

**Paper for Consideration by S-101PT6****Units of Measure in S-100**

<b>Submitted by:</b>	S-101 PT Chair
<b>Executive Summary:</b>	This paper presents an issue identified during development and testing of S-101 1.1.0. It proposes some minor changes to the GI Registry and changes to the Feature Catalogue Builder to resolve this issue in S-101 1.1.0.
<b>Related Documents:</b>	S-101 Edition 1.0.0, <a href="#">S-100 NIWC Testbed Report for S-101 PT5</a>
<b>Related Projects:</b>	S-100 5.0.0, IHO GI Registry

**Introduction / Background**

1. S-100 establishes a framework for geospatial data products. Through the General Feature Model, feature and attribute concepts are established. These attributes may include a measurement of the magnitude of some characteristic such as weight, length or depth in a specific unit. The IHO GI Registry (Data Dictionary Register) includes the Quantity Specification to which a unit of measure can be related but currently the details of units of measure are only defined in the Feature Catalogue.
2. At S-101 PT5 US Navy NIWC reported that the S-101 Feature Catalogue did not contain units of measure for attribute values. S-52 Presentation Library (Part I, clause 10.8 rule 4) specifically requires units to be included in pick reports for weights and measures.
3. It is worth emphasizing that clear and consistent units are vital for navigational safety but increasingly important as automation increases across the maritime domain. This paper seeks to present this issue for clarification and to identify actions that will allow S-101 Edition 1.1.0 to be prepared with complete units of measure information. The NASA Mars Orbiter mishap provides a good example of the importance of this from a different domain<sup>1</sup>.

**Analysis/Discussion**

4. In support of this complex topic the following aspects of S-100 Edition 4.0.0 are presented to set the context for the discussion that follows:

**Conceptual Schema**

S-100 Part 1 describes the conceptual schema language used for S-100. At clause 1-4.5.3.5 it provides the class S-100\_UnitOfMeasure which has a name definition and symbol which are related to a given measure value. See Figure 1.

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<sup>1</sup> NASA Orbiter Mishap [HTTPS://LLIS.NASA.GOV/LLIS\\_LIB/PDF/1009464MAIN1\\_0641-MR.PDF](HTTPS://LLIS.NASA.GOV/LLIS_LIB/PDF/1009464MAIN1_0641-MR.PDF)



## GFM

The S-100 Part 3 - General Feature Model, sets out the very core of S-100. Although at clause 3-5.3.1 a detailed model of attributes is included, units of measure are not present.

## Feature Catalogue

The Feature Catalogue is a fundamental component of S-100 which formalises the GFM into a document structure which defines the application schema of a product specification. As this is the machine-readable component to support units of measures in S-100 systems, this must allow for units of measure to be included where appropriate. As shown in Figure 3, along with quantity specification S-100UnitOfMeasure is present albeit optional. More specific and detailed constraints are also provided.

