

14.8.2025

Regional product harmonisation guidelines for S-102

Version history

Version	Date	Description	Author
0.1 Draft	1.11.2024	Draft	Traficom
0.2 Draft	2.12.2024	Second draft	Traficom
0.3 & 0.4	-	Online comments, new versions created automatically in Project Place	-
0.5 Draft	17.12.2024	Third draft	Traficom
0.6	8.1.2025	First finalised document version for commenting / approval process	Traficom
0.7	17.2.2025	Edited based on received comments	Traficom
0.8	15.4.2025	Edited based on results from scenario testing and comments of the VTC meeting 14.4.2025	Traficom
0.9	28.4.2025	Edited based on received comments	Traficom
1.0	5.5.2025	Edited based on received comments	Traficom
1.1	1.7.2025	Edited formatting and the sections concerning "display scale" and "numerous small no-data areas"	Traficom
1.2	14.8.2025	Edited based on received comments	Traficom

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Annex A Questionnaire to Baltic Sea Hydrographic Offices in Baltic Sea e-Nav project

Annex B Questionnaire results

Preface

The Baltic Sea e-Nav project

This harmonisation work and document has been prepared under the Baltic Sea e-Nav project (Shared waters – Same standards. Baltic Sea Partnership for Future Navigation) funded by Interreg Baltic Sea Region (EU). The Baltic Sea e-Nav project is dedicated to modernising the digital navigation tools for maritime navigation, in the Baltic region. The first objective is to empower data producers to generate next-generation navigational products by enhancing their capabilities and upgrading systems to S-100 standards. Secondly, the project aims to harmonise these products regionally under the Baltic Sea Hydrographic Commission (BSHC), ensuring a uniform user experience.

Questionnaire

The harmonisation effort began by gathering insights and requirements through a questionnaire (see Annex A). This questionnaire was distributed by BSH (Bundesamt für Seeschifffahrt und Hydrographie) to the seven Hydrographic Offices (HOs) participating in the Baltic Sea e-Nav project: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, and Sweden. The results are presented in Annex B.

The questionnaire results indicate considerable variation in the planned resolution of S-102 products. Some countries also plan to publish S-102 in multiple different resolutions. The spatial resolution varies in these plans from 0.5 m to 8 m and 1 m to 32 m depending on the intended use. There are also different views on tiling. Some HOs are planning to use regular tiling (3) while some are not (2) and others (2) have not decided.

The S-102 standard determines WGS84 to be used as the coordinate reference system, but it is up to the HO to decide whether geographical or projected (UTM, UPS) system is used. Indeed, there are different views on whether a projection is used. Three of the HOs plan on using UTM projection, while three are using unprojected data, and one has not decided.

In terms of vertical reference system, the Baltic Sea Chart Datum 2000 (BSCD2000) has been agreed to be used for sea areas (in the Baltic Sea).

The results indicate that despite various views on spatial resolution, tiling schemes, and the use of projection, not many topics requiring harmonisation were identified. Harmonisation in general is seen as important especially where S-102 products from different countries align.

Finally, the questionnaire results capture the position of the HOs at May 2024. Thus, the position at the time when this document was finalized may differ.

S-102 Harmonisation meetings

The harmonisation effort of S-102 has been carried out by means of two face-to-face meetings (in conjunction with general Baltic Sea e-Nav project meetings in Tallinn in December 2024 and in Rauma in April 2025) and three VTC meetings in November and December 2024 and April 2025. In addition to these meetings, harmonisation topics and questions have been raised in other project and working group meetings. Harmonisation drafts have been shared with all project partners followed by commenting periods.

S-102 Harmonisation guidelines

General

As the primary purpose of a S-102 product is to provide high-resolution bathymetric information, it is expected to provide added value compared to the S-101 ENC. The user experience and expectations should be carefully considered when designing and producing S-102 products to ensure usability and trust.

- 1) *Recommendation: As the primary purpose of an S-102 product is to provide high-resolution bathymetric information, it is expected to provide added value compared to the underlying S-101 ENC(s). User experience and expectations should be considered in the planning and production of S-102 products to promote usability and accuracy.*

Vertical reference system

Baltic Sea Chart Datum 2000 (BSCD2000) must be used as the vertical reference system for S-102 in the Baltic Sea as agreed.

