

## Paper for Consideration by S-101PT

### S-101 and Navigational Purpose

<b>Submitted by:</b>	NIWC
<b>Executive Summary:</b>	Identifies ECDIS chart display issues caused by the absence of navigational purpose in S-101
<b>Related Documents:</b>	S-101 PS, S-101 DCEG
<b>Related Projects:</b>	S-100

### Introduction / Background

NIWC has begun implementing testbed phase six: shore based ECDIS. The NIWC ShoreECDIS application provides the ability to test aspects of ECDIS that cannot be tested using the NIWC S100Viewer application developed during testbed phase three.

This paper presents issues discovered during ShoreECDIS implementation and testing of S-52 and S-101 requirements. The root cause of these issues is S-101 using a single attribute to serve multiple purposes.

S-101 provides a **maximumDisplayScale** attribute in the dataset discovery metadata. The **maximumDisplayScale** serves the following purposes, as spelled out in S-101 4.5.3:

1. Shorthand for data coverage maximum display scale.
  - a. The dataset maximum display scale is equivalent to the largest maximum display scale of the datasets data coverage features.
2. The maximum display scale [of the data coverage] is considered to be the equivalent of the compilation scale of the data.
3. Proxy for navigational purpose.
  - a. Data coverage features of the same maximum display scale are not permitted to overlap.
4. Affects the dataset loading and unloading algorithm detailed in S-101 4.7.

One of fifteen values must be selected for maximum display scale, as specified in S-101 Table 1.

### Issue 1: NULL encoding of *minimumDisplayScale*

S-101 PS Table 1 modifies *S100\_DataCoverage minimumDisplayScale* to allow encoding NULL, although it is not specified how NULL should be encoded on an integer attribute.

We recommend that the multiplicity of 12.1.2.3 *S100\_DataCoverage minimumDisplayScale* should be 0..1 in S-101, where absence of *minimumDisplayScale* is only permitted when maximum display scale is 10,000,000.

## Issue 2: Graphical Index of Navigational Purpose

S-52 PresLib ed. 4.0.2 Part 1 10.1.5:

*A graphical index of the navigational purpose of available data should be shown on demand.*

S-52 PresLib ed. 4.0.2 Part 1 10.1.7:

*Since the HO will not issue a data coverage diagram, the ECDIS must compile a graphical index of the HO ENC data available, classified by navigational purpose, and make it available to the mariner. [...]*

S-52 PresLib ed 4.0.2 Part 1 10.1.9.2:

*The chart catalogue for official charts may be used as a model for the graphical index of navigational purpose, except that minor changes in compilation scale that lie within the range of a navigational purpose must not be drawn on this index. Only the significant changes from one navigational purpose to another must appear.*

The ShoreECDIS implements a graphical index which shows the outline of all installed datasets. The above requirements cannot be met since navigational purpose and compilation scale are not independently available.

This issue highlights the challenge of mapping S-52 requirements to S-101 when the data model has been changed. We recommend adding navigational purpose and compilation scale to S-101 to support implementing these requirements, or clarification of the requirements with regard to S-101.

