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Human Centered Design Crucial to Unmanned Systems Operator & Mission Success

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ABSTRACT

The use and operation of unmanned systems are becoming more commonplace and as missions gain complexity, our warfighters are demanding increasing levels of system functionality. At the same time, decision making is becoming increasingly data driven and operators must process large amounts of data while also controlling unmanned assets. Factors impacting robotic/unmanned asset control include mission task complexity, line-of-sight/non-line-of-sight operations, simultaneous UxV control, and communication bandwidth availability.

It is critical that any unmanned system requiring human interaction, is designed as a "human-in-the-loop" system from the beginning to ensure that operator cognitive load is minimized and operator effectiveness is optimized. Best practice human factors engineering in the form of human machine interfaces and user-centered design for robotic/unmanned control systems integrated early in platform concept and design phases can significantly impact platform mission success and operator effectiveness with regard to intuitive controls and cognitive load.

INTRODUCTION

Today's war fighter is facing increasing demand to interact with a wide range of unmanned and manned systems to successfully execute a variety of missions within the context of unconventional and urban warfare. The advancement in capability of unmanned systems requires increasing complexity of control systems as increased functionality is required to maintain battlefield superiority through improved C4ISR and force protection which, in turn, destabilizes the enemy. While more complex unmanned systems, whether ground vehicles or air vehicles, provide enhanced mission capability, operators are being taxed with processing more and more data while also maintaining precise control over their unmanned platforms. The resulting increases in cognitive load must be managed by balancing human capability with system requirements.

The use of best practice human factors engineering as a program addresses the cognitive load of the operator as the unmanned system is being developed. Typical systems today require the operator to engage multiple inputs simultaneously. The operator must prioritize and analyze the data, then provide a proper assessment of the situation such that appropriate and timely action is taken effectively. Human factors engineering proactively manages the relationship between the operator and the unmanned system. As the efficiency of the system increases due to the resulting development of intuitive controls, the cognitive load capability of the operator also increases. The operational complexity of missions conducted for modern warfare will require not only interoperability and networking of unmanned systems, but also the simultaneous control of multiple unmanned platforms by a single operator. While current solutions may suffice for 1:1 operator control, increasing demand on the operator will require developers to place as much importance on the human in the loop as on the platform design and development itself.

PROJECT TIMING FACTORS

Human machine interfaces need to be defined as the platform requirements are defined and the development project is initiated. Basic mechanical, visual, environmental, and electronic requirements are crucial to a project's success as simply mapping out inputs and outputs is insufficient. As the cognitive load imposed on the war fighter increases, intuitive placement of control components for quick and intentional actuation becomes even more mission critical. As portable control systems become more the norm to support the warfighter versatility required by unconventional warfare, control systems not only need to offer increased functionality and reliability, but also reductions in the size, weight and power so as not to add to the operator's physical load. While more complex control systems allow the operator to do more with less, they also tax the operator's capability to process and respond accurately and appropriately. By addressing the impact on the operator early in the project life cycle according to both platform capability and CONOPS, the impacts on operator cognitive load can be mitigated for improved mission success in theater.

Late design phase identification of control system deficiencies not only jeopardize mission success, but can add significantly to a system's cost. Failures of this nature can be avoided by managing risks and initiating human factors engineering tests at the outset of the system development. Generating prototype controls and conducting user juries to collect end-user feedback from the potential operator pool, is not only a worthwhile exercise, but a critical one especially for more complex unmanned vehicles and systems. [1] The goal is to provide the most intuitive control solution with the best feel to lower the stress on the operator and improve his ability to effectively and efficiently control the unmanned platform in theater. Implementing human interface trials and testing early in the project will minimize the possibility of lack luster system performance, optimize system and operator capability and further enhance mission success.

As technology advances the operator must make more decisions based on a greater number of inputs than were ever required before. Advances in situational awareness including video of an area under surveillance, input from vibration sensors, infra-red images, and voice input from other operators, along with the evolving need for simultaneous control of multiple unmanned platforms along with their payloads, will render obsolete the typical process of specifying control system as an "afterthought". [2]

LEVERAGING PRIOR HUMAN EXPERIENCE

Given the generally accepted worldwide familiarity with game controls, today's warfighter has typically developed a familiarity with the form factor that can be considered to be almost second nature. As a result, commercially available devices are frequently used as an initial HMI device for robotic control as the platform is developed and functionality is proven out. While the use of gaming style controllers in this way leverages prior human experience, and even expertise, the practice does not lend itself well to implementation of complex, mission critical unmanned operations. However, by leveraging the form factor in a fully ruggedized, customizable design, the skillsets of today's warfighters can be leveraged to minimize cognitive load while also providing the balance with the unmanned system operator requirements. In fact, it has been demonstrated that using the game style form factor is so effective with reducing operator cognitive load, that training times are reduced.

