commercial requirements of the company, it will transmit a new recommended route plan to the ship.

A.7.2 Information exchange diagram

The diagram shown in Figure A.23 shows the interaction between the ship and shipping company.

All messages are formatted as routes. The messages exchanged are as follows.

- 1) The ship sends a planned route to the shipping company. This contains waypoints, corresponding transit times and speed over ground (SOG). The planned route has RouteInfoStatus = Planned.
- 2) The company may respond to a planned route from the ship with new route orders containing a new destination, a different set of waypoints or changes to the ship speed to improve safety, energy efficiency or to minimize waiting times. The new route from the company shall be a route with RouteInfoStatus = Recommended. Alternatively, the company may raise issues with the planned route from the ship, in which case RouteInfoStatus = Route Issues.
- 3) If the ship is satisfied with a recommended route received from the company, it sends the same planned route back to the company; otherwise, it sends a revised planned route to the company. In either case, RouteInfoStatus = Planned.
- 4) When the company is satisfied with a planned route received from the ship, it sends the route back to the ship with RouteInfoStatus = Acknowledged; otherwise, the process iterates from step 2).

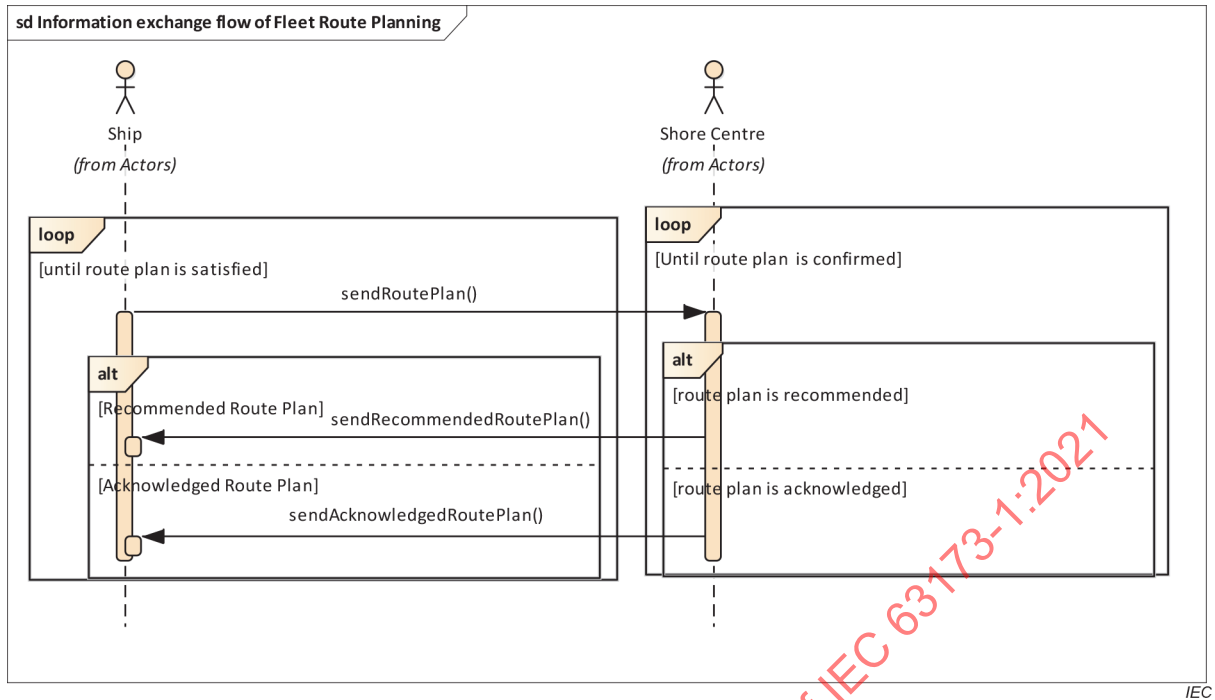


Figure A.23 – Information sequence diagram

A.7.3 State transition diagram

The routes used in fleet route planning will transition through the states shown in Figure A.24 and Figure A.25.

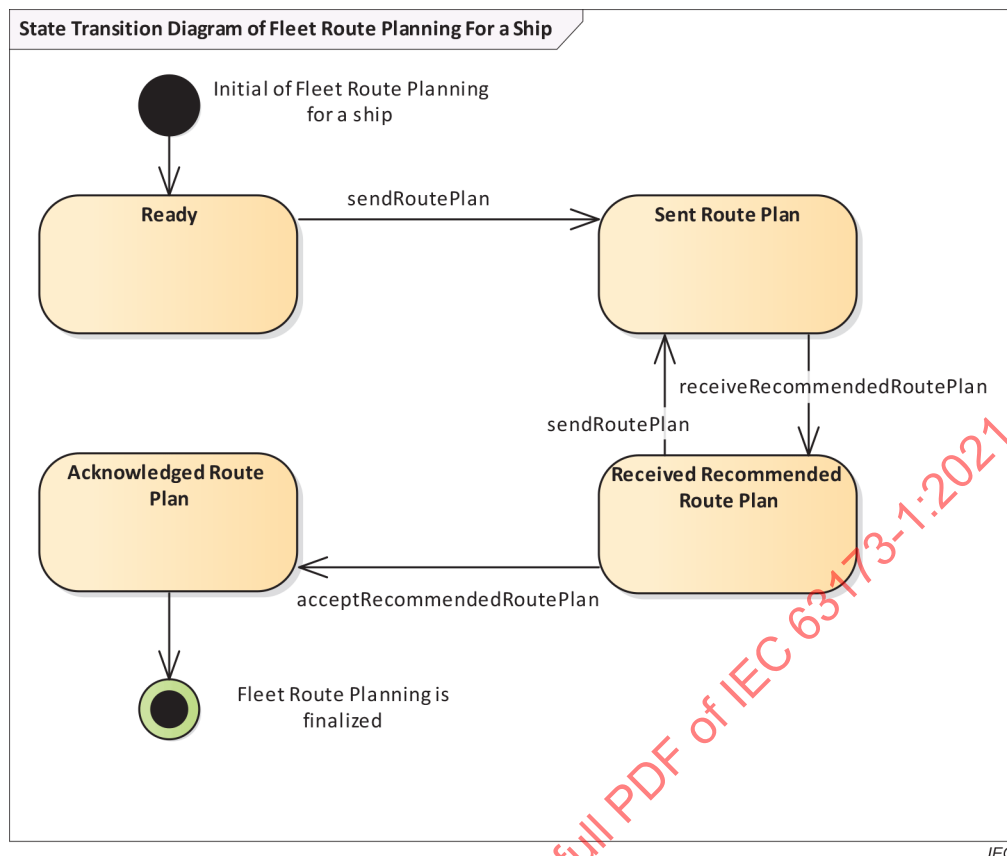


Figure A.24 – State transition diagram for a ship

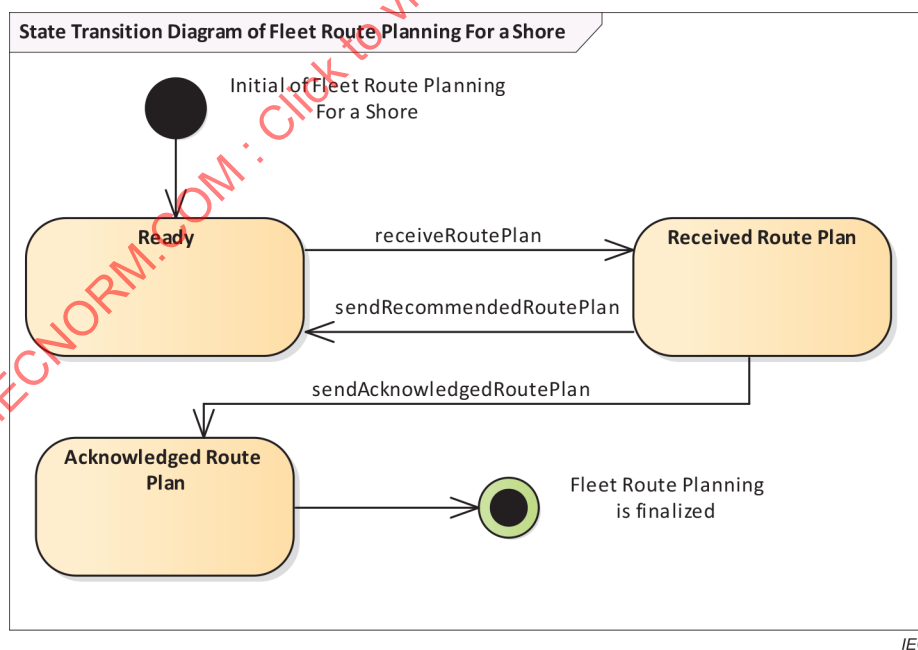


Figure A.25 – State transition diagram for a shore

The following states apply to the ship.

- Ready: the ship enters this state when it has created an initial planned route and is ready to send it to the company.
- Sent Route Plan: the ship enters this state after sending a planned route to the company.
- Received Recommended Route Plan: the ship enters this state after receiving a route with routeInfoStatus = Recommended from the company. If the recommended route is acceptable, the ship sends the same route back to the company. If the received route is not acceptable, the ship sends a revised planned route to the company. In either case, RouteInfoStatus = Planned.
- Acknowledged Route Plan: the ship enters this state when it receives a route from the company with routeInfoStatus = Acknowledged.

The following states apply to the company/shore side system:

- Ready: in this state, the company is waiting for a planned route from the ship.
- Received Route Plan: the company enters this state after reception of a planned route from the ship. The company checks the planned route and calculates a new route if necessary. Then it replies, either with a revised route plan (routeInfoStatus = Recommended), or an acknowledgement if the planned route from the ship is acceptable (routeInfoStatus = Acknowledged).
- Acknowledged Route Plan: the company enters this state after sending a route with routeInfoStatus = Acknowledged.

A.7.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the attributes of Table A.11 are used and have a special meaning in this profile.

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Table A.11 – Objects and attributes used by fleet route planning

Object name	Attribute name	Description of use	Comment
Route	routeID	Unique route identifier	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Start from 1 for each new route. Set by the vessel, increased by one if vessel requests a new schedule for the same route Exception for the case when shore creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
routeInfoVesselVoyage	routeInfoVesselVoyage	Unique voyage identifier	Only for human reading purposes MtoM functionality is based on routeInfoVesselVoyage From ship (mandatory) To ship (mandatory)
	routeInfoAuthor	Author of the route	From ship (optional) To ship (optional)
	routeInfoEditionTime	Time when this edition of route plan is edited	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	Additional information for the status of the route	From ship (optional) To ship (optional)
	routeInfoStatus	Enumerated status value of the route	From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Start of validity period	From ship (not applicable) To ship (optional)
	routeInfoValidityEnd	End of validity period	From ship (not applicable) To ship (optional)
	routeInfoDeparturePortID1	Primary departure port identifier for this route	From ship (mandatory) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeInfoDeparturePortID2	Secondary departure port identifier for this route	From ship (optional) To ship (optional)
	routeInfoArrivalPortID1	Primary arrival port identifier for this route	From ship (optional) To ship (mandatory)
	routeInfoArrivalPortID2	Secondary arrival port identifier for this route	From ship (optional) To ship (optional)
	routeInfoReferencePrevRoute	Reference previous route	From ship (optional) To ship (optional)
	routeInfoReferenceNextRoute	Reference next route	From ship (optional) To ship (optional)
	routeInfoVesselVoyage	Unique voyage identifier	From ship (mandatory) To ship (mandatory)
	routeInfoVesselMMSI	Ship's MMSI (XXXXXXXXXX)	From ship (mandatory) To ship (mandatory)
	routeWaypointID	Identifier of the waypoints. The identifier shall be unique in the system	From ship (mandatory) To ship (mandatory)
	geometry	Geographical position of the waypoint in degrees	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Turn radius in nautical miles	From ship (mandatory) To ship (mandatory)
RouteScheduleManual/ RouteScheduleElement or RouteScheduleCalculated/ RouteScheduleElement	routeWaypointID	Used to link schedule element to one of the waypoints of the route	From ship (mandatory) To ship (mandatory)
	routeScheduleElementETA	Planned time of arrival requested by the vessel at WOL	Mandatory for the schedule element of the last waypoint. From ship (optional)
	routeScheduleElementETD	Planned time of departure assigned by company	Mandatory for the schedule element of the first waypoint From ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before planned time	From ship (optional)

Object name	Attribute name	Description of use	Comment
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after planned time	From ship (optional)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before planned time	From ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after planned time	From ship (optional)
	routeScheduleElementNote	Notes for the route schedule element	From ship (optional)
RouteScheduleRecommended/ RouteScheduleElement	routeWaypointID	Used to link schedule element to one of the waypoints of the route	To ship (mandatory)
	routeScheduleElementPlanSOG	Planned speed over ground	To ship (optional)
	routeScheduleElementETA	Recommended time of arrival assigned by company	Mandatory for the schedule element of the last waypoint To ship (optional)
	routeScheduleElementETD	Recommended time of departure assigned by company	Mandatory for the schedule element of the first waypoint To ship (optional)
	routeScheduleElementETAWindowBefore	Beginning of time window set by company for the arrival	To ship (optional)
	routeScheduleElementETAWindowAfter	End of time window set by company	To ship (optional)
	routeScheduleElementETDWindowBefore	Beginning of time window set by company for the arrival	To ship (optional)
	routeScheduleElementETDWindowAfter	End of time window set by company	To ship (optional)
	routeScheduleElementNote	Notes for the route schedule element	To ship (optional)

A.7.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.11.

The test data for this scenario shall be prepared from the full generic test data according to Table A.12.

Table A.12 – Test procedures for fleet route planning

Step	Applicable for onboard EUT	Applicable for shore EUT
Fleet route planning without leg		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route with RouteInfoStatus = Planned from Table A.11 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.11 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.11, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.11 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11 and that RouteWaypoint objects and value of "routeEditionNo" are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11 and that the value of "routeEditionNo" has been increased by one compared to that imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.11. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.11. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to the user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.11.
Fleet route planning with leg		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route plus leg information with RouteInfoStatus = Planned from Table A.11 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.11 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.11, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements and optional leg information from Table A.11 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11.
	Confirm by observation that when a route with RouteInfoStatus = Recommended is imported it is processed correctly and that the route cross check process is ended or continued as step 1.	Confirm by observation that, based on an imported route, it is possible to create a recommended route with new leg information (including leg notes) with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11.
	Confirm by observation that, when a route with RouteInfoStatus = Route Issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that route cross check process is ended or continued as step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.11. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that a route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.11.

A.8 Chart management

A.8.1 Description

For chart data and chart license management, it may be required to send one or more routes from the ship to a chart data provider.

At least one route for the intended voyage is needed. Multiple routes, for example alternatives for different weather conditions or further subsequent routes, are permitted with a series of route requests.

The chart data provider may either be ashore or represented by a separate unit on board of the ship. The chart management involves two actors.

- 1) Ship: the routes for the upcoming voyage are planned.
- 2) Chart data provider: needs the basic geometry (waypoints only) of the route(s) to determine the required charts and licenses to cover the route(s).

Figure A.26 illustrates a ship transmitting an intended route to a chart data provider ashore, who then will create the required chart exchange sets and who will issue the required licenses.

A.8.2 Information exchange diagram

The message sequence diagram in Figure A.26 describes the interaction between the ship and the chart data provider.

The message is formatted as a route plan. The meaning of the message is:

- 1) a planned route from the ship to the chart data provider. This route contains waypoints with their positions;
- 2) the chart data provider provides the confirmation information to the ship when it is ready to provide the requested chart information. This is not within the scope of this document.

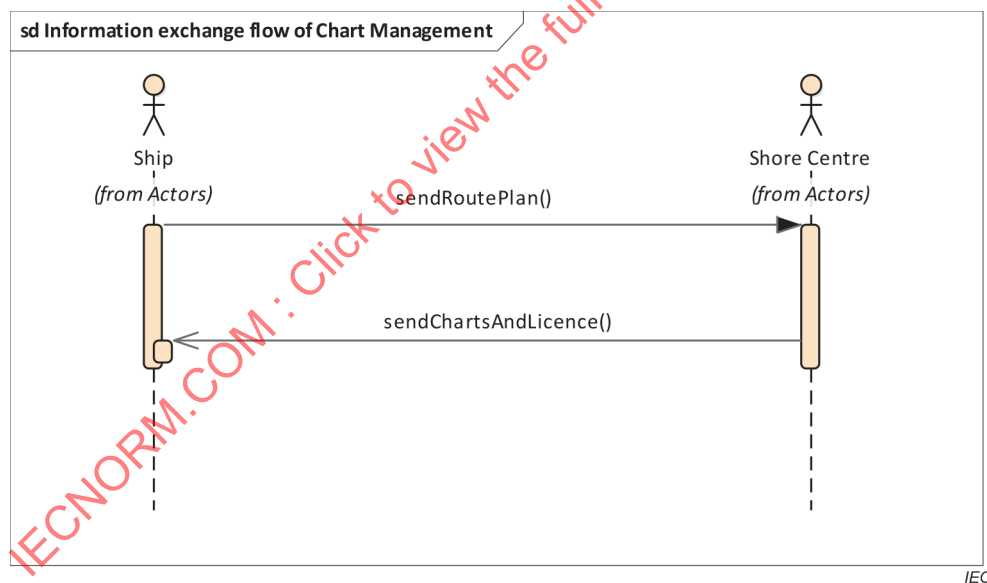


Figure A.26 – Interaction diagram

A.8.3 State transition diagram

A.8.3.1 General

The state transition diagram is omitted due to the simplicity of this profile.