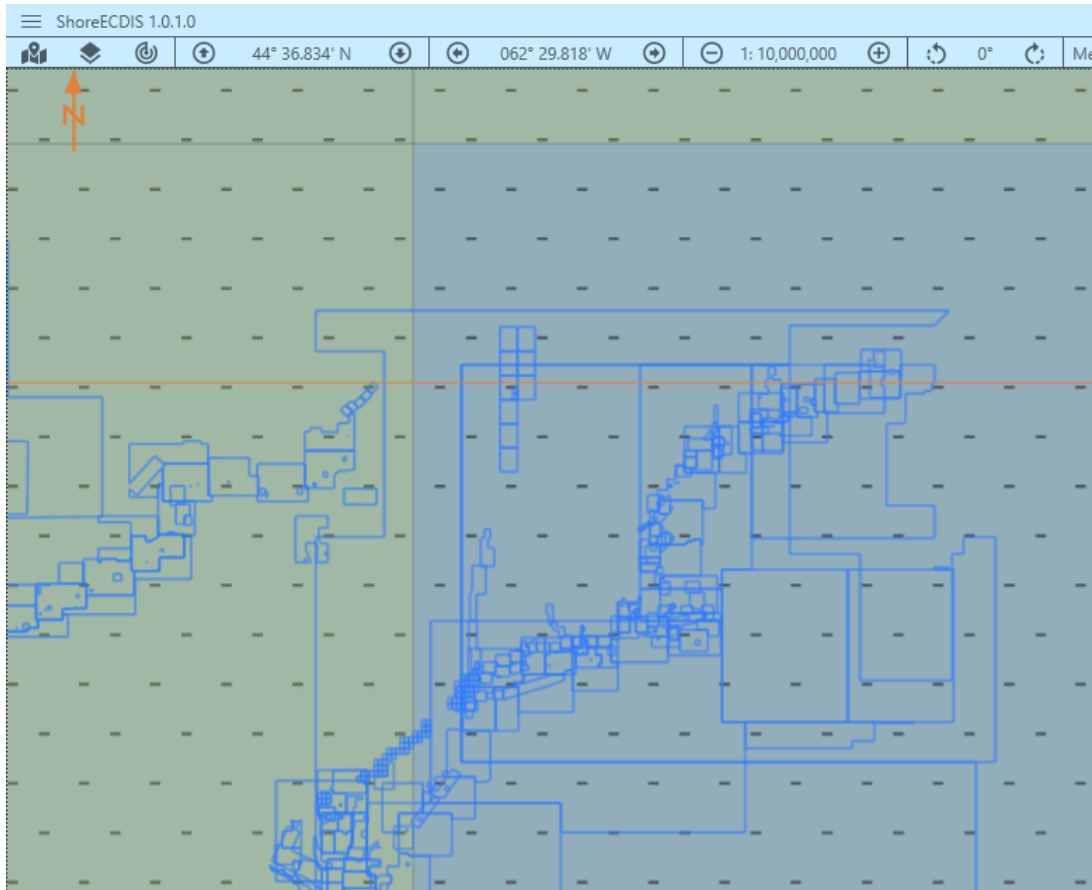


Figure 1 - NIWC ShoreECDIS Chart Catalog

### Issue 3 and 4: S-101 Dataset Loading Algorithm / S-52 Seamless Presentation

ShoreECDIS displays multiple datasets according to the S-101 PS 4.7 dataset loading and unloading algorithm. It also implements requirements from S-52, including S-52 PresLib ed. 4.0.2 Part 1, 10.3.4.1:

**Note: To ensure seamless presentation of a single intended usage (navigational purpose) all objects of same display priority from all cells in same intended usage must be drawn together.**

ECDIS normally renders larger scale charts on top of smaller scale charts. The larger scale charts obscure the smaller scale charts at areas of overlap. The above requirement comes into play when two or more charts share a navigational purpose – even if they have different compilation scales.

S-57 ENC's of the same navigational purpose are required not to overlap. The S-52 note above ensures that charts of the same navigational purpose (which abut) do not obscure each other's features during rendering, particularly during rendering of skin of the earth features.

For instance, if we were to draw two datasets which abut so that we rendered all the features from dataset one, followed by all the features from dataset two, the second datasets skin of the earth features could obscure labels, sector arcs, leading lines, or other features from the first dataset. This can occur when feature portrayal extends beyond the edge of the dataset.

S-101 must carry forward this S-52 requirement to ensure features are not obscured where datasets abut. It must also ensure that features from a more general navigational purpose *are* obscured by features from a better navigational purpose in areas of overlap. For instance, soundings from a more general navigational purpose should not be visible where they intersect a better scale chart.

The navigational purpose of the dataset is needed to implement these requirements, however navigational purpose is not provided in S-101. S-101 does provide two elements which are possible proxies for navigational purpose: ***specificUsage*** in ***S101\_DatasetDiscoveryMetadata***, and ***maximumDisplayScale*** in ***S101\_DataCoverage***.

