DEVELOPMENT AND SIMULATOR TESTING OF A DECISION-SUPPORT SYSTEM FOR STS OPERATIONS

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Abstract

As part of the ongoing development of a navigation support and guidance system for ship-to-ship operations, interviews and a questionnaire survey among ship officers in charge of lightering operations with crude oil tankers has revealed what kind of information that is required to improve the decision-making process during the approach between two vessels that aim to get alongside with forward speed in open waters. Graphical user interfaces (GUIs) tailored for the typical approach phases in ship-to-ship operations have been proposed, developed and tested on experienced ship officers in a full-mission ship-handling simulator to assess the potential for enhancing operational safety. To evaluate the operational improvement of the decision support system (DSS) a deeper test in a realistic lightering operation in a simulator wave been carried out.

Keywords: Information Support Navigation Instruments STS Lightering Decision-support Display.

1. INTRODUCTION

A ship-to-ship, STS, lightering operation typically involves two tankers maneuvering in close proximity, at a speed range of 4-6 knots, in order to come alongside and commence cargo transfer. This is a challenging task for the officer in charge of the operation, the mooring master, whose decision-making process during the approach is commonly based on radar measurements until the vessels are approx. 0.1 n.mil apart. The final approach phase is carried out using visual observations only. In an STS lightering operation, the Captains are, as always, in charge of their respective ships. However, it is industry standard to have a mooring master on board the maneuvering ship, acting as a Pilot and advising the Captain and his crew on how to navigate and maneuver. Experienced and trained officers are needed to minimize the risk of miscommunication between the ships, [1].

In a normal STS lightering operation at open sea, one ship is required to maintain speed and course, and is referred to as the Ship to be Lightered (STBL). The Service Ship (SS), will approach until it is parallel with the STBL before commencing the final approach phase, which is to maneuver until the ships are moored and transfer of cargo can commence, Figure 1, [2].

Figure 1: The approach phase of a lightering operation.

A user survey among European and US mooring masters has revealed potential improvement to the overall safety in such operations. Real-time information about distances between the two vessels and their relative movement, when presented graphically in an understandable way and relayed to the decision-maker on the bridge, could speed up the decision-making process, [3].

2. DESIGN AND DEVELOPMENT OF THE DECISION SUPPORT SYSTEM, DSS

The mooring masters, as end-users, have been involved in the design of the Decision Support System, DSS, and given feedback and comments especially on the user interface. It has been a conscious choice to place the user at the centre of the design in a natural operational environment in a navigation simulator. Affords have been made to simplify the structure of the user interface and not overload the short-term memory with information. In the development of the graphical user interfaces (GUIs), questionnaires, interactive interviews, and various graphical proposals for information parameters were discussed with several groups of experienced mooring masters. The mooring master is on the bridge wing in the final decisive phase. An immobile device inside the bridge will be inaccessible, but a hand-held device can communicate the information needed. Relative speeds, distances and the angle between the two vessels are parameters mooring masters use as references in their decision-making process. This information is considered to be key parameters in the process. Different paper prototype displays and mock-ups, presenting this key information in a simple way were further integrated and tested in a simulator setting, [4]

2.1. THE DSS

The Master PC processes data collected from GPS and AIS sensors, or in this case from the simulator. The size of both vessels and the positions of their GPS antenna must be entered into the Master PC before start up. The portable Tablet-PC receives data wirelessly from the Master PC and presents the result as GUIs, Figure 2.

