Training Tools for Research

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Introduction

In the Navigation Technology Department, a special interaction exists between scientific education and research on the one hand and skill based education on the other. The skill based education consists besides theoretical courses of a lot of practical courses. The NLDA can provide their students with some special training facilities. These include a Warfare Electronic Chart Display and Information System (WECDIS) trainer, a radar simulator, a training sailing vessel, a training vessel (see Figure 1) and a Full Mission Bridge Simulator (FMBS).

Figure 1: Navy training vessel Van Kinsbergen.

Some of these facilities are used for research. The training vessel Van Kinsbergen is also used for research in manoeuvring behaviour. The FMBS is used for research as well. Most of the bridge simulator research is focused on the so called "non-technical skills" which are used in Crew Resource Management. An example is the dissertation by Letty Aarts [1]. This dissertation focussed on the factors that influence the overview in a bridge environment. Recently, Lt Beemsterboer executed an experiment on the bridge simulator to measure Situation Awareness (SA) effects as part of his bachelor thesis [2]. Lt De Jonge is currently working on a bachelor paper that is based on the findings of Lt Beemsterboer. The bridge simulator and the training vessel Van Kinsbergen are being used for this research.

The advantages of using these training facilities for research are numerous. Students can use training facilities they are familiar with for their scientific research. Using the facilities during normal training hours will normally have little impact on the running training program. Results acquired by the research can be incorporated in the current training programs at very short notice.

To give an impression of the research done with our training facilities, a summary of the bachelor paper of Lt Beemsterboer follows.

The thesis of Lt Beemsterboer focusses on SA on the bridge of a ship. The aim of this paper is to indicate the influence of the increasing number of navigational means for the SA for the Officer of the Watch by means of an experiment.

What is SA?

The definition of Situational Awareness used in this paper is the following:

"Situational Awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the future" [3]

SA is knowing what is happening around you [4, p2]. This is of the utmost importance for the Officer of the Watch as this is the basis of his decision making. As a consequence, sound decision making results in safe navigation.

We can identify three levels of SA:

- Level one: Perception

- Level two: Comprehension
- Level three: Projection in the future

Level one SA is monitoring important data and elements from the environment. This is fundamental for requiring good information which is vital for a good SA. When monitoring is insufficient, there is a big chance that a wrong perception of the situation occurs.

The way important data and elements are acquired is displayed in Figure 2. Besides input from other team members and own observation, systems can deliver input as well. When used properly, all these aspects will result in a good SA level one.

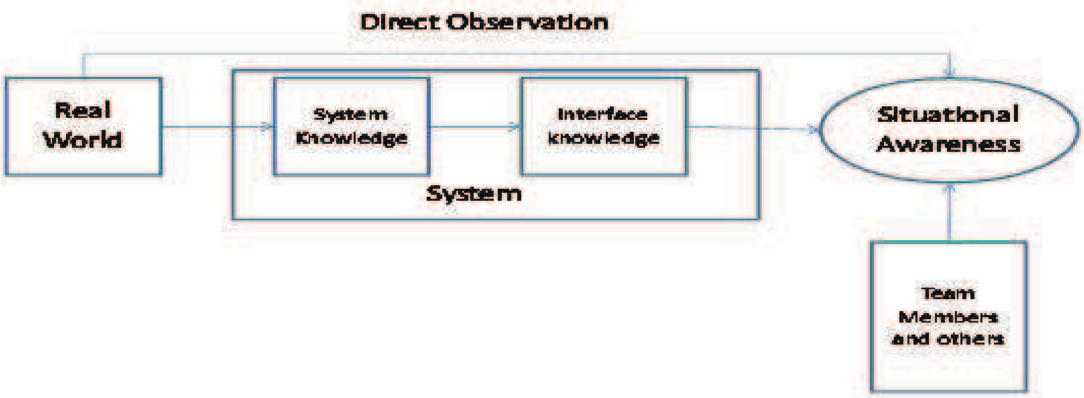

Figure 2: Conceptual model of Situational Awareness [4, p7].