Resolution

The HO's face different restrictions on the resolution and maximum coverage of S-102 products due to naval or security considerations. Defining the resolutions of all S-102 products according to the most restrictive option is not beneficial for the end users. The harmonisation of resolution is not considered crucial. Thus, each HO is advised to produce S-102 data according to their capabilities and data restrictions. A resolution of 10 meters or finer is recommended as a general guideline for S-102 products.

The question of how to choose an appropriate resolution for S-102 for certain areas has been brought up for discussion. Possible data restrictions may limit the resolution and/or extent of S-102 products. Balancing is needed to find the best solution between the user needs and keeping the number of products and their sizes reasonable. The survey method and data quality on the other hand impose limitations that can be tackled either by interpolating or reducing the resolution. For example, too low resolution may cause narrow shipping channels to be generalised based on surrounding shallow waters leading these channels to disappear from the S-102 product.

- 2) *Recommendation: Suggested grid cell size (resolution) for fairways, harbour areas, and other areas requiring higher precision data is less than or equal to 10 m (taking into consideration local data publicity restrictions).*

Product scheming

When it comes to product schemes, countries have different plans: regular tiling schemes, irregular schemes, or "stand-alone" products. Product scheming is left for each HO to decide as no need or means for harmonisation of product schemes were identified.

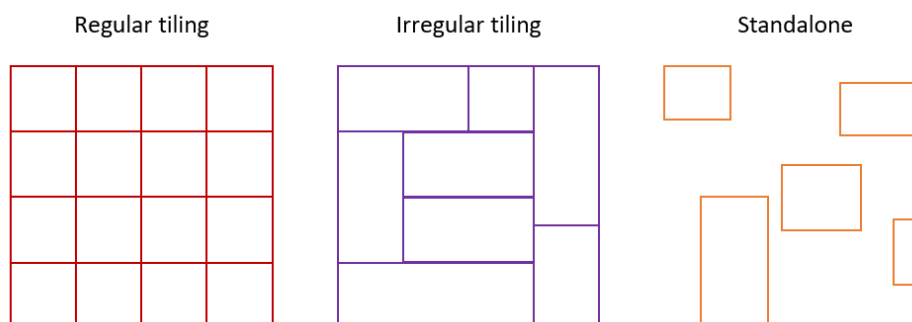


Figure 1. Different product scheming options

No harmonisation recommendation is needed regarding tiling schemes/product boundaries.

Projection

The use of projected or geographical coordinate systems has its advantages and disadvantages. When using a geographic coordinate system in high latitudes the "distortion of scale" (change of spatial resolution) may become significant already within a single product - when compared to UTM projected. This is especially true on products having a larger north-south dimension, like those from the approaches to major ports in southern Finland. On the other hand, S-101 ENC's use geographical coordinate system, and thus it may appear logical to use unprojected data also for S-102 products. The use of projection is left for each HO to decide.

No harmonisation recommendation is needed regarding the use of projection.

Areas of responsibility

- 3) *Recommendation: The Hydrographic Offices are responsible for the production and distribution of S-102 within their area of responsibility for the production of ENC's.*

Display scale ranges

Defining display scale range values is essential for user-friendly experience of S-102 products and will be needed especially if overlapping products of different scales exist. Currently, display scale attributes are only metadata but if S-102 is to be turned into a scaled product, the populated display scale ranges would allow multiple overlapping S-102 products for different use cases. When setting the display scale attributes, consideration must be given to the compatibility with the S-101 products intended for use alongside the S-102 products.

- 4) *Recommendation: Minimum and maximum display scale attributes should be populated with meaningful values. It is recommended to define display scale attributes based on following criteria:*
- a) *The HO should carefully consider which S-101 ENC's they intend to be used alongside the S-102 in question and base the selection of display scale values on these.*
 - b) *The maximum display scale of S-102 product should be equal to or greater than the (greatest) maximum display scale of the relevant S-101 ENC(s). The greatest possible value is "1".*
 - c) *The minimum display scale should be selected from the list of allowed values for S-101 minimum display scale (Table 3-1 in S-101 ed. 2.0.0) and should be smaller than the (smallest) optimum display scale of the relevant S-101 ENC(s).*
 - d) *In cases of overlapping S-102 products, the maximum-minimum scale ranges must not overlap.*

Table 1. ENC Minimum Display and Optimum Display Scales (Table 3-1 in S-101 ed. 2.0.0)

Scale
NULL (only allowed on minimum display scale (data will continue to be displayed at all smaller scales))
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 (only allowed on optimum and maximum display scale)

See examples of defining the display scale range values of S-102 products in tables 2 and 3.