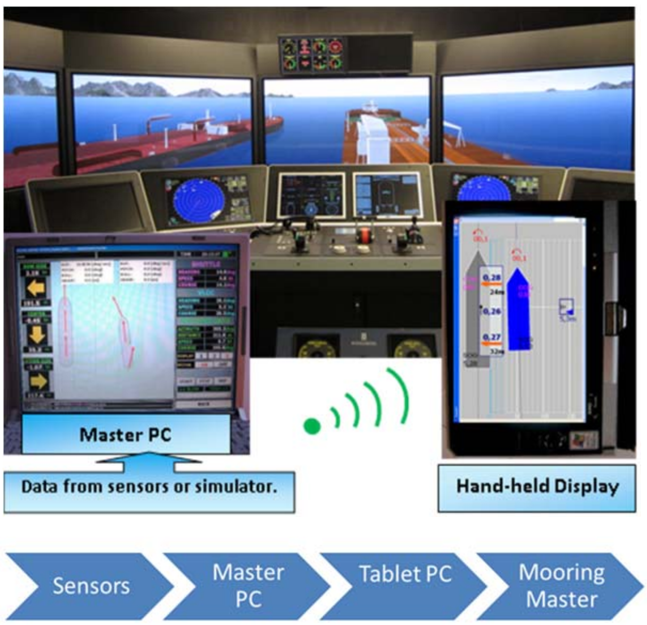

Figure 2: System structure with wireless connection.

3. TESTING THE DECISION-SUPPORT SYSTEM

After several tests and iterations different screenshots of the GUI's were programed on the Tablet-PC, Figure 3, [*4*]. When the vessels are very close the longitudinal distance between the hose connection-points are visualized with a square box containing a grey and a blue triangle.

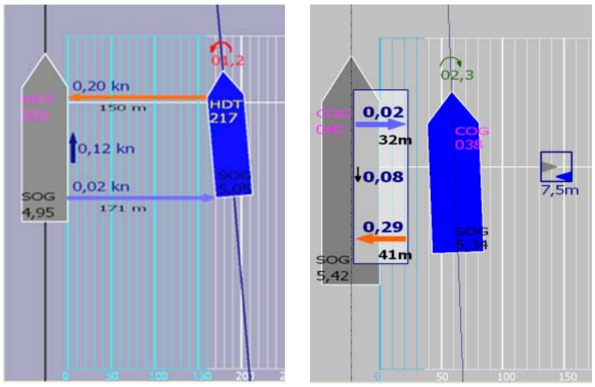

Figure 3: The GUI, vessels getting close to landing.

The next step in the development of the DSS for STS operations is to validate the system. To see if the performance and the safety is improved. Tests are performed at in the simulator center at University of Tromsø. The test group is divided in two and half of this group will use normal standard decision making artefacts as radar, gyro and Doppler log together with visual observation, called the STD test group. The other part, the DSS test group, will use only the DSS observing the GUI on the Tablet PC and used this information in the decision making to adjust the propulsion and the course of the Service Ship. The whole group will be screened so test subjects with the same skills and experience will be compared. To clarify the appropriate setup for this test and to establish possible parameters to compare, a pilot test wave been conducted. In this pilot the test subjects were two officers with approximately the same skill level. The test began with an introduction to the lightering operation. Including a short film showing the preparation and execution of the operation, guided by a skilled mooring master. A normal track to follow in the lightering scenario was then presented to the test subjects, Figure 4. The subjects were then asked to follow this planned route within the framework which these figures provide. The service ship started up seven cables astern of the STBL on her starboard side, 3 cables off.

Information regarding the interaction effects between the vessels during landing was given. In particular, the transversal forces on their own ship bow were pointed out. The vessels specifications were reviewed. The service ship was a shuttle tanker of 124,000 (dwt) in ballast. This vessel had good manoeuvrability with two propellers and two high effect Schilling rudders. Length of the ship is 265 meters. The STBL was a super tanker, VLCC, of 386,000 (dwt) with a LOA of 353 meters. The VLCC was equipped with Yokohama fenders. The test subjects operated with manual steering control, controlling both the rudder and the engine themself. The test person who used radar inserted the parallel index and used this together with the VRM to control the voyage.

