Work Envelope Evaluation of Final Frontier Design IVA Spacesuits using Motion and Video Capture

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Overview
To survive in the harsh environment of space, explorers will require humankind's tiniest spaceship: the spacesuit. As many as a half a dozen vehicles taking crew and passengers to suborbital, orbital, deep space, and planetary surface destinations. Most providers are trying to design their systems (for suborbital) to be a shirt-sleeve environment, but safety regulations and approvals may require spacesuits, just as many USA states require helmets on motorcycles.

The ERAU S.U.I.T. Lab
The Spacesuit Utilization of Innovative Technology Laboratory (S.U.I.T. Lab) at Embry-Riddle Aeronautical University (ERAU) is committed to spacesuit education and research, aiding industry in the test and evaluation of suits for the next generation of operators and explorers. The S.U.I.T. Lab has been privileged to have commercial spacesuit developer Final Frontier Design (FFD) collaborate on several pilot studies evaluating range of motion (ROM) and work envelope, primarily for intravehicular activities (IVA). Suited participants on suborbital profiles will nominally be unpressurized, and only pressurized (approx. 3.5 pounds per square inch differential (psid)) in emergency scenarios such as rapid cabin depressurization. In both scenarios, it is critical that the IVA spacesuits do not inhibit critical ROM tasks of reach and operation of controls or reduce human performance.

S.U.I.T. Lab ROM Investigations
The goals of collaborative research with industry is to use three-dimensional data acquired from motion capture to aid with spacesuit design and performance including (but not limited to): suit fit; identifying potential injury points; evaluating mobility changes, i.e. loss of reach capability; finding unique interactions not captured by traditional two-dimensional video capture; cockpit layout criteria; and a physiological inspection of metabolic workload using wearable sensors. This work gives students “gloves-on” experiential learning including task checklist creation, test experience, and data analysis.

Motion and Video Capture
A basic video capture data acquisition trial was conducted with the assistance of FFD, April 2017 (three test configurations in figure below: unsuited; suited and unpressurized; and suited and pressurized to 3.5 psid). The video analysis calculated joint angles for elbow flexion and extension. Students designed the test protocols, a fundamental spaceflight operations activity in verification and validation stages, which will also be needed for TRL evaluations of future spacesuits.

The next incremental test involves motion capture (November 2017 with FFD), investigating seated ROM in the three configurations tested before. Students are preparing the motion capture protocols based on NASA standards and industries that use ROM (medical rehab, gaming, film, and more). Students from ERAU’s new Aerospace Physiology program are working in the S.U.I.T. Lab and inspecting wearable devices for capturing metabolic workloads.

Limitations
More cameras and the advanced OptiTrack Body software would enable more efficient data analysis. The lab is fortunate to have one test per semester, but would greatly benefit from having its own FFD suit on campus for rapid protocol development and providing more suit-time for researchers. External grants and partnerships are being sought to address these limitations.

Next Steps / Conclusions
The S.U.I.T. Lab is designing the motion capture system to be portable so that it can be moved anywhere that requires data collection. The lab would like the opportunity to compare several IVA and EVA spacesuits using this approach to help advance mobility needs for future explorers.