



7th Meeting of the Tides, Water Level and Currents Working Group

DQWG Report on the cross check of DQ chapters of S-104 and S-111

Agenda Item 4.6 (taken under Agenda Item 4.3)

VTC, 28-Feb-2023 ~ 02-Mar-2023



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1. INTRODUCTION/OVERVIEW

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According to the action DQWG 17/07, the subWG comprised of DQWG Chair, NL, SE and UNH has implemented the cross check of DQ chapters of S-104 and S-111.

IHO S-100 based Product Specifications (S-1XX):		
S-101	ENC Product Specification (Edition 1.0.0, December 2018)	Link
S-102	Bathymetric Surface Product Specification (Edition 2.1.0, October 2022)	Link
S-104	Water Level Information for Surface Navigation Product Specification (Edition 1.0.0, August 2021)	Link
S-111	Surface Currents Product Specification (Edition 1.0.0, December 2018)	Link
S-121	Maritime Limits and Boundaries Product Specification (Edition 1.0.0, October 2019)	Link
S-122	Marine Protected Areas (Edition 1.0.0, January 2019)	Link
S-123	Marine Radio Services (Edition 1.0.0, January 2019)	Link
S-127	Marine Traffic Management (Edition 1.0.0, December 2018)	Link
S-128	Catalogue of Nautical Products (Edition 1.0.0, May 2022)	Link
S-129	Under Keel Clearance Management (Edition 1.0.0, June 2019)	Link
A complete list of all S-100 based Product Specifications, including Product Specifications in development and published, is maintained here		
Please note: S-101, S-104, S-111, S-121, S-128 and S-129 Edition 1.0.0 and S-102 Edition 2.1.0 Product Specifications are released for implementation and testing purposes only.		



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2. PRINCIPLES OF THE CROSS CHECK OF DQ CHAPTERS

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The cross check of DQ chapters follows principles as below:

- a) The cross check shall be carried out in accordance with IHO publication S-97 Ed 1.1.0 - “IHO Guidelines for Creating S-100 Product Specifications”。
- b) Only the DQ chapters of S-1XX PSs shall be checked and the results will be presented in the form of cross check matrix.
- c) DQ elements included in the other parts of each S-1XX PS shall be described in the form of Notes under its cross check matrix.



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

3.1 Identify the DQ requirements for S-1xx PS in S-97

10 recommendations for the development of S-1xx based Product Specifications.

10 Recommendations
1.Completeness
2.Conceptual consistency
3. Domain consistency
4. Format consistency
5. Topological consistency
6. Positional Accuracy
7. Thematic Accuracy
8. Temporal Quality
9. Aggregation
10. Introduction to DQ Paragraph

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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

3.1 Identify the DQ requirements for S-1xx PS in S-97

The recommended data quality measures of each S-1XX PS have been identified by the subWG according to S-97 part C Table C-7-1 – Recommended data quality measures.

