Paper for Consideration by S-101 Project Team

S-57 to S-101 Converter Update

Submitted by:	Esri
Executive Summary:	This paper summarizes the status of the S-57 to S-101 Converter.
Related Documents:	(1) S-100, S-100 Test Framework, (2) S-101 ENC Product Specification 20150623 baseline.docx, (3) S-101 Data Classification and Encoding Guide Final Baseline.pdf April 2014, (4) Part 10a ISO-IEC 8211 Encoding_2.1.0.doc, (5) Feature Catalogue 0.8.8.
Related Projects:	IHO S-100/S-101 Test Bed Project

Introduction / Background

In 2010 Esri was tasked with the development of the S-57 to S-101 Convert. This jointly funded project with NOAA has continued over the past 5 years with multiple releases of the software to coincide with developments of the S-100 and S-101 standards by TSMAD/S-100WG. The version of the S-57 to S-101 Converter associated with this paper was developed against the baseline documents and Feature Catalogue adopted by the S-100/S-101 Test Bed Project and listed above in Related Documents.

The S-57 to S-101 Converter plays an important role in the S-100/S-101 Test Bed project and will allow hydrographic offices to quickly convert their existing S-57 ENC datasets to S-101 compliant datasets for distribution once the S-101 product specification is approved.

The converter is freely available to all working group and IHO members and can be distributed publically upon request. Upon approval of the S-101 product specification by IHO and member states the S-57 to S-101 Converter will be formally handed over to IHO for official distribution.

This paper was originally written and reported at the S-100WG Test Strategy Development Meeting in Korea during the week of September 22, 2015. Addendum A contains changes to the S-57 to S-101 Converter since version 0.8.14 was released.

Analysis/Discussion

Version 0.8.14 of the S-57 to S-101 Converter is the latest version to be released to the S-100/S-101 Test Bed Project team when this paper was submitted. Additional versions will be made available if critical issues are discovered by the test program. Addendum A contains a list of changes to the S-57 to S-101 Converter since version 0.8.14 was released.

The following describes the updates to the S-57 to S-101 Converter.

Implemented Requirements

- **Support S-100 Edition 2.0.0 changes to the Feature Catalogue schema**:
  The previous version of the S-57 to S-101 Converter supported version 0.8.5 of the Feature Catalogue (FC) developed by ROK. With the release of S-100 Edition 2.0.0 ROK updated their Feature Catalogue builder to support the new schema with the release of version 0.8.8 of the FC for S-101. The S-57 to S-101 Converter now supports the Feature Catalogue schema found in S-100 Edition 2.0.0 and version 0.8.8 of the S-101 FC.

- Calculate ECDIS System Attributes:
  In order to streamline the creation of ECDIS SENC files and reduce the dependency on custom symbology procedures the following attributes are now calculated by the converter
    o **Default Clearance Depth:** Based on TSMAD28_DIPWG6_9.4A paper
    o **Surrounding Depth:** Based on TSMAD28_DIPWG6_9.4A paper
    o **Sector Extension:** Based on S-52 6.0 Presentation Library 4.0 LIGHTS06 Conditional Symbology Procedure
    o **In the Water:** Based on DCEG definition of navigable water
    o **Flare Angle:** Based on S-52 6.0 Presentation Library 4.0 LIGHTS06 Conditional Symbology Procedure

- **Support new Bridge modelling**
  Implemented new bridge modelling according to the April 2014 DCEG baseline.

  Since there is no information in S-57 ENC datasets required to show a relationship between BRIDGE features and their PYLONS a spatial algorithm was developed to identify this relationship in order to convert them to the correct S-101 features and use the new Bridge Association to aggregate them.

  Since there are no available S-57 ENC encoding guide specifying how a bridge should be collected with regards to pylons it was found that in some cases area bridge features overlapped pylon area features and sometimes they were adjacent to one another. This requires the algorithm to treat any adjacent or overlapping feature as part of the aggregation.

  Once specific use case has been identified as a current limitation of the conversion process. In this use case the pylon area feature is shared by more than one bridge. The individual bridge and pylon features are correctly converted as individual features as with all other bridge use cases but the Bridge Association is created once for all bridges sharing the pylon. Figure 1 shows an example of this in S-57.

