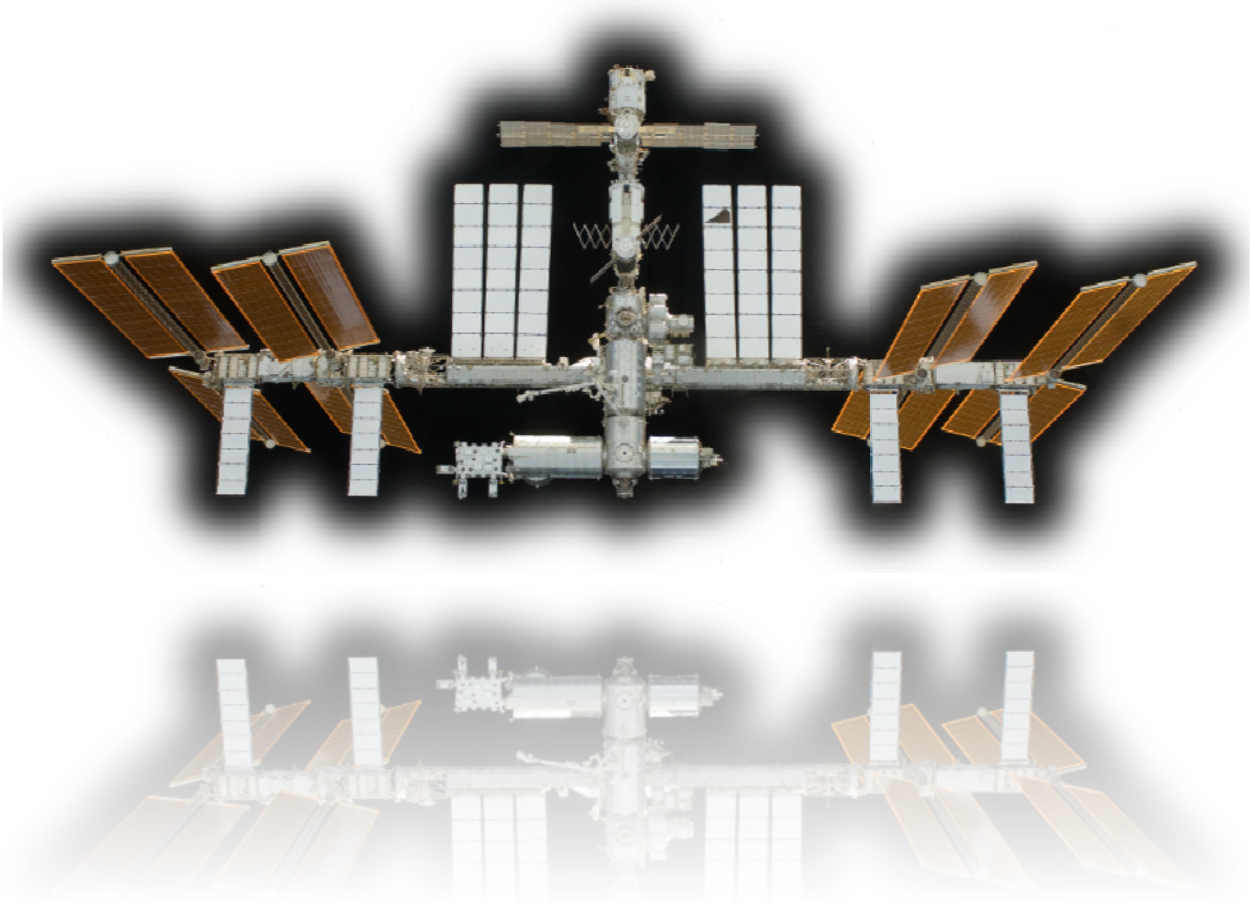
International Exercise Countermeasures Hardware Catalog



International Countermeasures Working Group
Trieste, Italy
June 2010

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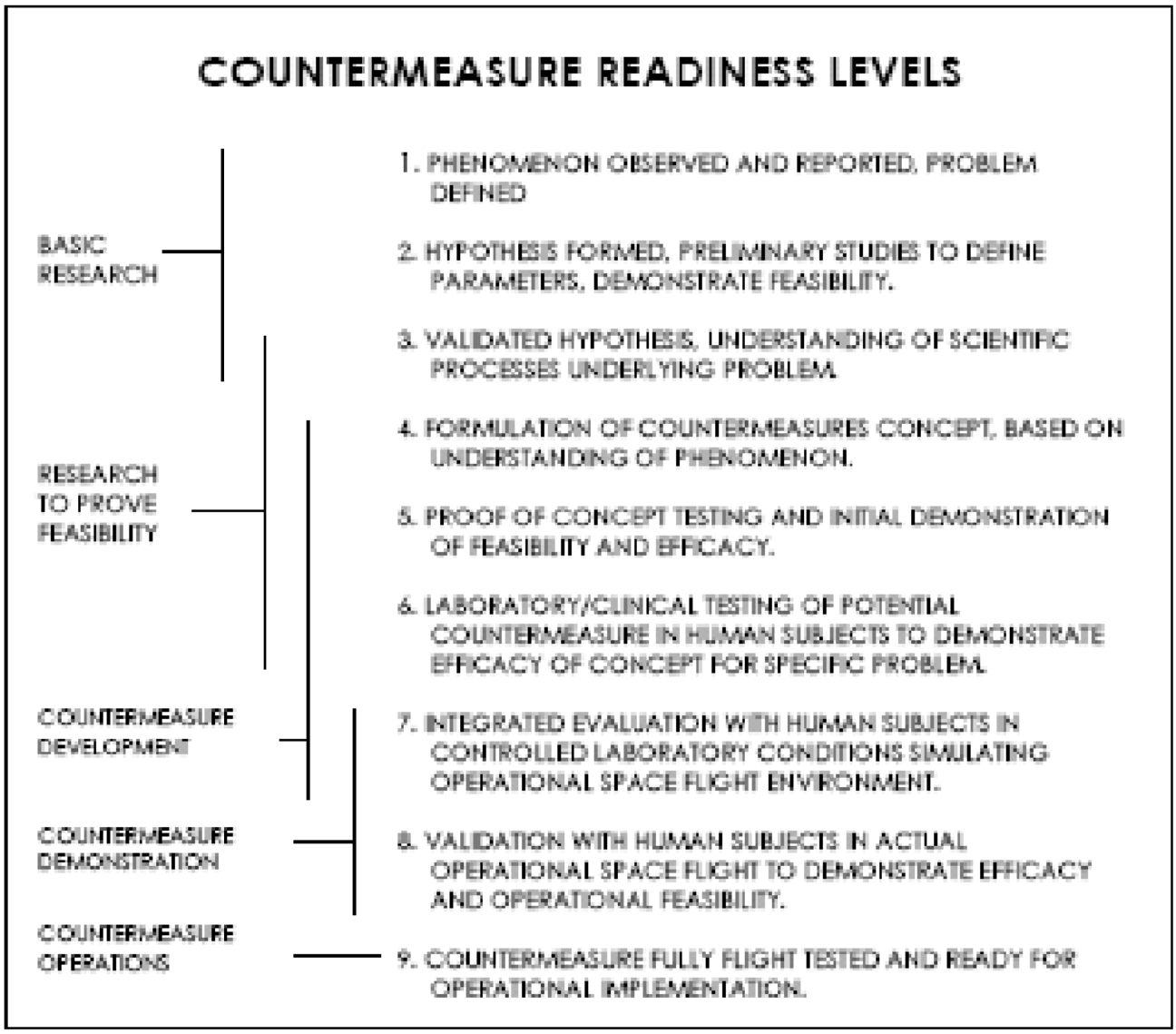
Countermeasure Readiness Levels



National Aeronautics and Space Administration (NASA)

Cycle Ergometer with Vibration Isolation and Stabilization (CEVIS)

Description:

CEVIS provides aerobic and cardiovascular conditioning through cycling activities. CEVIS can be used for either leg or arm ergometry. The arm handle and pedal crank assemblies are attached with identical interfaces and can be changed out for upper or lower body exercise sessions.

