

# INTERNATIONAL HYDROGRAPHIC ORGANIZATION



## S-100 NIWC Test Bed Report for S-101PT5

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## 1 Contents of the Reporting Template

### 1.1 General Information

Name of Test Bed	NIWC S100 Test Bed Program
Location of Test Bed	Virginia Beach, Virginia USA
Time and duration of Test Bed	Ongoing
Contact person(s)	Karen Lehman, <a href="mailto:karen.lehman@navy.mil">karen.lehman@navy.mil</a> (Acting Project Manager)  Mikan Stamenkovich, <a href="mailto:mikan.stamenkovich@navy.mil">mikan.stamenkovich@navy.mil</a> (Project Technical Lead)
Test Bed website	N/A
Organisation(s) involved	NIWC Atlantic (Formerly known as SPAWAR)
Funding programme and budget	Ongoing

### 1.2 Executive Summary

The NIWC S-100 Test Bed Project aims to provide empirical proof of the S-100 design through phased implementation of an ECDIS. The Test Bed will implement data import and validation, data loading and portrayal of S-100 based products in the context of a Simple Viewer (Phase 3) and Shore Based ECDIS (Phase 6).

In order to support development through Phase 6 various elements of the S-100 Test Bed initiative are exercised by the NIWC Test Bed Project. Testing areas include Phase 1 (Feature and Portrayal Catalogue use), Phase 2 (validation of S-101 converted data and S-100 based portrayal). Additional testing during Phases 4 and 5 will be used to support the Shore Based ECDIS development of Phase 6.

### 1.3 Test Bed Information

The type of user group(s) involved in the test:

- Shipboard users
- Shore-based users
- SAR users

Details of e-navigation gap/s considered for the Test Bed (some examples are given below. For a complete list, please refer to the IMO MSC 91 report)

- Information/data management
- Effective and robust voice communication and data transfer
- Systems and equipment

- Ship reporting
- Traffic monitoring; and/or
- Training and familiarization

The category of e-navigation gap/s considered in the Test Bed

- Technical
- Regulatory
- Operational: and/or
- Training

Details of e-navigation solution/s considered in the Test Bed (solutions prioritised by IMO are listed below. For a complete list, please refer to the IMO MSC 91 report)

- S1: Improved, harmonized and user-friendly bridge design
- S2: Means for standardized and automated reporting
- S3: Improved reliability, resilience and integrity of bridge equipment and navigation information
- S4: Integration and presentation of available information received via communication equipment
- S9: Improved Communication of VTS Service Portfolio

Compliance to SOLAS navigation – if the product or Test Bed will be used as part of SOLAS navigation the system should be able to meet the following:

### 1.3.1 Expected Functionality per Product (i.e. S-101)

- Is the functionality limited for “just display”?
- Even “just display” requires selectors controlling what is displayed or how items are displayed
- Warnings and indications with time limits associated with the up-to-dateness of the data
- If required, alerts or indications based on the content of the product
- If required, requirements for pick reports
- If required, rules for interoperability (to be displayed together, how to display together, etc.)

Details of service

- File name and folder conventions
- Up-to-dateness information
- Authentication method, including method of pre-sharing of related key(s)
- If used, method of encryption and method of managing of decryption keys

Format of S-10X product

- Machine readable feature catalogue
- Machine readable portrayal catalogue
- Machine readable schema
- If required, machine readable alerts and indications catalogue
- If required, machine readable interoperation catalogue

Test data and expected results

- Test datasets and test cases

### **1.3.2 Expected Functionality per Product (insert as needed)**

The primary users are S-100 Working Group members and other interested IHO parties. The Test Bed aims to identify gaps in utilization of the S-100 family of product specifications with initial focus on S-101. Support for S-100 products based on GML and HDF-5 encodings are in development and awaiting prototype datasets against S-100 version 4.

The S-100 Test Bed phases implemented to date are:

- Ingest and display S-101 converted data (Phase 3 Simple Viewer)
- Preliminary data validation (Phase 4)

The S-100 Test Bed phases currently in development are:

- Multiple Datasets / Interoperability (Phase 6 Shore Based ECDIS) using
  - Converted and/or native S-101 data
  - S-100 simple overlays

The category of S-100 Test Bed solutions considered in the NIWC Test Bed project were both technical validation of the specifications and operational considerations in the context of ECDIS.