Data Quality Measure	DQ measure / description	Applicable to spatial representation types	S-104	S-111
Completeness / Commission	<u>numberOfExcessItems</u> / This data quality measure indicates the number of items in the dataset, that should not have been present in the dataset.	All S-100 based PS	Y	Y
Completeness / Commission	<u>numberOfDuplicateFeatureInstances</u> / This data quality measure indicates the total number of exact duplications of feature instances within the data.	All S-100 based PS	Y	Y
Completeness / Omission	<u>numberOfMissingItems</u> / This data quality measure is an indicator that shows that a specific item is missing in the data.	All S-100 based PS	Y	Y
Logical Consistency / Conceptual Consistency	<u>numberOfInvalidSurfaceOverlaps</u> / This data quality measure is a count of the total number of erroneous overlaps within the data. Which surfaces may overlap and which must not is application dependent. Not all overlapping surfaces are necessarily erroneous.	PS with geometric surfaces.	N	Y
Logical Consistency / Domain Consistency	<u>numberOfNonconformantItems</u> / This data quality measure is a count of all items in the dataset that are not in conformance with their value domain.	All S-100 based PS	Y	Y
Logical Consistency / Format Consistency	<u>physicalStructureConflictsNumber</u> / This data quality measure is a count of all items in the dataset that are stored in conflict with the physical structure of the dataset.	All S-100 based PS	Y	Y
Logical Consistency / Topological Consistency	<u>rateOfFaultyPointCurveConnections</u> / This data quality measure indicates the number of faulty link-node connections in relation to the number of supposed link-node connections. This data quality measure gives the erroneous point-curve connections in relation to the total number of point-curve connections.	PS with curves.	N	N
Logical Consistency / Topological Consistency	<u>numberOfMissingConnectionsUndershoots</u> / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to undershoots.	PS with curves	N	N
Logical Consistency / Topological Consistency	<u>numberOfMissingConnectionsOvershoots</u> / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to overshoots.	PS with curves.	N	N
<u>Z</u> Logical Consistency / Topological Consistency	<u>numberOfInvalidSlivers</u> / This data quality measure is a count of all items in the dataset that are invalid sliver surfaces. A sliver is an unintended area that occurs when adjacent surfaces are not digitized properly. The borders of the adjacent surfaces may unintentionally gap or overlap to cause a topological error.	PS with geometric surfaces.	N	N
Logical Consistency / Topological Consistency	<u>numberOfInvalidSelfIntersects</u> / This data quality measure is a count of all items in the dataset that illegally intersect with themselves.	PS with curves / geometric surfaces.	N	N

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Logical Consistency / Topological Consistency	<u>numberOfInvalidSelfOverlap</u> / This data quality measure is a count of all items in the dataset that illegally self-overlap.	PS with curves / geometric surfaces.	N	N
Positional Accuracy / Absolute or External Accuracy	Root Mean Square Error / Standard deviation, where the true value is not estimated from the observations but known a priori.	PS with objects that have coordinative values associated	Y	Y
Positional Accuracy / Vertical Position Accuracy	<u>linearMapAccuracy2Sigma</u> / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	PS with objects that have a vertical coordinative values associated	Y	Y
Positional Accuracy / Horizontal Position Accuracy	<u>linearMapAccuracy2Sigma</u> / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	PS with objects that have a horizontal coordinative values associated	Y	Y
Positional Accuracy / Gridded Data Position Accuracy	Root mean square error of <u>planimetry</u> / Radius of a circle around the given point, in which the true value lies with probability P.	PS with objects that have a gridded coordinative values associated	Y	Y
Temporal Quality / Temporal Consistency	Correctness of ordered events or sequences, if reported.	PS with objects that have a time value associated.	Y	Y
Thematic Accuracy / Thematic Classification Correctness	<u>miscalculationRate</u> / This data quality measure indicates the number of incorrectly classified features in relation to the number of features that are supposed to be there. [Adapted from ISO 19157] This is a RATE which is a ratio, and is expressed as a REAL number representing the rational fraction corresponding to the numerator and denominator of the ratio. For example, if there are 1 items that are classified incorrectly and there are 100 of the items in the dataset then the ratio is 1/100 and the reported rate = 0.01.	All S-100 based PS.	Y	Y
Aggregation Measures / Aggregation Measures	<u>DataProductSpecificationPassed</u> / This data quality measure is a <u>boolean</u> indicating that all requirements in the referred data Product Specification are fulfilled.	PS that require a complete pass of all elements of a dataset/dataset series/spatial object types	Y	Y
Aggregation Measures / Aggregation Measures	<u>DataProductSpecificationFailRate</u> / This data quality measure is a number indicating the number of data Product Specification requirements that are not fulfilled by the current product/dataset in relation to the total number of data Product Specification requirements.	PS that require a complete pass of all elements of a dataset/dataset series/spatial object types	Y	Y



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

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3.2 Implement the cross check of DQ chapter of S-1XX PSs one by one

The cross check of DQ chapters of S-1XX PSs including S-104 Ed1.0.0 and S-111 Ed1.0.0 have been implemented one by one to verify whether these recommended DQ measures are included.



