

Paper for Consideration by S-100WG5**S-100 Demonstrator – Norwegian S-100 Testbed Report**

Submitted by:	PRIMAR
Executive Summary:	A summary of S-100 Demonstrator, a Norwegian S-100 Testbed – with the emphasis on the last operational test where S-129 data was produced and used during a commercial voyage. The test involved creation and use of S-102 and S-111 as input in the S-129 model creation.
Related Documents:	
Related Projects:	

Introduction / Background

In line with the increasing development and growing interest of the IHO S-100 Universal Hydrographic Data Model framework, Electronic Chart Center AS (ECC) and Kongsberg Digital AS (company in the Kongsberg Group) have, over the last 3 years, initiated a project to further test the usability and advantages with compatible products, produced on the S-100 framework.

The basic approach for the project:

- a) Identify real world challenging operations in the maritime domain.
- b) Produce S-100 data in areas of interest.
- c) Conduct those challenging operations using S-100 data in an end user application.
- d) Gain experience on potential added value for the maritime industry.

The key mission has been to define how the combination of the new standards can create value for different actors in the maritime industry and improve products and business opportunities.

During the test period several larger trials have been conducted:

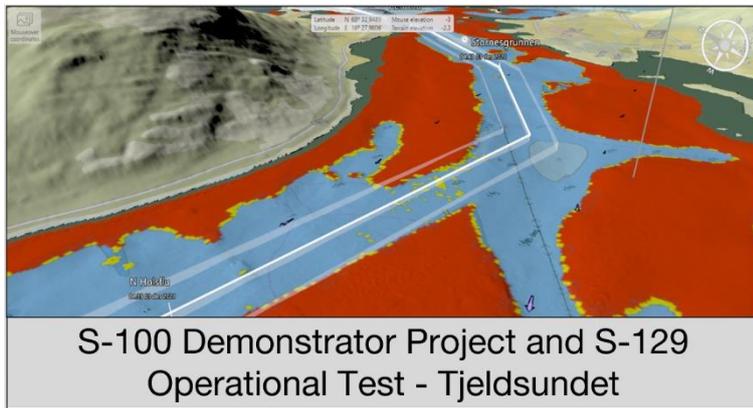
1. Bringing the world's largest crane vessel into the narrow port of Haugesund:
 - o <https://s-100.no/operational-tests-2/operational-tests-sleipnir/>
 - o <https://youtu.be/5NWDJ3vDFpo>
2. Bringing the world's largest catamaran crane vessel into the Port of Kristiansand:
 - o <https://s-100.no/pioneering-spirit/>
3. Simulations of historical voyages in the Port of Kristiansand:
 - o <https://s-100.no/https-s-100-no-operational-tests-2-historical-voyages/>
4. Planning process for excavation and planned quay in the Port of Stavanger - Simulation of the world's largest Cruise ship Oasis of the Seas port entry:
 - o <https://s-100.no/stavanger-harbour-excavation-and-planned-quay-at-bjergsted/>
5. S-129 Under Keel Clearance management tested in the narrow strait of Tjeldsundet:
 - o <https://s-100.no/operational-test-s-129-under-keel-clearance-management-tested-in-tjeldsundet-norway/>

After initially focussing the tests on data produced according to the S-102 Bathymetric Product Specification, the project culminated with the S-129 Under Keel Clearance Management test in Tjeldsundet - where the S-100 datatypes S-101, S-102, S-111 and S-129 were all involved.