  It is recommended that producers that have this use case create a C_AGGR feature prior to converting their data to S-101. If adopted Esri will modify the S-57 to S-101 Converter to apply this encoding guidance.
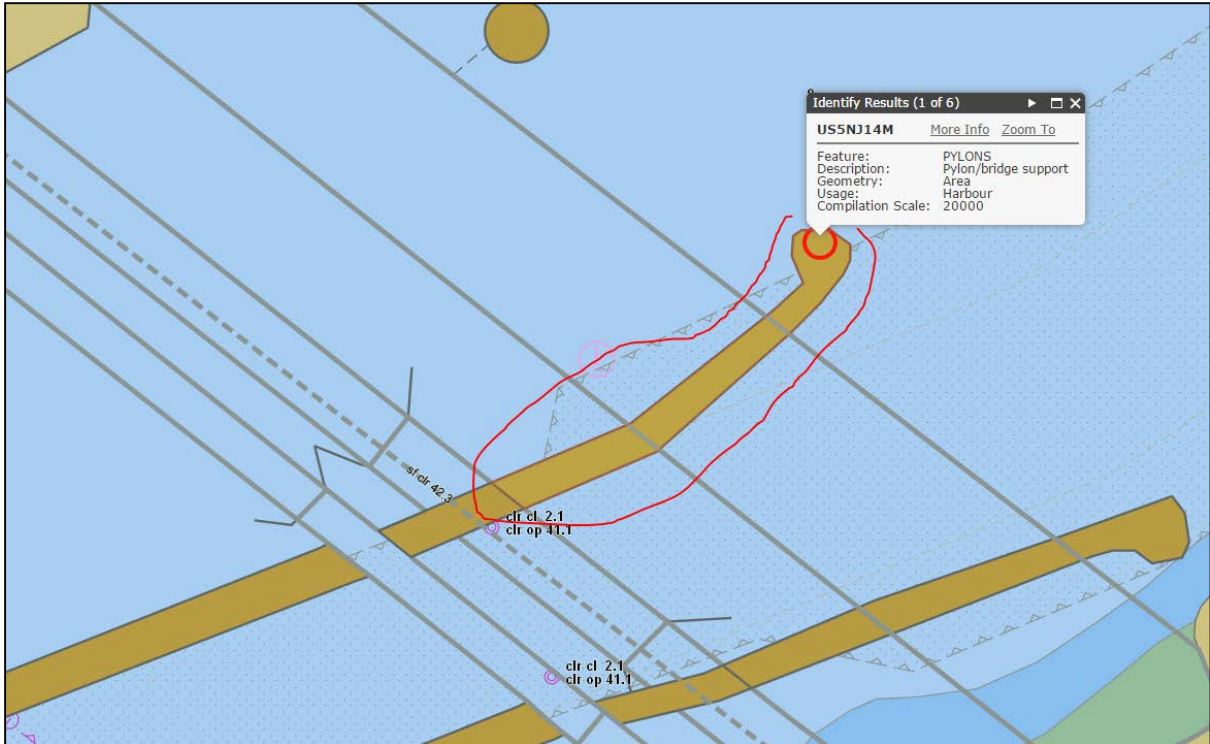
Figure 1: Area pylon shared by multiple area bridge features

- **Convert M_CSCL features to Data Coverage features**
  All M_CSCL features are converted to Data Coverage features using CSCALE to populate maximum display scale and the dataset's CSCL value to populate minimum display scale.

- **Implement min/max display scale override support for DataCoverage features**
  As part of the S-101 Converter project it was requested that users of the S-57 to S-101 Converter be able to override existing S-57 compilation scale values when converting data to S-101. It was agreed that an XML override file would be provided allowing users to enter S-57 dataset information that would let the converter know that the S-57 values would be replaced by the values in the XML during the conversion process. The override values must still conform to the S-101 minimum display scale and maximum display scale values as defined in the S-101 Feature Catalog

    o **Features**
      1. The override xml file will be located in the same install location as the other required xml and dll files for the converter. Currently that default install location is C:\Program Files\S-101 Converter

      2. The xml override file will be named MinMaxDisplayScaleOverride.xml

      3. Each time the converter is run it will check the override XML for the S-57 Dataset about to be converted. If found (search by cell name without extension) it will apply the override values in the XML file.

