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Young Australian Aerospace Engineer shows NASA the Future of Space Suits

- Mars Society of Australia member Dr. James Waldie, 32, a Postdoctoral Scholar at prestigious Massachusetts Institute of Technology (MIT)
- Working on several of his own innovative spacesuit projects for NASA and European Space Agency (ESA)
- Recently flew his Gravity Loading Suit on the 'Vomit Comet' aircraft, which simulates weightlessness. NASA believes his suit "could be a tremendous breakthrough in solving one of the fundamental problems of long-duration space flight".
- Another project bridges science fiction and reality by investigating skinsuits as spacesuits on Mars.
- Also called in by NASA to help with astronaut injury study at Johnson Space Center in Houston

Dr. James Waldie, 32, is currently living out his dream and developing a range of next generation spacesuits for NASA. Waldie, who obtained his PhD from RMIT, is currently a Postdoctoral Scholar at arguably the most prestigious technological university in the world: the Massachusetts Institute of Technology (MIT) in Boston, USA. This role has allowed him to continue work on his spacesuit concepts, but also to explore new innovations through the supervision of MIT graduate students.

Waldie's main project is a gravity loading skinsuit to be worn by astronauts when they are inside the spacecraft or habitat. He came up with the concept almost 10 years ago, and it is proving to be a promising new countermeasure to the extreme bone loss suffered by astronauts – one of the major concerns of NASA for future missions. Waldie: "On Earth, our bones are strong to support and move our body mass. In space, astronauts are just floating around without any weight or loading, so their body adapts by allowing their bones to atrophy to a much lower strength. It's like an extreme version of osteoporosis."

MIT Professor Jeff Hoffman, of the department of Aeronautics and Astronautics, knows how important the problem is: he was a NASA astronaut for almost 20 years, flew on the shuttle 5 times, and is seconded to MIT from NASA. Hoffman says "Waldie's gravity-loading suit addresses a long-standing astronaut health problem: how to keep the body's musculo-skeletal system healthy without the pull of gravity that we experience on the Earth." Standing on earth, the body would normally experience a gradual increase in weight or load from head to feet: for example the shoulders support your head and arms, the hips support only the upper body, and the feet support the entire bodyweight. Hoffman continues: "This new elastic gravity-loading suit uses an innovative technique to create greater load in the lower body than in the upper body, mimicking the effect of gravity. This gradual load may be especially important in allowing astronauts' exercise routines to stimulate the musculo-skeletal system in a way more like exercise does on Earth, hopefully reducing the muscle deterioration and bone calcium loss that occur during long-duration space flight."

To test the comfort, mobility and material properties of his suit, Waldie recently flew on a zero-gravity or 'vomit comet' aircraft that provides brief periods of true weightlessness. Waldie: "The aircraft flies up and down in a continuous wave between about 24 and 32 thousand feet. As it dives over the crest and downwards, it is flying toward earth at the same rate as the air and passengers inside are falling – this is when you feel about 10 seconds of weightlessness. The aircraft then pulls heavily out of the dive, regains altitude, and pitches over for another go. Luckily, I didn't get sick!" The flight tests proved a huge success for Waldie, who is building more suit prototypes for research later this year. Hoffman: "More research and

testing is necessary to understand whether the promise of this gravity-loading suit can be realized, but this could be a tremendous breakthrough in solving one of the fundamental problems of long-duration space flight." The European Space Agency (ESA) also agree, and are co-sponsoring his research.