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

3.2.1 S-104

3.2.1.1 DQ chapters of S-104

The DQ chapter of S-104 is as follow:

6 Data Quality

6.1 Introduction

Quality of water level data for navigation consists of quality of the observed/predicted/forecast data, quality of the positional data, and quality of the time stamp. Quality of the observed data depends on the accuracy of the water level gauges and their processing techniques; and is normally available in field survey reports or quality controlled analyses. Quality of predicted/forecast data depends on quality, timeliness and spatial coverage of the input data as well as the mathematical techniques. Temporal accuracy for observational data is normally available in field survey reports or quality controlled analyses. Temporal accuracy for predicted/forecast data is normally described in technical reports.

6.1.1 Data quality metadata (informative)

The data quality information will list the following:

For Single station data product:

- 1) Port Type- a) Standard/major or b) Secondary/minor;
- 2) Sigma confidence of predictions/models; or
- 3) Instrument measuring accuracy for observed.

For Gridded data product:

- 1) Sigma confidence of predictions/model.

6.1.2 Data quality elements and data quality measures

Data quality allows users and user systems to assess fitness for use of the provided data. Data quality measures and the associated evaluation are reported as metadata of a data product. This metadata improves interoperability with other data products and provides usage by user groups that the data product was not originally intended for. The secondary users can make assessments of the data product usefulness in their application based on the reported data quality measures.

For S-104 the following Data Quality Elements have been included:

- Conformance to this Product Specification;
- Intended purpose of the data product;
- Completeness of the data product in terms of coverage;
- Logical consistency;
- Positional uncertainty and accuracy;
- Thematic accuracy;

- Temporal quality;
- Aggregation measures;
- Validation checks or conformance checks including:
 - General tests for dataset integrity;
 - Specific tests for a specific data model.

Table 6-1 below indicates which of the data quality measures recommended in S-97 Part C have been identified as applicable to S-104. Columns 1-4 are taken as-is from S-97; the contents of column 5 are from S-97, annotated with whether the measure applies to S-104. Note that for attributes which allow fill values (see clause 10.2.2.2) the presence of a fill value is not counted as an error for the purposes of the data quality measures.

Table 6-1 - Quality measures applicable to S-104 (from S-97 Part C Clause 7)

Data quality measure	Definition	DQ measure / description	Evaluation scope	S104 applicability
Completeness / Commission	Excess data present in a dataset, as described by the scope.	numberOfExcessItems / This data quality measure indicates the number of items in the dataset, that should not have been present in the dataset.	dataset/data set series	Yes (All S-100 based PS)
Completeness / Commission	Excess data present in a dataset, as described by the scope.	numberOfDuplicateFeatureInstances / This data quality measure indicates the total number of exact duplications of feature instances within the data.	dataset/data set series	Yes (All S-100 based PS)
Completeness / Omission	Data absent from the dataset, as described by the scope.	numberOfMissingItems / This data quality measure is an indicator that shows that a specific item is missing in the data.	dataset/data set series / spatial object type	Yes (All S-100 based PS) See clause 6.2 below
Logical Consistency / Conceptual Consistency	Adherence to the rules of a conceptual schema.	numberOfInvalidSurfaceOverlaps / This data quality measure is a count of the total number of erroneous overlaps within the data. Which surfaces may overlap and which must not is application dependent. Not all overlapping surfaces are necessarily erroneous.	spatial object / spatial object type	No (S104 does not define vector surface features) (Applies to PS with geometric surfaces.)
Logical Consistency / Domain Consistency	Adherence of the values to the value domains.	numberOfNonconformantItems / This data quality measure is a count of all items in the dataset that are not in conformance with their value domain.	spatial object / spatial object type	Yes (All S-100 based PS)
Logical Consistency / Format Consistency	Degree to which data is stored in accordance with the physical structure of the data set, as described by the scope	physicalStructureConflictsNumber / This data quality measure is a count of all items in the dataset that are stored in conflict with the physical structure of the dataset.	dataset/data set series	Yes (All S-100 based PS)