Characteristics/Specifications

Functional Capabilities	Resistance: 0 to 350 W Pedal Speed: 0 to 125 rpm Incremental increase at 1 or 10 W
Major Components	Load Module Mounting Frame Assembly Seat Assembly Control Panel Power Cable Vibration Isolator Heart Rate Measurement
Complementary Hardware	Heart Rate Monitor (HRM2) Blood Pressure/Electrocardiogram (BP/ECG) Portable Pulmonary Function System (PPFS) MEC
Provider/Sustaining Users	NASA Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/U.S. Laboratory Module (Destiny)

Treadmill with Vibration Isolation System (TVIS)

Description: The treadmill is a device used to compensate for the negative influence of microgravity on crewmembers. The TVIS provides aerobic conditioning by simulating 1-G running or walking in the microgravity environment of the ISS. The treadmill is designed to allow walking and running, knee bends, and resistive exercise in a microgravity environment for maintenance of cardiovascular fitness, muscular strength, and the exercise of neurophysiologic pathways and reflexes required to walk upon return to Earth. The vibration isolation system is intended to minimize the transfer of dynamic forces caused by operation of the treadmill to the structure of the Service Module (SM) and other parts of the ISS, while maintaining a stable running/walking surface at the same time.

Characteristics/Specifications

Functional Capabilities

Measurement Parameters/Analysis Capabilities:

Display	**Units**	**Range**	**Precision**
Tread Speed	km/h or mph	0–16 km/h (0–10 mph)	0.2 km/h (0.1 mph)
Restraint Force	kg or lb	0–100 kg (0–220 lb)	1 kg (1 lb)
Distance	km or mi	0–99 km (0–99 mi)	0.02 km (0.01 mi)
Elapsed Time	hh:mm:ss	0–99 h 99 min	1 s
Exercise Profile	N/A (Graphic)	N/A (Graphic)	N/A (Graphic)
Heart Rage	bpm	0–240 bpm	5 bpm
Control	**Units**	**Range**	**Precision**
Tread Speed (motorized mode)	km/h or mph	0–16 km/h (0–10 mph)	0.2 km/h (0.1 mph)
Restraint Force	kg or lb	0–100 kg (0–220 lb)	4.5 kg (10 lb)

Major Components

Treadmill Assembly
Forward Closeout Panels (2)
Aft Closeout Panels (2)
Closeout Skirt
Control Panel
PCMCIA Card
Electronics Box
Electronics Box Battery
Flywheel Case
Transfer Case
Treadmill Harness
Isolation Cage
Subject Load Device (2)
Subject Positioning Device (2)
Motor Box
Vibration Isolation and Stabilization
TVIS On-Orbit Kits

Complementary Hardware

Heart Rate Monitor 2 (HRM2)
MEC

Provider/Sustaining Users

NASA/Russia
Medical Operations
Human Research Program

Countermeasure Readiness Level

9

Ground/Flight

Flight

Vehicle/Location ISS/Service Module

Second Generation Treadmill (T2)

Description: The treadmill (T2), also known as COLBERT, is the second generation ISS treadmill intended for use by USOS crewmembers. T2 is a modified commercial-off-the-shelf Woodway Path treadmill designed to allow walking and running exercises. T2 was also designed to minimize the transfer of dynamic forces caused by use of the treadmill to preserve the microgravity environment of ISS as well as minimize loads imparted to the ISS structure

Characteristics/Specifications

Functional Capabilities	Range: 1 – 12.4 mph, operationally limited to 2.5 –12.4 mph because of low frequency vibrations Active Mode: Runner uses the uplinked protocol files and starting default speed is 3 mph (4.8 km/h) Manual Mode: Runner overrides prescription mode and manual mode sessions are 30 minutes in length
Major Components	T2 Belt, Belt Housing, and Motor is a single orbital replacement unit Vibration Isolation System T2 Pacebook T2 Rack Power T2 Instrumentation T2 Handrail Subject Loading Device Emergency Stop Magnet ` Internal Thermal Control System Power Interface Data Interface
Complementary Hardware	Heart Rate Monitor 2 (HRM2) MEC
Provider/Sustaining Users	NASA Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Node 3

Interim Resistive Exercise Device (iRED)

Description: The iRED is designed to prevent atrophy of the major muscle groups and to minimize bone loss in a microgravity environment by maintaining strength and endurance. The device provides eccentric and concentric contraction through a full range of motion of the following exercises: squats, deadlifts, hip extension, hip flexion, hip abductions, hip adductions, leg curls, heel raises, bent over rows, upright rows, shoulder raises, shoulder presses, bicep curls, tricep extensions, wrist curls, bench presses, and sit ups.

Characteristics/Specifications

Functional Capabilities	Operating ranges: 10 lb – 160 lb per RED assembly (i.e., canisters) ± 2 lb (4.5 – 113.5 kg ± 00.9 kg)
Major Components	iRED assembly, fore and aft iRED squat support assembly (2) iRED adapter plate assembly iRED resupply kit iRED accessory kit iRED calibration tool kit
Complementary Hardware	Contingency Resistive Exercise System (CRES) bungees MEC

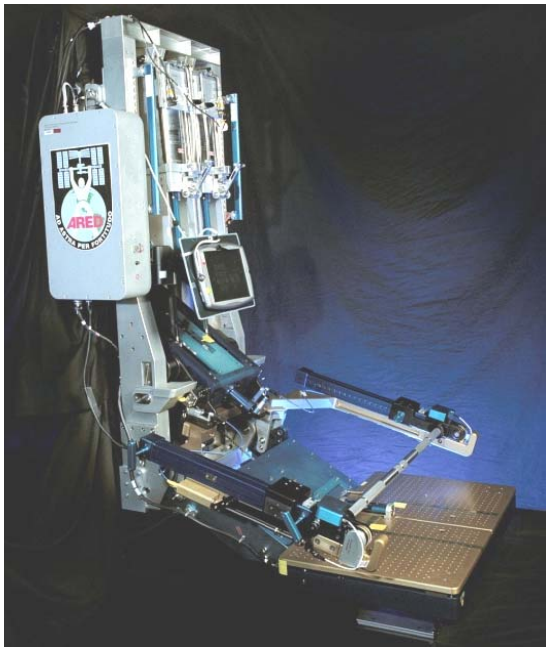
Provider/Sustaining Users	NASA Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed in one of the Russian Pressurized Mating Adapters

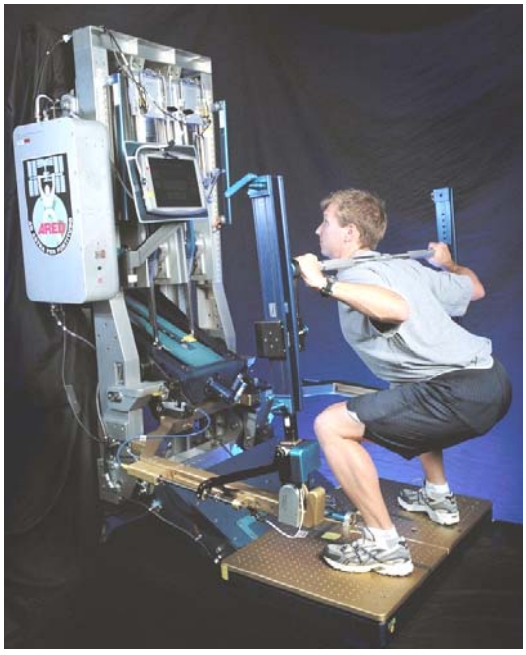
Advanced Resistive Exercise Device (ARED)

Description: The resistive exercise device (RED) functions to maintain crew health in space. Crew members exercise daily on RED to maintain their preflight muscle and bone strength and endurance. EVA, IVA, re-entry, and emergency egress necessitate the crew members' continued strength and endurance. The Advanced RED (ARED) will have the capability to exercise all major muscle groups while focusing on the primary resistive exercise: squats, deadlifts, and calf raises. The ARED will accommodate all crew members, from the 5th percentile Japanese female to the 95th percentile American male. The ARED is a device that is used to maintain muscle strength, bone strength, and endurance through the simulation of free weights by providing both a constant and inertial load.

