Next Generation Universal Ground Control System HMI Design

Cory Anderson, Arianna Efaw, Edward Emery, John Mueller, and James Schreiner

United States Military Academy West Point, New York

Corresponding author's Email: Cory.anderson@usma.edu, Arianna.efaw@usma.edu, Edward.emery@usma.edu, John.mueller@usma.edu, James.schreiner@usma.edu

Author Note: The authors would like to thank CPT Scott Zimmerman, Mr. Barry Boike, and Ms. Kristen Regula from Program Management Unmanned Aircraft System (PM UAS) Common Systems Integration (CSI) Product Office, and Mr. Scott Brown at Management Consulting Research (MCR) Federal Product Engineering for their guidance, resourcing, and technical support on the project. We would also like to sincerely thank the 15Ws and the USMA faculty and Cadets who were instrumental in the idea generation and evaluation of next generation designs.

Abstract: The existing Human Machine Interface (HMI) for the Army’s Universal Ground Control Station (UGCS) represents a 1980s, windows-based technology which is neither intuitive nor scalable for operators. It creates high levels of cognitive load on the operators, and its closed architecture limits its adaptability for UAS missions as technologies evolve. This research presents a methodology for creating and evaluating next generation HMI designs while leveraging GNU Image Manipulation Program (GIMP) and TELLUS flight simulation software in the creation of five HMI prototype designs. A proof of concept approach in the evaluation of prototypes was performed with five UAS Aircraft Operators (15W MOS) and five USMA cadets; examination of the impact of age and experience on the perceived value of new HMI designs will influence recommendations on full experimental design. The value-focused approach to design presented in this paper and prototype designs provide a basis for full prototype development and experimental testing through PM UAS with the Intelligence and Maneuver Centers of Excellence. Results include a trade space and sensitivity analysis towards development of improved HMI designs. The methodology and high performing prototypes for HMI design will be integrated by the PM UAS CSI Project Office for further development and full experimental analysis.

Keywords: Universal Ground Control System, Human Machine Interface, Unmanned Aircraft Systems

1. Introduction and Background

The UGCS currently supports two U.S. Army UAS platforms: Shadow and Gray Eagle (SCI, 2016). The fundamental problem for PM UAS is that the command and control software is over twenty years old. The current software is a 1980s and 1990s windows-based design which has been proven less than ideal for command and control of a single Army UAS; there are currently over 1200 different screens and controls that a UGCS operator can manipulate during operation of their UAS (SCI, 2016). An overhaul is currently being conducted to update the software of the system, and in time, the hardware as well. This research is focused on presenting a methodology for the evaluation and design of the next generation UGCS HMI. The implementation goal for the new system, with the current UGCS hardware, is 2021 with an estimated 25-35 year system life cycle for the Army (SCI, 2016).

Research in Human Factors on HMI design characteristics could guide efforts in value modeling and idea generation for this research. PM UAS CSI actively employs subject matter experts in this field early on in the design process. Since PM UAS CSI has not adopted a standard to measure cognitive load or system usability, industry accepted tools could present ways to capture universal attributes to any HMI design. Prior to initial meetings with stakeholders at PM UAS, it was determined in cooperation with professors in the Engineering Psychology Department at USMA that the NASA-TLX test and the System Usability Scale (SUS) would present models of high statistical validity which should be considered for employment in evaluation of the prototypes. The NASA-TLX model measures cognitive load using Likert scale questions on six defined NASA-TLX tasks. For each of the tasks, NASA-TLX produces a value and a weight from which a composite score is generated capturing total cognitive load for the prototype (Hart et al, 1988) (Thomas, 2017); a lower composite score is better. The System Usability Scale (SUS) model measures system usability and ease of use using Likert scale questions and returns one composite score capturing total usability of the system (Brooke, 1996) (Affairs, 2013); a higher composite score is better.

With the current UGCS interface reaching the end of its life cycle, PM UAS’s initial problem was to develop an intuitive, scalable HMI capable of controlling multiple UAS payloads no later than 2021 for the Army (SCI, 2016). An interface