Human Physiology and Adaptation Research

ISS Facilities support an array of scientific investigations concerning human physiology, adaptation and the health of crewmembers. All facilities in this section support investigations that directly employ human subjects as the focus of the experiment. Much of the hardware serves the dual purpose of maintaining or assessing crewmembers' health as well as equipment capable of supporting scientific research.

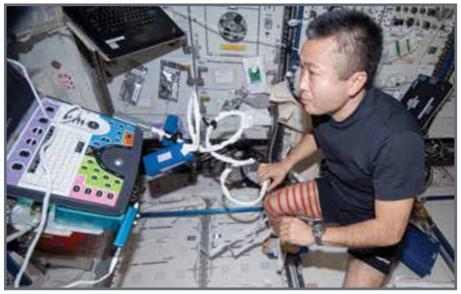
This section provides overviews and highlights with regard to facilities that can support research into human physiology and space adaptation presently available onboard the ISS:

- Advanced Resistive Exercise Device (ARED) [NASA]
- Cycle Ergometer with Vibration Isolation System (CEVIS) [NASA]
- Combined Operational Load Bearing External Resistive Exercise Treadmill (COLBERT) [NASA]
- ELITE S2 [NASA, ASI]
- Human Life Research Complex [Roscosmos]
- Human Research Facility (HRF-1 and HRF-2) [NASA]
- Intra-Vehicular Tissue Equivalent Proportional Counter (IV-TEPC) [NASA]
- Measuring Radiation Hazards in Space (Matryoshka) [Roscosmos, ESA, JAXA]
- Muscle Atrophy Research Exercise System (MARES) [ESA]
- Onboard Diagnostic Kit (ODK) [JAXA]
- PAssive Dosimeter for Lifescience Experiments in Space (PADLES) [JAXA]
- Percutaneous Electrical Muscle Stimulator (PEMS) [ESA]

Muscle Atrophy Research Exercise System (MARES) [ESA] is used for research on musculoskeletal, biomechanical and neuromuscular human physiology to better understand the effects of microgravity on these related systems. This instrument is capable of assessing the strength of isolated muscle groups around joints by controlling and measuring relationships between position/velocity and torque/force as a function of time.

CSA astronaut Chris Hadfield and NASA astronaut Tom Marshburn work with MARES hardware (ISS034E014618).

Human Research Facility (HRF-1 and HRF-2) [NASA] enables human life science researchers to study and evaluate the physiological, behavioral and chemical changes induced by long-duration spaceflight. **HRF-1** and **HRF-2** are ISS racks that contain a range of hardware as well as infrastructure to allow for remote commanding, data storage and uplink/downlink capability to support human research. Included in the suite of hardware is the **Refrigerated Centrifuge [NASA], Ultrasound 2 [NASA], Space Linear Acceleration Mass Measurement Device (SLAMMD) [NASA], Cerebral Cochlear Fluid Pressure Analyzer (CCFP) [NASA], Distortion Product Otoacoustic Emissions (DPOAE) [NASA], Holter Monitor 2 (HM2) [NASA], Actiwatch Spectrum System [NASA]** and the **Pulmonary Function System (PFS) [ESA, NASA]**.



ISS crewmember Koichi Wakata performing an Ultrasound Scan for the Sprint investigation using the HRF Ultrasound2 (ISS038E007119).

Techniques developed for using ultrasound technology on the ISS are now being used in trauma facilities to more rapidly assess serious patient injuries.

Advanced Resistive Exercise Device (ARED) [NASA] provides resistive exercise capabilities to crewmembers on the ISS. The **ARED** also collects data regarding the parameters (loads, repetitions, stroke, etc.) associated with crew exercise, and transmits it to the ground.

ISS crewmember Dan Burbank exercises using the ARED) in the Tranquility node of the ISS (ISS030E012688).

Combined Operational Load Bearing External Resistive Exercise Treadmill (COLBERT) [NASA] is an exercise treadmill that can be used to collect data such as body loading, duration of session, and speed for each crewmember.

ISS crewmember Mikhail Kornienko uses the COLBERT on the ISS for the Roscosmos Great Start investigation (ISS045E028084).

ISS crewmember Barry Wilmore exercising on the CEVIS in the Destiny U.S. Laboratory (ISS042E016676).

The **Cycle Ergometer with Vibration Isolation System (CEVIS) [NASA]** is a structurally isolated aerobic exercise cycle that serves as a countermeasure to cardiovascular deconditioning on orbit.

