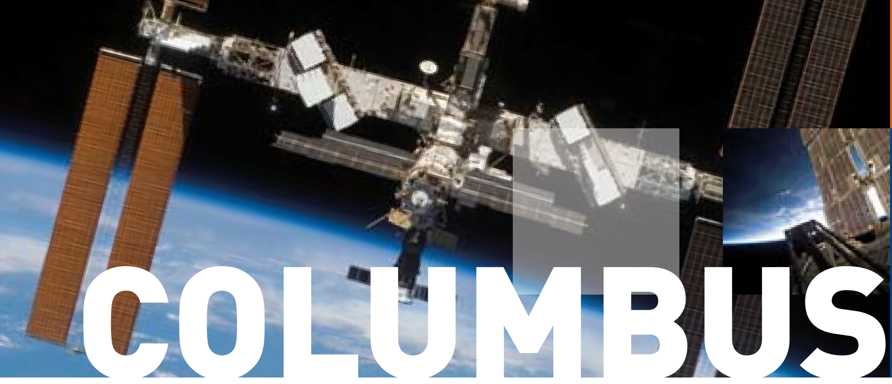
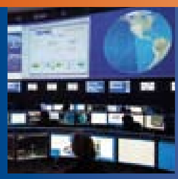
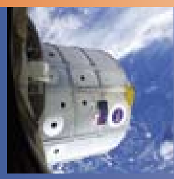
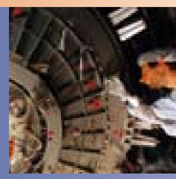
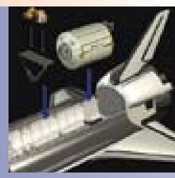


The International Space Station with the Earth as a backdrop as viewed by a departing Space Shuttle crew in the summer of 2007.

A new European science laboratory in Earth orbit

Five hundred years after the historic New World voyages of Christopher Columbus, the nations of Europe have embarked on a new mission of discovery.

The installation of the multi-purpose science laboratory Columbus on the International Space Station (ISS) represents a new step in Europe's capability to perform cutting-edge research.

The 4.5 metre-diameter cylindrical module, equipped with flexible research facilities that offer extensive science capabilities, is Europe's most important contribution to the Space Station.

Complementing the ISS facilities of the other partners, it offers opportunities for space-based research in physical and life sciences, the latter including biology, biotechnology, medicine and human physiology.

"We like to think of Columbus as being the epitome of small-is-beautiful," said Alan Thirkettle, ESA ISS programme manager.

"It is the smallest laboratory on the Space Station but its innovative design enables it to have the same experiment capabilities as the American and the Japanese modules."

To maximise the return from the space available, European engineers designed equipment that is both robust enough to withstand years of service and sufficiently flexible to be adapted for different kinds of research.

The first four internal experiment facilities launched inside Columbus – Biolab, the Fluid Science Laboratory, the European Physiology Modules and the European Drawer Rack – are each dedicated to a major science discipline and expected to perform large numbers of experiments during the laboratory's lifetime.

Outside, Columbus has four platforms exposed to the vacuum of space. These can be used for technology experiments, and space science observations.

Inside Columbus is a series of ten experiment racks, each of which can accommodate various types of science equipment.

The cabin air allows astronauts to work in similar conditions – except for weightlessness – to a research laboratory on Earth.

Columbus and its facilities are largely automatic or controllable from ground stations and several experiments can run at the same time.

For several years European scientists have been performing scientific experiments on the ISS based on special agreements to use Russian and American research facilities. Columbus, however, will increase significantly the number of facilities and the research time available to European scientists.

Scientists using Columbus from all over Europe will be able to monitor and control their own experiments via a network of specialist user centres, known as USOCs, or User Support and Operation Centres.

The Columbus module before it left Europe for the United States on the first leg of its journey into orbit.

Their efforts are channelled through the Columbus Control Centre, a dedicated ESA facility near Munich in Germany.

The Columbus laboratory offers European scientists and industry the opportunity to work at the cutting edge of scientific and technological research, facilitating a wide range of experiments to be conducted in materials science, medicine, biology and technology.