Characteristics/Specifications

Functional Capabilities	55W average, 65W peak 16.8 V A31p 120 VDC power supply 0 – 600 lb for lift par and 0 – 150 lb for exercise rope (5 – 100 lb ±1.0 lb and 101 – 600 lb ±1.0%) 72 in. stroke
Major Components	Frame Belt Pulley Cylinder Flywheels Main Arm Vibration Isolation System Display with Stylus Instrumentation Box Accessories Calibration Tools
Complementary Hardware	Pacebook MEC
Provider/Sustaining Users	NASA Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Node 3





Heart Rate Monitor 2 (HRM2)

Description: The HRM2provides heart rate monitoring capability and exercise level control during exercise activities. The HRM2 is a commercial-off-the-shelf Polar Heart Watch Model S810i

Characteristics/Specifications

Functional Capabilities	Displays heart rate, elapsed time, time of day Records heart rate data at 5, 15, or 60-s intervals Stores up to approximately 99 data files, ranging from 42 h 30 min to 99 h 59 min (depending on heart rate interval) Transmitter transmits at 5 KHz to the HRM watch and 868.35 MHz to receivers in the TVIS or CEVIS control panel HR data sent to HRM/MEC interface device via an infrared signal at 5 KHz Transmitter can be work without watch to transmit data to CEVIS or TVIS display
Major Components	HRM2 Watch HRM2 Transmitter HRM2Transmitter Battery Kit HRM2 Chest Strap HRM2/MEC Interface Device
Complementary Hardware	CEVIS TVIS T2 MEC
Provider/Sustaining	NASA
Users	Space Medicine Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location U.S. Laboratory Module. Those issued to crew are stowed at crew discretion.

Blood Pressure/Electrocardiogram (BP/ECG)

Description: The BP/ECG monitor provides the capability for automated, auscultative, noninvasive systolic and diastolic blood pressure measurements and the capability to monitor and display to the crew accurate heart rates/ECG waveforms on a continual basis during the performance of exercise countermeasures on orbit. Data downlink is stored and then downlinked.

Characteristics/Specs

Functional Capabilities	Range: 0 –300 mmHg ±3 mmHg or ±2% of full scale for blood pressure Heart Rate: 0–240 ±2 BPM Pressure cuff limit < 310 mmHg; time duration < 180 s
Major Components	ECG Unit Plot Pressure Device Lead Box Consumables Kit
Complementary Hardware	CEVIS MEC
Provider/Sustaining	NASA
Users	Space Medicine Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location U.S. Laboratory Module

Medical Equipment Computer (MEC)

Description: The MEC is a standard IBM A31p laptop with a customized Medical Operation Software load. The purpose of the MEC is to:

- Display physiologic data from exercise devices
- Collect and store CHeCS data
- Maintain medical records
- Assess crew health
- Provide uplink/downlink capability through the C&DH system or Ops Local Area Network (LAN)

Characteristics/Specifications

Functional Capabilities	20 VDG, < 40W power 28 BCD or 120 BDC Rechargeable battery (internal) 9.6 volt Li-Ion battery
Major Components	MEC Kit containing 1553 card/cable and RF LACN card ISS CD Library containing the following MEC components: • MEC Disk Image, version 19 (760XD Version) • MEC Disk Image, version NGL 1.0 (7 CDs) • MEC Disk Image, version NGL 2.0 (1 DVD)
Complementary Software	1553 (allows for ground commanding) Audio Dosimeter Carbon Dioxide Monitor log (for contingencies) Compound Specific Analyzer–Combustion Products log (for contingencies) EarQ (hearing assessment) EGDH (BP/ECG) (for "store and forward" of data) GDH (EGDH for real-time downlink) In-flight Examination Program (IFEP) IV–CPDS Noise Explorer (sound level meter log) Nutrition (questionnaire) Polar (heart rate watch data log) Tissue Equivalent Proportional Counter (TEPC) log (for contingencies) Total Organic Carbon Analyzer (TOCA) log (for contingencies) TVIS card format utility WinSCAT (Spaceflight Cognitive Assessment Tool for Windows)
Provider/Sustaining	NASA
Users	Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location U.S. Laboratory Module

Ultrasound

Description: The Human Research Facility on the ISS is equipped with a space-adapted, rack-mounted version of the HDI-5000 CV Ultrasound System (ATL/Philips, Bothwell, WA). This ultrasound device uses high resolution imaging to conduct ultrasound exams on crewmembers during ISS missions for the purposes of performing physiologic research, supporting medical operations, and further developing diagnostic telemedicine techniques in both space and on Earth. It is able to perform in various 2-D modes (M-mode, spectral Doppler, tissue Doppler, color Doppler, color power angiography, continuous wave Doppler, and color M-mode) and is capable of recording analog and digital images locally and downlinking them for further analysis on Earth. It is also capable of transmitting live video to Mission Control for assistance with remotely-guided activities.

Characteristics/Specifications

Functional Capabilities	Constrained to a maximum of 8 hours in a 24-hour period, and it is required to be run at least one time per increment Allows for stereo, audio output, and voice annotation by the ISS crew. Allows the realization of the great scientific potential of ultrasound imaging in conditions of space flight, acquiring morphological (form and structure) and morphometric (size and shape) as well as physiologic information from virtually every area or organ system of the human body.
Major Components	Hi-8mm Video Recorder Digital and Output Storage Capability Clock Display Microphone Deployable Keyboard and Display Screen
Complementary Hardware	HRF Laptop

Provider/Sustaining	NASA
Users	Space Medicine Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/European Columbus Module

Photos

Stand alone Zero-gravity Locomotion Simulator (sZLS)

Description:
The sZLS provides the capability of aerobic and cardiovascular conditioning while subjects are suspended in a horizontal position. The recumbent orientation of the subject may be required for spaceflight analog bed rest studies or may be needed for a subject rehabilitating from a condition where ambulatory aerobic exercise is counter-indicated.

Characteristics/Specs

Functional Capabilities	Provide recumbent aerobic exercise (primarily by treadmill) 0 to 9 mph treadmill speed (up to 12 mph with modifications) 0 to 220 lb of subject loading to the treadmill
Major Components	Vertically mounted treadmill with force measurement Pneumatic subject loading device (pSLD) Subject horizontal suspension system, including limb off-loading Heart rate measurement Real-time viewing and data acquisition of force applied to treadmill, subject load, and heart rate
Other Capabilities	Other exercise devices could possibly be mounted to the sZLS to utilize the pSLD for alternative countermeasures

Provider/Sustaining	NASA
Users	Human Research Program
Countermeasure Readiness Level	N/A
Ground/Flight	Ground
Vehicle/Location	University of Texas Medical Branch/Flight Analog Research Unit

Horizontal Exercise Fixture (HEF)

Description: The HEF was designed by NASA engineers and exercise physiologists (U.S. Patent 7,125,370 B1) to allow a person to perform a range of resistive exercises while lying in a supine or prone position. This device has not been used in a NASA bed rest study to date, but plans are in work for a new study to use the HEF starting in the fall of 2010.

