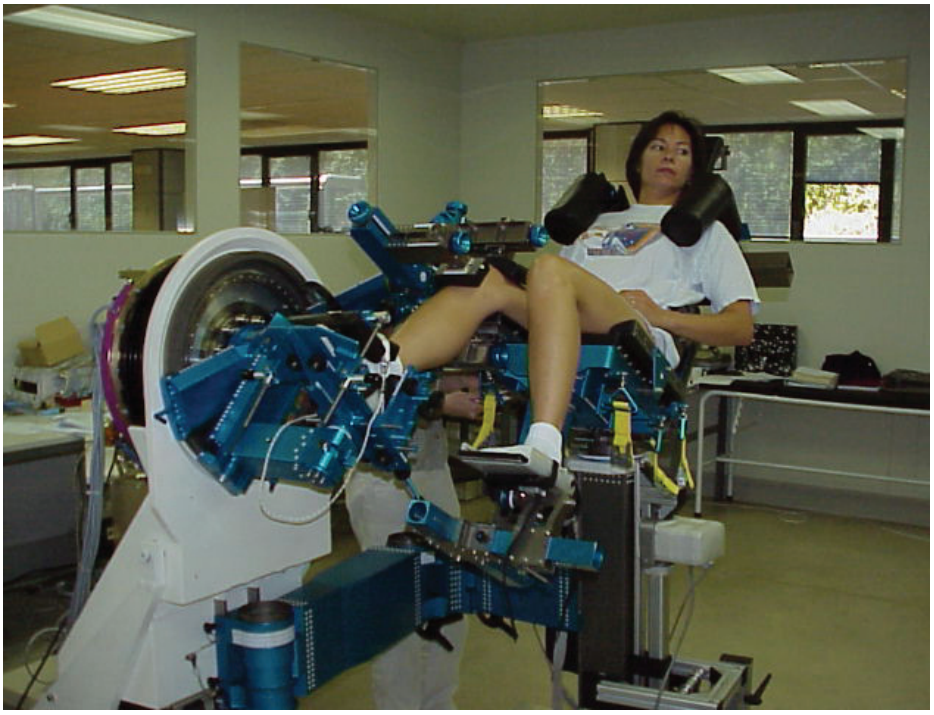
→ COUNTER MEASURE DEVICES

Exercise devices on the International Space Station

On board of the International Space Station are several exercising devices to support muscle and bone strength of the astronauts during long-term space flights. Four of them are: Flywheel Exercice Device (FWED), Muscle Atrophy Research and Exercise System (MARES), T2 COLBERT treadmill and Advanced Resistive Exercise Device (ARED).



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COLBERT and ARED

COLBERT

OBJECTIVES

COLBERT stands for T2 Combined Operational Load Bearing External Resistance Treadmill.
The T2 treadmill is the second installed aboard the Space Station. Astronauts during long-term missions have to perform exercises up to 2 h daily to prevent muscle and bone degeneration under the conditions of weightlessness. The first treadmill, already in space can handle the load of three crew members, but would not be enough for an expanded Station crew of six.

UTILISATION

The T2 has data collection devices that will allow doctors and scientists to see how well the treadmill exercise is minimizing the amount of bone and muscle density loss due to life without gravity. They are using data on treadmill speed, session duration and body loading.

COLBERT's maximum speed is 20 km per hour while most crew members will run about 6 to 13 km an hour. The runner is fixed to elastic straps that fit around the shoulders and waist to keep the runner on the running surface.

The treadmill is equipped with a system to stop the vibrations and disturbing the microgravity environment on the Space Station. While the first Station treadmill relied on a powered system of gyroscopes and mechanisms to reduce vibrations, the COLBERT's Vibration Isolation System was designed to work without power and be more reliable than its predecessor. The treadmill is resting on springs that are hooked to dampeners. That unit is connected to a standard-sized rack that has been extensively reinforced to handle the power produced by T2 users. The rack alone weighs 1000 kg, which is its limit. COLBERT is louder than the first treadmill, but this was necessary to increase its reliability.

T2 was launched by Space Shuttle Discovery STS-128 mission from Kennedy Space Centre 28 August 2009.

COLBERT was first mounted inside the Harmony module (Node2) in September 2009, which connects the European and Japanese laboratories on the Station. The treadmill rack will be on the floor of the Node. Later, COLBERT was moved to its permanent place into Tranquility, the Station's third Node, which was launched aboard STS-130 in February 2010.
The treadmill is designed to last 240,000 km of running what is expected to cover the life time of the Station.

COLBERT treadmill and its parts are packed for loading into the Multi-Purpose Logistics Module Leonardo in preparation for launch to the International Space Station.

