



INTERNATIONAL HYDROGRAPHIC ORGANISATION
BUREAU VERITAS MARINE & OFFSHORE

CONNECTIVITY COVERAGE

FOR REMOTE OPERATIONS

COLLABORATIVE DEVELOPMENT
S-123 PRODUCT SPECIFICATION

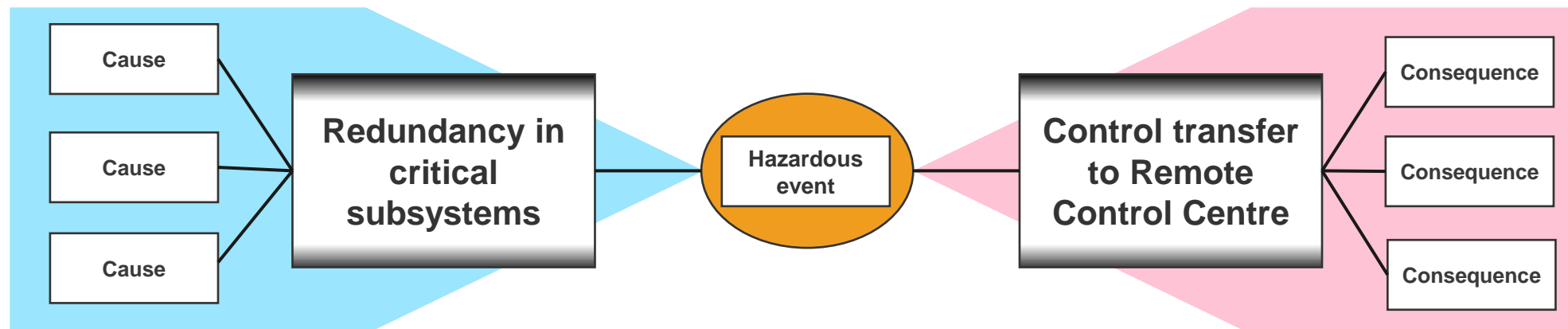
OCTOBER, 2024

ROLE OF SHIP-SHORE COMMS

RATIONALE



- Ship-shore communication is a critical enabler for autonomy
- EU Project AUTOSHIP D2.4a “Risk assessments, fail-safe procedures and acceptance criteria”, 2020:
 - *“The critical hazards were primarily related to the **transit** and **emergency** operating phases and to the **novel navigation** and **emergency management** functions. ... The main preventative control measures were the use of redundant components in the situation awareness, communication and propulsion systems, whilst the main mitigative measure was related to the control transfer to the ROC.”*



SYNC-COM-R

CLASSIFICATION FOR AUTONOMY

- | New additional class notations have been created by BV for ships using ship-shore communication in remote control:
 - **SYNC-COM** for non-redundant comms
 - **SYNC-COM-R** for redundant comms

- | The classification of the ships and offshore units includes
 - design approval based on the submitted documentation,
 - initial and periodic surveys with the sea and river trials

- | Type approval of the equipment based on BV requirements, IACS UR E10, E22, E27

- | For communication systems which can ensure **synchronous** transfer of data (sensitive to delays) between the ship and the shore **for control, excluding GMDSS**



CHALLENGES FOR AUTONOMY

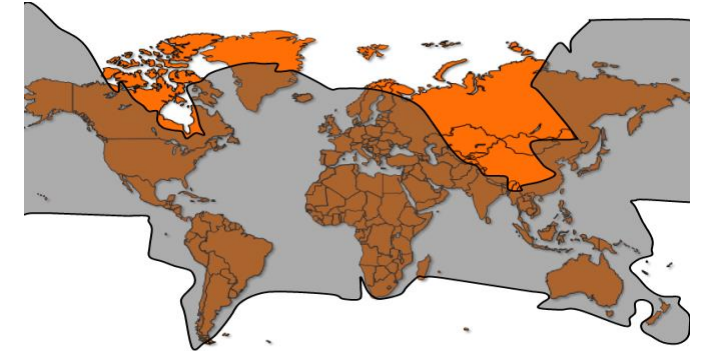
CONNECTIVITY COVERAGE

The satcom and cellular comm providers are **not yet offering:**

- | QoS data (minimum signal power, guaranteed or best effort, frequency range, bandwidth, etc.) in a **unified** format
- | Geographic coverage in an ENC format easily **compatible with ECDIS**

Satcom and cellular connectivity coverages are **not explicitly mentioned as dedicated vector objects** in S-57 or S-123.

The **lack of detailed and accurate information** on the coverage and on QoS forces the Shipowners to **measure and plot the signal availability on their own**, when planning and testing new autonomous or remotely operated services and routes



Unpredictable QoS
parameters for communication

=

Unpredictable availability of the
main mitigative measure

IHO



International
Hydrographic
Organization

The **International Hydrographic Organization** works to ensure that all the world's seas, oceans and navigable waters are surveyed and charted, thereby supporting **safety of navigation** and the **protection of the marine environment**.

It coordinates the activities of national hydrographic offices and **sets standards in order to promote uniformity in nautical charts and documents**.

It issues survey best practices and provides guidelines to **maximize the use of hydrographic information**.



DEGREE OF CONTROL

Technology with a different degree of remote control may be deployed with regard to the interaction with the Remote Operations Centre (ROC), e.g. as per BV M&O NI641 Guidelines:

Degree RC1 - Available remote control

Operators are available in a ROC outside the ship, ready to take control in case of warning or alert from the system, but they may be not at the control station (e.g. periodically unmanned remote control station).

Degree RC2 - Discontinuous remote control

The system or ship is monitored and controlled by operators from a ROC outside the ship. But monitoring and control may be discontinuous during a short period. Operators are always available at the remote control station, ready to take control in case of warning or alert from the system

Degree RC3 - Full remote control

The system or ship is actively monitored and controlled at any time by operators from a ROC outside the ship



DISCONTINUOUS CONNECTIVITY

It should be noted that depending on the designed interaction level of the autonomous vessels, they **may operate without a need of continuous connectivity** with the Remote Operations Centre (ROC) allowing them to exit the connectivity coverage areas.