Characteristics/Specs

Functional Capabilities	Provide supine resistive exercise capabilities (especially squat) 0 – 510 lb (current) 34 in. range of motion (by the subject)
Major Components	Subject Support Platform Pelvic Sled/Shoulder Tilt Plate Weight Stack Assembly Hoist Data Collection System
Other Capabilities	In addition to the squat motion, the HEF can be used to conduct prone row, bench press, heel raise, hip flexion, and hip extension exercises

Provider/Sustaining	NASA
Users	Human Research Program
Countermeasure Readiness Level	N/A
Ground/Flight	Ground
Vehicle/Location	Wyle off-site facilities (current) University of Texas Medical Branch (future)

Advanced Exercise Concepts

Description: The HRP Exercise Countermeasures Project is developing advanced exercise concepts for possible use on ISS and for future exploration missions. These "proof of concept" devices are being developed in-house at NASA's Glenn Research Center and Johnson Space Center, through National Space Biomedical Research Institute (NSBIR) grants, as well as through NASA's Small Business Innovation Research (SBIR) awards. These concepts include the Lunar Electric Rover (LER) ergometer that has been evaluated in the LER during past field trials, the Wyle Inertial Wheel Exercise Device, the Zin Air Spring Device, the Valeo Constant Force Resistive Exercise Unit (currently in SBIR Phase 2), a next-generation flywheel funded via NSBRI, and the Streamline Automation Electric Servo-Motor based concept (currently in SBIR Phase 2 development). These and other next generation exercise concepts, if proved promising in meeting functional and design goals, must be evaluated in ground and analog studies before flight validation is undertaken.

Characteristics/Specs

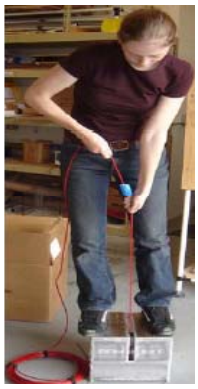
Functional Capabilities	The goal is to provide both aerobic and resistive exercise capabilities within one device: • 0 – 600 lb (target) • 1:1 eccentric:concentric ratio (target) • Adequate stroke rate to elicit 85% VO_2max (target) • Range of motion to accommodate 5 – 95th percentile
Major Components	Dependent upon the concept
Other Design Goals	Concepts to require little vehicle or crew resources to deploy, operate, and maintain. Some concepts are being designed to "harness" or store energy generated during exercise for use to power other mission hardware.
Provider/Sustaining	NASA
Users	Human Research Program
Countermeasure Readiness Level	early CRL 4 (component and/or breadboard validation in a laboratory environment)
Ground/Flight	Ground (possibly progressing to flight)
Vehicle/Location	Various

Streamline Automation Electro-Servo Motor

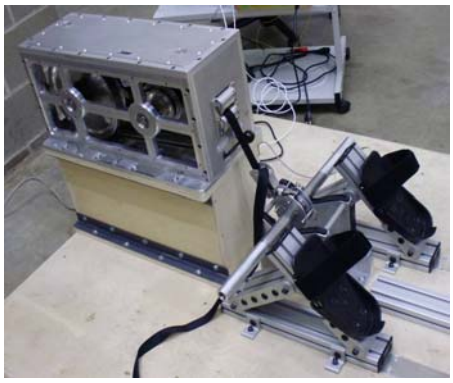
HRP Next Generation Flywheel

Zin Technologies Gas Spring

LER Ergometer



Valeo Constant Force
Exercise Resistive Device



Wyle Inertial Wheel
Exercise Device

Russian Space Agency (RSA)

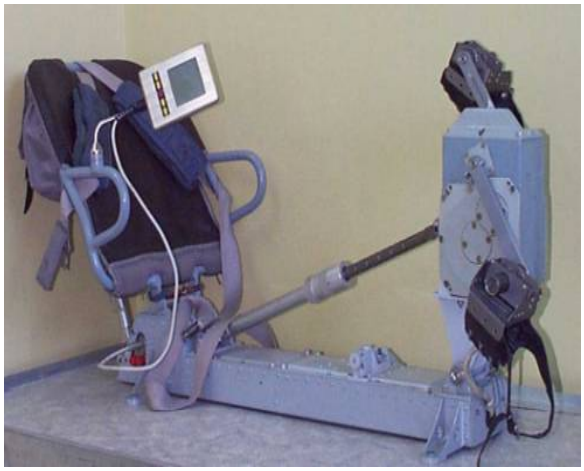
Veloergometer (VB-3)

Description: The Veloergometer (VB-3) is designed for multi-purpose physical exercise of the operators to prevent negative space flight effects and for space station onboard medical examination (functional tests with a graded physical load). The VB-3 is used for aerobic training, medical tests, and pedaling regimes.

Characteristics/Specifications

Functional Capabilities	Resistance: 100 – 225 W Pedal speed: 40 – 80 rev/min Incremental increases at 25 W Measures: • Frequency range of pedal shaft rotation: 0 – 120 rev/min • Time of total work during training • Time of work under specified load • Total work during training • Distance traveled
Major Components	General Assembly Control Module Control Panel
Complementary Hardware	

Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Service Module

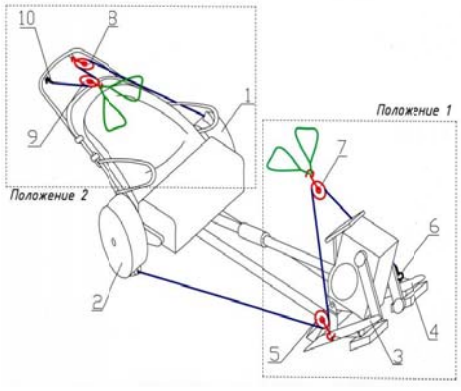


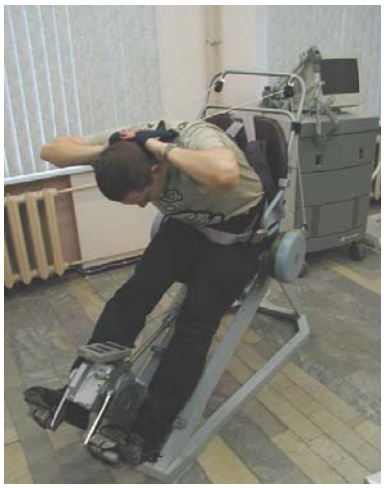
Force Training Device (NS-1)

Description: The purpose of the force training device (NS-1) is for crewmembers to perform various types of physical exercise on the ISS Russian Segment as a countermeasure for long-duration in situ testing. The device supports performing resistive exercises where the arms, legs, and back are subjected to loads.

Characteristics/Specifications

Functional Capabilities	Applied loading of 5 – 30 kg to each side, loading with 60 kg is also possible Types of exercises: • Body flexion/extension • Imitates rowing • Imitates hammer throwing • Simultaneous and alternative flexion/extension of forearms • Alternate arm flexion/extension
Major Components	Boot plate Chassis Control panel Frame Loader 1 Loader 2 Loader power supply unit Pedal (2) Power source
Complementary Hardware	Velo
Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Service Module





Penguin Suit

Description: The axial loading suit compensates insufficient loading of the musculoskeletal system as well as lack of weight-bearing and proprioceptive afferentation in space environment.

Characteristics/Specifications

Functional Capabilities	Produces compressive loading up to 40 kg
Major Components	Penguin Suit Footwear Cover Bag Plastic Bag Cue Card
Supporting Hardware	N/A

Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location: Service Module

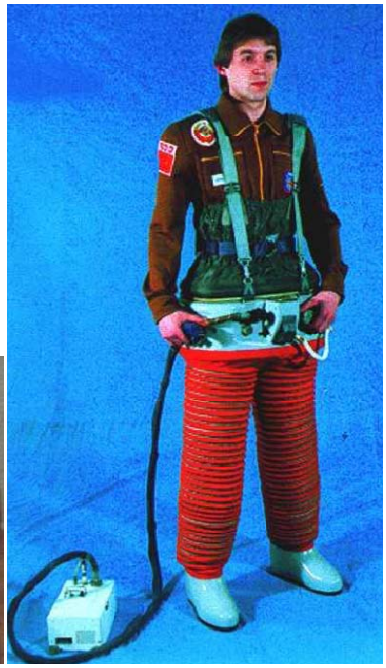
CHIBIS

Description: The CHIBIS system is designed to create a negative pressure around the lower part of the human body and to apply a longitudinal load on his skeletomuscular system to prevent disorders caused by long exposure to microgravity. This system provides ventilation of the human body and maintains its mobility and capability to translate inside the object.

