

## Life Science & Fluid Physics Equipment

### Bioreactors

#### Application

Bio-reactors are used to support Life Science experiments on board the International Space Station. The use of rodents (mice and rats) for scientific investigations to bridge the gap between cellular biology and human physiology has been highlighted by the scientific community as well as by most of National Space Agencies. The aim of MDS and MISS is to provide Bio-reactors able to support scientific research in space whose results can be used for both, on-ground applications in clinical practice (diagnosis and therapy) and identification of counter-measures for long-term manned missions. In particular, MDS and MISS will be used for experimentation in the following fields of research:

- Bone physiology
- Neuromuscular investigations
- Neuroscience and Development
- Metabolic studies
- Cardiovascular investigations
- Behaviour

#### Description

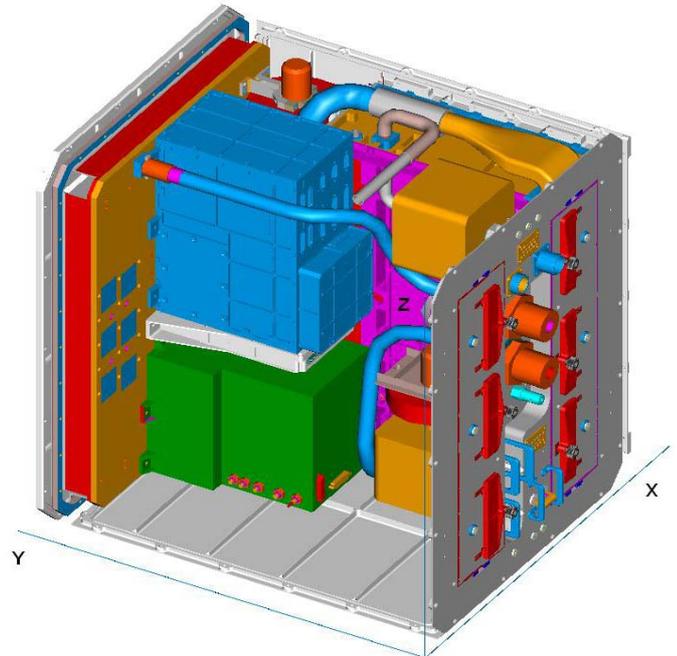
Bio-reactors are defined as those environments able to house living specimen and that provide controlled conditions and services necessary to guarantee their well-being.

During the past years, Scientific Equipment Directorate has acquired and constantly improved the know-how related to the design, development and integration of Bio-reactors for the execution of experiments under weightlessness conditions. This know-how includes the design and development of Bio-reactors related Life Support Systems, necessary to guarantee the well-being of living specimen and to provide controlled environmental conditions.

Due to the high variety of living specimen, Bio-reactors characteristics and applied technologies can be rather different and involve the use of bio-compatible materials, design and development of specific micro-mechanism and Life Support related technologies for air revitalization and conditioning, waste management and food and water delivery.

Mice for a total mass of 900 grams can be accommodated either individually (maximum 30) or in groups for at least 100 days.

The following Bio-reactors are currently under development:



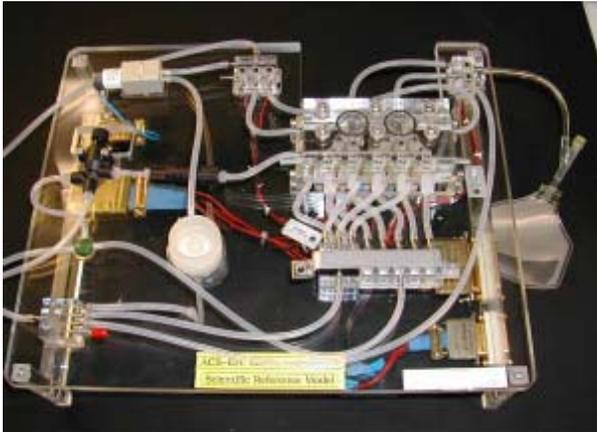
#### Mice Drawer System (MDS):

it supports scientific experiments in several fields of research on board the International Space Station using mice as a model. This Bio-reactor provides basic services for animal well-being according to guidelines and recommendations used for on-ground laboratories. In particular it includes the Air Conditioning S/S for air ventilation and air temperature and humidity control, a Food and Water Delivery S/S to deliver programmable quantities of food and water, an Illumination S/S for light/dark cycle implementation and an Observation S/S for animal monitoring.

Mice for a total mass of 240 grams can be accommodated either individually (maximum 6) or in groups for at least 100 days.

#### Mice on International Space Station (MISS);

it supports scientific experiments in several fields of research on board the International Space Station using mice as a model. This Bio-reactor provides basic services for animal well-being according to guidelines and recommendations used for on-ground laboratories. In particular, it includes the Air Conditioning S/S and the Thermal Control S/S to control respectively the concentration of oxygen and carbon dioxide and the temperature of air provided to mice, a Food and Water Delivery S/S to deliver programmable quantities of food and water, an Illumination S/S for light/dark cycle implementation and an Observation S/S for animal monitoring.



