Paper for Consideration by DQWG

Autonomous shipping and Data Quality

Submitted by:	NLHO (Netherlands)
Executive Summary:	Autonomous ships are being developed by the shipping industry. This paper raises the question how ENCs can have an active contribution to these developments.
Related Documents:	A2 Final Summary Reports_EN.pdf; S-100WG5-04.3; DQWG16_2021_09.1B_EN_Autonomous shipping and Data Quality – Mindmap.pptx, DQWG Terms of Reference, IHO CL30/2019 (par.13)
Related Projects:	S101PT

Introduction / Background

At the A-2 meeting (November 2020), the Council Chair provided brief background information on the S-100 Implementation Strategy and the importance of S-100 Services and the S-100 Roadmap as the key element of the Implementation Strategy. He stated that the main drivers for developing S-100 are the increasing digitalization in the shipping industry; the advent of autonomous shipping; efficiency wins to gain particularly in ports; and that S-100 based data services will provide a cyber-secure, easily maintained software foundation that will support creative industry policy.

DQWG Terms of Reference state that the WG should propose new data quality topics for consideration by HSSC.

Analysis/Discussion

At www.imo.org > Search > autonomous shipping, various documents can be found presented by the industry. Particular papers of interest are:

- Technology Progression of Maritime Autonomous Surface Ships (Rolls Royce) - *20181203_Technology_Progression_In_MASS_IMO_Final_For_PDF*
- Smart Marine ecosystem approach (Wärtsilä) – *Smart Marine ecosystem approach MSC 100 symposium.pdf*
- Human element in shipping – are seafarers indispensable? (International Transport Workers Federation) - *Final_MSC100_PT_Are seafarers indispensable.pdf*

At S-100WG5 meeting (2020), SINTEF Ocean (Norway), presented a paper (S-100WG5-04.3) on Uncertainty Zones and Relative Distance/Speed for Objects in Simultaneous Operations – Dynamic Data Exchange for Autonomous Functions. The paper describes the work done in the Hull-to-Hull (H2H) project. SINTEF asked which working group/forum is most appropriate to continue this work within IHO. The S-100 Chair and DQWG Chair agreed that at the moment, the DQWG should be the appropriate WG and SINTEF has been informed of this decision.

The concept of using Data Quality for autonomous shipping is presented in the presentation DQWG16_2021_09.1B_EN_Autonomous shipping and Data Quality – Mindmap. This paper provides an explanation to the slides:

[slide 2 – Concept of Data Quality] is an image from ISO19157.

[slide 3 – Accuracy] describe the definition of accuracy in ISO19157. Positional accuracy can be divided into absolute or external accuracy, relative or internal accuracy and gridded data accuracy. Within S-101 feature catalogue, this is defined as horizontal position uncertainty and as vertical uncertainty. Both items are complex attributes, composed of two attributes: uncertaintyFixed and uncertaintyVariableFactor. The general public will recognize the word accuracy, within S-101 we use the word uncertainty (high accuracy = low uncertainty).

[slide 4 – autonomous shipping]: autonomous shipping is partly about avoiding collision. In congested areas, the primary risk is collision to other ships (H2H). In remote areas, the primary risk is collision to underwater objects/shoals dangerous to safe navigation. The presented possible levels of automation is provided by the paper introduced by Rolls Royce at IMO.

[slide 5 – Uncertainty Zone]: is an image from SINTEF, describing the uncertainty zone of a vessel to other vessels and to man-made structures. SINTEF also provides a conceptual proposal how to present the Uncertainty Zones to the seafarer. For a single point, the presentation is a circular area. For a 2-D area, the presentation is an outer area around the object. For a 3D volume, the presentation is an outer volume around the object. By default it will show the 95% Confidence Interval, which is the standard value used within IHO standards (S-44, S-57, S-101). For a line, a (or two) parallel line would present the uncertainty.

[slide 6 – Zone of Confidence]: Within S-57, the Zone of Confidence (CATZOC) has been in use for > 25 years to provide a generic quality indicator. This is presented in a screen wide symbology by upside down triangle or horizontal bars, with stars inside indicating the quality level. The S-57 UOC par.6.3.2 shows an example how an obstruction area can be created around two or more adjacent wrecks. It indicates the known extent of the actual physical area obstruction that caused these wrecks. This area may have its own area of uncertainty.

