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Test Report: Ship to Ship Route Exchange (S2SREX) - Controlled simulation trials
# DOCUMENT STATUS

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## Abbreviations

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<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIS</td>
<td>Automatic Identification System</td>
</tr>
<tr>
<td>ARPA</td>
<td>Automatic Radar Plotting Aid</td>
</tr>
<tr>
<td>CoC</td>
<td>Certificate of Competency</td>
</tr>
<tr>
<td>CTH</td>
<td>Chalmers University of Technology</td>
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<tr>
<td>COLREG</td>
<td>International Regulation for Preventing Collisions at Sea</td>
</tr>
<tr>
<td>CPA</td>
<td>Closest Point of Approach</td>
</tr>
<tr>
<td>ECDIS</td>
<td>Electronic Chart Display and Information System</td>
</tr>
<tr>
<td>EMSN</td>
<td>European Maritime Simulator Network</td>
</tr>
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<td>ENC</td>
<td>Electronic Nautical Chart</td>
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<tr>
<td>HF</td>
<td>Human Factors</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
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<tr>
<td>INS</td>
<td>Integrated Navigation Systems</td>
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<tr>
<td>OS</td>
<td>Own Ship</td>
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<tr>
<td>OOW</td>
<td>Officer of the Watch</td>
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<tr>
<td>RDV</td>
<td>Rendezvous</td>
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<tr>
<td>S2SREX</td>
<td>Ship to Ship Route Exchange</td>
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<tr>
<td>STM Client</td>
<td>ECDIS with additional STM functionalities</td>
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<tr>
<td>STM</td>
<td>Sea Traffic Management</td>
</tr>
<tr>
<td>TG</td>
<td>Target Ship/Traffic Ship</td>
</tr>
<tr>
<td>TSS</td>
<td>Traffic Separation Scheme</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency radio transmission</td>
</tr>
<tr>
<td>VTS</td>
<td>Vessel Traffic Service</td>
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<tr>
<td>WMA</td>
<td>Warsash Maritime Academy</td>
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1 Background

The aim of the Sea Traffic Management (STM) concept is to use more of a Need-to-Share attitude instead of Need-to-Know approach, as is mostly practiced today. With greater use of System-wide Information Management at sea, we can move closer to the air traffic control concept of sharing voyage plans among parties both in tactical and executional situations. STM can provide Masters with the optimal available voyage plans for their ships in terms of shortest route, minimal fuel consumption or other criteria chosen by Masters. The voyage plans will be optimized, calculating with real-time data, such as information from meteorological information/warnings providers, ports, Particularly Sensitive Sea Areas (PSSAs) and Maritime Safety Information (MSI), etc. all in order to gain the optimal route to follow. The routes will be shared and available among other ships in order to increase the on-board situational awareness as ships approach potential collision points (or areas of high traffic density).

The ship to ship route exchange concept was developed as a part of the future tools which will be available on the navigating bridges. This service provides the navigator with a route segment consisting of the next 7 waypoints of the monitored route of another vessel. Route segments are broadcasted through AIS and give additional information to the presently available data obtained by radar/ARPA and AIS. Nothing in the S2SREX information exonerates the navigator from applying the International Regulations for Preventing Collisions at Sea (COLREG) and rather than being used in a close quarters situation, the S2SREX may be used as a strategic tool for supporting decision-making and situational awareness at a longer range.

The STM project defined S2SREX to fulfil the following criteria:

- The STM compliant ship system shall be able to present a route segment in the ECDIS.
- In the STM compliant ship system it shall be possible to make a default choice that the route segments will be shared or not with other STM-ships.
- STM compliant ship systems should be able to calculate CPA and intersection points between own/other-ships route segments (including leg speed), even if the routes are not crossing each other.
- If a ship is deviating from its intended route (exceeding pre-set limits, geographically and in time, set by own ship), that should (somehow) be presented on own ships STM compliant ECDIS.
- It should be possible to do some kind of a "Trial Manoeuvre" including own and other ships routes (including leg speed).
There is a concern that implementing S2SREX may encourage the use of STM compliant ECDIS alone for navigation and collision avoidance decision-making and may be detrimental to safety. In IMO Resolution A.1106(29) REVISED GUIDELINES FOR THE ONBOARD OPERATIONAL USE OF SHIPBORNE AUTOMATIC IDENTIFICATION SYSTEMS (AIS) the potential of AIS as an assistance for anti-collision device is recognized and AIS may be recommended as such a device in due time as long as the AIS information is only used to assist in collision avoidance decision-making with the following cautionary points in mind:

.1 AIS is an additional source of navigational information. It does not replace, but supports, navigational systems such as radar target-tracking and VTS; and

.2 the use of AIS does not negate the responsibility of the OOW to comply at all times with the Collision Regulations, particularly rule 7 when determining whether risk of collisions exists.

The STM project is clearly of the view that the user should not rely on AIS as the sole information system and should make use of all safety-relevant information available. Rather than being used in a close quarters situation, the S2SREX may be used as a strategic tool for supporting decision-making and situational awareness at a longer range.

