Paper for Consideration by S-102PT13

Grid cell boundaries and cell areas

Submitted by:	Sweden, Germany and Finland
Executive Summary:	This paper proposes a way forward on how to handle bounding box extents and cell value representation issues raised in GitHub issue #29. The changes are to be made to the S-102 PS as a clarification in edition 2 in a redline version.
Related Documents:	GitHub issue #29, S-100 part 8-6.2.8 Grid cell structures, S-98 Annex C section C-4-1.2
Related Projects:	None

Introduction / Background

The ongoing GitHub issue (#29) identifies two main questions within the product specification (PS) that needs addressing:

1. The bounding box versus the data coverage discrepancy and the absence of a definition for how to handle NoData/FillValue.
2. The grid cell representation as center node versus cell area.

Analysis/Discussion

In the current PS there is an ambiguity between the bounding box and the actual coverage of the product. This ambiguity causes a discrepancy between the two, see image below. These differences between the bounding boxes would indicate that there are gaps in between S-102 products. These gaps could in reality be several meters if the grid cell size is, for example, 10x10 meters, even though there is a continuous coverage. It would also be impossible to create a product portfolio that would not indicate gaps using a center grid node based bounding box, since that would mean overlapping S-102 products. This is not allowed in the PS today, see section 4.6 Dataset Rules. By using the grid cell outer boundaries defining the Bbox rather than center nodes these problems can be avoided.

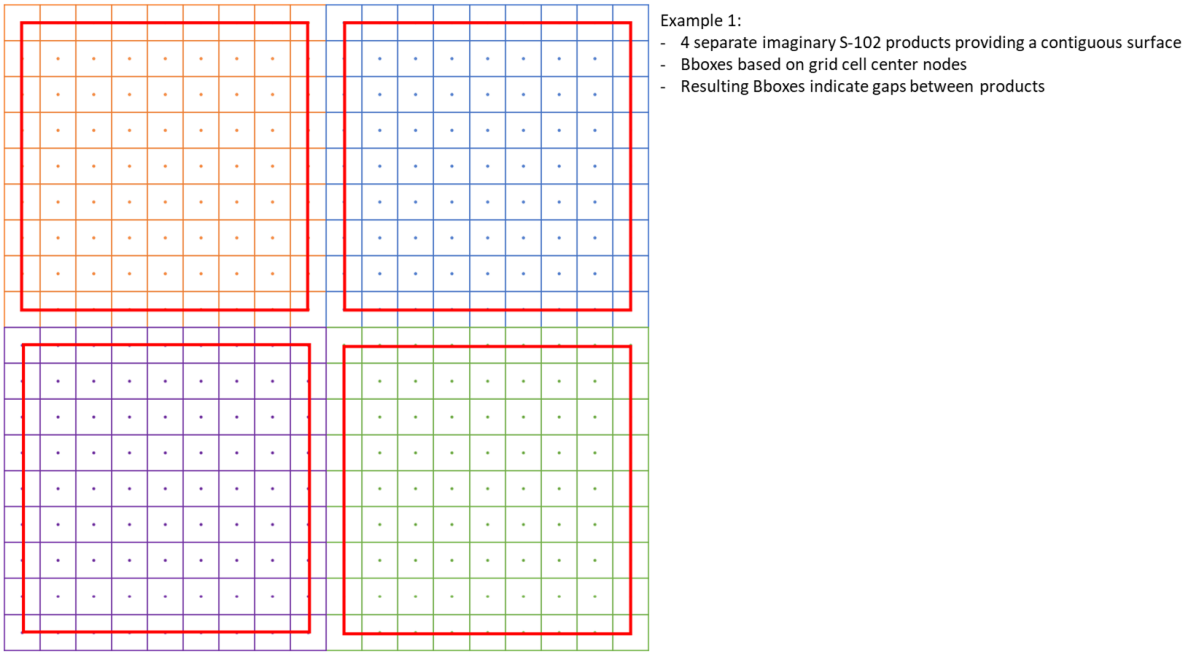


Image credit: Topi Filppula/Traficom, Finland.

The current PS also lacks clear definitions of NoData/FillValue handling with regards to bounding box creation, see image below.