Analysis/Discussion

The S-100 Demonstrator project is still ongoing with a planned end date in June 2023. Full conclusions and summary reports from the entire project are not yet available. For the S-100WG we would at this point in time

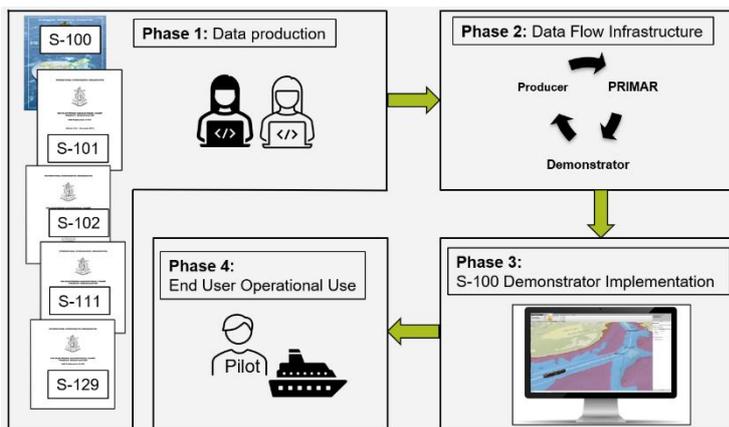
report specifically on the latest operational test conducted – anticipating to provide a complete test report for the next S100WG meeting.



For the S-129 operational test the intention was to produce several products built on the S-100 Universal Hydrographic Data Model and use them together in one application during a commercial voyage in confined and challenging waters. The main intention was to demonstrate the advantages of using compatible S-100 products in navigation planning and voyage execution processes, with an emphasis

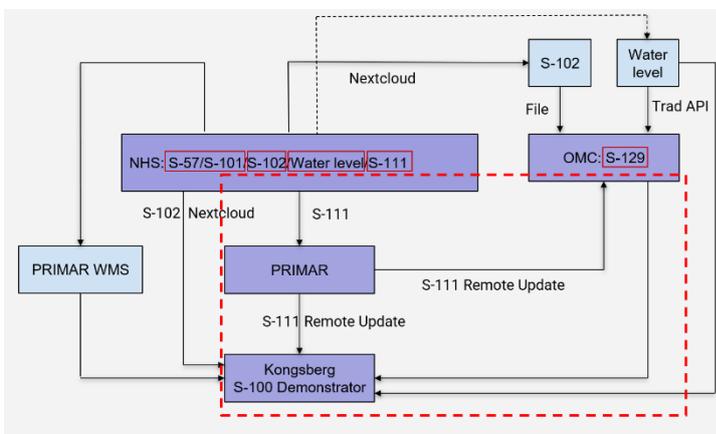
on the S-129 Under Keel Clearance product. The test was separated in 4 phases:

Phase 1 Data production.



Several products were created, involving production of S-101 (conversion from S-57) by ECC, S-102 and S-111 by NHS and S-129 by OMC International. During the production process the producers built experience on production software and accompanying IHO standards, exposing potential challenges and possible valuable feedback to IHO standardisation working groups. Their contributions were also deemed valuable for potential future production lines within their organisations.

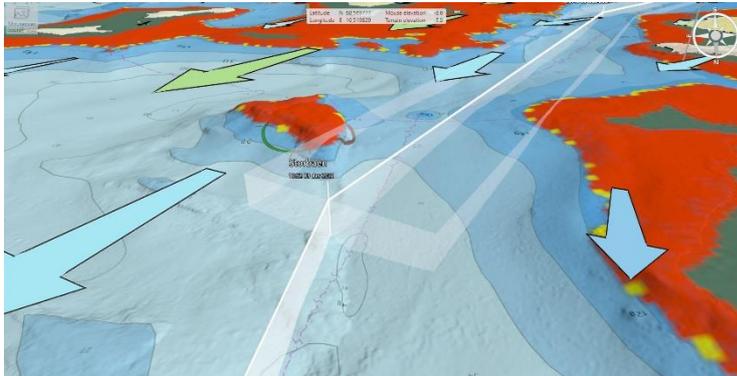
Phase 2 Data Flow infrastructure.



The flow of data from producer to end user, through PRIMAR as a service provider, was demonstrated. Facilitating support for the S-100 Data protection scheme using the PRIMAR Remote Update Protocol was a key element, creating secure and user-friendly connections directly in the end user application (S-100 Demonstrator) for direct access to the data. It was also demonstrated how S-100 products such as S-102 and S-111 could be used as input data in the creation of S-129, and how S-

129 updated plans produced at 1 minute intervals were automatically downloaded and made available in the S-100 Demonstrator application.