S-100 calls out *specificUsage* as intended to support navigational purpose:

*The use for which the dataset is intended. [Remarks:] For example, in the case of ENC's this would be a Navigational Purpose classification.*

However, S-101 specifies encoding as {1} to {3}, and remarks show values as equivalent to Port Entry, Transit, and Overview. Encoding an enumeration value in a CharacterString is questionable practice, but there are no restrictions on dataset overlaps related to ***specificUsage***, so it is not a suitable proxy for navigational purpose with regard to the above S-52 requirements, and it serves no useful purpose in the current version of S-101.

Per S-101 PS 4.5.3, data coverage features of the same ***maximumDisplayScale*** must not overlap, except at the agreed adjoining national data limits. It is therefore a good candidate to serve as a proxy for navigational purpose, and the ShoreECDIS uses ***maximumDisplayScale*** to (try to) meet the S-52 requirement for seamless presentation.

The ShoreECDIS also uses ***maximumDisplayScale*** as a proxy for compilation scale, which is unavailable in S-101. Note S-101 PS 4.5.3 bullet seven:

*The maximum display scale is considered to be the equivalent of the compilation scale of the data.*

# Test #1

Using the following datasets:

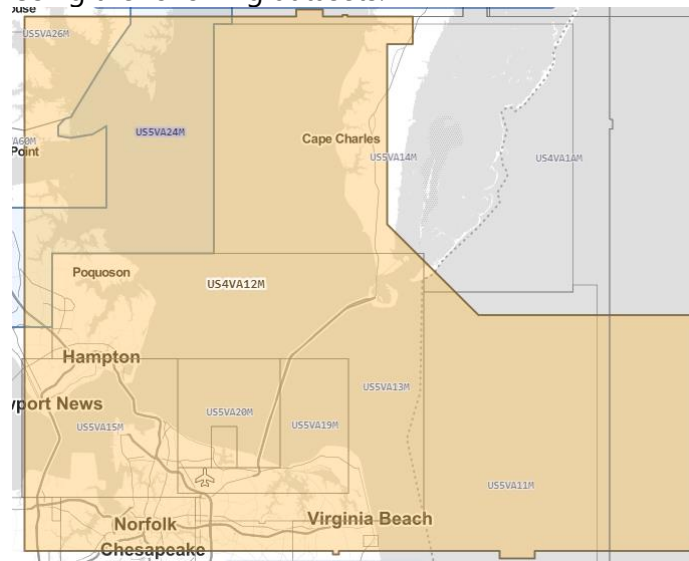


Figure 2 - US4VA12M, 1:80k

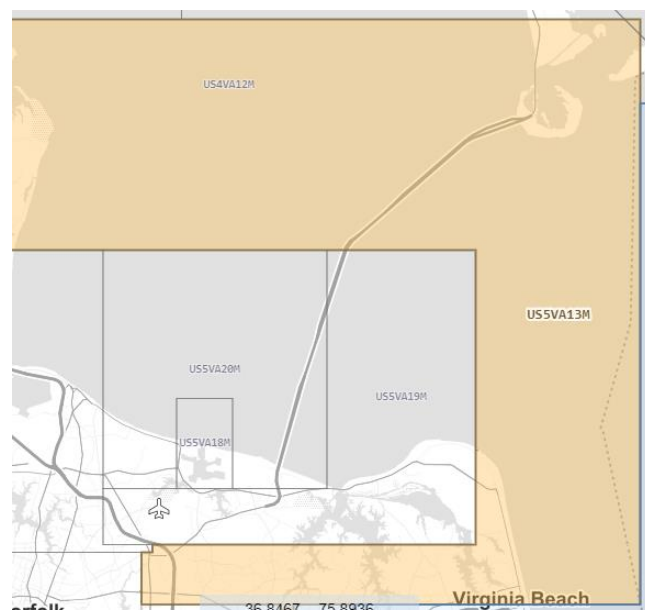


Figure 3 - US5VA13M, 1:40k

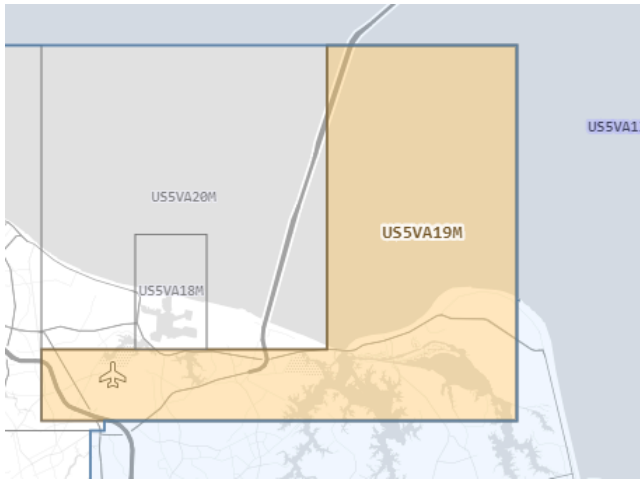


Figure 4 - US5VA19M, 1:20k

The dataset converter was used to convert these datasets to S-101. The converter assigned the following maximum and minimum display scales to the generated datasets:

- US4VA12M: 1:45k, 1:90k
- US5VA13M: 1:22k, 1:45k
- US5VA19M: 1:12k, 1:22k

#### Expected result

The S-57 ENC's should be drawn so that US4VA12M (band 4) is below US5VA13M and US5VA19M, whereas US5VA13M and US5VA19M should be drawn using the S-52 requirement for seamless presentation of an intended usage (both band 5).