Level two SA goes further than just perceiving vital information. It incorporates combining, interpreting, storing and maintaining this vital information. The Officer of the Watch receives his information from looking outside, the chart, radar and other sensors. All this information needs to be integrated to form a good assessment of the situation. The SA of the Officer of the Watch will improve when observation of another ship is a combination of a compass bearing and radar. When the Officer of the Watch observes more ships, he will be able to make priorities.

A good level two SA can only be achieved with a good level one SA. When the perception of a situation is wrong, the comprehension of this situation will be wrong as well. The decision to reduce speed for another ship to avoid a collision when missing the ship that is at your stern overtaking you, may result in an even more dangerous situation. The importance of level one SA is stated in the following:

"A person with level two SA has been able to derive operationally relevant meaning and significance from the level one SA data perceived".

A level three SA is projecting the current SA in the future. An Officer of the Watch has achieved the highest level of SA when he is able to predict how a situation will develop in the future. The Officer of the Watch is now able to anticipate future situations. The coming together of all three levels of SA is shown in Figure 3.

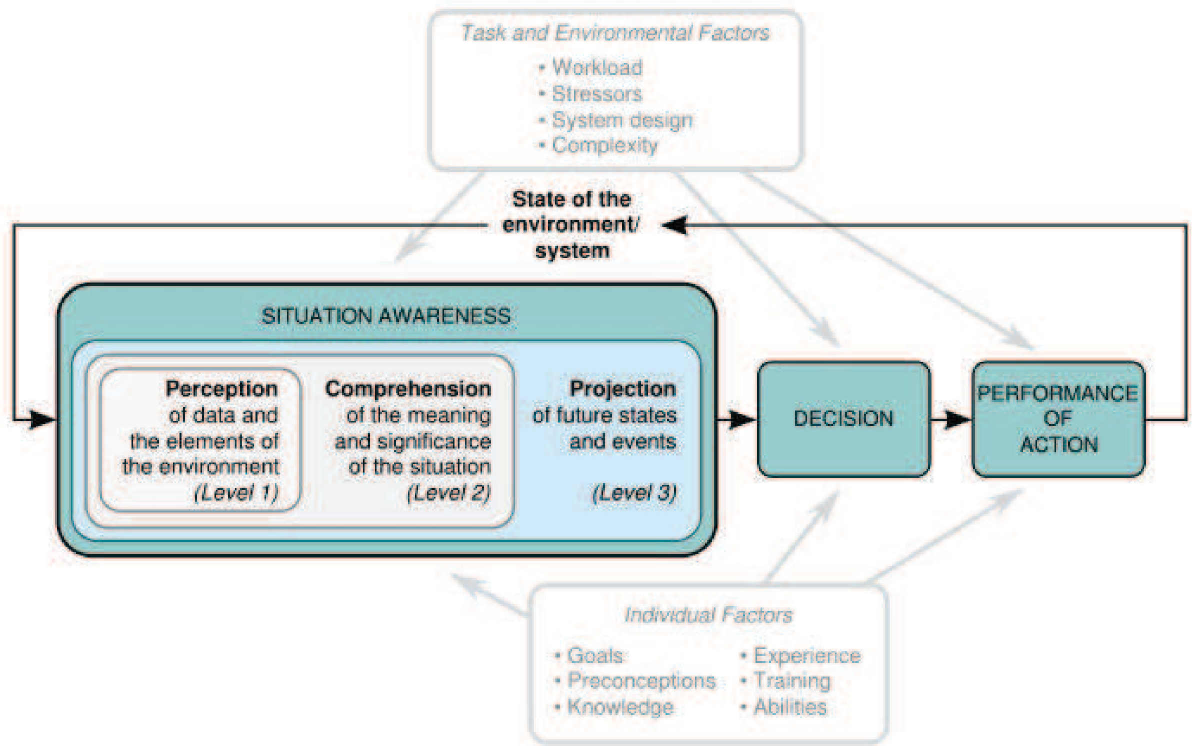

Figure 3: The three levels of SA. These three levels form the basis for a sound decision making. The building of SA itself is subjected to individual task factors and task and environmental factors. [4, p6]

How do we measure SA?

To measure SA in the experiment, the Situation Awareness Global Assessment Technique (SAGAT) method was used [3]. The SAGAT method was primarily developed for measuring the SA of pilots.