Characteristics/Specifications

Functional Capabilities	Size – for a person having a leg length (step size) of no more than 820 mm (32.3 in.), upper thigh size of no more than 660 mm (26.0 in.), minimal waistline of 780 mm (30.7 in.), maximal waistline of 980 mm (38.6 in.), and foot size of no more than 300 mm (11.8 in.). Range of manual adjustment of the negative pressure inside the suit is 10 – 60 mmHg Compression force on the human skeletomuscular system is 10 – 60 kg (22.1 – 132.3 lb). Maximal negative pressure inside the suit is 60.5 mmHg
Major Components	Suit Unit Hose bundle connecting the suit and the unit Cover for the hose bundle (1) Package for the suit (1)
Complementary Hardware	TBD

Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location: Service Module



Braslet-M

Description: The Braslet–M is a preventive-care device is intended for creating compression in the upper portions of the lower extremities for the purposes of artificially depositing blood in them. The Braslet–M device is made of constriction cuffs that consist of alternating multilayer elastic materials and non-stretchable materials. A tightening belt and buckle are fastened to the cuff. Fluid naturally tends to accumulate in the upper portions of the body away from the legs, causing some discomfort (such as stuffy sinuses) and the Braslet is used to counteract this by compressing the lower extremities and forcing blood to circulate there. Ultrasound will be used to potentially validate this as appropriate methodology for steady static cardiovascular physiology in long duration flight.

Characteristics/Specifications

Functional Capabilities	Sizes – 50, 52, 54, 56, 58 (upper thigh size can be varied from 49.5 to 65.0 cm [from 19.5 to 25.6 in.]) When the Braslet is worn, its effectiveness is rated according to the following 3-point scale: • 0 – There is no effect from the usage of the device • 1 – An effect is observed • 3 – A pronounced positive effect
Major Components	Braslet: • Belt • Constriction Cuffs (left and right) (one pair) • Packaging (one unit) Braslet–M: • Constriction Cuffs (left and right) (one pair) • Packaging (one unit)
Supporting Hardware	HRF Ultrasound

Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/Stowed location: Service Module

Electrostimulator (Tonus-3)

Description: The Tonus–3 is designed to supply stimulating electrical signals to human skeletal muscles to prevent hypodynamic disorder, to maintain human performance, and to provide medical treatment onboard the station.

Characteristics/Specifications

Functional Capabilities	Tonus–3 has 6 electrically independent galvanic circuits with local continuous adjustment of current peaks for output signals .Output signals are bursts of electrical pulses filled with harmonic signals (10 1.5) Hz. Frequency of pulse bursts is (60 6) Hz. Maximum peak-to-peak output current signal on equivalent load is (300 – 45) mA. Pulse envelope has a steep leading edge and an exponential drop. Duration of a pulse envelope leading edge is (25 – 15) s, pulse duration – (1 0.2) ms. Each circuit supports two modes of operation: First mode: sends pulse bursts (0.5 – 0.05) s and (1.5 0.15) s long and (1.5 – 0.15) s interruptions between the bursts; Second mode: sends pulse bursts (10 – 1) s long and (50 – 5) s interruptions. The unit provides an opposite phase sequence of pulses and interruptions as an output 1 and 4; 2 and 5; 6 and 3 circuits. Tonus–3 provides electrical stimulation based on 4 program classification: • Program I: shin and front thigh muscles • Program II: shin and back thigh muscles • Program III: shin, abdominal, and back muscles • Program IV: forearm muscles
Major Components	Pulse generator Set of electrodes (2 units) including: • Electrodes for right and left thigh • Electrodes for right and left skin • Electrodes for abdomen and back • Electrodes for the forearms Electrode Cable (2 units [only 1 bag is packed])
Complementary Hardware	TBD

Provider/Sustaining	RSA
Users	Medical Operations
Countermeasure Readiness Level	9
Ground/Flight	Flight and ground
Vehicle/Location	ISS/Stowed in: Service Module

European Space Agency (ESA)

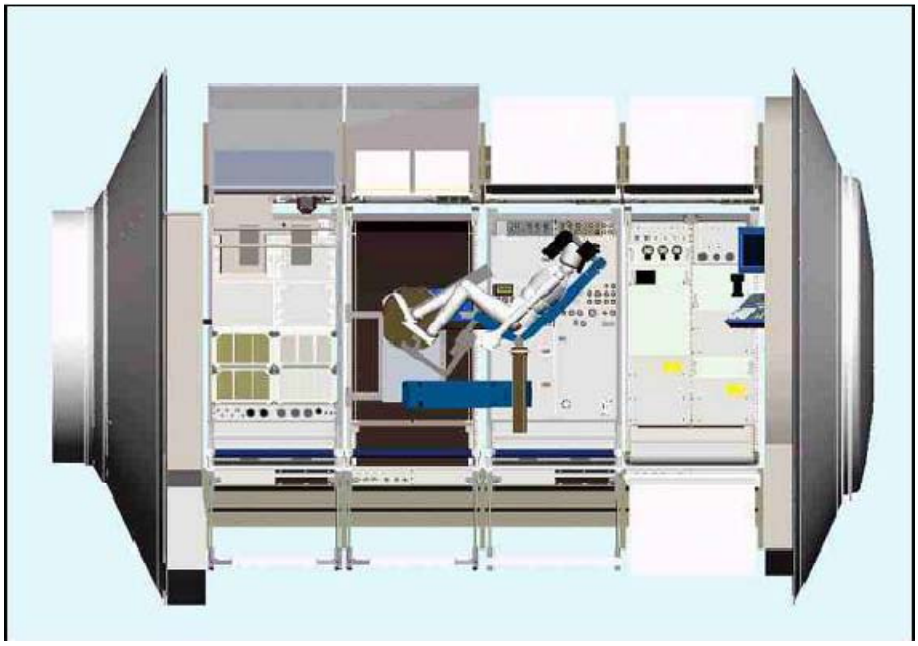
Muscle Atrophy Research and Exercise System (MARES)

Description: The MARES is a general-purpose instrument intended for (neuro) muscular and exercise research on the ISS. 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.

