HUMAN FACTORS ENGINEERING & MTI'S TECHNICAL APPROACH TO HUMAN SYSTEM INTEGRATION (HSI)

Human factors and ergonomics is the application of psychological and physiological principles to the engineering and design of products, processes, and systems. The goal of human factors is to reduce human error, increase productivity, enhance safety and comfort, and decrease lifecycle costs with a specific focus on the interaction between the human and the system or thing of interest.

The field is a combination of numerous disciplines, such as psychology, sociology, engineering, biomechanics, industrial design, physiology, anthropometry, interaction design, visual design, user experience, and user interface design. In research, human factors employ the scientific method to study human behavior so that the resultant data may be applied to the four primary goals. In essence, it is the study of designing equipment, devices and processes that allow human to interact with technology more effectively and efficiently. The human factors engineer helps the entire development team understand users and their challenges by studying users; collecting data to understand capabilities; by writing functional requirements; and by defining the needs of users. Once development begins, our human factors engineers improve human machine interactions by designing the user interfaces. Throughout the lifecycle of the product, our human factors engineers conduct usability testing to ensure the product does what the users need it to do, and that the product is understandable and easy to use.

Human factors engineering can be applied not only to the development of new or existing systems but also to modeling and simulation (M&S). Our human factors engineers assist with verification and validation through appropriate mission analysis, task analysis, workload/workflow analysis, iterative prototyping, useability testing, user functional requirement development, data collection and analysis, and operational functionality trouble reports.

Our HSI team uses a User-Centered Design (UCD) approach, conducting a series of iterative testing evolutions to evaluate the user interface, using the results of each testing evolution to design and implement usability improvements. UCD involves frequent user interactions to support spiral development of working software to provide more relevant functionality and improved usability with each spiral.

The goal of UCD is to improve usability by eliciting and addressing user needs that are not well-supported, leading to a more intuitive human machine interface (HMI).

Our UCD approach uses agile methods to create and build interactive prototypes tailored to the identified technology advances in program of record (POR) related decision making. The "agile" approach to developing the HMI is to enable an iterative design cycle that supports innovation and focuses on critical focal stages in the decision sequence that enables the POR task domain. The approach is "top-down" defining the task domain and user roles to enable military operations, following the below itemized process:

1. Task Domain Definition: Users, Task Descriptions & Workflows: Identify the users, including producers of planning information and consumers of planning products. Identify and document tasks including inputs, constraints, objectives, and task products. Define workflows through task sequences relative to a mission essential story.

2. Heuristic Review: Review the pre-existing baseline product interfaces with human factors heuristics to identify possible design improvements.

3. Design Trade-Off Analysis: Identify gaps in current processes where tools can aid user performance relative to constraints, existing technology, methods, and algorithms relative to project scope and funding. Select focal tasks (see below) based on priority and need.

4. Create HMI Designs: Design functionality and HMI via decision-aids, visualization, and task-centered sketching tools. Create storyboards with the HMI designs for use in cognitive walk-through exercises.

5. Initial Prototype: Refine initial designs with users and software engineers. Through iterative reviews, finalize paper HMI concepts and define features for software implementation.

6. Usability Testing - Evaluate and Test Design Concepts: Conduct iterative usability testing and review of concepts of software releases in multiple design spirals to improve design quality and ensure usability. Record tests and analyze results. Compute usability rating metrics.

7. Refine Prototype: As usability tests and reviews are evaluated, update prototype HMI to correct usability issues or add additional functional changes to improve performance.

8. Transition to Product: Validated concepts are evaluated for the completed software spiral and incrementally added to the fielded software toolset in software upgrades.

9. Reports and Project Communication: Provide technical reports, monthly progress updates, software incremental releases, and test results as produced according to the project schedule.

The "agile" process includes a Domain Analysis, describing "focal tasks" which are high-payoff work focus areas for mission and user benefit. Focal tasks can be described for the normative system - as performed today, and the formative system - as can be done in the future.

The formative system workflows are designed for work process efficiency and HMI designs created following human factors design principles. As each design cycle increases the prototype fidelity, usability analysis provides design feedback for inclusion into the next software spiral.

The design matures and increases in task support and complexity as more focal tasks are added to the integrated system. "Agile" involves iterative drill-down into task and sub-task details until the project team determines that sufficient detail is gathered to enable software development for each sprint. This approach presents HMI visualizations at each design step to be discussed by end-users, designers, and developers. This provides a team approach to the visualization of system concepts, as opposed to traditional design processes with textual descriptions of requirements. Formal documents can be created later, but the agile innovation approach supports rapid brainstorming and concept development. The wireframes are then reviewed, and HMI format designs are created for an initial low-fidelity wireframe storyboard. The most important key to success is the design process and philosophy for transforming task flows and wireframes into a workable design product, following a design technique called "task-centered" design (TCD).

