

Integrating Usability Engineering in the
Iterative Design Process of the Land Attack Combat System (LACS)
Human Computer Interface (HCI)

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Abstract

Usability engineering are the set of design and development practices the Space & Naval Warfare Systems Center (SSC San Diego) followed in order to ensure that the Tomahawk Operators can succeed in using the Land Attack Combat Systems (LACS) for its intended purposes. This paper presents our approach of the usability engineering activities and the results from a 1-year Fiscal Year 2003 effort for the development of the LACS Human Computer Interface (HCI). Iterative usability evaluations and design processes were conducted quarterly on the LACS HCI in order to develop the HCI that best supported the tasks of the Tomahawk Operators. Usability evaluations consisted both of Heuristic Reviews and Usability Testing. Results from these iterative evaluations were integrated into successive design builds for further evaluations.

Introduction on LACS

Increasingly new weapons and new controls capabilities and requirements will continue to increase the demands placed on Navy operators. The capability for small team of operators to plan for simultaneous control and launch of multiple weapons types is highly desirable. Designing an effective HCI that provides this capability, without increasing current manning requirements, workload or situational awareness levels is future challenges (Kellmeyer, Lulue, Osga, and Campbell, 2001). Funded by two Future Naval Capability's (FNC) of the Office of Naval Research (ONR), SSC San Diego is leading the work on the development of the LACS HCI. This effort is the ATTD Transition Candidate for TTWCS version 6 that will enhance the current Tactical Tomahawk Weapons Control Systems (TTWCS) version 5 HCI.

The LACS HCI consists of two displays: The Task Manager and TacSit. The Task Manager provides the TTWCS team an interface for supervisory control of all Tomahawk Land Attack Missile taskings. Supervisory control allows the team members to work in collaboration with automation as well as each other. The TacSit provides the situational awareness plot with enhanced capability to provide the TTWCS operators with increased situational awareness and understanding to quickly see the tactical situation.

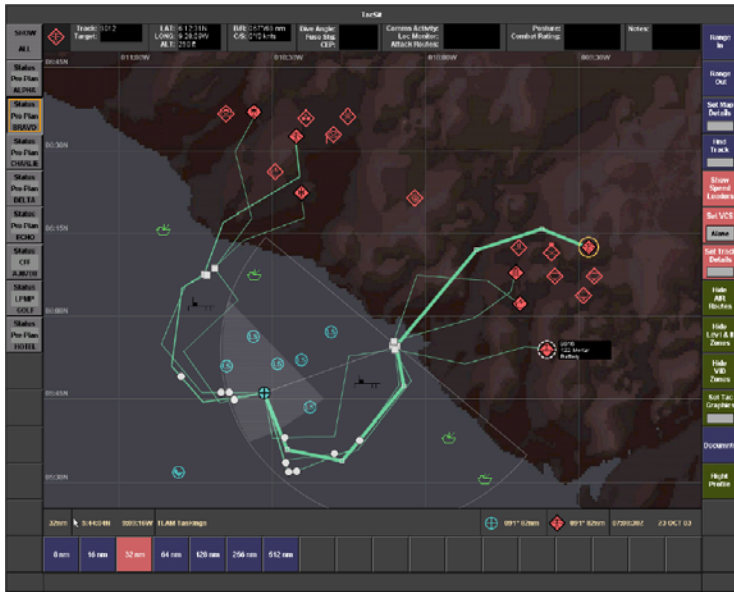


Figure 1.0 Task Manager (Situational Awareness)

BUCK	Map Readiness		Battleforce NA		Contact DSM		Prepare Loadings		TLAM Loadings		GRN Loadings		Reberon Loadings		Task Manager
	Tasking	Fwd	Casualty	Releas Request	Mission	Target	Launch Pace	Wave's Duration	Exception Report	SCO	Less Burn Report	Post Launch Control	Comments	TOL_TOT	
ESP ID	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	
ESM	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	
ESM	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	
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ESM	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	
ESM	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	
ESM	1010	10 P/vis	10 P/vis	1	0	Pre-Plan	7	3:46:00h 10:31:31W	0	0	7	A.M	None	07:07:09Z 07:12:09Z	

Figure 2.0 TacSit (Task Management)

Importance of Usability Engineering for the LACS HCI

Employment of the Usability engineering process produces highly usable LACS HCIs that are essential to increased productivity and timeliness, reduced manning, reduced mental workload, reduced training, reduced human error, and warfighter trust. It is the systematic application of established human factors engineering expertise and

practices. Usability development practices offer a means of quantifying, designing, and testing the system's "fit" to the warfighter and their tasks. Activities in this engineering process include, but not limited to, task analysis, user and environment profiles, rapid prototyping, heuristic reviews, and usability testing.

Too often, many program managers and developers misunderstand usability engineering add cost and development time to the product's development lifecycle. However, applying usability engineering in the product's lifecycle reduces cost over the life of the product's development, by reducing the need to add missed or fix unusable functionality later in the development cycle. As part of SSC San Diego's spiral development, Human Factors Engineers apply the usability engineering process and iteratively perform heuristic evaluations and usability testing in the design of the LACS HCI. These evaluations were conducted rather cost effectively, but we gained valuable insight on how the warfighters use and perceive the LACS HCI. This paper will focus on these usability evaluations and present the process and results that stemmed from these activities.