The ship crew will send a planned route(s) prior to departure to the chart data provider in order to obtain the latest charts and licenses for the intended voyage.

A.8.3.2 Ship side

A system requires the sending function "send a planned route". Ship shall send the route with ship waypoint and position.

A.8.3.3 Shore side

No sending of routes from the chart data provider is required.

Sending of charts and licenses is outside the scope of this document.

A shore system has the following states.

- "received a ship info": the system receives ship information for administrative purposes;
- "received a planned route": the system receives the route waypoints positions.

A.8.4 Functional requirement

This chart management profile is only a one-way service. There is no requirement to exchange route information from the shore side or chart management service provider.

A.8.5 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the attributes in Table A.13 are used and have a special meaning in this profile.

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Table A.13 – Objects and attributes used by chart management

Object name	Attribute name	Description of use	Comment
Route	routeID	Unique route identifier	From ship (mandatory)
	routeEditionNo	Route edition number	From ship (mandatory)
RouteInfo	routeInfoVesselName	Set by vessel	For identification of the ship From ship (optional)
	routeInfoVesselMMSI	Set by the vessel	For identification of the ship From ship (optional)
	routeInfoVesselIMO	Vessel IMO number	This may be an empty value if it is not available From ship (optional)
	routeWaypointID	Reference number used to connect schedule and waypoint together	This may be an empty value if it is not available From ship (mandatory)
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	geometry	Geographical position of the waypoint in degrees	From ship (mandatory)

A.8.6 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.13.

The test data for this scenario shall be prepared from the full generic test data according to Table A.14.

Table A.14 – Test procedures for chart management

Step	Applicable for onboard EUT	Applicable for shore EUT
1	Use the EUT and create a route of 5 waypoints, which contain at least all minimum elements of a route from Table A.13 for chart management. Set routeInfoStatus = Planned. Use the EUT and export the route. Use a tool to view the contents of the route and confirm by observation that all mandatory elements from Table A.13 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.13, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.13 and routeInfoStatus = Planned. Confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.13. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.13.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.13. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.13.
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to the user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.13.

A.9 Route optimization

A.9.1 Description

The purpose of route optimization is to optimize a route based on various aspects such as energy, cost, environmental impact, and can be based on parameters such as geometry, UKC, wind, waves, current, regulations, or other restrictions. This is for operational rather than regulatory purposes. See Figure A.27.

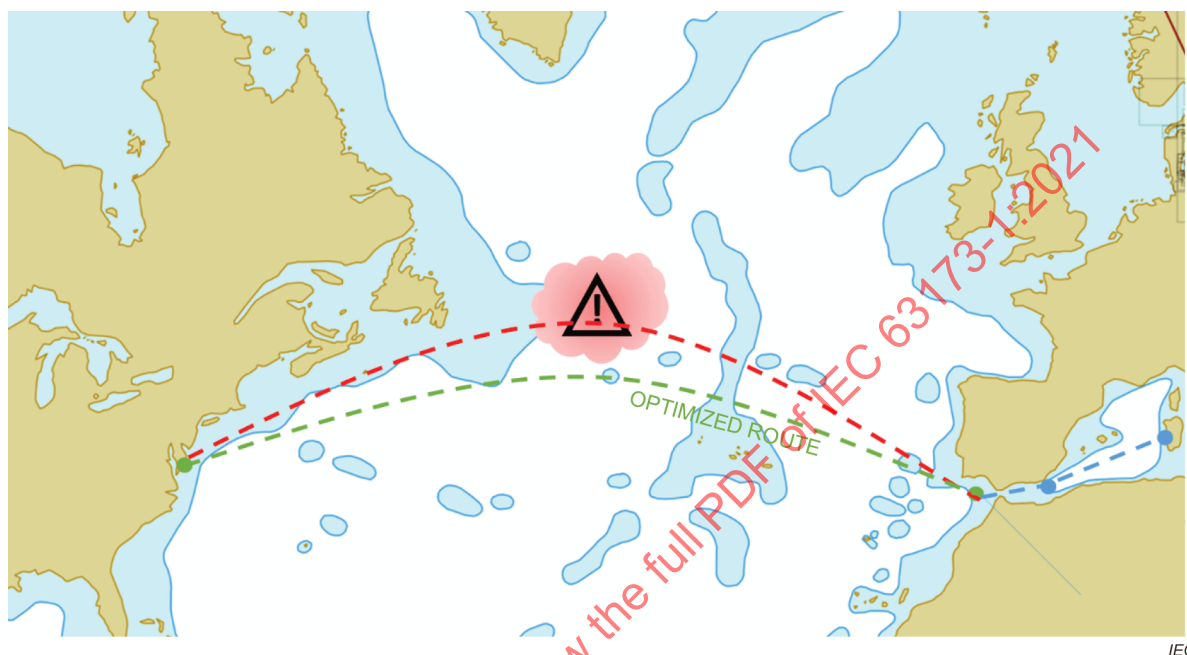


Figure A.27 – Route optimization example

Route optimization involves two actors:

- 1) ship;
- 2) route optimization provider.

During a ship's route planning process, the planned route is sent to the route optimization provider. The route optimization provider identifies the ship and optimizes the route based on known and selected parameters, such as bathymetric, weather, ship static particulars and UKC.

The route optimization provider complements information from the route plan with bathymetric, weather, ship particulars, etc. from other sources. Each route optimization provider may use different parameters, and optimize on different aspects. The description provided by the specific route optimization provider needs to be known by the ship.

The route optimization provider sends back an optimized route to the ship, or a route with error message. Information about the optimized route is provided with routeInfoDescription.

A.9.2 Information exchange diagram

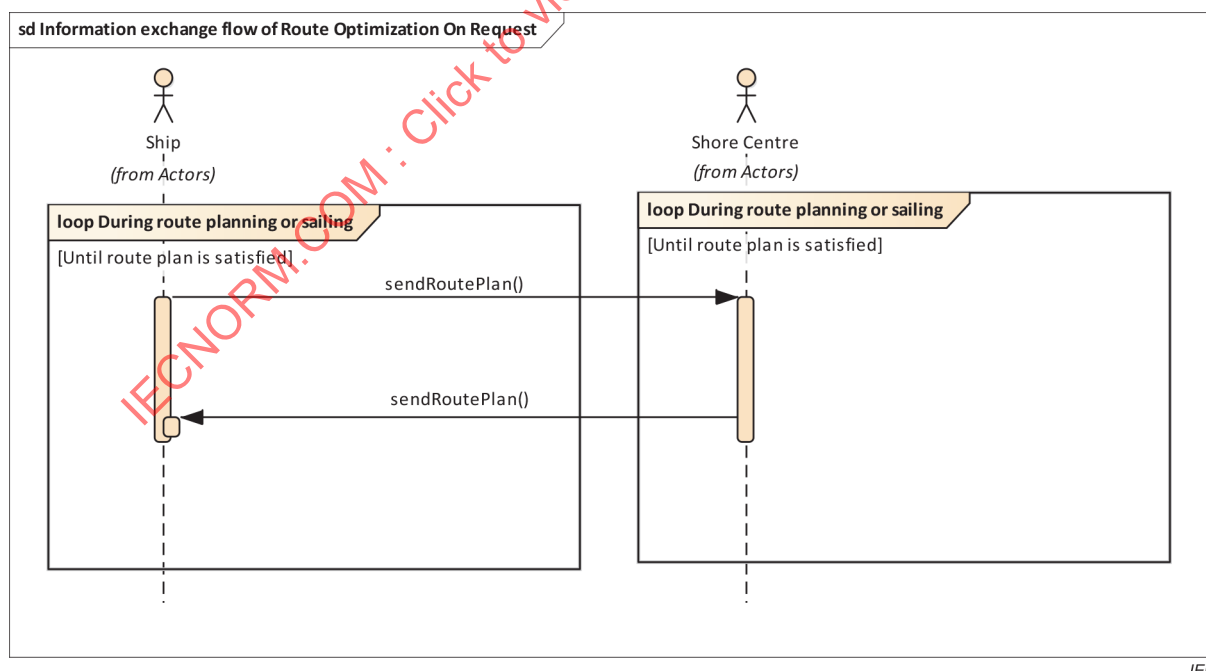
The sequence diagram in Figure A.28 describes a nominal sequence of information exchange.

- 1) The ship sends a route plan to the route optimization provider. The route plan includes routeID, routeEditionNo, ship identifier (MMSI), waypoints and optionally schedule(s). The values that the ship considers fixed are put into manual schedule, such as time of arrival to certain waypoint(s), for example PBG (pilot boarding ground), berth, time of departure. The leg to each waypoint can contain the planned speed and draft of the ship (maximum or separate for forward and aft).
- 2) The route optimization provider assesses the received route plan and tries to optimize the route.
 - a) If the route optimization provider is able to provide an optimized route, the optimized route geometry and schedule (if provided by the ship) is sent to the ship with routeInfoStatus = Recommended.

The optimized route may contain an altered list of waypoints. The routeID shall be identical with received route, the routeEditionNo is incremented and the routeInfoDescription describes the optimized route and the routeInfoAuthor is updated and reflect the route optimization provider.

 - b) If the route optimization provider is not able to provide an optimized route due to incomplete information from the ship the route plan is sent back with routeInfoStatus = Incomplete and a description of the missing attributes or missing static data in routeInfoDescription. The routeID shall be identical with the received route and the routeEditionNo is not changed.
- 3) When a ship under way requests route optimization, the last actual time of departure/arrival from/to a waypoint is provided in the route plan.

From the point of the view of the vessel, the route will transit through the states shown in Figure A.28.



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Figure A.28 – Interaction diagram on request

A.9.3 State transition diagram

The routes used in route optimization will transition through the states shown in Figure A.29 and Figure A.30.

The following states apply to the system on the ship side:

- Ready: the ship side enters this state when it has created an initial planned route and is ready to send it to the route optimization provider;
- Sent Route Plan: the ship side enters this state after sending the route plan to the route optimization provider;
- Received Route Plan: the ship side enters this state when it receives a route plan from the route optimization provider with routeInfoStatus = Recommended, Incomplete, Route Issues or Error.

The following states apply to the company/shore side system:

- Ready: the shore-side system is in this state when it is waiting for a request for route optimization from a ship;
- Received Route Plan: The shore-side system enters into this state after receiving a route plan from a ship;
- Sent Route Plan: The shore side system enters this state when it sends a route plan to a ship with routeInfoStatus = Recommended, Incomplete, Route Issues or Error.

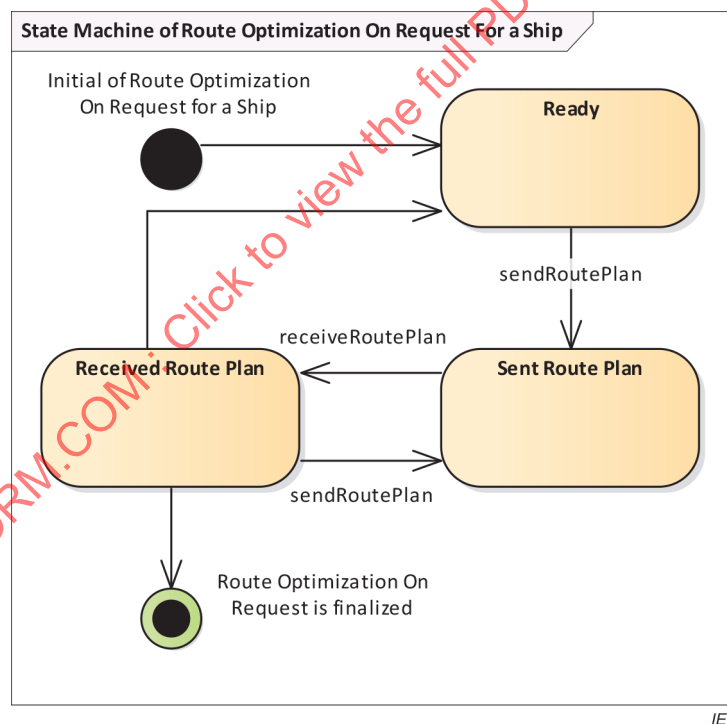


Figure A.29 – State transition diagram for a ship

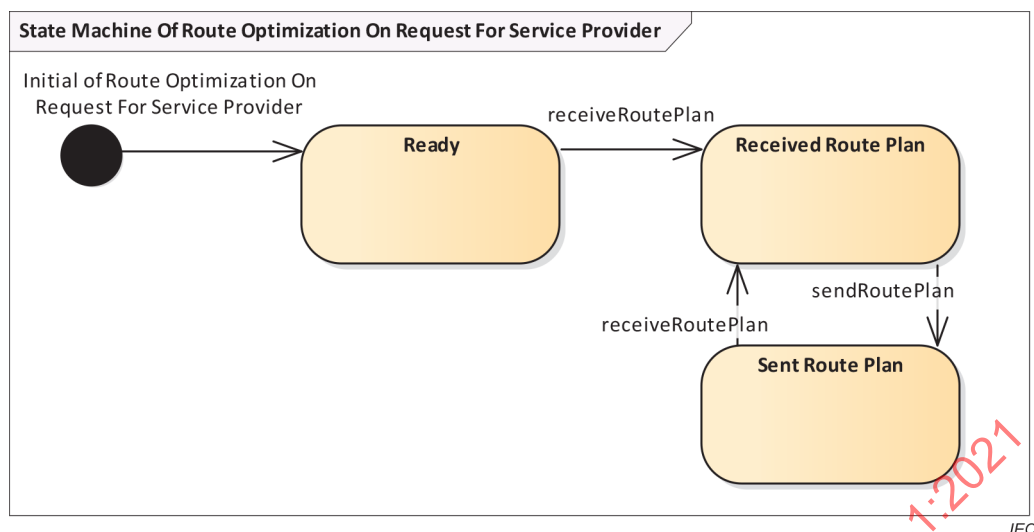


Figure A.30 – State transition diagram for a shore

A.9.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the attributes of Table A.15 are used and have a special meaning in this profile.

The static information of the vessel such as service max., service min., max. speed and wind area may be necessary for the route optimization. This information may be exchanged by other methods not with this object model.

