Data Quality for Nautical Publications

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David Acland, UKHO; Raphael Malyankar, Jeppesen; Eivind Mong, Jeppesen; Jens Schröder-Fürstenberg, BSH; Malcolm Tennant, UKHO, with contributions by Pelle Aargard, KMS.

Executive Summary

This paper outlines the current status of work by the SNPWG data quality sub-group on data quality for nautical publications information in the S-100 framework. The paper describes considerations identified by the sub-group as being relevant to the data quality of nautical publications information. A partial data quality model based on these considerations was prepared as a basis for discussion and is briefly described. The ISO data quality elements in the relevant ISO publications and S-100 are described, and their relevance to nautical publications information assessed. Further aspects of data quality for nautical publications are outlined, specifically, data quality measures, data quality indicators, and data quality management, strategies, and processes.

Attachment: Proposal for Nautical Publications Data Quality.

1. Introduction

This paper outlines the results of discussions on data quality for nautical publications information. The scope of this effort is limited to nautical publications; data quality issues for other types of data, in particular, ENC and bathymetric data, are not included. Tide tables are also excluded. The rest of this paper should be interpreted as referring to quality considerations only in the context of nautical publications, unless explicitly stated otherwise.

The overall question of data quality for nautical publications must be addressed from at least two points of view: the quality of collections of information, and the quality of individual chunks of information. ISO publications on data quality for geographic information, as well as the S-100 standard, largely address it from the `collections' aspect. The IHO Data Quality Working Group has recently prepared a proposal for data quality in S-101 ENC data which also addresses the issue from the point of view of uncertainty for specific features.

2. Definitions

data quality element
Quantitative component documenting the quality of a dataset. The applicability of a data quality element to a dataset depends on both the dataset's content and its product specification, the result being that all data quality elements may not be applicable to all datasets [ISO 19113].

data quality indicator
A numeric or categorical value, annotation, or visual indication, which conveys information about data quality to the application developer or end user. Indicators may be literal reports of quality metadata accompanying the data, or visual indications suitable for end-user displays.

data quality measure
A quantitative indication of quality according to a clearly defined criterion or computation. Measures may be reported as quality metadata. (ISO 19113: Type of test applied to the data specified by a data quality scope.)

data quality overview element

non-quantitative component documenting the quality of a dataset
NOTE: Information about the purpose, usage and lineage of a dataset is non-quantitative quality information. [ISO 19113]

data quality result
value or set of values resulting from applying a data quality measure or the outcome of evaluating the obtained value or set of values against a specified acceptable quality level
EXAMPLE: A data quality result of “90” with a data quality value type of “percentage” reported for the data quality element and its sub-element “completeness, commission” is an example of a value resulting from applying a data quality measure to the data specified by a data quality scope. [ISO 19113]

data quality sub-element
component of a data quality element describing a certain aspect of that data quality element. [ISO 19113]

data quality scope
extent or characteristic(s) of the data for which quality information is reported
NOTE: A data quality scope for a dataset can comprise a dataset series to which the dataset belongs, the dataset itself, or a smaller grouping of data located physically within the dataset sharing common characteristics. Common characteristics can be an identified feature type, feature attribute, or feature relationship; data collection criteria; original source; or a specified geographic or temporal extent. [ISO 19113]

data quality value type
value type for reporting a data quality result
EXAMPLE: “boolean variable”, “distance”, “percentage”, “ratio”
NOTE: A data quality value type is always provided for a data quality result. [ISO 19113]

3. Considerations for Quality of Publications Information

The group discussed several factors and identified the following as affecting the quality of publications information or as potential metadata which would help the mariner assess the quality.

The quality of ENCs is not part of this discussion. A discrepancy in the ENC is a matter for ENC Production groups.