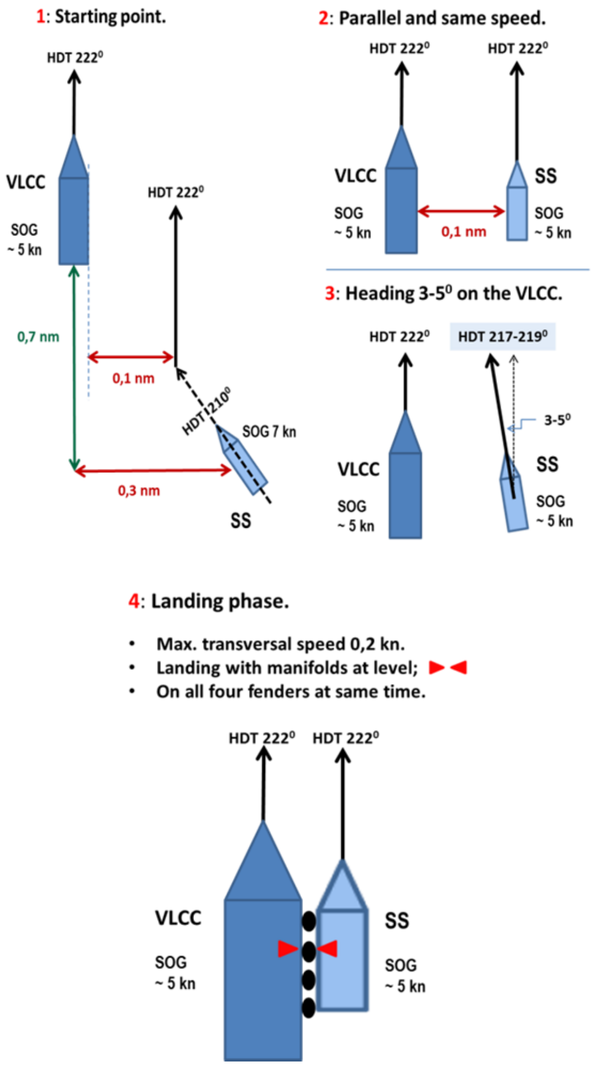

Figure 4: The optimum track to follow in the test scenario, with the criteria presented in the sketches from Position 1 to Position 4 as it was presented to the test subjects before the test.

4. ANALYSIS

4.1 EXPECTATIONS

The ideal outcome of the introduction of the DSS is that the real-time information of the vessels relative movement can improve the decision-making process. The input from a dedicated DSS goes faster through the steps in the decision-making process and does not need to be selected or filtered. A good GUI will provide more exact information, especially through situation awareness, and less time will be spent on selecting and comparing information with the internal memorized experiences of the decision-maker. This will hopefully give a safer and more efficient performance.

4.2 RESULTS OF THE TEST

During each test run several parameters were logged from the Kongsberg Maritime, KM, simulator and from the decision support system, DSS. Based on the data logged from the DSS different graphical representations of the parameters are presented. Figure 5 shows longitudinal relative positions differences between the DSS test and the STD test, from Position 2, parallel to the landing.

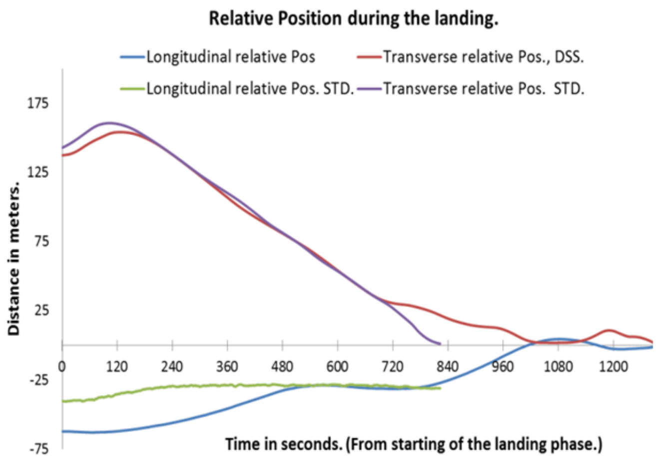

Figure 5: Longitudinal Relative Positions.

Figure 6 give information about the rudder orders from the start to the landing, both for the DSS test and for the STD test. The amount and the frequency of these orders can give an indication of the decision maker's control of the vessel. In Figure 7 the different transverse speeds of the DSS test during landing can be seen. The VLCC runs on autopilot and is affected by the interaction effect in the landing phase.