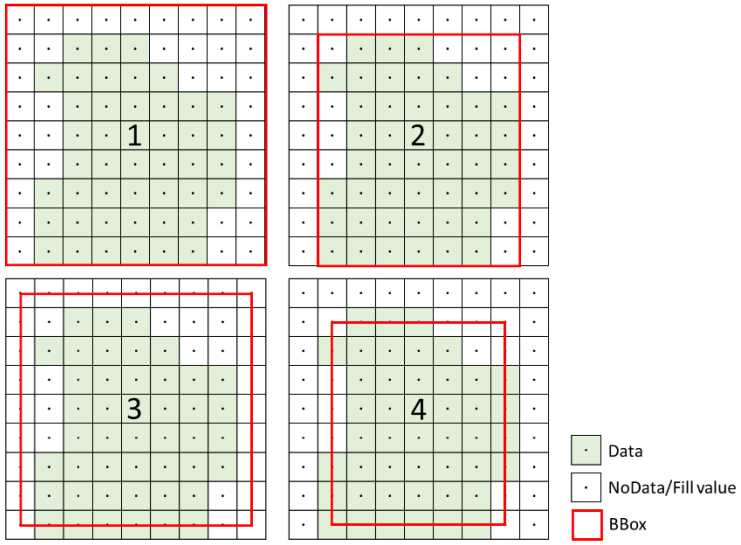
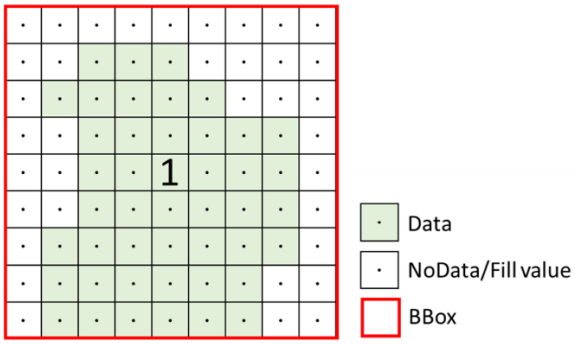
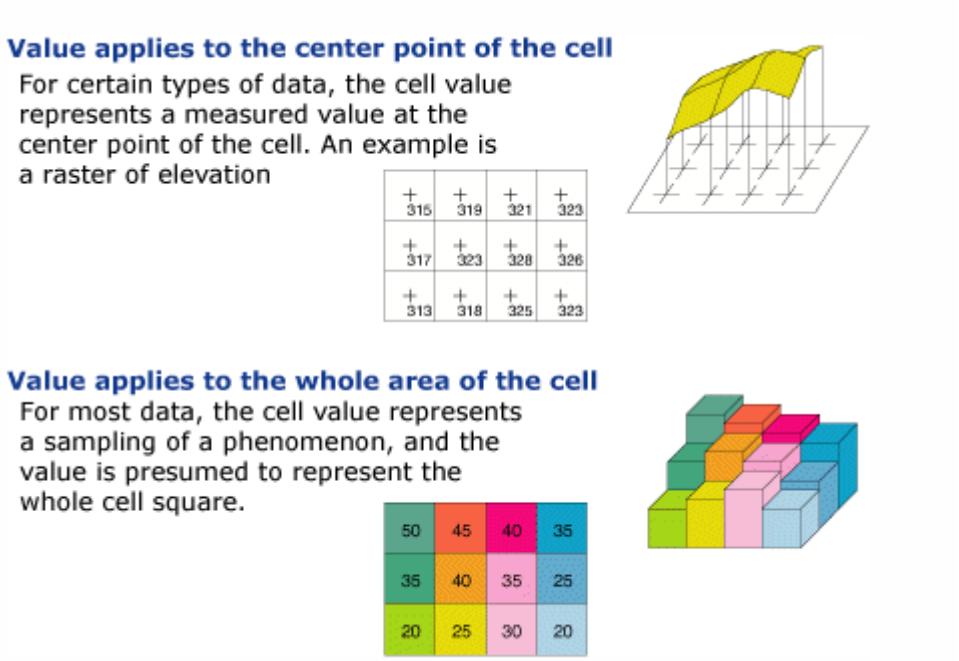


Image credit: Topi Filppula/Traficom, Finland.



Looking into the responses in GitHub issue #29, the majority supports option 1. One benefit of using option 1 is that it makes it easier to make product portfolios based on regular grids with predefined spatial extents.