Table 2. Example: One S-101 ENC considered relevant

	S-101 ENC	S-102
Maximum display scale	1:6 000	1:6 000 or greater
Optimum display scale	1:12 000	-
Minimum display scale	1:22 000	1:22 000 or smaller

Table 3. Example: Two S-101 ENCs considered relevant

	S-101 ENC	S-102
Maximum display scale	1:4 000, 1:11 000	1:4 000 or greater
Optimum display scale	1:8 000, 1:22 000	-
Minimum display scale	1:22 000, 1:90 000	1:45 000 or smaller

Harmonisation of products and data meeting at borders of areas of responsibility

- 5) *Recommendation: Neighbouring countries should agree on harmonisation of data coverage and display scales of S-102 products meeting at borders of areas of responsibility. It is recommended that data overlaps along borders be minimized and should not exceed the extent of a single grid cell.*

Data updating

- 6) *Recommendation: New bathymetric survey data or known changes in the topography of the seabed (e.g. dumping, dredging, or extracting; construction of new quays or locks) trigger the need for a new edition of the dataset. If updating the data is not feasible despite known changes in the seabed topography, the cancellation of the S-102 product should be considered.*

S-102 in relation to S-101

Due to interoperability reasons, S-102 should be limited to areas where S-101 is available.

- 7) *Recommendation: S-102 should only be released in areas where S-101 is available.*

Survey technique

No harmonisation is needed. The requirements for the survey technique are to be determined at the discretion of the HOs.

Uncertainty- & quality of bathymetry coverage bands

Both *uncertainty* and *quality of bathymetry coverage* bands are optional in S-102. Due to the optional nature of these bands and the likely differing capabilities between data producers in populating these bands (e.g. differences in source information type and/or availability), harmonisation of these bands does not appear feasible. However, Hydrographic Offices should consider including, as a minimum, the survey end date (as `surveyDateRange.dateEnd` of the `QualityOfBathymetryCoverage`) to provide mariners with valuable information, enabling them to determine which data is more reliable or up to date for safe navigation.

- 8) *Recommendation: Hydrographic Offices should consider including the `QualityOfBathymetryCoverage` band (and populating, as a minimum, the attribute "`surveyDateRange.dateEnd`") to provide mariners with valuable information, enabling them to determine which data is more reliable or up to date for safe navigation.*

Numerous small no-data areas

Numerous small holes in S-102 data significantly add to the complexity of calculating the border polygon (S-98 requirement) and safety contours based on S-102 in ECDIS. In order to avoid ECDIS performance issues, it is recommended to keep unnecessary holes in S-102 data to a minimum. See an example of potentially problematic data in figure 2.

