Integration of technology into bridge resource management: human factor perceptions

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Abstract

People make mistakes! No matter how well intentioned or conscientious a person may be, the simple fact is that eventually everyone will make a mistake. In the maritime transportation field, a mistake on the bridge of a ship can lead to catastrophic consequences. The primary methods used to prevent mistakes are the introduction of technology or people management and training.

Modern ships have a vast array of technology available on the bridge to assist watchstanders in making decisions concerning the safe navigation of the ship. One recent technological innovation is the Electronic Chart Display and Information System (ECDIS). ECDIS is a digitized display of a navigational chart that can be integrated with satellite positioning to indicate the vessel's position in real time. This system allows the navigator to do route planning, voyage monitoring, and other navigational tasks that have been traditionally done by paper and pencil.

Although the California Maritime Academy (CMA) requires that deck cadets take an ECDIS course in their third year at the academy, the cadets have traditionally not been allowed access to this technology during the bridge simulation course taken in the fourth year. The justification for this has been the belief that if students are allowed to use ECDIS they will abandon the more traditional navigation methods and those skills will not be developed or assessed.

The literature on learning suggests that students who perceive the benefit and real-world application of a subject have an increased motivation to learn. The purpose of this pilot study was to investigate student perceptions of the benefits of using ECDIS in the bridge simulation course. A better understanding of student perception will inform instructional pedagogy of both ECDIS and bridge simulation courses in order to enhance student learning. The study was carried out in the full mission bridge simulator at CMA using volunteer participants during October and November of 2007. Twelve sections of four participants each participated in two different scenarios. Approximately half of the simulations were conducted with the participants using ECDIS and the other half without. Quantitative and qualitative techniques were used and SPSS 13.0 was used for analysis.

The findings from this study are not generalizable. The qualitative data suggest that participants believed the use of ECDIS increased situational awareness, enabled them to reduce navigational cross-track error, and improved the over-all performance of their bridge team. In some cases these perceptions differed from quantitative measurements of those same variables.

1 Introduction

Ships are dangerous places. Every year hundreds of vessels collide, run aground or strike fixed objects. These accidents often result in fatalities and injuries (U.S. Department of Transportation 2007). In recent decades, maritime accidents, such as the *Exxon Valdez* (National Transportation Safety Board (NTSB) 1990) and *Cosco Busan* (NTSB 2008) incidents, have resulted in catastrophic environmental pollution and millions of dollars in clean-up costs. Perrow (1999) noted that an accident involving a liquid natural gas tank vessel could result in the destruction of part of a city.

In order to prevent marine accidents, legislative bodies have enacted regulations like the Oil Pollution Act of 1990 (OPA 90) and Safety of Life at Sea (SOLAS) regulations. In addition, Cunningham (2007) noted that the primary methods used to prevent mistakes are through the introduction of technology to assist watchstanders in their decision making or through personnel management and training.

Technology has radically altered the way ships are navigated. The past century has seen the advent of the gyrocompass, radar, and electronic and satellite positioning systems (Donderi, Mercer, Hong & Skinner 2004). Technology has had a positive effect on maritime safety. United States Coast Guard (USCG) statistics show that vessel accidents such as collisions and groundings significantly decreased during a recent five year period (USCG 2004). This has been attributed to enhanced navigation technology (Hetherington, Flin & Mearns 2006). In recent years, ECDIS has been introduced and is further transforming the practice of navigation (Donderi et al. 2004). ECDIS use on vessels is predicted to steadily increase in the coming years (Sauer, Wastell, Hockey, Crawshaw, Ishak & Downing 2002).

ECDIS is intended to contribute to navigation safety and enhance situational awareness (International Maritime Organization (IMO) 2004). Situational awareness has been defined as knowing what is going on around you (Endsley & Garland 2000). Or, in more detail, "Situational Awareness is the ability of an individual to possess a mental model of what is going on at any one time and also to make projections as to how the situation will develop" (Hetherington et al. 2006, p. 405). Loss of situational awareness can lead to maritime disaster. In a survey of maritime accident reports, Grech (2002) determined that 71% of human errors were attributed to situational awareness problems.