      4. For each S-57 Dataset you want to override you must enter the DSNM value in the xml *S57Dataset name = ''* attribute field.

5. If you want to override the S-57 DSPM CSCL value which gets converted into the dataset coverage attribute minimum display scale attribute then you must enter a value in the xml MinimumDisplayScaleOverride.

    -   This value will be set for all Data Coverage features as per S-101 Product Specification section 4.5.3 states *"When a dataset has multiple Data Coverage features, then the minimum Display Scale must be the same for all Data Coverage features within the dataset".*

    -   If the value entered does not match an existing value in the feature catalog it will step up to the next value in the domain. For example if you enter 80000 as your override then it will step up to 90000.

6. The xml S57ScaleOverride scale "" attribute value will be used to select the M_CSCL CSCALE value and override it with the *MaximumDisplayScaleOverride = ''* value in the xml.

    -   The xml S57ScaleOverride tag and attributes can be repeated for datasets with multiple M_CSCL features. See examples below.

    -   If you have multiple M_CSCL features with the same CSCALE attribute then you only have to set the override once and all features will be converted to the same value.

7. The DSPM CSCL value will be used for all M_COVR with CATCOV = 1 features when they are converted over to S-101 Data Coverage features. The xml MinimumDisplayScaleOverride value is ignored for M_COVR features.

    -   If the CSCL value does not match an existing value in the feature catalog it will step up to the next value in the domain. For example if you enter 80000 as your override then it will step up to 90000.

8. The DSPM CSCL value will be used for the dataset coverage attribute field for maximum display scale.

    -   If the CSCL value does not match an existing value in the feature catalog it will step down to the next value in the domain. For example if you enter 80000 as your override then it will step down to 45000.

9. If you do not list any override values in the override xml it will convert with the existing S-57 values.

o   **Examples**
1. Minimum Display Scale Override

```
<MinMaxDisplayScaleOverride>
    <S57Dataset name = "US4MI51M"  MinimumDisplayScaleOverride = "95000">
        <S57ScaleOverride  scale = ""  MaximumDisplayScaleOverride = ""/>
    </S57Dataset>
</MinMaxDisplayScaleOverride>
```

- In this example only the minimum display scale attribute will be overridden. The original value for the S-57 dataset's CSCL is 80000.

- Since 95000 is not in the feature catalog domain it will step up to the next value which is 180000. The minimum display scale attribute and all Data Coverage feature minimum display scale attributes will be set to this value.

- The maximum display scale attribute will still use the original S-57 dataset value of 80000. Since 80000 is not in the feature catalog domain it will step down to 45000.

- Any existing M_CSCL features will use their original S-57 CSCALE value to convert to Data Coverage maximum display scale attribute and step down to the next value if they do not match what is in the feature catalog domain.

2. Single M_CSCL Maximum Display Scale Override

```
<MinMaxDisplayScaleOverride>
  <S57Dataset name = "US4MI51M"  MinimumDisplayScaleOverride = "">
    <S57ScaleOverride  scale = "80000" MaximumDisplayScaleOverride = "50000"/>
  </S57Dataset>
</MinMaxDisplayScaleOverride>
```

- In this example only the minimum display scale attribute will not be overridden. The original value for the S-57 dataset's CSCL is 80000.

- Since 80000 is not in the feature catalog domain it will step up to the next value which is 90000. The minimum display scale attribute and all Data Coverage feature minimum display scale attributes will be set to this value.

- The maximum display scale attribute will still use the original S-57 dataset value of 80000. Since 80000 is not in the feature catalog domain it will step down to 45000.

- Any existing M_CSCL features that have an S-57 CSCALE value of 80000 will now use an override value of 50000 to convert to Data Coverage maximum display scale attribute and step down to the next value which is 45000.