However, the measures to reach a **fallback state** (defined in ISO 23860:2022) following an emergency situation may include the passage to the **nearest area with guaranteed connectivity coverage**.

EXPANDING S-123

Availability of a standardized approach for mapping the corresponding connectivity coverage objects can improve the safety for autonomous and remote operated shipping.

On 14/9/23 it was proposed to IHO to consider **including the connectivity coverage and QoS data objects into S-123 “Marine Radio Services” Product Specification.**



S-100 Product Specifications

S-123 specifies objects indicating the

- | location, availability, type of radio communications,
- | frequencies and content of radio services for navigational information and
- | other maritime radio communications.

INPUT PAPER CO-SPONSORED BY ORGANISATIONS RELATED TO AUTONOMY & ENC's



Bureau Veritas
Marine & Offshore



Electronic Chart Centre



Norwegian Forum for
Autonomous Ships (NFAS)



Robosys Automation Ltd.



One Sea Association



Seafar NV



NAVTOR AS



SINTEF



Norwegian Coastal
Administration

KYSTVERKET

See [presentation](#) and the [input paper](#) from the IHO website (<https://iho.int/en/nipwg10-2023>).



USE OF INFORMATION FOR ROUTE PLANNING AND EXECUTION

LAYER IN ECDIS

The boundaries of the connectivity service coverage and its expected impact on QoS can be used as a layer in ECDIS.

SAFETY CONTOUR

Created from bathymetric grid data, and connectivity service coverage, and based on values set by the user

COLOUR-CODING

The coverage map could be colour-coded based on expected received signal strength at any given location, seen in relation to the expected QoS performance for the communication system in question.

USE CASES

safety contour may be used for :

- route planning when automatically validating a route in ECDIS
- execution of passage to prevent a loss of connectivity.

SAFETY CONTOUR

Users in Remote Operations Centres (ROC) could benefit from a safety contour created from the following datasets and user settings:

