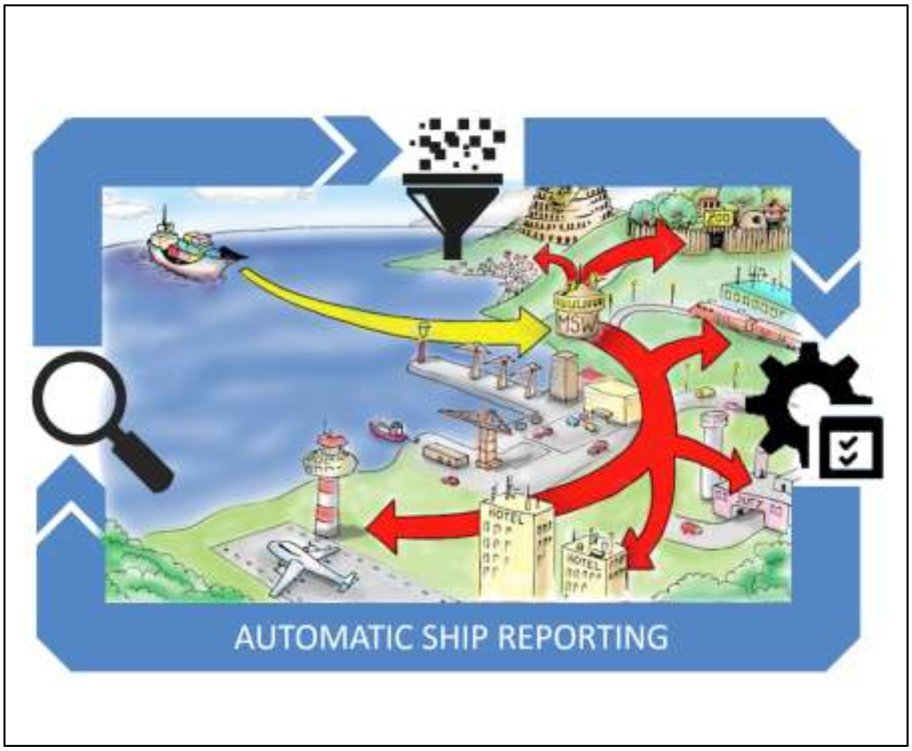

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Table of Contents

1 Technology development and testbed

1.1 Introduction

The term *Ship Reporting* in this document refers to the reporting obligations that the ships master needs to report to the shore authorities under certain conditions. The reporting obligations in different countries or areas are normally regulated domestically, regionally or internationally. General Ship Reporting is still a somewhat manual process and requires a great deal of attention from the ship master, with multiple forms to submit by using a confusing mix of procedures, technologies and formats. The term *Automatic Ship Reporting* refers to the same reporting obligations but also of the concept that the reporting obligations is done more or less automatic from the ship, as appose to the manual process that is often seen today.

A detailed overview of international ship reporting activities, data elements and its formats used in ship reporting today are further elaborated and detailed in the *OUTPUT 5.1 Use case, processes and data formats for automated ship reporting* document.

The STM BALT SAFE project plan for activity 5.3 was to report from live demonstrations of automatic ship reporting. However due to the Covid 19 situation with severe restrictions on travel and physical movement, the planned live demonstrations were not conceivable. The testing therefore was conducted over a period of time in a controlled environment. On the positive side of the situation, a controlled environment opened up for the possibility to include ship reporting tests using terrestrial VDES as a communication carrier.

1.2 Technology development

The reporting obligations usually lies with the Master on the ship, and obviously, there are a user- and operational aspect to the concept of automatic ship reporting. However, the activities in the WP addressed the technical aspects only, thus other concerns were therefore not addressed. Based upon the introduction it is very clear that to be capable of generating information and transmitting it more or less automatically is a foundation in the solution. A realistic implementation of these services required the involvement of both Competent Authorities and shipowners.

The concept of an automatic reporting schema comprises in principle two technical systems or services:

- on-board system (SHIP side), and
- on-shore system(s) (SHORE side)

The following is a description of the technical systems or services that were developed, deployed and tested during the project period. But first a brief description of a generic on-board system for automatic reporting.

1.3 On-board system

With ship reporting in mind, the main functionalities of the on-board system are to collect the relevant data and to report the data to the shore side. A conceptual reference ship system architecture to support the concept of Automatic Reporting was drafted in the WP and is described and depicted below. For simplicity and consistency, the conceptual ship system is foreseen to be installed and operated onboard the ship. However, from a practically and a real-world point of view, modules, services and databases might be implemented elsewhere i.g. on shore or in some kind of cloud implementation. The descriptions should be interpreted with these facts in mind.