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

Data quality measure	Definition	DQ measure / description	Evaluation scope	S104 applicability
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	rateOfFaultyPointCurveConnections / This data quality measure indicates the number of faulty link-node connections in relation to the number of supposed link-node connections. This data quality measure gives the erroneous point-curve connections in relation to the total number of point-curve connections.	spatial object / spatial object type	No (Applies only for PS with curves.)
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsUnder shoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to undershoots.	spatial object / spatial object type	No (Applies only for PS with curves.)
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfMissingConnectionsOvershoots / This data quality measure is a count of items in the dataset within the parameter tolerance that are mismatched due to overshoots.	spatial object / spatial object type	No (Applies only for PS with curves.)
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSlivers / This data quality measure is a count of all items in the dataset that are invalid sliver surfaces. A sliver is an unintended area that occurs when adjacent surfaces are not digitised properly. The borders of the adjacent surfaces may unintentionally gap or overlap to cause a topological error.	dataset/data set series	No (Applies to PS with geometric surfaces.)
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSelfIntersects / This data quality measure is a count of all items in the dataset that illegally intersect with themselves.	spatial object / spatial object type	No (Applies to PS with curves / geometric surfaces.)
Logical Consistency / Topological Consistency	Correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope.	numberOfInvalidSelfOverlap / This data quality measure is a count of all items in the dataset that illegally self-overlap.	spatial object / spatial object type	No (Applies to PS with curves / geometric surfaces.)
Positional Accuracy / Absolute or External Accuracy	Closeness of reported coordinative values to values accepted as or being true.	Root Mean Square Error / Standard deviation, where the true value is not estimated from the observations but known a priori.	spatial object / spatial object type	Yes, for data coding formats 1 and 8. (PS with objects that have coordinative values associated.)

Data quality measure	Definition	DQ measure / description	Evaluation scope	S104 applicability
Positional Accuracy / Vertical Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	linearMapAccuracy2Sigma / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	spatial object / spatial object type	Yes. (PS with objects that have a vertical coordinative values associated.)
Positional Accuracy / Horizontal Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	linearMapAccuracy2Sigma / Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.	spatial object / spatial object type	Yes. (PS with objects that have a horizontal coordinative values associated.)
Positional Accuracy / Gridded Data Position Accuracy	Closeness of reported coordinative values to values accepted as or being true.	Root mean square error of planimetry / Radius of a circle around the given point, in which the true value lies with probability P.	spatial object / spatial object type	Yes, for data coding formats 2, 3. (Applies to PS with objects that have a gridded coordinative values associated.)
Temporal Quality / Temporal Consistency	Consistency with time.	Correctness of ordered events or sequences, if reported.	dataset/data set series / spatial object type	Yes, for time series features. (Applies to PS with objects that have a time value associated.)
Thematic Accuracy / Thematic Classification Correctness	Comparison of the classes assigned to features or their attributes to a universe of discourse.	miscalculationRate / This data quality measure indicates the number of incorrectly classified features in relation to the number of features that are supposed to be there. [Adapted from ISO 19157] This is a RATE which is a ratio, and is expressed as a REAL number representing the rational fraction corresponding to the numerator and denominator of the ratio. For example, if there are 1 items that are classified incorrectly and there are 100 of the items in the dataset then the ratio is 1/100 and the reported rate = 0.01.	dataset/data set series / spatial object type	Yes (All S-100 based PS.)
Aggregation Measures / Aggregation Measures	In a data Product Specification, several requirements are set up for a product to conform to the Specification.	DataProductSpecificationPassed / This data quality measure is a boolean indicating that all requirements in the referred data Product Specification are fulfilled.	dataset/data set series / spatial object type	Yes (PS that require a complete pass of all elements of a dataset/dataset series / spatial object types.)