Many may eventually lead to benefits in commercial processes that will enhance everyday life on Earth.

"Columbus is a magnificent facility and it offers really excellent opportunities for scientists and technologists to perform world-class work," said Daniel Sacotte, ESA's Director of Human Spaceflight, Microgravity and Exploration.

The science and applications that will be carried out on Columbus – combined with the experience gained in the development and operation of the laboratory – also help prepare the nations of Europe for participation in future missions of exploration.

Opportunity for long-term experiments

Viewed from the outside, Europe's Columbus is a large silver cylinder, its functional exterior hiding a multi-purpose research centre.

Inside, it is packed with high-technology scientific equipment, video and communications links, and the cables, ducts and piping needed for power, cooling and life support.

The laboratory is part of a European family of modules for the International Space Station (ISS), which include the cargo-carrying Automated Transfer Vehicle (ATV), the Multi-Purpose Logistics Modules (MPLMs), and Nodes 2 and 3.

Its development owes much to the success and experience of Europe's Spacelab, a reusable laboratory that first flew on the Space Shuttle in 1983 and continued through 21 other missions.

Spacelab, the first joint European effort in manned space exploration, heralded a new approach to the use of space, allowing scientists to work in a typical laboratory environment while orbiting the Earth in conditions of weightlessness.

Whereas experiments on Spacelab missions were limited to a maximum of two weeks, Europe's new multi-purpose research facility provides an on-going opportunity stretching over at least a decade.