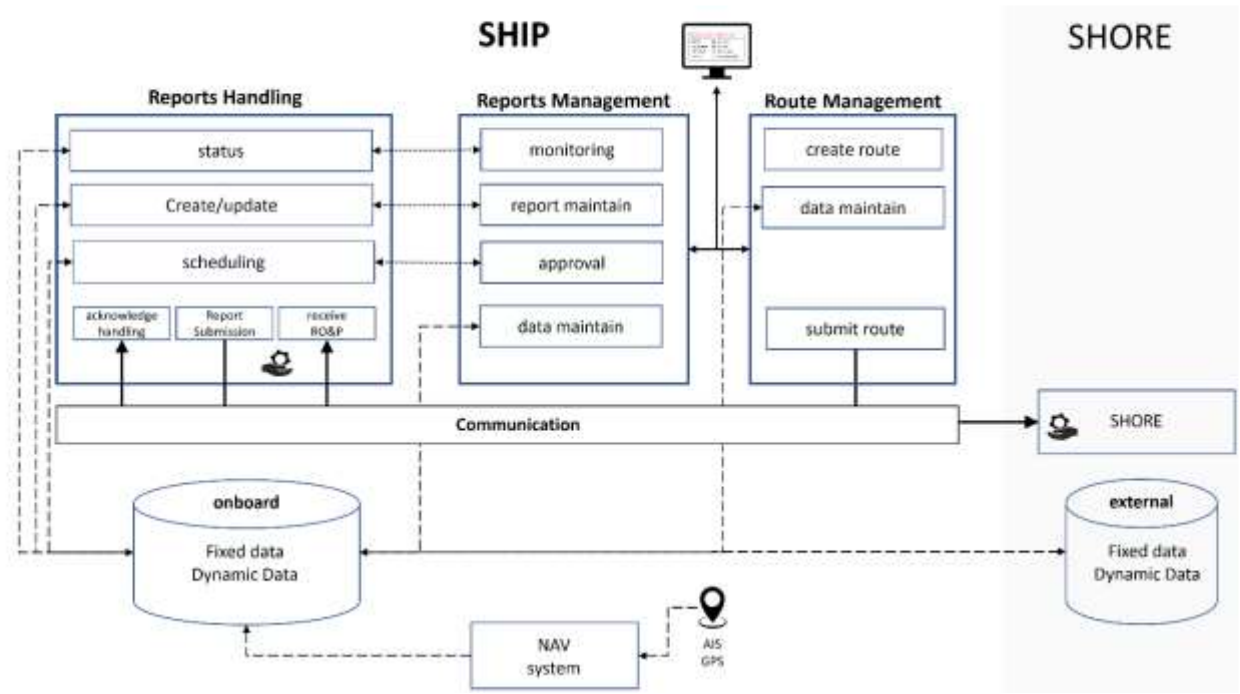

Figure 1 Onboard system architecture

The onboard system is foreseen to comprise three modules. Some user interaction is required in the management modules, whilst other module(s) should provide services to both the management modules and the shore services. The conceptual ship system should maintain the fixed and dynamic data related to reporting on board, but could also connect to external databases or registries outside the ship domain.

To enable dynamic updates and timely scheduling for submission of reports, the system should interact with the navigation system and sensors onboard.

- **Route Management**
  - The module requires user interactions.
  - This module basically contains functionalities that enables the possibilities to do route/voyage planning. Typically, these are functions that are already implemented on most modern ships today.

- **Reports Management.**
  - The module requires user interactions.
  - The user should register/update data that are otherwise not automatically collected from the onboard databases, external systems and from the navigation system.

- An important function is the ability for the master to approve the data that will be automatically submitted.
- There should be an interface that provides information to the master on the reporting obligation along the route, and the statuses on the submissions.
- The module should comprise functionality to maintain the fixed data which is stored in the database(s).

- **Reports Handling**
  - This module is foreseen to be a service module that will not require unnecessary user interactions.
  - The services should interact and support functionality in the Reports Management module.
  - Three basic services handle the interaction with the shore services.
    - The *Receive RO&P* service consume the shore service the exposes the Reporting requirements and procedures for the relevant MRS, SRS or shore reporting.
    - The *Report Submissions* consumes the shore service for reporting.
    - *Acknowledge handling* interact with the shore service for reporting and handles responses.
    - These functions also provide data to the *Create/update* (error handling, retransmit), and the *Status* function.

  - Using data from the NAV system and reporting procedures the *Scheduling* service make sure the timely submission of the relevant report.
  - Using data from the NAV system and Reporting obligations the *Create/update* service compile the report accordingly. The service exposes the missing information to the *Report Maintenance* UI.

1.4 On-board implementations

Three different systems/prototypes were implemented and used in the WP testing.

<table>
<tr>
<td>
NAVSTATION®
The Norwegian e-navigation specialist NAVTOR is delivering their NAVTOR Navstation® product which is a bridge-based decision-making tool.

Functionalities that utilized the on-shore TRS service was implemented in a test version of their product and was used extensively in the trials and testing to report MRS data.
</td>
<td>

</td>
</tr>
<tr>
<td>
VDES ship client prototype
Kongsberg Seatex is a leading marine electronics manufacturer specializing in developing precision positioning and motion sensing systems for safe navigation and operations at sea in the commercial offshore, maritime, hydrographics and defence industries.