ARED

OBJECTIVES

The Advanced Resistive Exercise Device (ARED) is a versatile machine that can be used to perform different customized exercises for which, it has been necessary to use different machines previously. ARED is conceived as a means of helping astronauts and others to maintain muscle and bone strength and endurance in low-gravity environments.

The ARED is a fairly simple, robust machine. It is designed to enable the user to perform the three primary resistive exercises, for stimulating bone regeneration and exercising the major muscle groups. It also has the ability to perform 15 other exercises for secondary muscle groups. For the original low-gravity application, it is required to simulate the lifting of weights in normal Earth gravitation, and to have an operational life of 15 years.

UTILISATION

The Advanced Resistive Exercise Device will not take up a rack location in Node 3 but will still be located in the new module. It was developed to improve existing ISS exercise capabilities. It mimics the characteristics of traditional resistive exercises (weighted bars or dumbbells) by providing a more constant force throughout the range of motion. It offers traditional upper and lower-body exercises, such as squats, dead lift, heel raises, bicep curls and bench press.

The ARED uses vacuum cylinders to provide concentric workloads up to 270 kg, with an eccentric load up to 90% of the concentric force. It also provides feedback to the astronaut during use and data to the NASA exercise physiologists. Flight surgeons, trainers and physiologists expect that the greater loads provided by ARED will result in more efficient and effective exercise, thereby preventing the muscle and bone loss that astronauts sometimes experience during long missions.

Astronaut Sunita Williams runs on the first treadmill installed on the International Space Station. Engineers applied lessons from the first treadmill when they designed the COLBERT.

Flywheel Exercise Device (FWED)

OBJECTIVES

The Flywheel Exercise Device (FWED) is used in human physiology studies of muscular and skeletal systems to prevent muscle atrophy, bone mineral density loss and impairment of muscle function in human beings in response to long duration in weightlessness. The Flywheel Exercise Device (Flywheel) is a non-gravity dependent exercise device that has been designed for resistance exercise training primarily to counter neuro-muscular de-conditioning. The Flywheel provides resistance against the subject through the use of a spinning mass which must be rotated by winding up and releasing an actuation belt.
Additionally, FWED is a compact lightweight, resistive exercise device 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 allowing for the squat, dead lift and heel raise and other important exercises.

TECHNICAL/FACILITY DESCRIPTION

The FWED is a strength training system that uses a rotating flywheel that replaces weight plates and other means of resistance training devices that rely on gravity.

The Flywheel Exercise Device was launched to the ISS together with the Columbus module in order to become an advanced exercise device for ISS astronauts and serving human physiology investigations in the area of advanced crew countermeasures. The current model in use is a prototype for a future standard model which it will also be possible to deploy on long-term missions to Moon and Mars.

UTILISATION SCENARIO

FWED will be used in the Columbus module on board the International Space Station.
The expected lifetime of the Flywheel will be 10 years.

OPERATIONAL CONCEPT

The FWED will be operated in the centre aisle of the ISS and stowed in a rack when not in use.

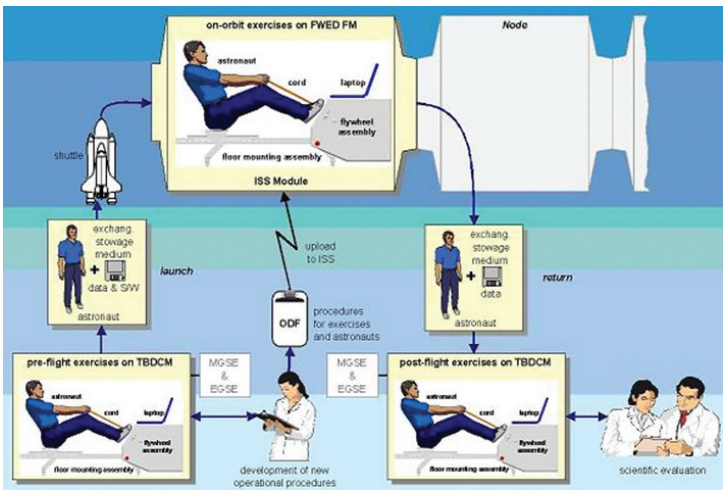
FLYWHEEL ON THE INTERNATIONAL SPACE STATION

On 26 October 2009 ESA astronaut and ISS Commander Frank De Winne unstowed the elements of ESA's Flywheel Exercise Device from the European Transport Carrier in the Columbus Laboratory, connected up a laptop (to record exercise device measurements) to the European Physiology Modules facility and assembled the roughly 10 parts of the new exercise device for the ISS crew in order to carry out a first functional checkout.