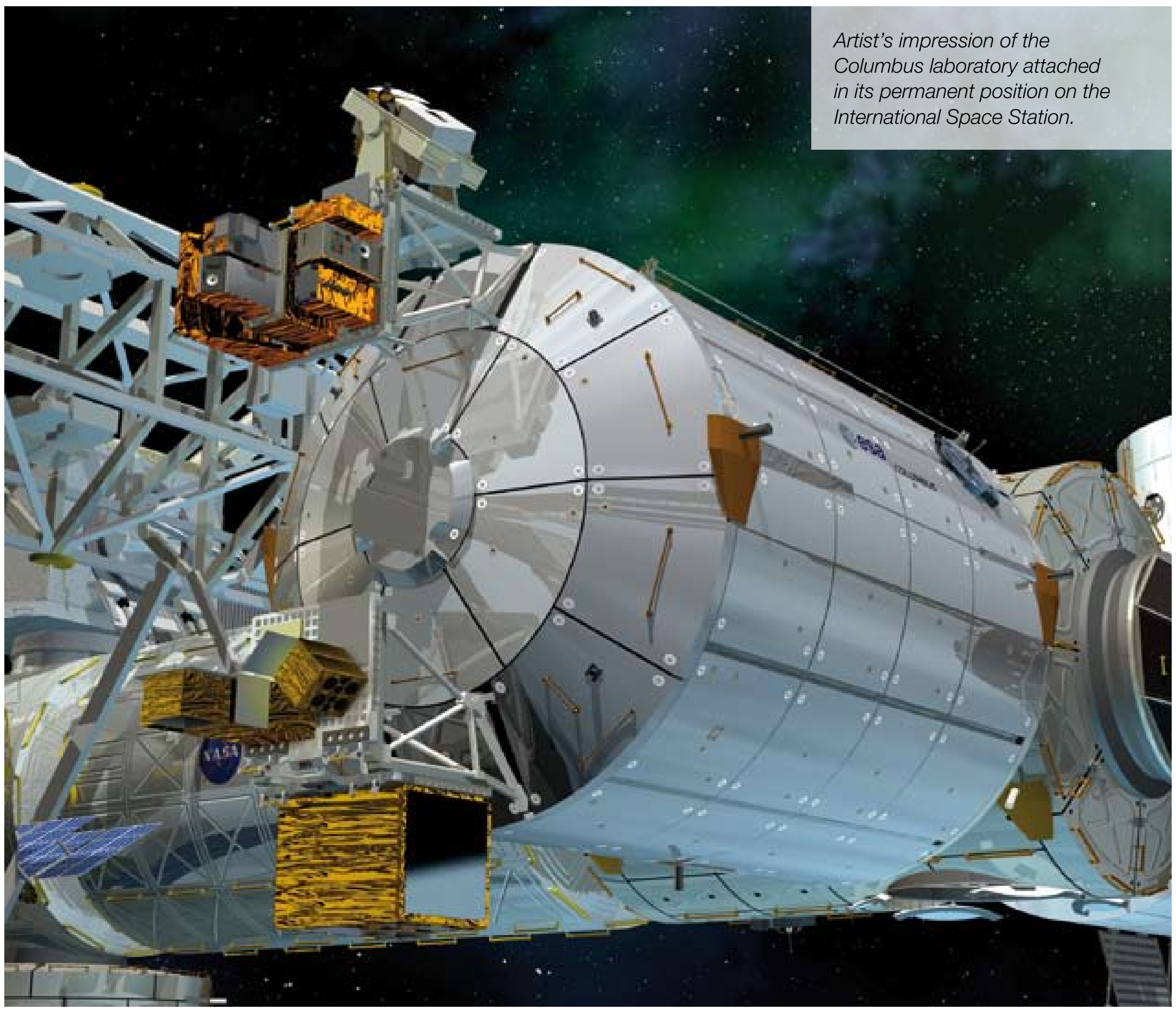
"Columbus is a sophisticated

esa COLUMBUS

laboratory and we've had a pretty clean run on the design and development, largely as a result of the heritage and experience of Spacelab," explained Alan Thirkettle, ESA's ISS programme manager.

"Now we want a strong utilisation programme so that Columbus becomes a place which scientists want to use for their experiments and where technologists want to develop and test their state of the art visions."

Columbus and its key systems were all developed in Europe under the industrial leadership of EADS Astrium in Bremen, Germany, which is the largest national supporter of the European ISS programme, paying 41 percent of Europe's contribution.



Artist's impression of the Columbus laboratory attached in its permanent position on the International Space Station.

Suite of advanced science and research facilities

Research in conditions of weightlessness in laboratories like Columbus is invaluable because the 'removal' of gravity can illuminate the nature and extent of its direct effects, as in many human physiology experiments.

Its 'absence' may also reveal the existence of other underlying processes which are otherwise obscured and impossible to observe. The removal, for example, of the gravity-associated effects of sedimentation, thermal convection and hydrostatic pressure offer the opportunity to establish unique conditions in which to probe basic processes.

Columbus offers a suite of advanced science facilities. Its four 'walls' harbour ten International Standard Payload Racks (ISPRs) each the size of a telephone booth and able to house its own autonomous and independent laboratory, complete with power, cooling, video and data & control links back to researchers on Earth.

Eight of the ISPRs are housed along the laboratory's sidewalls, with the remaining two in the ceiling area. Columbus subsystem equipment and overall Station stowage space occupy the equivalent of another three racks.

Fluid Science Laboratory (FSL)

A multi-user facility to study the dynamics of fluids in the absence of gravitational forces, allowing investigations into the effects of fluid dynamics, phenomena that are normally masked by gravity-driven convection, sedimentation, stratification and fluid static pressure.

The aim is to perform studies that will help optimise manufacturing processes on Earth and improve the quality of high-value products.

For example, if the behaviour of fluids can be controlled and predicted more accurately then it becomes feasible to better understand and improve a range of industrial processes that depend on fluids – such as in metal casting and semiconductor crystal growth.

European Physiology Modules (EPM)