This prototype (Maritime reporting system) application for ship reporting was developed by Kongsberg Seatex. The prototype application was used to do ship reporting using terrestrial VDES to report MRS data.
</td>
<td>

</td>
</tr>
<tr>
<td>
Reporting request client prototype
The Norwegian Coastal Administration developed a prototype web application to test and demonstrate the use of the Request and Respond Services.

The application comprised two parts:
The input section were ship, ship particulars, dangerous goods and sailing route is specified by the operator.
The prototype communicates with the RRS service onshore and provide information to the output section.
The output section gives the result dataset from the RRS service, including MRS(s) on route and reporting requirements.
</td>
<td>

</td>
</tr>
</table>

Table 1 Ship board systems and prototypes implemented in the project

1.5 On-shore system(s)

The shore side in the concept of automatic reporting is to provide services to ships that enables a high degree of automation as possible. It is therefore essential that the shore system (MRS) is able to provide information and services to the ships that enables the ship to report automatically according to the requirements at the particular reporting point and according to the procedures set out in the IMO Resolution A.851.

The WP therefor specified and implemented the following two shore-based services:

Request and Respond Services (RRS)
Upon a ship request, the Request and Respond Service is providing reporting obligation to the ships.

The return value from RRS includes:

- Name of the MRS area
- Reporting obligations (required, excluded, voluntary)
- Coverage area for the MRS (GeoJSON format)
- Which designators according to the A.851 the MRS requires
- A subset of ISO28005 XML which covers the reporting duty of MRS, based on required designators and report type.

Transmit and Receive Services (TRS)
The TRS service was implemented as service in the MRS system. The service enabled the ships to submit reports (new or updates) to the MRS's**.** The TRS was implemented according to ISO28005 standard.

The return value from TRS is the ID of the MRS message in MSR system. The ID is specified in the EPCMessageHeader.JournalNumber element. To update a previously sent MRS message, the submitter must supply the ID in JournalNumber.

1.6 IALA 1128 MRS Service Specification

The above-mentioned services were specified in a draft service specification document, according to the IALA G1128 guideline for the specifications of e-Navigation Technical Services. The purpose of this service specification document is to provide a holistic overview of the Mandatory Reporting System (MRS) Reporting Service and its building blocks in a technology-agnostic way.

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the MRS Reporting Service.

Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design, and development activities of other related services.

The aim of the document was to describe key aspects of the MRS Reporting Service at a logical level:

- **the operational and business context of the service**
  - requirements for the service (e.g., information exchange requirements)
  - involved nodes: which operational components provide/consume the service
  - operational activities supported by the service
  - relation of the service to other services

- **the service description**
  - service interface definitions
  - service interface operations
  - service payload definition
  - service dynamic behaviour description
  - service provision and validation aspects

The service specification also took into account results from activities in groups working on similar topics, such as:

- The IMO Expert Group on Data Harmonization (EGDH), responsible for the technical maintenance of the IMO Compendium and data set- and model in areas beyond the FAL Convention.
- The ISO28005-2 standard, which is used as the primary data model in the MRS Reporting Service.

In the project, the service specification was the primary tool that were used by the developers in charge of designing and developing the instance of the Reporting Service in the MRS systems that were a part of the WP trials.

1.7 On-shore Service implementation

The shore-based services described above was implemented and tested in the following Mandator Ship Reporting systems.

SRS	RRS	TRS
GOFREP	No	Yes
CALDOVREP	No	Yes
SSN / BAREP	Yes	Yes

Table 2 Shore-based services deployed

2 MRS reporting - testing

2.1 Introduction

The initial plan was to conduct automatic ship reporting trials and testing in a live (on-sea) environment and onboard one or more vessels. However due to the Covid 19 situation with severe restrictions on travel and physical movement, the on-sea trials were only done to a very limited extent.

2.2 Navstation®, the onboard application

The major part of the trials was done by the company Navtor, using a test version of the company's back bridge system Navstation® with built in functionalities to collect information, and to report relevant data to the shore services at the MRS.