#### Observed result

When rendering the S-101 converted datasets, they are drawn so that US4VA12M is below US5VA13M which is below US5VA19M. This is because the datasets are all treated as having different navigational purpose – they all have a unique **maximumDisplayScale**, which serves as the proxy for navigational purpose.

Figures 5 through 7 show the rendering of the three datasets as we zoom in from 1:90k to 1:22k.



Figure 5 - US4VA12M @ 1:90k



Figure 6 – US4VA12M on left “below” US5VA13M on right @ 1:45k. The light is from US4VA12M.

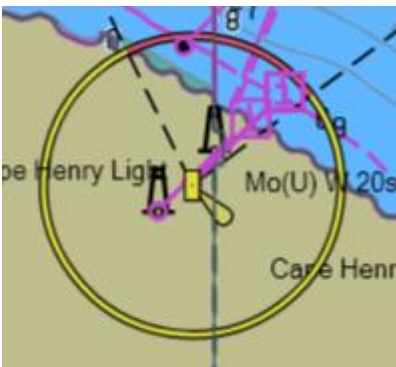


Figure 7 - US5VA19M on left “above” US5VA13M on right @ 1:22k. The light is from US5VA19M.

Figure five is as intended. Only US4VA12M is loaded and displayed because the display scale of 1:90k does not fall between the **minimumDisplayScale** and **maximumDisplayScale** of the other two datasets.

Figure six is not as intended – it indicates an issue in the S-101 PS 4.7.1 dataset loading and unloading algorithm. Clearly US5VA19M should have been loaded to ensure proper presentation of the sector arc. However, it is excluded because its minimum and maximum scale do not include the display scale of 1:45k. In order to have a seamless presentation, charts which share a navigational purpose must be loaded together. However, S-101 PS 4.7 dataset loading algorithm states:

*The concept of navigation purpose is restricted for use in presenting ENC's in a visual catalogue and must not be used for determining which dataset should be displayed.*

We recommend this requirement be removed and the dataset loading algorithm be updated to incorporate navigational purpose. We further recommend that navigational purpose be added to S-101.

Figure seven appears correct, but is actually incorrect. The correct datasets are loaded: US5VA19M and US5VA13M. However, if the light had been on US5VA13M, the left half of the sector arc would have been obscured. This is a result of using **maximumDisplayScale** as a proxy for navigational purpose – the algorithm has assigned the two datasets different navigational purpose.

