Study of the Extended Technology Acceptance Model in the U.S. Navy: Case of Combat Information System

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ABSTRACT
The U.S. Navy continues to be a major developer and procurer of information systems (IS), yet very limited research has been done to determine the factors that influence technology acceptance by naval personnel. Literature suggests that efforts to embrace information technology in improving decision-making and reducing workload heavily depend on the use of such systems. Moreover, previous research has shown the validity of the technology acceptance model (TAM) and computer self-efficacy (CSE) to model technology acceptance in numerous environments. However, very little research was done specifically addressing such technology acceptance with military combat IS. Thus, this study examines the applicability of the extended TAM with a CSE construct model to the U.S. Navy's combat IS. A survey sample of 237 sailors from five (5) different U.S. Navy aircraft carriers was used to assess such extended model on a U.S. Navy's combat IS. Results indicate that perceived ease-of-use, perceived usefulness, and CSE were valid antecedents of technology acceptance (as indicated by intention to use). Moreover, high Cronbach's Alpha was observed on all measures indicating additional reliability of the measures also in the context of military organizations.

Keywords: Technology acceptance model, computer self efficacy, IS in military/U.S. Navy, combat information systems, perceived usefulness of military IS, perceived ease of use of military IS, attitude toward military IS, intention to use IS in military.

INTRODUCTION
There is a large body of research regarding technology acceptance of information systems (Davis, 1989; Chau, 1996; Chau & Hu, 2001; Hu, Chau, Sheng, & Tam, 1999; Legris, Ingham, & Collerette, 2003; Venkatesh, Morris, Davis, & Davis, 2003; Ma & Liu, 2004), but a scarce number of studies regarding technology acceptance by members of the U.S. Navy. A common misconception of the military is that it is wholly structured. In reality, aboard a naval ship there are sometimes overlapping applications that a sailor can choose to use or ignore. Especially of interest is the usage or lack thereof of Decision Support Systems – that by their nature are designed to improve the quality of choices made by fleet personnel. There is anecdotal evidence that systems that provide situation awareness and decision support are not fully utilized by the intended audience.

Between 2001 and 2005, the U.S. Navy had an annual budget of about $120B (Globalsecurity.org, 2005). The exact amount that the Navy spends on information technology is hard to quantify, but a line item review of the budget indicates that the amount spent on information technology is measured in the billions of dollars (Globalsecurity.org, 2005). A focus of information technology development is to reduce shipboard manning. Achievement of this goal will require the development and integration of improved information systems (Bisantz, Rothe, Brickman, et al., 2003). It can be asserted that considering the funds being applied to information technology, a model for technology acceptance and the factors that influence information system usage should be determined (Davis, 1989; Chau, 2001).

Researchers have recommended replication of instruments and revalidation of models for unique environments (Amoako-Gyampah & Salam, 2004). Many technology acceptance studies have taken place in academic settings (Davis, 1989; Taylor & Todd, 1995; McFarland & Hamilton, 2006), but the military environment is different. Technology acceptance studies have been successfully replicated in many environments, but with varying factor loading between constructs (Legris, et. al., 2003). Examples of different environments where technology acceptance has been studied include a public hospital system (Chau & Hu, 2001), a construction-engineering environment (Lowry, 2002), Decision Support Systems in use in Egypt (Elbeltagi, McBride, & Hardaker, 2005) and a large corporation undergoing ERP implementation (Amoako-Gyampah & Salam, 2004).

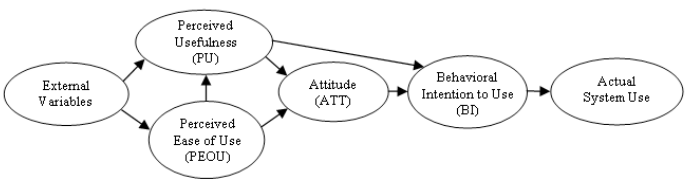
Development of a technology acceptance model for the U.S. Navy will result in a validated instrument for assessing the acceptance and expected usage of an information system. A validated model also can be used as a tool to identify weaknesses in a technology implementation and adjust the approach. This information is valuable to a Program Manager who must make decisions on how to invest in system improvements.

THEORETICAL BACKGROUND
Technology Acceptance Model (TAM)
The Technology Acceptance Model (TAM) has been studied extensively with many of variations and in many different environments (Chau, 1996; Hu et al., 1999; Legris et al., 2003; Venkatesh et al., 2003). The TAM model is grounded in Theory of Reasoned Action (TRA) proposed and validated by Ajzen and Fishbein (1975). The essence of the model is in using users' perceptions about usefulness, ease of use, and attitude toward technology in order to predict users' intention to use as well as actual usage of a technology. The overall approach of TAM is predictive in nature, attempting to uncover the constructs that impacts users' intensions to use technology. Figure 1 provides an overview of the conceptual map proposed by Davis, Bagozzi, and Warshaw (1989).