DATASETS

bathymetric grid data

connectivity service coverage



USER SETTINGS

safety contour depth value

redundant configuration of the connectivity system

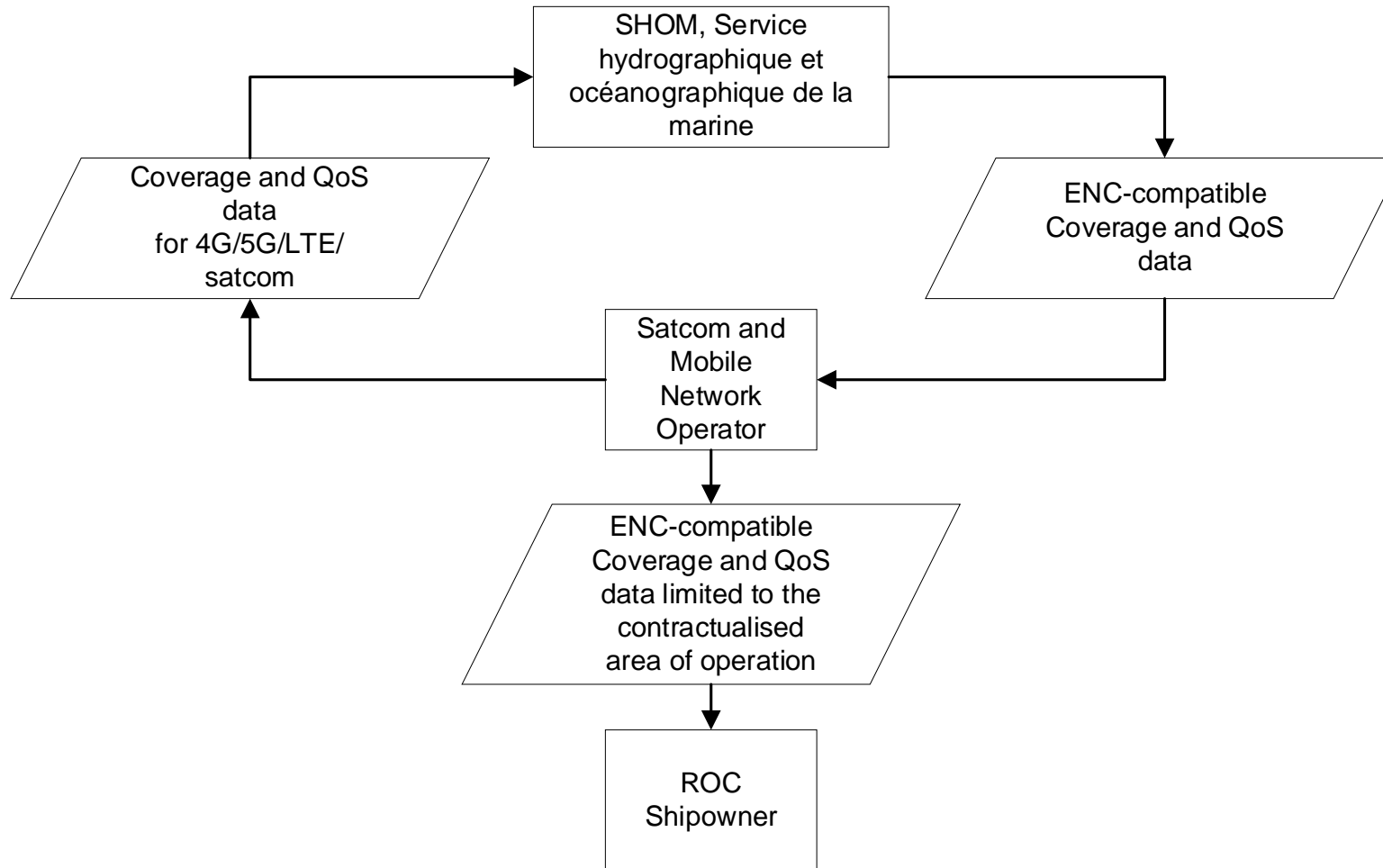
communication device (antenna) in use

height of the communication device above the water

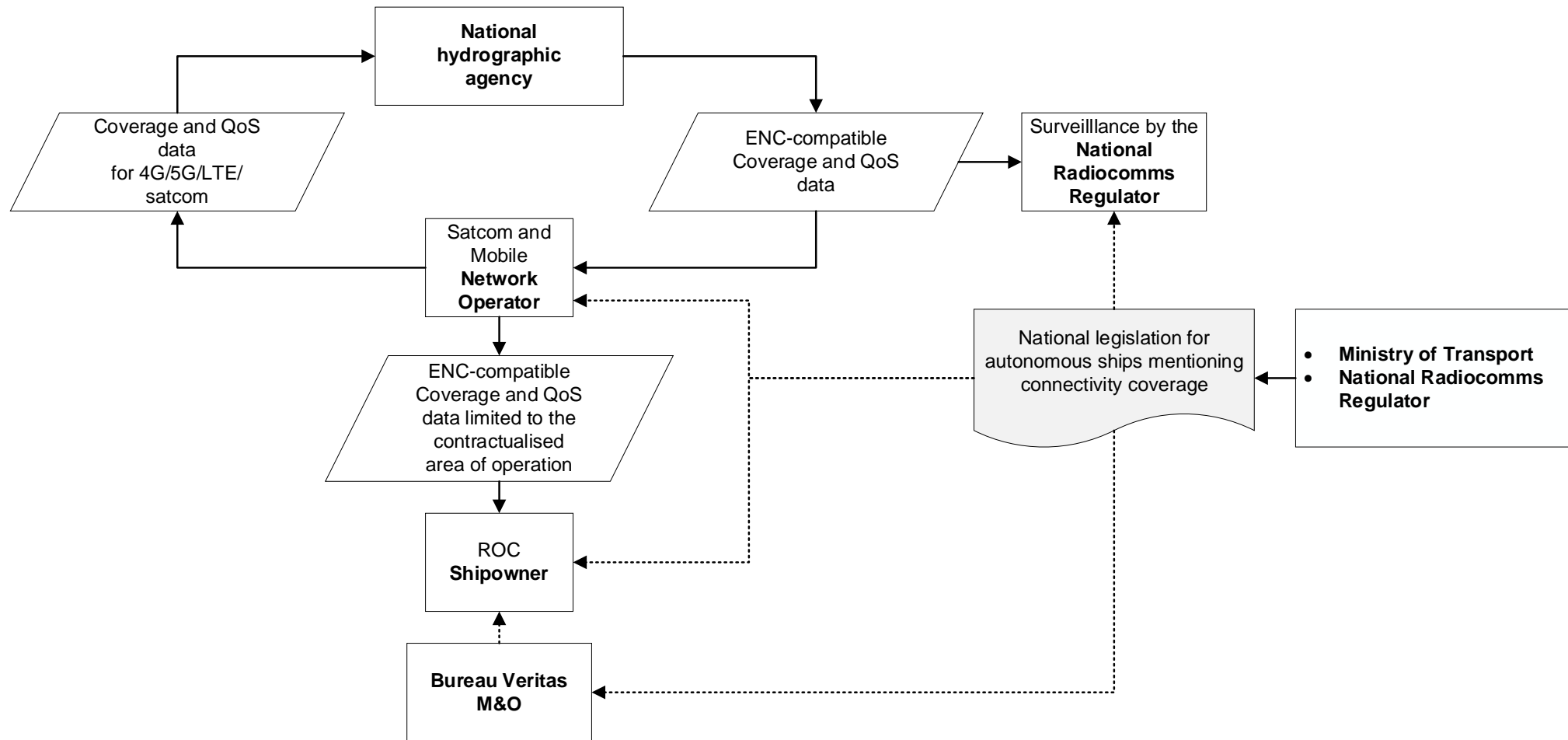
level of interaction between the ship and the ROC related to a mode of control

active subscription.