Phase 3 S-100 Demonstrator implementation.



The S-100 Demonstrator application was further developed with new functionality to use and display S-101 (through WMS API), S-111 and S-129. Various interaction functionality, like turning on/off information were developed. One example would be the ability to turn off route and control points individually in the S-129 product to avoid clutter in display of the data. In addition to support of the mentioned products, an automated

update integration of the predicted water level datastream was also developed.

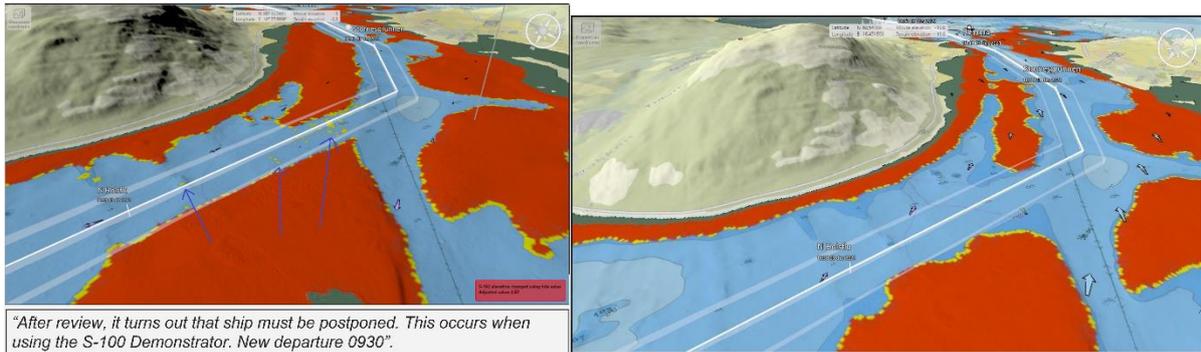
Phase 4 Test execution.

The test execution consisted of two parts. One was to determine the S-100 Demonstrator, with the S-100 products, usability for the voyage planning process, and the other to determine the usability in the voyage execution process. In the days before voyage execution S-129 plans were produced regularly, using daily produced S-111 products and updated water level predictions in the calculation and production of the S-129 products. The plans were assessed by the Pilot and designated training personnel. The test took place on the vessel Tern Ocean owned and operated by the company Termtank, and the vessel Captain and crew were informed of the project and test requirements in the week before voyage execution.



The operational test execution took place on 03.12.2021 at 09:30 - 13:30. On the day of the voyage, Tern Ocean was boarded with a Pilot boat at approximately 09:30. Upon boarding 4 individual computers were assembled and used to run the S-100 Demonstrator application. Pilot plugs, positioned on the bridge wing's, ensured that a position accuracy of 1 cm was achieved. During voyage

execution the Pilot used the S-100 Demonstrator as a navigation support system in addition to the vessel navigation system and the Personal Pilot Unit (PPU) SEAiQ. Designated personnel also used the S-100 Demonstrator recording the voyage and demonstrating the capabilities for those of the crew members on watch. When leaving the designated test area there was interaction with crew members gathering feedback on their views on the S-100 Demonstrator capabilities and the different layers of S-100 information. Upon completion of the voyage execution, all involved companies were given individual surveys to capture their feedback and experiences from the test participation.



As an addition to the 4 main phases, a trial of the PRIMAR RTZ service was also conducted. The Norwegian Coastal Administration is in the process of providing a number of reference routes for Norwegian waters. These routes are made available in the PRIMAR service, giving the opportunity to deliver both ENC's and routes to end users in one delivery. During the test Tern Ocean's Navigation Officer accessed and downloaded several routes covering the Tjeldsundet area from the PRIMAR system. One route was selected and loaded into the vessel's navigation system (Transas ECDIS), simplifying the route planning process.