Certain systems today do implement low cost commercial controllers (COTS) in the field. Though generally considered to be successful deployments and sufficient for requirements, the units are considered to be "throw aways", do not meet the demands of the operational environment and are not customizable. Unfortunately the production controller is often the last item considered during the system development and when a COTS controller is used to prove out the platform, operators become accustomed to them and making changes to optimize controls at that point can add excessively to cognitive load. Though the effect is temporary as preferences will often be re-established, maintaining involvement and input from operators throughout the design process eliminates this effect as the control system is constantly evolving to the optimal state through user feedback and environmental testing until the design is frozen.

TECHNOLOGY FACTORS

The cognitive load capability of the operator can be exceeded due to the number of inputs available from the system and/or their mechanical locations. [3] Managing how the inputs are presented to the operator and their configuration can increase or decrease the cognitive capability of the operator. Many studies on cognitive load have been conducted. [4] During testing for cognitive load capability, it was determined that the ease of operation and ability to switch quickly through inputs increases the effectiveness of both the operator and the system. Conversely, testing has also shown that the effectiveness of the operator degrades as cognitive load increases. Pairing these two findings together, the conclusion can be drawn that ease of use through the development of intuitive control systems will reduce operator cognitive load. The layout of the system must be matched to the needs of the operator to reduce fatigue and increase the effective usability of the entire system. As system complexity increases, the need for human centered design in tandem with platform development is critical.

System feedback is another way that operator intuitive control can be effectively managed. When an operator performs a function, he expects a predictable outcome or reaction. When that reaction provides data in and of itself that is easily perceived and understood by the operator, the operator can better manipulate the control system to achieve expected results. An early example of human interface controls providing operator feedback utilized potentiometer based sensing systems. Potentiometer based systems are prone to mechanical wear, accuracy limitations, and high functioning forces. Today, non-contact sensing technologies are available that provide greater control over force feedback in hand controls while also requiring lower break-out and travel forces. Human factors engineering has driven the need for lower force controls to lessen operator fatigue and make it easier for the operator to control the system, especially over prolonged missions. Providing the operator with the best system feel and reducing fatigue, increases the time the operator can use the system, as well as increasing the operator efficiency with the system.

At the same time that operator feedback is being used to reduce cognitive load, another developing area being leveraged is the use of semi-autonomous robots. A pre-guided robot or a robot that can perform routine functions, i.e. turning itself over or climbing stairs, autonomously, requires less frequent interaction and oversight from the operator. As a result, an operator may be left with downtime that could be used to manage additional robots. When a single operator is capable of effectively managing multiple robots or unmanned ground or air vehicles, the upfront mission planning and situational awareness both increase which provides significant benefit with regard to force multiplication and therefore further increases mission success. [4] The use of semi-autonomous unmanned systems result in operator dwell time which provides the capability to process ISR data and to observe other system inputs during an engagement.. Human factors engineering is currently being used to define how the operator can switch back and forth between robots or other devices quickly without detracting from operator effectiveness. [5] Even with the use of semi-autonomous robots, the basic feel and intuitive capability of the controller will aid or detract from total capability of the system depending on how well the control system was specified and integrated with the system requirements.

How many robots or unmanned systems a single operator will be able to control will be determined by the dwell time of individual vehicles as well as by the intuitiveness of the controls with regard to supporting transitions between platforms and or specific unmanned vehicles. It is only a matter of time before operators will be experiencing the full effect of operating more complex unmanned systems in theater. With additional focus on the development of combat unmanned systems, a human operator will always be in control of the weapon and the integrity of the control system will never be more critical. To ensure successful mission outcomes, it is essential that human factors engineering be employed in tandem with unmanned platform development to identify the optimal layout of the operator/system interface, including all component devices and their locations.

CONCLUSION

Implementing the use of human factors engineering maximizes the capability of "human in the loop" systems. Engaging users in the early design stage provides for the efficiency of the human-system interface to be maximized. The advances in technology being leveraged provide the war fighter with the best systems available to maintain battlefield superiority. Human factors engineering provides the best ergonomic and cognitive load solution by matching the capability, both physical and cognitive, of the user with the needs of the system.

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