Active Project (2015 - 2015)

Full Body Loading for Small Exercise Devices Project

Center Independent Research & Developments: JSC IRAD Program | Mission Support Directorate (MSD)

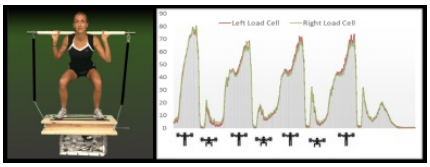

Figure 5. Human in the loop squat exercise with resulting load data using the Prototype Version 2 Full Body Loading Device attached to a pre-existing small exercise device

ABSTRACT

Protecting astronauts' spine, hip, and lower body musculoskeletal strength will be critical to safely and efficiently perform physically demanding vehicle egress, exploration, and habitat building activities necessary to expand human presence in the solar system. Functionally limiting decrements in musculoskeletal health are likely during Mars proving-ground and Earth-independent missions given extended transit times and the vehicle limitations for exercise devices (low-mass, small volume). Most small exercise device concepts are designed with single-cable loading, which inhibits the ability to perform full body exercises requiring two-point loading at the shoulders. Shoulder loading is critical to protect spine, hip, and lower body musculoskeletal strength. We propose a novel low-mass, low-maintenance, and rapid deploy pulley-based system that can attach to a single-cable small exercise device to enable two-point loading at the shoulders. This attachment could protect astronauts' health and save cost, space, and energy during all phases of the Journey to Mars.

ANTICIPATED BENEFITS

To NASA funded missions:

The MPCV-AEC29 states that the exercise device shall allow squat, deadlift, and heel raise exercises with proper body positioning. The proposed pulley-based system addresses SK and ER gaps by optimizing spine, hip, and lower-body musculoskeletal loading and improving the robustness of current small exercise device designs with little added volume, mass, and cost, respectively.

To NASA unfunded & planned missions:

Functionally limiting decrements in musculoskeletal health are likely during Evolvable Mars Campaign Missions given extended

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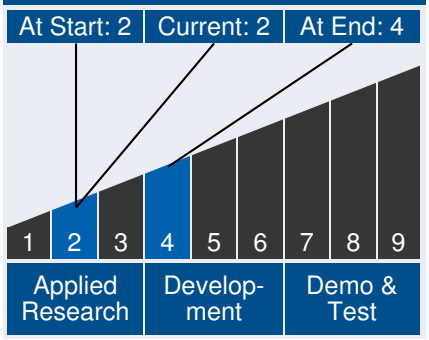
Technology Maturity



Management Team

Program Director:

- Douglas Terrier

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DETAILED DESCRIPTION

Mars proving-ground and Earth-independent missions will be 1-3 years in length. Significant and functionally limiting decrements in musculoskeletal health will occur without effective resistance exercise capabilities. Protecting musculoskeletal health maintains astronauts' capabilities to perform critical mission tasks, and is therefore fundamentally important to expand human presence into the solar system and to the surface of Mars. A Mars technology challenge for maintaining healthy astronauts and HAT Need Performance Target calls for optimized exercise equipment that is low-mass, rapid-deploy, and low-maintenance. Further, the MPCV-AEC29 states that the exercise device shall allow squat, deadlift, and heel raise exercises with proper body positioning. The proposed pulley-based system addresses SK and ER gaps by optimizing spine, hip, and lower-body musculoskeletal loading and improving the robustness of current small exercise device designs with little added volume, mass, and cost, respectively. This technology could also be used in bed-ridden patients who cannot use traditional exercise equipment.

The proposed hardware will be optimized for Earth-independent exploration. The hardware design will be based on previous technology developed for loading during vertical treadmill running. Key design objectives include small volume, adaptability to evolving small exercise device concepts, and support loads up to 400 lbs during dynamic movements. COTS products will be used to build the prototype. The hardware will

Management Team *(cont.)*

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Technology Areas

Primary Technology Area:
Human Health and Performance (TA 6.3)

Secondary Technology Area:
Human Health, Life Support, and Habitation Systems (TA 6)

undergo rigorous fit and function testing evaluations in stand-alone configuration and while paired with an existing small exercise device.