POSSIBLE INTERACTION FOR A CONNECTIVITY PROVIDER



TARGET REGULATORY ARRANGEMENT

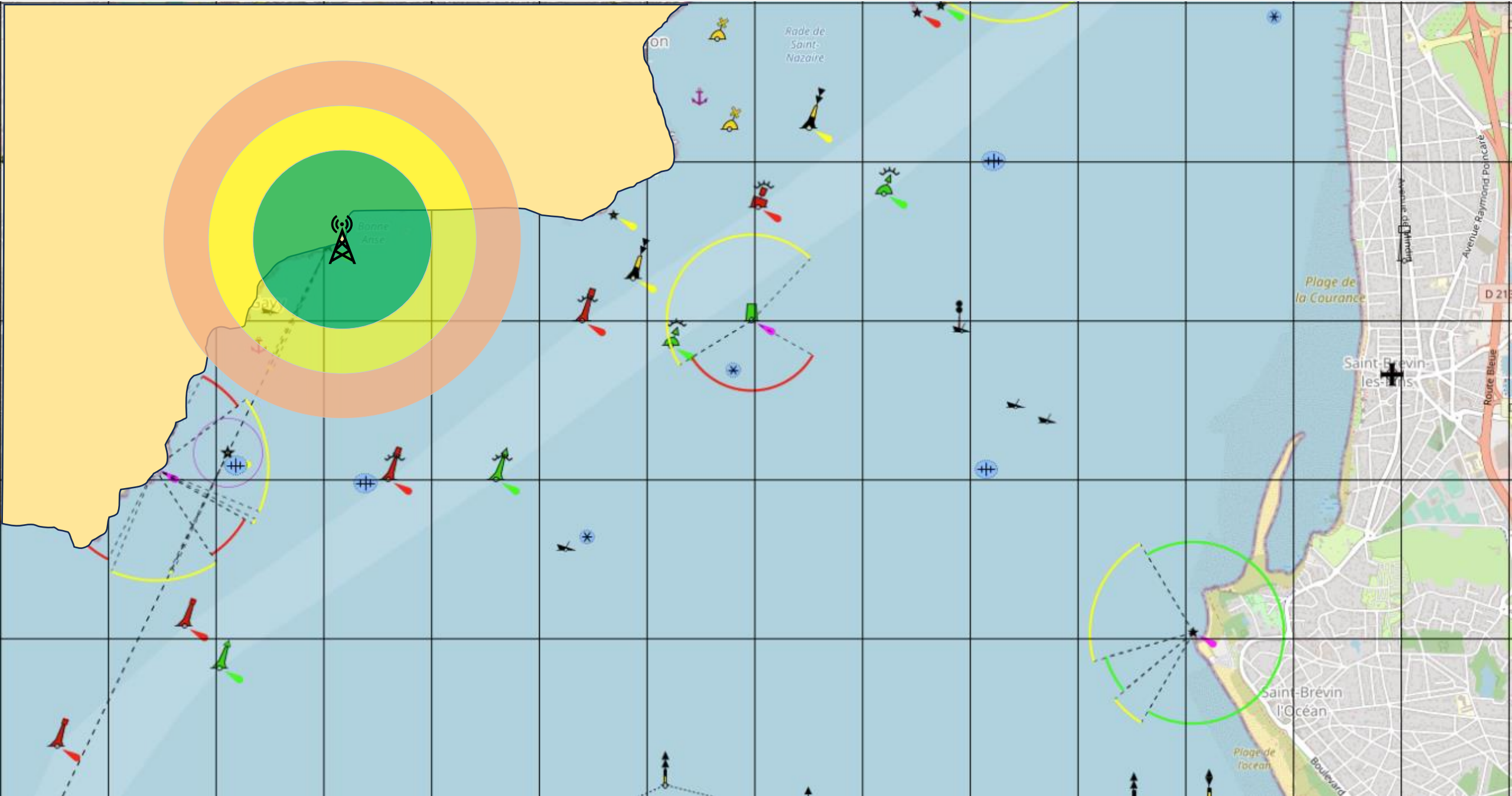


IHO NIPWG DRAFT, S-123 OBJECT PROPOSAL

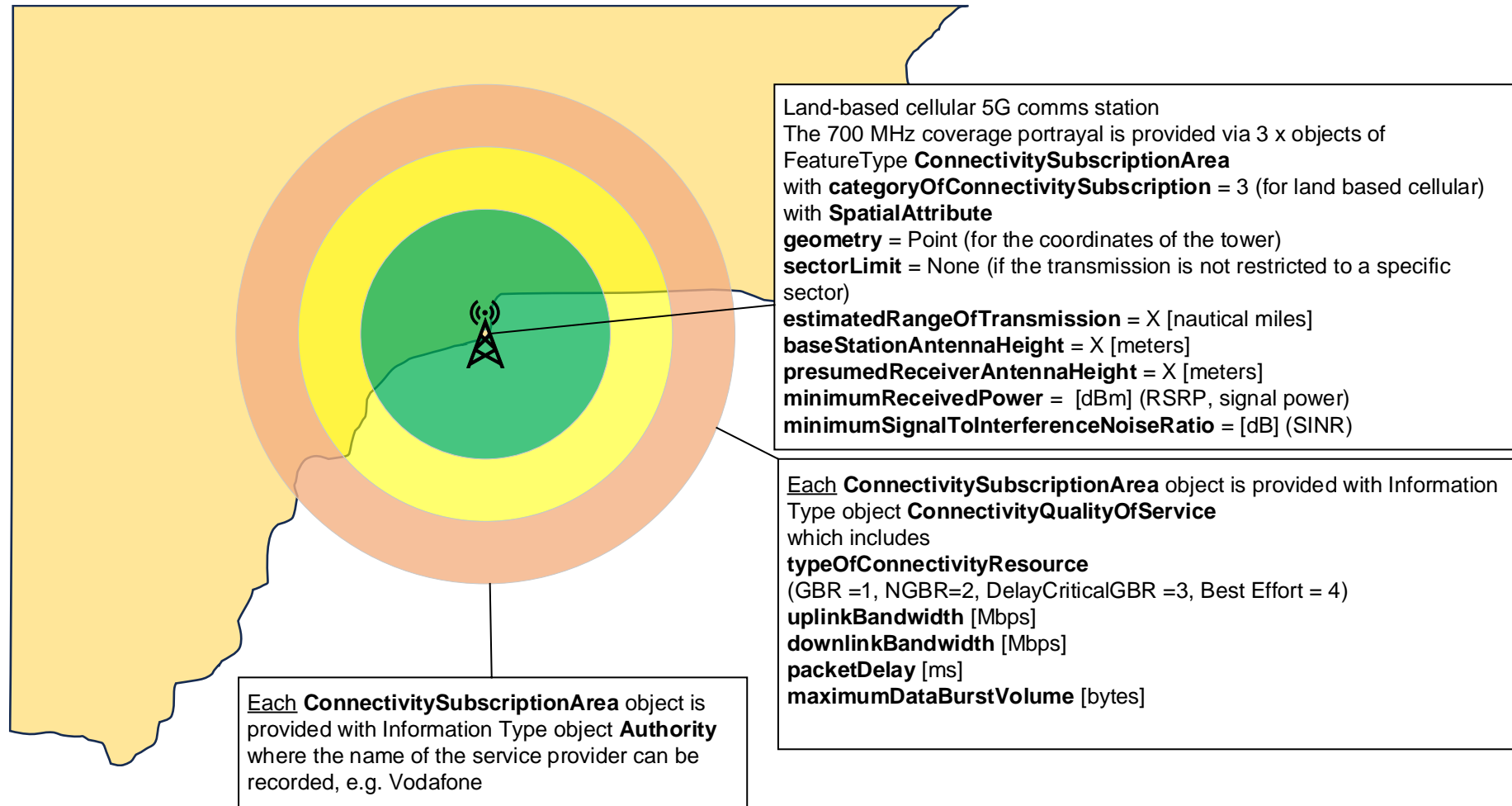
The initial draft prepared by Shwu-Jing CHANG (NIPWG member, NTOU) and approved by NIPWG Chairman is shared externally for comments from the stakeholders.