Salmon, Stanton, Walker and Green (2005) noted several methods in use to measure situational awareness in aviation. These methods include freeze probe techniques, real-time probe techniques, observer rating techniques, performance measures, process indices and self-rating techniques. Although self-rating techniques -- conducted post-trial -- have been criticized as potentially unreliable due to reliance on participant recall and sensitivity issues, they have the advantages of ease of application and non-obtrusiveness. This pilot study uses self-rating techniques to investigate student perception as other studies have (Rassuli & Manzer 2005).

Several studies have investigated the use of ECDIS on vessels. Smith, Akerstrom-Hoffman, Pizzariello, Siegel, Schreiber and Gonin (1995) used ECDIS in full-mission bridge simulations with experienced professional mariners. Their data suggest that ECDIS has the potential to improve safety by reducing the time spent navigating, which increases the time available for collision avoidance. ECDIS also improves situational awareness and reduces cross-track error, the offset of a vessel's position from its intended path of travel. In their study, participants self-evaluated their situational awareness at several points along the track. The perceived situational awareness level was significantly higher for mariners using ECDIS.

Gonin, Dowd and Alexander (1996) summarized four at-sea trials and one simulator experiment on ECDIS. The key findings of the studies were that ECDIS provides equivalent or greater navigational safety than paper charts and a reduction in the navigation workload. Cross-track error was the primary measure of navigational accuracy. This study reported that the mean cross-track error for mariners navigating using ECDIS was approximately one third of that for mariners without ECDIS. The use of ECDIS provided equivalent or greater safety than the use of paper charts and more traditional navigation methods. Exit interviews in the study revealed that mariners felt that ECDIS contributes to safe navigation.

Donderi et al. (2004) conducted a study that entailed two simulated navigation exercises on the approaches to Halifax, Nova Scotia. The effectiveness of the use of paper charts and of ECDIS was investigated. Cross-track error, contact closest point of approach (CPA) and number of helm orders were recorded. The NASA Task Load Index (TLX) was used to evaluate workload. The authors concluded that the use of ECDIS reduced cross-track error and navigation workload and optimized CPA.

Although technology has the potential to reduce maritime accidents, others have noted that technology alone does not prevent accidents and in some instances actually contributes to them. Human error, misinterpretation of data and poor decision making are still factors despite the presence of reliable technology (Hetherington et al. 2006). Often equipment is added to vessels with little effort to train bridge officers in its use. When this happens, the equipment is frequently underutilized or ignored completely (Olsson & Jansson 2006). On many vessels the reduced workload that the technology enables has resulted in reduced manning and an increase in the number and scope of tasks for which a bridge watchstander is responsible (Sauer et al. 2002).

The use of bridge simulations to evaluate human factors in the marine environment is an established practice (O'Hara & Brown 1985; Smith 1993; Smith & Mandler 1992). Simulation is also an accepted teaching technique with many advantages. Simulation provides many benefits over real-world environments such as: the ability to concentrate on events of interest, the capacity to control the external environment, the replication of events and circumstances with multiple groups, and the ability to safely evaluate high risk events while students learn from mistakes without experiencing serious negative consequences (Smith, et al. 1995; Hertel & Millis 2002). According to Hertel and Millis (2002), simulation can be an effective pedagogical method to (a) transfer knowledge, (b) develop skills and (c) apply both knowledge and skills. Students acquire discipline-specific knowledge that they are able to later apply in professional settings.

Researchers have determined that students are motivated to learn technical material, such as mathematics and sciences, when they see the real-world application of the subject (Turner, Cox, CiCintio, Meyer, Logan & Thomas 1998). Davis (1992) states that students feel that course material is boring when "severed from the real world (p. 730)." Student perception of the benefits of course material results in motivation to learn and an increase in student motivation can lead to an increase in ability in the subject area (Portal & Sampson 2001).