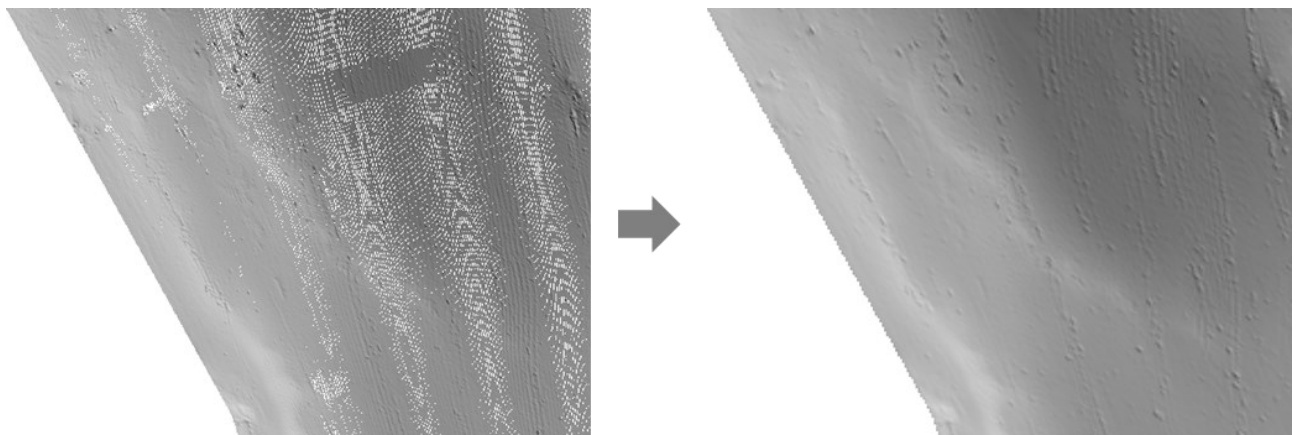


Figure 2. Insufficient survey data density: If survey data is not dense enough to support gridding at selected S-102 resolution level a large number of small holes within the coverage will occur. To mitigate this, coarser grid resolution or interpolation (to fill holes) should be considered. Also, the possibility of new survey and releasing S-102 later should be kept in mind.

- 9) *Recommendation: The presence of numerous small holes in S-102 data significantly adds to the complexity of calculating the border polygon (S-98 requirement) and safety contours based on S-102 in ECDIS. In order to maximise product usability and performance it is recommended that HO's aim to produce continuous depth information within their S-102 data coverage areas, trying to avoid unnecessary holes. Mitigation measures include changing to coarser grid resolution, cutting/trimming out insufficient data and interpolation.*

Summary of the harmonisation recommendations

- 1) *Recommendation: As the primary purpose of an S-102 product is to provide high-resolution bathymetric information, it is expected to provide added value compared to the underlying S-101 ENC(s). User experience and expectations should be considered in the planning and production of S-102 products to promote usability and accuracy.*
- 2) *Recommendation: Suggested grid cell size (resolution) for fairways, harbour areas, and other areas requiring higher precision data is less than or equal to 10 m (taking into consideration local data publicity restrictions).*
- 3) *Recommendation: The Hydrographic Offices are responsible for the production and distribution of S-102 within their area of responsibility for the production of ENCs.*
- 4) *Recommendation: Minimum and maximum display scale attributes should be populated with meaningful values. It is recommended to define display scale attributes based on following criteria:*
 - a) *The HO should carefully consider which S-101 ENCs they intend to be used alongside the S-102 in question and base the selection of display scale values on these.*
 - b) *The maximum display scale of S-102 product should be equal to or greater than the (greatest) maximum display scale of the relevant S-101 ENC(s). The greatest possible value is "1".*
 - c) *The minimum display scale should be selected from the list of allowed values for S-101 minimum display scale (Table 3-1 in S-101 ed. 2.0.0) and should be smaller than the (smallest) optimum display scale of the relevant S-101 ENC(s).*
 - d) *In cases of overlapping S-102 products, the maximum-minimum scale ranges must not overlap.*
- 5) *Recommendation: Neighbouring countries should agree on harmonisation of data coverage and display scales of S-102 products meeting at borders of areas of responsibility. It is recommended that data overlaps along borders be minimized and should not exceed the extent of a single grid cell.*
- 6) *Recommendation: New bathymetric survey data or known changes in the topography of the seabed (e.g. dumping, dredging, or extracting; construction of new quays or locks) trigger the need for a new edition of the dataset. If updating the data is not feasible despite known changes in the seabed topography, the cancellation of the S-102 product should be considered.*
- 7) *Recommendation: S-102 should only be released in areas where S-101 is available.*
- 8) *Recommendation: Hydrographic Offices should consider including the QualityOfBathymetryCoverage band (and populating, as a minimum, the attribute "surveyDateRange.dateEnd") to provide mariners with valuable information, enabling them to determine which data is more reliable or up to date for safe navigation.*
- 9) *Recommendation: The presence of numerous small holes in S-102 data significantly adds to the complexity of calculating the border polygon (S-98 requirement) and safety contours based on S-102 in ECDIS. In order to maximise product usability and performance it is recommended that HOs aim to produce continuous depth information within their S-102 data coverage areas, trying to avoid unnecessary holes. Mitigation measures include changing to coarser grid resolution, cutting/trimming out insufficient data and interpolation.*

Annex A

Baltic Sea e-Nav S-102 Status Assessment

Welcome to the status assessment survey!

