**RESEARCH OVERVIEW**

Embry-Riddle Aeronautical University’s Spacesuit Utilization of Innovative Technology Laboratory (S.U.I.T. Lab) is focused on improving human performance in spaceflight by concentrating on spacesuit research for intravehicular activities (IVA) and extravehicular activities (EVA). The design and execution of range of motion (ROM) protocols in an experimental setting will provide insight on the functions and restrictions of spacesuits, aiding in current and future designs or modification. The S.U.I.T. Lab worked with Final Frontier Design (FFD) to provide a quantitative analysis protocol for seated arm mobility of their NASA Flight Opportunities Program (FOP) IVA spacesuit. The lab used reflective tracking markers on three test subjects and recorded a set of arm ROMs using OptiTrack’s infrared motion capture system including: shoulder abduction/adduction; vertical and horizontal shoulder flexion/extension; and vertical and horizontal full-arm carveouts. All motions were recorded in three spacesuit conditions including: unsuited; suited unpressurized; and suited pressurized (2.5 psid). Motion capture data was edited and filtered for mobility analysis calculations. Programs were developed in MATLAB to analyze and plot angular metrics as well as three-dimensional reach envelopes. These programs allow the spacesuit manufacturer to visualize the mobility of their spacesuit design and associate qualitative mobility characteristics with quantitative results in the form of angular and volumetric data. The percentages of mobility retained between all spacesuit conditions reveal a quantifiable reduction in mobility going from unsuited to suited unpressurized to suited pressurized. Based off the performance of this investigation, FFD gathered preliminary data regarding the mobility of their NASA FOP spacesuit. Improvements to the equipment and protocol used by the lab for motion capture and analysis have been implemented since this study. Expanding from four to nine motion capture cameras, the lab has been able to capture spacesuit mobility data with far greater accuracy and completeness. Updated prescribed motion protocols instruct subjects to maintain straight arms reaching as far as comfortable and across their body in some cases, which is done to characterize shoulder mobility and is not reflective of the spacesuit’s maximum mobility.

**RESULTS**

**Three-Dimensional Range of Motion Analysis**

- Custom Built MATLAB Mobility Processing and Analysis Tools
  - Findpeaks enables automated angular analysis
  - Alphashape creates tight fit for 3D data

**Two-Dimensional Joint Angle Analysis**

- Angular ROM revealed the degradation of shoulder mobility
- Analyzed quantitative mobility data which yielded statistical insights
- Collected 3D data focused on shoulder mobility of the FFD FOP IVA spacesuit
- These procedures can be replicated and updated for future applications in spacesuit design, vehicle layout, human performance and safety analysis

**Conclusions**

- First attempt in developing procedures and data analysis
- Collected 3D data focused on shoulder mobility of the FFD FOP IVA spacesuit
- Analyzed quantitative mobility data which yielded statistical insights
- Angular ROM revealed the degradation of shoulder mobility
- These procedures can be replicated and updated for future applications in spacesuit design, vehicle layout, human performance and safety analysis

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