Numerously various studies have validated the TAM model in different contexts (Venkatesh et al., 2003). However, no prior work was done on validating the TAM model in military context, in particular not on combat information systems. As such, this study is unique in its attempt to validate an extended TAM model in the context of antecedent construct that impact soldiers' intension to use combat information systems.

The factors in TAM that predict usage are perceived usefulness, perceived ease of use, and attitude. Perceived Usefulness is defined as "the degree to which a person

Figure 1. Davis, Bagozzi, and Warshaw (1989)'s conceptual map of the TAM model



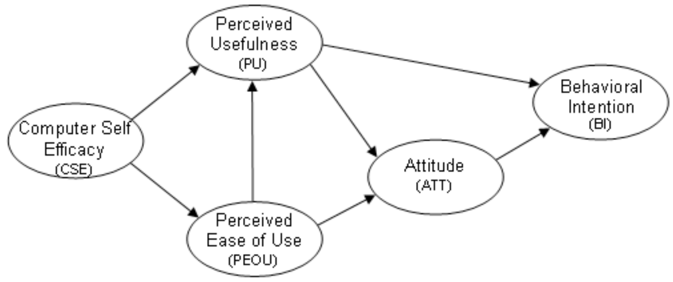
believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). Perceived Ease-of-use is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Attitude has been defined by Yang and Yoo (2004) as a combination of "how much the person likes the object of thought" and "specific beliefs related to the object" (p. 20).

Hu et al. (1999) studied how well the TAM modeled physician's intention to use telemedicine. The study, with 408 participants, examined perceived usefulness, perceived ease-of-use, attitude, and intention to use. Hu et al. (1999) found that TAM was applicable to the professional environment of a hospital. The attitude construct was found to significantly influence intention to use. In contrast, perceived ease of use did not have a significant effect on perceived usefulness and attitude. Hu et al. (1999) concluded "the explanatory power of TAM, particularly the perceived ease of use factor, may weaken as the competency of the users increases" (p. 106). This finding suggests that "competency" is an external variable to the TAM. Thus, this study adds a measure of perceived computer competency, computer self-efficacy, as an external variable to the TAM.

Computer Self-Efficacy

Computer Self-Efficacy (CSE) construct immerged from the general concept of self efficacy by Compeau and Higgins' (1995) and is founded on the social cognitive theory (Bandura, 1977; 1982; 1984). CSE is defined as "an individual's perception of his or her ability to use a computer in the accomplishment of a job task" (Compeau & Higgins, 1995, p. 193). Numerous studies in literature suggest that CSE has a very high reliability and strong validity across different contexts (Agarwal, Sambamurthy, & Stair, 2000; Chung, Schwager; & Turner, 2002; Durndell & Haag, 2002; Hasan, 2006; Potosky, 2002; Sheng, Pearson, & Crosby, 2003; Stone, Arunachalam, & Chandler, 1996; Stone & Henry, 2003; Thatcher & Perrewe, 2002; Torkzadeh, Chang, & Demirhan, 2006; Yi & Im, 2004). Moreover, CSE has been validated in numerous studies with its relationship as an extension of the TAM model (McFarland & Hamilton, 2006; Venkatesh & Davis, 1996).

Figure 2. Conceptual map of the research model



Chau (2001) conducted a study of extending the TAM model with CSE on 360 business students. Although providing validation for the TAM model, his study suggests that CSE as well as computer attitude should impact perceived ease of use and perceived usefulness. There is evidence from literature to support the belief that CSE may serve as a predictor of PEOU and PU, there is little support in literature for using attitude as a predictor of the two constructs, indicating somewhat a deviation from the original TAM model. Thus, this proposed study attempted to validate the use of CSE as an external variable that impacts the key TAM constructs following the traditional TAM where attitude is between PEOU, PU and BI. Figure 2 provides a conceptual map of the proposed research model. The proposed modified model is based on the relationships proposed in the extension of the TAM model noted by scholars (McFarland & Hamilton, 2006; Venkatesh & Davis, 1996).