- | **ConnectivitySubscriptionArea** feature object is to be created and linked to information type objects **ConectivityQualityOfService**, **ContactDetails** and **Authority**
- | The same **ConnectivitySubscriptionArea** feature object will be applicable both for the land-based cellular and satellite communication
- | The structure of **ConnectivitySubscriptionArea** allows portrayal of a polygon, a circular area or a sector
- | Quality of Service parameters are attributed via **ConectivityQualityOfService**
- | Connectivity provider is attributed via **Authority** with contact details in **ContactDetails**

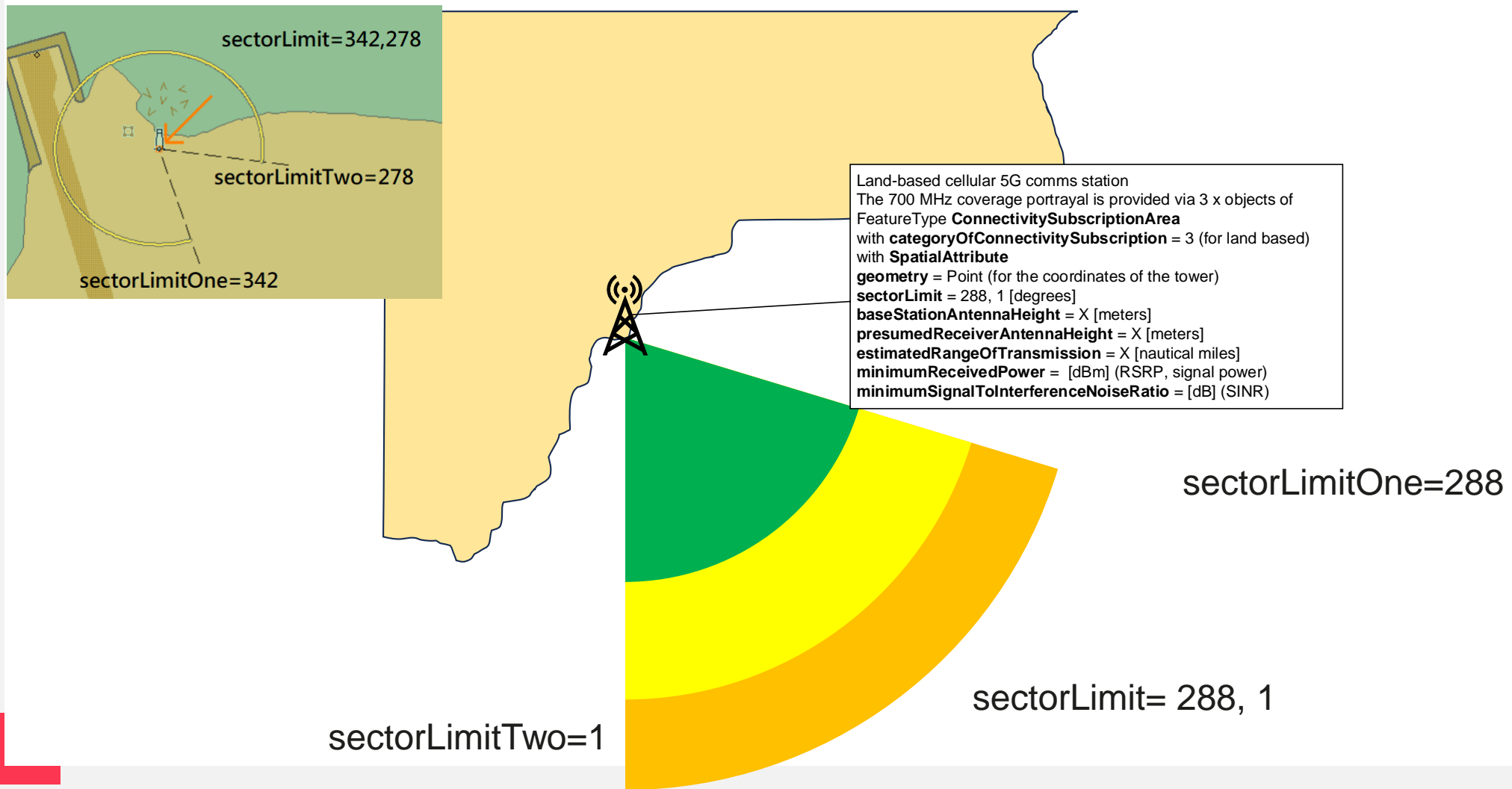
The original S-123 is downloadable from the NIPWG [webpage](#).



