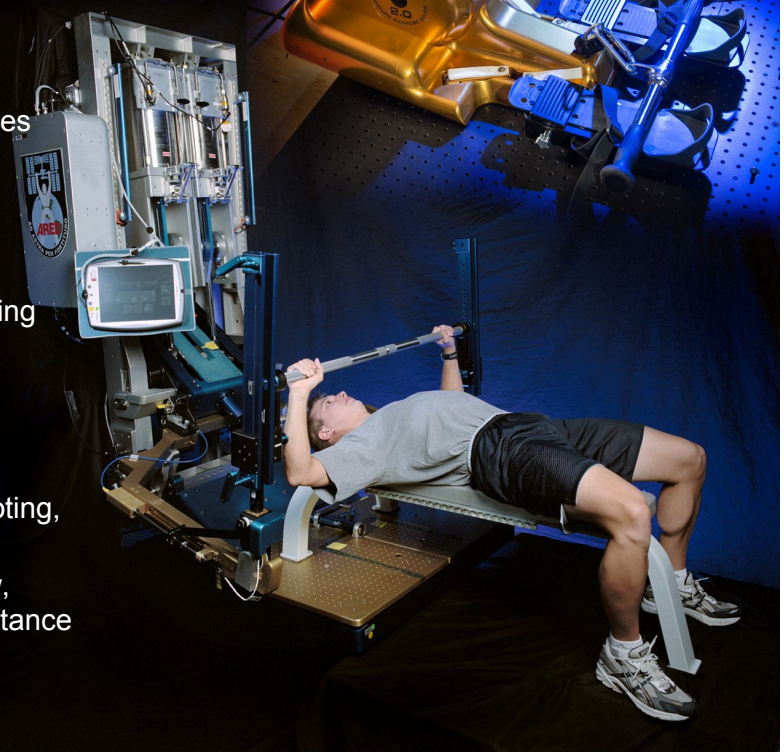
National Aeronautics and
Space Administration

Crew Exercise

Johnson Space Center (JSC) provides research, engineering, development, integration, and testing of hardware and software technologies for exercise systems applications in support of human spaceflight. This includes sustaining the current suite of on-orbit exercise devices by reducing maintenance, addressing obsolescence, and increasing reliability through creative engineering solutions. Advanced exercise systems technology development efforts focus on the sustainment of crew's physical condition beyond Low Earth Orbit for extended mission durations with significantly reduced mass, volume, and power consumption when compared to the ISS.



Services Provided

- Systems Engineering
  - Functional architecture definition
  - Concept of operations
  - Development and management of requirements and interfaces
  - Design integrations
  - Verification and validation
  - Flight certification
- On-Orbit Systems Management
  - Treadmill (T2)
  - Recumbent bike (CEVIS)
  - Resistive exercise (ARED)
  - Health monitoring (HRM)
- Design and Testing
  - Design and development of human health interfaces
  - Reduced gravity testing in the Active Response Gravity Offload System (ARGOS)
  - Digital Astronaut (DAS) – Advanced human and machine simulation to test and evaluate new exercise effectiveness during design and prototyping
  - Computer controlled exercise devices that can be tailored to a variety of loading profiles
  - Zero gravity countermeasure systems: aerobic and resistive exercise devices
  - Flight Systems anomaly investigation, troubleshooting, and resolution
  - Integrated exercise software, ease of use for crew, improved data collection, and virtual training assistance

http://er.jsc.nasa.gov/ER3/

Exercise Technology Development

We offer expertise in research and development, staying current on the latest technology advances to continuously evolve innovative exercise capabilities for long duration exploration-class vehicles and habitats.

