European Modular Cultivation System (EMCS)

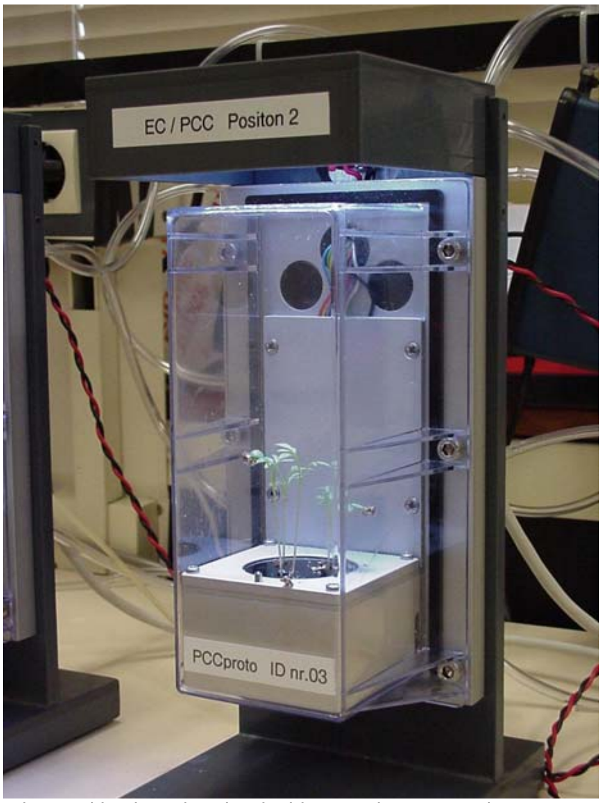
The EMCS will be flown to the ISS on the STS-121 Shuttle mission. It is an ESA experiment facility dedicated to biological experiments, with several experiments already planned dealing primarily with the effects of gravity on plant cells, roots and physiology. These types of experiments will help to provide new knowledge about growth processes in plants and have the potential for making improvements in food production techniques on Earth and in space. This will hold benefits for astronauts on longer-term missions such as an expedition to Mars as part of ESA's Aurora programme. Experiments with insects or amphibia and studies with cell and tissue cultures are foreseen in the EMCS as well. The ESA astronaut will be involved in the accommodation of the EMCS in an Express Rack in the US Destiny Laboratory.

ESA astronaut Reinhold Ewald inserting an experiment container into the EMCS Engineering Model. (Image: ESA)

The EMCS consists of a gas tight incubator where the humidity and composition of the air, temperature, light, water supply and a number of other parameters will be closely monitored and controlled. It contains two centrifuges, each one with space for four experiment containers. Each experiment container has an internal volume of 60 x 60 x 160 mm with a transparent cover. White light or infrared LED illumination is available for each single container. Video cameras are available for experiment observation. Each centrifuge can be programmed individually to provide from 0.001g up to 2g in weightlessness.

Video, data and command lines will allow experiment control by the ISS crew and from the ground.

During flight, equivalent ground control experiments may be performed inside dedicated experiment Reference Models, one located at the Norwegian User Support and Operations Centre in Trondheim, Norway, the other at the NASA Ames Research Center in the United States. The flight unit also provides the potential for 1g control experiments on board the ISS.



Plant Cultivation Chamber inside experiment container as part of Experiment Reference Model hardware.

The first experiments to take place within the EMCS include molecular and physiological analyses of a type of cress (Arabidopsis), and the short- and long-term effects of weightlessness on the development of rotifers and nematodes.

The scientific utilisation of the EMCS will be carried out in co-operation with the NASA Ames Research Center. EMCS is developed under ESA contract by an industrial team led by the company EADS Space Transportation (Friedrichshafen, Germany). Although it is provided as part of a barter agreement with the United States, European access is also possible.

MELFI (Minus Eighty - degrees - Laboratory Freezer for the ISS)

The Minus Eighty (Degrees) Laboratory Freezer for ISS (MELFI) will also be flying to the ISS on the STS-121 mission. It is a rack-size facility which will provide the Space Station with refrigerated volume for storage and fast freezing of life science and biological samples. It will also ensure the safe transportation of conditioned specimens to and from the ISS by flying in fully powered mode in the Multi-Purpose Logistic Module (MPLM) installed in the Shuttle's cargo bay. MELFI was designed for an operational lifetime of 10 years, with each continuous mission lasting up to 24 months. MELFI has also been qualified for 15 launches.