The purpose of this pilot study is to investigate student perceptions of the benefits of using ECDIS in a bridge simulation course. Multiple teams of cadets participated in two simulation exercises. Approximately half of the teams had use of ECDIS and half did not. The literature suggests that ECDIS will help the bridge team do their work more efficiently and accurately and will result in better situational awareness. Because all of the participants had previously been trained in the use of ECDIS, it is expected that those participants who had access to ECDIS would have the perception that their performance benefited from that access and those who did not would have the perception that they were disadvantaged. Specifically, it is expected that the participants with access to ECDIS would have the perception that they had better situational awareness, task prioritization, more confidence, improved vessel handling and better overall team performance than those teams without access to the technology. It is also expected that the participants without access to ECDIS would have the perception that had they had access to ECDIS their performance in those areas would have improved.

This pilot study will provide a better understanding of student perception of the use of technology in bridge watchstanding decision making and will inform instructional pedagogy of both ECDIS and bridge simulation courses in order to enhance student learning.

2 Methodology

This pilot study was carried out in the full mission bridge simulator at the California Maritime Academy, a campus of the California State University system. Students in the simulation course during October and November of 2007 volunteered to participate. This bridge simulation course is designed to have a maximum of four students per section. The four students in each section are the bridge team for that section during the course. Students may register for any section that fits their needs. Once enrolled in a section, however, the student remains in that same section for the nine scenarios making up the course. Because the enrollment at CMA is relatively small, the population for this experiment is a census of all enrolled cadets at CMA who are taking the bridge simulation course during the fall semester of 2007 ($N = 47$). The participants met all prerequisites for the course and had previously taken a 35-hour ECDIS course.

In total, twelve sections participated in two different scenarios. This pilot study utilized the last two scenarios of the nine-scenario course. The first scenario used was Scenario #8 in which the student team is required to navigate a containership from the San Francisco Main Ship Channel to a specified anchorage position in San Francisco Anchorage #8. The second scenario used was Scenario #9 in which the student team is required to navigate a tanker from the Bligh Reef light through the Valdez Narrows in Alaska. Each scenario takes approximately 90 minutes to complete and, once started, is run without interruption. Each team was given the same standing orders and had one week to develop a detailed voyage plan for each transit.

Approximately half of the teams were randomly selected to have access to ECDIS for Scenario #8. The remainder of the teams did not have access to ECDIS during the scenario. Then, for Scenario #9, those teams that did not have access to ECDIS during Scenario #8 were given access and those teams that did have access during Scenario #8 were denied access.

During the scenarios, the course instructor used a data sheet to record measurements at predetermined points during the exercise. These measurements provided the source for the quantitative data which have been reported elsewhere (Buckley & Pecota 2008). After each exercise (during the debriefing period) participants were given a survey that elicited responses about the performance of his/her group as well as his/her opinions as to the effects of having, or not having, use of ECDIS during the simulation. The survey instrument consisted of a series of five-point Likert-type perception statements about which the participants were asked to indicate the level to which they agreed or disagreed with that statement (1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree).

Data gathering took place during regularly scheduled class periods. Due to the nature of the data gathered, both quantitative and qualitative methods are used. From the survey questionnaire, nonparametric tests are used to test the hypotheses. Although nonparametric tests statistically are not as powerful as parametric tests for analysis because their underlying assumptions are less stringent (Cooper & Schindler 2003), nonetheless they do permit acceptable levels of analysis for categorical variables. The hypotheses testing were accomplished using the Statistical Package for Social Sciences (SPSS) software version 13.0. For a 95% confidence level, an alpha level of significance (2-tailed) of $\alpha = 0.05$ was set *a priori* for all tests.

The primary research hypothesis (null hypothesis) to be tested for all questions is that there is no difference between the perceptions of participants having access to ECDIS and those without access to ECDIS.

3 Results

For each of the perception variables, an independent sample *t*-test was used to test the hypothesis that there is no difference in the means of the participants that had access to ECDIS and those that did not have access to ECDIS. A Levene's test was used to determine homoscedasticity of the populations, which is an important assumption when using a *t*-test.