Crew health care hardware used for daily exercise onboard the ISS collects information on protocols and forces that are used as supplemental data for physiological studies including muscle and bone loss and cardiovascular health during long-duration spaceflight.

Human Physiology and Adaptation Research

Measuring Radiation Hazards in Space (Matryoshka) [Roscosmos, ESA, JAXA] consists of a spherical phantom (Matryoshka-R) that is used to measure radiation doses experienced by astronauts at various locations both outside and inside the ISS. Matryoshka-R represents a human body radiation equivalent and is filled with water and a series of passive radiation detectors that measure radiation entering the spherical phantom. Research institutes from around the world have collaborated and shared data from the project, and the results will allow researchers to better correlate between skin and organ dose and therefore provide better risk assessments for future long-duration spaceflight.

Cosmonaut Elena Serova is photographed during Phantom setup for the Matryoshka-R experiment (ISS042E207594).

Participants from 10 countries provided dosimeters and other components of **Matryoshka**, making it one of the most interesting collaborative investigations on the ISS. This program started in 2004 and continues under Russian leadership today.

Human Life Research Complex [Roscosmos] includes a variety of devices and systems designed to study human life in space. Components include the Cardiovascular System Research Rack, Weightlessness Adaptation Study Kit, Immune System Study Kit, and Locomotor System Study Facility.

Cardiovascular Research System

Weightless Adaptation

Locomotor System

The **PAssive Dosimeter for Lifescience Experiments in Space (PADLES) [JAXA]** contains the following set of hardware for assessing the space radiation environment: Area **PADLES** are used to monitor radiation at prescribed locations inside the Kibo module, Bio **PADLES** assesses the biological effects of radiation exposure, Crew **PADLES** measures the personal dose acquired by an individual astronaut, and Free-Space **PADLES** investigate the space radiation dose outside the JEM Kibo. These small, portable devices measure absorbed doses (Gy) and dose equivalent (Sv). Dose records are used to assess astronaut radiation exposure limits in low-Earth orbit and help researchers better understand human exploration beyond low-Earth orbit. By comparing the dose measured by the Area **PADLES** set in the interior of Kibo and the Free-Space **PADLES** exterior to the module, an evaluation of the radiation shielding capability of Kibo's hull wall becomes possible. This is the first time that a direct measurement of the radiation shielding of the Kibo module is measured in orbit. The data obtained from the **PADLES** experiments will assist with risk assessment of Extravehicular Activities (EVAs) and the assessment and optimization of hull wall thickness for manned spacecraft.

ISS Expedition 28 crewmember Furukawa poses with PADLES Dosimeters (ISS028E007155).

Human physiology research is coordinated by an internal working group to efficiently schedule experiments and share data. An astronaut or cosmonaut can participate in as many as, or sometimes more than, 20 physiology experiments on orbit during an increment.

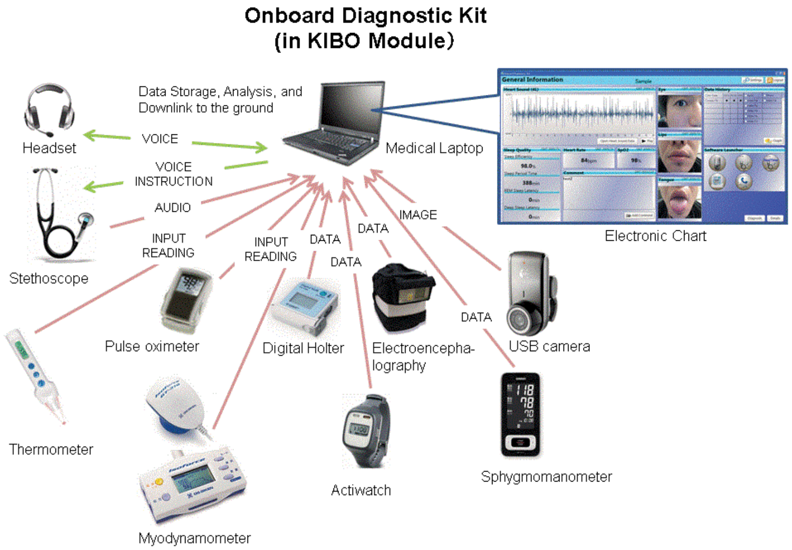
Intra-Vehicular Tissue Equivalent Proportional Counter (IV-TEPC) [NASA] is a portable, active ionizing radiation monitor that measures the internal radiation environment in near real time using a simulated tissue site device. Some of the information generated by this instrument is used to make operational radiation protection decisions and risk assessments by estimating the physiological consequences to crewmembers from radiation exposure during spaceflight. As a portable unit, it may be used to characterize the radiation environment in different locations within the ISS and assess varying impacts related to humans during long-duration spaceflight.