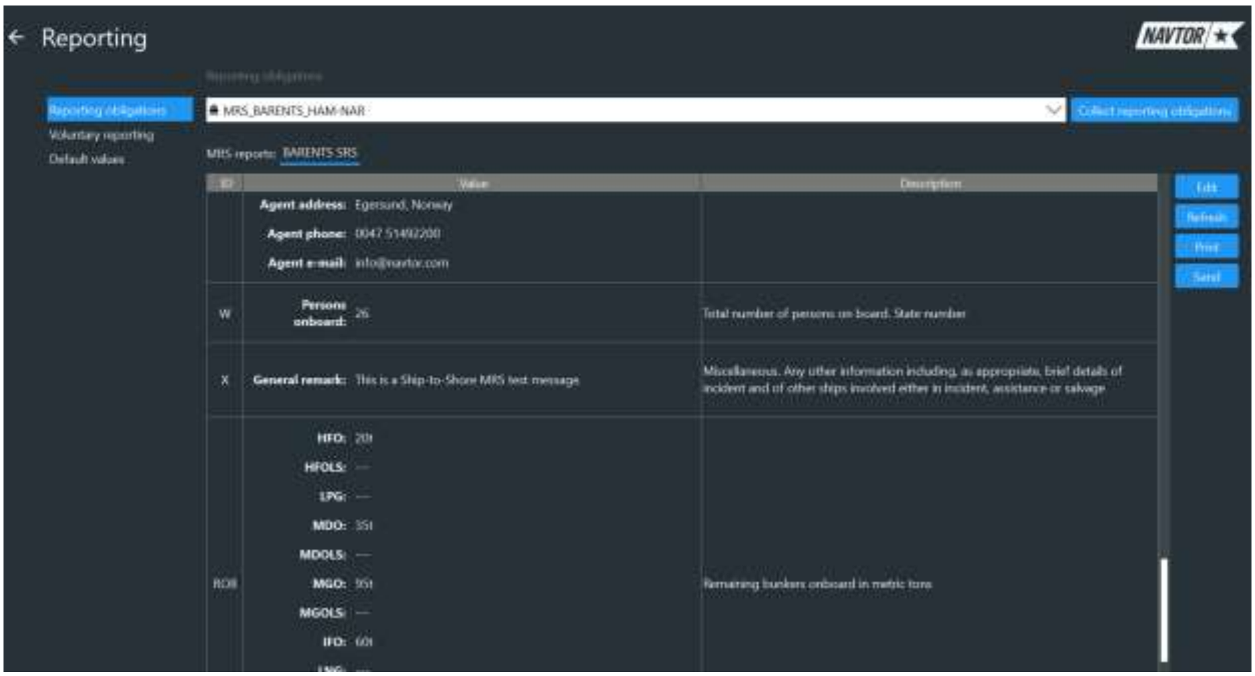

Figure 2 Navstation® reporting module

The Figure 2 Navstation® reporting module depict the reports handling interface. The picture shows the final report ready to submit to SSN/BAREP MRS. The example picture the resulting dataset after the system has automatically collected vessel, voyage and sensor data from the ships system(s). The obligatory information elements and the values are provided in a simple matrix for final verification by the responsible person before submitting the data on behalf of the captain.

The interface in Figure 2 allow the master (operator) to **Send** the report immediately or to **Edit** the information before sending the approved and final report to the MRS. The approval process was implemented to prevent unauthorized or incorrect data to be submitted to other stakeholders. Choosing **Refresh** will collect new and updated dynamic data from the ships system(s). The matrix will then be updated accordingly.

2.3 The high-level testbed setup

The technical setup of the testing environment is depicted in Figure 3. Based upon the 1128 MRS Service Specification developed in the WP, the TRS services were deployed at three different MRS locations by three different companies, representing in this case the BARREP, GOFREP and CALDOVREP MRS.

Figure 3 High-level testbed setup

The red cloud symbolises that the TRS service was deployed, and the blue/black cloud indicate the RRS service deployment. The figure also shows the onboard systems and to which MRS ship reports were submitted during the trial phase.

The green, red and black arrows indicate the communication between the ship and shore.

2.4 The detailed setup – SSN/BARREP

The most comprehensive and advanced technical shore-based solutions was deployed in the SSN/BARREP MRS instance in the testbed. I this setup the data submitted by the ship ended up and was displayed on the VTS operator’s console.

With reference to Figure 5. The rightmost part of the figure shows screenshots from the Route Management and Reports Handling onboard the ship. Once the report is approved by the master, the report is submitted to the Norwegian Single Window (SSNN/BARREP).

An acknowledgment is replied to the ship verifying the reception of a valid MRS message. SSNN also returns the message ID, which would be used if the ship submits an update to the previous message.

Figure 4 Acknowledge

The middle part of Figure 5 shows a screenshot from SSNN with a listing of some of the reports that’s has been successfully received from the ship. Once a report is registered in SSNN the information’s is in principle available for all the authorities that are entitle to receive the information (police, customs etc). However, the information in the tests were only shared with the VTS operators which can be seen on the rightmost part of the figure. This section of the figure shows a screenshot of the Operator Support System (OSS) which picks up the report from SSNN and displays the full information submitted in the report from the ship.

