



→ ESA'S 'REAL ESTATE' IN SPACE

Columbus in orbit

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The European Columbus laboratory has now become an integral part of the International Space Station (ISS) since February 2008, and the scientific return from ESA's 'real estate' in space has started.

The initial part of the Columbus assembly and commissioning mission on STS-122 flight of Space Shuttle *Atlantis*, in which ESA astronauts Hans Schlegel and Léopold Eyharts played a major role, went a long way to realising the potential of Columbus's science capabilities. This was

continued on orbit by Eyharts and the other permanent ISS crew members of Expedition 16 after *Atlantis* undocked, and is now continuing with the Expedition 17 crew. The hard work has continued on the ground as well, to bring Europe's laboratory up to fully functioning status.

It has been an extremely busy few months for all concerned: in the Columbus Control Centre in Oberpfaffenhofen, Germany, where overall Columbus operations are orchestrated; in the individual User Support and Operations Centres around Europe responsible for overseeing Columbus

payload operations activities; for the science teams of the experiments taking place; and for the international ISS partners and everyone else involved in making the systems and science equipment of Columbus become a working reality in orbit.

In addition to all the Columbus system and payload commissioning activities that have taken place in the past months, an extensive amount of experiment data has been continuously provided by the external experiment facilities EuTEF and SOLAR. The first runs of experiments have taken place using Columbus internal multi-user facilities including the recent successful runs of the Geoflow experiment in the Fluid Science Laboratory. Adding this to the relocation to Columbus of experiment facilities from the US Destiny laboratory, additional European experiments taking place, and further science and commissioning activities to come, Columbus has already become the hub of European and even NASA utilisation on the ISS.

First experiment and external facilities

The first steps in scientific utilisation of Columbus took place during the assembly and commissioning mission itself in February 2008. The external payload EuTEF (European Technology Exposure Facility) carried out the first Columbus experiment, and this was before it was even attached to the European laboratory. EuTEF houses a suite of experiments



EuTEF seen mounted on the Columbus External Payload Facility

requiring long-term exposure to open space and covering a variety of disciplines including material science, plasma physics, astrobiology, astronomy and space technology.



Léopold Eyharts works in Columbus, anchoring himself with his feet. An EVA suit is stored in spared space (left)

→ EuTEF experiment performance

DEBIE-2

'Debris In orbit Evaluator', a standard *in situ* space debris and micrometeoroid monitoring instrument, still performing regular 24-hour experiment runs.

DOSTEL

Dosimetric Radiation Telescope, a small radiation telescope that continues to gather scientific data on the radiation environment outside the ISS.

EXPOSE

A series of five exobiology experiments, dealing with different elements of exposure, for example of lichens, fungi and micro-organisms to open space, continues to perform well.

EuTEMP

Completed science objectives

EVC

Earth Viewing Camera, a fixed-pointed Earth observation camera, previously returned good images but currently switched off awaiting a new data acquisition run.

FIPEX

This sensor continues with experiment runs that are helping to build a picture of the atmospheric environment in low Earth orbit by measuring atomic oxygen.

MEDET

Materials Exposure and Degradation Experiment, evaluating the effects of open space on materials being considered for future use on spacecraft in low Earth orbit.

PLEGPAY

Plasma Electron Gun Payload, studying the interactions between spacecraft and the space environment in low Earth orbit, with reference to electrostatic charging and discharging.

TRIBOLAB

A series of experiments in tribology, i.e. the research of friction in mechanisms and lubrication, under long-term open space conditions. Ball-bearing experiments 1, 2, 3 and 4 ran from June to present with a break in between to carry out ISS activities.

All 13 experiments on EuTEF have successfully produced research results so far according to the individual experiment protocols, the majority on a regular basis.

EuTEMP, a multi-input thermometer, was the first EuTEF (and Columbus) experiment to start and reach its objectives. During the final spacewalk of the Columbus mission on 15 February, when EuTEF and SOLAR were being deployed on the Columbus External Payload Facility, EuTEMP successfully measured EuTEF temperatures during transportation from

the Shuttle's cargo bay. This experiment is now inactive, having completed its science objectives, but scientific data continues to be acquired by other experiments housed on EuTEF (see Table 1).