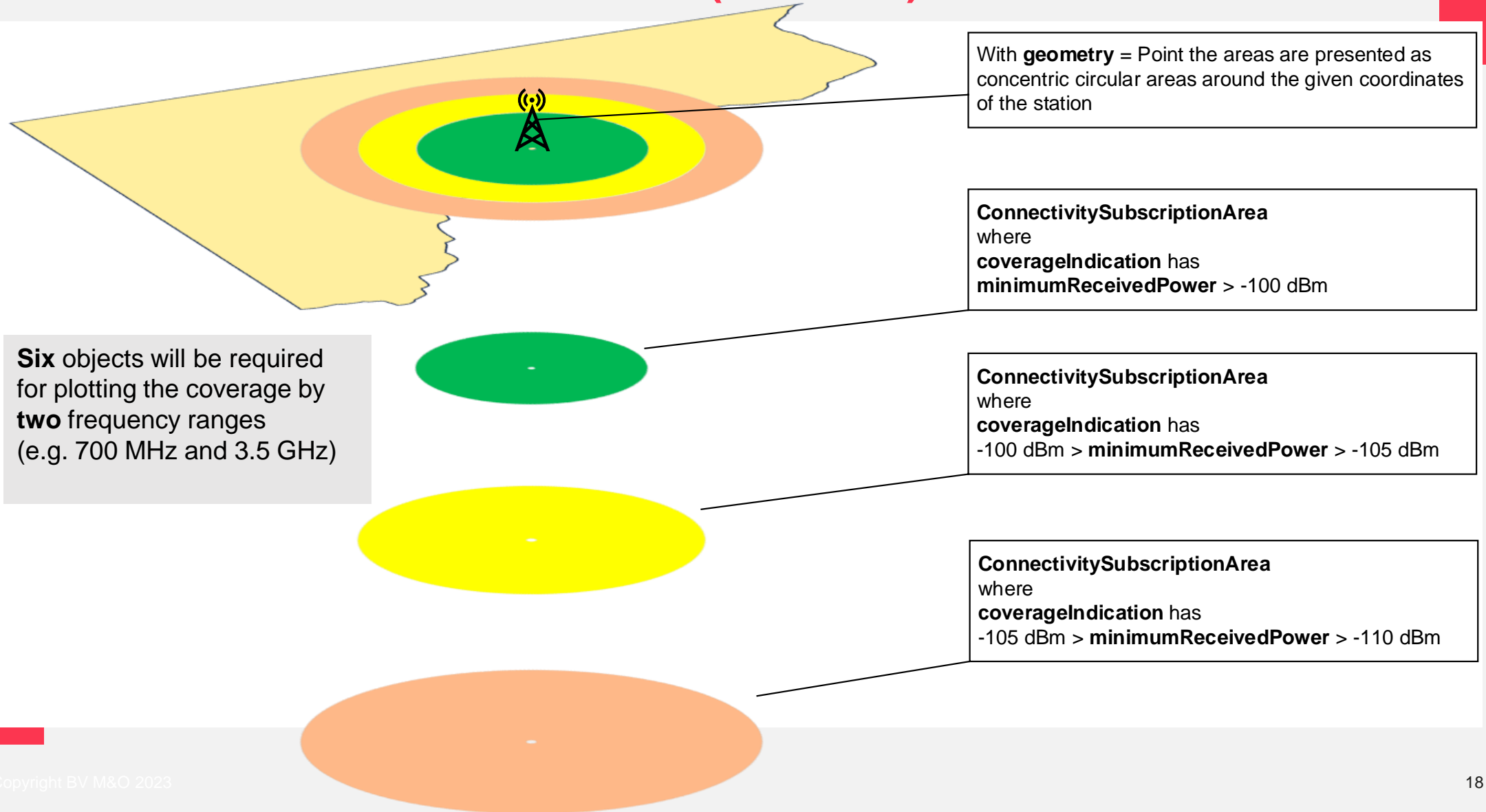
IHO NIPWG DRAFT, S-123 OBJECT PROPOSAL BY SHWU-JING CHANG (NTOU)



IHO NIPWG DRAFT, S-123 OBJECT PROPOSAL BY SHWU-JING CHANG (NTOU)



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With **geometry = Point** the areas are presented as concentric circular areas around the given coordinates of the station

ConnectivitySubscriptionArea
where
coverageIndication has
minimumReceivedPower > -100 dBm

Six objects will be required for plotting the coverage by two frequency ranges (e.g. 700 MHz and 3.5 GHz)

ConnectivitySubscriptionArea
where
coverageIndication has
-100 dBm > **minimumReceivedPower** > -105 dBm

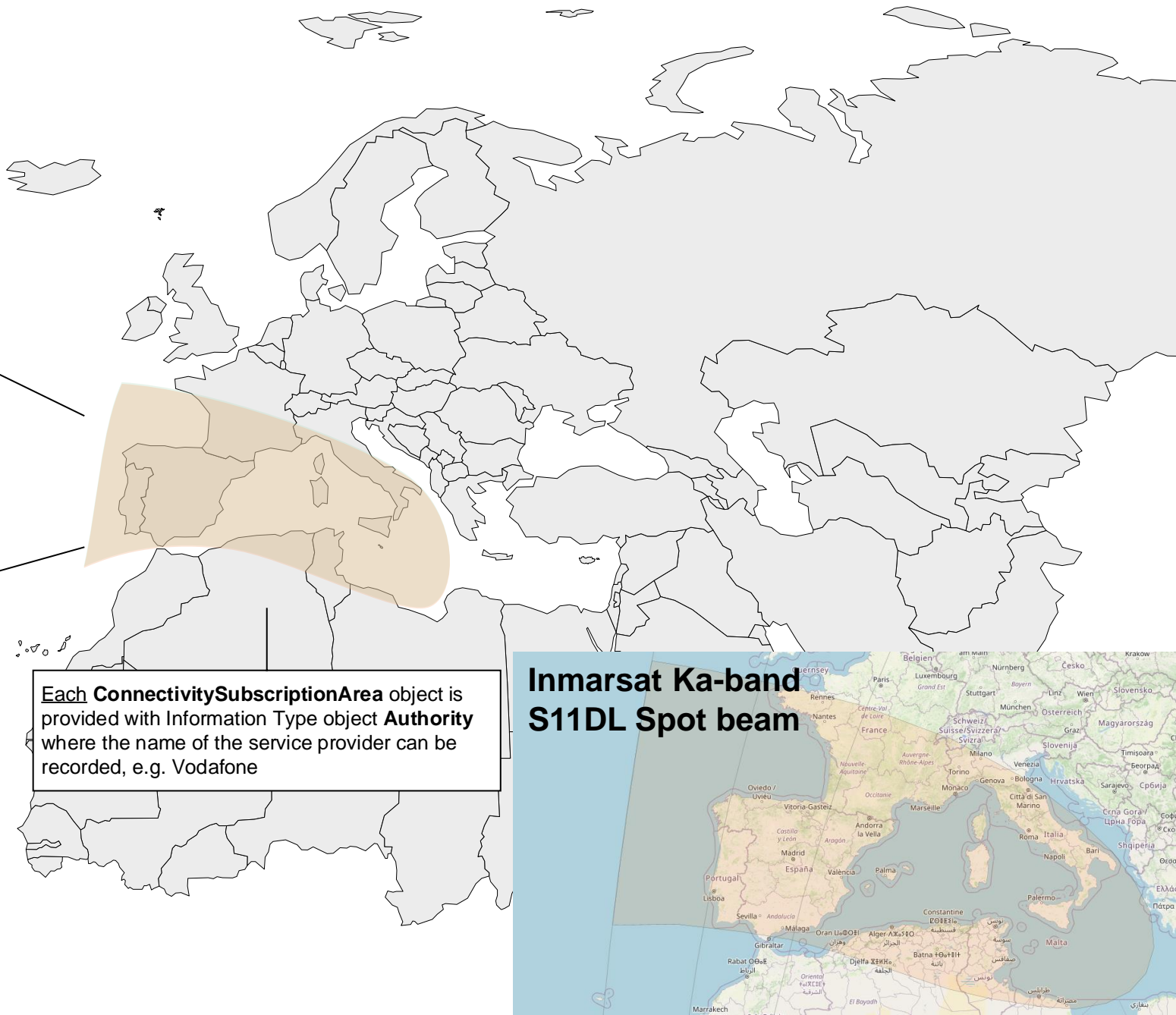
ConnectivitySubscriptionArea
where
coverageIndication has
-105 dBm > **minimumReceivedPower** > -110 dBm