## **1.4 Test Bed Methodology**

Methodology used for data collection:

Method	S100Viewer user experience feedback
Validity	
Reliability	

Summary information on Test Bed respondents / participants: (See section 1.5.2 for details)

Number	10
Background	Various
Experience	Various
Demographics	Various

Procedure used in the Test Bed:

Test Bed setup	Windows 10 installer distributed via Basecamp
Technical solutions used	C# application, XML, XSLT, Lua scripting
Standards	IHO S100WG standards support. Application specific information and limitations are available in the release notes of each Test Bed application.

## 1.5 Test Bed Results

Summary of findings:

### 1.5.1 Presentation of data (e.g. statistics)

This section identifies issues with presentation of data using S100Viewer or Shore ECDIS.

#### 1.5.1.1 S-100 Part 10a / ISO-8211 DSID record incorrect

S-100 section 10a-5.1.2.1

- No entry shown for update number (UPDN)
  - S-100 10a-3.4 shows a UPDN field
- DSED shown as A() [ASCII] vice integer
  - S-100 10a-3.4 correctly shows as integer

We recommend that S-100 10a-5.1.2.1 be updated to: include the UPDN field; modify the DSED field format to integer. The example DSID record in 10a-3.4 should match the definitive DSID record to avoid confusion.

#### 1.5.1.2 Portrayal of shared curves can obscure line patterns

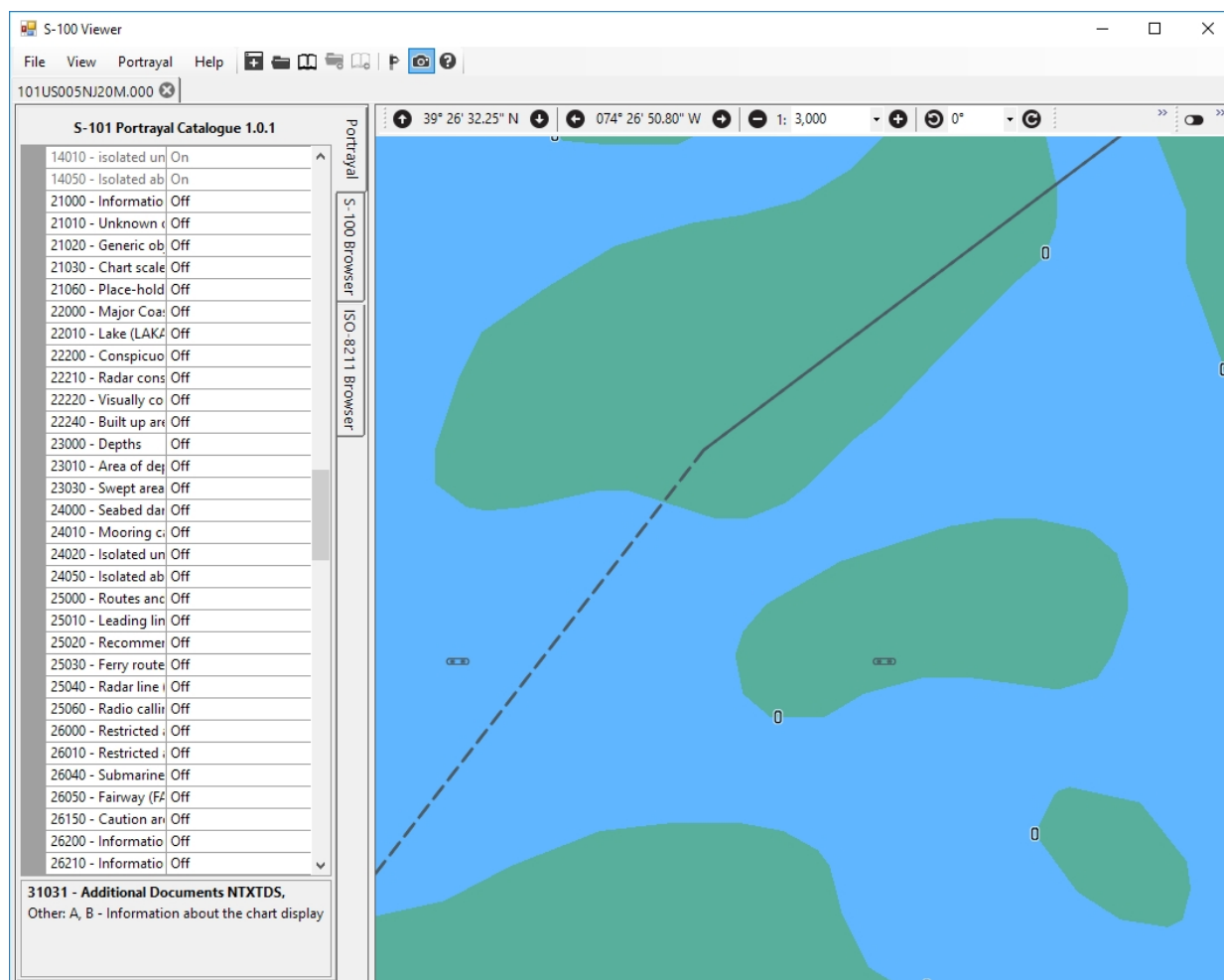
Shared / coincident curve: a curve associated (directly or indirectly) with more than one feature.