The other external payload facility, SOLAR, has also carried out repeated study cycles of the Sun with unprecedented accuracy across most of its spectral range. It is located on the Columbus External Payload Facility along with EuTEF. Due to the nature of such a study, this is not a continuous process,

because observations can only occur outside eclipse periods when the ISS is in a suitable orbital attitude and profile. The coarse-pointing device of SOLAR hosts three spectrometers (SOVIM, SOLSPEC and SOLACES) and tracks the Sun automatically with high precision. SOLAR will continue its measurement cycles in space for about two years.

Having the External Payload Facility installed outside Columbus has been a valuable asset in Columbus utilisation because it has enhanced the scientific return from the laboratory without significantly increasing the infrastructure cost, by exploiting automated operations with almost no crew intervention. The external surface of Columbus also provides an attachment location for two of NASA's Materials on the ISS Experiments, which evaluate the effect of the space environment on a large variety of exposed materials.

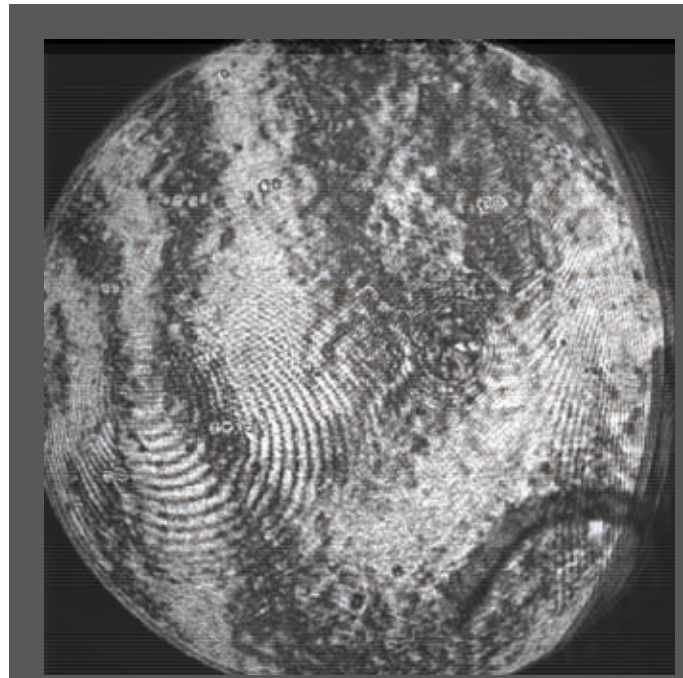
Fluid Science Laboratory and Geoflow

Looking at the research facilities inside the ISS, one of the experiments that successfully finished its first experiment runs in Columbus is the Geoflow experiment in the Fluid Science Laboratory (FSL). The FSL is a multi-user facility designed to study the dynamics of fluids in the absence of gravitational forces using advanced optical diagnostics for in situ observation of physics processes. The first run of Geoflow took place on 7 August and runs will continue in the next ISS Increment science programme into mid-2009.

The Geoflow experiment investigates the flow of a viscous incompressible fluid between two concentric spheres rotating around a common axis, under the influence of a simulated central force field. This is of importance for astrophysical and geophysical problems, such as global-scale flow in the atmosphere, oceans or the liquid cores of planets. Results from Geoflow will also be useful for making improvements in a variety of engineering applications, such as spherical gyroscopes and bearings, centrifugal pumps and high-performance heat exchangers.



SOLAR mounted on the top of the External Payload Facility



The first Geoflow interferometric images delivered by ESA's Fluid Science Laboratory (C. Egbers, BTU Cottbus)

Live interferometric images received during the experiment were very good and the scientific data stored in the FSL were downlinked to the Columbus Control Centre in Oberpfaffenhofen, Germany. This was then forwarded to the responsible User Support Operation Centres: MARS/Naples, E-USOC/Madrid and the User Home Base of the science team for detailed analysis.

