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Advances in Space Research 36 (2005) 1162–1166
ADVANCES IN SPACE RESEARCH (a COSPAR publication)
www.elsevier.com/locate/asr

ESA hardware for plant research on the International Space Station

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Received 20 July 2004; received in revised form 26 January 2005; accepted 9 February 2005

Abstract

The long awaited launch of the European Modular Cultivation System (EMCS) will provide a platform on which long-term and shorter experiments with plants will be performed on the International Space Station (ISS). EMCS is equipped with two centrifuge rotors (600 mm diameter), which can be used for in-flight 1*g* controls and for studies with acceleration levels from 0.001*g* to 2.0*g*. Several experiments are in preparation investigating gravity relating to gene expression, gravisensing and phototropism of *Arabidopsis thaliana* and lentil roots. The experiment-specific hardware provides growth chambers for seedlings and whole *A. thaliana* plants and is connected to the EMCS Life Support System. Besides in-flight video observation, the experiments will be evaluated post-flight by means of fixed or frozen material. EMCS will have for the first time the possibility to fix samples on the rotating centrifuge, allowing a detailed analysis of the process of gravisensing. About two years after the EMCS launch, ESA's Biolab will be launched in the European "Columbus" Module. In a similar way as in EMCS, Biolab will accommodate experiments with plant seedlings and automatic fixation processes on the centrifuge. The hardware concepts for these experiments are presented in this communication.

Keywords: European Modular Cultivation System (EMCS); BIOLAB; Experiment hardware; Acceleration studies; Gravitropism

1. Introduction

ESA's contribution to the International Space Station (ISS) for experiments with plants will be the European Modular Cultivation System (EMCS) in the US Destiny Laboratory, and Biolab in the European Columbus Laboratory (Fig. 1). A detailed description of Biolab and EMCS has been given elsewhere (Brinckmann, 1999; Brinckmann and Brillouet, 2000; Brinckmann, 2003) and can be found on the web pages for Biolab at www.spaceflight.esa.int/users/Biolab and for EMCS at www.spaceflight.esa.int/users/file.cfm?filename=fac-iss-dest-emcs. In general, both facilities have an incubator with two centrifuges each allowing microgravity research or acceleration studies in the range of 0.001*g* to 2.0*g*. The experiment containers (2×4 in EMCS, 2×6 in Biolab) are placed by the crew on the centrifuge rotors, where they are connected to the Life Support System with a controlled atmosphere. O_2 and CO_2 concentration can be varied over a wide range, trace gases like ethylene and CO_2 can be removed, and the air humidity can be controlled. The latter is done on an individual container level in EMCS, including a drying capability permitting attainment of 30% relative humidity. The EMCS rotor has a reservoir for fresh

Abbreviations: ABA, Abscisic Acid; cDNA, complimentary DNA; CB, Cultivation Box; EC, Experiment Container; EMCS, European Modular Cultivation System; EUE, Experiment Unique Equipment; ESA, European Space Agency; *g*, Gravity (vector); IAA, Indole Acetic Acid; ISS, International Space Station; LED, Light Emitting Diode; NASA, National Aeronautics & Space Administration; NTNU, Norwegian University of Science & Technology; PCC, Plant Cultivation Chamber.

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0273-1177/$30
doi:10.1016/j.asr.2005.02.019

