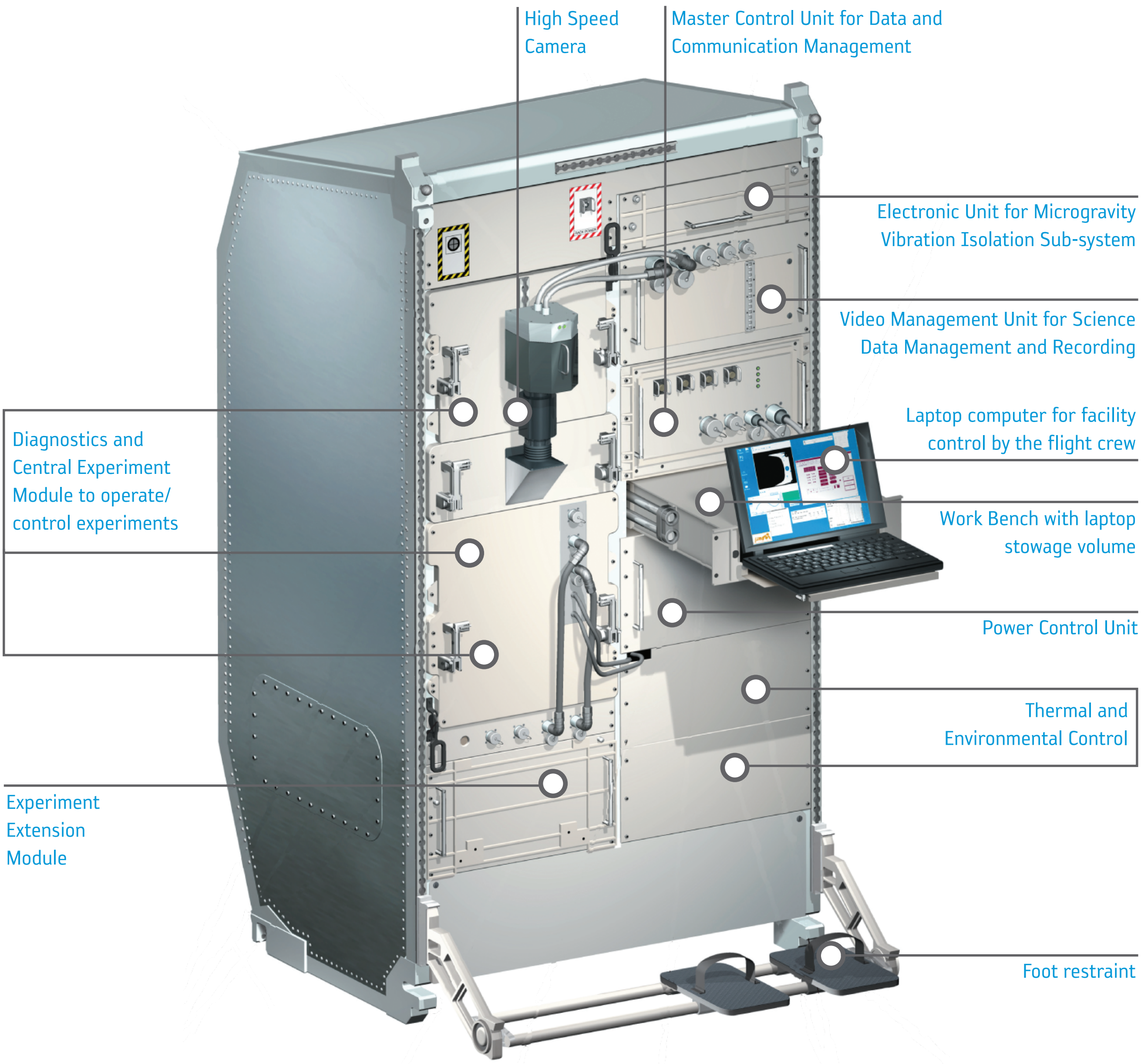
→ FLUID SCIENCE LABORATORY (FSL)

Fluid physics research facility in Columbus

The Fluid Science Laboratory is a-multi user facility to study the dynamics of fluids in the absence of gravitational forces. This allows investigation on fluid dynamic effects, phenomena that are normally masked by gravity driven convection, sedimentation, stratification and fluid static pressure. Such effects include e.g. diffusion-controlled heat and mass transfer in crystallization processes, interfacial mass exchange, simulation of geophysical fluid flows, emulsion stability and many more.