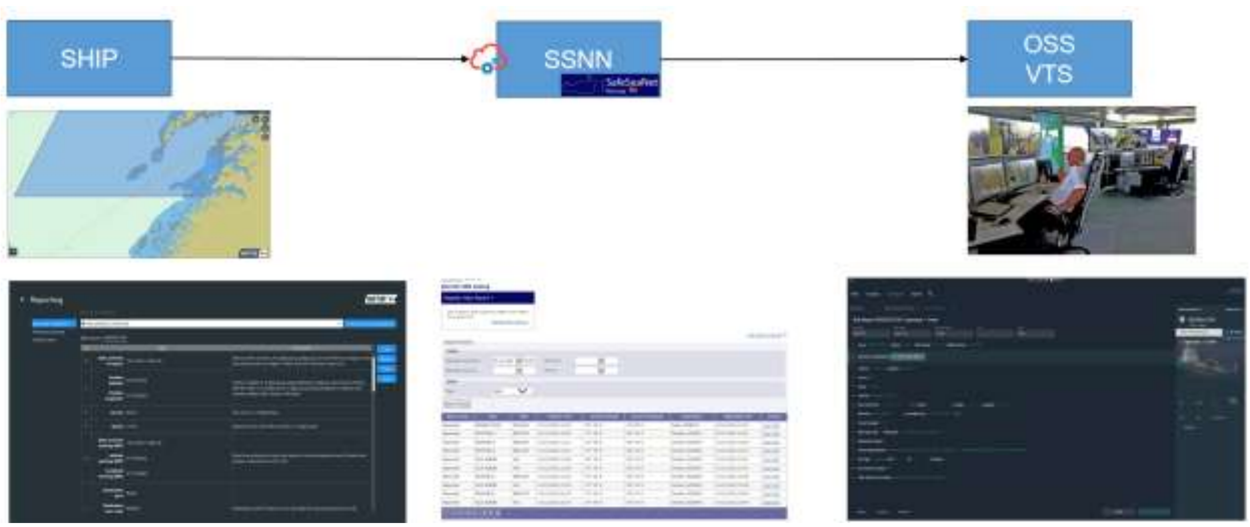

Figure 5 SSN/BARREP MRS dataflow

3 MRS reporting – testing, using VDES

AIS is well recognized as a system for vessel traffic monitoring and maritime safety. The growing demand for maritime data services has led to the development of a new VHF Data Exchange System (VDES), which will provide two-way communication at higher data rates than possible with current AIS systems.

The maritime VHF Data Exchange System (VDES) has been developed by the Coastal Administration international organization (IALA) for maritime applications using the VHF frequencies. The ITU standard 2092-1 defines the system.

VDES equipment will support ship to ship, ship to shore direct and ship to shore via satellite using existing whip antennas and relative low-cost equipment. VDES will support the distribution of maritime data, including meteorological and hydrographic data and traffic information.

VDES is a very relevant communication platform for ship reporting, and the collaboration with Kongsberg Seatex gave the opportunity to explore MRS reporting using VDES equipment.

This section of the report therefor contains the description of the setup and results where a prototype application for ship reporting developed by Kongsberg Seatex was used to do ship reporting using terrestrial VDES to report MRS data. The prototype ship application was in the tests consuming the services defined and developed in the WP during the project.

Due to Covid 19 restrictions and convenience the tests were conducted in a controlled environment on the vessel *Ocean Space Lab* sailing close to the port of Trondheim.

Figure 6 VDES testbed area

3.1 The setup

The actual schematics of the setup is depicted in Figure 7 MRS test setup. In the tests a computer onboard is running the MRS application. The computer is connected to the VDES mobile unit.

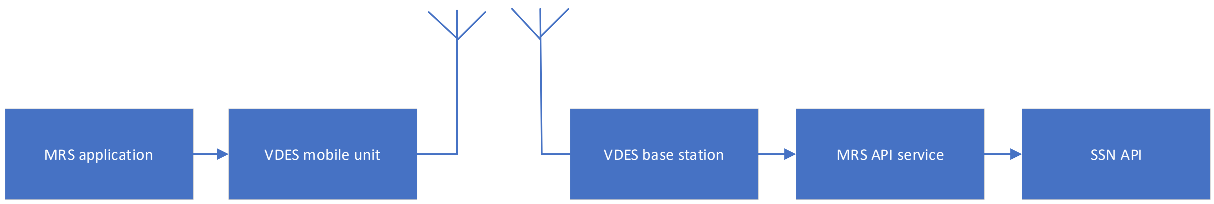

Figure 7 MRS test setup

To be able to monitor the whole dataflow, a second computer (not shown in the setup) onboard was connected to the internet and has a remote desktop connection to a workstation running an MRS API service which is connected to both the VDES base station and the SSN REST API over internet.

The onboard MRS prototype application comprise a web form where the information relevant for a particular report can be filled in. In our test case the MRS BAREP was used.

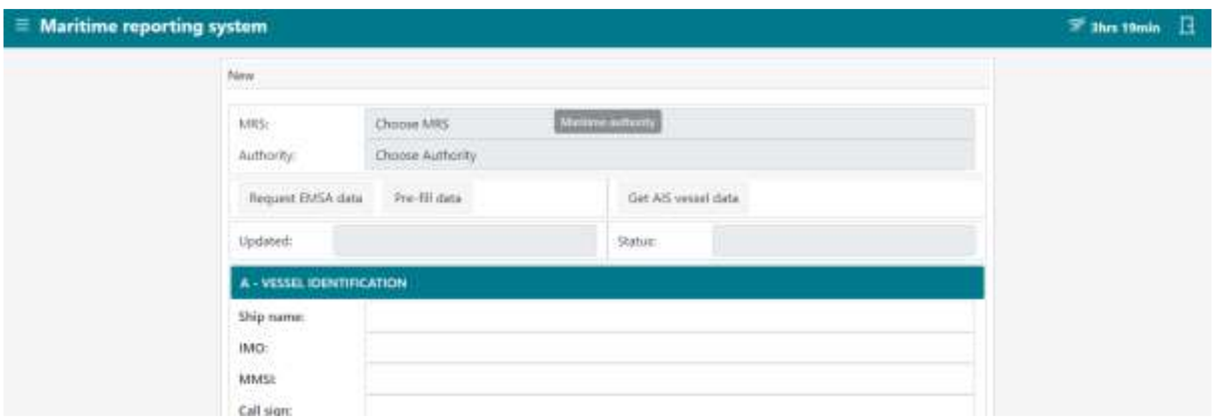

Figure 8 screenshot of onboard MRS application

After populating the data in the web form the data is stored in a local database. New instances in the database are automatically pulled by a local service and transformed to a dataset in an application specific json format. See ANNEX 1. json format used in transmission.