Characteristics/Specifications

Functional Capabilities	Offers 14 predefined basic movement units (BMUs) that cover 3 possible basic modes of muscle contraction know from physiology (isometric, isotonic, and isokinetic) plus 11 additional BMUs that can be used in support of more sophisticated experimental requirements. Records 14 (BMU), during any one BMU the relationship between position (or velocity) and torque/force is governed by a single, relatively simple, mathematical formula.
Major Components	Aisle mounted and interfaces with the European Columbus Laboratory Main Box containing sensors, direct drive motor, battery, and electronics) Microgravity Isolation Frame Set of Human Adapters (subject restraints) Chair Laptop Computer Dedicated Experiment Software
Supporting Hardware	Human Research Facility portable computer

Provider/Sustaining	ESA/NASA
Users	Human Research Program
Countermeasure Readiness Level	7/8
Ground/Flight	Flight
Vehicle/Location	ISS/Columbus Module



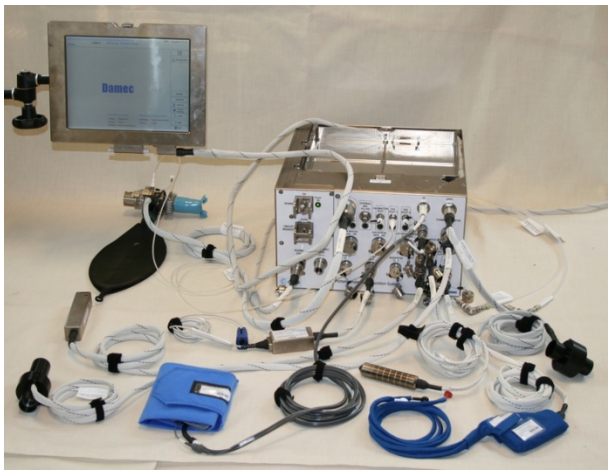
Portable Pulmonary Function System (PPFS)

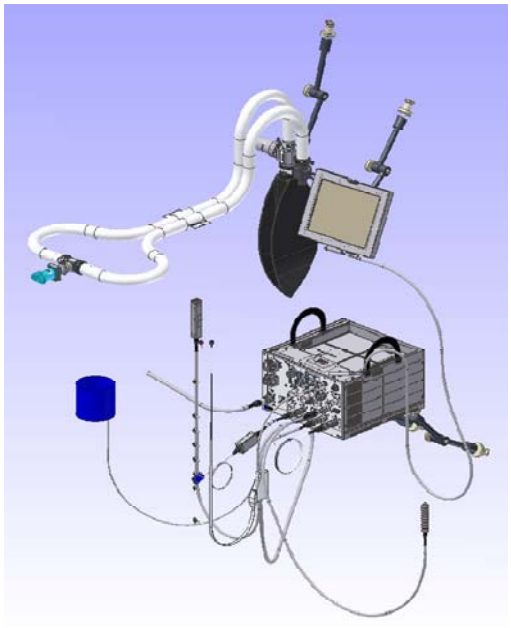
Description: The portable pulmonary function system (PPFS) is new equipment added to the already developed European Physiology Module (EPM) pool of instruments. The PPFS is an evolution to the existing pulmonary function system (PFS). The PFS is the EPM contribution to NASA's Human Research Facility (HRF) and will support a wide range of respiratory and cardiovascular measurements.

Characteristics/Specifications

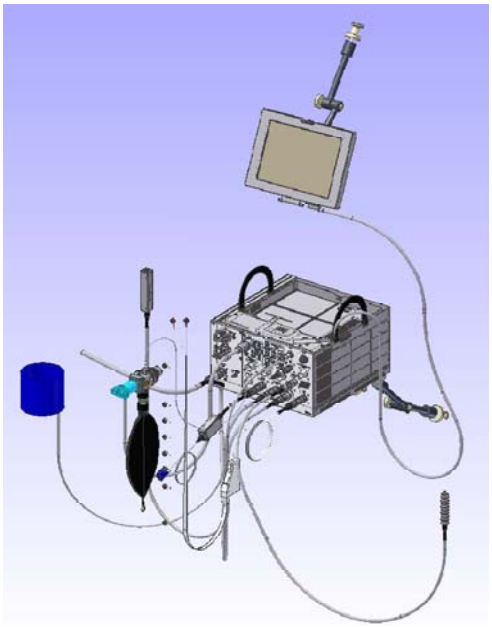
Functional Capabilities	Measures: • Cardiac output, Pulmonary Blood Flow • Functional Residual Capacity • Lung Tissue Volume (volume of pulmonary capillary blood) • Total Lung Capacity • VO_2, VCO_2, VE (Breath-by-breath or Mixing-bag-system) • Respiratory exchange ratio VO_2/VCO_2(Breath-by-breath or Mixing-bag system) • Fractional inspiratory and expiratory volumes, FIO_2 and FEO_2, $FICO_2$ and $FECO_2$ • Alveolar Ventilation • Vital Capacity • Dead Space Volume • Expiratory Reserve Volume • Forced Expired Spirometry • Residual Volume • Tidal Volume • Vital Capacity • Heart Rate • ST measurements • ST slope • Arrhythmia's • Systolic Blood Pressure • Diastolic Blood Pressure • Mean Blood Pressure • Oxygen saturation, SpO_2
Major Components	Multi Gas Analyzer System (MGAS) Photoacoustic Gas Analyzer (PGA) O_2 sensor Gas Supply System (GSS) Respiratory Valve System (RVS) Flowmeter System (FS) Turbine Flowmeter sensor Differential Pressure Flowmeter (DPFM) sensor Mixing Bag System (MBS) 12-lead ECG System Non-Invasive Blood Pressure System (NIBP) Pulse Oximeter, SpO_2 Ambient Conditions Monitoring System (ACMS) Sensor GO-switch Touch Screen Display Data Management Unit Power Distribution System
Complementary Hardware	CEVIS HRM2 HRF Power Converter PFS Gas Cylinders (portable gas delivery system)

Provider/Sustaining	ESA
Users	Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/U.S. Orbital Segment (currently solely the U.S. Destiny Laboratory)





Portable PFS Mixing Bag System setup



Portable PFS Rebreathing setup

Pulmonary Function System (PFS)

Description: The pulmonary function system (PFS) is a respiratory physiology instrumentation package cable of a wide range of noninvasive respiratory and cardiovascular measurements not only in a relaxed position, but also during cardiac exercise stress tests. The PFS uses an operationally simple photo-acoustic method to analyze gas as compared to previously used mass spectrometers

Characteristics/Specifications

Functional Capabilities	Measures: • Breath-by-breath of VO_2, VCO_2, VE • Diffusing capacity of the lung for CO_2 • Expiratory reserve volume • Forced expired spirometry • Functional residual capacity • Respiratory exchange ration VO_2VCO_2 • Residual volume • Total lung capacity • Tidal volume • Alveolar ventilation • Vital capacity • Volume of pulmonary capillary blood • Dead-space ventilation • Cardiac output • Numerous other specialized tests of pulmonary function
Major Components	Respiratory Valve Unit Mouthpiece Pressure – MPP (3 pieces) Turbine Flowmeter Differential Pressure Flowmeter Bag-in-Box System Ambient Condition Monitoring Subject Display
Complementary Hardware	Gas Delivery System (GDS) Respiratory Inductance Pleythysomograph Continuous Blood Pressure Device CEVIS HRM2
Provider/Sustaining	ESA/NASA
Users	Medical Operations Human Research Program
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle/Location	ISS/European Columbus Module

PFS in HRF Rack 2

Rebreathing activity using the PFS

Flywheel Exercise Device (FWED)

Description: The flywheel exercise device (FWED) is a non-gravity dependent resistance exercise device that acts to countermeasure muscle atrophy, bone loss, and impairment of muscle function in human beings, which develop in response to long-duration spaceflight. The FWED is a compact lightweight, resistive exercise devise using the flywheel principle, which allows for back, trunk, and upper and lower limb exercises. It is a multi-exercise device that will be employed as an onboard exercise countermeasure devise allowing for the squat, dead lift, and heel raise and other important exercises.