The ESA astronaut will be involved in commissioning activities when it arrives at the ISS and will also use the facility for storage of samples from the physiology experiments CARD and Immuno. The samples can be stowed in four compartments (dewars), whose temperature can be independently controlled at different levels (-80, -26, +4 ^{o}C). Each dewar is a cylindrical vacuum insulated container, having an internal volume of about 75 litres, divided internally in four sectors. Each sector hosts one tray, which can be extracted without disturbing the samples in the other three. MELFI provides standard accommodation hardware for the insertion of samples of different shapes and sizes.

The MELFI cooling system has been the subject of a very intense technology development programme. In particular, the sophisticated cooling machine, which is able to provide the required temperatures while using very limited power (less than 1 kW in the worst case). It is mounted within a complex enclosure, called the Cold Box, in order to minimize any thermal loss and contamination of the cooling fluid. The Cold box contains in addition two heat exchangers, consisting of a total of 10 km of piping.

The cooling machine is designed to be an Orbital Replacement Unit. It can be dismounted from the Cold Box with the help of dedicated tools, in less than eight hours, allowing the preservation of specimen even in case of machine failures. In order to improve the reliability and availability of the freezer, the present launch configuration includes a spare electronic unit and a spare cooling machine. The cooling fluid is high purity nitrogen. All the lines and components through which the nitrogen flows are double walled, with high vacuum and multi-layer insulation in between the two walls. This allows maintaining the selected temperature for up to eight hours even without power.

The present launch configuration of MELFI includes the MELFI On-Orbit Commissioning Experiment (MOOCE), also developed by ESA. This will be carried out few weeks after installation to monitor the thermal behaviour of one of the compartments. MELFI will be immediately used to store samples processed in e.g. the Human Research Facility.

Second MELFI flight unit at the Kennedy Space Centre in 2004 with Expedition 11 Crew: Sergei Krikalev (background) and John Phillips (foreground).

Upon arrival to ISS, MELFI will be transferred to its location within the US Destiny Laboratory and will be ready to start its service life.

MELFI was developed by the European Space Agency (ESA) in the frame of international barter agreements. Two flight units have been supplied to NASA and one the Japan Aerospace Exploration Agency (JAXA). In addition, ESA has delivered to NASA ground units for training and experiments preparation and will provide the necessary spares and sustaining engineering to maintain MELFI for up to 10 years of operations.

EADS- ASTRIUM (France) led the Industrial Team including L'Air Liquide (France), LINDE (Germany), Kayser-Threde (Germany) and ETEL (Switzerland).

Microgravity Science Glovebox

Pedro Duque during operations for the PROMISS experiment in the Microgravity Science Glovebox during the Cervantes mission. 20 October 2003. (Image: NASA)

The Microgravity Science Glovebox was the first European ISS-Rack Facility that was launched to the International Space Station in 2002. The device will allow astronauts aboard the ISS to perform a wide range of experiments in a fully sealed and controlled environment, completely isolated from the rest of the Station. It is currently installed inside the US Destiny laboratory, though will be transferred to the European Columbus laboratory following its launch in 2007.

It has been used successfully during several Soyuz Missions to perform Physical Sciences experiments and was recently used by Bill McArthur, the ISS Expedition 12 Commander, to perform the PROMISS-4 experiment, an experiment that was historically developed in the frame of the Belgian Odissea Mission in 2002 with ESA astronaut Frank De Winne, and has evolved since then to a versatile instrument for the protein crystallisation science community.

When the STS-121 crew arrive at the ISS they will carry out maintenance on the Microgravity Science Glovebox. The main window and seals will be exchanged to ensure the extension of its certification. Several European payloads, currently under development, will be installed and operated within the Microgravity Science Glovebox in the next years.

Percutaneous Electrical Muscle Stimulator (PEMS)

The Percutaneous Electrical Muscle Stimulator. (Image: ESA)

The Percutaneous Electrical Muscle Stimulator (PEMS) will be flying to the ISS on the STS-121 Shuttle mission and will be checked out by the ESA astronaut as part of his scheduled activities.