3.1 Scenario #8 Results

Scenario #8 required the participants to navigate a containership from the San Francisco Main Ship Channel, under the Golden Gate Bridge, along the San Francisco waterfront, through the Alpha-Bravo span of the Oakland-Bay Bridge, and finally to anchor the vessel in a specified anchorage position in San Francisco Anchorage #8. Twelve teams participated in this exercise and each had previous experience navigating in San Francisco and maneuvering this particular ship model.

The results of the perceptual data for this exercise are shown in Table 3.1. The null hypothesis for these tests is that there is no difference in means between the two groups. As can be seen from the table, based on the observed significance level, and using a level of significance of $\alpha = 0.05$, there are no statistically significant differences between those participants using ECDIS and those not using ECDIS in their perceived agreement that their team's task prioritization was very good, that their team was confident throughout the scenario, that they maneuvered their vessel efficiently, that their performance was good, and that ECDIS would have/did improve situational awareness, task prioritization, turn accuracy, and overall performance. Therefore the null hypothesis cannot be rejected for those questions.

However, based on the observed significance level of .039, and using a level of significance of $\alpha = 0.05$, the null hypothesis that there are no differences in perception between those groups using ECDIS and those groups not using ECDIS with regards to their perception that using ECDIS would have/did improved(d) the team's ability to maintain the track can be rejected. In this case, although both of the populations agree with the statement, their means appear to be unequal, with the groups not using ECDIS having a much stronger feeling that ECDIS would have improved their ability to maintain the track than the groups that had access to ECDIS felt that it actually did improve their ability to maintain the track. The quantitative data in cross-track error suggests that there were no actual differences in the teams' ability to maintain the track (Buckley & Pecota 2008) but there is a statistically significant perception difference between the groups. Both groups were neutral about whether piloting without ECDIS would be unsafe.

Table 3.1

Survey Sheet (#8) Independent Sample T-Test Result (Yes n=27, No n=18)

Survey Question	ECDIS	Mean	Std. Dev.	*t*-test for Equality of Means (α = 0.05)			Ho
				T	df	Sig. (2-tailed)	
1. I feel the bridge team's situational awareness was very high.	Yes	4.33	.620	3.212	43	.002	Reject
	No	3.67	.767				
2. I feel the bridge team's task prioritization was very good.	Yes	4.04	.649	.194	43	.847	Not Reject
	No	4.00	.594				
3. I feel that the team was confident throughout this scenario.	Yes	4.07	.616	1.550	43	.128	Not Reject
	No	3.78	.647				
4. I feel the vessel was maneuvered in an efficient manner.	Yes	3.89	.698	.840	43	.405	Not Reject
	No	3.72	.575				
5. I feel the team's overall performance in this scenario was very good.	Yes	4.07	.675	.092	43	.927	Not Reject
	No	4.06	.639				
6. I feel that using ECDIS would have/did improve(d) the team's situational awareness.	Yes	4.30	.775	-.392	43	.697	Not Reject
	No	4.39	.778				
7. I feel that using ECDIS would have/did improve(d) the team's task prioritization.	Yes	4.07	.874	.417	43	.678	Not Reject
	No	3.94	1.211				
8. I feel that using ECDIS would have/did improve(d) the team's ability to maintain the track.	Yes	4.30	.869	-1.904	43	.039	Reject
	No	4.72	.461				
9. I feel that using ECDIS would have/did improve(d) the team's turn accuracy.	Yes	4.00	.961	-1.736	43	.090	Not Reject
	No	4.44	.616				
10. I feel that using ECDIS would have/did improve(d) the team's overall performance.	Yes	4.19	.622	-0.625	43	.571	Not Reject
	No	4.33	.970				
11. I feel that piloting without ECDIS is	Yes	2.89	1.086				

				t-test for Equality of Means (α = 0.05)			
not safe.				-.482	43	.633	Not Reject
	No	3.06	1.211				
12. I feel that using ECDIS would not have enhanced the team's situational awareness.	Yes	2.44	1.251	.530	43	.599	Not Reject
	No	2.22	1.555				

3.2 Scenario #9 Results

Scenario #9 required the participants to navigate a tanker in Alaska's Prince William Sound from the Bligh Reef light through the proper inbound traffic lane to Tongue Point and from there through the Valdez Narrows. The participants did not have previous experience navigating in Prince William Sound but they did have experience maneuvering this particular ship model.