The dataset is then finalized by a VASP header being prepended to the dataset, and the service and message IDs specifies that the payload is an MRS report.

The final dataset is then converted and packed into a set of NMEA sentences and sent to the VDES mobile unit. The NMEA format (TAB) specifies that the data is sent as an addressed binary message terrestrial VDE message.

The transport channel used was LCI17.

The binary data is re-packet into a set of VDE sentences 74, 75 and 76, where 74 is the start sentence and 76 is the end sentence.

The process and dataflow is depicted in Figure 9 Transmission flow.

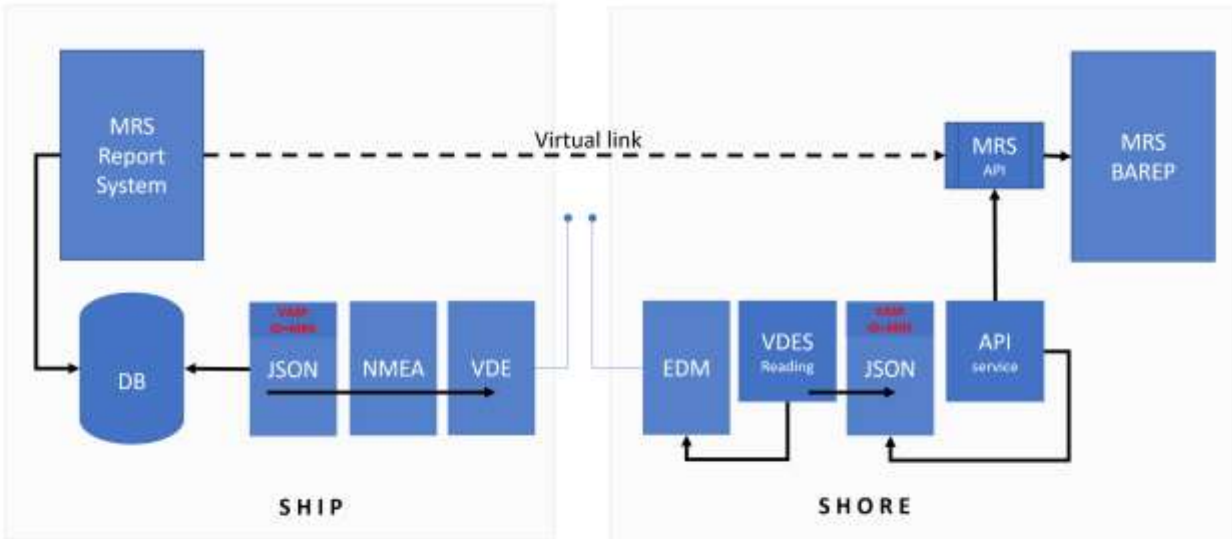

Figure 9 Transmission flow

Example listing of the NMEA and VDE sentences can be found in Annex 2 and 3.

The VDE data is received on the VDES base station and re-packed to a set of EDM sentences and served on the PI interface. These are assembled in an VDES reading service, where the VASP header is read, and the payload is extracted and saved as a MRS file.

The MRS file is picked up by an SSN API service, which read the data content and maps it to a format recognized by the SSN API. This data is then sent as a HTTP post query to the SSN REST API.

If the transmission where ok, the SSN REST API will acknowledge the submission.


```
OK
{
  "EPCMessageHeader": {
    "SentTime": "2021-11-03T15:08:04.2116625+01:00",
    "JournalNumber": "667875176",
    "MessageType": 13
  }
}
```


Figure 10 Acknowledge

3.2 Content in the BAREP reporting system

The figure below is a sample listing of some of the reports submitted during the testing.

Report Type	Ship	IMO	Postion Time	Current latitude	Current longitude	Destination	Destination ETA	Actions
Reported	Soviknes	N/A	04.11.2021 23.00	63° 27' N	10° 24' E	Trondheim (NOTRD)	06.11.2021 01.00	View Edit
Reported	Soviknes	N/A	03.11.2021 16.00	63° 26' N	10° 24' E	Trondheim (NOTRD)	06.11.2021 01.00	View Edit
Reported	Soviknes	N/A	03.11.2021 14.00	63° 26' N	10° 24' E	Trondheim (NOTRD)	06.11.2021 01.00	View Edit

Figure 11 Submitted MRS reports

The figure below shows the content of one of the reports.