2 Scope and purpose

So far there is no evidence as to how and if S2SREX is affecting the behaviours and the decisions taken by the OOW in traffic situations. Simulations and human factors assessment are required to evaluate the tool and how it may affect the decisions and actions taken by the navigator in various traffic situations including the risk of misusing or placing over reliance on its functionality.

3 Simulation scenarios

To evaluate the STM S2SREX and RDV, a series of carefully crafted simulation exercises were created and run in a controlled environment to capture as much data as possible. The simulation scenarios covered a mix of traffic situations, including longer & shorter-range scales in more confined waters. However, no scenarios were set in any VTS areas, port areas and/or areas with compulsory pilotage. Three vessel types of various sizes were used in the traffic scenarios in calm weather conditions and good visibility. In all the scenarios there was enough time for the test participants to assess the traffic situation and to decide on any actions to be taken. The scenarios included the following situations:

- Give-way & Stand-on in a crossing,
- Head-on meeting,
- Overtaking and being overtaken
• Approaches to Narrow Channels/junction points and
• Traffic Separation Schemes

or a combination of the above.

All scenarios were run with and without the use of S2SREX to evaluate the possible effect of S2SREX on the test participant’s decisions and behaviour and are further described in Annex Simulation scenarios.

4 Questions to which the simulations may provide some answers

Although the intention of using S2SREX is thought to be providing additional information which may assist the navigators in their decision making on a longer range and not a substitute of the COLREGs, there are several questions which need to be addressed:

i. Is S2SREX used as a decision tool in a traffic situation?
ii. Is S2SREX considered as trustworthy?
iii. Is there a risk that navigators put any overreliance in S2SREX?
iv. Is there a tendency for a shift towards using the ECDIS (and the intended routes) when ascertaining the risk of collision?

v. Will using S2SREX make navigators contradict the COLREGS?
vi. Is there a change in communication on VHF?

vii. Knowing that the monitored route is broadcasted, do navigators follow their routes to a higher extent?

5 Delimitation

There is virtually an unlimited number of possible traffic situations making it necessary to focus only on selected scenarios where it is believed that S2SREX may have an influence on the decisions taken by the OOW. Also, weather conditions, visibility, geographical area, type and condition of the vessels involved are likely to have an influence on the decisions taken by the Officer on the Watch. Eventually, six scenarios with 3 Own Ships, i.e. manned bridges, in each were developed and approved by subject matter experts. All scenarios were run in day light conditions, calm weather and good visibility. However, considering that there are far more factors that possibly affect the decisions and behaviours of navigators in traffic situations, further studies are recommended.

It also needs to be stressed that this study is based on the opinions of test participants collected through digital post scenario questionnaires and open-ended debriefings. This data is clearly
subjective and is complemented with an objective numerical analysis capturing comparative data from e.g. distances between ships when taking action and resulting CPAs.
6 Experimental Design Matrix for S2SREX Scenarios

Both CTH and WMA executed the scenarios following the same protocol where the order of the scenarios was randomized to avoid the learning effect

- 1 test person per bridge
- 3 test persons per day at each center
- The simulations were run for 4 days
- Total Number of test persons recruited at each center:
  - 12 Chalmers
  - 12 Warsash

<table>
<thead>
<tr>
<th>Date</th>
<th>Preparation Day</th>
<th>DAY 1</th>
<th>DAY 2</th>
<th>DAY 3</th>
<th>DAY 4</th>
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<td>Registration, briefing, familiarization of bridges</td>
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<td>0930-1030</td>
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<td>Scenario 2 incl. upload and debrief S2SREX</td>
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<td>Scenario 6 incl. upload and debrief BASE LINE</td>
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<td>1500-1600</td>
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<td>Scenario 4 incl. upload and debrief BASE LINE</td>
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<td>1600-1630</td>
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Notes:
1. Scenarios with ID 1-6 are marked as S1, S2, ..., S5, S6.
2. Participants with ID 1-12 are marked as P1, P2, ..., P11, P12.
3. For each scenario, there will be two conditions:
   - **Blue marking** means that scenario will be a baseline scenario without using S2SREX.
   - **Red marking** means that scenario will be using S2SREX.

Each scenario will thereby be executed with and without S2SREX by 12 different test participants, e.g.

<table>
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<th>P2</th>
<th>P3</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Baseline</strong></td>
<td></td>
<td><strong>S2SREX</strong></td>
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7  Technical set up of the simulations

7.1 Chalmers
Chalmers used a Transas NTPro 5000 Full Mission Bridge Simulator consisting of 3 bridges, one instructor room with two instructor stations having visual surveillance of several bridge screens, CCTV and audio channels. Furthermore, there was one class room with briefing and debriefing functionalities and one instructor station.

The bridge layout consisted of a modern cockpit design with real ship bridge consoles, visual channels, monitoring and control equipment. Each bridge was equipped with Transas MFDs consisting of NaviSailor 4000 ECDIS and NaviRadar, Conning display and GMDSS.