The results of the qualitative data for this exercise are shown in Table 3.2. As before, the null hypothesis for these tests is that there is no difference in means between the two groups; those with access to ECDIS and those without access to ECDIS. As can be seen from the table, based on the observed significance level, and using a level of significance of α = 0.05, the null hypothesis that there are no differences between those groups using ECDIS and those groups not using ECDIS in their perception that the team's situational awareness was high, that their task prioritization was very good, that the team was confident throughout the scenario, that the vessel was maneuvered in an efficient manner, that the team's performance was very good, and that they felt that ECDIS would have/did improve(d) the team's task prioritization, ability to maintain the track, and turn accuracy cannot be rejected.

Table 3.2
Survey Sheet (#9) Independent Sample T-Test Result (Yes n=19, No n=28)

Survey Question	ECDIS	Mean	Std. Dev.	t-test for Equality of Means (α = 0.05)			Ho
				T	df	Sig. (2-tailed)	
1. I feel the bridge team's situational awareness was very high.	Yes	4.42	.607	.452	45	.653	Not Reject
	No	4.32	.819				
2. I feel the bridge team's task prioritization was very good.	Yes	4.32	.749	-.767	45	.447	Not Reject
	No	4.46	.576				
3. I feel that the team was confident throughout this scenario.	Yes	4.37	.831	-.120	45	.905	Not Reject
	No	4.39	.567				
4. I feel the vessel was maneuvered in an efficient manner.	Yes	4.32	.820	-.509	45	.613	Not

				t-test for Equality of Means ($\alpha = 0.05$)			
	No	4.43	.690				Reject
5. I feel the team's overall performance in this scenario was very good.	Yes	4.42	.692	-.233	45	.817	Not Reject
	No	4.46	.576				
6. I feel that using ECDIS would have/did improve(d) the team's situational awareness.	Yes	4.68	.671	2.945	45	.005	Reject
	No	3.93	1.086				
7. I feel that using ECDIS would have/did improve(d) the team's task prioritization.	Yes	3.89	1.100	1.364	45	.179	Not Reject
	No	3.46	1.036				
8. I feel that using ECDIS would have/did improve(d) the team's ability to maintain the track.	Yes	4.32	.946	1.236	45	.223	Not Reject
	No	3.93	1.120				
9. I feel that using ECDIS would have/did improve(d) the team's turn accuracy.	Yes	4.00	1.247	.411	45	.638	Not Reject
	No	3.86	1.113				
10. I feel that using ECDIS would have/did improve(d) the team's overall performance.	Yes	4.21	.976	2.195	45	.033	Reject
	No	3.54	1.071				
11. I feel that piloting without ECDIS is not safe.	Yes	3.11	1.100	1.444	45	.156	Not Reject
	No	2.64	1.062				
12. I feel that using ECDIS would not have enhanced the team's situational awareness.	Yes	2.26	1.098	-1.211	45	.232	Not Reject
	No	2.64	1.026				

Based on the observed significance level of .005, and using a level of significance of $\alpha = 0.05$, the null hypothesis that there are no differences between those participants using ECDIS and those not using ECDIS about their feeling that using ECDIS would have/did improve(d) the team's situational awareness can be rejected. Although both groups of participants agree with the statement, those with ECDIS have a statistically stronger feeling that using ECDIS did improve their team's situational awareness. With an observed significance level of .033, the null hypothesis that there are no differences between participants about their feeling that using ECDIS would have/did improve(d) their team's overall performance can be rejected. Although the participants agreed with the statement, those with ECDIS have a statistically stronger feeling. Both groups were neutral about whether piloting without ECDIS would be unsafe.

