Operations and Utilisation

Accommodation & Transport

After selection of the experiments in the frame of an international Life Science Research Announcement (LSRA) for all European Experiments the Experiment Unique Equipment (EUE) is developed under ESA contract by EADS-ST Friedrichshafen, Germany. This hardware development is done in close cooperation with the investigators. The standardised ECs are ESA provided. The final preparation for European experiments will be performed at the EMCS N-USOC in Trondheim, Norway and then sent to Kennedy Space Center. It should be emphasised that the samples have to stay in a safe transport condition for several days before they can be loaded into EMCS due to the transport time to the Space Station.

Operational Concept

For experiment verification and ground control experiments, two Experiment Reference Models (ERM) will be provided, one at the Facility Responsible Centre - FRC at the University of Trondheim, Norway, the other at NASA Ames Research Center at Moffett Field, California (USA).

The objectives of the ERM are:

- test and verification of EMCS experiment protocols with life samples;
- 1-g ground reference experiments parallel to flight experiments;
- validation of experiment specific software running at the EC internal microcontroller;
- writing, testing and verification of the experiment specific schedules;
- experiment definition studies.

To achieve these objectives, the ERM is equipped with flight identical features (temperature, humidity, gas composition, pressure, water supply, illumination, observation, power and data handling), but the system configuration is different due to the direction of the g-vector on ground: the ECs are not mounted on rotors, but on a static shelf with the same direction of the illumination and of the g-vector as on the centrifuge platter in the Flight Model. Prior to the ERM, a Test Bench had been established under ESA contract at the University of Trondheim, Norway (Prof. T.H. Iversen) to validate various aspects of experiment development with plants: plant cultivation chambers, gas supply & monitoring; temperature; liquid supply; illumination; observation; contamination prevention; biocompatibility of lubricant and gas removal system; vibrations; electromagnetic interference.

After development and testing of the experiment specific hardware (e.g., biocompatibility, vibrations, off-gassing, electromagnetic forces), a final interface test will be done in the Experiment Reference Models - to assure flight readiness of the experiment. During flight, ground control at the two Facility Responsible Centres in Norway and the USA will be performed in the ERM together with potential 1-g controls on board. The scientific utilisation of the EMCS will be carried out in co-operation with NASA Ames Research Center.
After flight, the experiment is handed back to the investigator for evaluation.

EMCS is developed under ESA contract by an industrial team led by the company EADS-ST Friedrichshafen (Germany). The Flight Model was delivered to NASA in July 2002.

Schedule

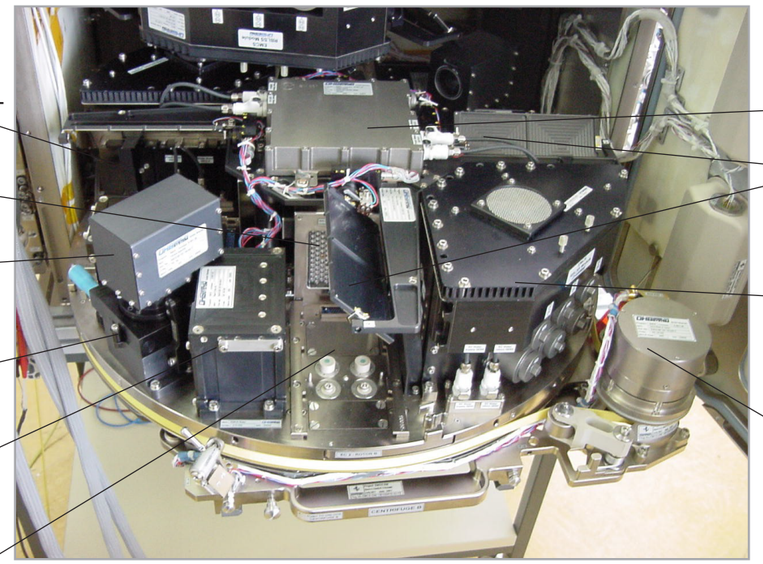
EMCS will be operated during a two-year period on board the US Destiny Laboratory. It is designed to fly in NASA Express Rack 6. The launch of the EMCS will be on board of Utilisation Flight UFL 1.1, currently scheduled for after 2005.