3.1. Age

Age may be a factor for some kinds of information but is not necessarily a measure of quality. Something may be 50 years old but still reliable. Meta-information such as the date of the publication is often used to evaluate reliability. If the age of specific information matters, the information may be qualified by a note saying when the information was last obtained/confirmed or a warning that it may change (e.g., “channel may shift due to silting”). Factors which may affect either the data itself or which may guide the metadata published with the information itself are:

1. How old is the data, or when was it last confirmed?
2. Will the data get out of date? Why? Examples:-
   2.1. Mobility of seabed due to silting, storms, etc.
   2.2. New construction and demolition, tree line changes, landscape changes
   2.3. Seasonal changes such as the effects of icing on location of “shoreline” and seasonal changes in navigation aide – e.g., winter buoyage.
   2.4. Regulatory changes.
   2.5. Events - mishaps to navigation aids and vessels, equipment failure and drift of aids.

Date is sometimes included in the text. Statements like "Development in progress (2008)" might suggest that the new facility is complete and already in service in 2011. In an S-100 product we should increasingly be able to populate the source date (SORDAT) attribute.

3.2. Source

Source is apparently used sometimes as an (informal?) measure and is sometimes reported as a proxy for quality metadata.

1. Dependency on charted data – publications may remark on or mention the presence of major navigation aids, landmarks, radar reflectors, etc. Whether these are correctly represented is theoretically a factor in the quality of NPubs information. ENC quality is not in scope of this paper.
2. Publications sometimes have information about features which are not included in the ENCs.
3. For information obtained from port authorities or extracted from port information guides, mentioning the source may be a useful indicator.
4. For routeing measures and traffic separation schemes, mentioning the source may be a useful indicator.
5. Sometimes mariners' reports are the source of information. Questions arise when information provided by mariners is used, such as: How is it verified? How reliable is it? How does an HO indicate its reliability? UKHO rule of thumb is that the word of a qualified mariner is not normally disputed, particular if he or she has taken the trouble to make the report. However in all cases official support is sought for the initial report. If it arrives, great; if not, a decision has to be made based on the merit of the report and consequences of not publishing. If the information cannot be verified before publication it will be noted as "reported" and usually qualified by a date.
6. The source of a regulation may be an indicator of information quality. This is discussed in more detail in Section 3.3.

3.3. Special considerations for regulations, restrictions, recommendations, and nautical information

1. Regulations are issued by many authorities. There may be a question about which should prevail. The authority issuing the regulation should be considered as an indicator (perhaps given in the publication) of the reliability. The question is, under what circumstances should this be done?
2. Timeliness – how up-to-date is the material in the publication?
3. Accuracy:
   3.1. There may be a loss of nuances in encoding natural language with code lists. Coded data (coded in the SNPWG data model) may leave out nuances in language and detailed descriptions compared to the original text written in a human language.
   3.2. Summaries and extracts may not be completely faithful to the full text of regulations – for example, exceptions or special cases may be glossed over.
   3.3. General geographical position descriptions in regulations are portrayed with accurate position in GIS systems.
   3.4. Full text is the only option indicating that that the text was taken literally from the Act/Law.

3.4. Indication of locations

Many entries in sailing directions are made with reference to a prominent feature. Often the hazard or information refers to something which may be phrased something like: " ... between 10 and 20 miles southwest of Cape Snipwig" or even " ... to seaward of Cape Snipwig". This may be something which depends on the encoding – GML allows us to indicate geometry latitude/longitude,

reference to a fixed point (i.e., a radius) or describing a location verbally using a text string. Discussions of the relative locations approach and the implications for data quality are ongoing as of the writing of this paper.

3.5. Data purpose and usage

Purpose and usage may affect the measures and indicators for data quality.

3.5.1. Voyage monitoring vs. voyage planning

There is no reason to distinguish voyage monitoring and voyage planning as far as data quality is concerned.

3.5.2. Data consumer

The sub-group discussed distinguishing between SOLAS and non-SOLAS shipping. The important point here is whether the information is to be "used for navigation" or not. If it is to be used for navigation by vessels which need to comply with SOLAS Chapter V it has to be issued by an HO. However HOs can also issue information designed for the leisure market. In the case of charts, that means they can stick port plans all over the seaward part of a chart, where they would never be for a SOLAS product. Similarly in a leisure publication, detail might not be updated so often, there may be many more glossy photographs and details of grocery stores or fuel points could be included which has no relevance to SOLAS shipping.