Outside experiment runs, the internal accelerometers of FSL were used on 13 August to take measurements of the change in microgravity levels during a boost of the ISS to a higher altitude by the ATV *Jules Verne*. Data from the accelerometers are helpful in providing the range of vibration levels experienced by the Columbus internal payloads during such activity.

Though the commissioning activities of FSL finished later than originally expected, the fact that the facility was brought online and completed runs of the Geoflow experiment is a testament to the abilities of the control centre teams and the astronauts on orbit. They overcame any problems and carried out all necessary commissioning tasks as quickly as possible. This includes the ISS crew repairing damaged data cabling and replacing optical elements as well as ground-controlled software upgrades and functional performance testing of the facility's optical equipment in July.

Biolab and WAICO

The Biolab facility, designed to support biological experiments on micro-organisms, cells, tissue cultures, small plants and small invertebrates, ran the first experiment to

take place inside Columbus. The experiment, called WAICO (Waving and Coiling of *Arabidopsis* Roots at Different g-levels) was activated by Léopold Eyharts on 29 February 2008. The experiment, which is due to have a second run in 2009, investigates the effect of gravity on plant root growth, concentrating on a wild type and genetically modified type of *Arabidopsis* seed.

The samples from WAICO developed well and the zero-g ones were returned to Earth on Shuttle flight STS-123, which landed on 26 March 2008. These were handed over to the lead scientist for the experiment who issued a report at the beginning of July stating that interesting and partially unexpected results had been achieved. The 1g reference samples on orbit could not be retrieved however due to a Biolab centrifuge blockage. The crew replaced the centrifuge locking pin at the end of May, and a power supply module at the end of July. With the facility now ready again for operations, the two centrifuges and Handling Mechanism will now be tested to confirm full functionality of Biolab prior to the second run of WAICO.

With an eye on future plans for long-term human exploration missions to the Moon and Mars, WAICO could contribute to our knowledge of growing crops in space, providing astronauts with fresh produce with enough nutritional value for a voyage that could last up to two years, and could also help increase the efficiency of agricultural processes on Earth by understanding growth issues at a cellular level.

European Drawer Rack and European Physiology Modules

ESA's remaining two experiment facilities in Columbus have been commissioned and are waiting to start their first experiments: the European Physiology Modules and the European Drawer Rack, which houses the Protein Crystallisation Diagnostics Facility. For the European Physiology Modules, which are designed to investigate the effects of long-duration spaceflight on the human body, final calibration of one of the facility's science modules (called the Multi-Electrode Electroencephalogram Measurement Module) will take place towards the end of September 2008. This module will be used for different types of non-invasive brain function investigations and can also easily be reconfigured to support research in the field of muscle physiology.

The SOLO experiment will carry out research into salt retention in space and related human physiology effects at the end of Increment 17 by the NASA crew member using certain capabilities of the European Physiology Modules and NASA's Human Research Facility. The first experiment to use the full capabilities of the European Physiology Modules facility is called NeuroSpat and will take place when the next European astronaut arrives on the ISS in May 2009. This will be ESA astronaut Frank De Winne (B), who will become a member of the first six-person ISS expedition crew. NeuroSpat will investigate the ways in which crew members' three-dimensional perception is affected by long-duration stays in weightlessness.

→ Léopold Eyharts



Test pilot, French Air Force
Born: 28 April 1957, in Biarritz, France

Experience: Engineer, French Air Force Academy, Salon-de-Provence, 1979. Graduate of French test pilot school (EPNER), Istres 1988, then Brétigny-sur-Orge Flight Test Centre near Paris, becoming Chief Test Pilot in 1990. Eyharts has logged 3800 hours flying time on over 50

types of aircraft and 21 parachute jumps including one ejection.

Selected by the French space agency CNES in 1990. Assigned to support the Hermes space plane programme. Pilot and engineer for CNES parabolic flights.