The SAGAT method is best explained by the following seven steps.

1. The pilot flies a certain scenario.
2. The simulation is paused at a certain moment.
3. The pilot must answer a questionnaire in order to determine his knowledge of the situation. The questionnaire is derived from the desired SA qualifications for a pilot. The answers are processed in a computer.
4. It is impossible to make a questionnaire that includes all the SA requirements. Hence it is a random selection of all the SA requirements.
5. The answers are compared with the real situation, which is easily measured in a simulator.
6. The answers will generate a SAGAT score which is divided in three zones; immediate, intermediate and long-range.
7. This process will be repeated several times to meet the statistical requirements.

Because the SAGAT method was specifically designed for pilots, some adjustments had to be made for the experiment on the bridge simulator. Another reason to adjust the experiment is that not all the required means for a full SAGAT method are available on the FMBS.

The Experiment

On the bridge of a ship, several systems are used to acquire and maintain a good SA. On board the new Royal Netherlands Navy ships, these systems are normally integrated. This study does not focus on the integrated bridge system. The purpose of this study is to analyse the effect of the increasing number of navigational aids on the SA of the Officer of the Watch.

It appears that despite the known knowledge of SA, there has not been any research into the effect of increasing aids to navigation and the SA of the Officer of the Watch on board a ship. This research was therefore executed on the bridge simulator in Den Helder (see Figure 4).

The experiment has used students who were nearly finished with their study. They had a limited amount of experience as watch keeping officers,

Figure 4: Full Mission Bridge Simulator of the NLDA at Den Helder.

mainly obtained on the training vessel van Kinsbergen and the Full Mission Bridge Simulator. Measuring the SA of these people was the main focus of the experiment. Besides the persons acting as officer as the watch, two important questions have to be answered:

1. What is the role of the Officer of the Watch on board of a navy ship?

   The Officer of the Watch has to maintain the safe navigation of the vessel and is responsible for the daily routine on board. The Officer of the Watch can even be put in charge of the operational deployment of the ship. The following definition of navigation will be used:

   "Navigation is the art of moving a vessel from a given position to a desired position following predetermined criteria." [5]

   The Officer of the Watch is responsible for the navigation. It is paramount for the Officer of the Watch to have a clear picture of navigational, meteorological and operational matters. The Officer of the

Watch has to take all measures necessary to ensure the safety of the ship.

2. What does SA mean for the Officer of the Watch?

   Every watch keeping officer on the bridge of ship needs to have a good knowledge of the Rules of the Road. These rules are internationally agreed by and used by all seamen on the high seas. Rule number 5 of the Rules of the Road states:

   "Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision."

   This rule applies to all circumstances. All three levels of SA can be traced in this rule. Maintaining a proper look-out at all times is level one SA. To make a full appraisal of the situation and of the risk of collision is level two and three of SA. By making a full appraisal of the situation, level two results in determining whether there is a risk of collision. Knowing the moment of the risk of collision is level three. Other rules can be used in the level three SA by supporting the decision making process of the Officer of the Watch. Rule 8, describing the actions to avoid collision, states:

   "Any action taken to avoid collision shall be taken in accordance with the Rules of this Part and shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship."[6]

   Making the right decision in ample time means that a good level three SA is required.

Method of research

The nucleus of this research is the experiment on the bridge simulator to measure the effect of increasing the number of available navigational aids on the bridge. Due to the different nature of the bridge simulator, the SAGAT method had to be adjusted. The (increasing) number of systems available will be the variables in the experiment. The setup of this experiment contained the following system combinations:

1. Bearing compass and paper chart.

2. Bearing compass, paper chart and GPS.
3. Bearing compass, paper chart, GPS and radar.
4. Bearing compass, paper chart, GPS, radar and Warfare Electronic Chart Display and Information System (WECDIS).

There were 12 persons available for the experiment, so all system combinations could be tested three times. Every simulator run took 60 minutes and during every run two measurements were made. An overview of the scenario is presented in Figure 5.