The shared curve can be drawn twice, once for the surface on the left, and again for the surface on the right. The curve is drawn in opposite directions in order to traverse each surface in the appropriate direction, which is necessary to properly portray the curve when it uses more complex symbolization (e.g. anchor symbols surrounding an anchorage).

Spaces in the pattern will be partially or fully obscured unless there is coincidental alignment of the dash offsets. In the picture below, the left and right feature are both of type *QualityOfBathymetricData*; since they have the same drawing priority line suppression does not apply. The intended portrayal would show dashes along the entire length of the solid grey line.



This issue is also applicable to S-52, where it has presumably been overcome; we recommend consultation with OEM's and the ENCWG to determine how to address in S-100 / S-101.



### 1.5.1.3 *id* attribute values in Portrayal Catalogues

S-101 *DisplayModes* are coded using *id* attribute values of "1", "2", and "3". This makes it impossible to synchronize settings across product types or between catalogue editions.

For instance, S-102 has a single *DisplayMode* which has an *id* attribute value of "1" to indicate "OTHER". When a user sets the ECDIS to the "OTHER" *DisplayMode* the system must select S-101 *DisplayMode* "3" along with S-102 *DisplayMode* "1". These values should match to facilitate machine readable synchronization.

We recommend changing the *id* attribute values in all portrayal catalogues to meaningful values which support synchronization; *DisplayMode id* values should be "Base", "Standard", or "Other" vice integer values.

```

<displayMode id="1">
  <description>
    <name>Base</name>
    <description>Always
    <language>eng</lang>
  </description>
  <viewingGroupLayer>1</
</displayMode>

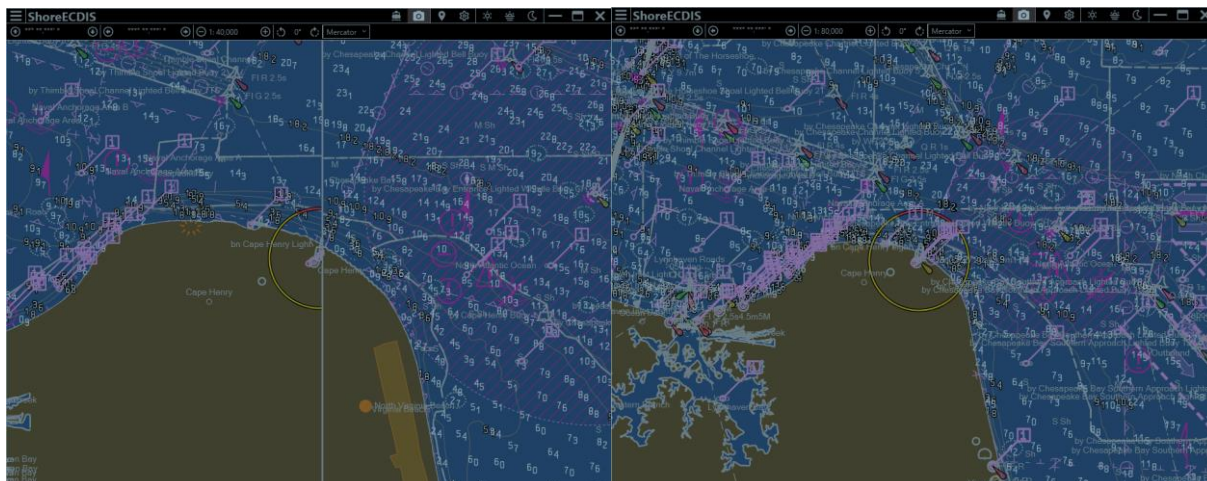
```

#### 1.5.1.4 Dataset loading and unloading algorithm

Multiple datasets are not always presented correctly due to a combination of issues including:

- S-101 dataset converter limitations.
- Problems with the S-101 data loading / unloading algorithm.
- Removal of metadata (navigational purpose, compilation scale) from S-101 as compared to S-57 ENC.

