Paper for consideration by HSSC

Proposal for a conditional visualization methodology of Quality of Bathymetric Data

Submitted by:	DQWG Chair
Executive Summary:	Paper proposing a new method to display quality information in an ECDIS.
Related Documents:	HSSC9-05.2D, NCWG3-08.4A, DQWG14-08C, DQWG14-Final Minutes, S-101 Data Classification and Encoding Guide_1.0.0_Clean_20181022
Related Projects:	HSSC10/47, IHO CL50/2017

Introduction / Background

At HSSC-1 (22-24 October 2007) a revised DQWG Work Plan was proposed and endorsed, including defining a better way of depicting to the mariner the quality of the underlying data that has been compiled into the chart or ENC. Up to HSSC9 this was not completed. At HSSC9, DQWG was requested to develop a conditional visualization methodology of quality of bathymetric data in liaison with NCWG, NIPWG, ENCWG, S-101PT. (ref HSSC9/35. HSSC10/47). This paper is the result of the efforts of the DQWG since HSSC9.

Analysis/Discussion

The list below shows the various efforts that have been previously made by DQWG to depict quality and reported at HSSCs:

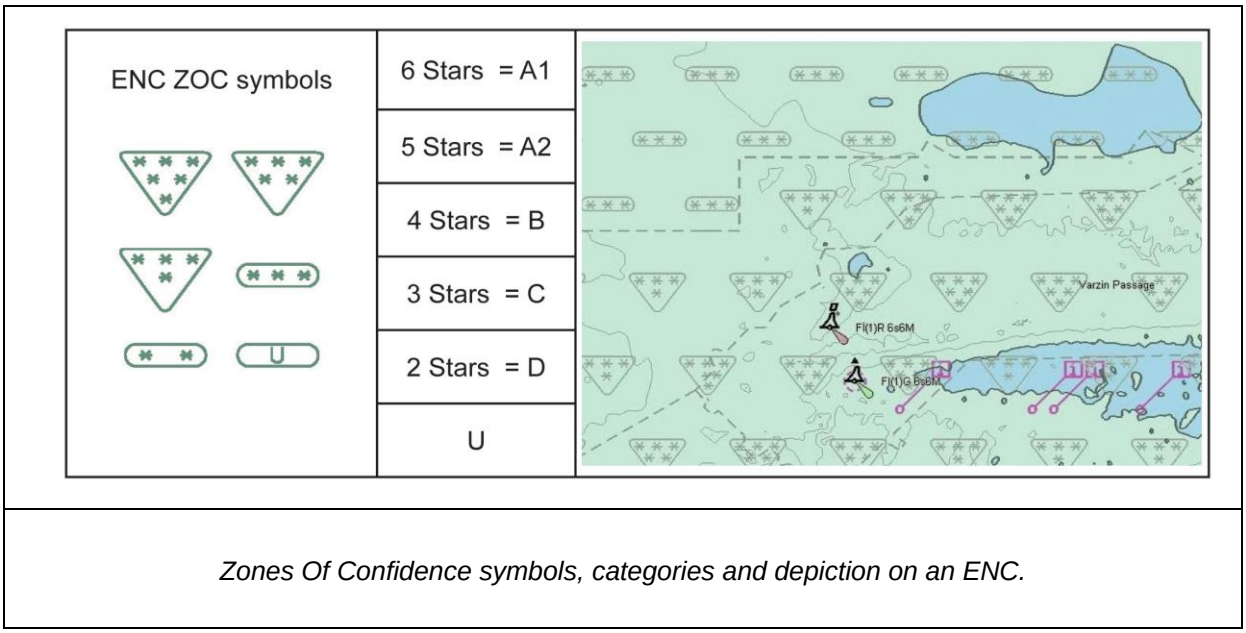
- "The fundamental problem is to define a better way of depicting the quality of the underlying data that has been compiled into the chart or ENC to the mariner." (HSSC1-06.6A rev.2).
- "The DQWG concluded that to support future expected uses of data quality in S-101, hydrographic offices should populate POSACC, SOUACC and TECSOU in M_QUAL if these values are better than specified by the CATZOC shown for the area. This will allow S-101 to build a different (as yet undecided) composite data quality indicator from S-57 data sets." (HSSC3-05.6A).
- "The University of Southern Mississippi (USM) propose a two stage approach: stage 1 will visualize individual data quality indicators (e.g. color banding based upon horizontal uncertainty). Stage 2 will look at how these individual visualizations can be combined to provide a composite indicator." (HSSC4-05.6A).
- "Essentially the findings of USM confirmed that the concept of representing data quality by a color wash overlay of red for poor, yellow (amber) for medium and green (or clear) for good is the most intuitive and clearest means of doing so." (HSSC5-05.6A)
- "One conclusion from this work was that the long held view that the final data quality display should be a red, amber or green color wash overlay was abandoned." (HSSC6-05.6A rev.1).