Data quality measure	Definition	DQ measure / description	Evaluation scope	S104 applicability
Aggregation Measures / Aggregation Measures	In a data Product Specification, several requirements are set up for a product to conform to the specification.	DataProductSpecificationFailRate / This data quality measure is a number indicating the number of data Product Specification requirements that are not fulfilled by the current product/dataset in relation to the total number of data Product Specification requirements.	dataset/data set series / spatial object type	Yes (PS that require a complete pass of all elements of a dataset/dataset series / spatial object types.)

6.2 Completeness

A time series is complete when there is a value or a null indicator at every time in the series. A water level coverage data set is complete when the grid or point set coverage value matrix contains height value or fill (missing) value for every vertex point defined in the grid; and when all of the mandatory associated metadata is provided. See Annex F – Validation Checks.

6.3 Assessment of data quality

The prescribed precision (see Annex A – Data Classification and Encoding Guide) of water level (0.01 m) is close to the perceived accuracy of the data.

Important factors in the quality of water level information for navigation consists of the quality of:

- The observed data;
- The predicted/forecast data;
- The positional data; and
- The time stamp.

Factors determining the accuracy of the data are shown in Table 6-2 below. Information of the quality of the components of the data is normally available in field survey reports, Quality Control analyses or other technical reports.

Table 6.2 - Data types and accuracy factors

Type of Data	Factors Influencing Accuracy
Observed water level	Accuracy of the sensors Processing techniques
Predicted/forecast Water level	Quality of input data Timeliness of input data Mathematical modelling techniques Accuracy of harmonic constants
Horizontal Position	Accuracy of geolocation techniques Model grid accuracy
Vertical Position	Accuracy of vertical datum
Time stamp	Sensor accuracy Data time tagging accuracy

Data quality measures for the entire data set are described in Table 12-4. These include, *horizontalPositionUncertainty*, *verticalUncertainty*, and *timeUncertainty*. The additional data quality measure for uncertainty in *waterLevelHeight* is described in clause 10.2.2.4.



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

3.2.1.2 Result of cross check

Recommendations	S-104
1.Completeness	Y
2.Conceptual consistency	N/A
3. Domain consistency	Y
4. Format consistency	Y
5. Topological consistency	N/A
6. Positional Accuracy	Y
7. Thematic Accuracy	Y
8. Temporal Quality	Y
9. Aggregation	Y
10. Introduction to DQ Paragraph	Y

Y=YES, N=NO, N/A=not application

NOTES:

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3.2.1.3 DQ elements included in the other parts of S-104

No DQ element is included in the other parts of S-104.



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3. IMPLEMENTATION PROCESS OF THE CROSS CHECK OF DQ CHAPTERS

3.2.3 S-111

3.2.3.1 DQ chapters of S-111

The DQ chapter of S-111 is as follow:

In each case, missing data or points over land are tagged with a unique value. A Surface Current coverage data set is complete when the grid coverage value matrix contains direction and speed values or the null value for every vertex point defined in the grid, and when all of the mandatory associated metadata is provided. See Annex D – Tests for Completeness (Normative).

Logical Consistency ensures that the data are stored in a consistent manner: The HDF structure used to hold the data was designed to enforce such consistency. In addition, the placement of current arrow symbols is consistent with the accepted coastline so that the centroid of the arrow is place within the water domain (see Figure 9.1), and if the water depth is zero, the symbol is not shown.

Thematic Accuracy insures that the values represented (speed and direction) are representative of the true situation. Measurement and modeling errors may put limits on these values.

Aggregation describes global quality values related to a particular dataset. For surface currents, each dataset will be evaluated separately.