Due to the complexity and importance of this issue a separate paper will be presented which details the issues and recommended mitigations.



#### 1.5.1.5 DCEG vs Feature Catalogue associations / bindings

The S-101 DCEG describes associations in a manner which cannot be expressed within the feature catalogue. For instance, the DCEG describes a bridge aggregation as consisting of one or more span fixed, span opening, or pylons:

Aggr	Bridge Aggregation	Bridge	Component of	1,1	Span Fixed, Span Opening, Pylon/Bridge Support	Consists of	1,*
------	--------------------	--------	--------------	-----	--	-------------	-----

S-100 feature catalogues must describe each component of the relationship separately, e.g. a bridge has an association to zero or more span openings. The current S-101 feature catalogue incorrectly describes the multiplicity of these bindings, using a value of "1" instead of "0" for the lower value of the multiplicity.

```

<S100FC:featureBinding roleType="aggregation">
  <S100FC:multiplicity>
    <S100Base:lower>1</S100Base:lower>
    <S100Base:upper xsi:nil="true" infinite="true"/>
  </S100FC:multiplicity>
  <S100FC:association ref="BridgeAggregation"/>
  <S100FC:role ref="consistsOf"/>
  <S100FC:featureType ref="SpanOpening"/>
</S100FC:featureBinding>

```

To support proper validation we recommend an update to the S-101 feature catalogue to correct the multiplicity issues. We also recommend ensuring S-58 checks are provided to ensure that at least one of the associated features described in the DCEG is present on the appropriate side of the binding.

#### 1.5.1.6 ISO-8211 / S-101 encoding of Boolean attributes

Based on correspondence with Teledyne, ISO-8211 / S-101 4.3.5.1 encoding of Boolean attributes is ambiguous.

Type	Definition
Boolean	the value is a logical value either 'True' or 'False'
Integer	the value is an integer number
Real	the value is a floating point number
Enumeration	the value is one of a list of predefined values

It was agreed that SevenCs would submit a proposal to the S-100WG to address this issue. In the meantime, the NIWC test bed has been updated to accept any of the following as Boolean values:

"True"	Case insensitive
"False"	Case insensitive
0	False
Non-zero	True

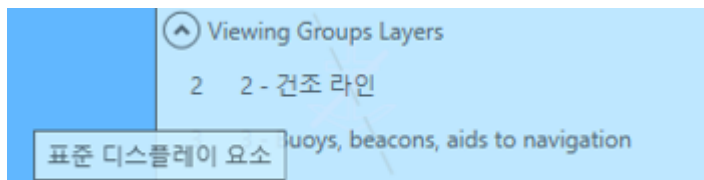
#### 1.5.1.7 Light descriptions when *lightCharacteristic* is unknown

The current S-101 portrayal catalogue rule LITDSN02 does not output a light description when *lightCharacteristic* (LITCHR) is unknown. There is no guidance addressing this issue in S-52 or the S-101 DCEG.

Input from the S-101 PT is requested to facilitate development of proper portrayal rules.

### 1.5.1.8 Portrayal Catalogue Translations

We recommend populating the language independent text within the portrayal catalogue. This will facilitate reporting on national language support throughout the test bed. We recommend the team identify resources to perform the desired translations.



### 1.5.1.9 S-52 e6.0 3.2.3.8b Overscale area at scale boundary (overscale pattern)

NOTE: This issue may be OBE dependent on discussions related to the paper on navigational purpose.

S-52 requires that an overscale pattern is shown in certain situations when data is displayed at two or more times its compilation scale.