Most of Waldie's research, however, has been on skinsuits to support life outside (rather than inside) the spacecraft, during spacewalks on Mars. "The current spacesuits are big body-shaped balloons – they let you take a bit of the atmosphere around with you when you go for a spacewalk. They are a marvel of engineering, but because they are an inflatable they become bulky and rigid in space. A tear in the suit can also mean a catastrophic full body depressurisation. Skinsuits have a gas-pressurised helmet for breathing, but compress the rest of the body with form-fitting elastic garments. They are much lighter and more flexible, and a tear would only give you bruising in the torn area." Waldie has studied the physiological properties of skinsuits, and the necessary material properties to develop the required compression on the body. He has also studied the flexibility advantages of the suits by conducting simulated spacewalking tasks in the Australian Outback with the Mars Society of Australia. "We had dozens of people trying sample spacewalking tasks with their bare hands, with skinsuit gloves, and with gas-pressurised gloves. We found that tasks took 1.5 times longer with the skinsuit gloves, but up to 6 times longer with the gas-pressurised gloves. It clearly showed the mobility and tactility benefits of skinsuits." The major barrier to having skinsuits accepted as a viable alternative to the traditional gas suits is problems getting them on and off (donning and doffing), because they are so tight. He is currently developing a new donning method via an exoskeleton of pressurised tubes, which could bring skinsuits from the pages of science fiction to reality. "Future explorers of Mars will require highly robust, light and flexible suits for years of use, which are a significant improvement over the Apollo suits. Skinsuits may be able to offer that technological leap."

NASA recently called Waldie to help study glove injuries astronauts at the Johnson Space Center (JSC) in Houston. Astronauts need to adjust their rigid, bulky gloves to be as tight-fitting as possible on spacewalks, but their fingers become highly fatigued and rub inside the glove, causing many problems, the worst of which is fingernail delaminations from the nail bed. Despite trying sizing readjustments, bandages, topical treatments, severe cutting of nails and other approaches, the problem is still so bad an astronaut removed his fingernails before flight so there wouldn't be any problems during the spacewalk. "We are studying blood flow and contact forces on the fingers inside the current spacesuit glove in a chamber at JSC to simulate the conditions in space. So far we have found that pressure on the fingerpads used to flex the glove causes a bigger decrease in blood flow than pressure directly on the fingertip and nail." Back at the lab at MIT, Waldie and a student are trying some new ways to reduce the stiffness of gas-pressurised suits. If they succeed, not only will future gas suits be more flexible, but the JSC study indicates this may reduce the number of hand injuries as well. Whether it is gas-pressurised or skintight spacesuits, for use inside or outside the spacecraft, Waldie hopes to play a big role in the future manned exploration of space.

Waldie on MIT: "MIT has a staggering history and reputation, particularly in manned spaceflight. Four of the twelve Apollo astronauts who walked on the Moon are MIT alumni, and MIT also developed the guidance and navigation systems that took them there and landed them on the surface. Since then, rarely has a NASA mission flown without a graduate from MIT. No other institute has had more alumni selected as astronauts, except for the military colleges. During the recent Apollo 40th anniversary celebration at MIT, I had the chance to meet both Neil Armstrong and Buzz Aldrin (MIT ScD '63). That night, MIT organised a concert of Holst's 'The Planets', played by the Boston Pops and narrated by Buzz. It looks like a normal university when you walk around, but there is always something special going on behind the walls. This is a truly astonishing place."

Despite the absence of an Australian Space Agency, Waldie has been active in suit research in his home country primarily through the Mars Society of Australia, which he joined in 2001 to become the Project Manager of MarsSkin. The MarsSkin project aims to design, produce and test analogue skinsuits which will behave in a near identical fashion to how real suits of the future will behave on Mars. The MarsSkin suits are worn during simulated spacewalks, and allow the researchers to leave the mockup Mars habitats through airlocks and walk around the desert just as if they were walking on Mars. This research helped Waldie obtain his PhD from RMIT, and resulted in the deployment of several versions of MarsSkin suits at mock habitats in Australia, Europe and the US. He also developed highly successful spacesuits for students at the Victorian Space Science Education Centre (at Strathmore Primary School), which are worn daily to inspire Australian youth about science and space exploration.

James Waldie can be reached at MIT at jwaldie@mit.edu.

Waldie in his gravity loading skinsuit floating to the ceiling during his flight on the ‘vomit comet’.