Usability will be continually assessed through user and manufacturer response to the symbols and analysis presented in the latest Product Specification.

6 Data Quality

6.1 Assessment of data

Data quality allows users and user systems to assess fitness for use of the provided data. Data quality measures and the associated evaluation are reported as metadata of a data product. This metadata improves interoperability with other data products and provides usage by user groups that the data product was not originally intended for. The secondary users can make assessments of the data product usefulness in their application based on the reported data quality measures.

The prescribed precision (see Annex A – Data Classification and Encoding Guide) of current speed (0.01 kn) and direction (0.1 arc-deg) is close to the perceived accuracy of the data, but the increased precision is useful for time integration of current vectors and for the computation of spatial gradients (that is, non-navigational uses).

Important factors in the quality of surface current data for navigation consists of the quality of

- the observed data;
- the predicted/forecast data;
- the positional data; and
- the time stamp.

Factors determining the accuracy of the data are shown in Table 6.1. Information of the quality of the components of the data is normally available in field survey reports, QC analyses, or other technical reports.

Table 6.1 – Data types and accuracy factors

Type of Data	Factors Influencing Accuracy
Observed Current	Accuracy of the sensors Processing techniques
Predicted/forecast Current	Quality of input data Timeliness of input data Mathematical modelling techniques Accuracy of harmonic constants
Horizontal Position	Accuracy of geolocation techniques Model grid accuracy
Vertical Position	Accuracy of vertical datum
Time stamp	Sensor accuracy Data time tagging accuracy

Data quality measures for the entire data set are described in clause 10.2.3. These include, *horizontalPositionUncertainty*, *verticalUncertainty*, and *timeUncertainty*. The additional data quality measures *speedUncertainty* and *directionUncertainty* are described in clause 10.2.4.

6.2 Additional components

Additional data quality measures include Completeness, Logical Consistency, Thematic Accuracy, Aggregation, and Usability.

Completeness consists of commission and omission of data. For surface current data in gridded form, there is likely to be an excess of data for a region. For observed or historical, there is likely to be a dearth of data.



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3.2.3.2 Result of cross check

Recommendations ⁴⁾	S-111 ⁴⁾
1. Completeness ⁴⁾	Y ⁴⁾
2. Conceptual consistency ⁴⁾	N ⁴⁾
3. Domain consistency ⁴⁾	N ⁴⁾
4. Format consistency ⁴⁾	N ⁴⁾
5. Topological consistency ⁴⁾	N/A ⁴⁾
6. Positional Accuracy ⁴⁾	Y ⁴⁾
7. Thematic Accuracy ⁴⁾	Y ⁴⁾
8. Temporal Quality ⁴⁾	N ⁴⁾
9. Aggregation ⁴⁾	Y ⁴⁾
10. Introduction to DQ Paragraph ⁴⁾	N ⁴⁾

Y=YES, N=NO, N/A=not application⁴⁾

NOTES:

- a) In terms of “10. Introduction to DQ Paragraph” , S-111 doesn’t follow the template provided by S-97 but only includes the first paragraph of the template.
- b) S-111 does include an “Logical Consistency” , however, it has nothing to do with the proposed in S-97.

3.2.3.3 DQ elements included in the other parts of S-111

Conceptual consistency, Domain consistency, Positional Accuracy and Temporal Quality are included in Annex D.



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4. CROSS CHECK MATRIX

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NOTES:

- a) Similar to the previously reviewed product specifications, DQ chapters of S-104 and S-111 are not in a harmonized way.
- b) DQ chapters of S-111 doesn't follow the template provided by S-97.
- c) DQ chapter of S-104 could be recommended as a model to be used for S-111.



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3. ACTION

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The TWCWG is requested to:

- a. **Note** the information provided;
- b. **Take** any actions to improve the DQ chapters of S-111.
- c. **Nominate** a DQ focal point in TWCWG who is invited to participate in the activities of DQWG.