For the scenarios using S2SREX a STM client using MNS35 (with incorporated STM functionalities) software was integrated and replaced the standard NaviSailor 4000 ECDIS.

7.2 Warsash Maritime Academy
WMA simulator was a Kongsberg POLARIS Full Mission Bridge Simulator and 5 Part Task Bridge Simulators, three instructor rooms and eight instructor stations having visual surveillance of all bridge screens, CCTV and audio channels. Three Classrooms with briefing and debriefing functionalities.

The bridge layout comprise wrap around consoles, visual channels, monitoring and control equipment. Each Bridge is equipped with Sperry Visionmaster Radars (2), Kongsberg ECDIS, conning display and communication consoles including VHF and intercom.

For the scenarios using S2SREX the same STM client using MNS35 (with incorporated STM functionalities) software was integrated and replaced the Kongsberg ECDIS.
8 Transas ECDIS software with S2SREX functionality

In the S2SREX simulations, in addition to the standard bridge equipment, i.e. radar, conning, etc. a STM Client consisting of a Transas NaviSailor 4000 (MNS35) ECDIS with S2SREX and Rendezvous (RDV) presentation capability was used.

8.1 Presentation of route from other ship(s)

The monitored routes from all ships are automatically broadcasted and the OOW may choose to present them or not individually.

8.2 Rendezvous (RDV)

Once the route is displayed, targets may be acquired to obtain the RDV information which is presented the following way:

- The own ship position at the point of its route intersection with the AIS target’s route is shown on the Chart Panel with the symbol ◯. This point is “clickable” to show more information such as Time to Go and ETA.
- The ECDIS calculates the STM AIS target’s position at the time when the own ship is going to cross the STM AIS target’s route. On the chart panel, this position is indicated with a mark perpendicular to the STM AIS target’s route. This point is also “clickable” showing target information such as the name, call sign, MMSI, predicted time to go, etc.
- The CPA RDV intersection points are shown as bold dots on the routes. These are the points of the own ship and STM AIS target’s positions at the minimum CPA moment. As above, these points are “clickable” showing predicted time to go, RDV meeting time and RDV route CPA.

In addition to the graphic presentation, the RDV panel gives the following information:

- Other ship’s predicted position when own ship is at route intersection point
- Predicted Route RDV for own and other ship. The distance between the points is the Route RDV CPA

![Route Data](image)
In this panel the RDV point can also be predicted for any planned speed changes (only own ship):

![Image](image.png)

9 Test participants

To recruit participants familiar enough with both the simulator equipment and the STM client, the following conditions applied:

- Participants were either required to have participated in the STM EMSN simulations (March 2018 or June 2018) fulfilling the minimum qualification requirements stated for these trials, i.e. professional mariner (active or recently active Masters, Mates, Officers and Maritime Pilots).

Or:

- New participants were to be professional mariners (active or recently active Masters, Mates, Officers and Maritime Pilots) who were familiar with the simulator equipment and were available to attend a STM services familiarization session at a different time (other than the simulation day).

10 Human Factors measurements and evaluation

10.1 Human Factors experimental set-up

The study had a quasi-experimental design consisting of four days of simulations for both Chalmers and Warsash simulation centres as described in Chapter 7. Before the study with test participants, a one-day pilot study with three in-house highly experienced mariners was performed at Chalmers. The different scenarios were either run as control/base line condition or experimental condition, with the difference being that during the experimental condition, the
test participants had access to an ECDIS with S2SREX and RDV enabled. In all scenarios, the routes were pre-planned by the instructor and set on monitoring on the ECDIS before the start of the exercise.

The total number of test persons recruited was twenty-four, consisting of twelve at Chalmers and twelve at Warsash. Prior to the data collection, each participant filled out an individual digital and paper Consent Form as well as a digital demographic’s questionnaire. On each day three participants played the roles of officer of the watch (OOW) for their individual vessel involved in the scenario. An in-house bridge simulator instructor and a human factors specialist were the observers during the simulations in the control room of the simulation centre. All participants were given identical briefings at each Simulation Centre every morning complemented with a familiarization session with the S2SREX and RDV service for the experimental conditions. The participants were given a chance to explore the features of S2SREX service in a few exercises predefined by the simulator instructor. After each simulation scenario, the participants were required to fill in a short questionnaire regarding their perceived performance and opinions about the scenario. By the end of each day, there was be a common debriefing regarding their overall perceived performance and opinions about the S2SREX and RDV tool.

10.2 Test participants demographics

Three female and twenty-one male test persons participated in the simulator trials. The country of origin was either Sweden or the United Kingdom for nineteen participants with the rest from Latvia and Nigeria. Regarding their current role or last role if not currently working, there were ten deck officers, six chief officers, three captains and one VTS operator among all the test participants with the remaining ticking “other” in the questionnaire.

![Figure 1: Age of test participants and experience as a seafarer](image)
In terms of the participants’ experience of computer usage, it is noted that most of the participants started using computers at a young age and spent more than 21 hours per week on a computer.