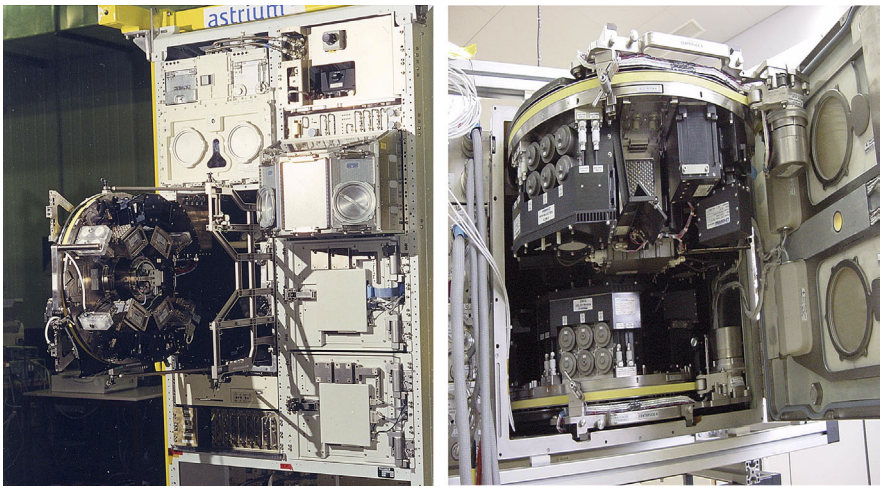

Fig. 1. Biolab (left) and EMCS (right) with one of the two centrifuge rotors (diameter = 600 mm) extracted from the incubator. The BioGlovebox and two cooler/freezer units are on the right side of the Biolab rack; the incubator, handling mechanism, automatic storage and analysis instruments are on the left part of the rack. The EMCS facility consists of an incubator with two rotors, life support system, rotor-based water supply and video/data system. The latter is routed to a dedicated drawer below the EMCS incubator (not shown). On the extracted EMCS rotor, the illumination panel with 143 LEDs is visible behind the empty position of the experiment container. Left of it are located the six filter boxes of the rotor-based life support system.

and wastewater in its center, whilst Biolab uses its robotic Handling Mechanism to supply and withdraw liquids to and from the experiment. Illumination and colour video observations in white and infrared light are possible on the rotors of both facilities.

Since both facilities are designed for multiple users, each Experiment Container (EC, Fig. 2) provides a standard interface to the Experiment Unique Equipment (EUE), which is developed specifically for the experiments. Five plant experiments are presently in

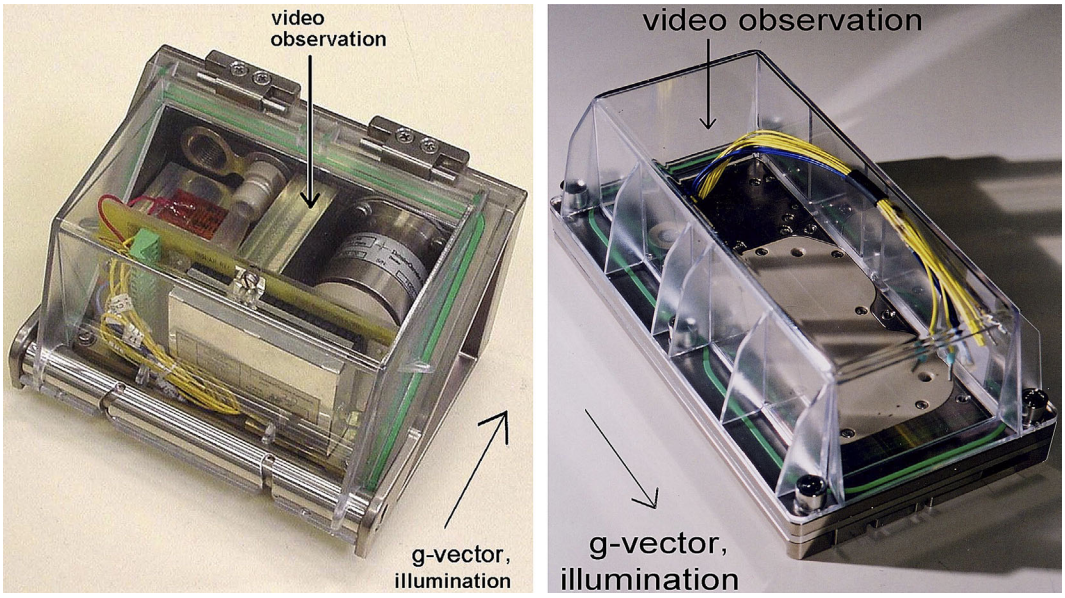

Fig. 2. Experiment containers for Biolab (left) and EMCS (right). The Biolab EC is filled with instrumentation for reference measurements; the EMCS EC is empty and shows the interface plate with threads and the cable harness to accommodate the experiment hardware. The EC bottom plate is the interface to the centrifuge platter. The volume for EUE is in the Biolab EC $60 \times 60 \times 100$ mm (60 mm in g-direction), in EMCS EC $60 \times 60 \times 160$ mm (160 mm in g-direction). The observation direction in both containers is through the cover top, and the illumination is perpendicular to the observation and parallel to the g-vector.