3.3 Comparing Scenario #8 and Scenario #9 Result

As noted earlier in this paper, although both scenarios required the participants to navigate a ship with which they were filiar, there was a significant difference in their familiarization with the area in which they were navigating and the environmental conditions during the run. The geographic construct for Scenario #8 was very familiar to the participants and the exercise started during daylight hours and transitioned to darkness. By contrast, the geographic construct for Scenario #9 was not familiar to the participants and the exercise began in darkness and transitioned to daylight.

The results of the qualitative data for these two exercises for the participants without access to ECDIS are shown in Table 3.3. The null hypothesis for these tests is that there is no difference in means between the two scenarios for those participants without access to ECDIS. As can be seen from the table, based on the observed significance level, and using a level of significance of $\alpha = 0.05$, the null hypothesis that there are no differences between the participants in the two scenarios that did not have access to ECDIS in their feeling that using ECDIS would have improved the team's situational awareness and task prioritization cannot be rejected.

Although the participants in both scenarios generally agreed with the questionnaire statements, based on the observed significance level of .010, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that their team's situation awareness was very high can be rejected. For this question, the participants in Scenario #9 had a significantly stronger feeling. Based on the observed significance level of .012, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that their team's task prioritization was very good can be rejected. For this question, the participants in Scenario #9 had a significantly stronger feeling. Based on the observed significance level of .001, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that their team was confident throughout the scenario can be rejected. For this question, the participants in Scenario #9 had a significantly stronger feeling. Based on the observed significance level of .001, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that their vessel was maneuvered in an efficient manner can be rejected. For this question, the participants in Scenario #9 had a significantly stronger feeling. Finally, based on the observed significance level of .030, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that their team's overall performance was very good can be rejected. For this question, the participants in Scenario #9 had a significantly stronger feeling.

Based on the observed significance level of .002, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that using ECDIS would have improved the team's ability to maintain the track can be rejected. For this question, the participants in Scenario #8 had a significantly stronger feeling. Based on the observed significance level of .036, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that using ECDIS would have improved the team's turn accuracy can be rejected. For this question, the participants in Scenario #8 had a significantly stronger feeling. Based on the observed significance level of .014, the null hypothesis that there are no differences between the participants in the two scenarios about their feeling that using ECDIS would have improved the team's overall performance can be rejected. For this question, the participants in Scenario #8 had a significantly stronger feeling. The participants from both scenarios were neutral about whether piloting without ECDIS would be unsafe.

Table 3.3
Scenario #8 and #9 Combined (No ECDIS) Independent Sample T-Test Result (Scenario #8 n=18, Scenario #9 n=28)

Survey Question	Scenario	Mean	Std. Dev.	t-test for Equality of Means ($\alpha = 0.05$) t	df	Sig. (2-tailed)	Ho
1. I feel the bridge team's situational awareness was very high.	8	3.67	.767	-2.712	44	.010	Reject
	9	4.32	.819				
2. I feel the bridge team's task prioritization was very good.	8	4.00	.594	-2.635	44	.012	Reject
	9	4.46	.576				
3. I feel that the team was confident throughout this scenario.	8	3.78	.647	-3.399	44	.001	Reject
	9	4.39	.567				
4. I feel the vessel was maneuvered in an efficient manner.	8	3.72	.575	-3.609	44	.001	Reject
	9	4.43	.690				
5. I feel the team's overall performance in this scenario was very good.	8	4.06	.639	-2.250	44	.030	Reject
	9	4.46	.576				
6. I feel that using ECDIS would have improved the team's situational awareness.	8	4.39	.778	1.557	44	.127	Not Reject
	9	3.93	1.086				
7. I feel that using ECDIS would have improved the team's task prioritization.	8	3.94	1.211	1.436	44	.158	Not Reject
	9	3.46	1.036				
8. I feel that using ECDIS would have improved the team's ability to maintain the track.	8	4.72	.461	3.336	44	.002	Reject
	9	3.93	1.120				
9. I feel that using ECDIS would	8	4.44	.616				

				t-test for Equality of Means ($\alpha = 0.05$)			
have improved the team's turn accuracy.	9	3.86	1.113	2.229	44	.036	Reject
10. I feel that using ECDIS would have improved the team's overall performance.	8	4.33	.970	2.555	44	.014	Reject
	9	3.54	1.071				
11. I feel that piloting without ECDIS is not safe.	8	3.06	1.211	1.218	44	.230	Not Reject
	9	2.64	1.062				
12. I feel that using ECDIS would not have enhanced the team's situational awareness.	8	2.22	1.555	-1.014	44	.320	Not Reject
	9	2.64	1.026				

