The Columbus laboratory

Increasing possibilities for microgravity research

From late next year the science community in Europe will be able to carry out extended forms of research in microgravity, when the European Columbus laboratory will be in service. With the laboratory in space and fully manned, European researchers will get unique possibilities to increasing research in microgravity.

The research laboratory will be permanently attached to the International Space Station and provides internal payload accommodation for experiments in the field of multidisciplinary research into material science, fluid physics and life science. In addition, an external payload facility hosts experiments and applications in the field of space science, Earth observation and technology.

The laboratory is now at Kennedy Space Centre for final preparations before launch, planned for late 2007.

How reach microgravity conditions?

Gravity affects many physical, chemical and biological processes on earth and in many cases it is desirable to eliminate this influence, but how?

All microgravity research must not be carried out through expensive experiments in laboratories placed in orbits around Earth; there are other quite useful and valuable methods. The simplest method is the drop tower, a high tower from where experiments are dropped and stay a few seconds in microgravity conditions. Such a construction is relatively cheep to build and use, as well as it is useful in terms of testing equipment and for other experiments. Such an installation is, among other places, in service in Germany.

The next step can be experiments through parabolic flights with the help of large aircrafts. ESA carries out some campaigns with specially equipped aircrafts from Toulouse in France. These methods provide microgravity conditions in minutes, and are very useful in terms of testing the equipment, training of personal, pre-operation of experiments that are planned for staying in orbit, and for experiments that do not depend on long time in microgravity.

In terms of spending longer amount of time in microgravity conditions, the use of sounding rockets is useful in many cases. The staying time in the right conditions may vary, it depends on how large rockets one uses. There are several places in Europe one can launch such rockets from, but the most well-known is Esrange in northern Sweden. Different campaigns with different microgravity time can be carried out here, and the Maxus campaigns provides the longest time, between 12 and 13 minutes before a parachute provides a soft landing for the experiments. High-altitude sounding rockets enable European scientists to, in a simple, fast and low-cost way; carry out experiments in almost weightlessness.

All these types of microgravity are based on reduced gravity through holding the experiments within a suitable hull and in free fall towards Earth, after lifting to a desirable height with different types of vehicles. To place experiments in real micro gravitation conditions is not realistic, because one needs to travel hundreds of millions of kilometres away to free ourselves completely from gravitation. However, the combination between centrifugal forces and gravitation provides the orbital height for the International Space Station, around 400 km, conditions almost free for gravitation in spite of the real gravitation is only ten percent lower than on the Earth's surface.

This phenomenon provides the researches possibilities to carry out experiments in microgravity at a relatively short distance from Earth, and at bearable costs. The idea for a space station is based on this.

The Columbus section of the International Space Station is only a scientific laboratory with a standard at three persons, but that may vary with assistance from parts of the ISS crew in hectic periods. The environment in the laboratory is close to similar to the environment on Earth with a cabin temperature between 16 and 27 degrees Celsius and an air pressure between 969 and 1013 hPa.

The Columbus laboratory is ESA's biggest single contribution to the International Space Station. The 4.5-metre diameter cylindrical module is equipped with flexible research facilities that offer extensive science capabilities. During its 10-year projected lifespan, Earth-based researchers will be able to conduct thousands of experiments in life sciences, materials science, fluid physics and a whole host of other disciplines, all in the weightlessness of orbit.

Experiments at space

The Columbus laboratory has room for ten International Standard Payload Racks (ISPRs), eight situated in the sidewalls, and two in the ceiling area. Each rack is the size of a telephone booth and able to host its own autonomous and independent laboratory, complete with power and cooling systems, and video and data links back to researchers on Earth.

ESA has developed a range of payload racks, all tailored to squeeze the maximum amount of research from the minimum of space and to offer European scientists across a wide range of disciplines full access to a weightless environment that cannot possibly be duplicated on Earth.

The Biolab, for example, supports experiments on micro-organisms, cells and tissue cultures, and even small plants and small insects.

Another rack contains the European Physiology Modules Facility (EPM), a set of experiments that will be used to investigate the effects of long-duration spaceflight on the human body. Experiment results will also contribute to an increased understanding of age-related bone loss, balance disorders and other ailments back on Earth.

The Material Science Laboratory Electromagnetic Levitator (MSL-EML) is a facility for the melting and solidification of conductive metals, alloys or semi-conductors and a Fluid Science Laboratory (FSL) will accommodate experiments in the strange behaviour of weightless liquids. Outside, Columbus has four mounting points for external payloads. Exposed to the vacuum of space, and with an unhindered view of Earth and outer space, science packages can investigate the space around

The researchers on the ground

Columbus in orbit is only the most obvious and impressive part of the whole research programme. Columbus on the ground will involve researchers all over Europe, all of whom will be able to control their own experiments directly from several User Centres or even directly from their workplaces. Their efforts will be channelled through the Columbus Control Centre in Germany, which will interface with the module itself and also ESA's NASA partners in the United States.

BIOLAB: Biological Experiment laboratory in Columbus

Experimental racks inside a mockup of Columbus. Photo credit: ESA

Columbus is, as earlier mentioned, equipped with ten racks onboard. The principle for utilisation of these experiment racks are nearly the same, independent of what fields of research they are about to support. Let us look closer at the facilities in the Biolab rack.

The Biolab facility is the laboratory designed to support biological experiments on micro-organisms, cells, tissue cultures, small plants and small invertebrates. The major objective of performing Life Sciences experiments in space is to identify the role that microgravity plays at all levels of an organism, from the effects on a single cell up to a complex organism including humans.

Operational Concept

The biological samples, together with their ancillary items are transported from the ground to Biolab either within the Experiment Containers or in small vials. The latter case will apply if the samples require storage prior to use, in the Minus Eighty Laboratory Freezer for ISS (MELFI). On-orbit, the Experiment Containers are manually inserted into Biolab for processing, whereas the frozen sample will first be thawed-out in the Experiment Preparation Unit (EPU) installed inside the BioGlovebox.

Once this manual loading is accomplished, the automatic processing of the experiment can be initiated by the crew member. The experiments are undertaken in parallel on a 0 g and a 1g centrifuge respectively, the latter providing the flight reference experiment, whilst the ground reference experiment is performed at the Facility Responsible Centre (FRC). During processing of the experiment, the facility handling mechanism will transport the samples to the facility's diagnostic instrumentation, where, through teleoperations, the scientist on the ground can actively participate in the preliminary in-situ analyses. Typical experiment durations range from 1 day to 3 months.