In order to ensure features are not obscured without adding navigational purpose, it would be necessary for data producers to have all charts of a shared navigational purpose use a single shared **maximumDisplayScale** – otherwise they would not be loaded together. S-101 PS 4.5.3 bullet four enforces this requirement:

*Datasets may overlap, however there must be no overlapping Data Coverage features of the same maximum display scale, except at the agreed adjoining national data limits, where, if it is difficult to achieve a perfect join, a 5 metre overlapping buffer zone may be used; and for this situation, there must be no gaps in data.*

The dataset converter does not enforce this restriction, and it seems unlikely that all data producers will accept this restriction. We again recommend the addition of navigational purpose to S-101 so that it can be used directly to ensure seamless presentation, regardless of the scale of a given data coverage.

This issue is not strictly a converter issue: all data producers will need to manage 15 different seamless coverage portfolios to ensure the proper portrayal of datasets.

Furthermore, since a dataset can have multiple data coverages, and each coverage may have a different maximum display scale, we recommend requiring all data coverages within a dataset to share a navigational purpose. Without this restriction it would be necessary for the ECDIS to examine each data coverage (as opposed to examining just the dataset) during application of the S-101 loading / unloading algorithm. It is unclear how to map the feature and spatial objects within a dataset to their containing data coverage.

## Test #2

The following datasets were used:



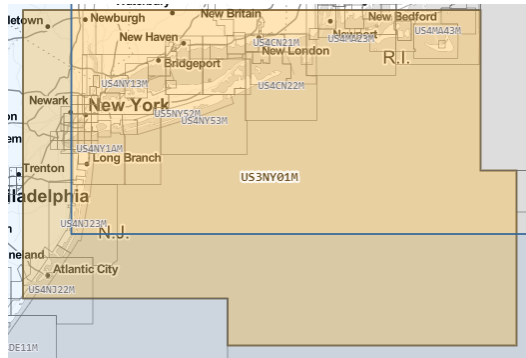


Figure 8 - US3NY01M, 1:400k

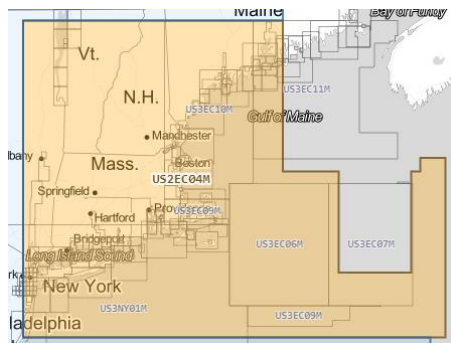


Figure 9 - US2EC04M, 1:675k

The dataset converter was used to convert these datasets to S-101. The converter assigned the following maximum and minimum display scales to the generated datasets:

- US3NY01M: 1:350k, 1:700k
- US2EC04M: 1:350k, 1:700k

Note the S-101 restrictions on encoding maximum and minimum display scale:

**Spatial Resolution:**

An ENC dataset and **Data Coverage** must carry a value for maximum display scale. Each **Data Coverage** must also carry a value for minimum display scale. Values must be taken from the following table:

Scale
NULL (only allowed on minimum display scale where the maximum display scale = 10,000,000)
1:10,000,000
1:3,500,000
1:1,500,000
1:700,000
1:350,000
1:180,000
1:90,000
1:45,000
1:22,000
1:12,000
1:8,000
1:4,000
1:3,000
1:2,000
1:1,000

Table 1- ENC Minimum Display and Maximum Display Scales

Due to these restrictions, the converter has assigned charts from two different navigational purposes (band 2 and band 3) the same maximum and minimum display scales.

Since we are using **maximumDisplayScale** as a proxy for compilation scale, these charts also now have the same compilation scale, leading to a 48% scale error in US2EC04M, and a 14% scale error in US3NY01M. Whereas there was a 51% scale difference between the two S-57 charts, there is now no difference in scale between the two S-101 datasets.

**Expected result**

US3NY01M is drawn on top of US2EC04M.

