NASA Telesuit: Designing a Spacesuit Layer for Information Displays with Augmented Reality Environments

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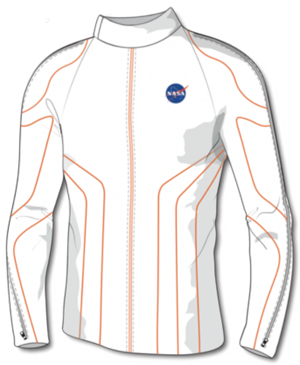
As the spaceflight agenda evolves, the spacesuit must also meet the changing and elevated demands to aid in the successful accomplishment of the missions (Bertrand, Reyes, & Newman, 2016). One such update in progress is the Exploration Extravehicular Activity mobility Unit (xEMU), the next-generation spacesuit which requires a visual display system for lunar activity (NASA, 2020c). NASA is currently pursuing Artemis, landing the first woman and the next man on the Moon by 2024 (NASA, 2020a). Due to this goal, the agency is investing in surface architecture and innovative technology development, and seeks to ensure that crewmembers are properly equipped for the demands of lunar exploration (NASA, 2020c). To assist their crew members, NASA is interested in human-autonomy enabling technologies such as augmented reality (AR) (NASA, 2020c). This tool would enable interfacing with lunar payloads, terrain navigation, science work, and interaction methods. The NASA SUITS (Spacesuit User Interface Technologies for Students) Challenge for 2020 asked student finalists to target key aspects of this mission, so that the agency may draw upon the results (NASA, 2020c). The mission objective was to develop a user interface for a head-mounted display (HMD) in an AR device to assist astronauts with specific tasks by providing vital information and instructions. In order to address these tasks and enhance astronaut performance, the multidisciplinary team decided to design and develop wearable technology to connect to the AR device.

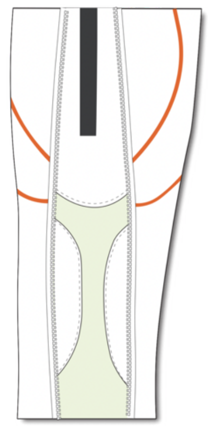
Thus, the purpose of this project was to develop a proof of concept prototype for NASA that gathered biometric data which could be transmitted and displayed on an AR device. Specifically, the study investigated the current areas needing improvement and synthesized these discoveries into a design that focused on the user. Furthermore, as current wearable technology garments that connect to AR are limited, the development of the NASA Telesuit highlights the unique intersection between fashion and robotics.

Using Human-Centered Design (HCD) this process employed historic research, an analysis of current events, qualitative interviews, an analysis of current biometric type garments, industry contact, and mentor feedback for the development of the functional, technical, and aesthetic properties of the garment. First, a base understanding of space garments was gathered through a literature search. This was followed by a visit to the Smithsonian Institute's Air and Space Museum to observe a visual representation of NASA's journey throughout history. The visit, combined with online research led to a color profile, mood board, reference photos, and a greater understanding of NASA as a brand. Then an analysis of current periodicals related to NASA spacesuits was conducted. As NASA has currently put out a call for both female and male astronauts (NASA, 2020b), and as there has been negative press about the suits not being made in small enough sizes (Schwartz, 2019; Talmazan,2019), it was determined that the prototype would be a size small with a unisex design. Then, qualitative interviews took place which included key personal such as an experienced (male) astronaut and NASA's Chief Planetary Scientist. The interviews were conducted over video conference and were facilitated by the NASA SUITS coordinators. The purpose of these interviews was to be able to incorporate feedback from an end user and gain a greater understanding of the considerations needed for the mission objectives. Based on the interviews and the task set, a list of improvement areas and desired capabilities was composed. With these focus areas in mind, further research was conducted to gain insight from current performance enhancing wearable technology and learn how to synthesize the findings and build upon them for the project. This analysis started with the Athos suit, Teslasuit, and Telesuit and helped lead to an industry mentor from Recap Motion (Athos, n.d.;Teslasuit, n.d.; Cardenas et al., 2019; Recap Motion, n.d.). Recap Motion offers wearable motion capture compression garments and is a company that explores innovations in biomechanics, data collection, and analysis (Recap Motion, n.d.). The research resulted in 16 front sketches and 11 back sketches. Crucial feedback was given by Recap Motion and three other mentors whose expertise are in robotics and wearable fashion technology. This input was refined into a final design for the NASA Telesuit which resulted in the development of a proof of concept prototype. For the sake of the project, only a jacket was made. The jacket has a center front zipper and raglan sleeves. The raglan sleeves maximize the length that closed inset zippers are able to extend throughout the arm. These arm zippers conceal and allow clean access to the hardware which consists of polymer-based strain sensors. All the sensors are attached to the base arm layer which is a compression sleeve emulating the pressure of kinesiology tape through a combination of strategically patterned 4 way stretch and a 2 way stretch spandex (Schroeck, 2019). Elastic pockets were placed throughout to allow for further sensor and battery placement.

It should be noted that while the original plan was to evaluate and test the prototype through an onsite visit to the Johnson Space Center in Huston, Texas during April 2020, this date had to be converted to a virtual remote test at a later date, due to the outbreak of COVID-19.



Front Design



Upper Sleeve Detail (Unzipped)

Back Design

Note for Upper Sleeve Detail: The black is the polymer portion of the sensor, the yellow is the fabric with 2 way stretch, and the white is fabric with the 4 way stretch.

This study provides insight regarding critical thinking and spacesuit layer design to help guide designers and manufactures to develop adequate gear that centers around the wearer and not only meets astronauts' unique needs, but actively assists them.

References

Athos. (n.d.). Athos Training System. https://www.liveathos.com/

Bertrand, P., Reyes, S., &Newman, D. (2016). "Pressure and kinematic in-suit sensors: Assessing human-suit interaction for injury risk mitigation," *2016 IEEE Aerospace Conference*, Big Sky, MT, 2016, pp. 1-10.

Cardenas, I. S., Vitullo, K. A., Park, M., Kim, J., Benitez, M., Chen, C., Ohrn-McDaniels, L.. (March, 2019). *Telesuit: An Immersive User-Centric Telepresence Control Suit.* Published in the 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI) 2019. NASA. (2020a). Artemis. https://www.nasa.gov/specials/artemis/

NASA. (2020b, February 11). *Explorers Wanted: NASA to Hire More Artemis Generation Astronauts*. https://www.nasa.gov/press-release/explorers-wanted-nasa-to-hire-more artemis-generation-astronauts

NASA. (2020c) *NASA SUITS*. Microgravity University. https://microgravityuniversity.jsc.nasa.gov/nasasuits.cfm

Recap Motion. (n.d.). Our Reticulated Solution. http://recapmotion.com/

Schroeck, C. A., "A Reticulation of Skin-Applied Strain Sensors for Motion Capture" (2019). *ETD Archive*. 1148. https://engagedscholarship.csuohio.edu/etdarchive/1148

Schwartz, M. S. (2019, March 26). NASA Scraps First All-Female Spacewalk for Want of a Medium-Size Spacesuit. National Public Radio. https://www.npr.org/2019/03/26/706779637/nasa-scraps-first-all-female-spacewalk-for -want-of-a-medium-sized-spacesuit

Talmazan, Y. (March 26, 2019). NASA scraps all-female spacewalk because spacesuit in wrong size. NBCnews. https://www.nbcnews.com/mach/news/nasa-scraps-all-female-spacewalk-because-space-suit-wrong-size-ncna987296

Teslasuit. (n.d.). The Suit. https://teslasuit.io/