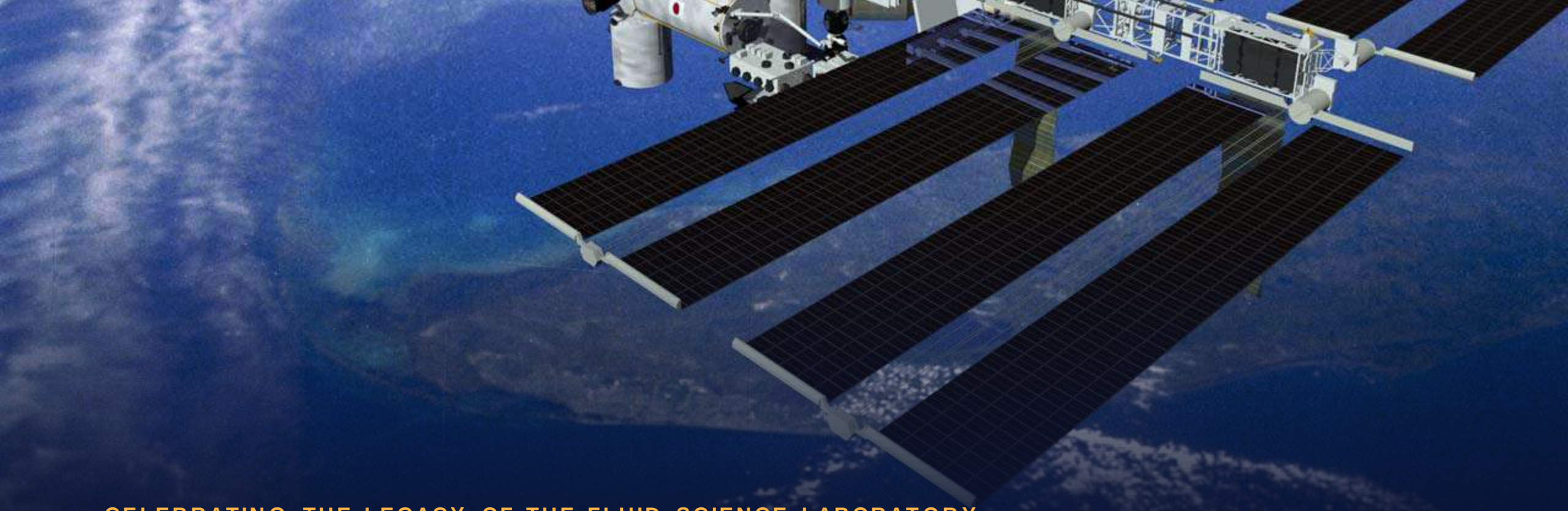


CELEBRATING THE LEGACY OF THE FLUID SCIENCE LABORATORY

FSL: A Personal Journey

from Development to Operations

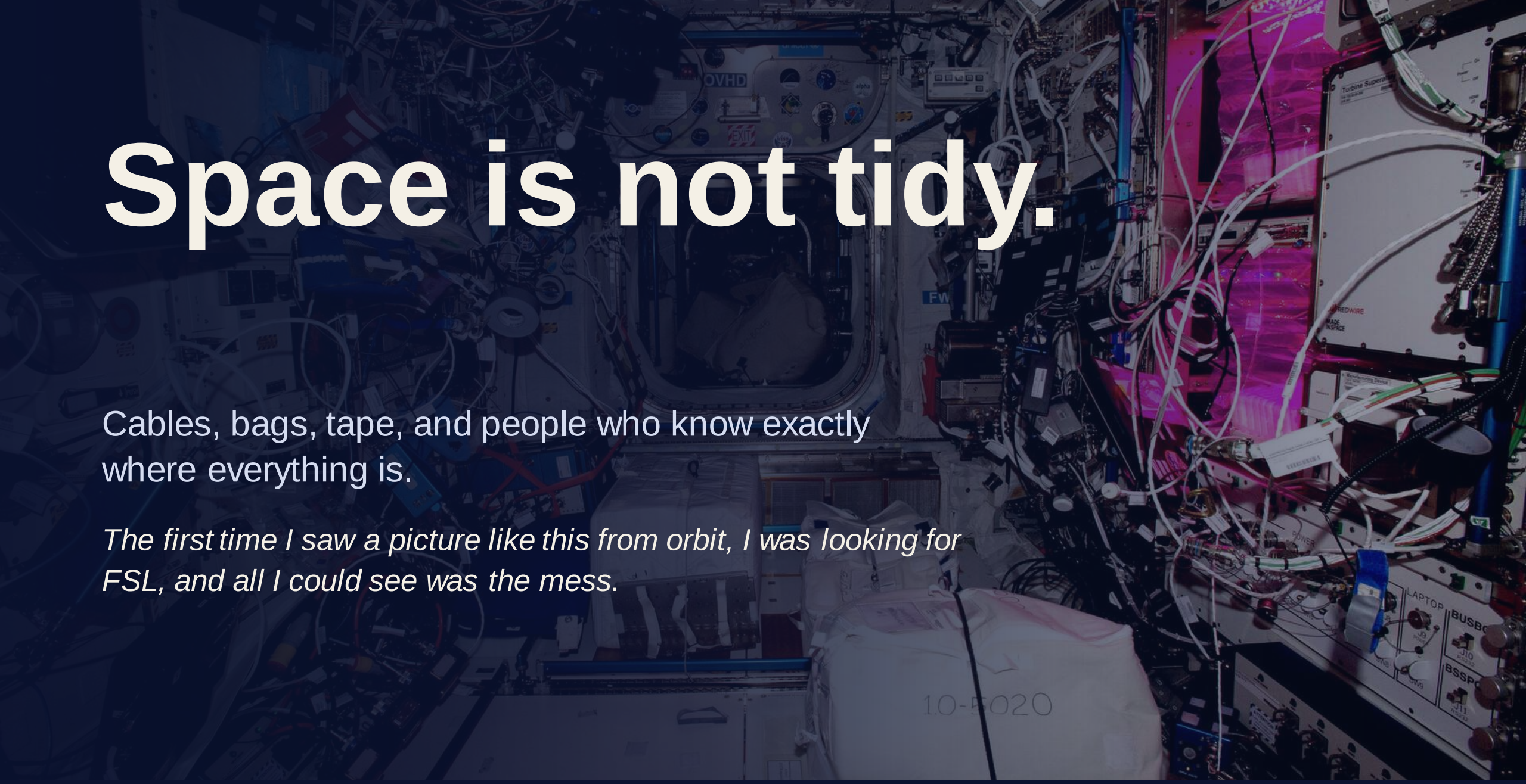
2008 – 2026 · A final farewell to the Fluid Science Laboratory

Giorgio Trinchero · Thales Alenia Space

Space is not tidy.

Cables, bags, tape, and people who know exactly where everything is.

The first time I saw a picture like this from orbit, I was looking for FSL, and all I could see was the mess.