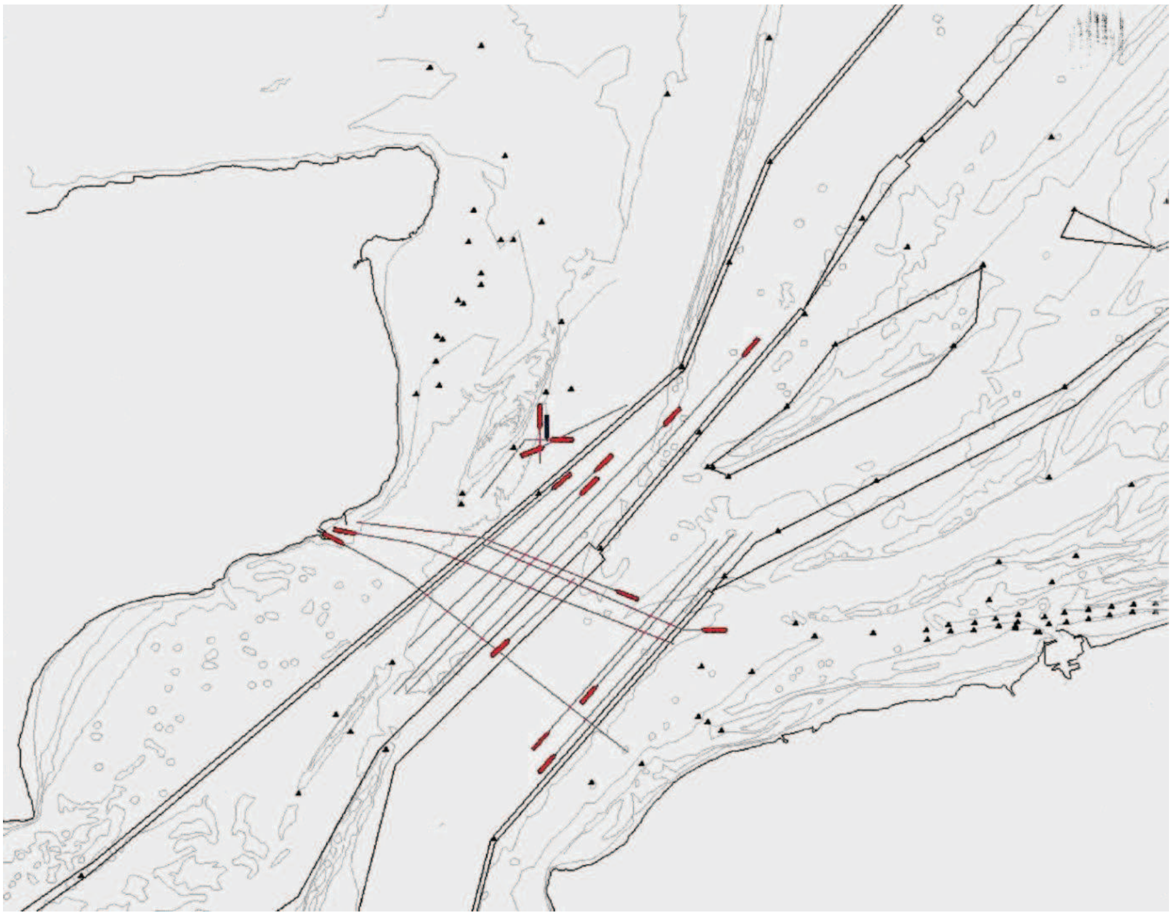

Figure 5: Overview of the scenario. Own ship is blue and the other shipping is presented by the red ships with planned tracks.

The scenario contained the following points:

- Close to land to provide landmarks for position making;
- Two tracks had to be sailed;

- The initial speed was 12 knots;
- Visibility was 20 Nautical Mile (NM);
- Other shipping consisted of sixteen contacts;
- Great variety in shipping;
- Different movements of other shipping;
- Presence of navigational dangers like wrecks and shallow waters;
- At the start of the run, no dangerous shipping in the area in order to provide time to build up a good SA.