Characteristics/Specifications

Functional Capabilities: Provides variety of different exercises targeting different muscle groups and designed for eight exercises:

Mandatory	**Optional**
Squat/leg press	Seated row
Calf press/heal raise	Upright row
Dead lift/back extension	Lateral shoulder raise
	Biceps curl
	Reverse curl

Major Components:
Body Harness with back and neck protector
Cord Reel/Actuation Cord
Dead man Provision of Emergency Brake
Laptop Unit of DMS
Wheel and Brake Assembly
Roller Chair
Rail Assembly
Floor Mounting Structure inclusive AVS
Foot Rest Plates
Drive Unit

Complementary Hardware: TBD

Provider/Sustaining: ESA
Users: Medical Operations
Human Research Program
Countermeasure Readiness Level: 8/9
Ground/Flight: Flight
Vehicle/Location: ISS/European Columbus Module

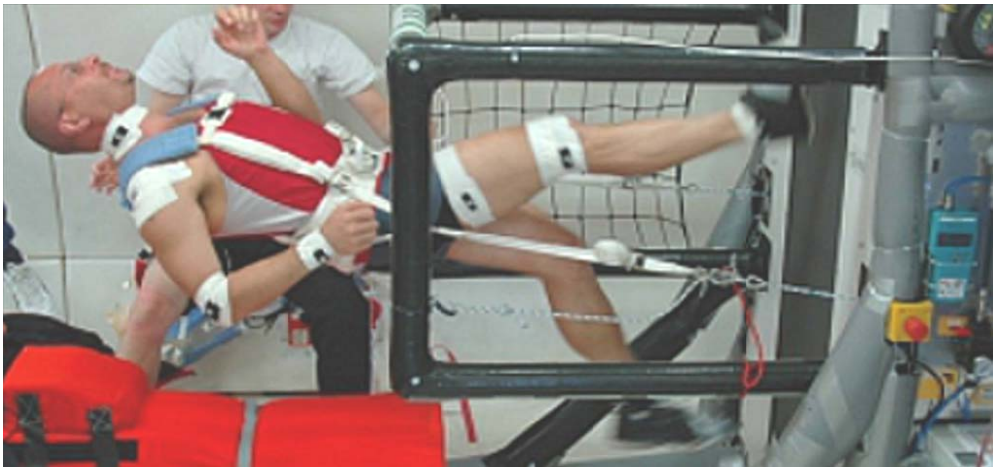
Subject Loading System (SLS)

Description: Treadmill exercise is believed to have the most benefits for both muscles and bones of the lower limbs (legs) under weightlessness, because it places the highest possible loads on the human body and is also accompanied by eccentric muscle contractions, despite the lack of gravitational forces. A subject loading system (SLS) is required to restrain a running astronaut to the treadmill's running surface in an approximation of gravity. The SLS system provides a pull-down force to the subject running on the treadmill through tension preloaded ropes that are attached to the left and right side of a special harness.

Characteristics/Specifications

Functional Capabilities	Provide pull-down force to the subject running on the treadmill 178 N to 978.6 N pull-down force ranges
Major Components	Restraining Ropes Belt Transmission Mechanism Pneumatic System Compressor Avionics
Supporting Hardware	Second Generation Treadmill (T2)

Provider/Sustaining	ESA
Users	Medical Operations Human Research Program
Countermeasure Readiness Level	7
Ground/Flight	Flight
Vehicle/Location	ISS Node 3 – anticipated



(Subject Loading System integrated with the T2 Treadmill during parabolic flight testing – May 2010)

Resisitive Vibration Exercise (RVE)

Description: The RVE combines resistive exercise with whole body vibration. RVE can be used for lower leg, thigh, and hip exercise. The aim is to perform short bouts (< 7 min) of strengthening exercise as a countermeasure against leg muscle atrophy and bone loss.

Characteristics/Specifications

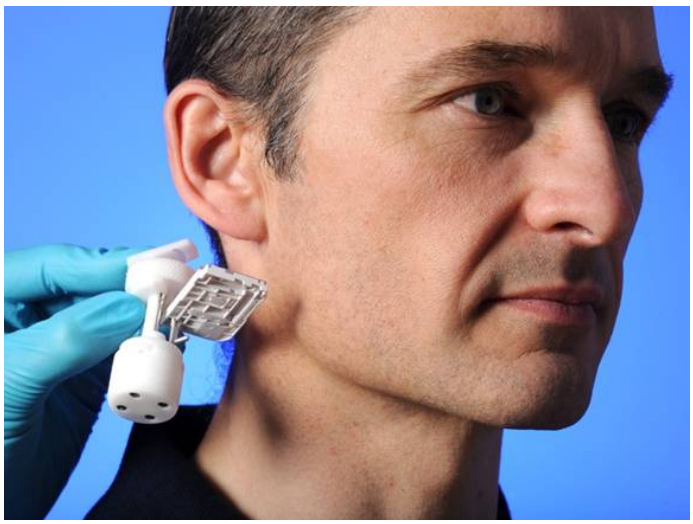
Functional Capabilities	Provide recumbent aerobic exercise (ergometer) 5 – 30 Hz 8 mm peak-to-peak displacement
Major Components	Vibration Unit (platform) Subject Loading Unit Bed for Subject Support Control Panel for vibration unit Control Panel for subject loading unit (for force and position) Measurement Unit for force and displacement Electrical Power Unit
Complementary Hardware	Heart Rate Monitor 2 (HRM2) Muscle Atrophy Research and Exercise System (MARES) device
Provider/Sustaining Users	ESA/DLR Medical Operations Human Research Program
Countermeasure Readiness Level	7
Ground/Flight	Ground
Vehicle/Location	Novotec Medical, Pforzheim, Germany

Earlobe Arterialized Blood Collector (EAB C)

Description: The EAB C has been developed to obtain samples of blood from the arterioles of the ear in a microgravity environment. Arterialized blood measurements under certain circumstances are equivalent to arterial blood measures and thus offer a clinical diagnostic capability without the need for puncturing arteries. The device has been developed to work in conjunction with the i-STAT portable blood analyzer, currently in use on the ISS. Obtaining blood in this manner from the ear does not require a physician or detailed training and offers not only a clinical benefit but also health monitoring potential for example through the acquisition of blood lactates measurements during exercise. Device currently undergoing R&D, with plans for scientific assessment on the ISS in 2011.

Characteristics/Specifications

Functional Capabilities	Perform standardized Arterialized Blood Collection Simple operation for collection Embedded cutting, collection and analyses modules Grip & Rotate operation 4 mm × 2 mm incisions (l × d)
Major Components	Main Body • Front Clip for earlobe fixation • Module compartment with spring • Inner Shaft for device closing Cutting Module • Ophthalmic Blade • Blade Adaptor Collection Module • Metal clip adaptor • Capillary tube adaptor for blood conduction • Blood Analyses Cartridge (Abbott)
Supporting Hardware	Abbott i-STAT portable blood analyzer and associated cartridges
Provider/Sustaining	ESA
Users	Present – R&D subjects. Future – all crew where indicated
Countermeasure Readiness Level	6/7
Ground/Flight	Ground
Vehicle/Location	NA



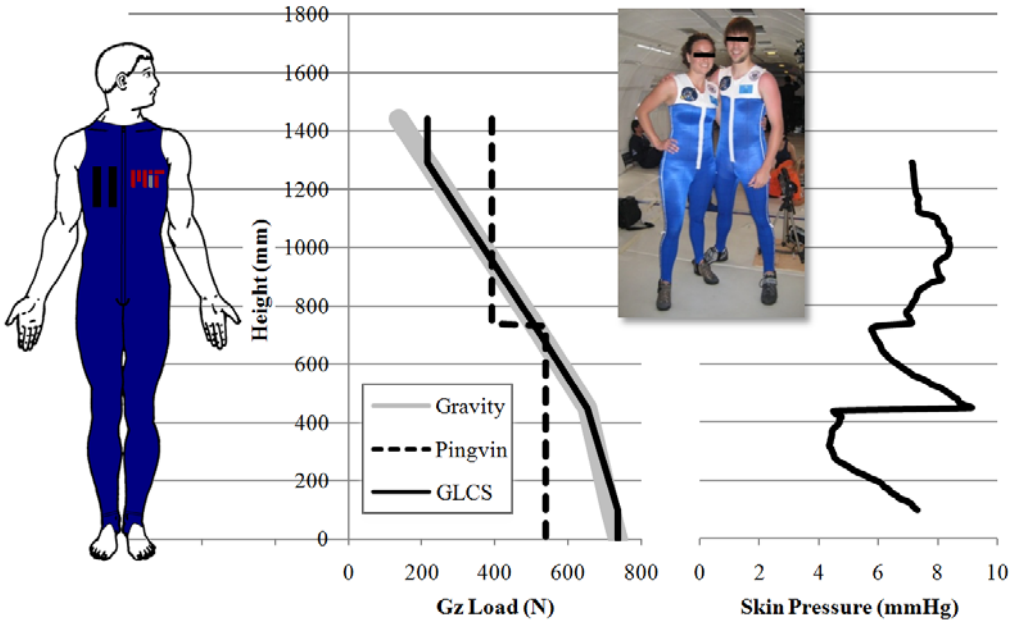
Gravity Loading Countermeasure Skinsuit (GLCS)