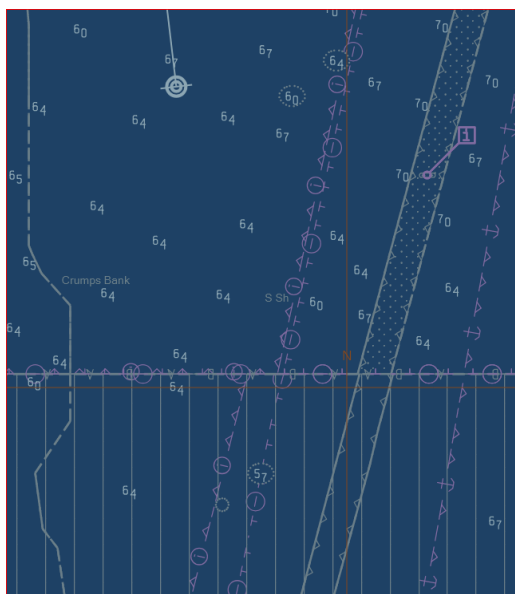
*AP(OVERSC01): overscale part of a display containing data from more than one navigation purpose.*

Given that S-101 has neither compilation scale nor navigational purpose, recommend using more than the *maximumDisplayScale* rather than "more than twice the compilation scale". Since there is no navigational purpose in S-101, all charts displayed at larger than their maximum display scale would have this pattern applied, whereas in S-52 only charts from a different navigational purpose would be drawn with this pattern.

*S-52 e6.0 3.2.3.8b Overscale area at scale boundary (overscale pattern):*

*All the chart data on the display must be shown at the same scale. In order to avoid leaving part of the display blank, the chart display may extend beyond the edge of a relatively large scale ENC to include information from an adjoining smaller scale ENC, which may be from a different "navigational purpose". The smaller scale data will normally be enlarged to match the larger scale ENC, and in this case the "overscale area" symbol should be used to identify any part of the chart display shown at **more than twice the compilation scale**. See Presentation Library, Part I, section 12.2.2 DATCVR for details.*

*Note that this symbol applies only to the automatic overscaling performed by the ECDIS in matching ENCs at different compilation scales. It should not be applied to an overscale display deliberately requested by the mariner, which should trigger the overscale indication required by IMO Performance Standard section 6.1.1.*



#### 1.5.1.10 Need guidance on implementation of "temporary" overlays

The requirements for implementation of a "Temporary" overlay are not defined.

*S-52: "The [INFORM symbol] may cause clutter, and should only be displayed temporarily*

Note: S-52 Presentation Library 4.0.2 10.6.1.1 Standard Attributes INFORM, NINFOM, TXTDSC, NTXTDS and PICREP:

*NOTE: ECDIS must provide independent user selection to turn on and off the symbol INFORM01 for two cases:*

- 1. INFORM, NINFOM [DG: S-101 PC viewing group 31030]*
- 2. TXTDSC, NTXTDS and PICREP [DG: S-101 PC viewing group 31031]*

*[...]*

***SY(INFORM01) is intended as a temporary overlay.***

*The display priority is 8, overradar, category other, viewing group 31030*

We recommend that the S-101 Product Specification provide implementation guidance or explicitly revoke this S-52 requirement.

#### 1.5.1.11 S-101 Portrayal Catalogue and mariners viewing groups / viewing group layers

The current S-101 portrayal catalogue includes viewing groups intended for mariners' information. OEM's may prefer to merge their own mariner layer implementations rather than having them provided within the S-101 catalogue.

We ask that the team direct the inclusion or removal of these viewing groups and viewing group layers.

### 1.5.1.12 Guidance needed for handling of datasets with invalid geometries

Converting and importing the NOAA ENC catalogue (~1500 datasets) reveals invalid geometries in a small number of cases (~10 datasets, less than 1%), typically caused by self-intersecting surfaces. S-52 / IEC 61174 only address data integrity on the application of updates. Validation checks in S-58 only apply to data producers.

Guidance should be provided regarding how to handle datasets with invalid geometries. We recommend disallowing installation of datasets with invalid geometries.

### 1.5.1.13 CHDATD01 symbol missing portrayal parameters

S-52 gives no guidance on which display plane, drawing priority, viewing group and RADAR flag to use when displaying the CHDATD01 symbol used to identify date dependent features. The NIWC provided portrayal catalogue currently uses the rules for INFORM01 as described in S-52 10.6.1.1.

We recommend the team endorse use of the INFORM01 attributes or provide other guidance.

### 1.5.1.14 Pick Report: Units of Measure

Note S-52 10.8 rule 4:

#### 10.8 Cursor Pick and Interface Panel Display

There are a number of rules that must be applied to all ECDIS cursor pick reports.