The bronze box is the IV-TEPC radiation monitor after it was located to JEM1 F3 (ISS043E241659).

ELITE S2 [NASA, ASI] is a passive optoelectronic analyzer. Retroreflective markers are applied on the subject body on specific landmarks; digital cameras collect the markers' position, reflecting the light provided by infrared illuminators; the tridimensional coordinates of the markers are acquired by specific software running on the payload computer. Part of the instrument is mounted into a NASA rack for the scientific data acquisition and collection, the power management and the connection to the ground control center for command and data transmission. The rack-mounted equipment is connected to the cameras deployed in the ISS by means of cables. The instrument makes use of a laptop computer to provide the crewmember with directions and feedback.

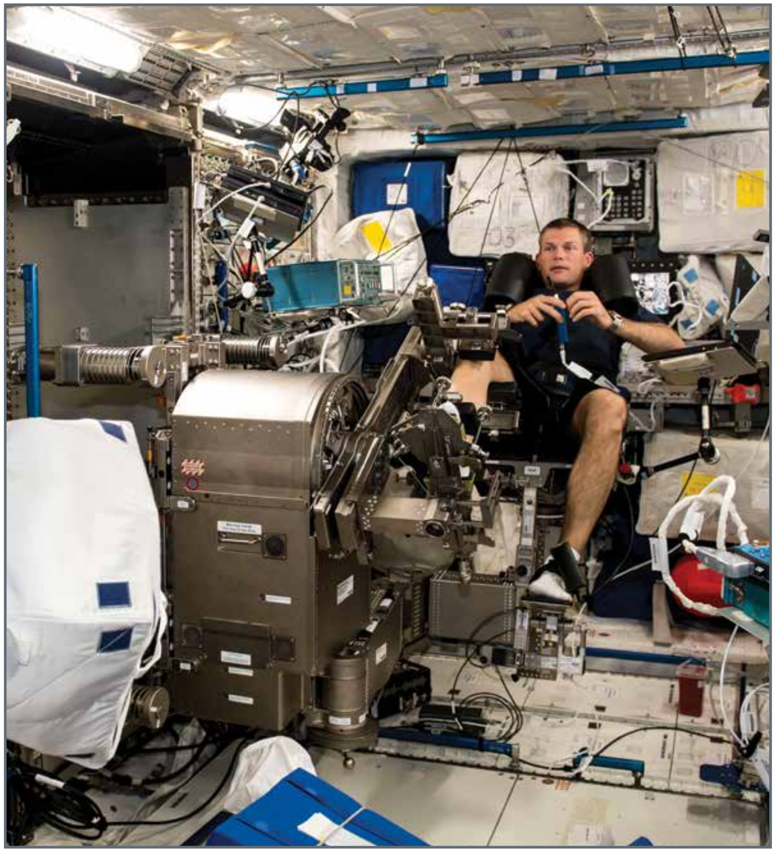
Elite S2 Interface Management Unit (ISIS Drawer) integrated in EXPRESS Rack (ISS033011716).

The **Onboard Diagnostic Kit (ODK) [JAXA]** is a non-invasive, health-monitoring system capable of measuring, storing and analyzing crewmember medical data while onboard the ISS. The medical data collected onboard can be sent to the ground immediately, whereby doctors can quickly diagnose crewmember health.



One component of the ODK is the digital Holter ECG recorder, a portable 24-hour electrocardiogram recording device used to monitor ISS crewmembers' cardiovascular and autonomic functions (JAXA).

Percutaneous Electrical Muscle Stimulator (PEMS) [ESA] is a portable, self-contained neuromuscular research device that may be used stand-alone or in conjunction with other physiological instruments. The purpose of this device is to deliver electrical pulse stimulation to non-thoracic muscle groups of a human test subject, thereby creating contractile responses from the muscles. It is capable of providing single, variable amplitude pulses or pulse trains according to a pre-adjusted program.



ISS crewmember Andreas Mogensen setting up the ESA MARES rack and its ankle mechanism assembly in the Columbus module. PEMS is located to the right (ISS044E101255).