Photos: ESA

European Modular Cultivation System (EMCS)

Biological facility for multi-generation cultivation research on the International Space Station

The EMCS is a new ESA gravitational biology payload dedicated to experiments on plants, especially multi-generation (seed-to-seed) experiments and studies on gravity effects on early development and growth, on signal perception and transduction in plant tropisms. Experiments with insects, amphibia, and invertebrates as well as studies with cell and tissue cultures are also foreseen in EMCS.

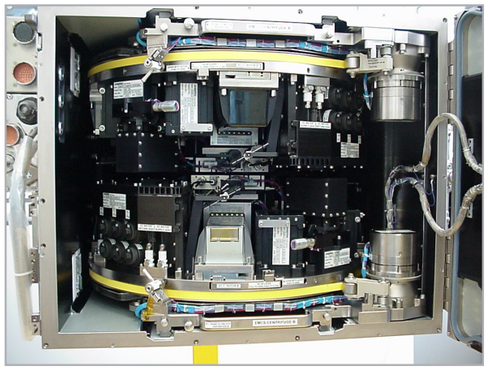


esa	PROJECT : **International Space Station**		
TITLE: **European Modular Cultivation System**		DOCUMENT N° EUC-ESA-FSH-045	REV. 1.0

Facility Description

EMCS consists of a gas tight incubator containing two centrifuges with space for 4 Experiment Containers - ECs on each rotor; also the life support and water supply system, the illumination and the observation system are located on the rotors. External to the incubator are the Standard Payload Computer (SPLC), the gas supply module and the thermal control system. The flight unit is accommodated in NASA's Express Rack # 6 for the Destiny Laboratory on the International Space Station occupying a volume of four Shuttle Middeck Lockers with the associated control electronics contained in an International Subrack Interface Standard (ISIS) drawer. Video, data and command signals will allow experiment control by the Space Station crew as well as from the ground.

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



View into the EMCS incubator with its two centrifuges.

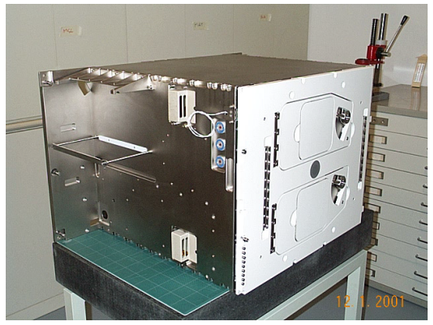
Scientific Objectives

The main research focus with the EMCS facility is on plant biology. EMCS will support understanding of:
- Long term growth stability in plants including multi-generation studies (seed to seed)
- Early development events in plants
- Gravity influence on early development and growth (g-level threshold research)
- Perception and signal transduction in plant tropism
- Possibility for research on small animals, tissues and cell cultures, also on radiation effects.

EMCS provides a promising next step in the development of advanced facilities dedicated to biological research in space. It builds upon the experience gained by ESA in flying similar facilities over the last two decades.

Incubator

The incubator is housing all parts of EMCS and provides a gas tight, thermally controlled environment to the Experiment Containers (EC). The gas atmosphere is common to all 8 ECs and is composed of an air mixture of 30 % oxygen/70 % nitrogen and carbon dioxide, stored in gas bottles, and of pure nitrogen, originating from the Space Station. Additional items like glovebox, stowage, cooler and freezer are available elsewhere on the Space Station. Television, data and command lines allow experiment control by the crew and from ground (telescience).

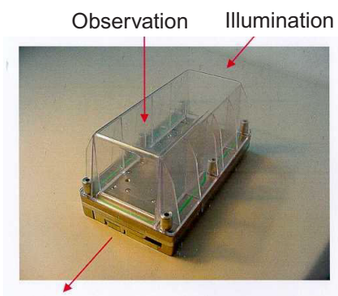


The outer holding structure of EMCS.

