**S-101PT5-10**

**Paper for Consideration by S-101PT**

**Issues Regarding Vertical Datum**

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| ***Submitted by:*** | NIWC |
| ***Executive Summary:*** | Summarizes issues affecting machine readability of Sounding Datum and Vertical Datum |
| ***Related Documents:*** | S-101 PS, S-101 DCEG |
| ***Related Projects:*** | S-100 |

**Introduction / Background**

We have encountered an issue while implementing S-52 PresLib requirement Part 1 10.6.2 ECDIS Legend. It is not currently possible for an application to unambiguously distinguish the default sounding datum from the default vertical datum.

10.6.2 specifies that the sounding and vertical datum for a given coordinate are displayed using:

> *SDAT and VDAT subfields of the DSPM field or the VERDAT attribute of the M_SDAT object and M_VDAT object when available. (VERDAT attributes of individual objects must not be used for the legend.)*

Translating to S-100 / S-101 terminology: Use the datasets default sounding / vertical datum, or the ***verticalDatum*** attribute of the ***SoundingDatum*** / ***VerticalDatumOfData*** feature when available.

Although there is no direct requirement in S-52, it is also assumed that S-101 should support algorithmic determination of the sounding and / or vertical datum for individual objects.

Data producers and ECDIS OEMs will need guidance on how to address the following two issues:

1. How to identify a datasets default sounding and vertical datum?
2. When a feature type has a binding to a ***verticalDatum*** attribute, which of the ***SoundingDatum*** or ***VerticalDatumOfData*** apply, and to which of the features other attributes? The current model does not support machine readability.

**Issue 1: How to determine a datasets default sounding and vertical datum?**

S-101 provides two mechanisms for determining a datasets default sounding and vertical datum:

1. ***S101_DatasetDiscoveryMetadata*** provides ***verticalDatum*** and ***soundingDatum***, which unambiguously describe the default values (but do not describe the CRS axes / units)
2. The datasets default sounding and vertical datum are both encoded in ISO-8211 VDAT *fields* (S-101 DCEG mistakenly refers to VDAT as a *subfield* of CRSH) within the CSID.

The first mechanism is currently unavailable as there is no metadata available for any S-101 datasets, and the S-57 to S-101 dataset converter does not produce dataset discovery metadata. The discovery metadata does not describe the CRS axes or unit of measure, although for S-101 the unit of measure is always meters with the vertical datum oriented up and sounding datum oriented down.

The second mechanism requires reading the encoding and examining the CSID record. A sample of the CSID encoded by the S-101 dataset converter for a typical S-101 dataset follows:

```
CSID (Coordinate Reference System Record Identifier) - 7 Bytes
        RCNM = 15
        RCID = 1
        NCRC = 3
    CRSH (Coordinate Reference System Header) - 17 Bytes
        CRIX = 1
        CRST = 1
        CSTY = 1
        CRNM = WGS84
        CRSI = 4326
        CRSS = 2
        SCRI =
    CRSH (Coordinate Reference System Header) - 36 Bytes
        CRIX = 2
        CRST = 5
        CSTY = 3
        CRNM = Depth - mean lower low water
        CRSI =
        CRSS = 255
        SCRI =
    CSAX (Coordinate System Axes) - 3 Bytes
        AXTY = [12]
        AXUM = [4]
    VDAT (Vertical Datum) - 27 Bytes
        DTNM = mean lower low water
        DTID = 12
        DTSR = 2
        SCRI =
    CRSH (Coordinate Reference System Header) - 31 Bytes
        CRIX = 3
        CRST = 5
        CSTY = 3
        CRNM = Depth - mean high water
        CRSI =
        CRSS = 255
        SCRI =
    CSAX (Coordinate System Axes) - 3 Bytes
        AXTY = [12]
        AXUM = [4]
    VDAT (Vertical Datum) - 22 Bytes
        DTNM = mean high water
        DTID = 16
        DTSR = 2
        SCRI =
```

Although an application can determine that “mean lower low water” and “mean high water” are encoded in the two VDAT fields, it cannot distinguish the default sounding datum from the default vertical datum. Furthermore, in the event that more than two VDAT records are present, it would need to examine the entire dataset to determine which VDATs are referenced by dataset features in order to find the two unreferenced VDATs which encode the default sounding and vertical datum.

There is no order specified in the S-101 encoding, so order cannot be used to distinguish among the VDAT records.