- SOLAS shipping (primary): SOLAS shipping is currently considered the primary target of data quality measures and indicators being defined by SNPWG.
    - Constraints: SOLAS shipping must comply with IMO regulations and are liable to inspection by Port State inspectors.
    - Users: Masters of vessels and bridge watch keepers are trained in the use and maintenance of nautical charts and publications and hold the required professional qualification for their role.
- Non-SOLAS shipping, for example; pleasure boating, fishing, navy, governmental, on-shore operation, etc. (The inland waterways commercial sector may also be relevant. They are probably more regulated than leisure users; the sector is not always contained by one nation state, particularly in Europe where waterways span several nations. However the IHO does not control standards for nautical products for this sector.)
    - Constraints: Non SOLAS vessels must comply with national regulations. In some states regulation is limited. Charts and publications are not likely to be up to date, if carried at all. Those that are carried, including electronic products, are likely to be unofficial.
    - Users: Characterized by users of a very wide ability, often with limited training and with little or no formal qualification.

Consequences for data quality discussion: The focus of our Data Quality discussion should be on SOLAS shipping. However we should be open to the techniques and experience in inland waterways and non-SOLAS sectors. Within these parameters, the data quality discussions should take into account the constraints and user characteristics in designing the data quality model and determining quality elements.

3.5.3. Use

Quality considerations should address the coarseness of information. (How scale-independence of data might change these considerations is TBD.)
The usage bands in S57 can be used as a proxy for information uses. The bands are:

1. Overview
2. General
3. Coastal
4. Approach

5. Harbor
6. Berthing

Oceanic data on climate can be coarser than harbor and berthing data which needs to be finer grain.

3.5.4. Use environment

Considerations which may affect the definition of quality measures and indicators are:

1. Printed information vs. on-screen display: should be taken into consideration for symbology, fonts, etc. “Designed for printing” vs. “designed for online use” also might be used as quality indicator especially for graphics.
2. Local data vs. Web access: This might affect the size of data or downloads available, perhaps also timeliness (consider near-real-time updates vs. updates distributed by mail).

3.6. Considerations for pictorial information

Graphics in nautical publications may need quality measures and indicators specialised for nautical publications. Metadata for support files required by S-100/S-101 includes creation or update date and a CRC value computed on the content.

If quality measures specific to graphics are necessary, measures for the following types of graphics may be considered:

- Photographs
- Diagrams and harbor sketches
- Chartlet/chart extract
- Graphics for print use vs. graphics for online use (e.g., resolutions)

Another question is: What are the differences between quality measures for printed vs. online use?

Specific quality measures for pictorial information are given later in this paper.

Some quality measures may be mandatory; others not.

4. Data quality scopes

Quality information can be provided for subsets ranging from the exchange set through defined feature collections down to individuals. The quality metadata levels (data quality scopes) are listed below:

- Exchange set
- Data set
- Support file
- Area (e.g., specified port, waterway, or VTS area)
- Feature class (all features of a specified class or classes, e.g., all VTS areas)
- Feature instance level – pertaining to an individual feature or information object.
- Attribute level – pertaining to a specific feature attribute (but it is not clear at the moment whether this is possible within the S-100 framework).

5. Data Quality Core Model

The Data Quality Working Group (DQWG) recently proposed a model for ENC data quality (TSMAD 23-4.5.13, 13A, 13B). The DQWG model proposes encoding data quality at three levels: dataset, meta feature area, and feature instance. This proposal was adapted for nautical publications

information and the adapted proposal is described in an attachment to this paper. It is supplied as a basis for further discussion by SNPWG and includes a UML model as well as possible new features and attributes.

The model described in the attachment would be a “core” model, extensible for MPA or other products as necessary. The classes and attributes are somewhat different from the DQWG figure, being constructed from the “Considerations” in the previous section. Note that it covers only some of the data quality considerations and scopes mentioned earlier in this paper; the remainder will be addressed in other places, e.g., the “purpose” considerations appear to be appropriately addressed in dataset or exchange set metadata, the pictorial information considerations in support file metadata.