The second question addressed, is linked to the perception and handling of the S-102 product as a whole. The assigned depth value in the nodal position must represent the depth of the whole grid cell area, and not only the center nodal position. The main consequence of handling the product simply as a center node based coverage is that it may create contours not safe for navigation. The safety contours could potentially be generated on the wrong side of the true position of the shoalest depth in the cell, regardless of the grid resolution. Using a node-based approach would either mean a regularly spaced point set with no depth information available in between grid nodes or (linear-) interpolation of depth between grid nodes. The first of these provides no depth information in between grid nodes and the latter is potentially unsafe for navigation. Using grid cell area based approach removes this problem and provides the mariner with depth information everywhere within the data coverage, not just on grid node point locations. To illustrate these issues, see images below. By making the necessary changes to the S-102 PS it would create a better alignment with S-98 Annex C-4-1.2 Data Constraints. For this second question, a clarification is needed in the PS, as a suggestion in section 4 Data Content Structure.



Source: https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/introduction-to-raster-data.htm

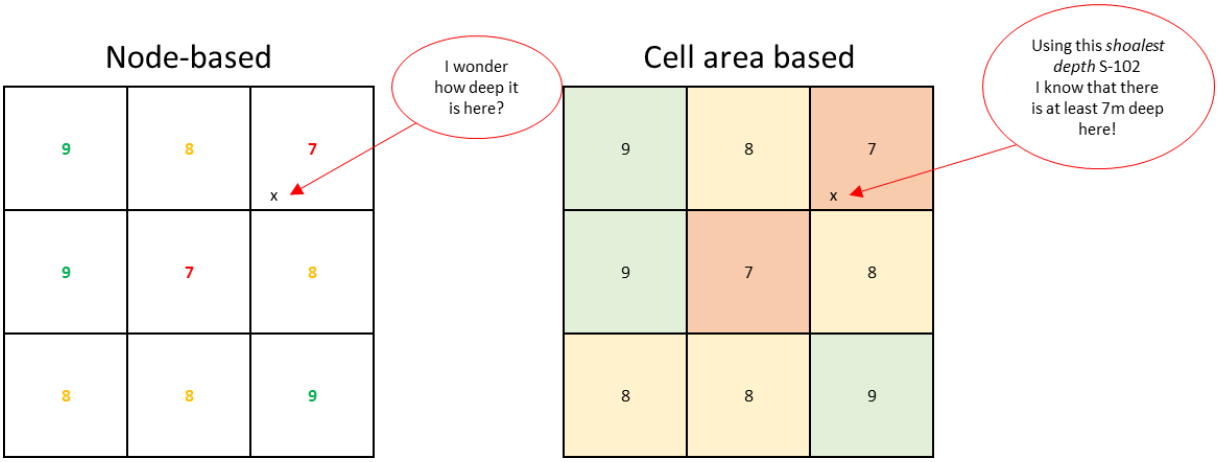


Image credit: Topi Filppula/Traficom, Finland.

This topic also aligns with ISO 19123 as stated in S-100 part 8-6.2.8 Grid cell structure; "Data values at a sample point represent measurements over a neighbourhood of the sample point. This neighbourhood is assumed to extend a half-cell in each dimension. The effect is that the sample space corresponding to each grid point is a cell centred at the grid point."

Another example to further support this proposal is in part 10.2.1.1 Gridding Method/Table 9 – S-102_GriddingMethod parameters; "The Shoalest Depth algorithm examines depth estimates within a specific area of influence and assigns the shoalest value to the nodal position. The resulting surface represents the shallowest depths across a given area." Note that this would exclude "tilting" (interpolation of values between cells), as described in the image above.

Conclusions
The issues described above needs to be investigated and discussed further. The ambiguities have to be clarified and necessary changes have to be made to the S-102 PS.

Recommendations
1. Use current GitHub Issue #29 (https://github.com/iho-ohi/S-102-Product-Specification/issues/29) and create a development branch.
2. Make the necessary changes to the S-102 PS as a clarification in edition 2 in a redline version.
3. Merge the changes from the branch into the new S-102 version.

Justification and Impacts
The bounding boxes will match each other and prevent gaps in between neighboring S-102 products.

Furthermore, an intuitive and uniform concept of what the value of a grid cell describes in terms of its area is needed for the S-102 PS. This will also better support safe navigation by means of stronger alignment with S-100 and enable unambiguous contouring/WLA in S-98.

These changes have no impact on other S-100 PS.

Action Required of S-102 PT
The S-102 PT is invited to:

a. Approve to investigate and make the necessary changes to the S-102 PS;
   - so that bounding box and depth coverage matches, based on the whole grid cell area and the outer boundaries, not the center node position,
   - on how to handle NoData/FillValue with regards to the bounding box, and
   - to clarify the representation of depth value within a grid cell.
b. Approve that Sweden take lead in the work to change the PS accordingly, together with other interested parties.
c. Contribute to the work through the GitHub issue #29.