![Figure 2: Computer literacy](image)

10.3 Responses on perceived failure to maintain a safe CPA and being surprised by the manoeuvres of another vessel

The post scenario questionnaires got 143 valid responses and 1 corrupted response (3 responses per scenario x 6 scenarios per day x 8 days), revealing that on several occasions the participants considered themselves having failed to maintain a safe CPA and got surprised by the manoeuvre of other vessels under both conditions (i.e., baseline without STM services and controlled with STM services).

Generally, the use of STM services (S2SREX and RDV) was considered to improve the likelihood of maintaining a safe CPA (e.g., scenario 2, 5 and 6) but not necessarily decrease the likelihood of getting surprised by the manoeuvre(s) of other vessels. As indicated in figure 3, scenario 4, overtaking and being overtaking in a TSS area, seemed to be regarded as the easiest scenario to maintain a safe CPA and not getting surprised by the manoeuvre(s) of other ships. This is probably because of the relatively narrow channel combined with a TSS and that the ships were all lined up having the same course over ground at the start of the exercise. Scenario 3 consisting of a multiple crossing event was also regarded as relatively easy to maintain a safe CPA but as the manoeuvring space for the ships is justifiably larger than that of scenario 4, the likelihood and possibilities of avoiding close quarters situations by changing course increased, which might explain the highest recorded occurrence of getting surprised. Scenario 6, crossing in the Dover Straits seemed to the most challenging scenario with multiple possibilities to avoid close quarters situations in a less-constrained area adjacent to a TSS. Scenario 2 and 5 were probably considered as easier than scenario 6 but all three
“difficult” scenarios demonstrated a potential value of the S2SREX service when it comes to maintaining a safe CPA.

Figure 3: Perceived failure to maintain a safe CPA and getting surprised by the maneuver of another vessel

10.4 Responses on the perceived influence of S2SREX on Situational Awareness

Among all 143 valid responses there were 71 responses related to the scenarios when the S2SREX service was available. All participants chose to use the S2SREX service in these scenarios, i.e. 100% usage. The top three reasons chosen by the participants to use the S2SREX service are

- “to enhance Situational Awareness”,
- “to supplement information from other means (ARPA, AIS etc)”, and
- “to help in assessing if a close-quarters situation was developing”.

Compared to 100% of S2SREX usage, only 74.65% of responses showed that the Rendezvous (RDV) function got used in the trials. The leading reason for people not to use RDV was that it was considered not helpful (76.19%) or unnecessary (14.29%) in that particular situation (e.g., “CPA through radar was enough in this situation”, “no need”, and “In this situation it made no difference. Seeing the routes of the other vessels was enough both to make decisions and to understand the other vessels’ intentions.”). The RDV functionality got most usage when it came to the assessment of a developing close-quarters situations, i.e., the least appreciated purpose for using the S2SREX service in the top 3 noted above. In terms of the question about how the tool was affecting their situation awareness (SA), 95.77% of responses acknowledge that S2SREX only did improve SA while the number is 84.91% for S2SREX/RDV function.
10.5 Responses on the perceived influence and importance of S2SREX on decision making

The S2SREX service appeared to not only affect the test participants’ SA development but was also considered to influence their decision-making. 67.61% of the responses in the scenarios with the use of S2SREX stated that their decision-making was based on S2SREX information while the number was 52.83% for the S2SREX/RDV function.

41.67% of responses suggested that the S2SREX service was considered “very important” in the decision-making process while 46.43% thought that was also applicable to the RDV function, indicated by the following figures:
This perceived impact on their decision making was further confirmed by the responses collected in the debriefing questionnaire (24 responses representing 24 participants), which was provided to the test participants by the end of day. There were only 29.17% participants who believed the S2SREX just had a small influence on their decision concerning how they handled the traffic and 4.17% participants who believed that it did not influence them at all. 33.33% of the respondents believed that it was influencing their decisions “a lot” while 25% believed it was to “a moderate amount”. The rest 8.33% even believed it was influencing them “a great deal”. Knowing that the monitored route is broadcasted, the test participants even showed a tendency to be less willing to deviate from their routes:

10.6 Responses on S2SREX influencing navigation and communication

The introduction of the S2SREX service also seems to suggest that it is more likely that navigators may change their current means/approaches/preferences of communication and navigation. In terms of VHF communication, 50% of participants believed that with S2SREX, it is going to be less communication while the only 16.67% believed it would be the same and
33.33% believed it would be more communication. Most of the participants (66.67%) agreed that there is likely to be a shift towards using the ECDIS (with S2SREX and RDV information) instead of Radar/ARPA/visual means when ascertaining the risk of collision, while 4.17% of the participants even thought this is extremely likely to happen with the introduction of the services. The heavier reliance on ECDIS with the S2SREX and RDV information may also be based on the trust that the participants put on the service, i.e., 66.67% of participants thought they would trust the service most of the time.