6. Quality elements and metadata

6.1. Data quality overview elements

The data quality overview elements provide general, non-quantitative information for a dataset. The data quality overview elements defined in ISO 19113 are:

- purpose: The rationale for creating a dataset and information about its intended use.
- usage: The application(s) for which a dataset has been used. Usage describes uses of the dataset by the data producer or by other, distinct, data users.
- lineage: The history of a dataset and the life cycle of a dataset from collection and acquisition through compilation and derivation to its current form. Lineage may contain two unique components:
    - source information: The parentage of a dataset,
    - process step or history: A record of events or transformations in the life of a dataset, including the process used to maintain the dataset whether continuous or periodic, and the lead time.

6.2. ISO quality elements

The quality elements defined by ISO are a starting point for conceptual definitions. This section lists the ISO 19113 quality elements and their relevance to nautical publications. ISO definitions of data quality elements are reproduced in Table 1 and sub-elements in Table 2.

Table 1. Quality elements and defintions (from ISO 19113)

Data quality element	Definition
completeness	presence and absence of features, their attributes and relationships;
logical consistency	degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical);
positional accuracy	accuracy of the position of features;
temporal accuracy	accuracy of the temporal attributes and temporal relationships of features;
thematic accuracy	accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships.

Table 2. Data quality elements and sub-elements (from ISO 19113)

Data quality element	Data quality subelement	Definition
completeness	commission	excess data present in a dataset
	omission	data absent from a dataset
logical consistency	conceptual consistency	adherence to rules of the conceptual schema
	domain consistency	adherence of values to the value domains
	format consistency	degree to which data is stored in accordance with the

		physical structure of the dataset
	topological consistency	correctness of the explicitly encoded topological characteristics of a dataset
positional accuracy	absolute or external accuracy	closeness of reported coordinate values to values accepted as or being true
	relative or internal accuracy	closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true
	gridded data position accuracy	closeness of gridded data position values to values accepted as or being true
temporal accuracy	accuracy of a time measurement	correctness of the temporal references of an item (reporting of error in time measurement)
	temporal consistency	correctness of ordered events or sequences, if reported
	temporal validity	validity of data with respect to time
thematic correctness (thematic accuracy)	classification correctness	comparison of the classes assigned to features or their attributes to a universe of discourse (e.g. ground truth or reference dataset)
	non-quantitative attribute correctness	correctness of non-quantitative attribute
	quantitative attribute accuracy	accuracy of quantitative attributes

6.3. Quality metadata

S100 Part 4 can be extended with more quality measures as needed. Not all mandatory elements in S100 may be appropriate. Of the data quality metadata elements in Appendix 4c-B of S-100, the only mandatory elements appear to be scope, description, and one of “lineage” or “data quality report”; in Appendix 4c-C (Hydrographic Quality Metadata Attribute Definitions), the attributes have lower bound of “0” on multiplicity. The table below lists the data quality metadata classes from S-100 and their relevance for data originators, data providers, and end users in NPubs.

Many of the metadata elements in this table appear to apply at the dataset level and it would not be possible to provide this metadata at the feature level. We would prefer it at the dataset level, or perhaps one lower, perhaps like a port or waterway or a VTS.

Table 3. Data quality elements from S-100

Data quality metadata class	**Description**	**Relevance to NPubs**	
		Originator, Provider	**End user**
DQ_AbsoluteExternalPositionalAccuracy (Note a)	Closeness of reported coordinative values to values accepted as or being true [per ISO 19115]	yes	yes
DQ_AccuracyOfATimeMeasurement (Note b)	Correctness of the temporal references of an item (reporting of error in time measurement) [per ISO 19115]	no	no
DQ_CompletenessCommission	Excess data present in a data set per ISO 19115	Yes	No
DQ_CompletenessOmission	Data absent from a data set [per ISO 19115]	yes	yes
DQ_ConceptualConsistency (Note c)	Adherence to the rules of a conceptual schema [per ISO 19115]	yes	yes
DQ_DomainConsistency (Note c)	Adherence of values to the value domains [per ISO 19115]	yes	yes
DQ_FormatConsistency (Note c)	Degree to which data is stored in accordance with the physical structure	yes	yes