Table A.15 – Objects and attributes used by route optimization

Object name	Attribute name	Description of use	Comment
Route	routeID	Mandatory identifier of the route plan. Unique for complete route between A to B	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Mandatory edition of the route plan. Increased by 1 for every change.	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoEditionTime	Time of update	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	Additional information for the route info status in human readable text	From ship (optional) To ship (mandatory)
	routeInfoStatus	Status on route	From ship (mandatory) To ship (mandatory)
	routeInfoDeparturePortID1	Primary departure port identifier for this route	From ship (optional)
	routeInfoDeparturePortID2	Secondary departure port identifier for this route	From ship (optional)
	routeInfoArrivalPortID1	Primary arrival port identifier for this route	From ship (optional)
	routeInfoArrivalPortID2	Secondary arrival port identifier for this route	From ship (optional)
	routeInfoVesselName	Set by vessel	From ship (optional) To ship (optional)
	routeInfoVesselMMSI	Set by the vessel	From ship (mandatory) To ship (mandatory)
	routeInfoVesselIMO	Vessel IMO number	From ship (optional) To ship (optional)
	routeInfoDraftMax	Maximum draft of the route	From ship (N/A) To ship (optional)
	routeInfoAirDraftMax	Maximum air draft of the route	From ship (N/A) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeInfoBeamMax	Maximum vessel beam of the route	From ship (N/A) To ship (optional)
	routeInfoLengthMax	Maximum vessel length of the route	From ship (N/A) To ship (optional)
	routeWaypointFixed	Input to optimization for not to change the position of the waypoint(s)	From ship (optional)
	geometry	Mandatory position on waypoint	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Mandatory radius on waypoint	From ship (mandatory) To ship (mandatory)
RouteWaypointLeg	routeWaypointLegStarboardXTDL	Starboard cross track distance limit Used during the route monitoring onboard.	From ship (optional) To ship (optional)
	routeWaypointLegPortXTDL	Port cross track distance limit Used during the route monitoring onboard.	From ship (optional) To ship (optional)
	routeWaypointLegStarboardCL	Starboard cross track distance check limit Used to check route plan against the safety contour, areas with special condition and navigational hazards	From ship (optional) To ship (optional)
	routeWaypointLegPortCL	Port cross track distance check limit Used to check route plan against the safety contour, areas with special condition and navigational hazards	From ship (optional) To ship (optional)
	routeWaypointLegSafetyDepth	Enables refined optimization	From ship (optional) To ship (optional)
	routeWaypointLegGeometryType	Geometry type on leg; orthodrome or loxodrome	From ship (mandatory) To ship (mandatory)
	routeWaypointLegSOGMin	Regulatory speed window on leg	From ship (optional) To ship (optional)
	routeWaypointLegSOGMax	Regulatory speed window on leg	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteScheduleManual/RouteScheduleElement and RouteScheduleCalculated/RouteScheduleElement	routeWaypointLegSTWMax	Maximum safe speed through water	From ship (optional) To ship (optional)
	routeWaypointLegDraft	Enables improved accuracy on optimization	From ship (mandatory)
	routeWaypointLegDraftAft	Enables improved accuracy on optimization	From ship (optional)
	routeWaypointLegDraftForward	Enables improved accuracy on optimization	From ship (optional)
	routeWaypointLegDraftMax	Maximum draft limit of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegAirDraftMax	Maximum air draft limit of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegBeamMax	Maximum vessel beam limit of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegLengthMax	Maximum vessel length limit of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegSafetyMargin	Draft component including uncertainties	From ship (optional) To ship (optional)
	routeWaypointID	Links schedule element to one waypoint of the route	From ship (mandatory)
	routeScheduleElementPlanSOG	Manual/calculated set speed	From ship (optional)
	routeScheduleElementETD	Manual/calculated set time is an indication for the route optimization provider to not change this time, hence optimize route to meet the time	From ship (optional)
	routeScheduleElementETA	Manual/calculated set time is an indication for the route optimization provider to not change this time, hence optimize route to meet the time	From ship (mandatory)

Object name	Attribute name	Description of use	Comment
RouteScheduleRecommended/ RouteScheduleElement	routeWaypointID	Links scheduled element to one waypoint of the route	To ship (mandatory)
	routeScheduleElementPlanSOG	Estimated speeds on legs from optimization service	To ship (optional)
	routeScheduleElementWaypointETD	Recommended departure time from waypoints in calculated schedule Fixed departure time on waypoints in manual schedule	To ship (optional)
	routeScheduleElementETDWindowBefore	Recommended window around recommended time of departure reflects the uncertainty/probability to meet the recommended time.	To ship (optional)
	routeScheduleElementETDWindowAfter	Recommended window around recommended time of departure. Reflects the uncertainty/probability to meet the recommended time.	To ship (optional)
	routeScheduleElementETA	Recommended arrival time on waypoints in calculated schedule Fixed arrival time on waypoints in manual schedule	To ship (mandatory)
	routeScheduleElementETAWindowBefore	Recommended window around recommended time of arrival. The size of the window reflects the uncertainty/probability to meet the recommended time.	To ship (optional)
	routeScheduleElementETAWindowAfter	Recommended window around recommended time of arrival. The size of the window reflects the uncertainty/probability to meet the recommended time.	To ship (optional)

A.9.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.15.

The test data for this scenario shall be prepared from the full generic test data according to Table A.16.

Table A.16 – Test procedures for route optimization

Step	Applicable for onboard EUT	Applicable for shore EUT
Optimize route		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route with RouteInfoStatus = Planned from Table A.15 to the shore. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.15 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.15, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.15 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that a route with RouteInfoStatus = Acknowledged is imported and is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.15 and that RouteWaypoint objects and value of "routeEditionNo" are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes new waypoint(s) and/or new recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.15.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeInfoDescription and routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.15. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that the route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.15.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.15. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.15.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the variable elements are correctly encoded in the exported route as specified in Table A.15.

A.10 Port call synchronization

A.10.1 Description

This use case describes the usage of S-421 in port call synchronization.

Port call synchronization involves the following actors:

- 1) ship;
- 2) port coordinator: actors involved in port call, for example pilot, terminal, port authority, represented here by a virtual actor called "port coordinator".

During ship's route planning, the planned route is sent to port for confirmation of estimated time of arrival at, for example, pilot boarding area, berth, etc. The route plan may include reference to previous route plans and/or next route plans (routeInfoReferencePrevRoute and routeInfoReferenceNextRoute).

The ship expects the port to either confirm time of arrival or recommend new best time of arrival, or recommend new waypoints and recommended time of arrival (ETA in the recommended schedule), for example a new berth and time for berthing and/or pilot boarding.

The ship and port iterate the process until agreed in the route plan with acknowledged arrival time.

At some point in time, the ship activates the route (departs from previous port) and starts sailing according to the plan.

The port receives the active route and monitors the port availability against the ships route plan. If necessary, the port may send a new time of arrival to the ship.

The ship monitors the route plan and, if necessary, re-plans the route and sends updated time of arrival to the port. The ship expects to either get a new time of arrival acknowledged, or adjusted in a new recommendation/request (ETA in the recommended schedule).

The port estimates departure time and sends time of departure to the ship (ETD in the recommended schedule).

The ship plans the departure route and shares it with the port.

A.10.2 Information exchange diagram

The sequence diagram given in Figure A.31 describes a nominal sequence of information exchange.

– Route planning phase

- 1) The ship sends a planned route including time of arrival at waypoint (normally pilot boarding ground (PBG) or berth), departure and arrival port as UN/LOCODE (routeInfoDeparturePortID1 and routeInfoArrivalPortID1) and routeID + routeEditionNo to the port coordinator. The route plan can also contain reference to next and previous route plans. Optionally, an external identifier is set as reference on the waypoint for berth. Optionally, there is a reference to voyage number in routeInfoVesselVoyage and reference to departure and arrival port call identifiers.
- 2) The port coordinator correlates the route plan to an existing port call and port's planned arrival time based on provided port call identifier, ship identification (e.g. MMSI), arrival port and ships estimated time of arrival to <location>. If no port call exists, a new port call is created in the port community system (this action may be automated). The port can use the arrival (and departure) port information to validate the correct receipt of the port call synchronization information. The port can also correlate waypoints in the route plan with location defined in the port using a reference on the waypoint.
- 3) The port coordinator checks time of arrival from the ship against port and berth availability.

The port coordinator makes a decision as following

- i) Confirm time of arrival:
 - a) Send route confirmation (send identical route plan with routeInfoStatus = Acknowledged but same routeID and routeEditionNo to indicate no changes) or just the routeInfo with routeInfoStatus = Acknowledged referring to same routeID and routeEditionNo.
 - ii) Request new time of arrival to a waypoint, for example pilot boarding ground (PBG), berth:
 - a) send recommended (requested) time of arrival to ship with routeInfoStatus = Recommended and wait for response from ship;
 - b) recommended time of arrival in recommended schedule with reference to relevant waypoint. Same RouteID and increased routeEditionNo, and description in routeInfoDescription.
- 4) Ship receives response from port.
 - i) Confirmation
Ship continues as planned.
 - ii) Recommended time of arrival to waypoint with reason for recommendation (routeInfoDescription)
 - a) Ship accepts new recommend time of arrival and sets new estimated time of arrival and sends back an updated route plan to the port with increased edition number, same RouteID and increased routeEditionNo, and description in routeInfoDescription.
 - b) Ship rejects new time and sets same or adjusted time of arrival and sends back to the port. The route plan contains the recommended time of arrival from the port to show that it has been considered, but not accepted.
 - iii) Go to 3)

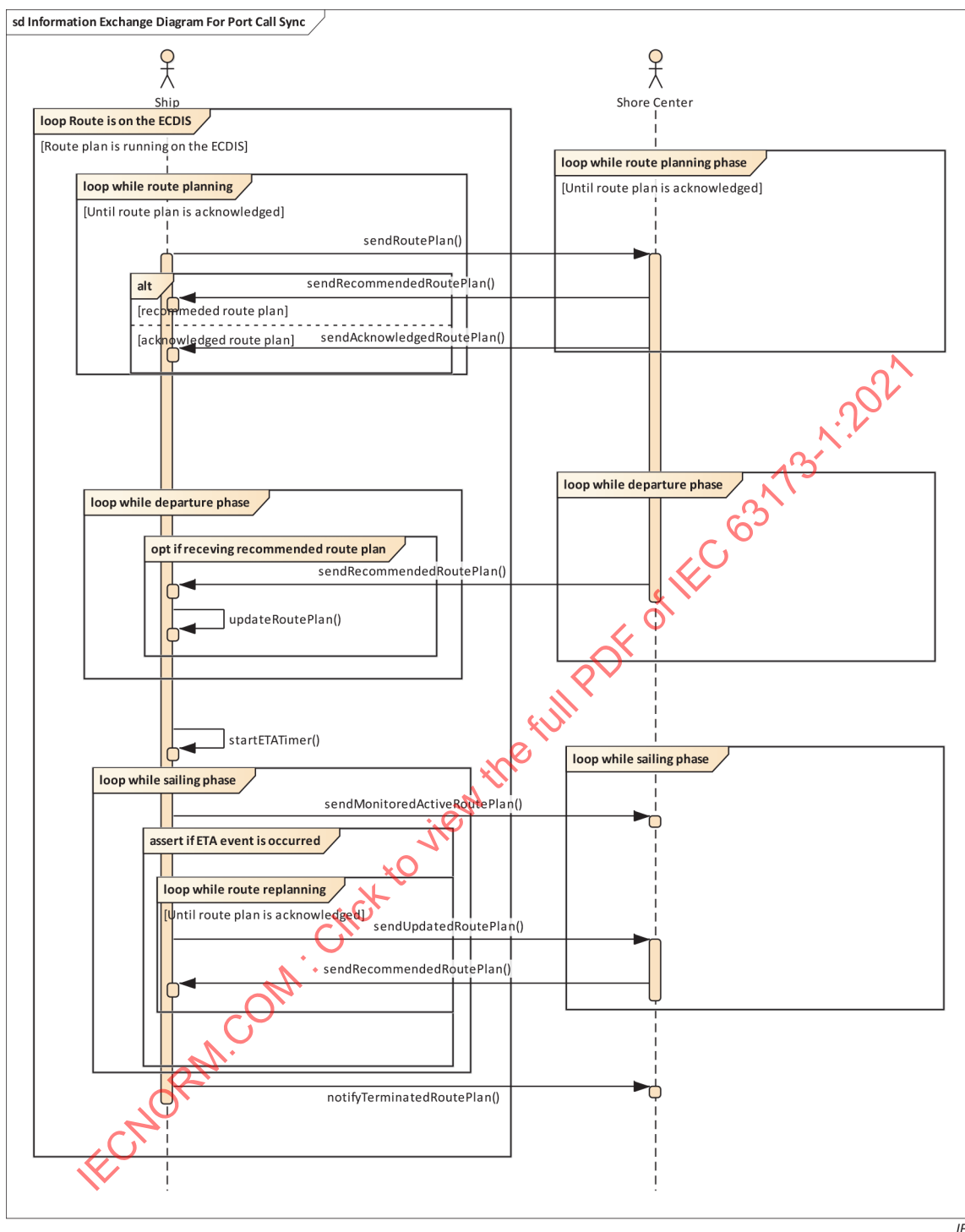


Figure A.31 – Interaction diagram

– Sailing phase

- 1) Ship sends active route with routeInfoStatus = Monitored to port coordinator.
- 2) If ship estimates difference on sent time of arrival of more than X minutes, the ship re-plans and sends an updated time of arrival to the port coordinator. The value of X will be defined by the master of the vessel or by requirements of the route plan receiver.
- 3) Port coordinator checks time of arrival from the ship against port and berth availability (see step 3 in route planning phase).

- Departure phase
 - 1) Port sends planned time of departure to ship
Recommended/requested time of departure is put in manual schedule in departure route, if shared by the ship.
 - 2) Ship receives recommended time of departure
Ship updates the route plan and shares estimated time of departure with the port with routeInfoStatus = Planned, departure and arrival port as UN/LOCODE (routeInfoDeparturePortID1 and routeInfoArrivalPortID1).

A.10.3 State transition diagram

The system on ship side requires the following sending and receiving functions as shown in Figure A.32.

- Ready: Port call synchronization for a ship side is ready.
- Sent Route Plan: After drafting a planned route plan and sending the planned route plan, the ship enters into this state.
- Received Recommended Route Plan: The ship receives the recommended route as the reply of sending planned route.
- Sent Active Route Plan: During sailing, the ship sends the active route used for monitoring.
- Send Inactive Route: If the position of the ship is arrived to the last waypoint or the route is cancelled, the ship sends inactive route to the shore.
- Sent Updated Route Plan: After receiving the recommended route, the ship assesses the recommended route information and considers the ETA and sends the updated route plan to the shore.
- Estimate Time of Arrival: Timer is repeated for checking the difference of ETA. If the difference is the greater than the threshold x , it triggers the update of route plan.

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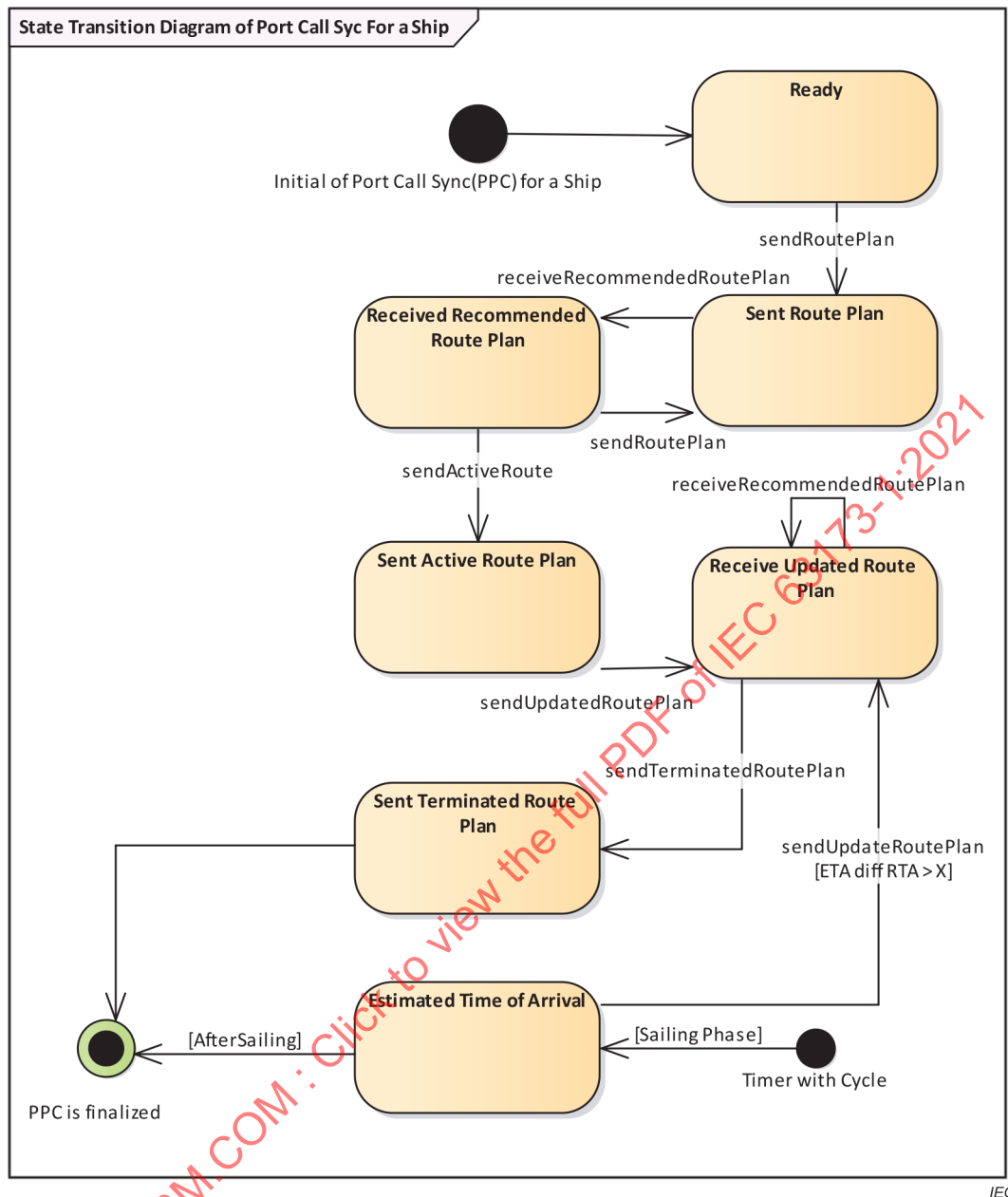


Figure A.32 – State transition diagram for a ship

The system on shore side requires the following sending and receiving functions as shown in Figure A.33.