![Figure 9: Trust in S2SREX information](image)

**10.7 Responses from the end of the day open-ended debriefings**

At the end of the day during an open-ended debriefing, questions to probe the participants’ subjective opinions about how S2SREX was influencing their decision-making processes and how it may have a general influence on the safety at sea were also asked. Their performance in the simulation trials was “replayed” to help the participants to recapitulate what was happening in each scenario. The replay video revealed that different navigational solutions to avoid any close quarters situation were applied across all scenario trials, where a “standard” solution (i.e. everyone did in this way) was hardly seen. Although there was no consensus about if they would have done manoeuvring differently with the S2SREX service (in their experienced baseline scenarios) or without the service (in their experienced controlled scenarios), the tool indeed could influence some of their decision-making processes. The impact of this possible influence was synthesised into two major aspects based on the majority of the responses from the participants:

1) The tool was perhaps not appropriate for **tactical manoeuvring** for the purposes of collision avoidance. This is because close quarters situations with multiple vessels involved may already be highly complex with strong temporal and spatial constraints. While using S2SREX
did not necessarily make the navigators violate the COLREGs by following the monitored routes, it is likely to cause potential confusions and risks when the “route” and “intention” were implicitly assumed to be same thing especially if the CPA value is relatively small. The issue of lacking information clarity with too many clustered routes was constantly brought up in the debriefings. A representing voice is that without the routes, the solutions to collision avoidance might be more straight-forward, as the display of multiple routes tangling together would likely increase the mental workload of the navigators, if they decided to base tactical decision-making on the information provided by the service in close quarter situations. This was also confirmed in the post-scenario questionnaire where the data showed that 9.86% of the responders were of the opinion that the information displayed for S2SREX was confusing and this number went even a little higher to 11.32% for the S2SREX with RDV function. In such cases the risks of over-reliance and misinterpretation of the data obtained from S2SREX and RDV cannot be ignored, which seemed to be associated with the responses in the debriefing questionnaire in terms of “risk level”: Half of the participants evaluated the risks as medium or high.

Figure 10: Perception on risks of over-reliance and mis-interpreting data

2) On the other hand, the service had been largely recognised as a helpful strategic planning support tool among the test participants. Informed by the feedback from the participants, one primary reason is that when there are less temporal and spatial constraints (e.g. the ships are far away from each other), the broadcasting of the routes allows involved ships to understand where the target ship(s) is (are) going. Thus, an early planning or warning for a possible future close-quarters situation was made feasible with S2SREX to take steps to avoid latent risks emerging from close quarters situations. The test participants appreciated the notion of using the S2SREX service to facilitate the formulation of a “collective decision” far in advance. An early planning would be helpful to develop navigators’ SA, which would in turn support their
navigational acting that follows COLREGs. This might explain why the most test participants still believed the tool was beneficial in developing SA and facilitating decision-making, even though it was recognized that there were potential risks involved when relying on the S2SREX and RDV data.

11 Analysis of VHF calls, distances when “taking action” and resulting CPAs

11.1 Analysis of VHF calls

The number of VHF calls and the information exchanged was recorded in each simulation run. The records show that there was a total of 17 calls on VHF in scenarios with S2SREX available and 12 calls in scenarios without S2SREX. The purpose of virtually all calls was about asking each other’s intentions.

![Figure 11: Frequency of VHF calls](image)

11.2 Analysis of distances when “taking action” and resulting CPAs

11.2.1 Methodology

Each simulation run was replayed on an instructor station and the following values were noted:

- The ships being observed in a traffic situation
- The type of situation (crossing, meeting or overtaking)
- Identification as to which ship was stand on or give way vessel
- The distance between the ships when one ship took action and the type of action taken (either change of course or speed or both)
- The size of the course change in degrees or the change of speed in percentage
- The number of course and/or speed changes
- The indicated CPA and TCPA before taking such action
- The resulting CPA after the action was taken
- If the action consisted in a breach of the COLREGs
- Any comments

Concerning the action(s) taken, each action was recorded as an event, i.e. a ship could perform several actions during the time of the scenario consisting of several course changes and/or speed changes. Course changes of less than 4 degrees were not noted as it was not verifiable if such course change was meant to be an avoiding manoeuvre.

CPA, TCPA values were taken from the calculations from the simulator software (instructor station) and may be slightly different from the values presented on the ARPA.

In some crossing scenarios, ships “followed each other’s stern” which is considered as good practice. In these cases, the course changes were many but seldom more than 4 degrees at the time and were not noted. However, the resulting “final” CPA was always recorded.

Not all ships necessarily followed their route strictly. Cutting corners at way points was frequently observed.

“Breach of COLREGs” is rather debatable subject and experts may not always agree upon what and when a breach is evident. In this analysis, a breach was conservatively defined as an action against the COLREGs at a distance of less or equal than 3,5 Nautical Miles (NM) and TCPA less than 12 minutes regardless of whether the ships involved in the scenario agreed on the avoiding manoeuvre by e.g. VHF.

