INMPROVED BUBBLE DETECTION FOR EVA

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INTRODUCTION
This project develops and validates dual frequency ultrasound for detecting and sizing bubbles. Assembly of the International Space Station (ISS) and lunar exploration require extensive and unprecedented extra-vehicular activity. Current spacecraft and suit designs force astronauts to move between different pressure environments, making decompression sickness (DCS) a potential risk. DCS risk mitigation strategies reduce operational efficiency. The objective of this effort is to improve EVA efficiency and safety by developing and validating new bubble detection technology using dual frequency ultrasound. Over the past year, our major development has been to demonstrate that dual frequency ultrasound can be used to detect stationary microbubbles in tissue.

RECENT RESULTS
Dual-frequency ultrasound bubble detection exploits the fact that resonating bubbles act as nonlinear mixers. Bubbles are driven with two frequencies: a lower “pump” (set to the resonant frequency of the desired bubble size) and a higher “image” frequency. A bubble of the resonant size emits the sum and difference of the two transmitted frequencies. A stationary, lipid-encapsulated microbubble ultrasound contrast agent (Definity®) was used as the bubble model. Solid polymer microspheres (SPM) were used to emulate non-gaseous (non-resonant) particles. Five solutions were placed in latex gloves: saline, 1/1000 dilution of SPM, 1/1000, 1/10000, and 1/1000000 dilutions of Definity®. The gloves were imaged using pump and image frequencies of 2.25 and 5.0 MHz respectively. The same solutions, as well as a pure Definity® solution, were injected into the thigh of an anesthetized swine. In the gloves, a difference signal of 2.75 MHz was detected for Definity® dilutions of 1/1000 and 1/10000. No difference signal was detected for any of the other solutions. In tissue, no difference signal was detected at any site prior to injection. After injection, a difference signal was detected at the 1/1000 Definity dilution and pure Definity injection sites. No difference signal was detected at the other sites.

CONCLUSIONS
This is the first demonstration that stationary microbubbles can be detected in tissue using dual frequency ultrasound. It has been hypothesized that microbubbles may exist normally in tissue and that the growth of these microbubbles during decompression is the cause of many DCS symptoms such as joint pain. We are proceeding to use dual frequency ultrasound to monitor microbubbles in tissue following decompression stress. This could eventually lead to a new understanding of the mechanics of bubble formation during decompression and DCS onset.