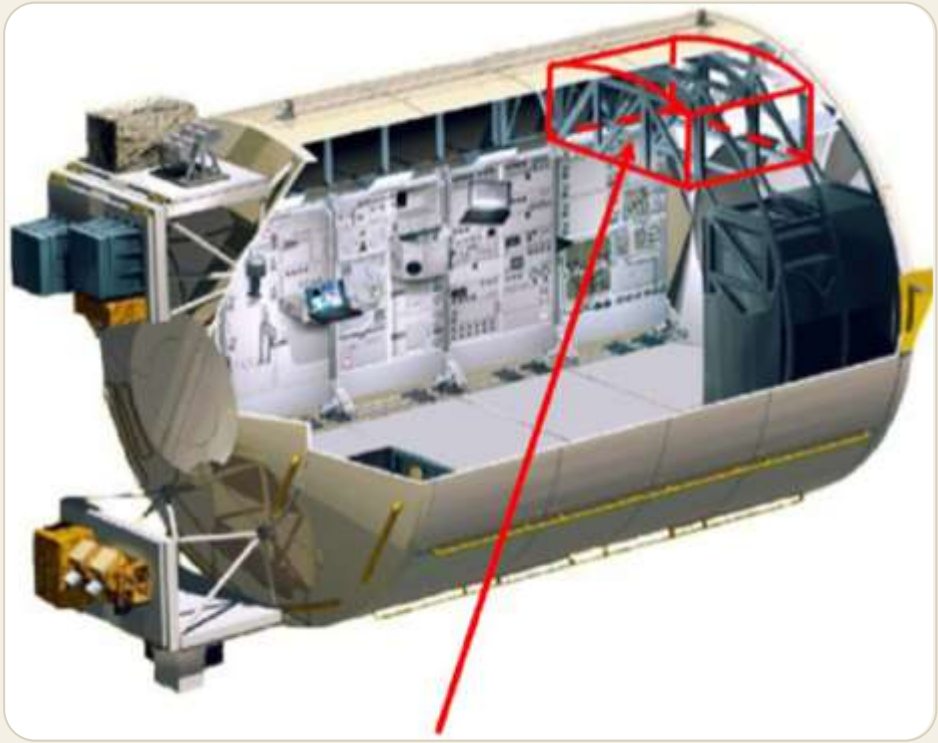
Inside the ISS · Credit: NASA

THE LABORATORY

A physics lab where gravity stays out of the way.

Heat flows, boiling, crystal growth, emulsions: fluids behave differently when Earth's pull stops distorting the picture.

- One rack inside ESA's Columbus module on the ISS.
- Commanded from the ground via *telescience*: scientists run their own experiments, and the crew performs them guided from the ground too.
- Nine years of development at Thales Alenia Space, launched in February 2008.



Inside Columbus: the red box marks where FSL sits

THE LABORATORY, UNDER THE HOOD

Six things that make FSL work.

Eyes

Lasers, cameras and interferometers: up to 88 optical modes to see inside the fluid.

Heart

The Experiment Container: a swappable 40 × 28 × 27 cm lab for each science team.

Brain

On-board software running each experiment: automatic, by the crew, or from the ground.

Memory

The Video Management Unit records up to three video channels at once and sends images down.

Calm

MVIS, built by Canada: magnetic levitation that filters out Station vibrations.

Lifeline

Up to 300 W of power and 420 W of cooling for each experiment, supplied through Columbus.

THE JOURNEY

One laboratory, four seats.

01

Software Engineer

Wrote the on-board software requirements and verified the software before launch.

02

System Engineering Manager

Owned the whole laboratory: optics, power, thermal, video and vibration isolation, working as one.

03

Payload Operations Manager

In charge of planning, executing and controlling the operations on FSL.

04

Payload Integration Manager, ESA

Turned a concept into a real activity on FSL.

SEAT 1 · SOFTWARE ENGINEER

Software is a promise to someone you had not met yet.

WHAT I DID

Wrote the on-board software requirements for the operator, the astronaut and the scientist, and verified before it left the ground.

WHAT WAS DIFFERENT

On orbit there is no second install. The software had to cope with cases nobody had planned for.

ONE LABORATORY, THREE USERS

Fully automatic, driven by the crew, or commanded from the ground.



The FSL rack on board Columbus

SEAT 2 · SYSTEM ENGINEERING MANAGER

Every part worked on its own. The real challenge was making them work together.

WHAT I DID

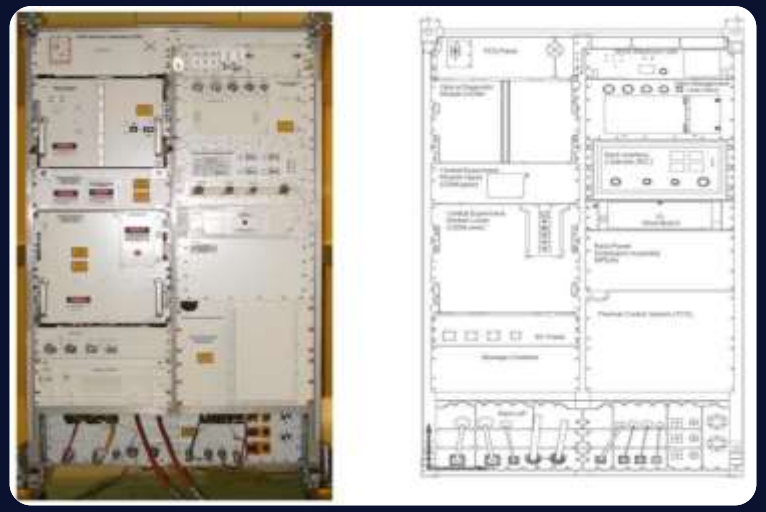
Technical responsibility for the whole rack: optics, thermal control, power, video, software, and the vibration-isolation system built by Canada.