No	Cursor Pick Rules
1	Full S-57 Object and Attribute names must be displayed.
2	Enumerate value names must be displayed.
3	There must not be any padding of attribute values, for example a height of 10 metres must not be padded to 10.000000 metres as this could potentially confuse or mislead the Mariner.
4	Units of measure must be included after all attribute values which are weights or measures.
5	<p>S-57 category "C" feature attributes must not be displayed unless requested by the user. Attributes in this subset provide administrative information about an object and the data describing it. In most cases it is of no practical use to the Mariner. This information is only relevant to S-57 data transferred between Hydrographic Offices.</p> <p>An exception to show the value of SORDAT if it is for the following objects:</p> <ul style="list-style-type: none"> <li>- WRECKS, OBSTRN, UWTRC, and SOUNDG with value QUASOU= 9 and geometry attribute QUAPOS=8</li> <li>- DRGARE with QUASOU=11</li> <li>- SWPARE</li> <li>- Any object class with attribute CONDTN=1 or 3 or 5</li> </ul>

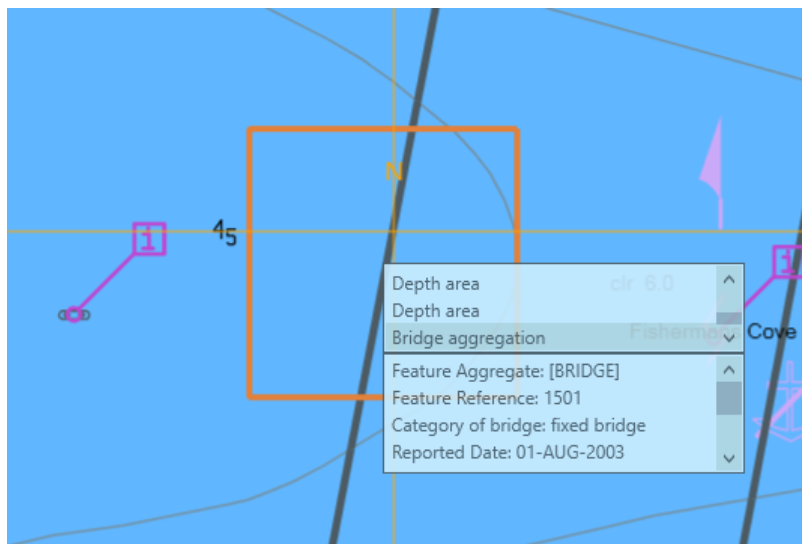
To support a machine readable implementation of this requirement, we recommend that the S-101 feature catalogue is updated to provide one or more complex attributes which can describe value(s) along with the associated units of measure (S100\_UnitOfMeasure).

### 1.5.1.15 Pick Report: Sorting by Significance

Note S-52 10.8.4 Sorting by Significance:

*A general cursor enquiry must be sorted by the drawing priority of the object as defined in the look-up table for symbolizing. When the drawing priority of objects is equal the geometric primitive will be used to order the information, points followed by lines and finally areas.*

S-101 should provide guidance for implementation of this requirement with regard to aggregate features.



#### 1.5.1.16 Pick Report: Category “C” attributes

Note S-52 10.8 rule 5:

*S-57 category “C” feature attributes must not be displayed unless requested by the user. [...]*

There is no machine readable mechanism provided by S-101 to implement this requirement. We recommend an update to the feature catalogue to facilitate machine readable indication of category “C” feature attribute values.

#### 1.5.1.17 Mariner selected date and safety check

Note: S-52 Presentation Library 4.0.2 Part 1, 10.4.1 [emphasis added]:

*To provide the Mariner with effective route planning capabilities **and for the look-ahead function during route monitoring** ECDIS must **display date dependent chart data based on a Mariner selected date or date range** (start viewing date and end viewing date)*

The current NIWC test bed implements this requirement as written: route monitoring safety checks are dependent on Mariner selected date(s).