The current system consists of S-57 data objects, attributes and S-52 presentation library. The current method to portray data quality is by activating the M_QUAL meta object with symbols for CATZOC. Below is a list of characteristics of the S-52 Presentation Library:

CATZOC	symbol name	symbol explanation	symbol size	color	pattern
A1	DQUALA11	5m accuracy, full seafloor coverage	16.97x11.84	CHGRD	constant staggered
A2	DQUALA21	20m accuracy, full seafloor coverage	16.97x11.84	CHGRD	constant staggered
B	DQUALB01	50m accuracy, lines of soundings	16.97x11.84	CHGRD	constant staggered
C	DQUALC01	low accuracy or incomplete chart	16.04x4.30	CHGRD	constant staggered
D	DQUALD01	unreliable chart	16.04x4.30	CHGRD	constant staggered
U	DQUALU01	chart with quality not assessed	16.04x4.30	CHGRD	constant staggered

Table1: list of S-52 symbols for M_QUAL/CATZOC

Symbols A11, A21 and B01 have a constant staggered pattern type with a distance of 14.00 mm. Symbols C01, D01 and U01 have a constant staggered pattern type with a distance of 16.00mm. Line weight of all symbols is 0.3 mm. Below a depiction of these symbols in an ENC.



Zones Of Confidence symbols, categories and depiction on an ENC.

Figure 1: ENC ZOC symbols on an ENC

The depiction is a constant and staggered pattern. This has the following disadvantages:

- the boundary of the area that the symbol is valid for is not clear;
- there is no direct visible relation between the size of the symbol and the area it is valid for;
- there may be a small area in-between the symbols with a different quality value;
- there are two types of symbols, a triangle and rounded rectangle, there are six different quality values;
- the number of * inside the symbols are not easy to differentiate;
- the size of the symbol is relatively large (in mm), when zooming in the symbol can be depicted over two different quality levels. The value at the pivot point of the symbol is taken and displayed. This can lead to serious misinterpretations of the quality of the underlying data.

Workshop at DQWG14 meeting:
Autonomous shipping is on the IMO agenda and navigation products have to be supportive to this development. There is a strong need to know the quality of the underlying information when decision making is done. The Chair introduced paper DQWG14-08C and the associated paper NCWG3-08.4A and the written response from the Australian Hydrographic Office. The following observations were made:

- A Data Quality Indicator is needed for Risk Management by the Mariner;
- A screen wide overview is needed for spatial awareness;
- Current CATZOC system and symbology are in use > 20 years, it is proven technology;
- Current CATZOC is (almost always) turned off during execution of the voyage;
- Current CATZOC symbols were developed when "simple" VGA monitors were the standard with low screen resolution, todays monitors can show more detail;
- The NCWG3-08.4A proposal symbology is not intuitive, it is not clear what the symbols mean when shown in isolation;
- The NCWG3-08.4A proposal is still cluttering the screen and likely to be turned off during voyage;
- The NCWG3-08.4A proposal to use a "safety corridor" as a check route functionally is welcomed:
- The DQWG14-08A proposal is usable for monitoring but lacks spatial awareness for planning;
- The DQWG14-08A proposal requires interaction of Quality of Bathymetric Data with other data elements of an ENC (e.g. isolated features hazardous to navigation);
- In current ECDIS systems, the Mariner has the option to set a Safety Depth (needed for under keel clearance) and XTD (needed to avoid isolated dangers hazardous to navigation);
- A new setting should be added: level of confidence;
- The Mariner can enter his required level of confidence, the combination of safety depth and level of confidence will compute a SAFETY ZONE around and under the vessel;
- Alarms (audible/visible) should be developed when the SAFETY ZONE is breached, both in planning and monitoring mode;
- It was recommended that in planning mode a message is displayed, that a planned route will not be saved automatically if the SAFETY ZONE for the intended route contains any dangers to the vessel, unless over-ridden by the Mariner.
- In planning mode, a "show detail" option is to be developed, providing detailed information along the route where the SAFETY ZONE is breached;
- DQWG welcomes the recommendation from the Australian Hydrographic Office that HOs are encouraged the use of QUAPOS=3 or 4 in DEPCNTs within ZOC D (any depth) or ZOC C areas (depth =<30m).

