David Cooper Lecture

From the Outback to the Space Station: Developing Revolutionary Spacesuits with NASA and ESA

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The next generation of spacesuits for use inside and outside the spacecraft may be based on form-fitting elastic skinsuits, and Australia has prominence at many levels. Gas-pressurised spacesuits have created history by enabling humans to walk in space and across the surface of the moon. Despite being effective as a life support system, the suits are a severe hindrance to astronaut function and capability. They are rigid, heavy, bulky, costly, leaky, and require high maintenance due to the complexity of constant volume joints and associated restraint layers. As an alternative technology, skinsuits have been in development since the 1960s and physically compress the body rather than pressurise it with a gas. This design looks promising to satisfy Martian exploration requirements for a light, durable, puncture resistant, low leakage suit with excellent full-body flexibility. More recently a NASA program has concentrated on glove development, based on recent material and tailoring advancements. Advances have also been made towards solving the key constraint to the feasibility of skinsuits: active materials to allow effective donning and doffing. Simulation skinsuits have also been trialled in the Outback and the US with great success through the Mars Society of Australia and the MarsSkin programme, in particular demonstrating the improvement to hand dexterity due to skinsuit gloves compared to gas-pressurised gloves.

Skinsuits may also help reduce some of the severe health problems of astronauts in space, and respond to the call from Space Agencies for new and innovative countermeasures. In particular, bone calcium loss is one of the most important limiting factors for long-term human spaceflight. It is likely that loading regimes that mimic those encountered on Earth will provide benefit during microgravity exposure. Conceived in Australia in 1999, a skinsuit that induces loading on the body to mimic standing on Earth has been evolved by the European Space Agency, MIT, Kings College, Dainese and RMIT. The form-fitting nature of the Gravity Loading Countermeasure Suit (GLCS) allows axial loading to increase gradually from the shoulders to the feet, thereby reproducing the regime normally imparted by gravity. It can also be used to harness the crewmember to exercise devices to produce Earth-like impact loads. As a light, comfortable and easy-to- use multi-purpose countermeasure, the suit can be used to provide a full 1-g on orbit, or adjusted to complete loading to 1-g when worn on the surface of the moon or Mars. The GLCS has been refined and validated through ground and parabolic flight trials, and was deployed in early September 2015 to the International Space Station for operational assessment, where it was worn by Danish astronaut Andreas Mogensen.