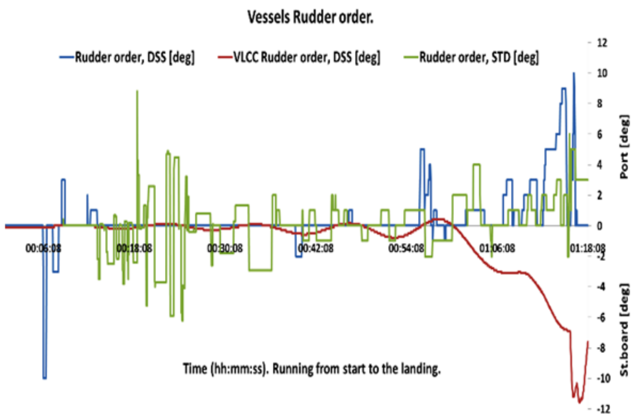

Figure 6: Rudder order for both DSS and STD test.

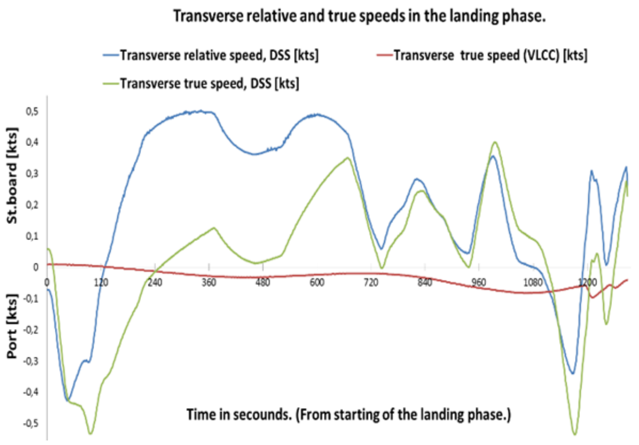

Figure 7: Transverse speeds in the DSS test.

In Figure 8 the transverse distance and speed at bow are compared in the last 30 seconds of the landing phase. In the DSS test the bow is moving away from the VLCC before closing in again. The DSS test had a lower transversal speed at bow in the landing than the STD test, around 1 (cm/s) and 3-4 (cm/s) respectively.

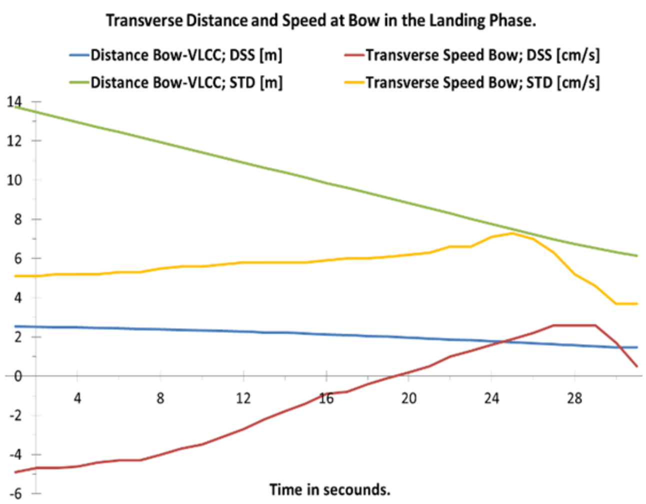

Figure 8: Test-data during landing are compared.

5 Conclusion

The objective of the pilot test was to evaluate the performance in order to establish suitable methods and procedures for later larger evaluation of the DSS. Analysis of time series plots can show the quality and the manoeuvring time of each STS approach manoeuvre. The degree of control in the landing phase is of high importance. In the STD test the service ship landed with a heading difference to the VLCC of 4 degrees, resulted in a landing on the forward fender only. It is apparently a problem to observe distances and angles between the vessels only by visual measurements.

A screening of the test subjects before commencing the test is therefore of significant importance to ensure that the performance are compared at the same level of skill and experience. It is however a reason to expect a certain difference in the decision-taker's human variation. For instance just a little too late helm orders can result in a disturbance in the test data. One important test criteria is the transverse landing speed and this can easily be deducted from these tests. The use of rudder and engine force can say something of the decision-taker’s sense of control during the operation and also an indication of the effectiveness.

6. REFERENCES

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