End users perspective on ENC and ECDIS

Intertanko has submitted a paper (HSSC9-05.2D) making reference to IHO CL50/2017. The paper has the following items to note:

- safety contour and safety depth;
- quality of ENC data;
- marking in ECDIS and charts;
- spot soundings in presentation library 4.0

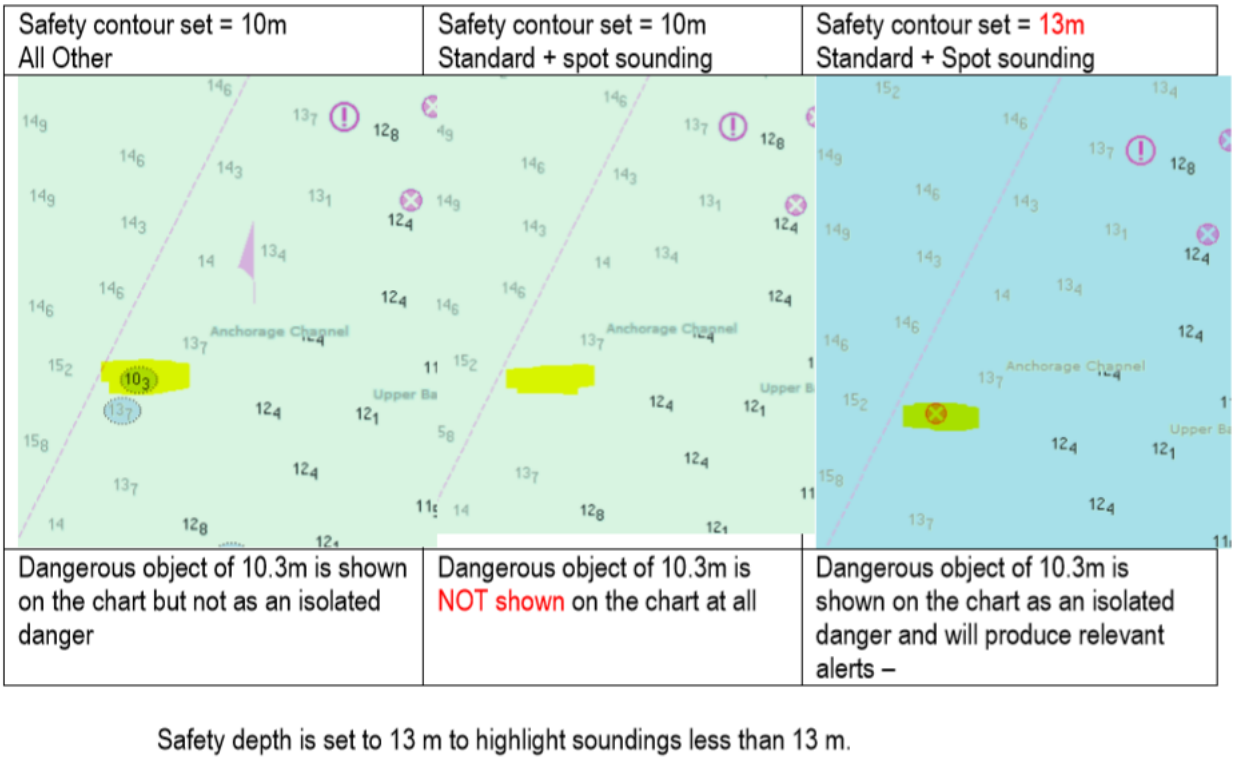


Figure 2: marking in ECDIS and charts

Above some images presented in this paper.
Comment from Intertanko: "It's very difficult to understand how it has been made selectable for obstructions with soundings in the ECDIS charts. This can prove to cause groundings if this has been unticked by mistake."

Proposal for the development of the conditional visualization methodology of the quality of bathymetric data
Based on the papers and the discussion at DQWG14, the following proposal is made:
A smart algorithm is needed. Vertical and Horizontal Quality of Bathymetric Data is taken into account when assessing a safe passage in planning mode and alerting the Mariner when executing the voyage. The vertical uncertainty of the depth area is used to test a safe passage using the associated Quality of Bathymetric Data. Isolated features, hazardous to navigation (UWTROC *under water rock*, WRECKS *wreck*, OBSTRN *obstruction* and SOUNDG *sounding*) have their own individual vertical uncertainty (QUAPOS, VERACC). However, this is at present in S-57 an optional field. If this field is left empty, the algorithm will use the vertical uncertainty of the area, apply this to the isolated feature and validate if a safe passage over the isolated object does not breach the vessel's SAFETY ZONE.

To stay horizontally clear of isolated features, dangerous to navigation, the horizontal uncertainty value is used. If an isolated feature has a value for its horizontal uncertainty (QUAPOS, HORACC) it is used. If the horizontal uncertainty of the isolated feature is unavailable, the horizontal uncertainty of the Quality of Bathymetric Data of the area that the isolated features is located in, will be applied.

When combining both the vertical and horizontal uncertainty, the algorithm will validate if the SAFETY ZONE (Under keel clearance, across track distance) is breached. This will trigger a SAFETY ZONE alert to be inspected by the Mariner. (show details – mandatory – before accepting this alert).

If the isolated feature (when applying associated uncertainty) is shallower than the vessel's draught, a GROUNDING ALERT will be triggered.