	of the data set. [per ISO 19115]		
DQ_GriddedDataPositionalAccuracy (Note d)	Closeness of gridded data position values to values accepted as or being true [ISO 19113]	no	no
DQ_NonQuantativeAttributeAccuracy	correctness of non-quantitative attribute [per ISO 19115]	yes	yes
DQ_ QuantativeAttributeAccuracy	Accuracy of a quantitative attribute [per ISO 19115]	yes	yes
DQ_RelativeInternalPositionAccuracy (Note e)	Closeness of the relative positions of features in a dataset to their respective positions accepted as or being true [per ISO 19115]	yes	yes
DQ_TemporalConsistency (Note b)	Correctness of ordered events or sequences, if reported. [per ISO 19115]	no	no
DQ_TemporalValidity	Validity of data with respect to time. [per ISO 19115]	yes	yes
DQ_ThematicClassificationCorrectness	Comparison of the classes assigned to features or their attributes to a universe of discourse. [per ISO 19113]. For example; ground truth or reference dataset.	yes	yes
DQ_TopologicalConsistency	Measures of the topological consistency of geometric representations of features. [Adapted from ISO 19138]	yes	no

Notes:
(a) Positional accuracy can be applied to many of the positions in SDs. The reason for most positions in the text of an SD is to guide the reader to the feature on the chart. The resolution of a geographic position should have been chosen to make sense in the context of the subject and the scale of the reference chart.
(b) Not required for most nautical publications in scope. It could be relevant for Tidal and water level Information but there is limited Tidal information in Pilots and SDs. There is a time, date or season component to some radio signals and environmental information but we do not need to give this information with a temporal accuracy. This appears to have more to do with data coming from a sensor.
(c) If this is like XML being "well-formed " and "valid".
(d) Although we have limited gridded data in SDs at the moment, this could change.
(e) The relevance of "relative or internal accuracy" is uncertain although relative positions are frequently used in SDs. The resultant area of uncertainty depends on the relative distance. Again the purpose is to guide the eye of the reader to the feature being described.

[This analysis may need to be extended to the attributes of the metadata classes in the table, defined in the same Part of S-100, depending on what decisions are made about dataset level metadata for nautical publications.]

7. Quality measures for nautical publications

The attributes of the S-100 quality elements listed in Table 3 define specific quality measures for the sub-elements. The criteria or computations of quality measures depend on the nature of the information and the domain. Examples of quality measures are such things as error probabilities, existence and numbers of excess items and missing items, etc.

In general, the content of nautical publications and particularly the content of Sailing Directions, is an agglomeration of wisdom collected from many generations of mariners. Calibrated imprecision is used so that a single or a few valuable reports are not exaggerated into an inaccurate generalization.

ISO 19138 defines several quality measures for geographic datasets. S-100 defines several measures in Appendix 4C-C (in the form of definitions of attributes for data quality elements). Questions arising are:

- Which of the quality measures applying to charted information or bathymetry also apply to publications?
- What additional measures should be defined for nautical publication information?
- What qualitative terms should be defined for NPubs?

7.1. Quality measures for NP feature and information types

Quality measures defined for the above elements and sub-elements depend on the product specifications and cannot be fully defined at this stage.
[Measures can be listed in this section when they are defined, or as part of the definitions of attributes of data quality elements, as is done in S-100. One approach may be to define general or basic measures here and state that product specifications must define specific measures as needed.]

Note: DQWG decided it was more appropriate to talk about uncertainty than accuracy. Therefore, for ENCs, removal/retirement of the attributes POSACC, SOUACC and VERACC has been proposed. To replace them DQWG has proposed positionalUncertainty and verticalUncertainty, the latter is to replace both SOUACC and VERACC, which were both for vertical measurements. The proposal stems from the understanding of accuracy being how accurate something is (e.g. accurate to how many decimals) and uncertainty expressing what the possible error in a measurement is (e.g. +/- 5m). The SNPWG data quality discussion may wait on this aspect till DQWG's proposal is made at the upcoming TSMAD 23 meeting.