The AXTY of the CSAX match, so they cannot be used to distinguish among the VDAT records. Permitted values for AXTY are specified in S-100 part 10a as:

| Axis Type | Axis direction | AXTY value |
|---|---|---|
| Geodetic Latitude | North | 1 |
| Geodetic Longitude | East | 2 |
| Ellipsoidal Height | Up | 3 |
| Easting | East | 4 |
| Northing | North | 5 |
| Westing | West | 6 |
| Southing | South | 7 |
| Geocentric X | Geocentric X | 8 |
| Geocentric Y | Geocentric Y | 9 |
| Geocentric Z | Geocentric Z | 10 |
| Gravity Related Height | Up | 11 |
| Gravity Related Depth | Down | 12 |

We posit that the converter should be encoding 11 (gravity related height) instead of 12 (gravity related depth) for the AXTY of the vertical datum, as currently all vertical clearances / elevations / etc. are encoded incorrectly (the encoding indicates positive values are oriented down). It is unclear if S-101 allows any value other than 12 to be encoded for AXTY.

We recommend:

- In order to support unambiguous determination of the default sounding and vertical datum, require the CRSH / VDAT fields in the encoding to be ordered such that:
  - the default sounding datum is the first VDAT field
  - the default vertical datum is the second VDAT field
- Require encoding:
  - AXTY of 11 for vertical datum
  - AXTY of 12 for sounding datum
  - Determine if other values of AXTY should be supported
- Update the dataset converter

**Issue 2: How to determine the datum associated with a features attribute values?**

This is a less pressing issue, but may have greater long term consequence. Although not applicable to the legend ("[…] *attributes of individual objects must not be used for the legend*"), it would be useful for an application to algorithmically determine the datum associated with relevant attribute values of a feature.

The attribute ***verticalDatum*** is intended to support this need. It serves a dual purpose – it is populated on a feature to override the sounding and / or vertical datum.

> S-101 DCEG 3.8.1 Sounding datum paragraph three:
> *If it is required to encode a sounding datum for individual features that is different from the dataset header, or a* ***Sounding Datum*** *feature covering the features, it must [be] encoded using the attribute* ***vertical datum*** *on the individual features.*
>
> S-101 DCEG 3.9.1 Vertical datum paragraph three:
> *[…] The attribute* ***vertical datum*** *on an individual feature applies to the elevation of lights and vertical clearances and must only be populated if different from the value given by the dataset metadata or* ***Vertical Datum of Data****.*

When a feature has a ***verticalDatum*** attribute, an application cannot determine whether the ***SoundingDatum*** feature or the ***VerticalDatumOfData*** feature are being overridden, assuming both are present. The application must code to specific implementations of a feature type described by a particular instance of a feature catalogue. If a new feature type with a ***verticalDatum*** attribute is added in a later catalogue edition the applications code must be updated to account for the new feature.

In order to support unambiguous specification of sounding and vertical datum, we recommend:

- Change name / code of ***SoundingDatum*** feature to ***SoundingDatumOfData***
- Add new attribute ***soundingDatum***
    - ***soundingDatum*** overrides ***SoundingDatumOfData***
    - ***verticalDatum*** overrides ***VerticalDatumOfData***

With the above recommendations, there is still an issue affecting machine readability – an application has no way to determine which attributes are affected by the presence or absence of the ***verticalDatum*** attribute - which attributes are depths, which are heights, and which are neither. The application must code to a particular instance of the feature catalogue.

For instance, ***LightAllAround*** has seventeen attributes, one of which is ***verticalDatum***. Currently an application must encode knowledge of which attribute(s) pertain to the ***verticalDatum*** / ***VerticalDatumOfData***. We therefore recommend:

- ***soundingDatum*** / ***verticalDatum*** should be part of one or more complex attributes, similar to the definition of ***verticalUncertainty*** / ***verticalClearanceValue*** in complex attributes ***verticalClearanceClosed***/***Fixed***/***Open***/***Safe***). The complex attribute ties the modifier (datum / uncertainty) directly to the value it pertains to.

**Conclusions**

The recommended changes support machine readability with regard to sounding and vertical datum.

**Recommendations**

Addressing Issue #1:

1. Require the CRSH / VDAT fields in the encoding to be ordered such that:
    a. the default sounding datum is the first VDAT field
    b. the default vertical datum is the second VDAT field
2. Require encoding:
    a. vertical datum using AXTY of 11
    b. sounding datum using AXTY of 12
    c. determine if other values of AXTY should be supported
3. Update the dataset converter to support these changes

Addressing Issue #2:

4. Change name / code of ***SoundingDatum*** feature to ***SoundingDatumOfData***
5. Add new attribute ***soundingDatum***
6. Modify the registry / feature catalogue / DCEG so that ***soundingDatum*** / ***verticalDatum*** are part of one or more complex attributes, similar to the use of ***verticalClearanceValue / verticalUncertainty***
7. Update the dataset converter to support these changes

**Justification and Impacts**
Justifications are presented above, impacts are:

- ENC / S-52 equivalence with regard to display of sounding and vertical datum cannot currently be implemented using S-101

**Action Required of S-101PT**

The S-101PT is invited to:

a. Determine a course of action to address the issues presented