Initially it was considered to evaluate each scenario separately. However, the amount of data was not regarded as being sufficient to permit a scenario-based analysis and it was decided to group the scenarios into 2 groups:

- Scenarios 1, 2 and 4: Meeting and overtaking scenarios in confined waters (recommended routes, TSS) where planning for meeting/overtaking may be important.
- Scenarios 3, 5 and 6: Crossing scenarios in more open waters.
### 11.2.2 Results

#### 11.2.2.1 Means all scenarios

**Means all scenarios: 1, 2, 3, 4, 5, 6**

<table>
<thead>
<tr>
<th></th>
<th>Distance when taking action (NM)</th>
<th>Counts course change</th>
<th>Mean course change (degrees)</th>
<th>Counts speed change</th>
<th>Mean speed change %</th>
<th>Resulting CPA (M)</th>
<th>Breach of COLREG</th>
</tr>
</thead>
<tbody>
<tr>
<td>No S2SREX</td>
<td>3.6</td>
<td>80.0</td>
<td>20.0</td>
<td>13.0</td>
<td>38.4</td>
<td>0.9</td>
<td>2</td>
</tr>
<tr>
<td>with S2SREX</td>
<td>4.1</td>
<td>87.0</td>
<td>22.1</td>
<td>15.0</td>
<td>33.0</td>
<td>1.1</td>
<td>11</td>
</tr>
</tbody>
</table>

*Table 1: Means all scenarios*

#### 11.2.2.2 Means meeting/overtaking scenarios 1, 2 and 4

**Meetings/overtaking scenarios in confined waters: 1, 2, 4**

<table>
<thead>
<tr>
<th></th>
<th>Distance when taking action (NM)</th>
<th>Counts course change</th>
<th>Mean course change (degrees)</th>
<th>Counts speed change</th>
<th>Mean speed change %</th>
<th>Resulting CPA (M)</th>
<th>Breach of COLREG</th>
</tr>
</thead>
<tbody>
<tr>
<td>No S2SREX</td>
<td>2.4</td>
<td>31.0</td>
<td>13.4</td>
<td>9.0</td>
<td>34.0</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>with S2SREX</td>
<td>2.6</td>
<td>32.0</td>
<td>13.9</td>
<td>10.0</td>
<td>31.5</td>
<td>0.9</td>
<td>3</td>
</tr>
</tbody>
</table>

*Table 2: Means scenarios 1, 2 and 4*

#### 11.2.2.3 Means crossing scenarios 3, 5 and 6

**Crossing and general traffic scenarios: 3, 5, 6**

<table>
<thead>
<tr>
<th></th>
<th>Distance when taking action (NM)</th>
<th>Counts course change</th>
<th>Mean course change (degrees)</th>
<th>Counts speed change</th>
<th>Mean speed change %</th>
<th>Resulting CPA (M)</th>
<th>Breach of COLREG</th>
</tr>
</thead>
<tbody>
<tr>
<td>No S2SREX</td>
<td>4.4</td>
<td>49.0</td>
<td>24.6</td>
<td>4.0</td>
<td>50.0</td>
<td>1.1</td>
<td>2</td>
</tr>
<tr>
<td>with S2SREX</td>
<td>5.2</td>
<td>55.0</td>
<td>27.2</td>
<td>5.0</td>
<td>35.0</td>
<td>1.3</td>
<td>8</td>
</tr>
</tbody>
</table>

*Table 3: Means scenarios 3, 5 and 6*
11.3 Discussion

Generally, it needs to be stated that the amount of data collected is not enough to draw any definite statistically supported conclusions. However, the data may identify some tendencies, but these must be interpreted cautiously.

Having access to other ships monitored routes and being able to predict/calculate the rendezvous points possibly influences the officers in their decision regarding at what distance action is taken. Although the difference in the mean distances when taking action are not statistically significant, there is a tendency in the data which points towards the officers taking action at a longer distance when having S2SREX available compared to not having such information. Also, the resulting CPAs when using S2SREX are somewhat larger than without having access to the other ship’s routes. In principle one could argue that S2SREX shows a tendency towards improving safety in traffic situations. Considering the numbers of VHF calls, the implications of “improving safety” the S2SREX enabled scenarios could also be a result of more VHF communications or S2SREX services combining with VHF communications. However, these arguments need to be contrasted with the number of breaches of the COLREGs which is significantly higher when S2SREX was available although none of the breaches resulted in any collisions. Introducing S2SREX may potentially introduce situations where the officers may well disregard the COLREGs as the following example illustrates:

In a crossing situation with two vessels in sight of one another ship B being the give-way vessel is to act according to Rule 15 and will normally alter its course to starboard. Ship A being the stand-on vessel will keep her course and speed. Without S2SREX service, both ships will likely ascertain the risk of collision by ARPA possibly supplemented by AIS information.
Having the routes displayed by S2SREX may present the OOWs with additional information indicating that if both ships follow their monitored routes, there will be no close-quarters situation.

![Diagram of ships A and B](image)

Even by claiming that nothing in the S2SREX information exonerates the navigator from applying the International Regulations for Preventing Collisions at Sea (COLREG) and rather than being used in a close-quarters situation, the S2SREX may be used as a strategic tool for supporting decision-making and situational awareness at a longer range, S2SREX may in such situations lead to the OOW taking different decision resulting in different outcomes:

- Both ships disregard the S2SREX information and strictly follow the COLREGs and pass each other at a safe distance.
- Both ships agree on VHF to follow their routes and pass each other at a safe distance. However, the COLREGs may be violated.
- Both ships assume that the other will follow the routes displayed by S2SREX and a confirmation by VHF is regarded as unnecessary. Both ships will pass each other at a safe distance.
- One ship assumes that the other will follow the COLREGs while the other assumes that the ships will follow the presented routes resulting in a dangerous close-quarters situation.