- Waiting: Port call synchronization (PCS) for a shore side is ready and waits for messages for PCS.
- Received Route: After receiving the planned route, the ship enters into this state. The shore replies with the acknowledged route or recommend route to the ship.
- Acknowledged Route Plan: The ship repeats the sending of the planned route while receiving the recommended route until the route is acknowledged.
- Received Active Route: After sailing, the ship sends the active route.
- Sent Recommended Route Plan: If the port recommends a new arrival time to the ship, the shore sends the recommended route.

- Received Updated Route Plan: After the ship receives the recommended route from the shore, the ship sends the updated route plan. This route is based on the recommended route, the ETA and ETD.
- Received Terminated Route Plan: If the next waypoint is the last waypoint, the ship sends the inactive route plan.

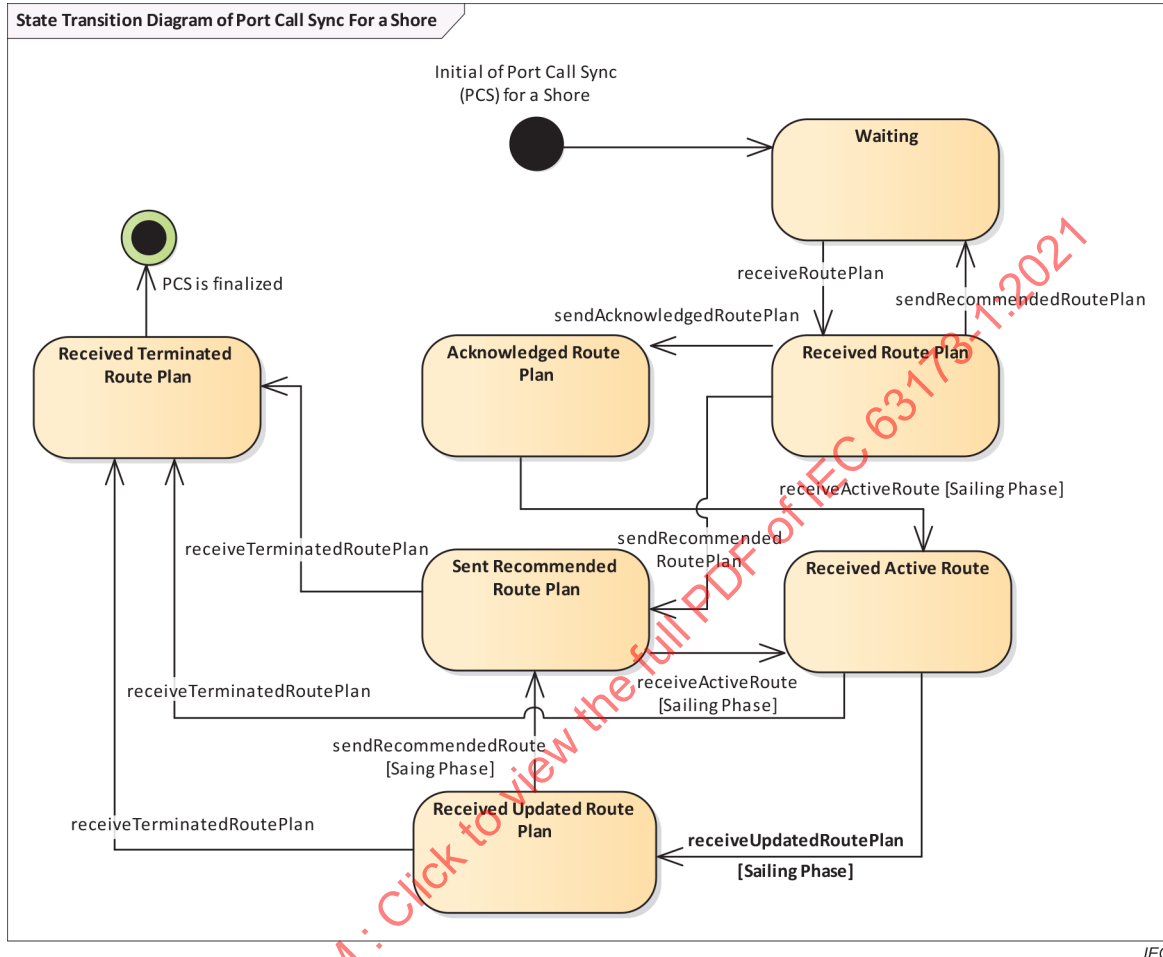


Figure A.33 – State transition diagram for shore

A.10.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes of Table A.17 are used and have a special meaning in this profile.

Table A.17 – Objects and attributes used by port call synchronization

Object name	Attribute name	Description of use	Comment
Route	routeID	Identity of the specific route from A to B	From ship (mandatory) To ship (mandatory)
	routeEditionNo	Start from 1 for each new route. Set by the vessel, increased by one if vessel requests a new schedule for the same route Exception for the case when shore creates new alternative routes available for the vessel	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoEditionTime	Time for update	From ship (mandatory) To ship (mandatory)
	routeInfoDescription	More information given related to the status and edition of the route	From ship (mandatory) To ship (mandatory)
	routeInfoStatus	Separate planned from monitored (active) route	From ship (mandatory) To ship (mandatory)
	routeInfoDeparturePortID1	Primary departure port identifier for this route	From ship (optional) To ship (optional)
	routeInfoDeparturePortID2	Secondary departure port identifier for this route	From ship (optional) To ship (optional)
	routeInfoDeparturePortCall	Reference to port call identifier in departing port	From ship (optional) To ship (optional)
	routeInfoArrivalPortID1	Primary arrival port identifier for this route	From ship (mandatory) To ship (mandatory)
	routeInfoArrivalPortID2	Secondary arrival port identifier for this route	From ship (optional) To ship (optional)
	routeInfoArrivalPortCall	Reference to port call identifier in arrival port.	From ship (optional) To ship (optional)
	routeInfoReferencePrevRoute	Refers to the identity (RouteID) of previous route	From ship (optional) To ship (optional)
	routeInfoReferenceNextRoute	Refers to the identity (RouteID) of next route. Connects inbound route with outbound route in a port call	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
	routeInfoVesselMMSI	To facilitate shore-based monitoring using AIS data	From ship (mandatory) To ship (mandatory)
	routeInfoVesselIMO	Identify of specific ship	From ship (optional) To ship (optional)
	routeInfoVesselVoyage	Connect the route to voyage and cargo	From ship (optional) To ship (optional)
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeWaypointID	Reference number used to connect schedule and waypoint together	From ship (mandatory) To ship (mandatory)
	geometry	Geographical position of the action point in degrees	From ship (mandatory) To ship (mandatory)
	routeWaypointExternalReferenceID	Increase integration between intermodal transportation in logistic chain, such as GLN id for berth	From ship (optional) To ship (optional)
	routeWaypointID	Link schedule element to one waypoint	From ship (mandatory)
RouteScheduleManual/RouteScheduleElement	routeScheduleElementETD	Manually set estimated time of departure	From ship (optional)
	routeScheduleElementETA	Manually set estimated time of arrival	From ship (optional)
	routeWaypointID	Link schedule element to one waypoint	From ship (mandatory)
	routeScheduleElementETD	Calculated estimation of time of departure	From ship (optional)
	routeScheduleElementETDWindowBefore	Describes the uncertainty of the predicted ETD before planned time	From ship (optional)
	routeScheduleElementETDWindowAfter	Describes the uncertainty of the predicted ETD after planned time	From ship (optional)
	routeScheduleElementETA	Calculated estimation of time of arrival	From ship (mandatory)
	routeScheduleElementETAWindowBefore	Describes the uncertainty of the predicted ETA before planned time	From ship (optional)
	routeScheduleElementETAWindowAfter	Describes the uncertainty of the predicted ETA after planned time	From ship (optional)
	routeWaypointID	Link schedule element to one waypoint	To ship (mandatory)
RouteScheduleRecommended/RouteScheduleElement	routeScheduleElementETD	Recommended time of departure (RTD)	To ship (mandatory f) Mandatory here means either ETD or ETA shall be provided.
	routeScheduleElementETA	Recommended time of arrival (RTA)	To ship (mandatory) Mandatory here means either ETD or ETA shall be provided

A.10.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.17.

The test data for this scenario shall be prepared from the full generic test data according to Table A.18.

Table A.18 – Test procedures for port call synchronization

Step	Applicable for onboard EUT	Applicable for shore EUT
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route from Table A.17. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.17 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.17, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.17 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use a simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.17 and confirm by observation that the route imports with an indication about incomplete route.
2	Confirm by observation that, when a route with RouteInfoStatus = Acknowledged is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create an acknowledged route with RouteInfoStatus = Acknowledged and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.17 and that RouteWaypoint objects and value of routeEditionNo are as imported from the vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Recommended is imported, it is processed correctly.	Confirm by observation that, based on an imported route, it is possible to create a recommended route which includes recommended schedule information with RouteInfoStatus = Recommended and to export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.17 and that value of "routeEditionNo" has been increased by one compared to that imported from vessel.
	Confirm by observation that, when a route with RouteInfoStatus = Route issues is imported, the user is informed about the issues, the user is able to read descriptions of the issues (routeWaypointLegIssue) and that the process is either continued onboard correctly or continued from step 1.	Use a simulator or test arrangements to generate a route with all mandatory elements from Table A.17. Import the route to the EUT. Use the EUT to set route issues for the route. Confirm by observation that a route is exported with RouteInfoStatus = Route Issues. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.17.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, it is processed correctly.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.17. Import the route to EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that routeInfoDescription contains the error description and the available elements are correctly encoded in the exported route.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that, when a route with RouteInfoStatus = Error is imported, it is processed correctly.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and observe that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error with information about deleted attributes not passing schema validation or application level context check included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.17.
3	Use the EUT and terminate the route. Export the route. Use a tool to view the content of the exported route and confirm by observation that routeInfoStatus = Terminated is set and all mandatory elements from Table A.17 are available and correctly encoded in the exported route.	Confirm by observation that, when a route with RouteInfoStatus = Terminated is imported, it is processed correctly.

A.11 Reference route

A.11.1 Description

Offering reference routes (see Figure A.34) is a service where navigators are assisted by a shore side service offering a reference route as a response when the navigator sends information on the arrival location, and eventually the departure location. Locations can be given by a name, a given location code or a position. The navigator can also ask for a reference route by providing a first sketch of a route. This document can assist such services. The service is established as a part of VTS navigational assistance service (NAS) specified further in IMO MSC. 467(101).

NOTE This use case is an example of reference routes given from a national authority. However, providers of reference routes can also be a company making common reference routes for their own vessels, or pilot routes provided from the pilotage services.

By utilizing S-421 in this way, services can contribute to better bridge resource management and increased navigational safety, facilitate more efficient and timesaving voyage planning and increase safety by offering validated and safe waypoints and legs for any given voyage serving as a start in the voyage planning. As the reference routes will have limitations given by waterway and environmental conditions, attributes holding this information are vital. For instance, a reference route may apply to all vessels with a draft up to 9 m and "length over all" up to 150 m. The data model gives attributes for this on both the entire route or, if applicable, for any given leg in the route. Additional information can be given in the attribute routeInfoDescription, and if found necessary, particular issues such as max. vessel length or max. vessel draft for a route can be included in routeInfoName.

Reference routes do not hold a schedule but hold the validity period for the route to be used for passage planning (routeInfoValidityStart/routeInfoValidityEnd).

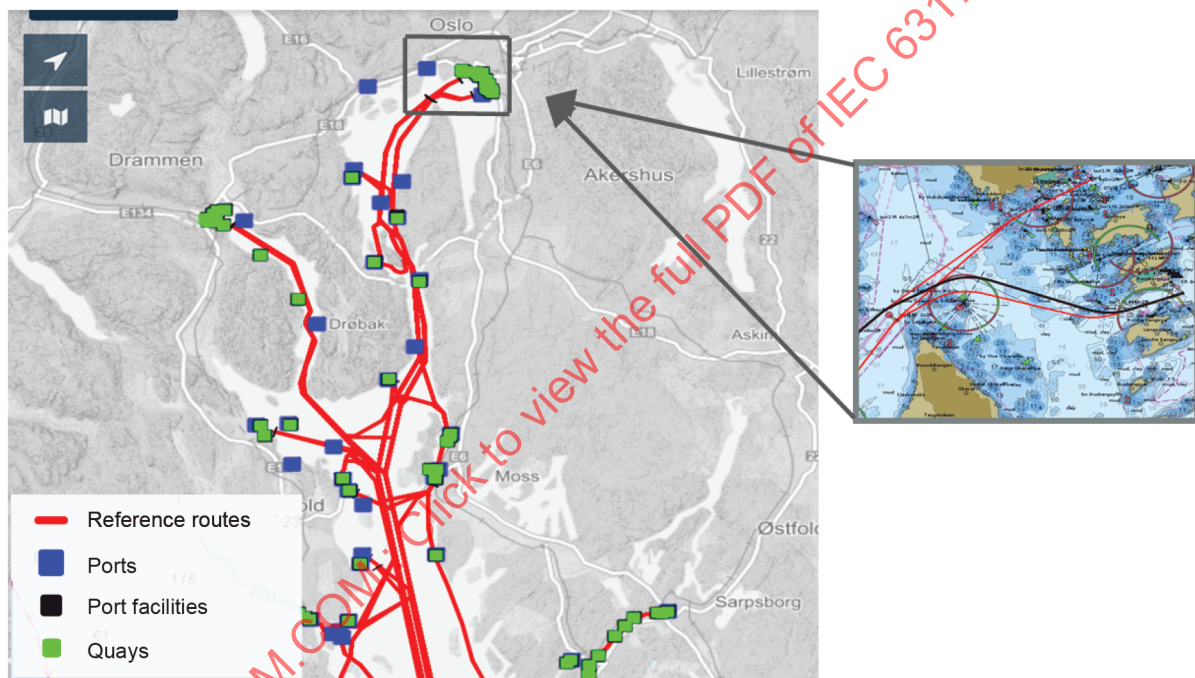
Reference routes may include the speed limitation as given by regulation (routeWaypointLegSOGMin and routeWaypointLegSOGMax).

Reference route services can offer routes which are based on other reference routes. For example, an outbound route from Stockholm to the open sea plus an open sea route Sweden – Norway, and finally an inbound route to Oslo. The routeInfoDescription is used to explain the origin of the route.

This use case involves both ship and shore.

- 1) Ship, where crew members or agents handling on their behalf by giving destinations, can ask for reference routes for all or part of a given voyage. Reference routes can also facilitate information exchange between navigators and pilots (ECDIS – portable pilot unit, PPU), as a common reference.
- 2) Shore center, which based on different information recommends a route for a given period and for a specified type of vessel. Ship type/cargo type limitations shall be given in the specific attributes or otherwise in routeInfoDescription.

Figure A.34 illustrates an example of an interface for navigators to call for a reference route (and route information not specified in S-421).



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Figure A.34 – Example of reference routes

One principle for this service is that the ship master has the final say in the matter of finalizing the route, and can override any parts of the route provided from the shore service.

A.11.2 Information exchange diagram

A reference route has a unique RouteID and RouteEditionNo set by the publisher of the route.

The ship can either start planning the route from scratch or select/receive a reference route from a service provider. In both cases, a new routeID and routeEditionNo is assigned to the planned route if modified from its original version. A planned route can be used more than once by a ship and become a common reference route managed by the company or the national authority. If a ship wants to indicate that the origin of a planned route is a particular reference route, this shall be written into routeInfoDescription (for example "route ### used as basis in route planning").

Further utilization and exchange of the route plan shall follow general guidance in this document, and the other use cases chosen to be implemented (Clause A.2 to Clause A.12).

A ship can request a reference route by providing an initial route, routeInfoStatus = Initial (Figure A.35), by including a destination. Destinations can be given by a name, a given location code or position in the attribute routeInfoArrivalPortID1 and routeInfoArrivalPortID2. Departure location given in the attribute routeInfoDeparturePortID1 and routeInfoDeparturePortID2 can also be provided in the request to allow the shore center to determine the best recommended reference route. To support a voyage with additional stops, this can be done by requesting reference routes for each part of the voyage (from A to B, from B to C, from C to D and so on).