Trained at the Yuri Gagarin Cosmonaut Training Centre, Moscow, 1991 and 1993. Back-up crew, French-Russian Cassiopée mission, 1996. Prime crew, CNES follow-on flight Pegase, 1998.

Joined ESA: 1998. Assigned to NASA Johnson Space Center, as Mission Specialist for Shuttle flights. Back-up flight engineer, Astrolab long-duration mission to ISS, 2006. Prime crew STS-122 and Expedition 16, two-month ISS mission to deliver the European Columbus laboratory, 2008.

Married, one child.

Hobbies: jogging, mountain biking, tennis, reading and computers.

Further scientific utilisation in the area of physiology has already taken place in Columbus with the 3D Space experiment. This study investigates the effects of weightlessness on the mental representation of visual information during and after spaceflight. Accurate perception is a prerequisite for spatial orientation and reliable performance of tasks in space. Three sessions were carried out in June and July by NASA astronaut Greg Chamitoff and a fourth session is planned for about two weeks before his return on Shuttle flight STS-126.

For the European Drawer Rack, ESA's flexible multi-experiment carrier in Columbus, the Processing Unit of the Protein Crystallisation Diagnostics Facility containing various protein solutions will be flown to the ISS in active mode (for continuous conditioning of samples) on Shuttle flight 15A, which is due for launch in February 2009. This facility will provide precision-controlled conditions for the

growth and *in situ* observation of sensitive organic protein macromolecules, and in the future potentially also inorganic zeolite crystals. The results generated will benefit various medical and industrial applications.

Software updates and testing

Complex software drives the Columbus laboratory and its systems. As in cutting-edge technological environments on Earth, this software must also be updated from time to time. Due to some updates in Columbus software, all the facilities (internal and external) and systems had to go through a functional check starting in August, to make sure that they were compatible with the new software. All the interfaces with the Columbus Data Management System were tested, and the systems of Columbus following the software upgrade are performing flawlessly.

Facilities relocated to Columbus from Destiny

Columbus was designed to get the maximum amount of research out of the minimum amount of space. Even though Columbus was launched with a full complement of European experiment facilities, the ingenious layout

of its systems means that there are still five locations for additional experiment facilities from NASA.

After Columbus was attached to the ISS, the Microgravity Science Glovebox and the European Modular Cultivation System (hosted in US EXPRESS Rack 3) were relocated from the US Destiny laboratory to Columbus on 21 March. These are ESA-developed experiment facilities provided to or shared with NASA under barter agreements respectively. The Microgravity Science Glovebox can perform a wide range of experiments in the fields of material science, fluid science, combustion science, biotechnology and crystal growth research, in a fully sealed and controlled environment, and has already been used by ESA extensively for European science experiments.

The European Modular Cultivation System is dedicated to biological experiments, namely in plant physiology. Both facilities have been utilised since relocation for NASA and JAXA experiments, respectively. During the next Increment, maintenance of the European Modular Cultivation System will be performed in anticipation of the challenging Genara experiment during Expedition 19/20. Genara is an ESA experiment that will study plant (*Arabidopsis*) growth activity at a molecular level in weightlessness. This will help to find plant systems that compensate for the negative impact on plant growth in space.

European science outside Columbus

Even though Columbus is the principal focus of European

→ Hans Schlegel



Physicist
Born: 3 August 1951 in
Überlingen, Germany

Experience: Second lieutenant, paratrooper, German armed forces, 1970-72. Masters degree, Physics, University of Aachen, Germany, 1979. Experimental solid-state physicist, Rheinisch Westfälische Technische Hochschule (RWTH) Aachen (University of Aachen) 1979-86.

Specialist in non-destructive testing methodology
Institut Dr. Förster GmbH & Co., Reutlingen, Germany, 1986-88

Selected by the German space agency DLR in 1988. A qualified research diver, he also holds a private pilot's license, including instrument rating and aerobatics. Back-up crew, German-Russian Mir '97 mission, 1997. Payload specialist, STS-55/D2 Spacelab mission, 1993.