If we follow the same concept as from SINTEF, than a circular area can be drawn around a single point object, an area around multiple point objects or one or more area objects. The portrayal symbology should be the same as the one that is used within the Uncertainty Zone concept around individual ships. This way, seafarers will easily recognize the meaning of the symbology.

[slide 7 – sounding different depth values]: The sounding value of a shoal, when related to a specific vertical datum, has three different values. First the stored value in the ENC as provided by the cartographer. Next the rounded depth value presented by the S-52 Conditional Symbology Procedure. Finally the worst-case depth taking into account the vertical uncertainty of the stored depth in the ENC. If SOUACC (S-57) or Vertical Uncertainty (S-101) is provided then that value is used. If individual values are not provided, than the value is computed from the CATZOC table (see paper HSSC12-05.5B).

[slide 8 – Sounding presenting the worst case]: This shows an example of a sounding with a stored value of 21.97 m. The ECDIS Conditional Symbology Procedure SNDFRM04 (S-52 Presentation Library Ed.4.0.2 part 1, page 178) will truncate this to 21.9 m. Depending on the overlaying CATZOC value, the worst case depth is 21.25, 20.53 or 18.87 m. Accordingly, the presented values will be rounded to the shallowest dm, providing a value of 21.2, 20.5 and 18.8 m. Accordingly a circular area is presented around the sounding to represent the horizontal position uncertainty.

[slide 9 – Depth contours, vertical uncertainty?]: In the current S-101 Data Model, depth contours are a feature type with the two attributes, value of depth contour (mandatory) and scale minimum (optional). A depth contour is defined as “a line connecting points of equal water depth which is sometimes significantly displaced outside of soundings, symbols and other chart detail for clarity a well as generalization.” The remarks are: “depth contours, therefor often represent an approximate location of the line of equal depth as related to the surveyed line delineated on the source.”

In the present S-57 model, depth contours do not carry a vertical uncertainty. It is suggested that in the S-101 the complex attribute vertical uncertainty is added to the feature type depth contour. The vertical uncertainty is a complex attribute that consists of the attributes uncertainty fixed (mandatory) and uncertainty variable (optional).

A measured depth has a 95% confidence interval. By subtracting the 95% confidence interval from the measured depth, the worst-case scenario is available for autonomous shipping as well as human interpretation. This will become vital in a scenario where autonomous ships will have to compute the minimum risk if it is faced with a situation where collision to another ship becomes likely but the maneuver to avoid this collision may actually increase the risk of collision to under water objects dangerous to navigation. In such a situation, the impact assessment does need appropriate uncertainty values of the ENC as provided by the Hydrographic Office.

Conclusions and recommendations

Since 2007, the HSSC has tasked the DQWG to provide a method to present the quality of data. At HSSC-12, the developed methodology was presented and accepted. Its results are handed over to the S-101PT. However, any technique developed will most likely be used for at least 25 years. It is believed that the focus should not only be about portrayal of data quality but also take into account the requirements to facilitate autonomous shipping.

NLHO has decided that when making the transition from S-57 to S-101, appropriate uncertainty values will be populated for all relevant objects and areas within the S-101 ENC to support any new portrayal mechanism to be developed by the S-101PT as well as autonomous shipping.

The ENC presentation to the seafarer can stay as it is today (according to S-52 Conditional Symbology Procedures). But with a simple ON/OFF switch, the worst-case values can be portrayed by simply using a new Conditional Symbology Procedure. Additionally, areas of uncertainty can/should be drawn around point objects and area objects. This way the human eye and computer algorithm for autonomous shipping have an identical picture/value and to humans it is understandable what the computer algorithm is doing.

It should be considered if depth contours in the S-101 data model should have the complex attribute vertical uncertainty added to its feature type.

Justification and Impacts

The IHO was established to globally improve the safety of navigation. In order to do so, it harmonized paper nautical charts and its presentation. Then it harmonized digital nautical charts and its presentation. It is only natural that for future technical developments in autonomous shipping, the IHO will continue to play an active role in the harmonization process by providing ENCs with accuracies/uncertainties as required and symbology procedures that are recognized by the shipping industry, seafarers and Hydrographic Offices.

Action Required of the DQWG

The DQWG is invited to:

a. Circulate this paper within its own organization;
b. Discuss this paper and presentation;
c. For DQWG Member States only, consider to adapt the policy to actively start populating appropriate uncertainty values in S-101 ENCs;
d. Bring this to the attention of the HSSC and request to consider a way forward.