We recommend working with the ENCWG to clarify this requirement as it appears unsafe. Our recommendations:

- Safety check during route planning: use mariner selected value(s)
- Safety check during route monitoring: use current date

### 1.5.1.18 61174 4.18 Default selector requirement

Note 61174 Table 3 – Control settings configured in response to “Default” selection:

**Table 3 – Control settings configured in response to ‘Default’ selection**  
(Appendix 6 of IMO resolution MSC.252(83))

Function	Setting
Display category	ECDIS Standard display
Chart related selector: Accuracy	Off
Chart related selector: Date dependent objects	current date
Chart related selector: Highlight date dependent	Off
Chart related selector: Full light lines	Off
Chart related selector: Highlight info	Off
Chart related selector: Highlight document	Off
Chart related selector: Unknown	On
Chart related selector: Scale min	Off
Chart related selector: Shallow pattern	Off
Chart related selector: Shallow water dangers	On
Chart related selector: Contour labels, if provided	Off
Chart related selector: Four shades, if provided	Off
Chart related selector: National language, if provided	Remain unchanged
Chart related selector: Paper chart / Simplified symbols	Paper chart
Chart related selector: Plain / Symbolized boundaries	Plain
Chart related selector: Text group layer	Important text
Selected sea area	Around own ship with appropriate off-set
Range	3 NM
Orientation	True motion, north-up

6	Chart scale boundaries	<input checked="" type="checkbox"/>
7	Cautionary notes	<input checked="" type="checkbox"/>
8	Ships' routing systems and ferry routes	<input checked="" type="checkbox"/>
9	Archipelagic sea lanes	<input checked="" type="checkbox"/>
10	Miscellaneous (Standard)	<input checked="" type="checkbox"/>
10a	Chart (Standard)	<input checked="" type="checkbox"/>
10b	Mariners (Standard)	<input checked="" type="checkbox"/>
10c	Alert Highlights (Standard)	<input checked="" type="checkbox"/>
11	Spot soundings	<input type="checkbox"/>
12	Submarine cables and pipelines	<input type="checkbox"/>
13	All isolated dangers	<input type="checkbox"/>
14	Magnetic variation	<input type="checkbox"/>
15	Depth contours	<input type="checkbox"/>
16	Seabed	<input type="checkbox"/>
17	Tidal	<input type="checkbox"/>
18	Miscellaneous (Other)	<input type="checkbox"/>
18a	Mariners (Other)	<input type="checkbox"/>
101	Important Text	<input type="checkbox"/>
102	Other Text	<input type="checkbox"/>
102a	Names	<input type="checkbox"/>
102b	Light description	<input type="checkbox"/>
102c	All other chart text	<input type="checkbox"/>
102d	Mariners text	<input type="checkbox"/>

These settings require “Standard” display mode with display of important text (S-101 viewing group layer 101). In S-101 important text is part of display mode “Other”.

Because S-100 has no text groups, implementing this requirement will result in a “Custom” display mode, which may be confusing to users. We recommend that S-101 provide guidance for the implementation of this requirement.

### 1.5.1.19 OEM guidance for application of changes to viewing groups

If a viewing group layer is moved from one display mode to another in two different portrayal catalogue editions, how should the ECDIS / application render the datasets?

Suppose that viewing group layer one was removed from the “Standard” display in a new catalogue edition:

PC Ed 1 (Standard)	PC ED 2 (Standard)	Result?
VGL 1 (VG 1, 2, 3)	VGL 2 (VG 4, 5, 6)	
VGL 2 (VG 4, 5, 6)		

When the ECDIS is set to “Standard” should viewing groups 1, 2, and 3 still be displayed on the applicable (older) datasets?

Alternatively, should the viewing groups be set individually per portrayal catalogue? This would be confusing to the end-user – features would be shown on older datasets but not on newer datasets.



We recommend that S-101 provide the following guidance: viewing groups / viewing group layers / display modes from the the most recent portrayal catalogue should be applied to all datasets.

#### 1.5.1.20 Feature Dependency Issues

Using the mechanism approved at S-100WG5 (drawing instruction dependencies), lights on buoys / beacons cannot be turned off when the viewing group for the buoy is disabled. Dependencies can only apply to a single feature instance; the buoy and light are separate feature types and separate instances of each type.

It may be possible to use feature associations to turn off dependent features when the viewing group of the "parent" feature is disabled. A challenge with this approach is that roles of the feature associations do not provide the information needed to determine which side of the association is the parent. It may be possible to encode this knowledge within the portrayal catalogue rules.



We recommend continued testing and reporting of findings along with recommendations at the next test strategy meeting.

#### 1.5.1.21 Null or missing attribute values

S-100 / S-101 provides no guidance on handling of null / missing attribute values with regard to:

- Validation
- Portrayal
- Safety check

We recommend an update to the S-101 Product Specification provide guidance for this issue.

