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 Thirsk, ESA’s 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.

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 Node 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 ongoing opportunity stretching over at least a decade.

“Columbus is a sophisticated 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 Thirsk, ESA’s ISS programme manager.

“Now we want a strong utilisation programme so that Columbus becomes a place where scientists want to come for their experiments and where technologists want to develop and test their state of the art visons.”

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.
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 physiological 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 "walk-in" 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 calling area. Columbus subsystem equipment and overall Station stowage space occupy the equivalent of another three racks.

Liquid Science Laboratory (LSS) 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 highvalue-added products. For example, if the behaviour of fluids can be controlled and predicted more accurately, 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.

European Drawer Rack (EDR) This is a modular and flexible experiment carousel 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 constraints: 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 pures gasless atmosphere.

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.

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