Ka-band spot beam
The coverage portrayal is provided via 1 x object of FeatureType **ConnectivitySubscriptionArea**
with **categoryOfConnectivitySubscription** = 1 (for GEO satellite)
with **SpatialAttribute**
geometry = Surface (polygon)
sectorLimit = Not applicable
estimatedRangeOfTransmission = Not applicable
minimumReceivedPower = [dBm] (RSRP, signal power)
minimumSignalToInterferenceNoiseRatio = [dB] (SINR)

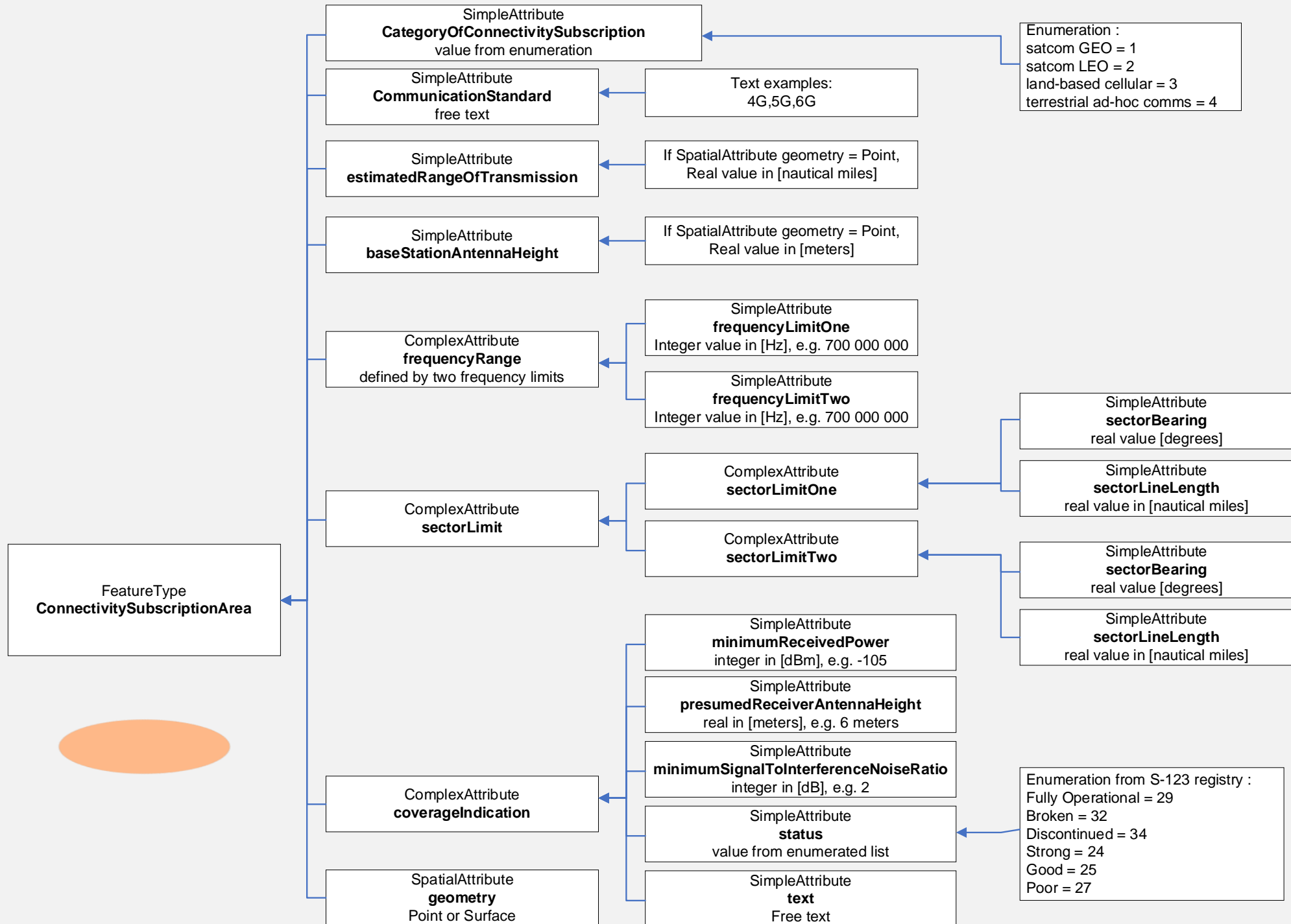
Each **ConnectivitySubscriptionArea** object is provided with Information Type object **ConnectivityQualityOfService** which includes
typeOfConnectivityResource
(GBR =1, NGBR=2, DelayCriticalGBR =3, Best Effort = 4)
uplinkBandwidth [Mbps]
downlinkBandwidth [Mbps]
packetDelay [ms]
maximumDataBurstVolume [bytes]