#### 1.5.2 S100Viewer Users assessment and experience

- S100Viewer tech assist to Alvaro Sanchez, Assistant Director Charting Quality Assurance, Australian Hydrographic Office
- Friedhelm Moggert-Kägeler, Solutions Director Maritime Spatial Data, SevenCs. Assisted with sample S-101 dataset production evaluation.
- Tore Halset, Electronic Chart Centre, Norway, reported issues with inconsistent filename case. We noted that the SVGStyle.css is not used by the portrayal and should be removed from the catalog. The NIWC PC was updated to address the filename case issues, and the SVG symbols were updated to reference daySvgStyle.css

- Provided assistance to Gert Morlion, with De Vlaamse Waterweg nv, regarding S-401 style sheets.
- Provided Lua scripting assistance in conversion of S-57 to S-101 data to Stelios Contarinis, Cartography Laboratory, University of Athens.
- Obtained useful insight from Bjorn Seastrad regarding regional settings for our S100Viewer.
- Worked with NAVO and NOAA to resolve HDF5 scan direction issues based on S100Viewer feedback for S-102 and S-111. NOAA: [Jason.Greenlaw](#), Barry Gallagher, NAVO: Stacy Johnson
- Assisted Hugh Astle, Senior Development Manager, Teledyne CARIS with production issues identified with S100Viewer.
- Assisted Raphael Malyankar, Portolan Sciences, S-101 viewing group assignments.
- Assisted Jonathan Pritchard, IIC Technologies, in S-101 production issues utilizing Teledyne production tools.

### 1.5.3 Other comments

An update to the NIWC test bed has been released. This update uses a unified / single installer to install all test bed components: S-100 Viewer, Lua Scripting Reference, and Shore-Based ECDIS. An updated S-101 Portrayal Catalogue is also provided.

#### 1.5.3.1 S100Viewer v1.9.0.0

- Uses updated portrayal schemas approved at S-100WG5
  - Supports latest NIWC S-101 portrayal catalogue
- Fixes support of regional number formats
  - Digit grouping and decimal symbols
- Fixes display of portrayal text
  - comma, ampersand, colon and semicolon are now displayed correctly
- Other minor updates and fixes

#### 1.5.3.2 Lua Scripting Reference 1.0.1

- Minor change to address compilation issue reported with some installs of Visual Studio

#### 1.5.3.2.1 Shore-Based ECDIS (SBE)

This report marks the initial release of the NIWC Shore-Based ECDIS. This release is targeted on testing the S-101 data loading / unloading algorithm and implementation of changes to the S-100 portrayal model approved at S-100WG5, including:

- Alerts and Indications
- Symbol dependencies
- Date dependent symbology
- Display plane ordering
- Pick report via hover

### 1.5.3.3 NIWC S-101 Portrayal Catalogue Updates

- Includes an alerts and indications catalogue
- Adds “order” attribute to display planes
- Adds symbol dependencies for Text / INFORM / CHDATD
- Adds hover instructions for INFORM / CHDATD / Lights / Beacons / Buoys / Landmarks
- Uses *displayName* attribute to control display of feature names (per DCEG)
- *QualityOfBathymetricData* reverted to testPCB area fill
- Other minor updates and fixes

We request that the team endorse this catalogue and use it to populate the portrayal registry.

## 1.6 Conclusions and Recommendations

We recommend the user community use and provide feedback on the S-101 Lua portrayal catalogue as soon as possible so that the S100WG and S101PT can fully mature the S-101 standard.

### 1.6.1 Lessons learnt

N/A

### 1.6.2 Own plans

We invite feedback on the Test Bed, S-101 Portrayal Catalogue, and Lua scripting reference implementation to advance the maturation of the S-101 standard.

1. Continue S-101 portrayal refinement based on community input.
2. Continue the design of Shore Based ECDIS in support of interoperability.

Suggested further studies: Items identified in section 1.5.1 require immediate attention.

## 1.7 Publications

Not applicable for this reporting period.

**Peer-reviewed publications**

**Technical papers**

**Reports**

**Communication material**

## **1.8 Reference Material**

S-100 Edition 4.0.0 Final

S-101 ENC Product Specification Baseline 1.0.0

S-101 Feature Catalogue S-101FC\_1.0.0\_20190409.xml

NIWC S-100 Test Bed 1.0.0.0

NIWC S-101 Portrayal Catalogue Version 1.1.1