S-102 v2.0.0 Status Update

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Executive Summary:	This paper discusses work by the S-102 Project Team in support of S-102 v2.0.0 finalization.
Related Documents:	
Related Projects:	

Introduction / Background

This past March the S-102 project team held a breakout session to discuss requirements to finalize version 2.0.0 of the S-102 product specification in preparation for submission to HSSC9 (June 2018). The team also discussed what will be required to support current and future S-100 interoperability studies. At the close of the breakout session several teams were formed to provide information and/or investigate areas of interest that will influence the creation and portrayal of S-102 data. The investigation period was recently completed (August 2017) and there are plans to disseminate this information to the entire project team near the end of September. This paper captures the results of the investigation period and discusses the work remaining to finalize v2.0.0 of the product specification.

Discussion

During S-100 WG2 a number of conceptual portrayal options for gridded bathymetry were presented to the working group. Potential options included display of soundings extracted from an S-102 dataset, generation and display of S-102 derived depth contours, generation and display of safety contour and associated depth zones, and display of nodal depth and associated uncertainty. The working group acknowledged that while these options were possible, providing the end user with the ability to auto-generate contours and soundings at sea was a serious concern because it bypassed traditional HO validation procedures (i.e. potential legal issues). The S-102 PT considered this feedback and agreed to scale back v2.0.0 portrayal, focusing solely on displaying gridded bathymetry and providing the ability for the mariner to display the nodal depth and associated uncertainty based on the location of the ECS cursor. To achieve alignment of the S-102 specification with these objectives the project team focused on elements associated with S-102 grid production (coordinate reference systems, recommended grid resolutions, tiling schemes, file size limits, and gridding methodology) and began documenting potential interoperability concerns between S-101 and S-102. The project team also initiated development of a BAG to S-102 conversion script.

S-102 Grid Production

Modern chart production software allows users to query, combine, and extract bathymetric information as gridded surfaces to support the compilation of charting products. Archived bathymetry is typically stored at the highest resolution possible to eliminate the need to constantly interact with large quantities of source bathymetry each time a charting product is required. As the S-102 PT initiated discussions to finalize elements associated with grid production it was noted that hydrographic offices store and access gridded bathymetry differently. It was also recognized that the project team would need to identify mandatory and recommended gridding parameters because a single gridding solution should not be levied on all HOs, and in most cases would not support all production and/or

charting requirements. For this reason, the group focused on coordinate reference systems, recommended grid resolutions, tiling scheme, file size limits, and gridding methodology.

Coordinate Reference Systems

During the breakout session project team members noted that version 2.0.0 of the specification stated that S-102 surfaces can be produced in any projected coordinate system. Multiple members expressed concern that having such a wide selection of coordinate systems would create unnecessary challenges for OEMs. The group decided that a limited number of CRS should be allowed for S-102 datasets, with approved CRS's defined with ESPG code. The group also noted that there is a need to include transformation parameters in metadata when necessary.

Ongoing discussions have focused on whether S-102 should utilize a geographic or projected CRS. Feedback from project team members has produced the following pro' and con's for each method.

Geographic CRS

Pros

- S-101 and S-102 product extents will be consistent, since S-101 utilizes geographic CRS (EPSG:4326/WGS84)
- OEMs (ECDIS manufacturers) won't need to reproject data

Cons

- Inconvenient at higher latitudes
- Requires that positions be reported as floating point numbers; inaccuracies in floating point calculation may yield positional uncertainties in generalization

Projected CRS (e.g., all UTM zones in WGS84)

Pros

- Product boundaries will conform to a regular grid

Cons

- S-101 and S-102 product extents won't be consistent HOs may have products that cross zones

Assessment of this study points towards the use of Geographic CRS, but a high percentage of project team members prefer Projected CRS because it allows for easier databasing of gridded surfaces.

Question for OEMs: *If project team consensus pushes the specification towards Projected CRS, is this solution viable? It was noted that OEMs, not the HO will bear the burden of implementing S-102.*

Grid Resolution

Feedback from the project team shows there are a number of factors that need to be considered to determine the "appropriate" grid resolution. These include: (1) the intended use of the S-102 dataset (e.g., to enable precision navigation, for generalized bathymetry, etc.), (2) whether product will be visible on ECDIS at the specified display

scale, and (3) file size, which is a function of both grid resolution and tile size. It is also noted that Interoperability with S-101 will need to be considered.