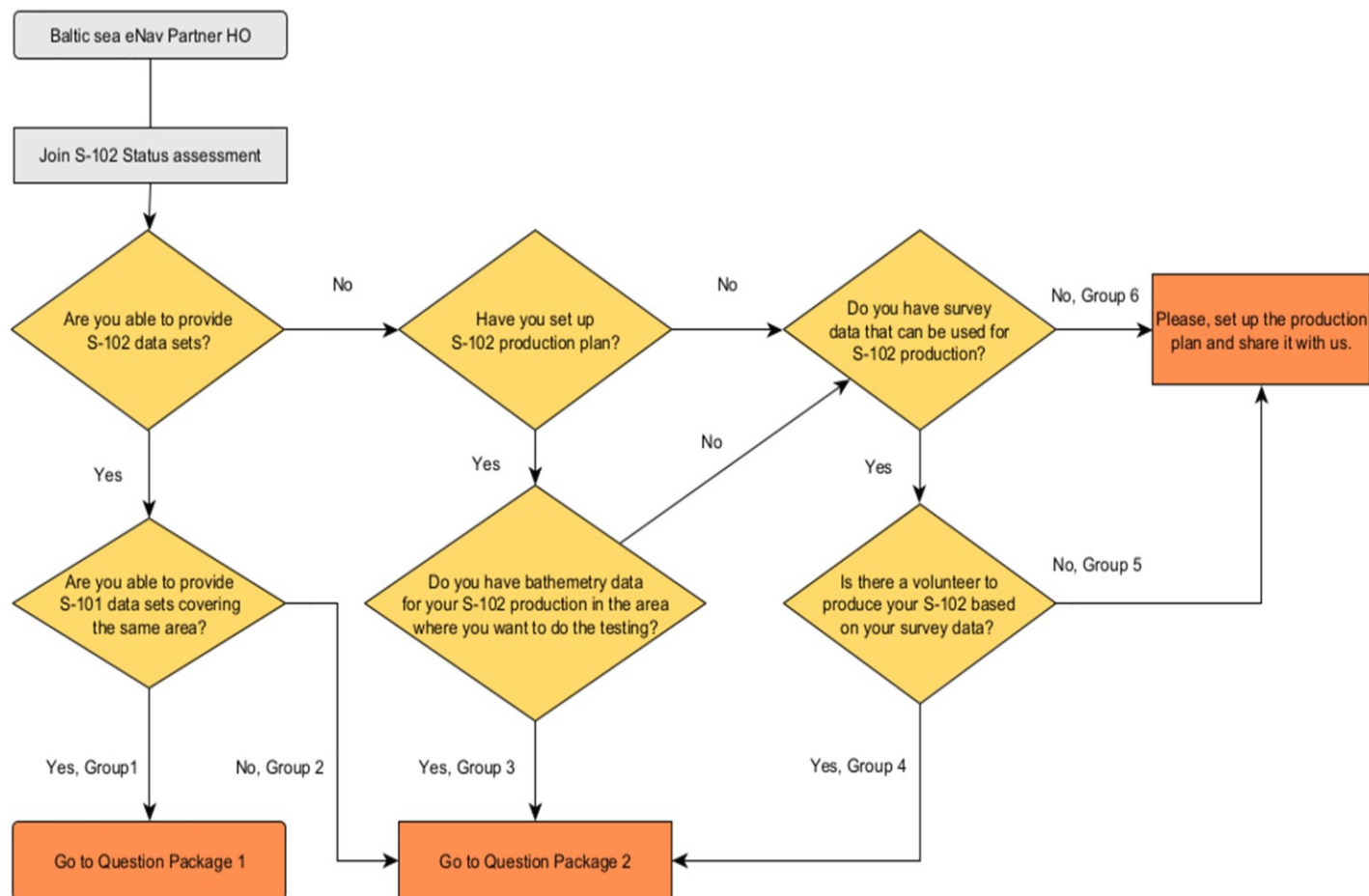
Your feedback is crucial, as we would like to have a clear overview of our current progress and identify areas for the S-102 testing in the Baltic Sea e-Nav project.

Please take a few moments to provide your Hydrographic Office (HO) status on S-102 production, which will guide our efforts to enhance our project. Thank you for your valuable input!

Please refer to the provided flowchart below to find out which question package to start with and indicate your corresponding group.