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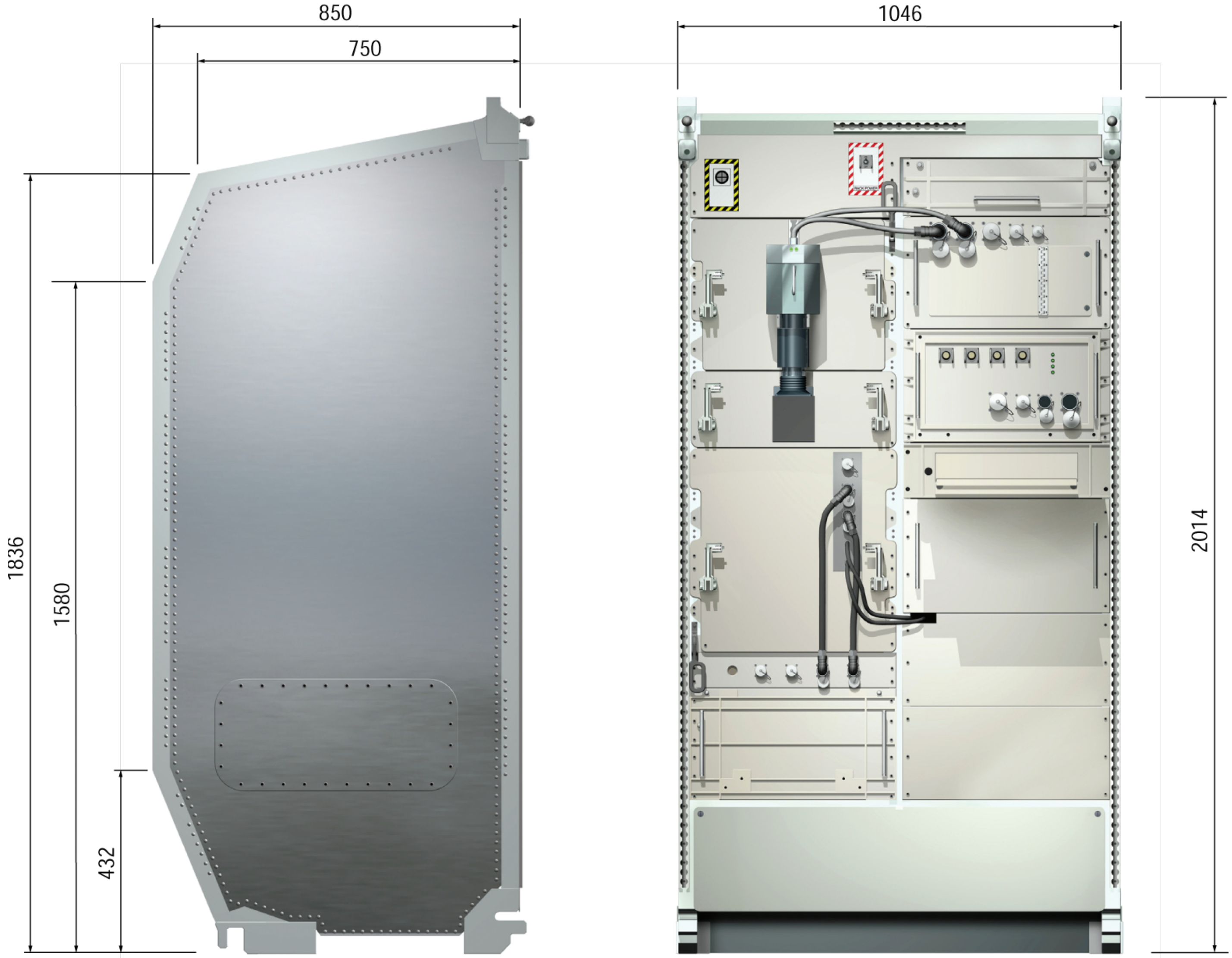
TITLE: Fluid Science Laboratory (FSL)		DOCUMENT N°: ESA-HSO-COU-009	REV. 2.0

ERASMUS Centre - Directorate of Human Spaceflight and Operations



Facility Description

The Fluid Science Laboratory fully occupies an International Standard Payload Rack. The Facility Core Element consists of the Optical Diagnostics Module and Central Experiment Module into which the Experiment Containers are sequentially inserted for operation.
The Optical Diagnostics Module houses the equipment for visual and interferometric observation, the related control electronics, and the attachment interfaces for Front Mounted Cameras. The Central Experiment Module is divided into two parts:

- The first part contains the suspension structure for the Experiment Containers, including all the functional interfaces and optical equipment, and is designed to be pulled out from the rack to allow insertion and removal of the Experiment Container.
- The second part contains all the diagnostic and illumination equipment and its control electronics to command and monitor the electromechanical and optomechanical components.

The Facility Core Element is complemented by the functional sub-systems for power distribution, environmental conditioning and data processing and management.