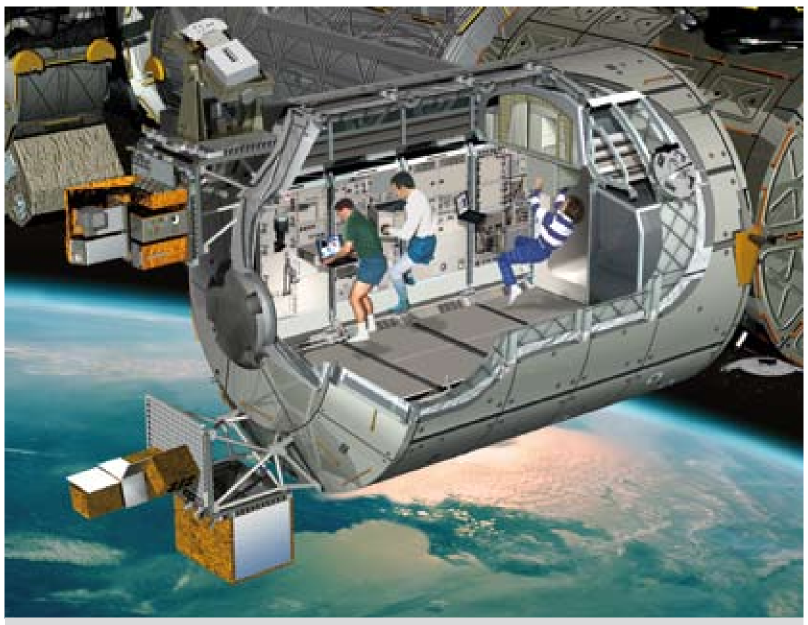
This is equipped with up to eight science modules that will be used to investigate the effects of long-duration spaceflight on the human body. Experiment results will contribute to an increased understanding of terrestrial problems such as the ageing process, osteoporosis, balance disorders and muscle wastage.

Biolab

A laboratory to support biological experiments on micro-organisms, cells, tissue cultures, plants and small invertebrates with the objective of understanding how important processes work at all levels of an organism, from single cells to small plants and small insects.

Biological samples are transported to Columbus within experiment containers. Once there, astronauts will manually insert them into Biolab for automatic processing. Typical experiment durations range from a day to three months.

Applications range from the improvement and increased control of environment-related bio-processes to the genetic enhancement of agricultural plants.



A cut-away view of the cylindrical Columbus module which has welded end cones, forming a pressurised, habitable volume 6.7 m long and 4.5 m in diameter. It is a very lightweight construction with walls that are only 4 mm thick in places. Total volume is about 75 m^3 and, with all the equipment racks installed, the working area for astronauts is about 50 m^3.

European Drawer Rack (EDR)

This is a modular and flexible experiment carrier system for a large variety of scientific disciplines, providing basic accommodation and resources for experiment modules housed within standardised drawers and lockers.

In contrast to the other Columbus modules, which have strictly defined parameters, the EDR allows scientists to design their own hardware whilst complying with only two basic conditions – overall size and power requirements.

Material Science Laboratory

A multi-user facility for the melting and solidification of conductive metals, alloys or semiconductors in ultra-high vacuum or in highly pure gaseous atmospheres.

The goal of such materials processing in space is to develop a better understanding of the relationship between processing, structure and thermophysical properties so that scientists can reliably predict the conditions required on Earth to achieve desired materials properties.

External experiments

The four platforms on the outside of Columbus offer an unhindered view of the Earth and outer space.

As the ISS orbit covers 85 percent of the Earth and 95 percent of the world's population, this is an ideal location for technology development that may involve testing new communications devices.

Looking in the opposite direction, it is also an excellent position for observing outer space, unhindered by the distorting effects of the Earth's atmosphere.

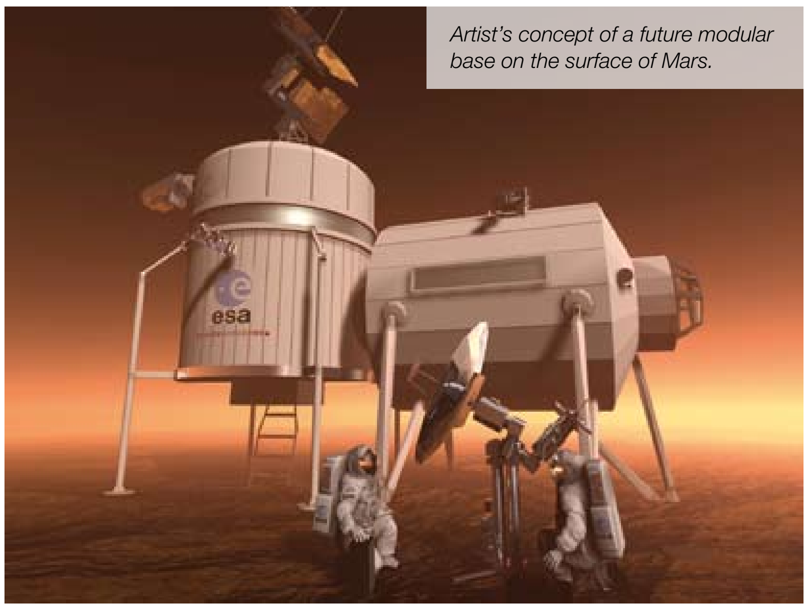
Numerous facilities will be attached to the outside of Columbus at different times, including:

European Technology Exposure Facility (EuTEF) – an infrastructure to accommodate up to seven experiments, including EXPOSE, which will test long and short-term exposure of biological samples to solar UV radiation.

SOLAR – a platform with three scientific instruments to study solar-related phenomena.

Atmosphere-Space Interactions Monitor (ASIM) – studies how severe thunderstorms are coupled to upper atmosphere, ionosphere and radiation belts, which in turn will help us to better understand Earth's climate and evolution.

Atomic Clock Assembly in Space (ACES) – the testing of a new generation of atomic clocks in microgravity, providing an ultra-accurate global time-scale and supporting precise evaluations of relativity.



Artist's concept of a future modular base on the surface of Mars.

Stepping stone to future exploration

To spread costs and keep reliability high, several key European elements for the International Space Station have all been derived from the same standard design which is based on the Multipurpose Logistics Module (MPLM) developed in Italy by Thales Alenia Space.

The same design was also used in the development and manufacture of the ISS Nodes 2 and 3 and the Automated Transfer Vehicle (ATV).

The International Standard Payload Racks (ISPRs) are inter-changeable between Columbus and other ISS laboratories, allowing the ISS to be modified to meet new requirements and opportunities. This means it will stay flexible and is not just reliant on the technology of today.

Such technology itself is a stepping stone to further exploration of the Moon and Mars, and one day the ISS could become a practical stopping-off point for future voyages or even a supervising base for the assembly of missions in Earth orbit.

In both construction and utilisation, Columbus and the ISS are a scientific and technological foundation for the future. For Europe, the experience of designing, constructing and operating Columbus also brings long-term benefits.

Just as this laboratory was derived from the experience of Spacelab then, in the future, the technologies and subsystems developed for Columbus will be transferrable to modules that might one day sit on the Moon or even Mars.

Round-the-clock operations at Columbus Control Centre

Daily operations on the International Space Station (ISS) are planned in minute detail and so, in principle, astronauts know what to do at any given time of their working day.

But as with any complex operation, priorities change as unexpected things happen or problems need fixing.

When this happens control centres in the United States, Russia and Europe reorganise schedules and activities so that this time-consuming activity does not fall on crew members.

ESA's Columbus Control Centre – located at and operated by the German Aerospace Centre (DLR), near Munich in Germany – is responsible for controlling and monitoring all the systems of the European laboratory.

It plays a key role in coordinating the priority of experiments, as well as monitoring resources and astronaut time.

ISS activities and operations are all interdependent and so are covered by a single master plan, making any rescheduling a highly complex task.

Each experiment carried out on Columbus has its own detailed schedule of operation and specific time-slot in a busy overall ISS schedule.

When adjustments are required ground controllers have to agree on new priorities and changes to astronauts' daily schedules. In Europe, this happens in close coordination with the User Support and Operation Centres (USOCs), which monitor and control their own experiments.

Flight controllers in the Centre conduct in-orbit operation and control of the Columbus laboratory's systems from two control rooms – one for real-time operations and a second acting as a backup system and being used for training and simulations.

Tasks include looking after power supplies, temperature, heating and cooling, humidity, air to breathe, water and gas for experiments, communications, antennas and all experiment and maintenance operations.

It also functions as a central point of contact for the various European centres involved in any aspect of Columbus operations, including the USOCs, and coordinates communications between them.

Decision-making in a fast-moving environment where multiple priorities have to be taken into account means it is essential for the Columbus Control Centre to be operational 24 hours a day, seven days a week.

Internal view of the Columbus Control Centre.

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