A reference route provided from the shore shall always have a routeInfoStatus set to "1" (Initial) as the route should be recognized as the start of the route planning process. The service can provide updates of a reference route by offering a new route with the same RouteID, with routeInfoStatus "1" and with a higher routeEditionNo than the previous one. By publishing a reference route with a higher RouteEditionNo holding a not valid period, the reference route can be made inactive (routeInfoValidityStart/routeInfoValidityEnd). The vessel asking for update of reference routes will then recognize the route as inactive.

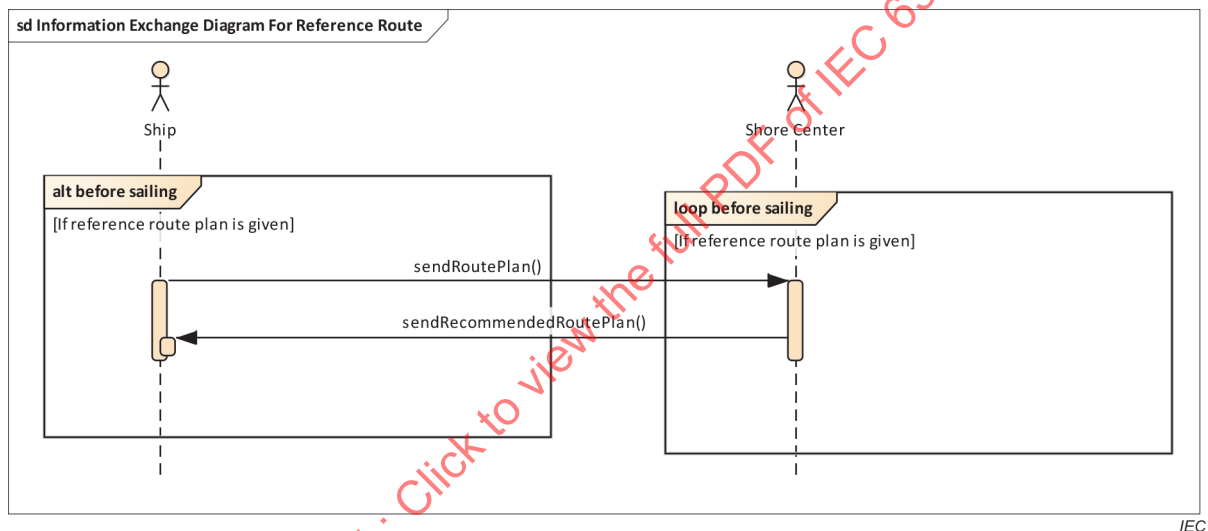


Figure A.35 – Data interaction diagram

A reference route is requested by providing the destination in the attribute routeInfoArrivalPortID1 and routeInfoArrivalPortID2, and eventually the departure location in the attribute routeInfoDeparturePortID1 and routeInfoDeparturePortID2. Destination and departure location shall be included in the initial route, holding two or more waypoints, to request a reference route.

A.11.3 State transition diagram

State transition diagrams are given in Figure A.36 and Figure A.37.

The states and transitions on ship side are as follows.

- Sent Initial Route: This state is the start of this service. The route plan including all fields is sent from the ship to shore.
- Received reference route: The ship has received a reference route from shore side.
- Route Planned: The ship has used a reference route to support the route planning.

The states and transitions on shore side are as follows.

- Waiting: This state is as the service is ready to provide reference routes.
- Received Initial Route: The shore has received an initial route from ship as a request for a reference route.
- Sent Reference Route: The shore has sent a reference route to support the route planning.

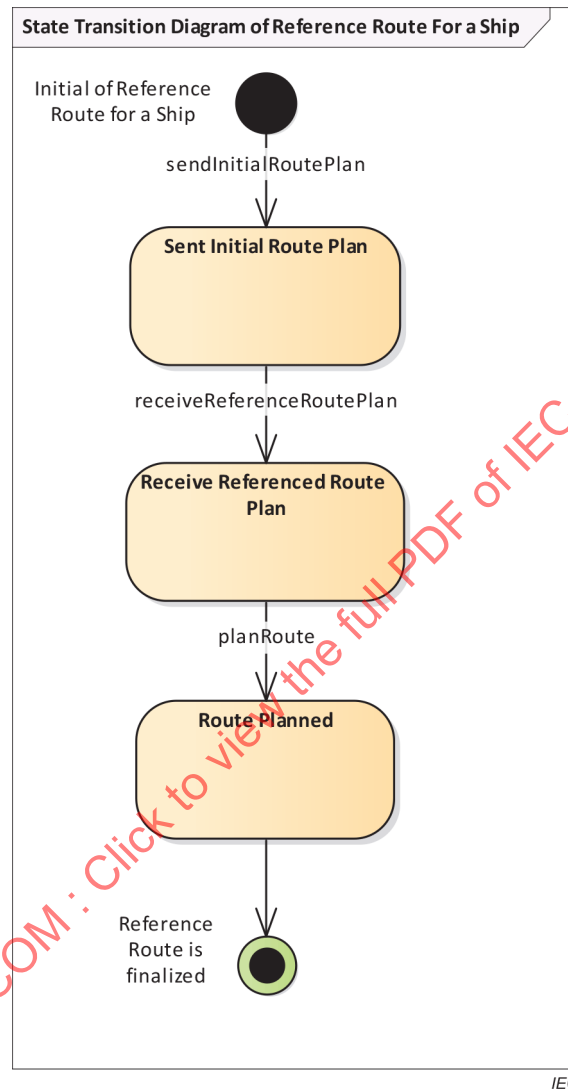


Figure A.36 – State transition diagram for a ship requesting a reference route

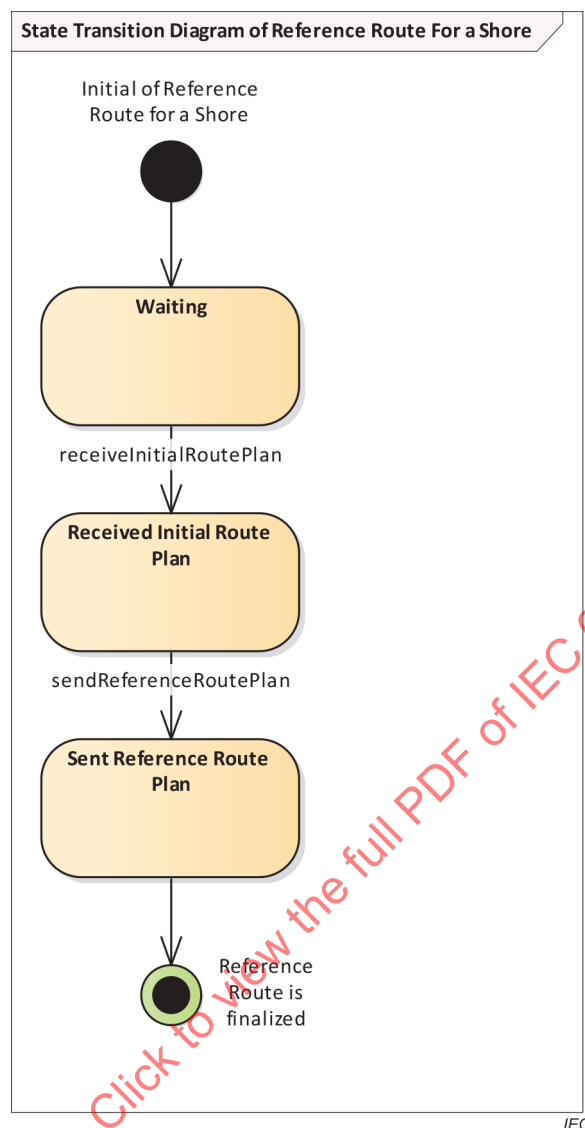


Figure A.37 – State transition diagram for a shore center providing a reference route

A.11.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes of Table A.19 are used and have a special meaning in this profile.

Table A.19 – Objects and attributes used by reference route

Object name	Attribute name	Description of use	Comment
Route	RouteID	A reference route will be found unique by the combination of RouteID and RouteEditionNo in the RouteInfo object. routeInfoStatus will always be 1. The publisher of a reference route can publish an update by increasing the RouteEditionNo. The active version should always have the highest RouteEditionNo. When a reference route is utilized for a specific voyage, the routeInfoStatus > 1, and then the route plan can be edited	From ship (mandatory) To ship (mandatory)
	RouteEditionNo	This number is increased by one whenever the route information has changed	From ship (mandatory) To ship (mandatory)
RouteInfo	routeInfoName	Most important information for the navigator may be included in routeInfoName. For example, inbound vs outbound, name of destination and eventually main fairway used, and specific size limitations for route. Publisher of route may also be included Example of value: "Oslo East – Hollenderbaaen Inbound"	From ship (mandatory) To ship (mandatory)
	routeInfoAuthor	Example of value: "Norwegian Coastal Administration"	From ship (optional) To ship (mandatory)
	routeInfoEditionTime	Time for this edition of route plan is edited	From ship (mandatory) To ship (mandatory)

Object name	Attribute name	Description of use	Comment
	routeInfoDescription	Description of the purpose of the reference route. For a planned route exchanged from a vessel which has been based on a reference route, the original ID can be referred to here (relevant for example in the route cross check scenario (Clause A.1). The belonging EditionNo of the Source reference route. More than one route can be referred to. Example of value: See information on the service site before use of this reference route in passage planning. Reference routes from NCA can be used as a basis in passage planning. Limitations in size of vessel, shiptype and cargo can differ along the route. Vessel size 150 m length (LOA) and 9 m draught has been used to quality assure the route.	From ship (optional) To ship (mandatory)
	routeInfoStatus	Always 1 (status initial) when the shore sends a reference route. When a reference route is utilized for a specific voyage, the routeInfoStatus > 1, before the route plan is edited.	From ship (mandatory) To ship (mandatory)
	routeInfoValidityStart	Example of value: "2019-12-31T02:00:00+02:00"	From ship (optional) To ship (mandatory)
	routeInfoValidityEnd	Example of value: "2021-06-31T02:00:00+02:00"	From ship (optional) To ship (mandatory)
	routeInfoDeparturePortID1	Example of value: "SESTO"	From ship (optional) To ship (optional)
	routeInfoDeparturePortID2	Example of value: "Stockholm"	From ship (optional) To ship (optional)
	routeInfoArrivalPortID1	Example of value: "NOOSL"	From ship (optional) To ship (optional)
	routeInfoArrivalPortID2	Example of value: "Oslo East"	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteActionPoint	routeInfoDraftMax	Maximum draft of the route	From ship (N/A) To ship (optional)
	routeInfoAirDraftMax	Maximum air draft of the route	From ship (N/A) To ship (optional)
	routeInfoBeamMax	Maximum vessel beam of the route	From ship (N/A) To ship (optional)
	routeInfoLengthMax	Maximum vessel length of the route	From ship (N/A) To ship (optional)
	routeActionPointID	Identifier of the action point. The identifier shall be unique in the route	From ship (optional) To ship (optional)
	routeActionPointName	Example of value: "Reporting point – VHF-19"	From ship (optional) To ship (optional)
	routeActionPointExternalReference	Example of value: "National Maritime Traffic Regulation"	From ship (optional) To ship (optional)
	geometry	Geographical position of the action point in degrees	From ship (optional) To ship (optional)
	routeActionPointRadius	Radius used to show a specific area in the chart interface. Example of value: "0"	From ship (optional) To ship (optional)
	routeActionPointTimeToAct	Time before or after the action point. Example of value: "-60" (Report 1 h ahead)	From ship (optional) To ship (optional)
	routeActionPointRequiredAction	Example of value: "2" (Report from vessel to shore)	From ship (optional) To ship (optional)
	routeActionPointRequiredActionDescription	Example of value: "permit to enter VTS service area must be acquired"	From ship (optional) To ship (optional)

Object name	Attribute name	Description of use	Comment
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeWaypointID	Reference number for the given waypoint	From ship (mandatory) To ship (mandatory)
	geometry	The route from the shore includes the reference route waypoint positions.	From ship (mandatory) To ship (mandatory)
	routeWaypointTurnRadius	Turn radius in nautical miles	From ship (mandatory) To ship (mandatory)
RouteWaypointLeg	routeWaypointLegStarboardXTDL	Starboard cross track distance limit	From ship (optional) To ship (optional)
	routeWaypointLegStarboardCL	Starboard cross track distance check limit	From ship (optional) To ship (optional)
	routeWaypointLegPortXTDL	Port cross track distance limit	From ship (optional) To ship (optional)
	routeWaypointLegPortCL	Port cross track distance check limit	From ship (optional) To ship (optional)
	routeWaypointLegGeometryType	Geometry type of leg	From ship (optional) To ship (mandatory)
	routeWaypointLegDraftMax	Maximum draft of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegAirDraftMax	Maximum air draft of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegBeamMax	Maximum vessel beam of the route waypoint leg	From ship (N/A) To ship (optional)
	routeWaypointLegLengthMax	Maximum vessel length of the route waypoint leg	From ship (N/A) To ship (optional)

A.11.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.19.

The test data for this scenario shall be prepared from the full generic test data according to Table A.20.

Table A.20 – Test procedures for reference route

Step	Applicable for onboard EUT	Applicable for shore EUT
Reference route without RouteActionPoint		
1	Use the EUT and create a route of 5 waypoints, which contains at least all minimum elements of a route from Table A.19 to request a reference route. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.19 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.19, if available, are correctly encoded in the exported route.	Use a simulator or test arrangements as the source to import a route with all mandatory elements from Table A.19 and confirm by observation that the route imports without error and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document. Use a simulator or test arrangements as the source to import a route with some missing mandatory elements from Table A.19 and confirm by observation that the route imports with an indication about incomplete route and that all parts of the route are correctly available for viewing by the EUT and that the presentation of route information is as specified in this document.
2	Confirm by observation that, when a route with RouteInfoStatus = Initial is imported correctly, the user is able to read routeInfoDescription and that the route can be used for further route planning.	Confirm by observation that, based on an imported route, it is possible to respond with a reference route (RouteInfoStatus = Initial) which includes all mandatory elements of a route from Table A.19, and then export the route. Use a tool to view the content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.19.
	Confirm by observation that, when a route with RouteInfoStatus = Initial including a RouteActionPoint is imported correctly, the user is able to read all attributes for the RouteActionPoint, and then export a route with RouteInfoStatus = Planned.	Confirm by observation that, based on an imported route, it is possible to respond with a reference route (RouteInfoStatus = Initial) which includes all mandatory elements of a route from Table A.19, and a RouteActionPoint. Then export the route. Use a tool to view content of the route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.19.
	Confirm by observation that, when a route with RouteInfoStatus = Incomplete is imported, the user is informed about the incomplete status. Based on user decision, the imported route may be subject to editing or the process may terminate. If a new or edited route is exported, continue from step 1.	Use a simulator or test arrangements to generate a route which is missing some mandatory attributes in Table A.19. Import the route to the EUT. Confirm by observation that the route is exported with RouteInfoStatus = Incomplete. Use a tool to view the content of the exported route and confirm by observation that all elements are available and correctly encoded in the exported route as specified in Table A.19.

Step	Applicable for onboard EUT	Applicable for shore EUT
	Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to user.	Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.19.

A.12 Search and rescue

A.12.1 Description

This use case describes the usage of S-421 in search and rescue (SAR) where a rescue unit receives a search pattern in S-421 format.

The use case involves the following actors:

- 1) MRCC (maritime rescue coordination center);
- 2) ship (rescue unit).

The MRCC creates a search pattern for a rescue unit. The MRCC sends the search pattern in S-421 format to the rescue unit. A search pattern is a route representing the specific pattern planned by the MRCC. The search pattern normally has no schedule, and the route is not intended to be a complete route plan for the rescue unit.

The rescue unit receives the search pattern from the MRCC (see Figure A.38). The rescue unit may confirm by sending an S-421 with "routeInfoStatus=acknowledged". The rescue unit may also complement the route with correct radiuses, drafts and other data according to its onboard processes and return it as monitored route. The monitored route may also contain a schedule with times on waypoints as information back to the MRCC. Alternatively, the rescue unit may reply with S-421 "routeInfoStatus = routeIssues" with explanation in routeInfoDescription.



Figure A.38 – A search and rescue example

The sequence diagram given in Figure A.39 describes a nominal sequence of information exchange for a SAR event.

- 1) The MRCC sends a search pattern as an initial route to the rescue unit.
- 2) The rescue unit receives the route and sends an acknowledged route if the route is confirmed
- 3) The rescue unit sends a monitored route including the search pattern and schedule.
- 4) Finally, the rescue unit sends a terminated route after it stops the search.



Figure A.39 – Interaction diagram

A.12.3 State transition diagram

System on ship side requires the following sending and receiving functions as shown in Figure A.40.