We kindly request that you submit the completed questionnaire by **May 31, 2024**.

Thank you for your cooperation.



Question Package 1

1.	Please provide spatial information of the geographical area (coordinate...) where you produce S-102 data sets and if the S-101 ENC is available in the same area.
<i>Please insert your answers here in each case.</i>	
2.	Are you able to deliver datasets (including the metadata, exchange set, etc...) according to the S-102 Product Specification (PS)? Which version of S-102 PS?
3.	What grid size (tiling scheme) do you provide? How are your S-102 tiles designed, according to your S-101 scale band? Is the grid spacing (resolution) similar to all your S-102 data sets (if the neighboring cell has same grid)?
4.	Which vertical reference system do you use for S-102 data sets?
5.	Which horizontal reference system do you use? Specify the used projection, if they are projected? (e.g. UTM 32N)
6.	How would you define S-102 harmonisation? For what purpose do we need to harmonize our S-102 together? And how? Please, share your opinion briefly.

Question Package 2

1.	What is the main issue on S-102 production in your HO? Do you already have a strategy to solve this?
<i>Please insert your answers here in each case.</i>	
2.	When do you expect to produce your S-102 datasets?
3.	What grid size (tiling scheme) are you planning to provide? Do you design your S-102 tiles according to your S-101 scale band?
4.	Which vertical reference system are you planning to use for the S-102 data sets?
5.	Which horizontal reference system are you planning to use for the S-102 data sets?
6.	Which projection are you planning to use for the S-102 data sets? (e.g. UTM zone 32N)

Contact

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Annex B

Baltic Sea e-Nav S-102 Status Assessment

HO	version	Grid size	resolution	VRS	CRS	Projection	Harmonisation	Volunteer
DE	S-102 2.1	regular tiling scheme (2' x 2')	1m (can be changed)	MSL(BSCD2000 available with S-102 3.0)	WGS84	UTM32		
SE	S-102 2.1, 2.2 (without exchange set)	regular tiling scheme	2m*2m, 10m*10m	BSCD2000	WGS84	N/A	<p>Harmonisation is important for the end users (mariners in the Baltic Sea). It is also important for the other services, for example UKCM.</p> <p>We would like to have discussions with neighboring HO's and talk about pros and cons for certain decisions. We would also like to share our own experiences and learn from others. The tests will be valuable to show how differences and similarities can be viewed in an ECDIS/PPU.</p>	
DK	S-102 2.2	navigation purpose 4 (Transit).	8m, 0.00012 decimal degree	MSL(planning BSCD2000)	WGS84	Unprojected	Harmonize how an S-102 relates to S-101 data sets. Range of usable grid resolution for navigation purpose to reduce visualization artifacts across the boundaries.	
LT	S-102 2.2 (Depends on ESRI)	not decided	not decided	BHS77 (planning BSCD2000)	WGS84	UTM34	Main issue with national security -Grid size, Resolution (different by the area) has been discussed with national security. Want advise from others on the optimum resolution of S-102 for the certain area... or depend on depth	PRIMAR
LV	S-102 2.1	not decided	MBES survey data :Open sea 5mx5m ports 0.5mx0.5m	BSCD2000	WGS84 EPSG 4326	not decided	All project participants use same standards and make a common agreement on details of provided datasets (responsible areas, resolutions, coordinates, data update etc.)	PRIMAR
EE	S-102 2.2	No regular tiling	4m	BSCD2000	WGS84 EPSG:4326	unprojected	Harmonisation is important where S-102 areas from different countries align, otherwise not so much. However this can be discussed in order to get similar cell sizes all over the Baltic Sea (if this is feasible)	

FI	S-102 2.1 (Depend on the SW, aiming 3.0 asap)	No regular tiling	2m (harbour) 4m (approach) 16, 32m (for larger area)	BSCD2000	WGS84	UTM34N, 35N	<p>Must harmonize:</p> <ul style="list-style-type: none"> - (Vertical datum, BSCD2000 already agreed upon) <p>Can harmonize, not a must (recommendations):</p> <ul style="list-style-type: none"> - Use projected grids (UTM) or not - Grid resolutions, use of quad-tree approach - Data content (MBES, Echo sweep, LiDAR, SBES) - To interpolate or not to interpolate (sparse data, holes) 	
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