In order to take structural dynamics measurements during the check-out activities De Winne installed a sensor enclosure from the Space Acceleration Measurement from the Kibo Laboratory on the front foot of the Flywheel Exercise Device. The check-out was successfully performed by De Winne on 28 October, with the execution of four series of exercises with different settings. The complete data files were transferred to ground. The Flywheel was stowed later.

The purpose of the FWED check-out was to verify the proper operational use of the hardware onboard the ISS and assess a subset of the FWED exercise modes from an operational point of view and with regard to vibrations.

The Flywheel device.



Operations Plan for the Flywheel device.

Muscle Atrophy Research and Exercise System MARES

OBJECTIVES

MARES is a general-purpose instrument for (neuro-) muscular and exercise research on the International Space Station. MARES 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. This is done during exercises, while the MARES motor puts a programmed load on the astronauts movements. With MARES, it is possible to easily set up an experiment to investigate the effect of the adaptation of the neuromotor control system to microgravity.

MARES can be used for investigation to look at the capability of a human subject to regulate his muscular force in order to follow a predetermined positional target, while being challenged by changing loads of three different kinds: a randomly varying inertial load, a randomly varying viscous load, and a randomly varying elastic load.

UTILISATION

MARES is mainly intended for research, but it can work as well as an exercising device. It is an ideal tool to do research on the efficacy of countermeasures.

With MARES, it will be possible to include in a countermeasure exercise routine, an exercise based on the bench press movement.

An appropriate Experiment Procedure guides the astronaut through four series of movements consisting of ten repetitions each:
The subject prompted to perform 10 concentric isokinetic flexion movements at 0.5 m/s.
Then 10 eccentric isokinetic flexion movements, aiming for a target force of 200 Newton.
After each flexion movement MARES will bring back the bar to the full extension position.
Followed by two series of similar extension movements.

The efficacy of different types and/or levels of resistances, using different BMU's (isotonic, spring, inertial, friction, etc.), can be investigated.

At the end of the exercise, a report appears on the laptop screen presenting also data from previous training sessions. This would allow the subject to monitor the evolution of his/her performance.

OPERATIONAL CONCEPT

MARES is a component of the Human Research Facility in the US laboratory Destiny. It is aisle mounted and has interfaces to the US Lab or Columbus Laboratory. Sensors, direct drive motor, battery and electronics are housed in the "Main Box". Chair and human adapters provide the subject restraints. The Microgravity Isolation Frame, to which the Main Box attaches, minimises disturbances to other payloads.

MARES uses the Human Research Facility portable computer (HRF PC) for interacting with the subject/operator.

MARES is capable of acquiring data, controlling and providing power to external devices (HRF PC, PEMS, EMG amplifiers, etc.), and transfers real time data to the rack mounted Workstation for downlink. It is capable of 1 hour of stand-alone data collection.

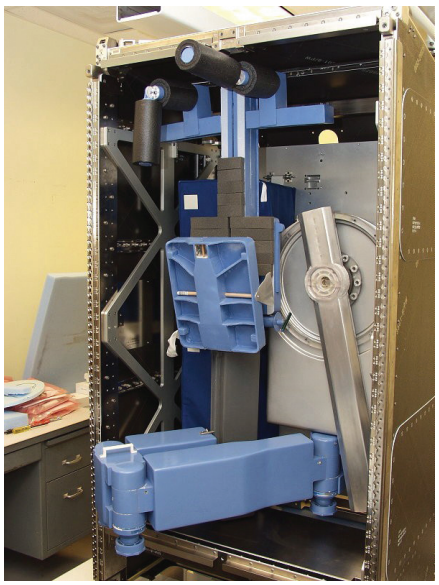
When not in use, all of MARES' elements will be stored inside the HRF rack.

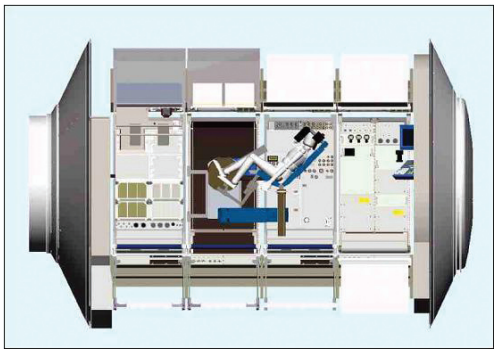
MARES has been launched on 19A flight with Space Shuttle Discovery STS-131 from KSC (Kennedy Space Center) on 5 April 2010.

The operations of MARES are performed by NASA's Marshall Space Flight Center in Huntsville, Alabama in the USA.

ESA-Astronaut Andre Kuipers is training on MARES.

MARES in stowage configuration.





Position of MARES inside Destiny.

Illustrations: ESA/NASA