Each **ConnectivitySubscriptionArea** object is provided with Information Type object **Authority** where the name of the service provider can be recorded, e.g. Vodafone

One object will be required for plotting each spot beam polygon



Inmarsat Ka-band S11DL Spot beam





FeatureType
ConnectivitySubscriptionArea

InformationType
ConnectivityQualityOfService
includes multiple attributes

SimpleAttribute
typeOfConnectivityResource
value from enumerated list

SimpleAttribute
uplinkBandwidth
integer value [Mbps]

SimpleAttribute
downlinkBandwidth
integer value [Mbps]

SimpleAttribute
packetDelay
integer value [ms]

SimpleAttribute
maximumDataBurstVolume
integer value [bytes]

SimpleAttribute
status
value from enumerated list

ComplexAttribute
information
attribution of descriptive files

Guaranteed Bit Rate = 1
Non-Guaranteed Bit Range = 2
Delay Critical Guaranteed Bit Rate = 3
Best Effort = 4

Enumeration from S-123 registry :
Fully Operational = 29
Broken = 32
Discontinued = 34
Strong = 24
Good = 25
Poor = 27

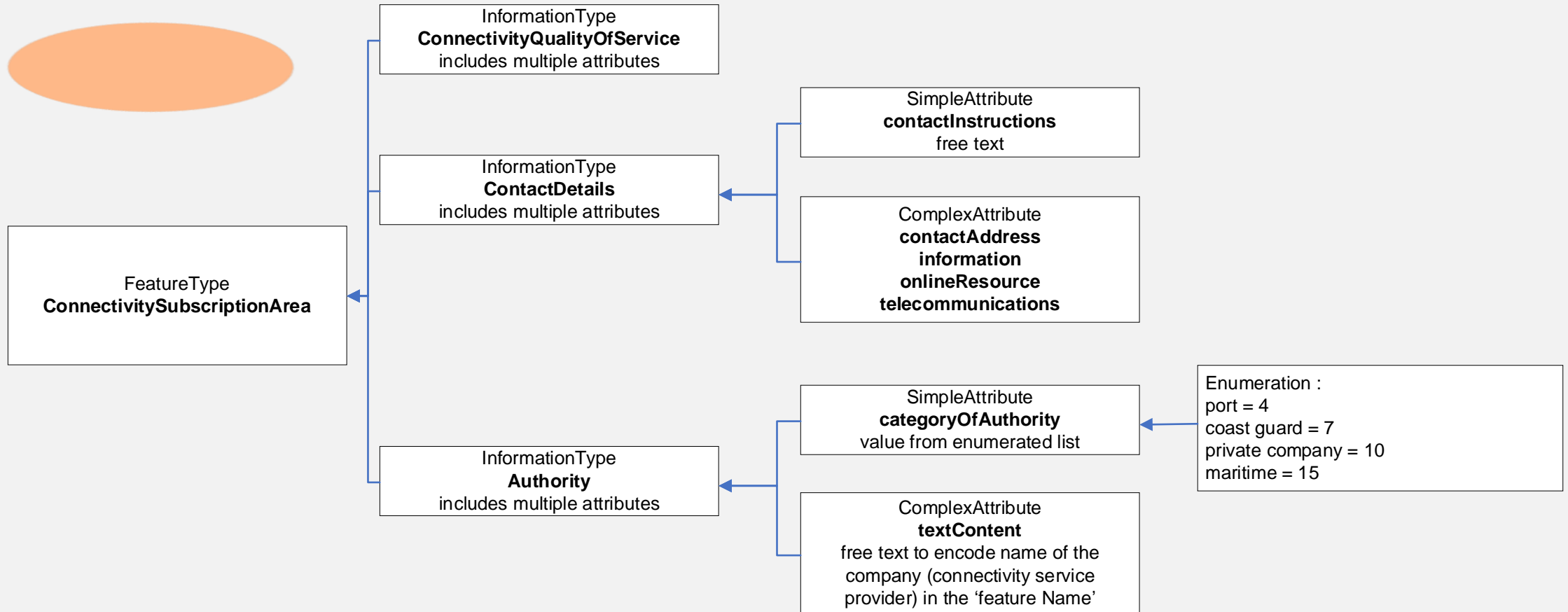
SimpleAttribute
fileLocator
text

SimpleAttribute
fileReference
text

SimpleAttribute
headline
text

SimpleAttribute
language
value from enumerated list

SimpleAttribute
text
free text



DEVELOPMENT SHOULD INVOLVE

- | ECDIS manufacturers
- | Mobile Network Operator
- | Satellite Communication Operator
- | Short Sea Shipping Shipowner
- | Inland Shipping Shipowner
- | National agency specialised in marine geospatial data



CONCLUSIONS

- | The **safety issue related to the provision of the coverage zones for connectivity** used in remote control with a mapping in ENC is **pertinent** for the emerging autonomous and remotely operated shipping both inland and at sea.
- | Creation of the dedicated data objects in S-123 is a **mitigation for the risk of the loss of remote control.**
- | **Availability of the standardised Product Specification from IHO** and of a roadmap for the implementation is important for the industry.





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