- Waiting: System onboard the rescue unit is ready for search pattern.
- Planned route according to received Search Pattern: The rescue unit receives a search pattern as an initial route. The rescue unit plans the route to the search area and includes the search pattern in the route plan.
- Confirmed search pattern: The rescue unit may send confirmation on the route as operational acceptance with "routeInfoStatus=Acknowledged".
- Activated monitored route plan: The rescue unit may send the monitored route including the search pattern and schedule back to MRCC.

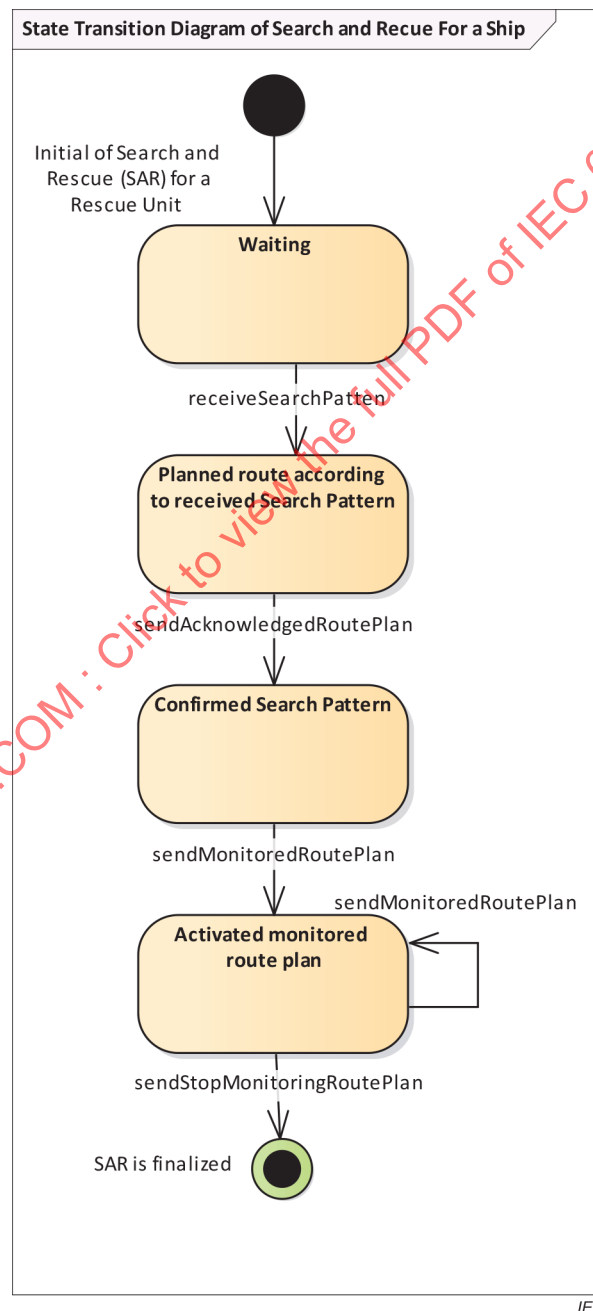


Figure A.40 – State transition diagram for a ship

The system on the shore side requires the following sending and receiving functions as shown in Figure A.41.

- Planning: MRCC plans and sends the search pattern to the assigned rescue unit.
- Acknowledged Route Plan: MRCC receives the operational acceptance with "routeInfoStatus=Acknowledged".
- Monitored Route Plan: MRCC receives the monitored route including the search pattern and schedule from the rescue unit.

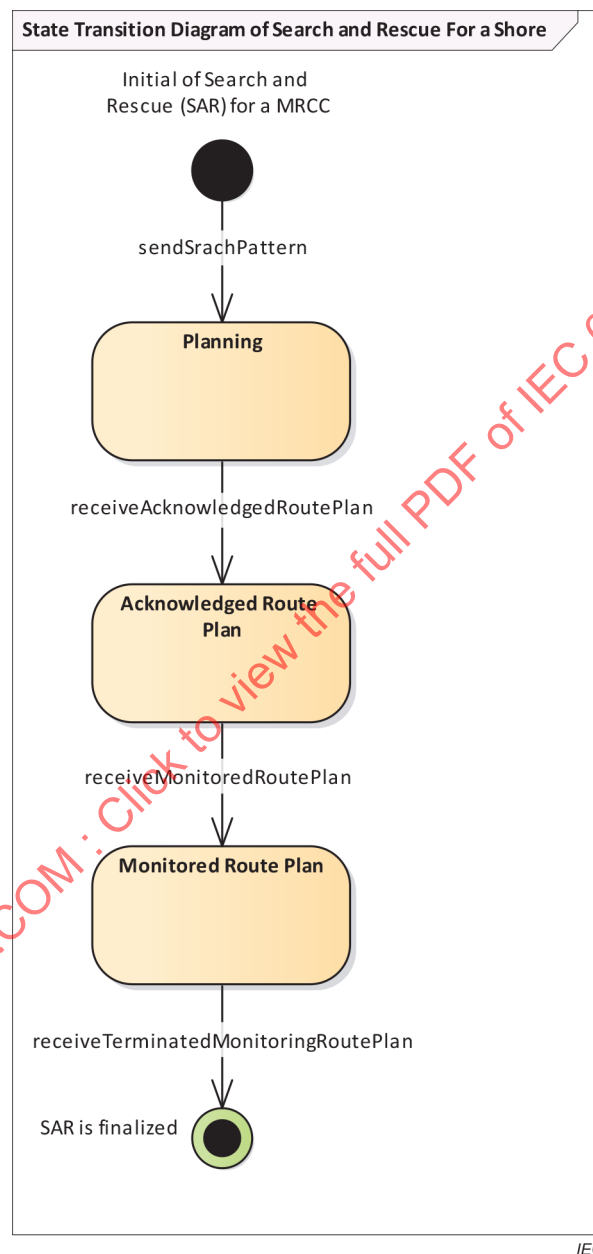


Figure A.41 – State transition diagram for shore

A.12.4 Required objects and attributes and their usage

In addition to data attributes defined as mandatory in this document, the objects and attributes given in Table A.21 are used and have a special meaning in this profile.

Table A.21 – Objects and attributes used by Search and Rescue

Object name	Attribute name	Description of use	Comment
Route	routeID	Identity of the specific route (search pattern). Required and mandatory to implement	To ship (mandatory) From ship (mandatory)
	routeEditionNo	Edition of the specific route from A to B Required and mandatory to implement	To ship (mandatory) From ship (mandatory)
RouteInfo	routeAuthor	Traceability Required in recommended route to ship	To ship (optional) From ship (optional)
	routeInfoEditionTime	Update time for the edition Required in recommended route to ship	To ship (mandatory) From ship (mandatory)
	routeInfoStatus	The search pattern to ship is a recommendation, hence status = 3 (recommended)	To ship (mandatory) From ship (mandatory)
	routeInfoDescription	More information given related to the status and edition of the route Not required, but mandatory to implement	To ship (optional) From ship (optional)
	routeInfoVesselMMSI	Ship identification To facilitate shore-based monitoring using AIS data Required and mandatory	To ship (optional) From ship (mandatory)
RouteWaypoint (optional for RouteInfoStatus values: Acknowledged, Terminated, Error, Service started and Service ended; mandatory for other values of RouteInfoStatus)	routeInfoVesselName	Ship identification Not required, but mandatory to implement	To ship (optional) From ship (optional)
	routeWaypointID	Required and mandatory even if no schedule is provided	To ship (mandatory) From ship (mandatory)
	geometry	Required and mandatory	To ship (mandatory) From ship (mandatory)
RouteScheduleCalculated.RouteScheduleElement	routeWaypointId	Link schedule element to one waypoint	From ship (optional)
	routeScheduleElementETA	Calculated estimation of time of arrival to WP	From ship (optional)

A.12.5 Test methods and expected results

Each typical and invalid route plan from shore to ship (GML-encoded XML file) and ship to shore (GML-encoded XML file) are available for the test based on Table A.21.

The test data for this scenario shall be prepared from the full generic test data according to Table A.22.

Table A.22 – Test procedures for Search and Rescue

Step	Applicable for onboard EUT	Applicable for shore EUT
SAR Search Pattern		
1	Confirm by observation that when a route with a search pattern and RouteInfoStatus = Initial is imported it is processed correctly. Confirm by observation that a search pattern is imported and processed correctly with RouteInfoStatus = Initial	Use the EUT and create a route with RouteInfoStatus = Initial and search pattern with minimum 5 waypoints, and containing at least all minimum elements of a route from Table A.21. Export the route. Use a tool to view the content of the exported route and confirm by observation that all mandatory elements from Table A.21 are available and correctly encoded in the exported route. Confirm by observation that optional elements from Table A.21, if available, are correctly encoded in the exported route.
2	Confirm by observation that an acknowledged search pattern is exported and processed correctly, with RouteInfoStatus = Acknowledged. Use a simulator or test arrangements to generate a route which does not pass schema validation or application level context check. Import the route to the EUT and confirm by observation that the route import terminates with an indication about invalid content of the route. If the EUT is able to respond to the sender, confirm by observation that the route is exported from the EUT with RouteInfoStatus = Error while information about deleted attributes not passing schema validation or application level context check are included in RouteInfoDescription. Use a tool to view the content of the exported route and confirm by observation that the available elements are correctly encoded in the exported route as specified in Table A.21.	Confirm by observation that an acknowledged search pattern is imported and processed correctly with the RouteInfoStatus = Acknowledged. Confirm by observation that an attempt to import a route with RouteInfoStatus = Error is indicated to the user.

A.13 Summary of objects and attributes used by service scenarios

Table A.23 summarizes the required objects and attributes which are used only for operational perspectives in each service scenario. This table does not consider the required objects and attributes by the schema. For example, routeFormatVersion is required by the schema but is not required by any service scenario. So it is marked as "N/A" for all services in the table. EP indicates Export from the ship, IP indicates Import to the ship, M indicates Mandatory, O indicates Optional.

Table A.23 – Objects and attributes used by service scenarios as seen from the ship

Object name	Attribute name	Service scenario																					
		Route cross check		Flow manage ment		Enhanc- ed monitor- ing		Ice naviga- tion		UKCM		Fleet route planning		Chart manage- ment		Route optima- zation		Port call synchro- nization		Referen- ce routes		SAR	
		EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP
Route	routeFormatVersion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	routeID	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
	routeEditionNo	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
	routeExtensions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RouteInfo	routeInfoName	M	M	N/A	N/A	M	M	N/A	N/A	M	M	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M	M	N/A	N/A
	routeInfoAuthor	O	M	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	O	N/A	N/A	N/A	N/A	N/A	N/A	O	M	O	O
	routeInfoEditionTime	M	M	M	M	M	M	N/A	N/A	N/A	N/A	M	M	N/A	N/A	M	M	M	M	M	M	M	
	routeInfoDescription	O	O	O	O	O	O	O	M	N/A	N/A	O	O	N/A	N/A	O	M	M	M	O	M	O	O
	routeInfoStatus	M	M	M	M	M	M	M	M	N/A	N/A	M	M	N/A	N/A	M	M	M	M	M	M	M	
	routeInfoValidityStart	O	O	O	O	N/A	N/A	N/A	O	N/A	M	N/A	O	N/A	N/A	N/A	N/A	N/A	O	M	N/A	N/A	
	routeInfoValidityEnd	O	O	O	O	N/A	N/A	N/A	O	N/A	M	N/A	O	N/A	N/A	N/A	N/A	N/A	O	M	N/A	N/A	
	routeInfoDeparturePortI D1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M	N/A	N/A	M	O	N/A	N/A	O	N/A	O	O	O	N/A	N/A	
	routeInfoDeparturePortI D2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	O	N/A	N/A	O	N/A	O	O	O	N/A	N/A	
	routeInfoDeparturePort Call	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	O	N/A	N/A	N/A	N/A

[illegible]

[illegible]

Object name	Service scenario																						
	Route cross check		Flow manage ment		Enhanc- ed monitor- ing		Ice naviga- tion		UKCM		Fleet route planning		Chart manage- ment		Route optima- zation		Port call synchro- nization		Referen- ce routes		SAR		
RouteWay pointLeg		EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP
		M	O	O	O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A		
		M	O	O	O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A		
		O	O	N/A	N/A	O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A		
		O	O	N/A	N/A	O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A		
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
		M	M	M	M	M	M	M	M	M	N/A	N/A	N/A	N/A	N/A	M	N/A	N/A	O	N/A	N/A		
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
		O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
		M	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M	N/A	N/A	N/A	N/A	N/A		
		O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
		O	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A		
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			

[illegible]

[illegible]

Object name	Attribute name	Service scenario																							
		Route cross check		Flow manage ment		Enhanced monitor-ing		Ice naviga-tion		UKCM		Fleet route planning		Chart manage-ment		Route opti-miza-tion		Port call synchro-nization		Referen-ce routes		SAR			
		EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP	EP	IP		
RouteScheduleRecommended/RouteScheduleElement	routeWaypointID	N/A	M	N/A	M	N/A	N/A	N/A	N/A	N/A	M	N/A	M	N/A	M	N/A	M	N/A	M	N/A	N/A	N/A	N/A		
	routeScheduleElementPlanSOG	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementETD	N/A	O	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementETA	N/A	M	N/A	M	N/A	N/A	N/A	N/A	N/A	M	N/A	N/A	N/A	M	N/A	N/A	N/A	M	N/A	N/A	N/A			
	routeScheduleElementETDWindowBefore	N/A	O	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementETDWindowAfter	N/A	O	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementETAWindowBefore	N/A	O	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementETAWindowAfter	N/A	O	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementNote	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
	routeScheduleElementExtensions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
Key																									
EP: Export from the ship																									
IP: Import to the ship																									
M: Mandatory																									
O: Optional																									
N/A: Not applicable																									

Annex B (normative)

Data classification and encoding guide

B.1 General

B.1.1 Overview

This S-421 data classification and encoding guide (DCEG) contains rules and guidance for converting data describing the real world into data products that conform to the S-421 specification.

The S-421 specification contains an application schema (UML model) describing the conceptual domain model in terms of classes and relationships, and a feature catalogue of S-421 that specifies the data model, i.e. specifies the data model types and associations corresponding to the various classes and relationships in the application schema.

To simplify the DCEG text, the various data model types are provided without the suffixes "class", "type" or "instance"; for example the term "feature" should be understood as "feature class" or "feature type" or "feature instance" as best fits the immediate context in which it is used (and where there might be confusion, it is written out in full as feature class/type/instance). The model defines real world entities as a combination of descriptive and spatial characteristics (see 5.4).

The features, information types, associations and attributes appear in **bold text**.

B.1.2 Descriptive characteristics

B.1.2.1 Feature type

B.1.2.1.1 General

A feature contains descriptive attributes that characterize real world entities.

The word "feature" as used in the ISO 191xx family of standards and in S-100 based product specifications has two distinct but related senses – "feature type" and "feature instance". A feature instance is a single occurrence of the feature and is represented as an object in a dataset.

The location of a feature instance on the Earth's surface is indicated by a relationship to one or more spatial primitive instances. A feature instance may exist without referencing a spatial primitive instance.

B.1.2.1.2 Geographic feature class

Geographic (Geo) feature types carry the descriptive characteristics of a real world entity which is provided by a spatial primitive instance.

B.1.2.1.3 Meta feature class

Meta feature type contains information about other features.

B.1.2.1.4 Charted background feature

This product would mostly be visualized as an overlay of an ENC or other GIS applications. Consequently, all necessary descriptive and spatial characteristics to provide a charted background should be provided by the underlying application.

B.1.2.2 Information type

An information type has no geometry and therefore is not associated to any spatial primitives to indicate its location.

An information type may have attributes and can be associated with features or other information types in order to carry information particular to these associated features or information types.

B.1.3 Spatial characteristics

B.1.3.1 Spatial primitives

The allowable spatial primitive for each feature is defined in the feature catalogue. Allowable spatial primitives are point, curve and surface for S-421.

Within this document, allowable spatial primitives are included in the description of each feature. For easy reference, Table B.1 summarises the allowable spatial primitives for each feature.

Table B.1 – Feature types

Feature types	Spatial primitives			
	P	C	S	N
Route				v
RouteActionPoints				v
RouteActionPoint	v	v	v	
RouteWaypoints				v
RouteWaypoint	v			
RouteWaypointLeg				v
Key P: point C: curve S: surface N: none v: allowable spatial primitive				

B.1.3.2 Capture density guideline

The route capture density of S-421 will follow the recommendation of the S-101 (ENC) DCEG that states curves and surface boundaries should not be encoded at a point density greater than 0,3 mm at permitted display scale. A curve consists of one or more curve segments. Each curve segment is defined as a loxodromic line on WGS84, or as an arc or circle. Long lines may need to have additional coordinates inserted to cater for the effects of projection change. The presentation of line styles may be affected by curve length. Therefore, the encoder should be aware that splitting a curve into numerous small curves may result in poor symbolization.