7.2. Quality measures for graphics

Diagrams and images may be accompanied with the following quality metadata (some of which might be pure metadata rather than quality):

1. Color, black and white, possibly grey scale
2. Resolution: 72dpi, 320dpi or other
3. Digital format: JPEG, JPEG2000, SVG, pdf, etc if more than one format is allowed.
4. Direction of view
5. Type of image: close-up, horizontal, bridge view, low oblique, high oblique, vertical
6. Date. For diagrams: compilation date
7. Position of camera: GPS, derived from the image, other
8. Attribution or credit for the image if known.

8. Quality Indicators

The quality measures defined earlier may (if appropriate) be reported as part of data quality metadata accompanying the dataset and therefore also function as quality indicators. It may be necessary to define means to provide quality metadata for different parts of the package – at the levels of exchange set, data set, support file, and records.

The DQWG draft proposal to TSMAD23 on data quality for ENC data proposes representing data quality using three main meta features; **QualityOfBathymetricData**, **QualityOfNonbathymetricData** and **QualityOfSurvey**. The first two are meta features which define areas within which uniform assessments of the quality of bathymetric and non-bathymetric data have been made; the quality values are encoded as their attributes. The third, **QualityOfSurvey** encode information about an individual survey and can apply to bathymetry (e.g. underwater rock), non-bathymetry (e.g. navigational aids) or a combination of these (e.g. lidar survey). The core model

described in the attachment uses similar meta features for NP information to carry the quality information.

8.1. Portrayal

The group decided to liaise with DQWG & DIPWG about this subject when quality indicators are sufficiently defined.

9. Data quality management, strategies, and processes

A simple and pragmatic approach is important, keeping in mind that nautical publications, and sailing directions in particular, are mainly companion guides to the chart, and also that concepts with quite ancient provenance like "Cautions", advice and information remain valid.

Considerations in the management of data quality are:

1. Importance of information
2. Frequency of use of information
3. Labor involved in improving quality, or achieving specified levels
4. Lifecycle of data
5. Volatility of data
6. Level of interaction with ENC when considering possibility of different update cycles which would affect portions of the data that is dependent on ENC data. – *depends on definition of products, which are yet to be defined.*
7. Provenance (original source, intermediaries, data transformations applied) – probably source and intermediaries are all that matters for publications?
8. Privacy – commercially sensitive information, privacy laws applicable – e.g., can photographs of the coastline be published if they include too much detail about dwellings?
9. Security considerations in connection with the level of detail in published information.

Concerning strategies and processes, the main questions here are about the definition of strategies (reference S-65 partially addresses similar issues for ENCs – see Stages 7, 8 in S-65). The strategies defined in S-65 will need to be adapted for nautical publications. The main questions are:

1. Should SNPWG prescribe or sketch strategies for text, graphics, and multimedia types and categories of NP data?
2. Should SNPWG define/refine strategies for quality control at different stages in the process?

Aspects to be considered are given below.

- Collection
- Data transformations (e.g., making extracts from shipping regulations; writing navigation notes pointing out specific dangers, etc.)
- Authoring of information unit in publication (e.g., writing a warning note, making a table of harbor services, etc.)
- Publishing
- Gathering of errata and updates
- Maintenance of publication

The definition of data management practices, processes and strategies is premature at this time and needs to be written after products have been created and used. Discussion of quality evaluation procedures will also take place later,

Definition of ‘Best Practice’ for different types of NP information (e.g., instructions for navigation, harbor facilities, rules and regulations, etc.) is considered to be premature at this time and is mentioned here only as a task to be taken up by SNPWG at a later date.

10. Next steps for SNPWG

At present it is possible to define only general elements, because products in the nautical publications domain need to be defined before specific elements can be defined.

Next steps for SNPWG:

1. Discuss this document in plenary or breakout sessions at SNPWG meeting(s).
2. Define a test product for product-specific data quality metadata and define the data quality considerations for it. The sub-group suggests the Marine Protected Area dataset.
3. Nominate a liaison with DQWG on quality measures and indicators.
4. Nominate a liaison with DIPWG on portrayal of quality information.

11. Actions required of SNPWG

The SNPWG is invited to:

1) Discuss this paper.
2) Arrange for liaison with DQWG and DIPWG as described in Section 10.

12. References

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