Description: The GLCS aims to apply loading on the body to mimic standing and - when integrated with other countermeasures - exercising on Earth. Compared to the 1- or 2-stage Russian Penguin Suit, the elastic mesh of the GLCS can create a loading regime that gradually increases in hundreds of stages from the shoulders to the feet, thereby reproducing the weight-bearing regime normally imparted by gravity with much higher resolution and comfort. The intention is for the skinsuit to offer 1-G long axis loading on orbit, and to be adjustable to complete loading to 1-G when worn on the surface of the moon or Mars. Modeling has shown that the skinsuit requires less than 10 mmHg (1.3kPa) of compression. Prototype suits have applied ~1-G from the shoulders to the knees, and 0.6-G on the shank. Negligible mobility restriction and excellent comfort properties have been noted during parabolic flights tests, suggesting that crewmembers should be able to work nominally and exercise or sleep while wearing the suit. The suit may serve as a practical 1-G harness for exercise countermeasures and vibration applications to improve dynamic loading. The suit may also provide health care benefits on Earth as an improvement to current physical rehabilitation suits.

Characteristics/Specifications

Functional Capabilities	Provides static gravitational loading Assists dynamic loading as 1-G harness to treadmill/ergometer Provides neuromuscular stimuli to the soles of the feet Resists spinal elongation Provides mild compression on torso/legs to reduce orthostatic intolerance
Major Components	Single Piece, Bi-directional Elastic Mesh Skinsuit Flight Shoes
Supporting Hardware	N/A

Provider/Sustaining	ESA
Users	Current – R&D subjects. Future – all astronauts
Countermeasure Readiness Level	5/6
Ground/Flight	Ground
Vehicle/Location	NA

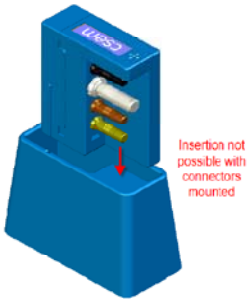


Long-Term Medical Survey System (LTMS)

Description: The LTMS is an ambulatory, wired or wire-less minimally obtrusive recorder of physiology parameters that records for up to 24 hours on the same time-base SpO_2, 2 channels (2-lead) ECG, breath rate, blood-pressure, body temperature. The system offers the possibility to accommodate commercially available sensors, e.g., fingertip or forehead SpO_2, ECG gel electrodes, auxiliary or ear temperature probes, and also custom-made probes for SaO_2 chest measurement, chest core-body temperature index computation and long-duration, low artifact dry ECG electrodes. The body network is wired, hence compatible with use in an ISS-like environment; communication with the data acquisition and processing unit accommodates both wired and wireless capabilities. The ambulatory part of the system is accommodated in a custom-made shirt and can be donned/doffed by one subject without any external help. A ground version accommodates also weight and 4-segment impedance body composition measurement (COTS system). The system is planned to be operational at the Antarctic station Concordia starting 2011.

Characteristics/Specifications

Functional Capabilities	Provide a multi-use platform to measure non-invasively and non obtrusively a suite of physiological parameters – 2-lead ECG, oxygen saturation, blood pressure, index of core body temperature, and body composition.
Major Components	Prototype, ambulatory unit: shirt, active electrodes, active SaO_2 sensor, active body temperature sensing unit, blood pressure Holter, data processing and datalogger unit, battery pack. Possibility to interface COTS sensors for ECG, SaO_2, and temperature. Data download and processing station (PC with custom software)
Complementary Hardware	TBD
Provider/Sustaining	ESA
Users	TBD
Countermeasure Readiness Level	3. 4 targeted by end of 2010, and 5 by end of 2011
Ground/Flight	At the moment, ground use only, prototype with specific electrodes being built, testing, and evaluation is planned to start by July 2010.
Vehicle/Location	N/A



CAD design datalogger and charging cradle. Weight: less than 2 kg with shirt, electrodes and batteries (NiMH)

Note – A possible, future space version, not currently planned, could interface with EPM or similar, for data download and processing, and for the battery charger.

Biofeedback and Virtual-Reality Systems – Enhanced Virtual-Reality System – eVRS

Description: This activity is a technology development. Its objective is to develop and validate the enabling technologies for a multi-purpose virtual reality stimulator platform for cognitive neurophysiology investigations. In a first phase, a flexible software and hardware system, based on the use of virtual reality and multimedia technologies and capabilities has been developed and validated. It supports the implementation of a wide range of experiments protocols in the fields of cognitive neurophysiology. Typical experiments are built for investigating:

- Orientation, depth, and motion perception
- Navigation abilities in 3-D environments
- Multi-sensory integration capabilities
- Vestibulo-ocular coordination in microgravity
- Reaction time measurements visual, aural, on simple and combined stimuli. Reaction time accuracy < 5 ms.

The system provides the user – the scientists with an intuitive and user-friendly (graphical) experiment definition platform allowing them to define experiment protocols and run them instantly, without having to learn any software or macro language. The platform is composed of a software + computer and suite of peripherals: head mounted display or screen, joystick, glove, tracking system, recording devices such as EEG, EMG, ECG, eye-tracking device, subject response input device.

The second phase will integrate new stimulations and features:

- Enhanced reaction time measurement
- Update of stimulations and environments as e.g. 3-D audio stimulations
- Integration of biofeedback loop to allow for e.g. studying response to stress and workload
- Adding and optimising "haptic" stimulation, eye tracking and see-through capabilities
- Design aim: assess the implementation of Clinical Protocols of Evoked Potentials

Characteristics/Specs

Functional Capabilities	Ground prototype of ISS-compatible virtual reality system.
Major Components	Headset (VR or see-through), tracking device, software, computer
Supporting Hardware	In a potential space version: space version: EDR, EMP

Provider/Sustaining	ESA
Users	Medical Operations
Countermeasure Readiness Level	Activity will start Q3 2010. Presently CRL 3. CRL 4/5 targeted at end of phase 2, by Q1 2012.
Ground/Flight	Ground prototype to be available at end of technology development activity.
Vehicle/Location	N/A

Examples of scenes

Japanese Space Agency (JAXA)

Holter ECG

Description: JAXA Holter ECG System is used for Biological Rhythms experiment, which is to analyze 24-hr ECG to monitor cardiovascular and autonomic function of ISS• astronauts. The system is the commercial medical equipment manufactured by Fukuda Denshi.

Characteristics/Specifications

Functional Capabilities	ECG channels – Unipolar and bipolar, 2 and 3 channels • 24-hr recording • Frequency response 0.05 – 40 Hz (HPF 0.67 Hz) • Sampling frequency is 125 Hz Recorder • Dimension – 65 mm (wide) × 62 mm (high) ×18 mm (deep) • Weight – 78 g (including battery and MMC) • Power – 1 AAA Alkaline battery
Major Components	Multi-Media Card (MMC) 64 MB Electrodes
Supporting Hardware	CM-510 Holter Software

Provider/Sustaining	JAXA
Users	JAXA Space Biomedical Research Office (J-SBRO)
Countermeasure Readiness Level	9
Ground/Flight	Flight
Vehicle Location	ISS/Stowed location: Japanese Experimental Module (KIBO)