Current grid resolutions proposals being considered:

1) The German Hydrographic Office proposed a grid resolution scheme derived from requirements in the ENC product specification ("linear features must not be encoded at a point density greater than 0.3mm at compilation scale").
2) The Finnish Transport Agency (FTA) noted that complex bathymetry areas may require higher grid resolutions. FTA's solution is to create a surface model with a base resolution of 5m and generalize to coarser resolutions (10m, 20m, 50m) as necessary for individual products using a shoal-biased generalization algorithm. Some areas, however, may require local surface models with higher resolution (1m to 2.5m).

The following table captures recommended grid resolutions as proposed by the German Hydrographic Office.

Navigational Purpose	Compilation Scales	Coarsest Recommended Grid Resolution	Note: German HO Recommendation
1 - Overview	1:3,000,000 and smaller	900 m and larger	900.0 m and larger
2 - General	1:700,000 1:350,000	210 m 105 m	210.0 m 105.0 m
3 - Coastal	1:180,000 1:90,000	54 m 27 m	54.0 m 27.0 m
4 - Approach	1:45,000 1:22,000	13 m 6 m	13.50 m 6.60 m
5 - Harbour	1:12,000 1:8,000 1:4,000	3 m 2 m 1 m	3.60 m 2.40 m 1.20 m
6 - Berthing	1: 3,999 and larger	1 m and smaller	1 m and smaller

Table 1 – Proposed resolutions by the German Hydrographic Office

Tiling Scheme and File Size Limits

During the breakout session the project team discussed how to avoid confusion for end users when issuing new editions of S-102 data. Representatives from PRIMAR proposed that new editions should cover the same area as the superseded edition. The group discussed the pros/cons of this suggestion and ultimately agreed that new editions should cover the same areas as any previous edition, but also discussed the need to establish a tiling scheme to help with dissemination.

The project team also noted that any proposed tiling scheme would also need to consider file size limits defined

in the specification. Current "Draft" v2.0.0 spec establishes both a10 MB (wireless transmission) and 256 MB (shore based loading) file size limit for gridded data. The project team discussed and is currently working to define a tiling scheme that supports product dissemination and version control while maintaining compliance with a current file size limits.

Multiple group members offered to investigate potential tiling schemes and provided feedback that will be compiled and pushed to the project team for consideration.

S-102 v2.0 currently has the following provisions affecting tiling scheme:

> **1.4, General S-102 Data Product Description:** "*A Bathymetric Surface Data Product may exist anywhere in the maritime domain. There are no limitations to its extent. A particular supplier, such as a national hydrographic office, may establish its own series of ENCs and auxiliary data that can be used together or with other S-100 data. These series may include Bathymetric Surface data. When used together with other data layers the requirement is that the reference system be the same or be directly convertible for all layers and that the tiling schemes align*."
>
> **4.2, Application Schema:** "*...The choice of whether to use a tiling scheme and which tiling scheme to use is left open. An implementer, such as a national hydrographic office, can select the tiling scheme, extent, resolution and other parameters most appropriate for their situation."*
>
> **Section 4.2.2, Tiling Scheme (Partitioning)** indicates that the current S-102 tiling scheme is defined externally, but a future S-102 edition will include the capability to define the S-102 tiling scheme internally (defined by S102_TilingScheme and sequence of S102_Tiles).

The following tiling options were explored:

> **Finnish Transportation Agency:**
>
> - Tiling extents freely definable
>   - Cons: overlapping products and extents; maximum file size limits extent and/or resolution
>
> - Tiling extents based on ENC cell boundaries
>   - Pros: ENC and S-102 product boundaries are the same
>   - Cons: ENC cells are typically large and have extents which are inconsistent and subject to change; product boundary mismatch between S-101 (geographic coordinates) and S-102 (projected coordinates); neighboring S-102 products may have mismatching boundaries
>
> - Tiling extents based on regular grid
>   - Pros: Products have predefined spatial extents; no overlapping of S-102 products; maximum file size is known (e.g., if tile size and resolution are fixed); temporally stable; simple updating/versioning 5
>
> **National Oceanic and Atmospheric Administration:**
>
> - Relationship between tile size, grid resolution and file size
>   - A test was performed using NOAA's LA/Long Beach project to examine the relationship between tile size, grid resolution and maximum file size: S-102 is a template application schema, which means (among other things) that the choice of attributes such as which tiling scheme to use is left open (See Table 2).