- Any M_CSCL features that do not have an S-57 CSCALE value of 80000 will use their original S-57 CSCALE value to convert to Data Coverage maximum display scale attribute and step down to the next value if they do not match what is in the feature catalog domain.

3. Multiple M_CSCL Maximum Display Scale Override

```
<MinMaxDisplayScaleOverride>
  <S57Dataset name = "US4MI51M"  MinimumDisplayScaleOverride = "">
    <S57ScaleOverride  scale = "15000" MaximumDisplayScaleOverride = "12000"/>
    <S57ScaleOverride  scale = "8000" MaximumDisplayScaleOverride = "4000"/>
  </S57Dataset>
</MinMaxDisplayScaleOverride>
```

- In this example only the minimum display scale attribute will not be overridden. The original value for the S-57 dataset's CSCL is 80000.

- Since 80000 is not in the feature catalog domain it will step up to the next value which is 90000. The minimum display scale attribute and all Data Coverage feature minimum display scale attributes will be set to this value.

- The maximum display scale attribute will still use the original S-57 dataset value of 80000. Since 80000 is not in the feature catalog domain it will step down to 45000.

- Any existing M_CSCL features that have an S-57 CSCALE value of 15000 will now use an override value of 12000 to convert to Data Coverage maximum display scale attribute. Since 12000 matches a value in the feature catalog domain it will use 12000.

- Any existing M_CSCL features that have an S-57 CSCALE value of 8000 will now use an override value of 4000 to convert to Data Coverage maximum display scale attribute. Since 4000 matches a value in the feature catalog domain it will use 4000.

- Any M_CSCL features that do not have an S-57 CSCALE value of 15000 or 8000 will use their original S-57 CSCALE value to convert to Data Coverage maximum display scale attribute and step down to the next value if they do not match what is in the feature catalog domain.

4. Multiple Datasets

```xml
<MinMaxDisplayScaleOverride>
    <S57Dataset name = "US4MI51M"  MinimumDisplayScaleOverride = "95000">
        <S57ScaleOverride  scale = ""  MaximumDisplayScaleOverride = ""/>
    </S57Dataset>
    <S57Dataset name = "US5CA72M"  MinimumDisplayScaleOverride = "">
        <S57ScaleOverride  scale = "45000"  MaximumDisplayScaleOverride = "90000"/>
    </S57Dataset>
    <S57Dataset name = "US5CA71M"  MinimumDisplayScaleOverride = "300000">
        <S57ScaleOverride  scale = "50000"  MaximumDisplayScaleOverride = "45000"/>
        <S57ScaleOverride  scale = "75000"  MaximumDisplayScaleOverride = "90000"/>
    </S57Dataset>
</MinMaxDisplayScaleOverride>
```

- **Support V-AIS modelling**
  NEWOBJ for virtual AIS features in S-57 are now Virtual AIS Aid to Navigation features.

- **Support CATZOC modelling provided by DQWG**
  DQWG released a CATZOC conversion report in November 2014. This report provided the mappings for the S-57 to S-101 Converter. Special code was required to map the CATZOC table to S-101.

  Since Quality of Bathymetric Data was not fully defined in version 0.8.8 of the S-101 Feature Catalogue Esri created version 0.8.9 which includes values found in both the baseline DCEG and DQWG report. Both version 0.8.8 and 0.8.9 are delivered with the S-57 to S-101 Converter with version 0.8.9 being used by default.

  Inconsistencies were found between the baseline DCEG and the November 2014 DQWG report. These inconsistencies were reported to DQWG.

    - Multiplicities were not defined for all attributes. Defaulted to 0,1 to avoid any conversion errors
    - Attributes defined as simple in version 0.8.8 of the S-101 Feature Catalogue were made complex by DQWG
        - verticalUncertainty is one example. Created a new complex attribute to avoid conflicts with existing uses of the attribute. The complex version is named verticalUncertaintyX for easy identification.

Dropped Requirements
During development the following requirements were agreed to be dropped by the S-100/S-101 Test Bed project lead.