### Rotifers and Nematodes Bio-reactors

they permit to study the effects of micro-gravity and cosmic radiation on the developmental process and on the morphology of small aquatic animals (Rotifers and Nematodes). These Bio-reactors are designed in order to be included within standard Experiment Containers of the EMCS Facility.

Specific Subsystems are embedded in the Bio-reactors in order to perform a daily exchange of culture medium (a solution of water plus food) in the cultivation chambers where animals grow and reproduce.

Due to reduced EMCS Experiment Container provided volume (60 x 60 x 160 mm), miniaturised actuators (pump, valves and motors) have been selected or developed.

#### **Multiwell;**

this Bio-reactor permits to investigate the effects of space radiation on adherent cell cultivation on board the ISS in order to predict health risks of crew members and to permit the identification of countermeasures necessary during long-term manned mission.

This Bio-reactor is designed in order to be included within standard Experiment Containers of the Biolab Facility.

Specific Subsystems are embedded in the Bio-reactor in order to perform a daily exchange of culture medium and cells fixation at the end of the experiment.

Due to reduced Biolab Experiment Container provided volume (60 x 60 x 100 mm), miniaturised actuators (pump, valves and motors) have been selected or developed.

#### **Heritage:**

The design and development of Bio-reactors is started in the second half of '90 in order to meet the scientific interest in the space experimentation based on the use of some living specimen (such as small mammals, small aquatic animals, plants and cells).

### **Technologies:**

Technologies adopted and developed are mainly related to the Life Support Systems (LSS) implementation. Traditional components of LSS are:

- **Atmosphere management:** atmosphere composition control, temperature and humidity control, pressure control, contamination control and ventilation
- **Waste management:** collection, storage and processing of generated waste
- **Food and water management:** provision of potable water, recovery and processing of waste water, provision and potential production of food

Other physical factors must be considered such as habitat volume and shape, vibration, acoustic noise, illumination, monitoring and radiation.

An additional aspect that affects LSS adopted technologies is related to the provision of resources needed during the mission and in particular:

- launch of required consumables at the start of the mission
- re-supplying of consumables during the mission
- re-cycling of materials during the mission

In case of short-duration space missions (about 15 days on board the Shuttle), air, food and water are launched at the start of the mission together with the Bio-reactor while waste are stored and returned to ground. These technologies are quite simple and highly reliable

For long-duration space mission (up to 100 days on board the ISS), technologies able to recycle consumables and to process the waste are essential to reduce mass and volume of uploaded/downloaded materials. In this case, so called re-generative functions can use:

- physico-chemical processes
- biological processes
- hybrid processes (including both, physico-chemical and biological processes)

Physico-chemical processes are well understood, compact and require low maintenance but they consume a lot of energy and are mainly applicable to atmosphere management functions (food has still to be re-supplied and waste collected, treated and stored).

Biological processes represent the new technology which, at the moment, is less understood, requires larger volumes and more maintenance but has the potential to provide more independent LSS in the future.

## Experiment Containers

### Applications

Application fields are mainly related to the design and development of Test containers for the Fluid Science Laboratory (FSL) that will be accommodated on board the International Space Station. In particular, Test containers for the following types of experiments can be considered:

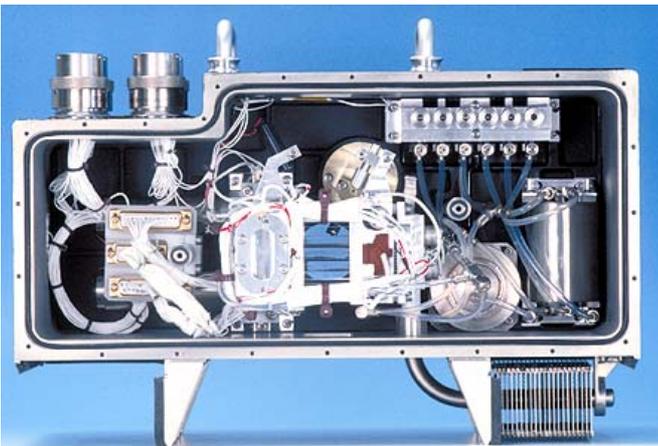
- Fluid physics including Electro-hydrodynamics and Marangoni effect experiments
- Crystal physics.

### Description

Scientific Equipment Directorate has acquired the know-how to design, develop and integrate Test containers devoted to conduct fluid physics experiments in weightlessness conditions. The capability ranges from the fluid cell/circuit, where the real “reaction” is conducted, through mechanism and structural design, thermal subsystem and data acquisition/management electronics.

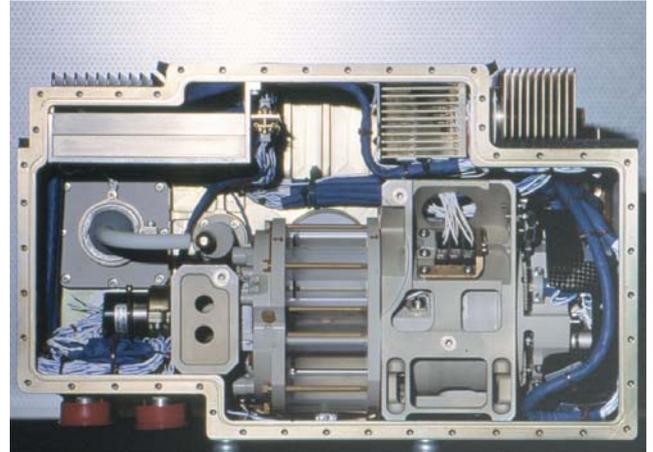
Moreover, expertise in High voltage technologies for electro-hydrodynamics experiments, fluid-material compatibility and optical performances has been acquired.

