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HUMAN SPACEFLIGHT SYMPOSIUM (B3)
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# NEXT-GENERATION HUMAN EXTRAVEHICULAR SPACEFLIGHT OPERATIONS SUPPORT SYSTEMS DEVELOPMENT

**Abstract**

This paper presents the research, design, and development efforts aimed at advancing the state-of-the-art in human spaceflight operational support systems. Specifically, this research designed and tested next generation software that supports human extravehicular activity (EVA), commonly known as a spacewalk. EVA operations today rely on an extensive team of Earth-based flight controllers who actively monitor and direct EVA progress while maintaining crew and vehicle safety. However, future mission destinations, such as Mars, will impose round-trip communication delays ranging from 8 to 40 minutes. As a result, astronauts will need to rely on local systems to make tactical decisions during execution without Earth-based support personnel. Currently, paper-based products for timeline management and digital displays for tracking spacesuit telemetry represent the state-of-the-art in EVA operational support. To design future systems, we performed a cognitive systems engineering examination of EVA operations to understand the present-day work products and practices. This paper first presents the results of these analyses and in-situ observations to illustrate the content, structure and form of existing EVA support systems. This paper then provides detailed descriptions of the software prototype designs, the process of designing prototypes, and the specific support features resulting from our examination of EVA operations. Two prototypes, (baseline and advanced), have been built and have been tested in a controlled laboratory setting as well as within NASA analog research environments. The prototypes were used by surrogate astronaut crewmembers located within a habitat or vehicle, known as intravehicular (IV) crewmembers, to provide local mission support. The baseline system consists primarily of existing artifacts reconfigured to support the envisioned work demands of a future IV crew, such as tracking and commanding timeline execution and monitoring life support systems. The advanced support system, known as Marvin, adds what the authors envision as next-generation capabilities. Marvin's software architecture and interface leverage open-source application frameworks, namely Electron and Node, that apply website development technologies to the development of desktop applications. The authors were able to harness the rapid prototyping capabilities and broad platform support of modern web technologies to iterate on designs and successfully deploy a high fidelity system to controlled laboratory simulations and NASA analog research sites. The results of this work provide an empirically derived set of design solutions to guide the future of EVA operational support systems for future human spaceflight missions.