US Navy

- Establish tile size based on number of grid nodes in the X and Y directions
    - Pros: Products have predefined spatial extents; no overlapping of S-102 products
    - Pros: S-102 files containing less than 2300 X 2300 grid nodes (rows X columns) will remain under the 256 MB file size limit identified in V2.0.0. Grid resolution does not impact final files size.

		Tile Size*			
		0.01° Tile (1.1 x 0.9 km)	0.02° Tile (2.2 x 1.8 km)	0.05° Tile (5.5 x 4.6 km)	0.10° Tile (11 x 9 km)
Grid Resolution	1 m Grid Resolution	4 MB	12.9 MB	NA**	NA
	2 m Grid Resolution	1.2 MB	4.2 MB	19.4 MB	NA
	4 m Grid Resolution	264 KB	1.1 MB	5.9 MB	NA
	8 m Grid Resolution	106 KB	270 KB	1.5 MB	NA
	16 m Grid Resolution	66 KB	110 KB	390 KB	NA

*Tile size dimensions in km were determined using Lat/Long of LA/Long Beach
**NA indicates that surface coverage was insufficient to determine maximum BAG file size (e.g., no fully populated tiles are available for the given resolution and tile size)

Table 2. Results from NOAA study on the relationship between grid resolution and tile size.

Current Results:

1. S-102 currently allows a lot of flexibility where tiling scheme implementation. This flexibility is good as it enables HOs to implement whatever tiling scheme works best for their S-102 production.

2. It looks like the metadata for defining the S-102 tiling scheme internally has already been defined.

Remaining effort: *Additional work needs to take place to review the current S102_TilingScheme definition and confirm it captures everything that is needed for successful implementation?*

2.4 Gridding Methodology

Different HOs use different algorithms for producing bathymetric grids. Some agencies, including FTA, use shoal-biased gridding methodology; other agencies, including NOAA and the US Navy, use uncertainty-weighted algorithms (e.g., CUBE).

- FTA has concerns about whether the shoal-biased depth is reported at the center of the grid cell or at the "true position" of the measurement.

Summary and Recommendations

- If gridding methodology is left to the discretion of the HO there should be a provision in the S-102 metadata to describe the gridding algorithm. The metadata should be sufficient such that an interpretation layer can decide how to handle the S-102 data set downstream.

Remaining effort: *Project Team needs to consult with OEMs and/or technical experts to determine what metadata shall be required.*

S-102 Interoperability

The Finnish Hydrographic Office feels that we must ensure no conflicts between S-102 and S-101

- This includes conflicts between S-102 bathymetry and S-101, as well as S-102-derived products (e.g., contours and/or depth areas) and S-101

Where conflicts do exist, however, how should they be handled?

- Conflicts due to scale mismatch (e.g., if S-102 dataset is provided at larger scale than the largest-scale ENC)
- Conflicts due to date mismatch (e.g., if S-102 dataset is released before the S-101 product can be updated -- post-dredge, etc.)
- Conflicts where S-102 is deeper than S-101 vs. Conflicts where S-102 is shoaler than S-101

  - Both scenarios may exist within the same S-100 exchange set

Summary

Although S-102 has a provision for portrayal, it is expected that difficult questions of interoperability may need to be addressed within a separate interoperability standard within S-100.

Creation of BAG to S-102 Script

US Navy is currently working to develop a script to convert a Bathymetric Attributed Grid (BAG) into an S-102 dataset. When complete this script will extract and replace BAG metadata with S-100 compliant metadata and output a true S-102 dataset for ingest into the S-100 test bed. US Navy had initially planned to complete this effort by August but ran into delays. Current plans are to finalize and deliver a completed script to the IHO for dissemination to the S-100 working group by the end of calendar year 2017.

Action Requested of TSM5

The TSM5 group is invited to:

a. Note the progress of the S-102 PT and provide comments as appropriate.