Figure 12 Report content

3.3 Pictures from the onboard setup

The pictures below are shot during the testing onboard the vessel.

Figure 13 MRS application(left) and remote desktop

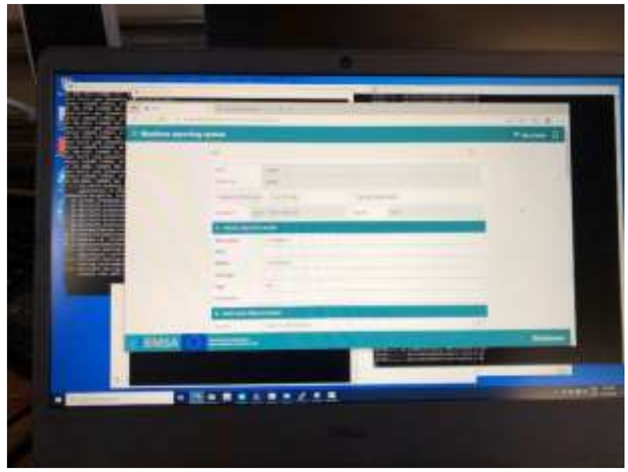

Figure 14 Onboard MRS application

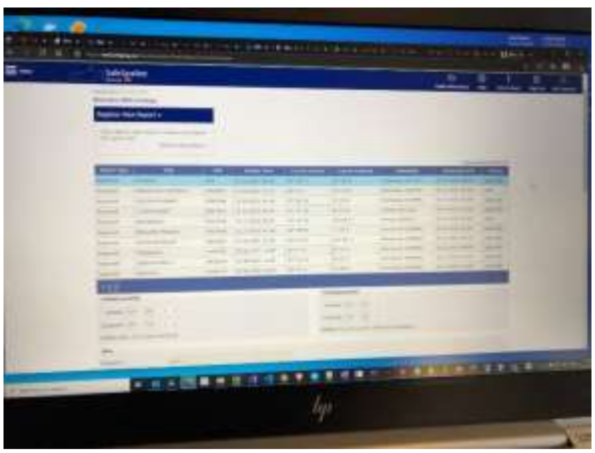

Figure 15 SSNN/BAREP - MRS report listing

Figure 16 Closeup VDES unit

Figure 17 The test vessel

4 Summary and technical conclusions

The general objective of the WP was to introduce the first steps to realize and verify the feasibilities of technical solutions that would correspond with the e-navigation solution 2, means for standardized and automated reporting.

Based upon the Use Cases agreed upon in the project, prototypes onshore and onboard applications and, services were deployed according to the service specifications worked out in the WP. It is well worth repeating that the three MRS instances was successfully deployed by three different contractors using the same service specifications. Same goes for the two onboard solutions. This fact alone justifies the efforts in the WP.

During the trial a total of 100-150 different MRS reports were successfully submitted from the ship and received by the MRS systems on shore.

The activities, development and test conducted during the project has increased the general knowledge of ship reporting and in particular highlighted the potential positive benefits of automated solutions. The successful technical trials and tests have also proven the importance of standardization. In the project the prototype solutions were developed using the ISO/IEC 28005 standard for message exchange. In addition, the data model work done at the IMO Expert Group on Data Harmonization (EGDH) were proven very important to the project.

The work done within the work package has already provided valuable input, knowledge and experience towards the work on standardization. The ideas, Use Cases and concepts has been well received within the consensus work done by various international committees and forums, including the IMO and EU (EMSA), thus contributing to the development of more standardized solutions and services for the future automated ship reporting.

Activities and successful trials using VDES as a communication carrier of MRS data also gave some valuable experiences in ship to shore communication using this new technology, and how the technology could be implemented in the future.

The development, deployments and trials have primarily been done from a technical standpoint. Also, no consideration towards digital security or cybercrime aspects was addressed. Going forward in further enhancing the concept and solutions for Automated Ship Reporting the activities should include requirements from the users onboard. In addition, proper maritime security solutions that provide integrated and cost-effective protection against cyber-attacks on critical safety and operational information should be assessed.

4.1 Acknowledgements

The Norwegian Coastal Administration and the STM BALT SAFE project is grateful for the efforts done by Navtor and Kongsberg Seatex in developing and testing the shore based solutions developed in the project, thus paving the way for a successful result despite the limitations due to the Covid 19 pandemic.