The product of this effort will be a novel prototype hardware device that allows for loading at the shoulders during squat and other full-body exercises using single-cable small exercise devices. Additional products will include a final report, poster presentation, and JTWG out-briefing that detail the innovative design and potential physiological benefits to astronauts as well as bed-ridden patients.

Following successful design, fabrication, and testing, this novel device was shared with teams developing and testing small exercise devices at JSC and Glenn Research Center with potential for inclusion in further evaluation efforts such as iExercise biomechanical modeling. Additional funding was sought and secured via IR&D for further device development and biomechanical evaluations to understand the potential musculoskeletal benefits of using the proposed device with a pre-existing small single-cable exercise device. ISS and HRP funding will also be targeted for ground and on-orbit testing of the proposed device with candidate small exercise devices.

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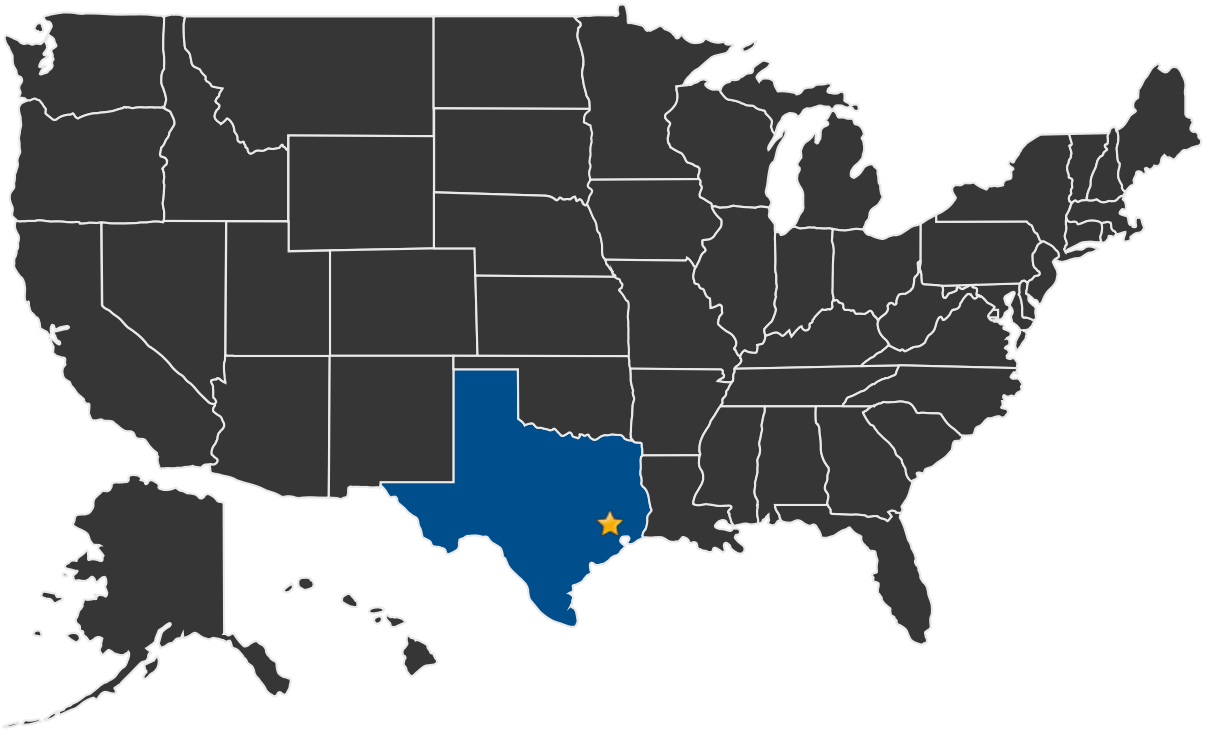
U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Johnson Space Center

Other Organizations Performing Work:

- Wyle Laboratories, Inc.