Heuristic Evaluations of the LACS HCI

Heuristic evaluation is the most cost-effective usability evaluation of the usability engineering process, intuitive to conduct, and extremely effective in the early phases of the development process. It is a technique in which one or more experts evaluate a design according to established usability principles (heuristics). Human Factors Engineers trained in cognition theory and human factors principles review the product and judge the usability of the product against these heuristics. Potential usability issues are identified and then used to derive recommendations for improving the HCI. To increase the effectiveness of the LACS HCI heuristic evaluation, multiple Human Factors Engineers from SSC San Diego, NAVAIR Orlando Training Systems Division, and NSWCDD independently performed heuristic evaluations on the prototype interface. Studies have shown that independent evaluations conducted by three to five Human Factors Engineers identify most of the potential usability issues (Nielsen, 1993). Each Human Factors Engineer evaluated the interface independently. The results are then combined to analyze common and conflicting results. The evaluations were conducted quarterly on various versions and different levels of fidelity of the HCI. Depending on the development cycle, the interface may have been a power point presentation or a high fidelity running prototype with automation and instantaneous feedback from the warfighters action. Over the course of the FY 2003 effort, a total of over 200 potential usability issues were found on various versions of the LACS HCI. The usability recommendations found from these heuristic evaluations were folded into subsequent version of the HCI for usability testing or documented for additional research.

Usability Testing

In a well-managed project, usability testing occurs at various times throughout the development lifecycle to ensure the usability of the product. Usability testing is a method in which real users of the intended product do real tasks. Trained Human Factors Engineers analyze the data, diagnose the real problems and recommend changes to fix the problems. Throughout FY 03, for the purpose of evaluating alternative design concepts, usability tests were conducted quarterly on initial LACS HCI designs. Usability tests were conducted quarterly at SSC San Diego and NSWCCD. A total of 34 fleet personnel from various facilities acted as participants. The participants include: FCTCPAC, FCTCLANT, USS Stethem DDG, USS Winston Churchill DDG-81, and COMSECFLT. Participants were recruited from various locations to provide a wider range of feedback. This was also to account for differing opinions and operating procedures from the various locations.



Figure 3.0 Participant in a usability study

Methodology

There are different types of usability tests conducted on the product at various stages of the development phase. During FY 03, the type of methodology conducted was an Exploratory Usability Test. An Exploratory usability test is a method best used to determine or explore the efficiency and effectiveness of the design concepts, also known as the user's conceptual or mental model. In this type of usability test, the participants are solicited for their ideas of the design concepts presented to them and how to improve any confusing areas. There is much discussion between the Test Administrator and the participants since the goal is to understand their thought processes and for the participants to answer questions posed to them by the Test Administrator. As the HCI matures and as the development phase moves from conceptual to design, the type of usability tests will move from qualitative feedback to quantitative performance metrics, also known as Validation testing.

Low fidelity testing with power point presentations was conducted early in the development cycle to explore the operator's mental model and design concepts. High fidelity usability testing was conducted with simulated prototypes to analyze how well the warfighters can perform full-blown tasks. A total of 6 usability tests were conducted in FY 03. Over 300 usability issues were found and recommendations provided to improve the LACS HCI. As with the heuristic evaluations, recommendations were folded into the subsequent versions of the HCI for further testing.

For each usability test, 5 – 7 participants participated in the usability test at SSC SD and NSWCDD. Participants were only required to have familiarity with the subject matter. The evaluations used a scenario that required the warfighters to complete a TTWCS taskings. The warfighters were allowed to freely navigate the HCI. This allowed the opportunity to observe the intuitiveness of the interface by using a discovery type method, as well as the subsequent learnability of the interface. As the participants moved through the various displays, the Test Administrator asked various questions regarding the usability of the displays. These questions were designed to elicit information on the intuitiveness, effectiveness and efficiency of the HCI and whether the information presented supports their taskings. The administrator recorded if the operator took the expected actions or gave the expected answer. The administrator and data logger also recorded any observations or operator comments.

Results

Results from FY 03's usability study indicated the LACS HCI effectively supports the warfighter's tasking. Effectiveness was measured as whether the information provided the needed information to complete their taskings, whether the warfighters launched the missiles on time, and anecdotal feedback that one warfighter can accomplish the taskings of a team of Tomahawk operators. Other anecdotal feedback states the warfighter's approval of the LACS HCI over the current HCI. Lastly, additional research questions were raised and are the focus of FY 04 activities.

References

Kellmeyer, D., Lulue, D., Osga, G., and Campbell, N. (2001). *User-Centered Design for Land Attack Warfare: Advanced Tactical Technology Demonstration (ATTD) (Tech. Rep. No. 1880)*. San Diego, CA: SPAWAR Systems Center (SSC).

Nielsen, J., *Usability Engineering*, Academic Press. 1993.