Due to the different settings and constraints delivered by the bridge simulator, the SAGAT method had to be adjusted. In the experiment, the pilot is of course replaced by an Officer of the Watch. Point three of the SAGAT method had to be adjusted as well with the following points:

- When the simulation was stopped at time t1, the Officer of the Watch was required to fill in two plot charts. In plot chart one, the current situation (t1) is plotted. In plot chart two, the anticipated situation of t1 + 30 minutes is plotted.
- The Officer of the Watch is required to fill in a plot chart at t1 + 30 min. Only the current situation is plotted.
- Besides the plot charts, a questionnaire is answered with questions concentrating on positions of own ship, buoys and other shipping.

By using the plot charts, point four of the SAGAT method is not applicable.

Quality control

The following three aspects are used for quality control.

Reliability Can we use all the measurements we made for our results? We have tried to prevent corrupt data in our results by using the SAGAT method.

Validity Are the measured data, the data that we need? By using the plotting charts and the questionnaire, we tried to get the most accurate picture of the three levels of SA.

Generalization To what degree do the results of the experiment represent other groups? We used midshipmen in their third year as officers of the watch. Although their background and education is the same as other officers of the watch, their experience level is of course less.

Restraints of the research

The following restraints were encountered during the research:

1. The experiment was executed with twelve officers of the watch. This is a relatively small number to draw conclusions. Due to practical reasons, it was impossible to increase the number of officers of the watch.
2. Despite the fact that all the officers of the watch are from a homogenous group, difference in performance due to the individual may influence the results. Although the four experiment groups were made at random, there may be a chance that one group exists of 'better' performers. The only way of eliminating this problem is by using more officers of the watch.
3. It is very hard to estimate distances on the bridge simulator due to the use of projectors. This does not help the process of assessing the positions of objects.
4. In the last experiment configuration, the WECDIS is used as an extra navigational aid. None of the officers of the watch are experienced WECDIS users. Better results will probably be attained with experienced users.

Data analysis

Data of the different runs has been collected from every system combination and was compiled from the questionnaires and plotting charts. An area of tolerance was used in order to allocate values to the collected data. We can compare the system combinations with the use of tolerance areas. Not all the questions from the questionnaire have the same tolerance but all are the same for every system combination. We have to refrain from taking major conclusions due to the small group of persons used in the experiment.

Based on the tolerance areas, every combination received a score. The score for combination two was higher than combination one and combination three scored higher than combinations one and two. It was expected that system combination four would give the best results due to the use of the WECDIS. In this combination the best technical means were available for acquiring and maintaining a good SA. The score was however lower than system combination three. There are two possibilities that might be the cause of the lesser results scored in combination four:

1. None of the officers of the watch in the experiment have followed a WECDIS course. The knowledge of the system was limited. The WECDIS was probably not used to its maximum effectiveness.
2. Another theory might be the lack of workload. People with a reduced workload will lose focus and get bored [7]. In this way reduced workload can result in a loss of SA. In combination four, the WECDIS will reduce the workload of the officer of the watch significantly and might have contributed to a lack of SA.

Conclusions and recommendations

At the end of the experiment, it seems there is an effect in increasing the number of available navigation systems and an increasing Situation Awareness.

We have to be careful of making any conclusions due to the small number of measurements. Doing more measurement with larger groups will add more weight to the results and will reduce the effects of failures and individual effects. Another recommendation is to do an experiment with increased workload for the Officer of the Watch, especially with regard to the use of the WECDIS system. Results in this area may lead to new insights and procedures for using the WECDIS.

Currently, Lt de Jonge has used the experiment of Lt Beemsterboer as the basis for his research in comparing students on the bridge simulator and on the training vessel van Kinsbergen. We are looking forward to the results of this study as they may help us to enhance our training program or even adjust current bridge procedures. All these experiments are very closely related to Crew Resource Management. Situation Awareness is one of the seven skills we teach our students in our Crew Resource Management course. Scientific research in this area will enhance our understanding and support our Crew Resource Management courses.

There is a very fine line between scientific research and the actual use of the results of this research in our courses, navigational developments, Crew Resource Management and standing procedures on board our ships. Due to the increasing automation of the bridge with integrated systems, this research will only grow in importance. The introduction of a new Full Mission Bridge Simulator in the near future with possibilities of camera monitoring, sound recording and extensive data collection and debrief facilities will greatly enhance our research possibilities, especially in the area of Crew Resource Management.

References

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