For observation of experiments the Fluid Science Laboratory includes:

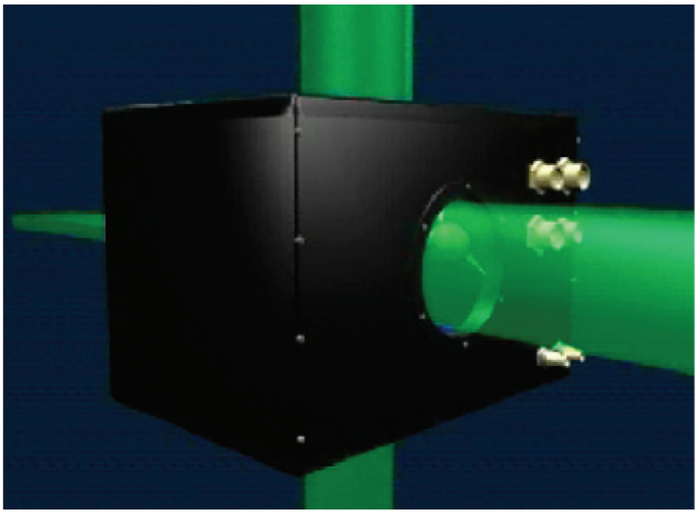
- Two-axis visual observation with electronic imaging and photographic back-up via Front Mounted Cameras which provide high speed imaging together with high resolution and colour recording;
- Background, sheet and volume illumination with white light and monochromatic (laser) light sources;
- Particle image velocimetry, including liquid crystal tracers for simultaneous velocimetry and thermometry;
- Thermographic (infrared) mapping of free liquid surfaces;
- Interferometric observation in two axes by convertible interferometers with active alignment:
- Digital Holographic interferometer;
- Wollaston/shearing interferometer;
- Schlieren mode combined with shearing mode;
- Electronic Speckle Pattern Interferometer.

Flight Support Equipment such as spare parts, special tools and consumables (e.g. cleaning agents), Front Mounted Cameras and Optical Reference Targets for experiment and diagnostic calibration is also available on-board to support user experiments.

Specifications

Experiment Container	
Power available:	+28, +15, -15, +12, +5, -5 Vdc
Mass:	25 to 40 kg (max)
Dimensions:	400 x 270 x 280 mm3
Fluid volume:	up to about 1,000 cm3
Measurement channels:	e.g. 16 analogue/ 8 digital
Experiment Container housing	
Containment:	Double/triple
Sealed:	Yes
Pressurised:	Yes
Toxic Fluids:	Yes
Diagnostic/Analysis tools	
Integrated cameras:	Integrated Charge Coupled Device imagers
Front-mounted cameras:	Still, high-speed, high-resolution, Infrared as required
Parameter setting & diagnostic calibration:	Optical reference targets
Standard facility diagnostic capabilities	
White light background:	Yes
White light and monochromatic light sheet:	Variable 0.1 – 30 mm
Infrared:	Yes
Visual spectral range:	Yes
Electronic Speckle Pattern Interferometer:	In reflection and transmission modes
Wollaston interferometer:	Yes
Schlieren interferometer:	Yes
Digital Holographic interferometer:	Yes
Complementary Experiment Container diagnosis possibilities	
Spectral interferometers:	Yes
Light scattering diagnosis:	Yes
Laser Doppler anemometer:	Yes
3-D photogrammetry:	Yes
Microscopes, endoscopes:	Yes
Special laser sources:	Selectable wavelengths
High rate non-optical diagnosis:	Pressure/temperature sensors
Microgravity reduction capability	
	Use of Canadian Space Agency provided Microgravity Vibration Isolation Sub-system (MVIS), for isolation from ISS dynamic perturbation.

Example of FSL Experiment Container



FSL Experiment Container with indication of its observation paths

Operations and Utilisation

ACCOMMODATION & TRANSPORT

The Fluid Science Laboratory (FSL) is located in the European Columbus laboratory, in which it was launched. Prepared Experiment Containers are transported separately within the Multi-Purpose Logistics Module (MPLM), which is a cargo carrier that is located inside the Space Shuttle cargo bay, or other available transport means such as the European Automated Transfer Vehicle (ATV) or the Russian Progress vehicles.

OPERATIONAL CONCEPT

An individually developed Experiment Container is used for each experiment or experiment Category. It is removed from on-board storage and inserted into the Central Experiment Modules drawer by a crew member. The Experiment Container is then cycled through an experiment and diagnostics calibration processing prior to initiation of the experiment itself.
Each Experiment Container has a typical mass of about 30 kg, with a maximum allowable mass of 40 kg, and standard dimensions of 400 x 270 x 280 mm.
The fluid cell assembly (including the process stimuli and control electronics) are accommodated within this volume. An Experiment Container may also be equipped with dedicated experiment diagnostics to complement the standard diagnostics provided by the Fluid Science Laboratory itself.
An Experiment Extension Module (EEM) provides additional accomodation possibilities for experiment equipment.
The control concept allows alternative modes of operation consisting of fully automatic, semi-automatic and fully interactive experiment processing (step-by-step command keying by a member of the crew). All these modes may be initiated either by the flight crew or from the ground (quasi-real-time telescience).

UTILISATION SCENARIO

The Facility Responsible Centre for the Fluid Science Laboratory has the overall responsibility to operate the facility according to the needs of individual Experiment Container Providers. The individual science team members monitor the processing of their experiments from their User Home Bases.

The Fluid Science Laboratory was launched aboard the Space Shuttle and accommodated within the Columbus laboratory on 7 February 2008.

A view inside the Columbus laboratory

ESA astronaut Léopold Eyharts installing FSL

FSL installed in Columbus laboratory

Illustrations: ESA/D. Ducros