**Observed result**

US3NY01M and US2EC04M are drawn according to the rules for seamless presentation, resulting in the appearance of the two datasets being "merged".

Use of **maximumDisplayScale** as a proxy for navigational purpose results in the two datasets being rendered according to the S-52 rules for seamless presentation since they share the same **maximumDisplayScale**. Note the presentation of two conflicting safety contours, one from each dataset.



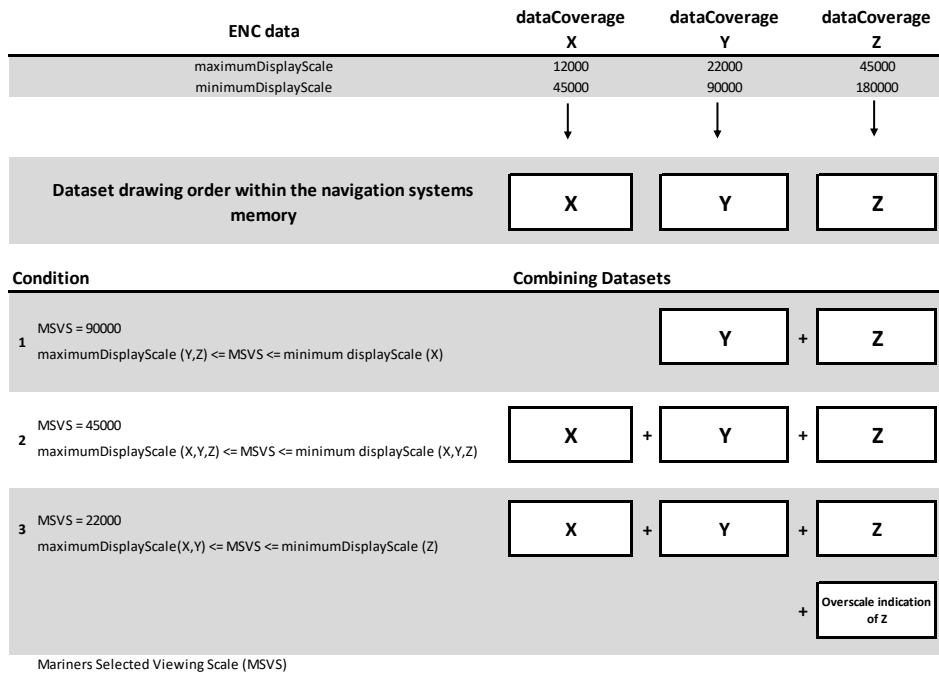
Figure 10 - US2EC04M merged with US3NY01M

The addition of navigational purpose to S-101 would allow the two datasets to be rendered correctly, even if they share a **maximumDisplayScale**. The navigational purpose would indicate that the datasets should be drawn one on top of the other.

The large scale error introduced by using **maximumDisplayScale** as a proxy for compilation scale is also a cause for concern. We recommend adding compilation scale to eliminate the scale error, which would allow maximum and minimum display scale to be used solely for their intended purpose of acting as SCAMIN and SCAMAX for the data coverage.

#### **Issue 5: S-101 Dataset Loading Algorithm with Multiple DataCoverages**

S-101 PS 4.7.1 defines the dataset loading and unloading algorithm. It instructs applications to use the minimum and maximum scale encoded in each of the datasets data coverage features to control the information which is loaded.



In the case where a dataset has multiple data coverage features, there is no simple way to determine how to assign feature and spatial objects to the data coverages given that the only topology restriction is that skin of the earth features must tessellate the data coverage.

Even if the dataset contents could be allocated to the individual data coverages, the loading rules would turn on and off individual coverages within the dataset based upon differences in the maximum display scale of each data coverage. This can prevent seamless presentation of the navigational purpose. Additionally, there is no specific support in S-100 part 9 for portraying partitions of a dataset.

We recommend that S-101 PS 4.7 be updated so that the dataset, rather than the data coverages, are used to control loading and unloading. To support this, the optimum display scale (compilation scale) of each dataset / data coverage should be made available, along with the navigational purpose of each dataset / data coverage.