- **Mapping Table:** Use of Alias in the Feature Catalogue addressed many use cases and the level of effort to write special code for the remaining use cases justified dropping the requirement for this round of development.

- **Adding DOCARE and LOKBSN features to Group 1:** Requires new geometries to be created as holes are created in existing Group 1 features. This would require the S-57 to S-101 Converter to create new geometries thus altering the original data which would no longer match its source. It is recommended that this situation be further discussed at TSM3 and the next S-100 WG meeting. DOCARE and LOKBSN features are still being converted as Group 2 features.

New Functionality added during Development

- **Added support to load datasets using a CATALOG.031 file:** New support for converting data using a CATLOG.031 files has been added. Updates and external file references are automatically applied.

- **Updated log file:** It was known that version 0.8.8 of the S-101 Feature Catalogue was incomplete and would not be enhanced until the new servers hosting the Feature Catalogue Builder were established. In order to support future updates to the Feature Catalogue an updated log file was created to identify missing content. This new log file is created in your output location. Below is an example.

```
Converting (1/6) GB4X0000 -> GB4X0000__.000...
Could not convert feature M_ACCY OBJL 300 not found in FC
Can't find attribute CATCOV(18) for DataCoverage
Can't find attribute EXPSOU(93) for Sounding
Can't bind information type SupplementaryInformation to AnchorageArea
Can't find attribute CATLIT(37) for LightAirObstruction
Can't find attribute CATBRG(9) for SpanFixed
Can't find attribute SCAMIN(133) for SpanFixed
Can't find attribute CATBRG(9) for SpanOpening
Can't find attribute SCAMIN(133) for SpanOpening
Could not convert feature CTRPNT OBJL 33 not found in FC
Can't find attribute SCAMIN(133) for DepthArea
Can't find attribute SCAMIN(133) for DockArea
Could not convert feature DMPGRD OBJL 48 not found in FC
Can't find attribute CATTSS(67) for InshoreTrafficZone
Can't find attribute SCAMIN(133) for LockBasin
Can't find attribute CATTSS(67) for TrafficSeparationLine
Can't find attribute CATTSS(67) for TrafficSeparationSchemeBoundary
Can't find attribute CATTSS(67) for TrafficSeparationSchemeLanePart
Can't find attribute CATTSS(67) for TrafficSeparationSchemeRoundabout
Can't find attribute CATTSS(67) for TrafficSeparationZone
GB4X0000 -> GB4X0000__.000 conversion complete in 1 secs.
```

- **Updated data dictionary information in the dump utility:** The S-100 Dump utility provides additional metadata about each record for more efficient quality control.

- **Implemented version control to support updated Feature Catalogue files:** It was agreed between Esri and ROK that a version control would be used to ensure updated S-101 Feature Catalogues could be released with additional bindings without the need to release an updated version of the converter. However if a Feature Catalogue schema change is required then the S-57 to S-101 Converter will more than likely require an update.

  Version 0.8.9 of the S-57 to S-101 Converter and above (version 0.8.14 was distributed during TSM3) supports version 0.8.8 and above of the S-101 Feature Catalogue. ROK will release content or binding updates by incrementing the third value (for example 0.8.10). ROK will release schema modifications by incrementing the second value (for example 0.9.1).

  The S-57 to S-101 Converter will automatically use the highest incremented S-101 Feature Catalogue if two versions are in the same directory.

  In order to support CATZOC Esri had to create an updated version of the S-101 Feature Catalogue (0.8.9) to include the necessary bindings to convert M_QUAL features to Quality of Bathymetric Data features. Both 0.8.8 and version 0.8.9 of the S-101 Feature Catalogue are delivered with the S-57 to S-101 Converter. Version 0.8.9 is utilized by default.

<u>Testing</u>
As a delivery requirement all NOAA ENC datasets as of June 25, 2015 were converted along with Mickelfirth datasets.

Esri would like to recognize the follow for their contribution to the development of the S-57 to S-101 Converter.
- IC-ENC for testing their complete set of ENC datasets and providing their log file for the project.
- Caris for their feedback on the original release version 0.8.9 which allowed additional changes to be made prior to TSM3 with the release of version 0.8.14 of the S-57 to S-101 Converter.
- ROK for providing a copy of their S-100 Viewer to help validate the output of the conversion process.