Conclusions

Key findings from the operational test have provided promising news for the future of S-100 within the maritime domain. The use, and especially the usage of the products in combination, proved to be beneficial for the safety of navigation, in addition to giving economic and environmental benefits for the parties involved in the trial scenarios.

Some specific conclusions:

- The production of the S-1xx products did give all producers valuable experiences on the production process and potential challenges in the internal workflow.
 - S-102:
 - Challenges related to the production process of uncertainty information, and also the understanding of the end user need for uncertainty information from the producer side were revealed.
 - Portrayal of uncertainty was identified as missing in the S-102 Product Specification.
 - S-111
 - Identified a potential limited understanding amongst end users and developers of the different data coding formats available in S-111 Product Specification.
 - A better understanding of the end user needs and requirements for S-111 should be provided. This includes an understanding of areas of interest and quality requirements.
 - It was also highlighted that for the S-111 production, no national agency is currently identified as responsible for production of this product.
 - S-129
 - The producer found the S-100 data XML structure to be a bit complex, compared to existing structures used in their commercial services.
 - The preference would be to produce the S-129 overlay product on board, a solution that may be possible in a future S-100 ECDIS designed for that purpose.
 - The producer pointed out that end user system interaction with the S-129 product is not standardized, making it up to each system implementer how they would support this.
 - The hands-on validation of one of the S-129 datasets revealed several inconsistencies in the Product Specification.

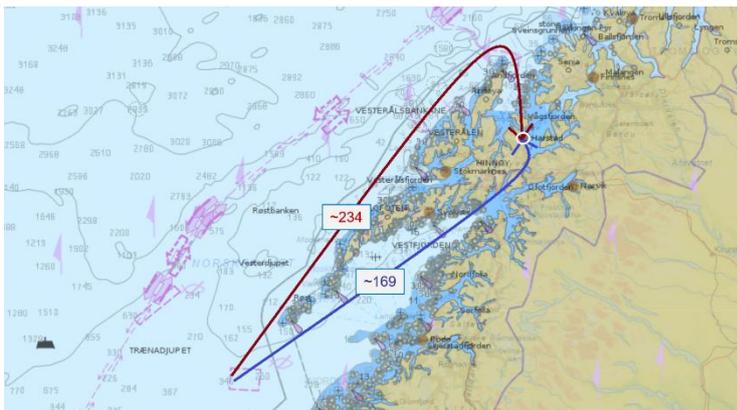
- The various aspects of data flow infrastructure between the project participants was covered. This includes successful implementation of several API interfaces, support for the PRIMAR Remote Update Protocol and the IHO S-100 data protection scheme and Data delivery to PRIMAR VPN.
 - When implementing support for the S-100 Part 15 Protection Scheme, the implementers highlighted the lack of necessary encrypted testdata on S-102 and S-111 format from IHO.
 - The IHO application interface for those applying for S-100 Manufacturer keys (M_KEY) and Manufacturer identity (M_ID) to implement support for the S-100 Part 15 Protection Scheme were found to be old fashioned. Renewal of the application interface supporting online solutions like digital signing of documents was recommended.
- The S-100 Demonstrator, supporting all the involved data types, was used as a navigational support tool for the Pilot during a commercial voyage. This includes it being used for:
 - Voyage planning purposes.
 - It was found especially valuable for planning purposes, giving the end user a good perception and understanding of available navigable space and proved to be very useful when identifying time slots for safe passage.
 - Having access to all information in one application was valuable
 - The inbuilt time factor in S-129 (displaying conditions ahead in time) was especially useful for understanding conditions along the route at the time the end user is expected to be there.
 - The different types of information available in S-129 (non navigable areas, almost non navigable areas, control points, route and route corridor) were all deemed to be valuable and of good use for the end user.
 - For planning purposes, the other products available in the S-100 Demonstrator (ENC on S-57 and S-101 format, S-102, S-111 and seabed information) were also valuable. Having the bathymetry model available in a 3D application, draping ENC or seabed information on top of it enhances the end user understanding of the physical conditions in the challenging area. The integration of surface current information also gave a good visual presentation and understanding of the predicted current conditions at chosen times.
 - It was stated that the S-100 Demonstrator and the products available could be valuable for information sharing between captain and Pilot before entering the voyage execution phase, and that S-100 Demonstrator and the products available adds additional value to assist the Pilots in their area of responsibility.
 - Voyage execution.