METHODOLOGY

A survey instrument was adapted from Chau and Hu (2001) which provides validated measures for the constructs relevant to perceived usefulness, perceived

Table 1. Descriptive statistics and Cronbach's Alpha

Summary of Measurement Scales: (n=206)				
Construct	**Measure**	**Mean**	**SD**	**Cronbach Alpha**
Computer Self Efficacy (CSE)				
CSE1	I am comfortable working with computers	1.85	1.28	
CSE2	If I am given some training, I can learn to use most computer programs	1.77	1.10	*0.77*
CSE3	I can learn to use most computer programs just by reading the manuals and help	2.86	1.67	
Perceived Usefulness (PU)				
PU1	Using [*] will improve my support of casualty control, situational awareness and logistical references	2.54	1.53	
PU2	Using [*] will enhance my effectiveness in supporting combat operations	2.27	1.27	*0.83*
PU3	I find [*] useful for my work on the ship	2.54	1.29	
Perceived Ease of Use (PEOU)				
PEOU1	It was easy for me to learn to use [*]	2.59	1.29	
PEOU2	It is easy for me to become skillful in [*]	2.67	1.27	*0.91*
PEOU3	I find [*] easy to use	2.72	1.36	
Attitude (ATT)				
ATT1	Using [*] is a good idea	2.25	1.28	
ATT2	Using [*] is pleasant	2.81	1.39	*0.65*
ATT3	Using [*] is beneficial to my ship	2.20	1.27	
Behavioral Intention (BI)				
BI1	I intend to use [*] for casualty control, situational awareness and logistical references as often as needed	2.54	1.36	*0.89*
BI2	To the extent possible, I will use [*] in my work	2.53	1.26	

* - *The name of the system was concealed for obvious reasons.*

ease-of-use, attitude, and behavioral intention to IS use. The measures used by Chau and Hu were adapted from measures validated by Taylor and Todd (1995) as well as Davis (1989). Computer self efficacy measures were adapted from Compeau and Higgins (1995). All measures for constructs (i.e. CSE, PU, PEOU, BI, and ATT) were adapted from their original sources noted above and slightly modified to fit within the survey format and better relate to the environment under study (i.e. a U.S. Navy's combat IS). This adaptation was accomplished by reviewing the survey instrument with subject matter experts experienced with the U.S. Navy's combat IS implementations on five U.S. Navy ships. The results of the subject matter expert reviews were minor wording changes to clarify the intent of the questions for the U.S. Navy sailors. The minor modifications included the notation to the system's name instead of generic notation of IS, particularly in the measures of the original TAM construct (i.e. PU, PEOU, ATT, and BI). The subject matter experts indicated that including the system's name may help reduce threats to internal validity (see questions text in Table 1).

An information system used by the combat systems department onboard U.S. Navy aircraft carriers was chosen as the target system for model testing. This IS is used by combat systems watch officers for situational awareness, casualty control, and maintenance management (Green, 2003). The system was selected for this study because its use is not mandatory, rather it is available to use at the discretion of the combat systems watch officer. The survey instrument was distributed onboard the five separate ships over a six-month period. The survey instrument was distributed on paper and was anonymously completed. Responses were collated and entered into two separate spreadsheets by two separate people. The separate spreadsheets were then compared to assure that no data entry errors were made. Any difference in data was traced back to the original survey questionnaire and the correct score was entered.

A total of five U.S. Navy aircraft carriers were represented in the sample. A total of 326 surveys were issued and 237 completed surveys were returned, for a response rate of 73%. The survey response rate was high because the sample population was a captive audience. Each of the 237 returned surveys were checked for completeness and analyzed to determine if the participant marked the same score for all items suggesting a response set. Kerlinger and Kee (2000) noted that "response-set can be considered a mild threat to validity measures" (p. 713). They noted that scanning the data for response-set and removing those from final analysis help with the overall validity of the results. Thus, the data were observed for response-sets indicating 31 cases of sailors who just marked the whole survey on the same score. Such response-sets were eliminated providing a total of 206 usable records for further analyses.

DATA ANALYSIS AND RESULTS

Analysis of Measurement Validity

Table 1 provides the results of the analysis of measurement validity. Results indicating that most measures produce a very high reliability of 0.91, 0.89, 0.83, 0.77, and 0.65 Cronbach's Alpha for PEOU, BI, PU, CSE, and ATT respectfully. These results provide an indication that the survey instrument is reliable in its measurements and consistent with results found in prior literature.