- Improves reliability and modularity to minimize sparing logistics and crew time required for maintenance
- Has intuitive operational interfaces
- Integrates multiple exercise modalities and other exercise benefits (e.g., sensorimotor, monitoring)
- Integrates other non-exercise functions where appropriate (e.g., augmentation, rehabilitation)
- Integrates (collects and adjusts) exercise prescriptions based on sensor data

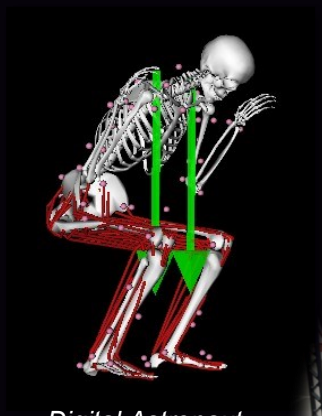
New Technology Pursuits

- Miniature Exercise Device (MED) – Compact motorized exercise device providing both resistive and aerobic exercise capability
- Hopper – Configurable multi-exercise device providing variable eccentric and concentric loading
- Force Shoes – Advanced exercise load measuring concept
- Portable Knee Dynamometer

Hopper

Next Generation Crew Exercise Software

We offer expertise in the development of the next generation of crew exercise (One Portal) software, a comprehensive system that incorporates Bluetooth technology, sensors, and biometric data with an easy to use app-like interface. This system reduces crew training, provides an integrated dashboard, a virtual training assistant, and integrates new instructional, motivational, and socialization techniques (including the incorporation of virtual reality environments) into a crew's health and conditioning program.



Digital Astronaut

Zero Gravity Testing

Force Shoe

One Portal SW

We have developed customer-friendly agreements to streamline business relationships and are eager to share our unique facilities and expertise with new customers. We invite your inquiries regarding application or adaptation of our capabilities to satisfy your special requirements. Briefings on general or specific subjects of mutual interest can be arranged at JSC or at your business site.

For More Information
http://er.jsc.nasa.gov/ER3/

Point of Contact
Phillip Callen ● (281) 483-8087 ● phillip.s.callen@nasa.gov
JSC Engineering Directorate ● Software Robotics & Simulation Division ● Flight Systems Branch Chief

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MED and Exploration Exercise

Our Vision

Leverage experience and technology to create intuitive, engaging, intelligent human-machine systems that are critical to optimizing human health during exploration missions beyond Earth.

Our Mission

Create and manage unprecedented human-machine systems with performance-enhancing experiences that are effective, immersive, captivating and reliable using technology, science and art. Evaluate, leverage, and integrate emerging sensor technologies and intelligent systems to enhance biofeedback and overall human health. Develop and retain team members, collaborators, customers, and end users who are valuable, loyal and enthusiastic.

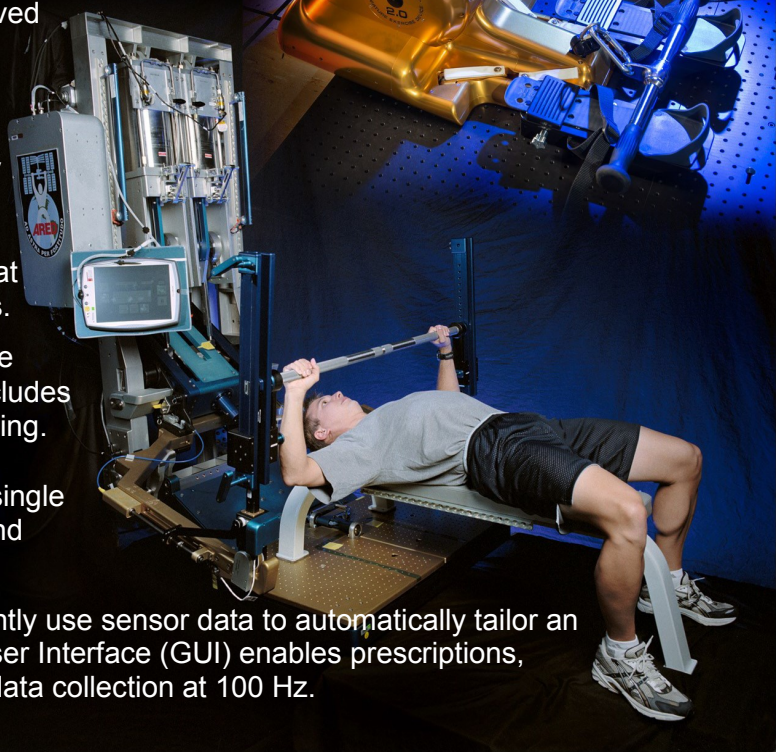
Miniature Exercise Device (MED)

Our team has a long history of developing, certifying, and sustaining the exercise system that has been critical to the success of human spaceflight missions and health of the crewmembers, including the following International Space Station (ISS) equipment.