Joined ESA: 1998. Trained as Mission Specialist at NASA Johnson Space Center, 1998. Mission Specialist, STS-122 mission to deliver ESA's Columbus laboratory to the ISS, 2008.

Married, seven children. Hobbies: skiing, scuba diving, reading, and being a handyman.



NASA astronaut Clay Anderson, Expedition 15 Flight Engineer, poses next to the ANITA equipment on the ISS

science on the ISS, the European utilisation programme has extended outside the European laboratory while it has been attached to the ISS. In the Russian segment, the ALTCRISS experiment continues to monitor radiation measurements in the Russian Zarya module.

The Nitric Oxide Analyser (NOA) experiments have been monitoring exhaled nitric oxide levels in astronauts as an early sign of airway inflammation during normal activity, or signs of decompression sickness after extravehicular activity. The simulated human head and torso of the Matroshka experiment has been measuring radiation doses experienced by astronauts. The Global Transmission Service has been continuously determining the performance and accuracy of a specially coded time and date signal transmitted to earth from the ISS. The Eye Tracking Device, and Immuno and Sample experiments respectively returned a hard disk drive, blood and urine, and biological samples on Soyuz 15S in April 2008. In Destiny, the Analyzing Interferometer for Ambient Air (ANITA) was monitoring trace gas levels in the ISS cabin atmosphere. After almost a year of service as an operational ISS system device, ANITA will be returned to Earth on Shuttle flight ULF-2 in November 2008.

Europe's growing success in mission control

Control centres are the 'brains' driving each element of a mission and credit has to be paid to the Columbus Control Centre (responsible for overall Columbus mission control) and the individual USOC teams for their hard work in providing the level of achievement delivered so far, especially when taking into account the many complexities in the commissioning process and in the day-to-day running of such a space laboratory.

This is compounded by the fact that the three-person ISS Expedition 17 crew (two Russian, one American), who are the on-orbit operators of Columbus, have additional commissioning activities in connection with the Japanese Kibo laboratory, which arrived at the ISS after Columbus, as well as other ISS maintenance tasks and scientific activities. The changeover to the six-person expedition crew in the middle of next year will provide more astronaut resources on the ISS to devote to scientific activities.

→ Frank De Winne



Assigned as Flight Engineer, Soyuz TMA-15 and Expedition 19, a long-duration mission to the ISS, May-November 2009.

Test pilot, Belgian Air Force
Born: 25 April 1961, in Ghent, Belgium

Experience: Graduate of Royal School of Cadets, Lier, 1979. Masters degree in telecommunications and civil engineering, Royal Military Academy, Brussels, 1984. Graduate of Empire Test Pilot School, Boscombe Down, UK, where he was awarded the McKenna Trophy. Various assignments as test pilot from 1992, including Eglin and Edwards Air Force Bases, USA. Senior test pilot, Belgian Air Force, 1996-98.

Commander, 349th Fighter Squadron, Kleine Brogel, Belgium. Commander of the Deployable Air Task Force, a combined Belgian/Dutch detachment during NATO operation Allied Force. He has flown 17 combat sorties. De Winne has logged more than 2300 hours flying time on several types of high-performance aircraft including Mirage V, F16, Jaguar and Tornado.

Joined ESA: 2000. Trained at the Yuri Gagarin Cosmonaut Training Centre, near Moscow, 2001. Flight Engineer, Soyuz TMA-1 Odissea mission to ISS, 2002. Back-up Mission Specialist for STS-122 and Expedition 16, 2005.

Married, three children.
Hobbies: football, small PC applications and gastronomy.



The Columbus Control Centre in Oberpfaffenhofen, Germany

Further credit is due for the talent and professionalism that the operations teams have shown in dealing with unexpected situations in the past months, ensuring that the experiments on orbit can fulfil their objectives. Sometimes this only needed the equivalent of a system reboot, but occasionally it might be more complex.