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IMAGE GALLERY

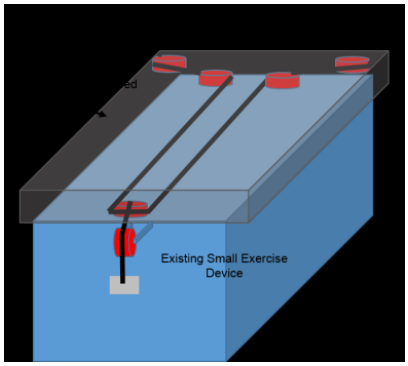

Figure 1. The pulley-based system allows for a single cable exercise device to be used for exercise that require a dual cable loading system such as squats with loading at the shoulders.

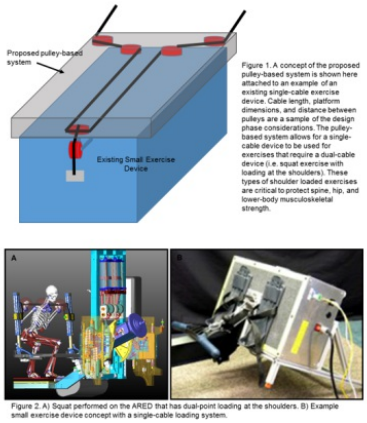

Figure 2. Pulley-based system for use with single cable exercise devices to allow dual point loading at the shoulders.

Figure 3. The first version of the full body loading protoype device attached to a pre-existing small exercise device. The full body loading device allowed for performance of shoulder loading exercises with high loading.

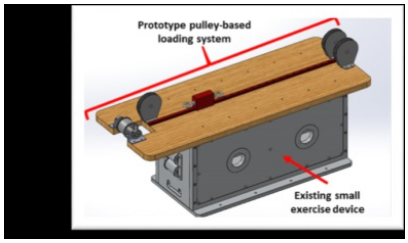

Figure 4. Protoype Version 2 of the Full Body Loading Device maintains the ability to perform shuoulder loading exercises with design improvements that decrease the friction in the system to provide a smooth and evenly distributed load.

DETAILS FOR TECHNOLOGY 1

Technology Title

Pulley based hardware to allow dual point loading with a single cable

Technology Description

This technology is categorized as a hardware component or part for other applications

The proposed technology is a novel low-mass, low-maintenance, and rapid deploy pulley-based system that can attach to a single-cable small exercise device to enable two-point loading at the shoulders.

Capabilities Provided

The proposed technology will help astronauts maintain muscoloskeletal health while confined to small transfer vehicles during long duration spaceflight missions to Earth independent locations. This pulley based system will allow astronauts to perform resistance exercise with loading at the shoulders using single cable exercise devices (Figure 5). Loading at the shoulders while performing resistance exercise is critical to protect spine, hip, and lower-body musculoskeletal health (Figure 2).

The resulting technology development led to the design and fabrication of two versions of the prototype full body loading device (Figure 1&3). Version 1 (Figure 3) successfully allowed for the capability to perform full body loading exercises (i.e. squat); however, the team quickly realized the friction in the system could be reduced and loading quality could be improved with fewer pulleys. Subsequently, Prototype Version 2 was designed, fabricated, and tested (Figures 4&5). Version 2 testing resulted in much improved load quality and Human-in-the-loop testing showed a typical loading pattern for squat exercise with even load distribution on both sides of the shoulders (Figure 5), which is critical for safe and effective exercise performance.

Potential Applications

In addition to the benefits to NASA and spacelfight, this technology could also be used in bed-ridden patients or in any confined space environment (i.e. submarines) where traditional exercise equipment cannot be used.