- The display of no-go areas in the S-129 products raises the navigator's awareness towards them.

- Having the online connectivity facilitating the data stream providing updated plans every minute added value during the voyage, as the plans were always up to date adjusting expected arrival times at the control points along the route
 - The inbuilt “forward in time” mechanism in S-129 probably adds value to the navigator's situational awareness and mental preparations for the situation ahead.
 - S-111: The end users found the S-111 product to be useful.
 - S-111: The current speed scale division did not make sense for the end user, indicating a need for more granularity at the high-speed end of the scale, where the current will affect the vessel much more than in the lower end
 - The intention of changes in the arrow's size at different times encoded in the dataset was also not understood by the end user.
 - It was also observed that the display of the S-111 arrows as overlay information could conceal other navigational significant information.
 - The display of the S-111 arrows could also be perceived as cluttering the display sometimes, making this test a good use case example illustrating the potential cluttering and concealment of important information when overlying S-111 data on top of ENC and 102 data.
 - Having access to all the relevant information in one end user system may contribute to increased situational awareness. This is due to the freeing of time when avoiding multiple application input, and avoiding mental capacity being used to merge information from multiple applications leading to less time used to assess the situation.
 - Having access to the products together in one end user system opens for new opportunities of interaction and presentation of the data that may add additional value to navigational safety, by increasing the end user outcome of the data content.
 - The information overflow topic was raised, underlining the importance of interoperability integration in, and training needed on, the end user applications.
 - All the products by themselves contain valuable information contributing to navigational safety when assessed and used in the decision making process.
- The Route Info Service from NCA, where reference routes created by NCA are available in the PRIMAR service, proved to be valuable in the onboard voyage planning process.

Expected Benefits



A set of expected benefits were identified early on, as the intended outcome of the test would be to open a narrow passage that would be a shortcut for the intended voyage, and as such influence the sailing distance giving economic and environmental benefits. All expected benefits were achieved – proving the added value of using the S-100 data types.

Expected Benefits		
Benefit 1 <i>Fuel reduction</i>	More cargo onboard and a shorter sailing route will contribute to reduction in fuel consumption.	✓

Benefit 2 <i>Environmental savings.</i>	The CO2 and NOx emission will be reduced due to reduction in sailing distance. More cargo onboard reduces the number of voyages necessary to transport a fixed size cargo, and as such contribute to emission reduction.	✓
Benefit 3 <i>Economical savings.</i>	A reduction in fuel consumption and a potential reduction in necessary voyages indicates potential cost savings.	✓
Benefit 4 <i>Better vessel exploitation.</i>	A demonstrated potential for better exploitation of vessels operating in narrow waters.	✓
Benefit 5 <i>Increased situational awareness and information sharing</i>	S-100 Demonstrator is expected to portray navigational significant information being more human recognizable than traditional tools by using 3D portrayal on the underlying S-102 data model. As such it is deemed to be more suitable for information sharing/understanding of the situation. E.g. between Pilot and Captain/crew.	✓
Benefit 6 <i>Uptake of S-1xx production.</i>	Increased knowledge within national and commercial data producing organisations on production of data on the S-100 format.	✓

Results relating to the specific product specifications involved have been given to the S-102PT, S-111PT and S-129PT.

For more information, please visit the project web pages:

<https://s-100.no/>

Action Required of S-100WG5

The S-100WG is invited to:

Note the report