Experiment Container

In addition to power and data lines and inlet/outlet gas connectors, the EC baseplate also has quick-disconnects for water supply from the fresh-water reservoir and removal to the waste-water reservoir on the rotor. Nutrients for plant growth are added within the EC to prevent contamination of the water reservoir. Any particulates in the air stream going into the EC from the incubator air volume will be trapped in membrane filters (0.2 µm pores) at the EC inlet. Each EC also has sensors for monitoring temperature and pressure. The internal volume (0.58 litres) is available for experiment hardware and plant specimens of up to 60 x 60 x 160 mm. The EC's large size allows the installation of highly automated hardware to support, for example, the growth of plant cultures without the need for astronaut interaction or the fixation of samples.

Feasibility studies have been performed by ESA for Experiment Support Equipment - ESE to help designing experiment specific hardware for insect cultures, small aquatic animals, cell cultures, (phase contrast) microscopes, a gentle agitation bioreactor and a microprocessor.



Specifications

Experiment Container:	**Atmosphere provided to all containers:**
Internal Volume: 60 x 60 x 160 mm	Oxygen 15 - 22 %, ± 0.5 %
Transparent cover for illumination and observation	Nitrogen difference up to 100 %
Sensors for temperature, humidity and pressure	Carbon dioxide 0 - 0.2% (± 0.01 %) or 0.2 - 5.5 % (± 0.3 %)
Controlled atmosphere and water supply	Ethylene removal
Single shot valves to isolate container during fixation	Air flow ~300 ml/min at EC inlet
Connection for power and data handling system for monitoring and control of experiment dedicated instrumentation.	**Humidity control selectable for each container:** 50 - 95 % relative humidity, 30 % in drying mode
2 analogue channels for experiment data	Pressure inside EC 60 hPa above ambient
4 digital in/out channels for experiment data 1 RS485 bus for experiment data and commands	**Temperature:** controlled in the range 18 to 40°C ± 0.5° C Video camera with 5 x zoom, resolution < 0.1 mm
Analogue NTSC video line for 2 of the 4 containers per rotor	Video frame grabber and text insertion

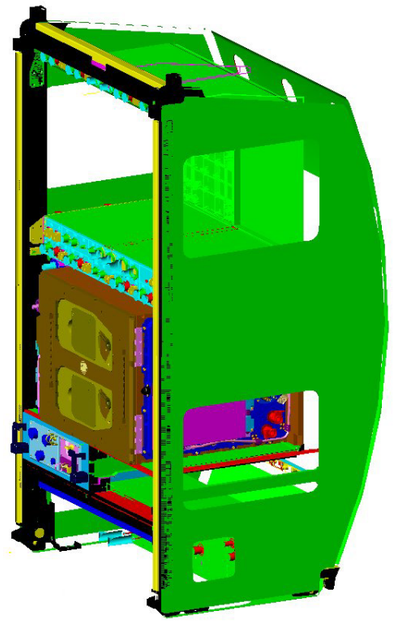
Centrifuge:
4 interfaces for Experiment Containers on each centrifuge, long axis (160 mm) in radial orientation
Life-support system for air humidification/dehumidification controlled individually for each Experiment Container
Central reservoir for fresh and waste water (each 250 ml)
Common illumination (white light or infrared) for all containers
1 array of light emitting diodes per container (75 W/m^2) for photosynthesis
Infrared illumination for "dark" observation (> 880 nm)
1 movable video camera for 2 ECs each, one video signal at a time transmitted per rotor
4 tilting mirrors for observation of the container interiors

Centrifuges

Two identical rotors, both with programmable rotational speed, providing 0.001 g to 2.0 g or microgravity level when not rotating. Normally, one centrifuge rotates and is held fast as the microgravity platform or it provides variable g-levels (10-3 - 2g). The second centrifuge rotates at 1.8 rpm to provide the 1g-reference environment for the experiments in space. Both rotors have a diameter of 600 mm.

Atmosphere and Temperature

The entire air volume inside the incubator is conditioned by an Atmopheric Control System - ACS - a gas supply unit, an ethylene removal unit and a sensor module. The humidity is controlled individually at the EC level: air from the incubator is filtered through the EC and conditioned by individual humidifier/dehumidifier units connected to each EC. This system also retrieves the evaporated water from the plants for re-use, avoiding condensation problems.



Accomodation of EMC in NASA's Express Rack in Destiny Laboratory.