The test participants were largely aware of the possible conflicts of using S2SREX in situations like the one described above. A representing voice is that without the routes, the solutions to collision avoidance might be more straight-forward, as the display of multiple routes tangling together would likely increase the mental workload of the navigators, if they decided to base tactical decision-making on the information provided by the service in close quarter situations.
12 Summary and conclusions

This simulation study was performed to evaluate the S2SREX function and how it may affect the actions taken by the navigator in various traffic situations including the risk of misusing or placing over reliance on its functionality. The study comprises a Human Factor assessment and an attempt to analyse numerical data from the simulations.

As there are virtually an unlimited number of possible traffic situations it made it necessary to focus on selected scenarios where it was believed that S2SREX may have an influence on the decisions taken by the OOW. All scenarios were run in day light conditions, calm weather and good visibility. The study aimed to provide answers to several questions as stated in chapter 4 and is summarized below.

i. Is S2SREX used as a decision tool in a traffic situation?

Participants considered that S2SREX has an influence on their decision-making. 67.61% of the responses in the scenarios with the use of S2SREX stated that their decision-making was based on S2SREX information while the number was 52.83% for the S2SREX/RDV function. 41.67% of responses suggested that the S2SREX service was considered “very important” in the decision-making process while 46.43% thought that was also applicable to the RDV function.

The test persons recognized that S2SREX is contributing to an enhanced situational awareness and that decisions taken to avoid other ships will likely be influenced by the presented S2SREX information. S2SREX was largely recognized as a helpful strategical planning support tool among the test participants and numerical data from the simulations indicate that there is a tendency which may point towards the officers taking action at a longer distance when having S2SREX available compared to not having such information. However, the average distances when taking action are statistically not significant.

ii. Is S2SREX considered as trustworthy?

66.67% of participants thought they would trust the service most of the time.

iii. Is there a risk that navigators put any overreliance in S2SREX?

50% of the test participants believed the risk of over-reliance is high and 8% as extremely high. The participants were fully aware of the risks of over-reliance and misinterpretation of the data obtained from S2SREX and RDV. Without the routes and using ARPA only, the solutions to collision avoidance might be more straight-forward, as the display of multiple routes tangling together may bring an extra mental workload to the navigators, if they decided to base tactical decision-making on the information provided by the service in close-quarters situations. Also, S2SREX may cause potential confusions and risks when the “route” and “intention” are implicitly assumed to be same thing. Although nothing in the S2SREX information exonerates
the navigator from applying the International Regulations for Preventing Collisions at Sea (COLREG), most breaches occurred in the crossing scenarios 3, 5 and 6 and interestingly scenario 3 and 6 ranked very highly in the frequency table concerning “getting surprised by the maneuver of the other vessel” (see 10.3).

iv. Is there a tendency for a shift towards using the ECDIS (and the intended routes) when ascertaining the risk of collision?

Most of the participants (66.67%) agreed that there is likely to be a shift towards using the ECDIS (with S2SREX and RDV information) instead of Radar/ARPA/visual means when ascertaining the risk of collision, while 4.17% of the participants even thought this is extremely likely to happen with the introduction of the services.

v. Will using S2SREX make navigators contradict the COLREGS?

The data shows that there were 2 breaches of COLREGs as defined in chapter 11.2 without the use of S2SREX compared to 11 when the service was available.

vi. Is there a change in communication on VHF?

In terms of VHF communication, 50% of participants believed that with S2SREX, it is going to be less communication while the only 16.67% believed it would be the same and 33.33% believed it would be more communication. However, data from the simulations show that there was a total of 17 calls on VHF in scenarios with S2SREX available and 12 calls in scenarios without S2SREX. The purpose of virtually all calls was about asking each other’s intentions.

vii. Knowing that the monitored route is broadcasted, do navigators follow their routes to a higher extent?

Knowing that the monitored route is broadcasted, the test participants even showed a tendency to be less willing to deviate from their routes: 37.5% thought it was somewhat likely and 42% neither likely nor unlikely.

To summarize, the study supports that S2SREX may enhance the officer’s situational awareness and shows a tendency to improve navigational safety in traffic situations when used as a tool for supporting decision-making and situational awareness at a longer range, i.e. during strategic navigation.

The study also indicates that there are several risks involved in using S2SREX, notably over-reliance/misinterpretation of the data and potential confusions/uncertainties when the “route” and “intention” are implicitly assumed to be same thing especially when using S2SREX in tactical navigation.
It is important to note that the study did not cover the evaluation of the possible effect of S2SREX on the test participant’s decisions and behaviour in e.g. adverse weather conditions, restricted visibility or dense traffic conditions. Considering that there are far more factors that possibly affect the decisions and behaviours of navigators in traffic situations, further studies are recommended.
13.1 Scenario 1
Type of situation: Overtaking and crossing situation in an area with recommended routes and TSS.
Area: Hatter Barn TSS
Use of S2SREX: S2SREX may support decision making with regard to overtaking and meeting.

