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A CRITICAL COMPARATIVE ASSESSMENT OF THE SIZING APPROACH TO SPACESUITS:
CUSTOM VS. MODULAR

Abstract

Since the first pressure suits were developed in the 1930's by Mark Ridge and Wiley Post, the importance of a well-fitting suit has been recognized as a requirement for successfully operating in low-pressure environments, such as high-altitude airplanes and balloons, as well as the vacuum of space. Customized pressure suits were fabricated for crewmembers who flew in the X-15, Mercury, Gemini, Apollo, and Skylab programs. Well-fitting suits are critically important for performing work outside a spacecraft in the vacuum of space, referred to as extravehicular activity (EVA). A well-fitting suit minimizes energy expenditures, optimizes performance (e.g. range of motion), and should be designed to minimize injuries. The EVA suits used during the Apollo program, and especially on the surface of the Moon, were customized to individual crewmembers, with three suits issued to each crewmember: one for flight, one for back-up, and one for training. With the advent of the Space Shuttle Program in 1981, it was decided by program management to fit the new large anthropometric population of both female and male astronauts into five generic sized Hard Upper Torsos (HUT) of the EVA Mobility Unit (EMU) while adjusting the length of the multi-layered fabric arms and legs to the crewmember. The EMU has since had a forty-year history of both successes as well as limitations. Those limitations have included crew shoulder injuries and restricted mobility. Due to budget limitations, five sizes were eventually reduced to three, which subsequently affected the sizes of experienced astronauts available for EVA assignment and reduced the range of new astronauts selected. The new Lunar xEMU is being designed to a "one size fits all" strategy, expanding the anthropometric range of both females and males. However, it is still an open question about whether or not this is possible: can a "one size" HUT with some adjustments still allow maximum performance for all female and male anthropometric sizes? What are the constraints to revisiting customized pressure suits? This paper will review both custom and standard-sized pressure suit approaches and perform a trade study that examines additional factors including launch/storage mass, interfaces to the Portable Life Support System (PLSS), and off-planet supply and repair. A recommendation is presented for a sizing strategy that would be best aligned for future human Design Reference Missions to the Moon (Artemis) and Mars.