Since the release of version 0.8.14 additional feedback from SevenCs and SPAWAR has been included in subsequent releases. At the time of this paper version 0.8.19 has been published with a new version being released shortly after the conclusion of the S-101 Project Team meeting.

<u>Items to Recognize</u>
Esri wishes to recognize the following points while developing the S-57 to S-101 Converter.
- It was agreed during TSMAD 29 that S-57 Object and Attribute acronym values will be added to the Feature Catalogue Alias field for use by the converter.
- As new bindings are added to the Feature Catalogue, using the existing S-100 Edition 2.0.0 schema, the S-57 to S-101 Converter will automatically discover them.
- Warning messages have been added to the log file to help identify gaps in the S-101 Feature Catalogue

<u>Conclusions</u>
The latest version of the S-57 to S-101 Converter is a simple way for ENC producers and the S-100/S-101 Test Bed project to produce S-101 datasets according to the current baseline. It also provides some additional capabilities to help identify gaps with the S-101 Feature Catalogue and potential limitations in the S-57 ENC datasets that require more discussion before the final version of S-101 is published.

<u>Recommendations</u>

1. Encourage ENC producers and distributors to convert their ENC datasets using the latest version of the S-57 to S-101 Converter and provide their log file to the S-100WG. This will help identify any issues with the converter and help identify gaps with the S-101 Feature Catalogue.

2. Create an updated S-101 Feature Catalogue that is up to date with the DCEG baseline document at a minimum. This will allow the converter to convert 100% of the S-57 ENC content to S-101 and provide richer test data for the S-100/S-101 Test Bed project.

3. Have the DQWG and the DCEG work item leader discuss and harmonize the inconsistencies for Quality of Bathymetric Data.

4. Propose encoding guidance to create a C_AGGR feature in S-57 ENC for bridge features that share the same pylon.

5. Discuss alternatives for converting DOCARE and LOKBSN features to Group 1.

   o At the time this paper was written for version 0.8.14 of the S-57 to S-101 Converter there was no path forward for converting these features. Esri since has come up with a means to converter these features but it will require the creation of new geometries. This was originally outside the

scope of the converter but is now a necessary requirement if we require DOCARE and LOKBSN features to be in Group 1.

S-101 Project Team is invited to:

1. Endorse version 0.8.19+ of the S-57 to S-101 Converter for the current baseline
2. Note the improvements to the converter
3. Convert your S-57 ENC datasets and provide feedback to the project team
4. Discuss proposed recommendations

Addendum A

The items listed in Addendum A reflect the discoveries and changes to the S-57 to S-101 Converter since the release of version 0.8.14 at the S-100 Test Strategy meeting in Korea during the week of September 22, 2015.

Updates since 0.8.14 was published and are currently in version 0.8.19

1. FIDN was not being initialized to zero when new features (mostly associations) were being created.
2. The following changes were discovered and documented on the S-100 Basecamp site under *ObservationsOnS101ISOEncoding_ESRI_COMMENTS.docx.*
   a. Observation 3: The field ATTR of the Data Set General Information record contains illegal values for the subfild ATIX.
   b. Observation 4: The feature to feature associations are defined in both directions. This leads to undefined references when the referenced object is defined in a record behind the current record.
   c. Observation 5: Duplicate association to an information type.
   d. Observation 6: In the file GB5X01SW I have found two attributes encoded as old style list attributes.

Updates planned for a post 0.8.19 version based on feedback from SPAWAR

1. Changes to the S100ISO8211.xml which is used to write the DDR. SPAWAR has already confirmed the fix.
   a. SEGH was C2IT instead of C2IL
   b. Entries for the tree sections rooted by the DSID and CSID field were also missing
2. Attribute visually conspicuous is currently set as Boolean in version 0.8.8 of the feature catalogue. The converter is treating this as enumerate based on the DCEG. If Boolean is required moving forward then the converter will be updated to support this.