B.2 Attributes

B.2.1 General

Attributes may be simple type or complex type. Complex (C) attributes are aggregates of other attributes that can be simple type or complex type attributes. Simple (S) attributes are assigned to one of the types collected at 7.6.2.

The binding of attributes to a feature, the binding of attributes to attributes to construct complex attributes, and attribute multiplicity are all defined in the feature catalogue.

Within this document, the allowable attributes are included in the description of each feature, as well as the allowable values for enumeration type attributes.

B.2.2 Simple attribute types with acronym

The data definition of simple type shall provide the acronym for DCEG (see Table B.2).

Table B.2 – Simple attribute types

Acronym	Type	Definition
EN	Enumeration	A fixed list of valid identifiers of named literal values
BO	Boolean	A value representing binary logic. The value can be either True or False. The default state for Boolean type attributes (i.e. where the attribute is not populated for the feature) is False.
RE	Real	A signed Real (floating point) number consisting of a mantissa and an exponent
IN	Integer	A signed integer number. The representation of an integer is encapsulation and usage dependent.
TE	CharacterString	An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets
DA	Date	A date provides values for year, month and day according to the Gregorian Calendar. Character encoding of a date is a string which follows the calendar date format. EXAMPLE 19980918 (YYYYMMDD)
TI	Time	A time is given by an hour, minute and second in the 24-hour clock system. Character encoding of a time shall be a complete representation of the basic format. Complete representation means that hours, minutes and seconds shall be used. Basic format means that separating characters are omitted. Time is preferably expressed as Universal Time Coordinated (UTC). EXAMPLE 183059Z Time may be expressed as a Local Time with a given offset to UTC. EXAMPLE 183059+0100 Time may be expressed as a Local Time without a specified offset to UTC. EXAMPLE 183059 The complete representation of the time of 27 minutes and 46 seconds past 15 hours locally in Geneva (in winter one hour ahead of UTC), and in New York (in winter five hours behind UTC), together with the indication of the difference between the time scale of local time and UTC, are used as examples. Geneva: 152746+0100 New York: 152746-0500 The service hours for a service, that is available all year in an area where Daylight Saving Hour affects the offset to UTC could be expressed as Local Time without specified offset. Opening: 074500 Closing: 161500
DT	DateTime	A DateTime is a combination of a date and a time type. EXAMPLE: 19850412T101530

B.2.3 Mandatory attributes by schema

Some attributes are mandatory and are required to be populated for a given feature. There are some reasons why attribute values may be considered mandatory:

- they are fundamental to the definition of a feature;
- they are required to support the correct portrayal of a feature instance;
- certain features make no logical sense without specific attributes.

Within this document, mandatory attributes are those with a multiplicity of 1,1 or 1, n ($n > 1$) or 1,* . The attribute multiplicity is identified in the description of each feature class (see Table B.3).

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Table B.3 – Mandatory attribute types

Feature types		
Feature	Mandatory attributes	Mandatory attributes in implementation
Route	routeFormatVersion routeID routeEditionNo	routeFormatVersion routeID routeEditionNo
RouteActionPoints	None	None
RouteActionPoint	geometry routeActionPointID routeActionPointRequiredAction routeActionPointRequiredActionDescription	geometry routeActionPointID routeActionPointRadius routeActionPointTimeToAct routeActionPointRequiredAction routeActionPointRequiredActionDescription
RouteWaypoints	None	None
RouteWaypoint	geometry routeWaypointID routeWaypointTurnRadius	geometry routeWaypointID routeWaypointName routeWaypointFixed routeWaypointTurnRadius
RouteWaypointLeg	routeWaypointLegGeometryType	routeWaypointLegGeometryType
Information types		
Information	Mandatory attributes	Mandatory attributes in implementation
RouteInfo	routeInfoName routeInfoStatus	routeInfoName routeInfoAuthor routeInfoEditionTime routeInfoDescription routeInfoStatus routeInfoValidityStart routeInfoValidityEnd routeInfoVesselMMSI
RouteSchedules	None	None
RouteSchedule	routeScheduleID	routeScheduleID
RouteScheduleManual	None	None
RouteScheduleCalculated	None	None
RouteScheduleRecommended	None	None
RouteScheduleElement	routeWaypointID	routeWaypointID routeScheduleElementPlanSOG routeScheduleElementETD routeScheduleElementETA

B.2.4 Missing attribute values

Mandatory attributes required by schema in an S-421 dataset are not permitted to contain a null value. All mandatory attributes shall contain meaningful data.

Where the value of a non-mandatory attribute is not known, the attribute shall not be used.

B.2.5 Multiplicity

In order to control the number of allowed attribute values or sub-attribute instances within a complex attribute, S-100 uses the concept of multiplicity. This defines lower and upper limits for the number of values, whether the order of the instances is significant and if an attribute is mandatory (see Table B.4).

Table B.4 – Multiplicity

Multiplicity	Description
0,1 or 0..1	An instance is not required; if provided there shall only be one instance.
1,1 or 1..1	An instance is required and there shall only be one instance.
0,* or 0..* or 0..1	An instance is not required and there can be an infinite number of instances.
1,* or 1..*	An instance is required and there can be an infinite number of instances.
1,* (ordered)	An instance is required and there can be an infinite number of instances, the order of which is significant.
2,2 or 2..2	Two instances are required and there shall be no more than two.

B.2.6 Spatial attribute types

Spatial attribute types shall contain a referenced geometry and may be associated with spatial quality attributes. Each spatial attribute instance shall be referenced by a feature instance or another spatial attribute instance.

B.2.7 Textual information

Textual information may provide additional information essential to understand the presence and other features of an S-421 product.

Complex attribute information defines a language sub-attribute for specifying the language in which the text or referenced file is encoded.

The exchange language for textual information should be English; therefore, it is not required to populate the sub-attribute language for an English version of textual information.

Languages other than English may be used as a supplementary option, for which language shall be populated with an appropriate value to indicate the language.

When a national language is used in the textual attributes, the English translation shall also exist.

B.2.8 Attributes referencing external files

B.2.8.1 Predefined derived types

Complex attribute information defines a language sub-attribute for specifying the language in which the text or referenced file is encoded (see Table B.5).

Table B.5 – Predefined derived types

Name	Description	Derived form
URI	A uniform resource identifier whose character encoding follows the syntax rules as defined in RFC 3986. EXAMPLE http://registry.iho.int	CharacterString
URL	A uniform resource locator (URL) is a URI that provides a means of locating the resource by describing its primary access mechanism (RFC 3986). EXAMPLE http://registry.iho.int	URI
URN	A persistent, location-independent, resource identifier that follows the syntax and semantics for URNs specified in RFC 2141. EXAMPLE urn:iho:s101:1:0:0:AnchorageArea	URI

B.2.8.2 Reference to textual files

Files shall only use UTF-8 character encoding even when the sub-attribute **language** is populated with a language other than English.

If it is necessary to indicate a specific section within a large text file, this may be done by encoding the location in the **fileLocator** sub-attribute of **information**, as described in Table B.6.

Table B.6 – File format

Format	File extension	Content of fileLocator
Text	Text	The offset of the start of the section relative to the beginning of the file (the first character in the file has offset 0).
HTML	HTML	The HTML fragment identifier, i.e., the value of the HTML name or id attribute of the target (as defined in the relevant HTML specification).
XML	XML	The XML fragment identifier as defined in the relevant specification, for example, the value of an xml:id attribute.

B.2.9 Dates**B.2.9.1 General**

Dates may be complete or truncated values. The definition of the attribute will indicate if it shall take a complete value (type Date or DA) or is allowed to take a truncated value (type S100_TruncatedDate or TD). Complete and truncated dates are different value types (see S-100:2018, 1-4.5.2).

For attributes that use the complete date type (type Date or DA), all their components (year, month, and day) shall be specified.

For attributes that use the truncated date type (type S100_TruncatedDate or TD), zero, one, or two of the year/month/day components may be omitted. If the year component is included, it shall be specified using exactly 4 digits.

B.2.9.2 Complete dates (informative)

Complete date values shall be encoded in conformance with the Date format as specified in S-100:2018, 1-4.5.2) which is the same as the DA format in Table B.2. The data values have to be provided in accordance with the Gregorian calendar starting with four digits for the year, two digits for the month and two digits for the day.

Example: The date 18 September 2010 is encoded as follows:

In the ISO 8211 format: 20100918

In the GML format: <date>2010-09-18</date>

B.2.9.3 Truncated dates (informative)

In truncated dates one or more components (year, month, or day) of the date is not specified. Truncated date values shall be encoded in conformance with the S100_TruncatedDate format or equivalent as specified in S-100:2018, 1-4.5.2 and 3-9 (see Table B.7).

Table B.7 – Truncated dates

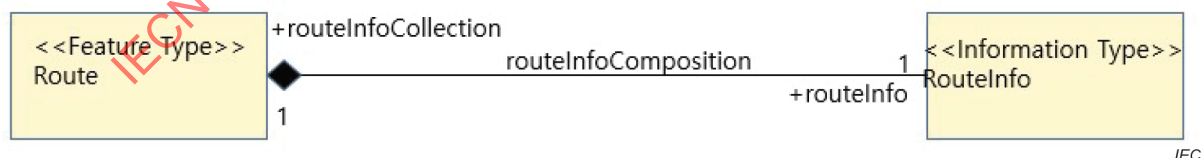
Description	ISO 8211	GML
No specific year, same day each year	– – – –MMDD	<gMonthDay>– –MM–DD</gMonthDay>
No specific year, same month each year	– – – –MM– –	<gMonth>– –MM</gMonth>
No specific day	YYYYMM– –	<gYearMonth>>YYYY–MM</gYearMonth>
Key YYYY = calendar year MM = month DD = day The dashes (–), indicating that the year, month or date is not specified, shall be included in the encoding (with no space between the dashes).		

B.3 Associations

B.3.1 General

An association expresses a relationship between two classes – features, information types, or a feature and an information type. Objects in the dataset (instances of feature/information types) are related only if the link between them is encoded in the dataset.

EXAMPLE A route feature type has the RouteInfo Information type. An association named routeInfoComposition is used to relate two classes; roles are used to convey the meaning of the relationship (see Figure B.1).



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Figure B.1 – Association routeInfoComposition

An association end may have a multiplicity which describes how many instances the feature or information type instance at the other end is allowed to link to. In Figure B.1, a single instance of RouteInfo links to the Route instance.

When this association is expressed in the XML schema, the object Route has an association link between the object Route and RouteInfo. But the object RouteInfo has no association link with the object Route.

B.3.2 Association names

The association name is normally provided by the UML diagram at the middle of the connection line/arrow between the two involved classes and can be obtained from the feature and information type tables provided in this document.

Association names may be omitted in the UML diagrams for the following reasons:

- a) the association is defined by an association class (the name of the association class is used);
- b) to avoid cluttering the diagram – however, the name is always documented in the feature/information type tables.

B.3.3 Association roles

Either or both association ends can have a name (role). In Figure B.1, the roles are routeInfoCollection and routeInfo. This association expresses the relationship that a Route shall have one RouteInfo, and a RouteInfo shall be contained in the Route.

Roles may be also omitted from the diagram to reduce clutter – again, the role name is documented in the feature/information type tables.

B.3.4 Use of various associations

In general, associations shall be encoded whenever the relationship is useful for navigation, monitoring, voyage or route planning, or reporting purposes, or any other purpose for which the dataset is intended. The multiplicity lower bound of "0" at an association end means only that the absence of a link to the relevant instance does not invalidate the dataset. The encoding instructions for individual feature and information types describe what associations are allowed and whether they are required or optional.

B.4 Datasets

A dataset is a grouping of features, attributes, geometry and metadata which comprises a specific coverage.

The types of route plan dataset in Table B.8 may be produced and contained within an exchange set.

Table B.8 – Dataset types

Dataset	Explanations
New dataset	Data for a route plan different (in coverage and/or extent) to existing datasets.
New edition of a dataset	A re-issue plus new information which has not been previously distributed by Updates. Each new edition of a dataset shall have the same name as the dataset that it replaces and should have the same spatial extents.

B.5 Metadata

B.5.1 General

The S-421 metadata description is based on the S-100 metadata document section, which is a profile of ISO 19115 (all parts). 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 document: dataset metadata and exchange set metadata (see Figure B.2).

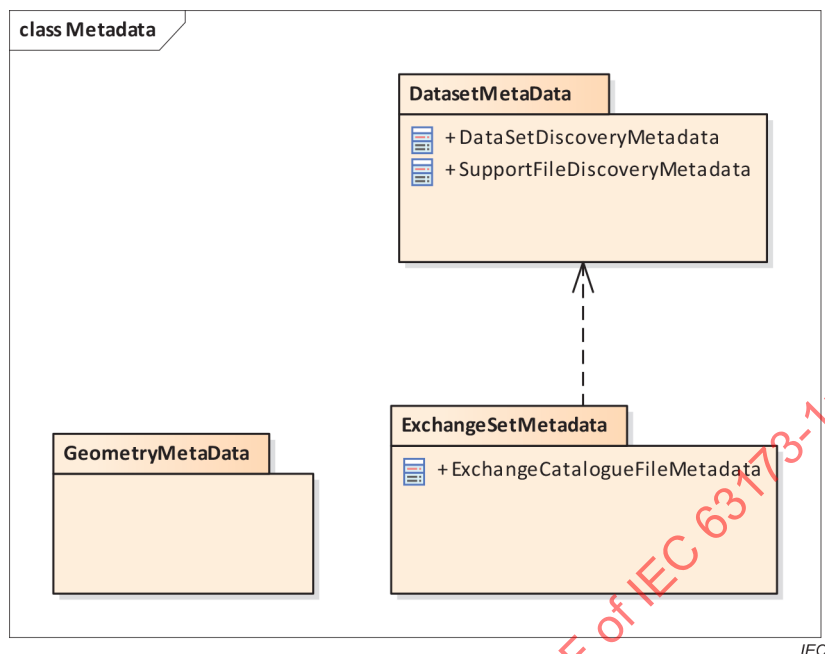


Figure B.2 – Metadata packages

NOTE 1 Types with CI_, EX_, and MD_ prefixes are from packages defined in ISO 19115 (all parts) 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 are blank.

B.5.2 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 (see Table B.9).

Table B.9 – Metadata for route plan

Name	Cardinality	Value	Type	Remarks
S421_DataSetDiscoveryMetadata				Extends S100_DataSetDiscoveryMetadata
S421_metadataFileIdentifier	1		CharacterString	Dataset file name with prefix "MD_" and suffix ".xml" or ".XML" instead of ".GML".
S421_metadataPointOfContact	1		CI_ResponsibleParty	Contact information for the data production authority
S421_metadataDateStamp	1		Date	When the dataset was created
S421_metadataLanguage	1..2		CharacterString	All dataset conforming to this document shall use English and optionally French
S100_DataSetDiscoveryMetadata Elements inherited by S-421_DatasetDiscoveryMetadata				
fileName	1		CharacterString	Dataset file name
filePath	1		CharacterString	Full path from the exchange set root directory
description	1		CharacterString	
dataProtection	0..1	{1} or {2}	CharacterString	1. Encrypted 2. Unencrypted
protectionScheme	0..1		CharacterString	For example S-63
digitalSignature	0..1		CharacterString	
digitalSignatureReference	0..1		CharacterString	
digitalSignatureValue	0..1		CharacterString	
copyright	0..1		MD_LegalConstraints >MD_RestrictionCode <copyright> (ISO 19115)	
classification	0..1		Class MD_SecurityConstraints>MD_ClassificationCode (codelist)	1. Unclassified 2. Restricted 3. Confidential 4. Secret 5. Top secret
purpose	1	{1}, {2}	CharacterString	1. New dataset 2. New dataset self-cancelling 3. New dataset with cancellation 4. New dataset with cancellation self-cancelling 5. In-force bulletin

Name	Cardinality	Value	Type	Remarks
specificUsage	1		MD_USAGE>specificUsage (character string) MD_USAGE>userContactInfo (CI_ResponsibleParty)	Brief description of the resource and/or resource series usage
editionNumber	1	{1}	Integer	When a dataset is initially created, the edition number "1" is assigned to it. The edition number is increased by one with each new edition.
updateNumber	1		Integer	Update number 0 is assigned to a new dataset
updateApplicationDate	1		Date	All updates dated on or before this date shall have been applied by the producer
issueDate	1		Date	Date on which the dataset was generated
productSpecification	1	S-421 version N.n	CharacterString	This shall be encoded as S421.N.n
producingAgency	1		CI_ResponsibleParty	Party responsible for generating the dataset.
horizontalDatumReference	1		CharacterString	EPSG
horizontalDatumValue	1		Integer	4326
horizontalDatum	1	(nulled)	S100_VerticalAndSoundingDat	(Should be nulled if possible – ignored by applications, not relevant to S-421)
verticalDatum	1	(nulled)	S100_VerticalAndSoundingDat	(Should be nulled if possible – ignored by applications, not relevant to S-421)
dataType	1	GML	CharacterString	
dataTypeVersion	1	3.2.1	CharacterString	
dataCoverage	1..*		S100_DataCoverage	
comment	0..1		CharacterString	Any additional information
layerID	0..*	S-101	CharacterString	Dataset shall be used with ENC in an ECDIS

B.5.3 Support file metadata

Support file metadata is intended to describe information about a data resource. It facilitates the management and exploitation of data and is an important requirement for understanding the characteristics of a data resource (see Table B.10).