PEMS is a self-contained device, the purpose of which is to deliver electrical stimulation to non-thoracic muscle groups of the human test subject, thereby creating contractile responses from the muscles. Its main purpose is to support human neuromuscular research. The device can provide either single pulse or pulse trains with two selectable pulse widths and variable amplitudes.

PEMS is portable, and designed to be used in conjunction with other physiological instruments, in particular the Muscle Atrophy Research and Exercise System (MARES). PEMS will be checked out and commissioned in the US Laboratory. Eventually PEMS should be used together with the MARES in the European Columbus laboratory after it arrives at the ISS, currently scheduled for 2007.

The Percutaneous Electrical Muscle Stimulator was developed by the Swiss company Syderal. This is a second generation of the PEMS device, the first generation PEMS having flown on the Space Shuttle in 1996.

Pulmonary Function System (PFS)

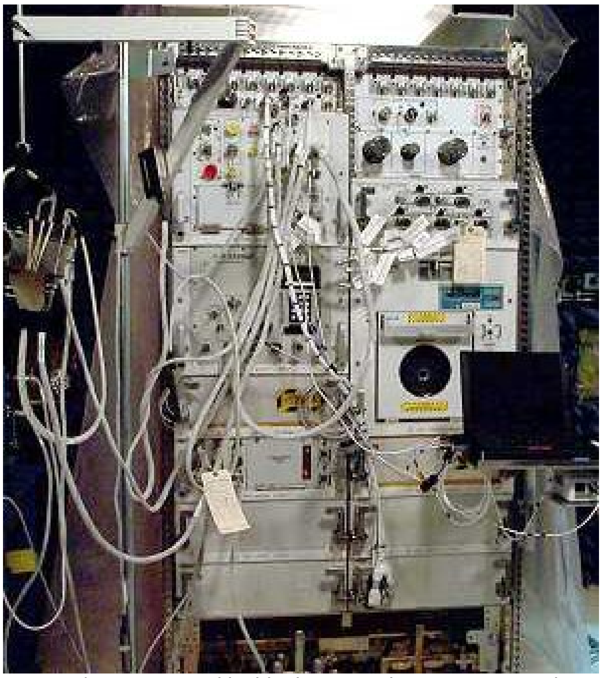
The Pulmonary Function System is an ESA-developed device that analyses exhaled gas from astronauts' lungs to provide near-instant data on the state of crew health. It was launched to the ISS on the STS-114 Return to Flight mission and was successfully commissioned by the Expedition 11 and 12 Crews.

The ESA-developed PFM/PAM units for the Pulmonary Function System in operational mode

Seven different gases can be measured simultaneously, with several measurements being made within a single breath. This will provide a lot of information about the subject's lung function, blood flow and entire cardiovascular system.

PFS will also be subject to a software and hardware upgrade, thereafter being used to perform the mandatory Personal Fitness Evaluation with Oxygen Uptake Measurements (OUM) from crew member medical operations. During the Astrolab mission the ESA astronaut will use the PFS to perform the CARD experiment.

The PFS is a collaboration between ESA and NASA in the field of respiratory physiology instrumentation. This is accommodated in the NASA Human Research Facility located in the US Destiny Laboratory on the ISS. The PFS consists of four separate components, two developed by ESA: The Pulmonary Function Module (PFM) and the Photoacoustic Analyser Module (PAM); and two developed by NASA: the Gas Delivery System and the Gas Analyser System for Metabolic Analysis Physiology. These four elements can be combined in two different configurations to provide a variety of different measurements.



PFM/PAM mounted inside the second Human Research Facility rack (HRF-2)

The PFM/PAM Unit consists of the Respiratory Valve Unit, with associated flow-meters, rebreathing bag, etc., and an electronics unit. The electronics unit is accommodated in a standard ISS drawer in the Human Research Facility rack, though there is a mode of operation in which this drawer is removed from the Human Research Facility rack and operated externally.

PFS is the first flight hardware developed by the Microgravity Facilities for Columbus Programme as part of the European Physiology Modules project, originally planned for launch in the Columbus Laboratory. The hardware was developed for ESA by the Danish company Damec.

Following great interest shown by NASA, ESA was offered an earlier flight opportunity to launch the PFS as part of the second NASA Human Research Facility to be installed on the ISS. The PFS flew to the ISS on the STS-114 Return to Flight Shuttle mission. The PFS will be relocated into the Columbus laboratory when it arrives at the ISS in 2007.