General notes:
Scenario duration approximately 30 min.

- Ship A overtaking B,
- For ship A: S2SREX may be useful to know if ship B is using the DW channel to decide on which side to overtake.

- Ship C and B will have closest CPA at end of TSS, for ship C it may be useful to know if ship B is taking the DW route (although being stand on vessel).

Ship A: Feeder container, (L 170m, B 27m, T 10m), speed 20 knots, AIS destination Hamburg
Ship B: Tanker (L 228m, B 32m T 13,6m), speed 11 knots, AIS destination Milford Haven
Ship C: Coaster, bulk (L 83m, B 12,5m, T 4,3m), speed 10 knots, AIS destination Rostock
13.2 Scenario 2

Type of situation: meeting in an area with recommended routes and TSS.

Area: Hatter Barn TSS

Use of S2SREX: S2SREX may support decision making in regard to knowing which routes the vessels involved take and where the meeting point will be.

General notes:

Scenario duration approximately 30 min.

- Ship A taking DW route even if actual draft recommends her to take the TSS
- Ship B taking DW route
- Predicted meeting ship A and B will be during the turn in the DW route
- Close quarters between ship A and C after TSS

Ship A: Container (L 222m, B 30m, T 12m), speed 20 knots, AIS destination Gdynia
Ship B: Tanker (L 228m, B 32m, T 13m), speed 11 knots, AIS destination New York
Ship C: Coaster, bulk (L 82m, B 12m, T 4m), speed 11 knots, AIS destination Kiel
13.3 Scenario 3
Type of situation: Multiple crossing with close quarters situations if all vessels follow their routes

Area: South of Isle of Wight

Use of S2SREX: Initially and using ARPA only, no close quarters situations are apparent. However, using S2SREX will show that all 3 ships will meet at the same point.

General notes:

- Scenario duration approximately 30 min.
  - Initially all ships with safe CPAs.
  - Following routes will create a close quarters situation.

Ship A: Feeder container (L 170m, B 27m, T 10m), speed 20 knots, AIS destination Hamburg

Ship B: Tanker (L 228m, B 32m, T 13.6m), speed 14 knots, AIS destination Santos

Ship C: Coaster, bulk (L 82m, B 12m, T 4m), speed 10 knots, AIS destination Southampton
13.4 Scenario 4

Type of situation: Overtaking and being overtaken in a TSS/Precautionary Area.

Area: Bornholm Gatt

Use of S2SRX: may support decision making in a TSS when approaching a Precautionary Area by being able to determine in advance other ship’s intended routes once they enter the Precautionary Area Bornholm Gatt.

General notes:
Scenario duration approximately 30 min.
Ship B needs to be in ballast as she is bound for the Sound! Max draft 7.2

Ship A: Feeder container (L 170m, B 27m, T 10m), speed 20 knots, AIS destination Rotterdam
Ship B: Coastal tanker (L 145m, B 23m, T 7m), speed 14.5 knots, AIS destination Rotterdam
Ship C: Coaster, bulk (L 82m, B 12m, T 4m), speed 10 knots, AIS destination Rönne (Bornholm)
13.5 Scenario 5
Type of situation: Meeting and crossing
Area: The Skaw
Use of S2SREX: may support decision making in a traffic area where it could be helpful knowing when a ship is intending to change course as to round the Skaw.
Ship B will be interested to know when ship C is intending (or if at all) to change course as to be able to change her course to starboard to meet ship A port to port.

General notes:
Scenario duration appr. 30 min.

Ship A: Feeder container (L 170m, B 27m, T 10m), speed 20 knots, AIS destination Hamburg
Ship B: Tanker (L 228m, B 32m, T 13,6m), speed 15 knots, AIS destination Gothenburg
Ship C: Coaster, bulk, (L 82m, B 12m, T 4m), speed 10 knots, AIS destination Helsingborg
13.6 Scenario 6
Type of situation: crossing, meeting
Area: Dover Straits

Use of S2SREX: using S2SREX and following the intended routes by ships A and C may be a breach of the COLREGs but would not result in a close quarters situation.

General notes:
Scenario duration appr. 30 min.

- Ship A will use Inshore Traffic Zone bound for Felixstowe.
- Ship C and A contravene The COLREGs if following their routes. However, safe CPAs if following the routes.
- For ship B it is unclear when/if ship C will cross TSS.
- If ship C follows route it will come into close quarters with ship B

Ship A: Feeder container (L 170m, B 27m, T 10m), speed 16.6 knots, AIS destination Felixstowe
Ship B: Tanker (L228m, B 32m, T 13.6m), speed 15 knots, AIS destination Santos
Ship C: Coaster, bulk, (L 82m, B 12m, T 4m), speed 10 knots, AIS destination Calais
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