A navigational purpose should be selected based on the mariner selected viewing scale and the compilation scale of available datasets. The ECDIS should then load all datasets of the selected navigational purpose, and fill in using datasets from more general navigational purposes. All data coverages within a dataset should be loaded and unloaded together, regardless of the minimum and maximum scale assigned to each data coverage. The S-52 requirement for seamless presentation within a navigational purpose should be carried forward.

## Issue 6: Dual Fuel Challenges

The proposed "dual-fuel" mode for ECDIS may require the loading and seamless presentation of both S-101 and S-57 / ENC datasets, and/or it may require the selection of best scale data by examining available datasets of both "fuel" types.

Neither of these are currently possible. Without a mapping from S-57 usage bands to S-101 *maximumDisplayScale* a shared presentation cannot be reliably generated.

When trying to determine the best charts for presentation the ECDIS may compare S-57 cells against S-101 data coverages. The correct chart may not be selected due to the scale errors introduced in S-101 due to the lack of independent compilation scale.

## Conclusions

The absence of navigational purpose in S-101 poses seemingly insurmountable challenges to ensuring a safe and effective ECDIS chart presentation, and may preclude a satisfactory chart presentation during "dual fuel" transition to S-101.

Large scale errors can result from the absence of compilation scale in S-101. These errors may cause issues with dual-fuel presentation.

These issues are compounded by use of data converted from S-57 to S-101.

## Recommendations

1. Add navigational purpose to S-101
  - a. Using *S100\_DatasetDiscoveryMetadata specificUsage*
  - b. Clarify encoding and S-101 constraints in 12.1.2 remarks column (e.g. "1" or "Harbour", etc.)
2. Update 12.1.2 *S100\_DatasetDiscoveryMetadata maximumDisplayScale*
  - a. The largest compilation scale of the data coverage features
  - b. Remove restriction on scale value
3. Add *S100\_DatasetDiscoveryMetadata minimumDisplayScale* (to S-101 12.1.2)
  - a. The smallest compilation scale of the data coverage features
  - b. Unrestricted value domain
4. Add *S100\_DataCoverage optimumDisplayScale*
  - a. The chart compilation scale
  - b. Simplifies mapping of S-52 requirements to S-101
  - c. Eliminate scale errors
  - d. Supports dual fuel
  - e. Determine whether selection of scale values should be constrained
5. Remove (no longer used)
  - a. *S100\_DataCoverage maximumDisplayScale*
  - b. *S100\_DataCoverage minimumDisplayScale*
6. Remove or update definition of Spatial Resolution on page 12

- a. Remove table 1
7. Update S-101 PS 4.5 to reflect recommended changes
  - a. All data coverages within a dataset share a single navigational purpose
  - b. Data coverages within a dataset must not overlap
  - c. The optimum display scale is considered to be the equivalent of the compilation scale of the data
8. Remove S-101 PS 4.6 (duplicates information in 4.7)
9. Update S-101 PS 4.7 – gather feedback from OEMs / ENCWG
  - a. Select navigational purpose based on optimum display scale of available datasets and selected display scale
    - i. Load datasets of selected navigational purpose, then fill in from more general usage bands
    - ii. All data coverages within a dataset must be loaded and unloaded together
    - iii. Add seamless presentation requirement for data from same navigational purpose
  - b. Or remove – no matching S-52 requirement
10. Update dataset converter or resource production of data which conforms to these changes

### **Justification and Impacts**

- Supports implementation of a subset of S-52 requirements related to graphical index of navigational purpose.
- Supports safe and effective presentation of multiple S-101 datasets and/or multiple S-101 data coverages within a dataset.
- Supports potential dual-fuel requirements.

### **Action Required of S-101PT**

The S-101PT is invited to:

- a. Note the issues presented
- b. Approve a course of action to address these issues
  - a. Develop change forms
  - b. Develop test data
  - c. Update test beds
  - d. Report results