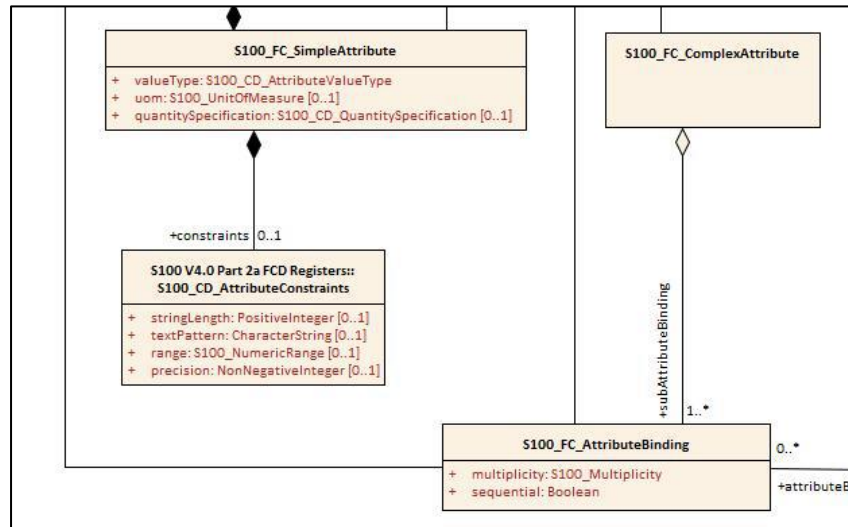


Figure 3 – Extract from S-100 Feature Catalogue Model

Reflecting this model the below attribute entry from the S-122 Data Product Specification includes unit of measure information.

```

<S100FC:S100_FC_SimpleAttribute>
  <S100FC:name>Direction uncertainty</S100FC:name>
  <S100FC:definition>The best estimate of the accuracy of a bearing.</S100FC:definition>
  <S100FC:code>directionUncertainty</S100FC:code>
  <S100FC:valueType>real</S100FC:valueType>
  <S100FC:uom>
    <S100Base:name>degrees</S100Base:name>
    <S100Base:definition>degrees of arc</S100Base:definition>
    <S100Base:symbol>°</S100Base:symbol>
  </S100FC:uom>
  <S100FC:quantitySpecification>planeAngle</S100FC:quantitySpecification>
  <S100FC:constraints>
    <S100FD:range>
      <S100Base:lowerBound>0.0</S100Base:lowerBound>
      <S100Base:upperBound>360.0</S100Base:upperBound>
      <S100Base:closure>closedInterval</S100Base:closure>
    </S100FD:range>
    <S100FD:precision>1</S100FD:precision>
  </S100FC:constraints>
</S100FC:S100_FC_SimpleAttribute>
  
```

IHO GI Registry <http://registry.iho.int/main.do>

The IHO GI Registry includes most properties in Figure 2 but in the below instance lacks a value of Quantity Specification and has Format rather than string length and pattern.

[Attribute] Dictionary Details	
Domain	IHO Hydro
Name	Direction Uncertainty
CamelCase	directionUncertainty
Definition	The best estimate of the accuracy of a bearing.
Data type	real
	Input data following data type
	Minimum Range 0.0
	Maximum Range 360.0
Additional Data	Range Closure
	Precision 0.1
	Quantity Specification
	Format xxx.x
Reference	2017
Reference Source	IHO Nautical Information Provision Working Group
Similarity to Source	Identical : The style of the definition has been changed to match the style and structure of other specifications in the r
Remarks	
INT1	<input type="checkbox"/>
S4	<input type="checkbox"/>

Figure 4 – GI Registry attribute details for Direction Uncertainty (accessed 20201127)  
(this specific item has had Quantity Specification added @ 20210113)

When submitting proposals to the IHO GI Registry (Data Dictionary Register) the Quantity Specification field is only available for attributes of type Integer and Real. This field is populated during the proposal process by a drop-down code list of allowable values as shown in Figure 2 above, in accordance with S-100 Part 2a, clause 2a-4.2.9.

Consideration may be given to adding a Units of Measure field in addition to the Quantity Specification field for Integer and Real type attributes defined in the Data Dictionary Register. This would then provide:

- the mechanism to provide consistent units of measure information in the Feature Catalogue via the FCB; and
- the context that is missing for the other fields in the Additional Data section of the attribute metadata (Minimum and Maximum Range; Range Closure; Precision; and Format) which cannot be populated with logical values based only on the Quantity Specification.

However, defining the units of measure at this level effectively forces all product specifications utilising the attribute to adopt that defined unit of measure; there is no flexibility for a different unit of measure to be adopted for a specific requirement (for example metres/kilometres vs Nautical Miles).

### Feature Catalogue Builder

While there is currently no mechanism at the Register level for the inclusion of units of measure information, it is possible to include units of measure information in the Feature Catalogue through the Feature Catalogue Builder (FCB) tool interface. However, the method for doing this is currently uncontrolled, as it is done via a form in which the information is added as free text; there is no guidance or access to controlled list(s) through which some level of standardisation may be introduced. KHOA has confirmed that this could be changed and would involve around a months work. The consequential preparation of an FC containing the values would take longer but this can logically be one as the S-101 1.1.0 FC is prepared.

Finally, to ensure the completeness and consistency of the FC appropriate checks possibly using Schematrons should be developed to confirm that units of measure are present in Feature Catalogues. Like datasets catalogues will need some degree of validation prior to release.

5. The development of an operational version of S-101 is dependent on resolving issues like this. With some minor changes to the GI Registry and extension of the Feature Catalogue Builder (if required) this issue can be resolved for S-101 Edition 1.1.0. The S-100 TSM is therefore invited to consider the recommendations listed below.

### **Recommendations**

A. Confirm what Unit of Measure information should be held in the GI Registry and make any required changes. (S-100TSM)

Proposed changes as follows (reflects S-100 4.0.0);

- Replace format with string length and pattern.
- Add a dedicated Unit of Measure codelist to the GI Registry, noting potential to adopt UCUM which is used by the OGC. <https://ucum.org/trac>

B. Modify the Feature Catalogue Builder to allow Units of Measure to be added to the Feature Catalogue. (KHOA)

C. Add Units of Measure to the S-101 Feature Catalogue where applicable. (S-101PT)

D. Develop a Schematron check of Units of Measure presence for FC validation. (S-100 WG)