- Resistive exercise (ARED)
- Treadmill (TVIS, T2)
- Recumbent bike (CEVIS)
- Health monitoring (HRM, BP/ECG)

However, to enable exploration missions beyond Low-Earth Orbit, the exercise system is being completely reconceived to have a significantly reduced mass and volume while improving effectiveness.

The MED is a portable 65-pound device that has been developed with these objectives in mind and is currently being evaluated on ISS. This single device integrates resistive exercise, aerobic rowing, and potentially bicycling. It will be a next-generational leap beyond what is currently found in fitness centers and training facilities.



Unlike traditional exercise capabilities, the loading profile provided by the MED is programmable and currently includes constant loading, inertial loading and eccentric overloading. The next step is to develop loading profile flexibility that allows user-specific tailored dynamic variation within a single repetition that could further enhance strength training and rehabilitation effectiveness.

The subsequent goal is to enable the device to intelligently use sensor data to automatically tailor an individual's loading profile. Our OnePortal Graphical User Interface (GUI) enables prescriptions, real-time adjustments, sensor display to the crew, and data collection at 100 Hz.

Exercise Technology Development

Through projects like MED and the future PHNX (Physiology-based Human-machine Nextgen eXercise) system, JSC (ER3) is developing the next vision of biofeedback integration in exercise:

- Improving reliability and modularity to logistics and maintenance means more time training with less overhead.
- Providing intuitive operational interfaces that humanize data allowing the athlete/operator and the system to make real time training decisions that promote changes to psychological architecture and enhance physiological adaptations.
- Integrating multiple exercise modalities, including difficult to train accessory elements (e.g. sensorimotor, monitoring), yield a more explorative training environment not limited to single plane movement or the confines of a gym space.
- Integrating augmentation, rehabilitation, etc. into the system framework to track changes to tissue loading, posture, movement patterns, etc. to help recover from injury or act as a proactive filter for future insults to physiology.
- Collecting and adjusting exercise prescriptions based on sensor data to create a fully, biofeedback oriented system making live modifications to motor loading/controls based on current and intended states of the athlete/operator. A smart system that takes in the data from the other 20+ hours you are not training and fuses it with the time under strain.

Next Generation Crew Exercise Software

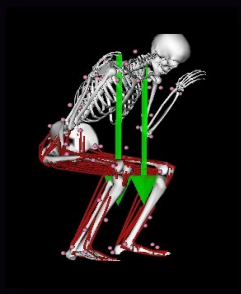
Data should not be a burden to a user; it should be provocative, detailed, and easily accessible. We have collaborated with multiple research groups developing a cross-platform architecture via OnePortal; an integrated exercise software, providing ease of use, improved data collection, and virtual training assistance that:

- Allows computer-controlled exercise devices to be tailored to a variety of loading profiles that include not only known effective modalities like eccentric overloading, but also produce profiles that cannot exist in the gym.
- Utilizes Bluetooth technology for sensor connection, response, command, and control of biometric data so that current and future wearable technologies will always be supported.
- Will include a virtual training assistant using real time motion capture technology that maps major body points and provides active coaching, follow-up critique, and pattern identification useful in injury prediction or rehabilitation.
- Supports exercise socialization technology to instruct, motivate, and immerse the user via virtual/augmented reality.

The Future of Exercise

Taking the next step in developing crew exercise equipment is not only about the six humans in space today, but it is about the success of future exploration and the seven billion people here on Earth. To have the largest impact, thinking one step forward is not appropriate methodology… we need to think a large leap into the future:

- Fully integrated exo-suit development technologies would allow for a human to train unique loading and conditioning profiles currently unavailable in multi-directional training and real-world exposure environments.
- Development of deep neural network, intelligent learning algorithms to define the relationships of human physiology on a level that supersedes the boundaries of individual discipline expertise; being able to analyze, predict, and proactively provide for users to maximize health and human performance
- Integrating an active vibration and isolation system (that minimizes load transfer) into virtual/augmented realities to enhance psychological, memory/learning, & experiential training to supplement physically-biased workout paradigms.



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