Model Testing Results

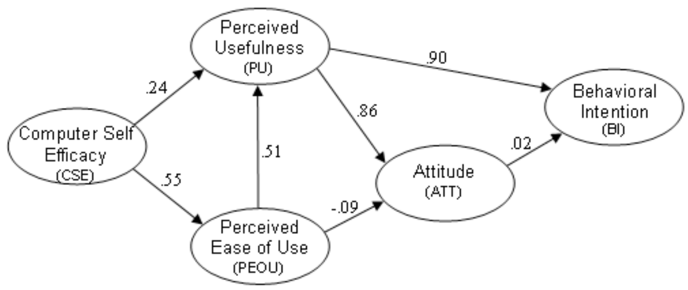
AMOS 6.0 was used to perform the path analysis model fit. Literature suggest seven common measures of model-fit analysis including chi-square/degrees-of-freedom (Chi-square/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI), and standardized root mean square residual (SRMSR) (Chau & Hu, 2001; Chau, 2001; Somers, Nelson, & Karimi, 2003). Within these seven model-fit measures, literature provides specific guidelines to the recommended values in order to indicate the performance of the model. Carmines and McIver (1981) recommended that a value of Chi-square/df less than three indicates good fit. Additionally, Somers et al. (2003) noted that Chi-square/df less than two indicates even "more restrictive [fit]" (p. 610) or a higher quality of model fit. Table 2 provides both the recommended values and the results of this study. Chi-square/df was found to be 1.6, which much lower than both the regular recommended value (<3.00) and the restrictive fit (<2.00) indicating a good support for the model-data fit. Two other common measures of model-fit analysis are GFI and AGFI. GFI measure is based on the amount of variance and covariance difference, while AGFI is similar to GFI but adjusted to the degrees of freedom relative to the number of variables in the model (Shumacker & Lomax, 2004). On both GFI and AGFI

Table 2. Goodness-of-fit measures of the research model

Goodness-of-fit Measure (n=206)	Recommended Value*	Research Model	Chau (2001)
Chi-square (χ^2)		112.2	NR
Degrees of freedom (df)		70	NR
Chi-square/df	<3.00	1.602	2.09
Goodness-of-Fit Index (GFI)	>0.90	0.930	0.90
Adjusted Goodness-of-Fit Index (AGFI)	>0.80	0.895	0.88
Normed Fit Index (NFI)	>0.90	0.940	0.94
Non-Normed Fit Index (NNFI)	>0.90	0.969	0.91
Comparative Fit Index (CFI)	>0.90	0.976	0.94
Standardized Root Mean Square Residual (SRMSR)	<0.10	0.054	0.05

* - Per Chau (2001)
NR – Not Reported

Figure 3. Extended TAM and CSE model testing results



zero (0) indicates no fit and one (1) indicate perfect fit. Researchers suggested that values for GFI and AGFI above .80 and .90, respectively, indicate a good fit (Chau, 2001; Chau & Hu, 2001; Somers et al., 2003). Results of this study's model indicate support for the model fit with GFI of .93 and AGFI of .895. Additionally, three more common measures of model-fit analysis are NFI, NNFI, and CFI. For these three measures researchers suggested that values for grater than .90 indicates support for the model fit (Chau, 2001; Chau & Hu, 2001; Somers et al., 2003). Based on these model fit measures, results of this study's model indicate a near perfect model fit with NFI of .940, NNFI of .969, and CFI of .976 providing additional support for a good model-date fit. Mayers, Gamst, and Guarino (2006) suggested that SRMSR below .08 indicates good fit, between .08 and .10 indicates moderate fit and above .10 indicates poor fit. Shumacker and Lomax (2004) also concurs such model fit values. Results of this study's model indicate SRMSR of .054, which additionally supports the fitness of the model.

Figure 3 indicates the results of the model path. As noted the direct effect between CSE and PEOU appears to be stronger (.55) than the direct effect between CSE and PU (.24). The effect of PEOU on attitude and the effect of attitude on BI appear to be narrow. Additionally, a strong effect was found between PU and attitude (.86), while the strongest effect found was between PU and BI (.90). This finding suggests that one unit increase in sailor's perceived usefulness results in a .86 unit increase in their attitude towards the system and a .90 unit increase in their intention to use it. These results are consistent with the Hu et al. (1999) study.

DISCUSSION

The TAM model has long been a central model in IS research with numerous studies validating it in various contexts. However, very little work was done in the context of military information systems, in particular assessing IS that provide combat support. This study is very unique as it provides additional empirical evidence by validating the extended TAM model in the context of a U.S. Navy combat IS.

Results of the model show very strong validation with high degree of model fit and with better results of what published previously in non-military context. Moreover, analysis of measures validity indicates high Cronbach's Alpha for four of the instrument constructs calculated at over 0.75, while the remaining construct (attitude) provided an acceptable reliability measure of 0.65. These reliability results further validate the survey instrument proposed in literature.

Several limitations and opportunities for future research can be observed for this study. First, examination of any military information systems is an unexplored phenomenon. Although results of this study are valid as indicated by the analyses, additional measures should be explored in the context of military information systems. An observed limitation of this study deals with the high amount of response-set. Although this study was able to collect relatively high response rate (~73%) from the U.S. Navy sailors, there was a large amount (~10%) of respondents who simply marked the survey the same score on all measures in order to obey the request of their military superiors to participate in the study. Thus by providing response-set, these sailors prevented assessment of their true perceptions and feelings about this U.S. Navy combat IS. This resulted in the need to eliminate these response sets from the data prior to any analysis and a final response rate of 63%.

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