Current ENC's have a number of standard contour lines in the range 0 to 200m. In the table below, the associated Vertical and Horizontal Uncertainties are listed:

	Vertical Uncertainty						Horizontal Uncertainty				
DEPCNT	A1	A2	B	C	D		A1	A2	B	C	D
0	0.5	1.0	1.0	2.0	>2.0		5.0	20	50	500	>500
2	0.5	1.0	1.0	2.1	>2.1		5.1	20	50	500	>500
5	0.6	1.1	1.1	2.3	>2.3		5.3	20	50	500	>500
10	0.6	1.2	1.2	2.5	>2.5		5.5	20	50	500	>500
20	0.7	1.4	1.4	3.0	>3.0		6.0	20	50	500	>500
30	0.8	1.6	1.6	3.5	>3.5		6.5	20	50	500	>500
50	1.0	2.0	2.0	4.5	>4.5		7.5	20	50	500	>500
100	1.5	3.0	3.0	7.0	>7.0		10.0	20	50	500	>500
200	2.5	5.0	5.0	12.0	>12.0		15.0	20	50	500	>500

Table 1: list of Vertical and Horizontal Uncertainty at mandatory DEPCNTs.

The concept of Spatial Quality is defined in the S-101 Data Classification and Encoding Guide, paragraph 24.5

IHO Definition: **SPATIAL QUALITY**. Definition required				
S-101 Information Type: Spatial Quality				
Primitives: None				
S-101 Attribute	**S-57 Acronym**	**Allowable Encoding Value**	**Type**	**Multiplicity**
horizontal position uncertainty			C	0,1
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
quality of horizontal measurement	(QUAPOS)	1: surveyed 2: unsurveyed 3: inadequately surveyed 4: approximate 5: position doubtful 6: unreliable 9: estimated 10: precisely known 11: calculated	EN	0,1
vertical uncertainty			C	0,1
uncertainty fixed	(VERACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	1,1

Table 5: S-101 Information Type Spatial Quality

POSACC and VERACC are numerical quality indicators.
QUAPOS is a descriptive quality indicator.

Autonomous shipping

When talking about maritime autonomous surface ships (MASS), the IMO Maritime Safety Committee (MSC) uses the preliminary definitions of MASS and degrees of autonomy – four of the latter:

- A ship with automated processes and decision support. Seafarers are onboard to operate and control shipboard systems and functions, but some operations may be automated;
- Remotely controlled ship with seafarers onboard;
- Remotely controlled ship without seafarers onboard;
- Fully autonomous ship.

The proposal for conditional visualization methodology of Quality of Bathymetric Data will support decision making by the seafarer. In future it may be integrated into remotely controlled ships and possibly finally in fully autonomous ships.

Conclusions

Current CATZOC symbology is still needed for overall spatial awareness but the type of symbol and the staggered pattern should not be used in S-101.The development of a methodology to depict Quality of Bathymetric Data has been a long outstanding request and proven difficult to resolve. The transition from S-57 to S-101 opens new opportunities to provide better mechanism to the Mariner to support decision making and improving safe navigation.

Recommendations

The following recommendations are made for the other HSSC WGs/PTs:

- A Data Quality Indicator is needed for Risk Management by the Mariner;
- A screen wide overview is needed for spatial awareness
- Quality of Bathymetric Data symbol should be area centered, maximum size = 5 mm;
- Avoid screen clutter;
- Boundaries of QoBD should be visualized;
- Check route functionality should be introduced for both planning and monitoring;
- Use QoBD values and if available QUAPOS, POSACC and VERACC to validate SAFETY ZONE under/around the vessel;
- Create clear warning signals (show details/accept) for SAFETY ZONE alerts in planning and monitoring mode.

The following recommendations are made for HOs:

- Provide meaningfull Quality of Bathymetric Data values (unassessed should not be used);
- Provide horizontal and vertical uncertainty of individual features, hazardous to navigation, mainly in areas shallower than 30m and in/close to major shipping routes;
- Assing DEPCNTs with QUAPOS = 3 (inadequately surveyed) or QUAPOS = 4 (approximate) in areas with CATZOC = D (all depths) or CATZOC = C (shallower than 30m);
- Be aware of the vertical uncertainty when generating high density ENCs in areas with CATZOC C or D.

Justification and Impacts

This concept will be supportive for the development of autonomous shipping and may prove to be very valuable when planning a safe voyage in areas of lower Quality or alerting Mariners for possible ground risks along their route.

Action Required of HSSC

The HSSC is invited to:

a. Note this paper;

b. Provide recommendations as needed;

c. Approve to continue this development for testing and implementation;

d. Assign the appropriate task to the HSSC WG (NCWG – lead?) in liaison with DQWG, NIPWG, ENCWG, S-101PT, involving if possible academia, training centers, expert contributors, and industry partners.