Paper for Consideration by NIPWG

Expanding S-123 object list with the connectivity coverage for remote operations

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Executive Summary:	The paper is submitted to draw attention to the safety issue related to the provision of the coverage zones for connectivity required for remote operations with a mapping in ENC
Related Documents:	IHO S-123 "Marine Radio Services" Product Specification, Ed 1.0.0,01/2019 BV NI641 "Guidelines for autonomous shipping" ETSI TS 123 203 V17.2.0 (2022-05) ISO/TS 23860:2022(en) Ships and marine technology — Vocabulary related to autonomous ship systems
Related Projects:	Not applicable to IHO projects

Introduction / Background

Autonomous and remotely operated[1] shipping is progressively developing worldwide while there is a need to guarantee that the systems are safe and robust. One of the key enablers is the deployment of connectivity systems on board. A variety of communication devices (4G, 5G, LTE, VDES, WiMax, Ku-band, Ka-band, L-band, MN-MANET, etc.) may form a part of the communication system, each may operate in a different electromagnetic spectrum and have its own limitations imposed by the geographic area of connectivity coverage provided by both satellite constellations and land-based relay stations.

Mapping of connectivity coverage enables the identification of no-go areas where there is no signal or where the Quality-of-Service (QoS) is not guaranteed. Previously Bureau Veritas Marine & Offshore published "Guidelines for autonomous shipping" NI641, where Sec 1 [2.10.3] and Sec 3 [8.2.3] refer to latency as one of QoS parameters and to the situational awareness about the range of the communications.

Sec 1, 2.10.3 *The remote operators should be aware of the latency due to the communication that cause a delay between his/her action and the actual ship reaction.*

Sec 3, 8.2.3 *In the case of remote control, it is the responsibility of remote operators to ensure that the ship remains within the range of its means of communication at all times and under all circumstances. When a ship is no longer within the range of its means of communication allowing its control, this ship should be able to enter into a failure sequence on its own.*

Availability of a standardized approach for mapping the corresponding connectivity coverage objects can improve the safety for autonomous and remote operated shipping. Therefore, it is proposed to consider including the data objects into S-123 "Marine Radio Services" Product Specification. 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.

Analysis/Discussion

Issue at the level of the connectivity providers

The satcom providers are not yet offering

- QoS data in a unified format
- Geographic coverage in an ENC format easily compatible with ECDIS

An example of specifying QoS can be taken from the ETSI standards for the cellular networks (LTE, 4G, 5G, etc.), e.g. ETSI TS 123 203 V17.2.0 [6.1.7], Table "Standardized QoS characteristics".

[1] Any terminology related to autonomous ship systems is used in this document as per ISO 23860:2022

QCI	Resource Type	Priority Level	Packet Delay Budget (NOTE 13)	Packet Error Loss Rate (NOTE 2)	Example Services
1 (NOTE 3)	GBR	2	100 ms (NOTE 1, NOTE 11)	10^{-2}	Conversational Voice
2 (NOTE 3)		4	150 ms (NOTE 1, NOTE 11)	10^{-3}	Conversational Video (Live Streaming)
3 (NOTE 3, NOTE 14)		3	50 ms (NOTE 1, NOTE 11)	10^{-3}	Real Time Gaming, V2X messages Electricity distribution - medium voltage (e.g. TS 22.261 [51] clause 7.2.2) Process automation - monitoring (e.g. TS 22.261 [51] clause 7.2.2)

GBR mentioned in the table stands for a Guarantee Bit Rate service where an information transmission path is used for which the capacity, delay and bit error rate are guaranteed by the external connectivity provider.

QoS parameters should also include, but not limited to,

- bandwidth of uplink and downlink,
- reliability of communication, i.e. a measure of probability for communication break,
- susceptibility to jamming.

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.

Issue at the level of the ENC providers

Satcom and cellular connectivity coverages are not explicitly mentioned as dedicated vector objects in S-57 or S-123. The existing coverage features listed in the S-123 vector model include:

- transmission power (applicable for land-based comms)
- GM_Point, (applicable for land-based comms)
- GM_OrientableCurve (applicable for land-based and satellite-based comms)
- GM_OrientableSurface (applicable for land-based and satellite-based comms)
- Estimated range of transmission (applicable for land-based comms).

Use of information for route planning and execution

The boundaries of the connectivity service coverage and its expected impact on QoS can be used as a layer in ECDIS. 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. Users in Remote Operations Centres (ROC)[2] could benefit from a safety contour created from

- bathymetric grid data, and
- connectivity service coverage,

and based on values set by the user for

- safety contour depth value
- redundant configuration of the connectivity system (there might be two redundant groups of the communication devices and the vessel may be required to navigate remotely controlled only in the area where a redundant coverage is provided, e.g. redundant group A – 5G antenna, redundant group B – Ku-band VSAT, the redundant coverage is achieved where these two overlap)
- 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.

Such a safety contour may be used for

- route planning when automatically validating a route in ECDIS

[2] ROC is defined the same as the Remote Control Centre (RCC) in ISO 23860:2022

- execution of passage to prevent a loss of 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.

Impacts

The subject addressed by the paper concerns the standardisation of the nautical charts to improve the safety of navigation and, hence, is within the scope of IHO objectives. The subject of the paper is within the scope of the current IHO work programme on S-123 development. S-123 can be used as an adequate industry standard for implementing the proposal.

The benefits of reducing the risk of a loss of connectivity for the remotely controlled vessels support the proposed action. Depending on the level of interaction and involvement required from the remote operator, a loss of control might increase the risk of a collision and grounding with the subsequent adverse effects for the humans, assets and environment.

The potential cost impacts on the maritime industry, Member States or other involved parties include:

- Producing the ENC compatible objects may incur costs for the connectivity providers, e.g., if it is outsourced to national agencies specialised in marine geospatial data
- Maintaining the coverage area mapping may be a cost for the connectivity service provider
- Transmitting of the relevant ENC updates may incur additional costs, as the data may be confidential and may require a different access management than currently implemented for the ENC products, i.e., a license from a specific external connectivity provider required to plot the corresponding coverage in ECDIS
- Subscription for the updates may be a cost for Shipowners.

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.

Recommendations

It is proposed to consider a potential solution at the level of NIPWG that might include:

- introducing the satellite connectivity object type in S-123 with the coverage, QoS parameters, frequency ranges, uncertainty level
- adapting radio station object type in S-123 to reflect the coverage, QoS parameters, frequency ranges, uncertainty level for the cellular network base stations
- issuing recommendation to satcom providers to regularly share the updates of the coverage with the minimum requirements to the format of data to be shared on the satellite status
- issuing recommendation to cellular network providers to regularly share the updates of the coverage with the minimum requirements to the format of data to be shared on the network status per base station along the coast or inland waterways.

Action Required of NIPWG

The NIPWG is invited to:

a. endorse the input paper “Expanding S-123 object list with the connectivity coverage for remote operations”

b. agree on the new data objects and a road map for their development within S-123

c. develop recommendations on ENC datasets and implementation workflow for the connectivity service providers