THE PROBLEM

During ground integration tests with the FASES experiment, its thermo-electrical cooler had a higher impedance than the interface required, and the FSL driver became unstable.

THE FIX

Fixed in 2009 with a limit added to the RIC software, validated on the ground and released for uplink.



The FSL rack and its layout: optics, experiment modules, video, control, thermal and power

SEAT 3 · PAYLOAD OPERATIONS MANAGER

Planning, executing and controlling the operations on FSL.

Scientist
At a home base lab, anywhere in the world

→

Operations Centre
MARS, Naples: prepares and conducts the operations

→

Columbus Control Centre
ESA's gateway to the Station

→

FSL on the ISS
Executes, then sends data and video back

PLAN

- Build the timeline and the procedures
- Validate them on ground models
- Support crew training

EXECUTE

- Run Experiment Procedures: automatic, semi-automatic or step by step
- Work in agreed operational windows
- Send non-hazardous commands directly

CONTROL

- Follow telemetry and science data in real time
- Switch to contingency procedures if something drifts
- Pass data to the scientists, take their requests

SEAT 3 · THE FIRST WEEKS ON ORBIT

Most early trouble came from the hands-on set-up, not from the design.

THE CABLES

The rear launch fixation bolts were not removed during the mechanical set-up, so the rack was tilted a second time and that damaged the umbilicals (Ethernet and MIL-1553) mated to the Columbus utility panel.

THE SAFETY SWITCH

The laser safety switch telemetry errors came from a drawer not correctly installed (rear blind connectors not engaged, rubber seals protruding).

THE LAMP

A lamp not correctly connected during set-up triggered a self-test error.



The cables torn from the Columbus panel · ISS crew photo



Crew at work on FSL · ISS, NASA

SEAT 3 · LESSONS LEARNED

The scarcest resource on board is crew time.

Most troubles came from the mechanical set-up done on orbit, and one wrong step can block most experiments.

Repairs used crew time outside the commissioning plan, so some optical checkouts were cut back.

On the ground, command and telemetry authorisations slowed the troubleshooting.

WHAT WE RECOMMENDED

- Train the crew for the delicate mechanical tasks
- Rehearse every procedure on the FSL ground model
- Streamline command and telemetry during troubleshooting

The TAS-I engineering support team was fundamental in the troubleshooting. At that time, FSL was the only Columbus internal facility fully operative and returning science.

SEAT 3 · FIRST LIGHT

First light: a model of the Earth's core, run from the ground.

THE EXPERIMENT

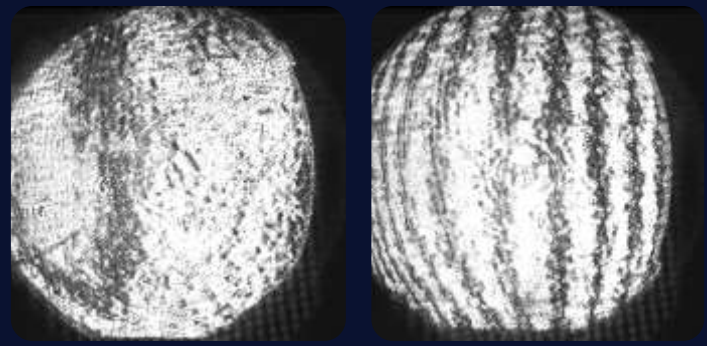
The first experiment in FSL. GeoFlow: oil between two concentric spheres, with an electric field playing the role of gravity, to model flows in the atmosphere, the oceans and the liquid core of our planet.

THE MILESTONE

First run completed on 7 August 2008, after the hard first weeks. Ten more followed until January 2009, with very good live images.