With respect to the external facilities, data links are one example of an issue that the Columbus Control Centre and USOC teams have been successfully troubleshooting for certain experiments. A Local Area Network connection issue between Columbus and SOLAR was solved at the end of July by rerouting communications for a power feeder through a different Ethernet network switch. As soon as this was done by NASA astronaut Greg Chamitoff, the SOLAR facility started to resend data to the ground and full control of SOLAR was recovered.

Another data link problem was discovered with the DEBIE-2 and FIPEX instruments on EuTEF. While a software patch was being developed, the control centre teams developed a work-around solution that allowed regular acquisition of scientific data. The control centre teams are also working on a high-rate data link issue with the Earth Viewing Camera on EuTEF. In all these activities, the control centre teams have received important expert engineering support from the industrial operators.

In the context of European human spaceflight activities, being faced with and overcoming these kinds of unexpected on-orbit situations is a positive achievement in mission control scenarios, because they highlight the experience that Europe has built up and is continuing to expand in this

area. This will be of immense importance when planning and flying future, longer-term European manned missions.

In the future

In the past months, since the arrival of Columbus at the ISS, there has been an upturn in the European utilisation on the ISS despite the limited crew resources and continued focus on ISS assembly. With Columbus, the infrastructure is now in place to further develop Europe's long-term science programme for the ISS in a variety of disciplines. New experiments and hardware are already in the pipeline for transport to the ISS on future flights and we will see two European astronauts flying to the ISS next year, with Christer Fuglesang (S) temporarily joining Frank De Winne to the ISS as a member of the STS-128 mission in August 2009. This mission also delivers ESA's Materials Science Laboratory.

In late September and early October 2008, before the next crew exchange, we will still see another two NASA facilities relocated to Columbus from the US Destiny laboratory. These are the two Human Research Facilities, one of which houses the ESA/NASA developed Pulmonary Function System, which can analyse exhaled gas from astronauts' lungs and provide near-instant data on the state of crew health. It is used to perform the Periodic Fitness Evaluation with Oxygen Uptake Measurements, part of the continuous crew medical operations and last happening on 21 August. Also on the issue of crew health, the Flywheel Exercise Device, which is now stowed in the European Transport Carrier in Columbus, will be deployed and checked out after Shuttle flight 15A in early 2009. This novel on-orbit training unit was launched to the ISS to become an advanced exercise device for astronauts on the ISS. ■

→ Christer Fuglesang



Assigned as Mission Specialist, STS-128 mission to ISS, July 2009.

Physicist
Born: 18 March 1957 in Stockholm, Sweden
Experience: Masters degree, Engineering Physics, Royal Institute of Technology (KTH), Stockholm, 1981. Doctorate, Experimental Particle Physics, 1987. Worked at CERN (European Research Centre on Particle Physics)

in Geneva on the UA5 experiment, which studied proton-antiproton collisions. Fellow of CERN, 1988; Senior Fellow and head of the particle identification subdetector, CERN, 1989. Lecturer

in Particle Physics, University of Stockholm, 1991. Affiliated Professor, KTH, 2006. Joined ESA: 1992.

Trained at the Yuri Gagarin Cosmonaut Training Centre, Moscow, with a view to future ESA-Russian collaboration on Mir Space Station. Back-up flight engineer, Euromir '95 mission, 1993-96.

Qualified for flight assignment as a Shuttle Mission Specialist in April 1998 at NASA Johnson Space Center, Houston, in 1998. Qualified as Russian 'Soyuz Return Commander', enabling him to command a three-person Soyuz capsule on its return from space. Support crew, second ISS increment crew, Johnson Space Center. Mission Specialist, STS-116 mission to ISS, December 2006.

Married, three children.
Hobbies: sports, sailing, skiing, frisbee, games and reading.

→ Columbus rack facilities photogallery



Fluid Science Laboratory (FSL)



European Physiology Modules (EPM)



Hans Schlegel working on the setting up of Biolab



NASA astronaut Greg Chamitoff works with the European Microgravity Science Glovebox



European Drawer Rack (EDR)



European Modular Cultivation System (EMCS)