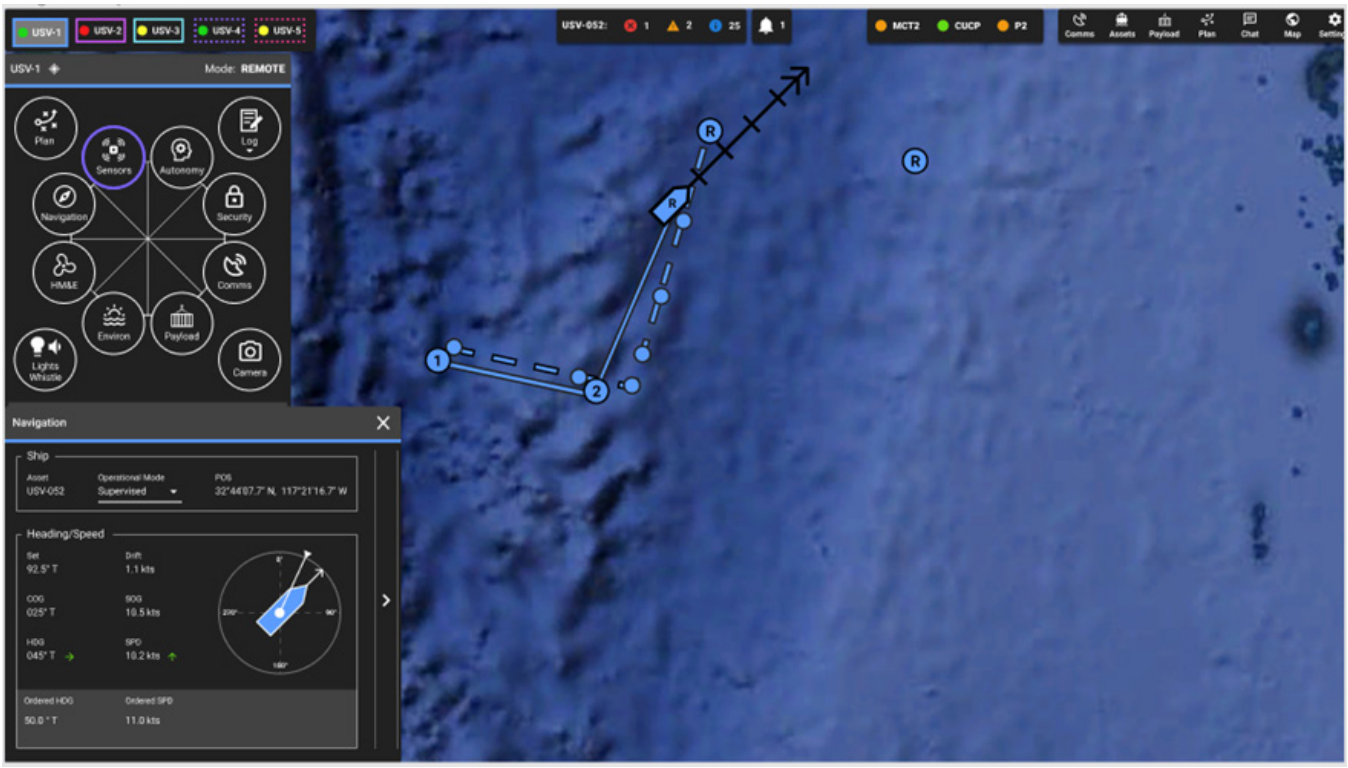

Figure 1. Large Ship Unmanned Surface Vehicle (USV) UI overall layout for routes and navigation.

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In the final phase of agile UCD analysis, the HMI design for each task is then done in the context of TCD in which the user-interface, methods, procedures, and training focus on the impact of the design on user performance. TCD means that task simplicity and efficiency is a core design goal. A task process with one step is more efficient than a design with two steps or two is better than four. Process consistency is also critical as it impacts the ease or difficulty of training. Task guidance, order, and sequencing are also reflected in the user-interface design. Human engineering design principles are applied concerning the quality of feedback and information in a user-system operator and control loop. The primary goal of UCD HMI design is to achieve mission situation awareness, identify mission issues, and enable rapid actions.

UxV Experience

DOLUS Large Unmanned Surface Vehicle (USV) 2017-2021. Naval Information Warfare Center, Pacific (NIWC-PAC) selected MTI to conduct the task analysis and design the UI for the "DOLUS" USV project. The DOLUS project supports a NAVSEA concept demonstration of a large displacement unmanned surface ship, investigating decision support for planning, controlling, and monitoring missions. The DOLUS supervisory control UI provides the ability to plan, monitor, and review USV missions remotely, including hull, mechanical and electrical systems, tactical employment, and navigation. MTI's experience with the capabilities and limitations of USV operations, and the supervisory control of remote USVs provides the contextual understanding required to address future POR system human automation interaction issues. The agile design approach used for DOLUS UI task analysis and design sprints is the framework for program UI development to ensure continuous engagement with knowledgeable users, to keep the development aimed squarely at the user needs.

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