THE MOMENT

Nine years of development, answered by a fringe pattern appearing live on our screens.



Two GeoFlow runs seen by interferometry: different convection, different rotation.

SEAT 4 · WHAT THE JOB IS

Payload Integration Manager: from a scientist's idea to an experiment on FSL.

Idea
A scientific question that needs weightlessness

→

Concept
Requirements and a design FSL can host

→

Integration
Experiment and facility matched and tested together on the ground

→

On orbit
A real activity performed on FSL

WHAT THE FACILITY OFFERS

The Experiment Container, about 40 × 28 × 27 cm, receives power, cooling, data and commands from FSL.

WHY INTEGRATE EARLY

Experiment and facility are built by different teams. Testing them together on the ground finds incompatibilities before launch.

TEAMS FOLLOWED FROM FIRST CONCEPT TO FLIGHT

National agencies | Universities | Internal ESA departments

SEAT 4 · PAYLOAD INTEGRATION MANAGER, ESA

Same programme. The other side of the table.

From building the facility inside the prime contractor to serving the scientists who use it: the facility is now the means, the scientists are the customers.

Many customers

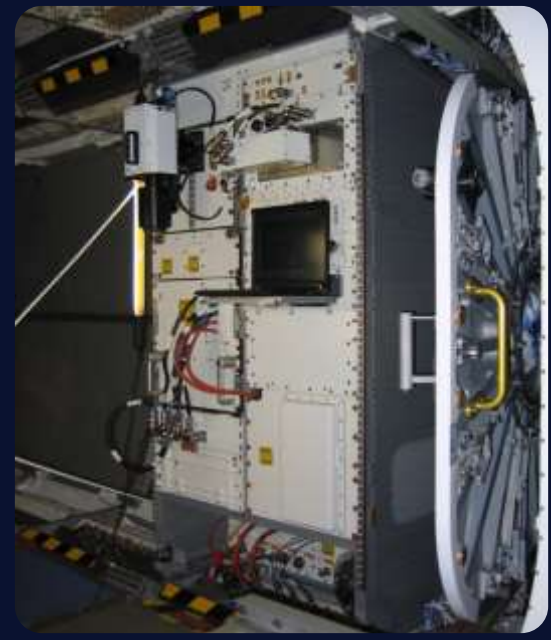
National agencies, universities and ESA departments, each with its own science and rhythm.

Two languages

Science on one side, engineering on the other. The job was to translate in both directions.

Their success was the goal

An experiment succeeds when the scientist's idea works in orbit, not when the hardware passes its review.



FSL in Columbus, ready to host experiments

WHAT THE SEATS TAUGHT ME

Three lessons.

1

Design for the person on the other side.

The code was used by operators. The operations depended on engineers' choices. Everyone is somebody's user.

2

Respect the interface.

From a thermal driver to a cable at the Columbus panel, the problems lived where two things met.

3

Plan for the unplanned.

On orbit the plan changes first. Crew time and trust are the budget you really spend.

THE REAL STORY

Nobody flew this alone.

Thales Alenia Space
European Space Agency
MARS Center
Columbus Control Centre
Canadian Space Agency
INOA-CNR
Telespazio
OHB
QinetiQ
EADS Astrium
BTU Cottbus
B-USOC

Behind these names, a community of scientists, engineers, operators and partners at the USOCs, in industry and at universities, across Europe and beyond. Their dedication, expertise and passion built FSL's success.

THE LEGACY

A laboratory built to be shared.

FSL was conceived as a shared laboratory, commanded from the ground. Its real product is the science of many teams.

Many teams → **One shared laboratory** → **Commanded from the ground** → **Science, experiment after experiment**

ALMOST TWO DECADES ON BOARD THE ISS

FASES · GeoFlow · FOAM-C · RUBI · CompGran · PASTA

7 February 2008: launch with Columbus. 17 July 2026: final experiment completed. 9 October 2026: decommissioning begins.

We did not just build a laboratory. We made it possible to do science in space.



Thank you

To every person that made FSL fly. Farewell, FSL.

Giorgio Trinchero · Thales Alenia Space · Celebrating the Legacy of the Fluid Science Laboratory