Table B.10 – Support files for route plan

Name	Cardinality	Value	Type	Remarks
S100_SupportFileDiscoveryMetadata				
fileName	1		CharacterString	
fileLocation	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>
purpose	1		S100_SupportFilePurpose	New, replacement, or deletion
editionNumber	1		CharacterString	When a data set is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each new edition. Edition number remains the same for a re-issue
issueDate	1		Date	
supportFileSpecification	1		S100_SupportFileSpecification	
productSpecification	1		S100_ProductSpecification	
dataType	1		S100_SupportFileFormat	

B.5.4 Exchange set metadata

Frequently, datasets are packaged and distributed as composite exchange sets by third party vendors. An exchange set could contain many different types of datasets, sourced from different data producers. For example, an exchange set may contain numerous dataset files, ancillary data files, discovery metadata files and others. Exchange set metadata contains metadata about the contents of the exchange set and metadata about the data distributor.

B.5.5 Catalogue file metadata

All S-421 catalogue metadata files shall contain at least the metadata elements given in Table B.11.

Table B.11 – File metadata for route plan

Name	Cardinality	Value	Type	Remarks
S100_ExchangeCatalogue				
Identifier	1		S100_CatalogueIdentifier	
contact	1		S100_CataloguePointOfContact	
productSpecification	0..1		S100_ProductSpecification	
metadataLanguage	1..2	English, French	CharacterString	All datasets conforming to this document use English language. The catalogue file shall be in English with the optional addition of French
exchangeCatalogueName	1	CATALOG.421.XML		
exchangeCatalogueDescription	1			
exchangeCatalogueComment	0..1			
compressionFlag	0..1			
AlgorithmMethod	0..1			
sourceMedia	0..1			
replacedData	0..1			
dataReplacement	0..1			

B.6 Description of table format for feature and information formats

Table B.12 shows an example of the description of table format for feature and information formats for S-421 on how to encode data. Table formats for feature and information types for S-421 are listed in Clause B.7 and Clause B.8. Abstract types as well as non-abstract types are described. Abstract types are feature types and non-abstract types are information types.

Table B.12 – Example of table format for feature

IHO Definition: FEATURE: Definition. (Authority for definition).							
S-421[Geo Feature/Information Type]: Feature (S-57 Acronym) S-421 feature and corresponding S-57 acronym (if applicable)							
Primitives: Allowable geometric primitive(s) [Point, Curve, Surface]							
<i>Real World</i> Example if real world instance(s) of the Feature.		<i>Paper Chart Symbol</i> Example(s) of paper chart equivalent symbology for the Feature (if applicable).		<i>ECDIS Symbol</i> Example(s) of proposed ECDIS symbology for the Feature.			
S-421 Attribute	S-57 Acronym	Allowable encoding value	Type	Multiplicity			
Category of routeInfoStatus		1 : Initial 2 : Planned for route 3 : Recommended 4 : Acknowledged 5 : Used for monitoring 6 : Inactive 7 : Errors 8 : Incomplete 9 : Route issues	EN	1..1			
This section lists the allowable attributes for the S-101 feature. Attributes are listed in alphabetical order. Sub-attributes (Type prefix (S)) of complex (Type C) attributes are listed in alphabetical order and indented directly under the entry for the complex attribute (see below for example).	This section lists the corresponding S-57 attribute acronym. A blank cell indicates no corresponding S-57 acronym.	This section lists the allowable encoding values for S-101 (for enumerate (E) Type attributes only).	Attribute type (see Table B.2).	Multiplicity describes the "cardinality" of the attribute in regard to the feature. If "(ordered)" is included, the order of the instances matters			
Fixed date range			C	0,1			
Date end	(DATEND)		(S) DA	0,1			
Date start	(DATSTA)		(S) DA	0,1			
Feature/information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Aggr Asso Comp	Name of the Association	Feature or Information Type at "this" end	At "this" end	At "this" end x..y	Feature or Information Type(s) at "other" end	Role name	At "other" end x..y
INT 1 Reference: The INT 1 location(s) of the feature – by INT1 section and section number (if applicable).							
X.X.X Sub-clause heading(s) (see S-4 – B-YYY.Y)							
Introductory remarks. Includes information regarding the real world entity/situation requiring the encoding of the Feature in the ENC, and where required nautical cartographic principles relevant to the Feature to aid the compiler in determining encoding requirements.							
Specific instructions to encode the feature.							
Remarks:							
– Additional encoding guidance relevant to the feature.							
X.X.X.X Sub-sub-clause heading(s) (see S-4 – B-CCC.C)							
Clauses related to specific encoding scenarios for the feature (if required).							
Remarks:							
– Additional encoding guidance relevant to the scenario (if required).							
Distinction: List of features in the Product Specification distinct from the feature.							

B.7 Feature types

B.7.1 Feature type in general

Table B.13 describes general feature types derived from S-100. All feature types of S-421 are based on this type.

Table B.13 – General feature types

IHO Definition: FEATURE TYPE : Generalized feature type which carries all the common attributes.							
S-421 Geo Feature: FeatureType (Abstract)							
Primitives: None							
<i>Real World</i>			<i>Paper Chart Symbol</i>			<i>ECDIS Symbol</i>	
S-421 Attribute	S-57 Acronym	Allowable encoding value	Type		Multiplicity	Implementation	
	A blank cell indicates no corresponding S-57 acronym.						
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Feature associations							
INT 1 Reference:							
Where a complex attribute has all its sub-attributes optional (e.g., multiplicity 0..1 or 0..*), at least one of the sub-attributes shall be populated.							
Remarks:							
– This document does not support RouteExtensions of RTZ. To use RouteExtesions format of RTZ, it can be added to routeExtensionNote as it is depending on the manufacturer. – Feature association: A feature association describes the relationship between two feature types. A feature association is bidirectional and has a separate role for each direction. For example, the association link between the object Route and RouteWaypoints is bidirectional. – Attributes of the object (feature or information type) are mandatory, optional and mandatory implementation. Whenever making a route plan which include some objects, the object related attributes mandatory in implementation as well as mandatory attributes shall always be added. The value description of implementation is mandatory or optional.							
Distinction:							

B.7.2 Route

Table B.14 describes the table format for Route.

Table B.14 – Table format for Route

IHO Definition: Route: Route plan with route information, route schedules, route action points and route waypoints from berth to berth.							
S-421 Feature: Route							
Supertype: FeatureType							
Primitives: None							
Real World		Paper Chart Symbol			ECDIS Symbol		
S-421 Attribute		S-57 Acronym	Allowable encoding value	Type	Mult.	Implementation	
routeFormatVersion				TE	1,1	Mandatory	
routeID				TE	1,1	Mandatory	
routeEditionNo				IN	1,1	Mandatory	
routeExtensions				C	0,1	Optional	
routeExtensionManufacturerId				TE	1,1		
routeExtensionName				TE	0,1		
routeExtensionVersion				TE	0,1		
routeExtensionNote				TE	0,*		
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Comp	routeInfoComposition	Route	routeInfoCollection	1,1	RouteInfo	routeInfo	1,1
Comp	routeSchedulesComposition	Route	routeSchedulesCollection	1,1	RouteSchedules	routeSchedules	0,1
Feature associations							
Comp	routeWaypointsComposition	Route	routeWaypointsCollection	1,1	RouteWaypoints	routeWaypoints	1,1
Comp	routeActionPointsComposition	Route	routeActionPointsCollection	1,1	RouteActionPoints	routeActionPoints	0,1
INT 1 Reference:							
Remarks:							
- routeFormatVersion: The first thing to check is the routeFormatVersion between the ship and the shore. The routeFormatVersion between ship and shore shall be same. - routeID: The routeID is the unique route identifier. - routeEditionNo: When making a new route plan, the attribute routeEditionNo starts from 1. Whenever the route plan is changed and ready to send the updated route plan to the other side, the attribute routeEditionNo is also increased by 1. The attribute routeID is a unique identifier. - routeExtensions: If there is a necessity of adding some information to the object Route, the attribute routeExtensions can be used. - Associations: The object Route is the root of S-421 data model. The object Route shall have mandatory association links to the object RouteInfo and RouteWaypoints. The association links between the object Route and routeSchedules or routeActionPoints are optional. The S-421 route plan says the object Route as a root of data model shall have at least the object RouteInfo, RouteWaypoints and at least two RouteWaypoints. - Route Plan Services: The route plan is used for route plan exchange services between ship and ship or between ship and shore. This is provided for ship to shore side for example, route cross check, flow management, enhanced monitoring, ice navigation, UKCM, fleet route monitoring, chart management, route optimization, port call synchronization, reference route, search and rescue, common recommended routes and so on.							
Distinction:							

B.7.3 RouteActionPoints

Table B.15 describes the table format for RouteActionPoints.

Table B.15 – Table format for RouteActionPoints

IHO Definition: RouteActionPoints:							
S-421 Feature: RouteActionPoints							
Supertype: FeatureType							
Primitives: None							
Real World		Paper Chart Symbol			ECDIS Symbol		
S-421 Attribute		S-57 Acronym	Allowable encoding value	Type	Mult.	Implementation	
routeActionPointsExtensions				C	0,1	Optional	
routeExtensionManufacturerId				TE	1,1		
routeExtensionName				TE	0,1		
routeExtensionVersion				TE	0,1		
routeExtensionNote				TE	0,*		
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Feature associations							
Comp	routeActionPointsComposition	RouteActionPoints	routeActionPoints	0,1	Route	routeActionPointsCollection	1,1
Comp	routeActionPointComposition	RouteActionPoints	routeActionPointCollection	1,1	RouteActionPoint	routeActionPoint	0,*
INT 1 Reference:							
Remarks:							
routeActionPointsExtensions: If there is a necessity of adding some information to the object RouteActionPoints, the attribute routeActionPointsExtensions can be used.							
Distinction:							

B.7.4 RouteActionPoint

Table B.16 describes the table format for RouteActionPoint.

Table B.16 – Table format for RouteActionPoint

IHO Definition: RouteActionPoint:							
S-421 Feature: RouteActionPoint							
Supertype: FeatureType							
Primitives: Point, Curve, Surface							
Real World		Paper Chart Symbol			ECDIS Symbol		
S-421 Attribute		S-57 Acronym	Allowable encoding value	Type	Mult.	Implementation	
routeActionPointId				IN	1,1	Mandatory	
routeActionPointName				TE	0,1	Optional	
routePointExternalReference				TE	0,1	Optional	
geometry				GM_Point GM_Curve GM_Surface	1,1	Mandatory	
routeActionPointRadius				RE	1,1	Mandatory	
routeActionPointTimeToAct				IN	0,1	Mandatory	
routeActionPointRequiredAction			1 : User Defined 2 : Report 3 : UKCM 4 : Note 5 : Reserved 6 : Reserved2 7 : Reserved3 8 : Reserved3 9 : Reserved4	EN	1,1	Mandatory	
routeActionPointRequiredActionDescription				TE	1,1	Mandatory	
routeActionPointExtensions				C	0,1	Optional	
routeExtensionManufactureId				TE	1,1		
routeExtensionName				TE	0,1		
routeExtensionVersion				TE	0,1		
routeExtensionNote				TE	0,*		
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Feature associations							
Comp	routeActionPointsComposition	RouteActionPoint	routeActionPoint	0,*	RouteActionPoints	routeActionPointCollection	1,1

B.7.6 RouteWaypoint

Table B.18 describes the table format for RouteWaypoint.

Table B.18 – Table format for RouteWaypoint

IHO Definition: RouteWaypoint :							
S-421 Feature: RouteWaypoint							
Supertype: FeatureType							
Primitives: Point							
<i>Real World</i>		<i>Paper Chart Symbol</i>		<i>ECDIS Symbol</i>			
S-421 Attribute		S-57 Acronym		Allowable encoding value		Type	Mult. Implementation
routeWaypointID						IN	1,1 Mandatory
routeWaypointName						TE	0,1 Mandatory
routeWaypointExternalReferenceID						TE	0,1 Optional
routeWaypointFixed						BO	0,1 Mandatory
geometry						GM Point	1,1 Mandatory
routeWaypointTurnRadius						RE	1,1 Mandatory
routeWaypointExtensions						C	0,1 Optional
routeExtensionManufacturerId						TE	1,1
routeExtensionName						TE	0,1
routeExtensionVersion						TE	0,1
routeExtensionNote						TE	0,*
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Feature associations							
Comp	routeWaypointComposition	RouteWaypoint	routeWaypoint	2,*	RouteWaypoints	routeWaypointCollection	1,1
Comp	routeWaypointLegComposition	RouteWaypoint	routeWaypointLegCollection	1,1	RouteWaypointLeg	routeWaypointLeg	0,1
INT 1 Reference: The object RouteWaypoint has geometry feature which is point. The point of geometry is GPS coordinate, latitude and longitude.							
Remarks: - Multiplicity of RouteWaypoint: The number of RouteWaypoint is at least 2 including starting point and ending point. - Route Sequence: The route planning consists of at least the start point and the end point. In this case, the first RouteWaypoint may have an association with RouteWaypointLeg. The order of RouteWaypoint is the sequence of the route for the vessel. Every RouteWaypoint may have one RouteWaypointLeg except the last RouteWaypoint. - mandatory attributes in Implementation: geometry, routeWaypointID, routeWaypointFixed, routeWaypointTurnRadius - routeWaypointExtensions: If there is a necessity of adding some information to the object RouteWaypoint, the attribute routeWaypointExtensions can be used.							
Distinction:							

B.7.7 RouteWaypointLeg

Table B.19 describes the table format for RouteWaypointLeg.

Table B.19 – Table format for RouteWaypointLeg

IHO Definition: RouteWaypointLeg:							
S-421 Feature: RouteWaypointLeg							
Supertype: FeatureType							
Primitives: None							
Real World		Paper Chart Symbol		ECDIS Symbol			
S-421 Attribute		S-57 Acronym	Allowable encoding value	Type	Mult. Implementation		
routeWaypointLegStarboardXTDL				RE	0,1 Optional		
routeWaypointLegPortXTDL				RE	0,1 Optional		
routeWaypointLegStarboardCL				RE	0,1 Optional		
routeWaypointLegPortCL				RE	0,1 Optional		
routeWaypointLegSafetyContour				RE	0,1 Optional		
routeWaypointLegSafetyDepth				RE	0,1 Optional		
routeWaypointLegGeometryType			1 : Loxodrome 2 : Orthodrome	EN	1,1 Mandatory		
routeWaypointLegSOGMin				RE	0,1 Optional		
routeWaypointLegSOGMax				RE	0,1 Optional		
routeWaypointLegSTWMin				RE	0,1 Optional		
routeWaypointLegSTWMax				RE	0,1 Optional		
routeWaypointLegDraft				RE	0,1 Optional		
routeWaypointLegDrftForward				RE	0,1 Optional		
routeWaypointLegDraftAft				RE	0,1 Optional		
routeWaypointLegDraftMax				RE	0,1 Optional		
routeWaypointLegAirDraftMax				RE	0,1 Optional		
routeWaypointLegBeamMax				RE	0,1 Optional		
routeWaypointLegLengthMax				RE	0,1 Optional		
routeWaypointLegStaticUKC				RE	0,1 Optional		
routeWaypointLegDynamicUKC				RE	0,1 Optional		
routeWaypointLegSafetyMargin				RE	0,1 Optional		
routeWaypointLegNote				TE	0,1 Optional		
routeWaypointLegIssue				TE	0,1 Optional		
routeWaypointExtensions				C	0,1 Optional		
routeExtensionManufacturerId				TE	1,1		
routeExtensionName				TE	0,1		
routeExtensionNote				TE	0,*		
routeExtensionVersion				TE	0,1		
Information associations							
Type	Association name	Class	Role	Mult.	Class	Role	Mult.
Feature associations							
Comp	routeWaypointLegComposition	routeWaypointLeg	routeWaypointLeg	0,1	RouteWaypoint	routeWaypointLegCollection	1,1