

## **Space Wear Vision**

### **-Development of a Wardrobe for Life in Space Vehicles and Habitats-**

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A new vision is needed for the development of a wardrobe for NASA's journey to Mars in the 2030s. All human space missions require significant logistical mass and volume that add an unprecedented burden on long-duration missions beyond low-Earth orbit. The logistical burden is at least twice as great for prolonged exploration and settlements on planetary surfaces compared to missions in low-Earth orbit. The space wear vision is to design apparel that uniquely meets criteria and constraints for sustaining human presence in space. For long duration missions without landing on planetary surface, humans can use only what they carry in their spacecraft, while for settlements, additional resources may be available.

The immediate space wear goal is to develop those elements needed for prolonged manned exploration beyond low Earth orbit. Three major objectives have been identified for achieving this goal: satisfying crew preferences, logistics reduction and repurposing, and systems integration. Garments must be comfortable, durable, safe to wear, and aesthetically pleasing. In addition, with limited cleaning resources, garments must be developed to reduce the logistical burden by reducing clothing mass and extending clothing wear. Furthermore, garments must have minimal impact on the life support systems of spacecraft.

The approach to achieving the immediate space wear goal is to conduct multiple studies on Earth and on the International Space Station (ISS), thus laying out the path for finding materials and designing garments that meet the three objectives of prolonged manned exploration.

Several studies have been undertaken recently for the first time, namely, to ascertain garment length of wear and to assess the acceptance of such extended wear. Most garments in these studies have been exercise T-shirts and shorts, and routine-wear T-shirts. Eleven studies have been completed: five studies of exercise T-shirts, three of exercise shorts, two of routine wear T-shirts, and one of shirts used as sleep-wear. The IVA (Intra Vehicular Activity) Clothing Study has been the first study with Roscosmos under the "Utilization Sharing Plan On-Board ISS," while the other studies have been conducted at the Johnson Space Center in a controlled environment similar to the ISS. For exercise clothing, study participants wore garments during aerobic exercise. For routine wear clothing, study participants wore the T-shirts daily in an office or laboratory. Daily questionnaires collected data on ordinal preferences of nine sensory elements and on reasons for retiring a used garment. More studies have been initiated on Earth, and some should be planned to engage more astronauts and cosmonauts in the design of the new space wear. Future studies will extend to other types of garments in the wardrobe; another will address microbial growth on textiles. Others will address cleaning and sanitation of clothing in space vehicles. Efforts will be made for additional ISS studies with NASA's international partners.

The aggregate of these studies will be crucial to any prolonged manned exploration, while, at the same time, taking advantage of the continuous advances in textile science to engineer clothing to respond to changes to the human body in space.