Several Test containers have been designed and developed to be utilised on past space missions.



### Electro-hydrodynamics of liquid bridges

Taylor electro-hydrodynamics theory contains some parameters that can be measured experimentally. An effective method is to measure the voltage (DC and AC) stabilising pinned columns of leaky dielectric fluids.



### Marangoni effect

The development of convection rolls by Marangoni instability under weightlessness in a sandwich configuration of three immiscible liquid layers (octane-methanol-octane) with a temperature gradient perpendicular to the layers has been studied. Microgravity permits to separate Marangoni convection and buoyant convection which is not feasible on Earth.

Curtains mechanisms has been developed to be smoothly removed by a motor in order to permit an undisturbed liquid-liquid interface. Thermal stability of liquid layers and predetermined changes in temperature permits to evaluate a velocity fluctuation at the interface region.

### Technologies

Technologies used and developed during past programs for Test containers are:

- Advanced polymers.
- Technical ceramics.
- Miniaturised electro-valves for space applications.
- Technologies for high voltage in manned space programs.
- Custom design of fretting-free sliding contacts for space applications.
- Heat transport from instruments to its cooling system.
- Material deposition processes
- Sealed containers for hazardous fluids.

## Heritage

The table in the following page shows a synthetic picture of our experience in Microgravity equipment.

<b>MICROGRAVITY EQUIPMENT</b>				
<b>Experiment</b>	<b>Mission</b>	<b>Application Field</b>	<b>Status</b>	<b>Main Activities</b>
SGF	EURECA	Material Science	1992	Technical Management, Design, AIT
BDPU	STS65	Fluid Science	1994	Technical Management, Design, AIT Experiment Control Unit development
-	IML2			
KOSTER	STS68			
LEGROS	LMS			
LEGROS-A			1996	
LEGROS-B				
SAVILLE				
APCF	STS ISS	Material Science	Many times launched	Design, MFG & AIT of the Electronic Unit, upgrading of E.U. for ISS
FSL	ISS- Columbus	Fluid Science	Phase C/D 2005	Design, MFG & AIT of Electronic Unit MCU, EGSE
PCDF	ISS	Material Science	Phase C/D 2005	Design, MFG & AIT of Electronic Unit PDE/ PUE1 and EGSE
ALTEA	ISS	Life Science	Launch 2005	Design, MFG, AIT Technical management
MDS	ISS	Life Science	Phase C/D 2006	Design, MFG, AIT Technical management
ACS	ISS US-LAB	Life Science	Phase B 2006	Design, MFG, AIT Technical management

## Facility Electronics

### **Applications**

Management of Life Science and Fluid Physics Experiments

### **Main Features**

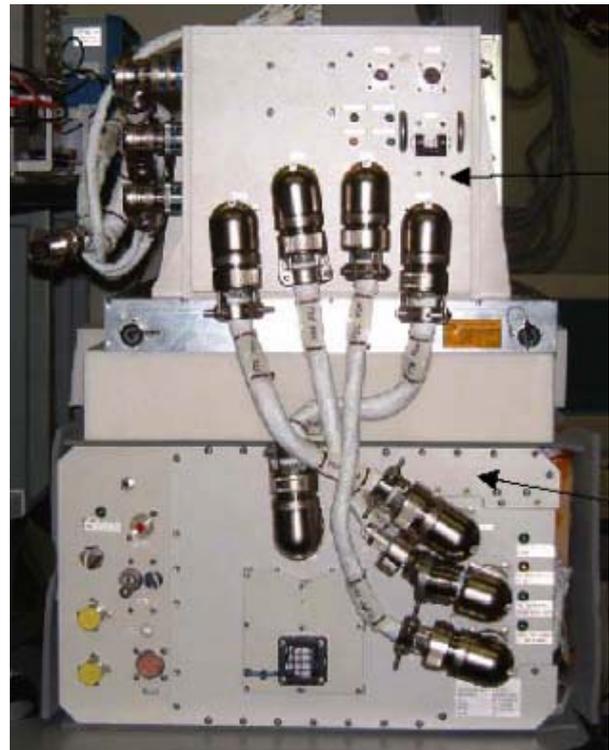
These Electronic Units are mainly in charge of:

- running the programmed experiments in automatic or manned mode
- managing the thermal control features of the facility
- actuating servo mechanisms
- collecting the scientific data and the facility status parameters
- storing the acquired data for late retrieval
- interfacing the ISS/STS through standard TM&TC links
- providing DC/DC conversion and regulation

## FSL Electronics



## PDPU Electronics



*This datasheet is not contractual and can be changed without any notice*

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**THALES**