5 ANNEX 1. json format used in transmission


```
{
	"MRSAreaName": "BAREP",
	"MRSAuthority": "BAREP",
	"Designators": {
		"Ship": {
			"ShipName": "SOVIKNES",
			"MMSI": "257147200",
			"CallSign": "LBKH",
			"Flag": "NO"
		},
		"DateAndTimeOfEvent": {
			"SentAt": "2021-11-03T15:00:00Z"
		},
		"ReportingPosition": {
			"Latitude": "63.44050666666667",
			"Longitude": "10.404363333333333"
		},
		"TrueCourse": {
			"Course": "0"
		},
		"Speed": {
			"Speed": "0"
		},
		"EntryIntoSystem": {
			"Latitude": "67.44050666666667",
			"Longitude": "11.404363333333333",
			"EntryTime": "2021-11-06T01:00:01Z"
		},
		"DestinationAndExpectedTimeOfArrival": {
			"PortOfArrival": [
				{
					"CountryCode": "NO",
					"UNLoCode": "TRD"
				}
			],
			"ArrivalDateTime": "2021-11-06T01:00:00Z"
		},
		"MaximumPresentStaticDraught": {
			"PresentDraught": "2"
		},
		"CargoOnBoard": {
			"CargoOverview": "0",
```

"DGInfoType": []
},
"Defects": {
"HullIntegrity": "",
"Manoeuvrability": "",
"Mooring": "",
"CargoHandling": "",
"Communication": "",
"Navigation": "",
"Other": "",
"AbilityToTransferCargoBallastFuel": ""
},
"ShipsRepresentativeOwner": {
"Name": "Rensvik",
"BusinessTelephone": "",
"Email": "Eirik",
"StreetName": "",
"StreetNumber": "",
"PostCode": "",
"CityName": "",
"CountryCode": ""
},
"NumberOfPersonsOnBoard": {
"PassengersNumber": "",
"CrewNumber": "",
"NumberOfPersonsOnboard": "2"
},
"Miscellaneous": {
"Remarks": "",
"NavigationalStatus": "",
"ROBBunkers": []
}
},
"Comment": ""
}

6 ANNEX 2. NMEA data sent to the transponder

Note; not full listing.

$SNTAB,40,01,1,257147200,2570248,0,,0,0@440<fHPV4004P6001j;vM`IGU:CUEdCT9SK,0*29

$SNTAB,40,02,1,,,,,,EI`E6m6M5aCBCI9Jla2EFeFDDUaMnUDETaDDEQF<657>GUQF58mBFag,0*02

$SNTAB,40,03,1,,,,,,JE5cAU=BET5aC4=:AEaHCW1J<SE`I4LqNF=qBCIUNDaDHDMdMlUbL3M,0*74

$SNTAB,40,04,1,,,,,,9K4qgHEQ2CmUG<Fi9JVuaEC0qEm=EM4uBETmaC4=:CUAFCTa9JVuaCF,0*0C

$SNTAB,40,05,1,,,,,,aE<lmDDC==JT5oBFUoJE4jAW=RATqhFS8lJDuaBTmAJoA9BFUoJE9eN,0*51

$SNTAB,40,06,1,,,,,,6QJNDTnBFdmD4Uf<7=9Jm9`I4MF@V9eDUEQEk5dE39JAVAeEWET@lTn,0*0E

$SNTAB,40,07,1,,,,,,IGU:E5aG=C1AF55aCnU9NDm4BGQ<E4EpC5A1NUI4AC9?JT5oCna1MmM,0*58

$SNTAB,40,08,1,,,,,,aBSU<@laCFUQ2MV=fDW1RKFAAHS=>L6A7K7IRJDTnIGU:CEUHDW1TB5,0*21

$SNTAB,40,09,1,,,,,,IcFU=9=TUbFGa<JU4hCDAEMlqbFC9>JUTjCVaI<lUaMnUDAkUmFS9d<,0*25

$SNTAB,40,10,1,,,,,,6AGDVi9JVuaCEA1MDq4@C1=NUUrCGa=NTmrCGa=NTmrBFphLlUdDWUT,0*22

$SNTAB,40,11,1,,,,,,EmI4HS=FNF<jEFU?KW=aDC8q<F=fCVi9JVuaCD=:>Di3BUASAmIdFT=,0*24

$SNTAB,40,12,1,,,,,,9=VEqBUASAmIdFT=9=TUb@FUVDoMaDULm<6=fK4aRKU9nEC=dNVA7EW,0*23

$SNTAB,40,13,1,,,,,,A9JW0oBFepJ6A7K31TEm9dBFagJDqbHoE>A55oCUA1<TqbFC9>JUTjC,0*14

$SNTAB,40,14,1,,,,,,VaSJDi3BTmR<SEfHEQB<Ea7EFU?JDUpCE<l<4m4DGa>JTmrCGa=NTmr,0*6B

$SNTAB,40,15,1,,,,,,CGa=NTmaC4=:AV9fDWUUEU9hHUMEJDuaBGU=A4UpC5A5N4iD@C9FA45,0*34

:

:

7 ANNEX 3. VDE messages sent from the transponder

Note; not full listing.


```
!AIEDO,06,01,008,,,BP3U3m?1@00W>0Qp20410@@0dqN2H@00B0H000Bt=2MUNDa>EFi>@V=eEVQD,0*7D

!AIEDO,06,02,008,,,KDIlFU=9=TUcBT9EJmIABFUoJEAFBUAAF5HhHDLqNF5HDSE9JVuaDFe6Dm9F,0*13

!AIEDO,06,03,008,,,@FU<@la5FUQ>L5`j=FQTAkUqHoU9=VEqBUAQAnioBFah=lUdCVuQF49?FELi,0*3B

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