Comparing the response means to each of the questions for the two different scenarios for the participants who had access to ECDIS showed there were no statistical differences in their responses to any of the questions.

4. Conclusions and discussion

This experiment is an important step in understanding the complexities of integrating ECDIS into bridge team management. Prior to conducting this pilot study, we expected that the participants with access to ECDIS would have the perception that they had better situational awareness, task prioritization, more confidence, improved vessel handling and better overall team performance than those teams without access to the technology. It was also expected that the participants without access to ECDIS would have the perception that had they had access to ECDIS their performance in those areas would have improved. In general, the data affirmed those expectations with several being statistically significant. These findings were consistent with Donderi et al. (2004), Smith et al. (1995) and Gonin et al. (1996).

When we compared those participants who used ECDIS in the simulated exercise in San Francisco Bay (SFB) in Scenario #8 with those who used ECDIS in the Prince William Sound (PWS) exercise in Scenario #9, there were no significant differences and they affirmed the previously discussed expectations. However, when comparing the two scenarios for those participants who did not have access to ECDIS, the results were surprising. Because CMA cadets are very familiar with operating actual and simulated vessels in SFB and have little or no experience in PWS, we expected that participants would be more comfortable navigating without ECDIS in familiar waters during daylight (Scenario #8) than in unfamiliar waters in the dark (Scenario #9). The results for each of the survey questions were contrary to what was expected and in most cases at a level that was statistically significant. Participant comments gathered during scenario debriefing provide possible explanation to these findings. They reported that in the absence of ECDIS, in Scenario #8 they relied extensively on single parallel index lines, a traditional navigation technique using radar, while during Scenario #9 they made extensive use of double parallel index lines to maintain track and felt more confident in the use of this technique and its reliability. Another possible explanation might be that because participants had had more simulation experience prior to Scenario #9 than they had prior to Scenario #8, that added experience might have resulted in greater confidence in their own abilities. Perhaps because the participants were not familiar with PWS and knew it would be dark during the exercise they more thoroughly prepared for Scenario #9 than they did for Scenario #8.

Although this pilot study has some interesting results, we do recognize and acknowledge the following limitations: small sample size, the difficulties in interpreting perception surveys, the limitations of a 5-point Likert scale, the inherent weakness of post-trial self-rating techniques and the fact that we compared two scenarios with different geographic locations and environmental conditions.

Students who perceive the real-world application of instructional material have increased motivation to learn (Turner et al. 1998). The results of this study indicate that students who are exposed to ECDIS in bridge simulation courses readily perceive its benefits to watchkeeping. Although current practice in simulation courses is to not allow access to ECDIS (Pecota pers comm. 2007), maritime training centers should consider incorporating advanced navigation techniques, including the use of ECDIS, as early in their programs as practicable in order to increase student motivation to learn those subjects.

While this pilot study answered some basic questions, many more questions were revealed. Will these results be replicable with more common scenarios? What would be the effect of running Scenario #9 earlier than Scenario #8? Instead of comparing a scenario involving a familiar geographic area with an unfamiliar area, what would result when two unfamiliar areas are compared? Would relocating the ECDIS display on bridge yield different results? Would the results be different with a one person watch than they were with a four person watch team? What would be the effect on student performance in an ECDIS training course of exposing students to ECDIS earlier in the training cycle?

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Acknowledgements

We would like to acknowledge and thank the following people for the help they provided in completing this experiment: Captain Samuel R. Pecota, Captain Mike Noonan, Captain Paul Leyda, and Captain Peter Hayes.