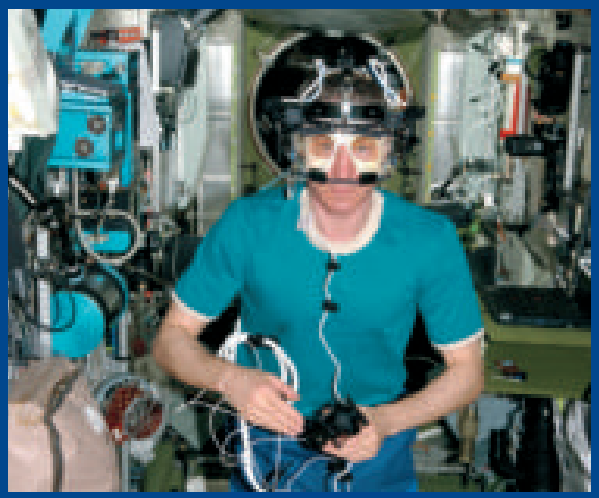
CHRONOS VISION, CHARITÉ BERLIN



Neurovestibuar research on ISS reveals the role of gravity

Throughout evolution gravity has provided a constant reference for spatial orientation. The otolith organs in the inner ear are responsible for the correct perception of the gravity vector. The aim of the Eye Tracking Device (ETD) experiment was to determine how the internal coordinate systems of the visual and vestibular systems are altered by the loss of the otolith-mediated gravity vector. The onboard experiments were performed with the ETD from 2004 to 2008. The results show that the gravity vector provides an essential reference to the central nervous system; its absence during spaceflight leads to a decoupling of the internal coordinate systems. This demonstrates that the central nervous system relies on gravity for spatial orientation and coordination. More recently pre- and postflight measurements conducted on Shuttle crew members has revealed the existence of a dominant balance organ, similar to handedness.

CHRONOS VISION provides eye tracking equipment for research and diagnosis worldwide. The company also manufactures eye tracker components for ophthalmologic laser surgical equipment. Such laser surgery of the eye demands realtime measurement of eye position in order to precisely control the operation laser by compensating for any movements of the operated eye.

SENSOMOTORIC INSTRUMENTS GMBH (SMI)

Cyclotorsion

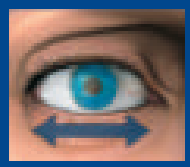
Y Eye Roll

X Eye Roll

Rotations

Translations

X Translation



Y Translation

Z Translation

Eye Tracking Solutions

The 3D VOG Video-Oculography® system is a fully integrated, lightweight system for the monocular and binocular analysis of horizontal, vertical and torsional eye movements. Other eye tracking solutions such as the SMI Eye Tracking Glasses are advancing a wide range of research areas in professional training, human computer interaction, psychology and neurosciences.

SensoMotoric Instruments (SMI) is a world leader in dedicated computer vision applications, developing and marketing eye & gaze tracking systems and medical solutions for a wide range of applications. More than 6,000 systems installed worldwide are testimony to SMI's continuing success in providing innovative products and outstanding services to the market.

Founded in 1991 as a spin-off from academic & medical research at FU Berlin, SMI was the first company to offer a commercial, vision-based 3D eye tracking solution which was employed by the ESA, the NASA and on board of the Russian space station MIR.

KORALEWSKI
INDUSTRIE-ELEKTRONIK
OHG

HealthLab – an innovative health monitoring system

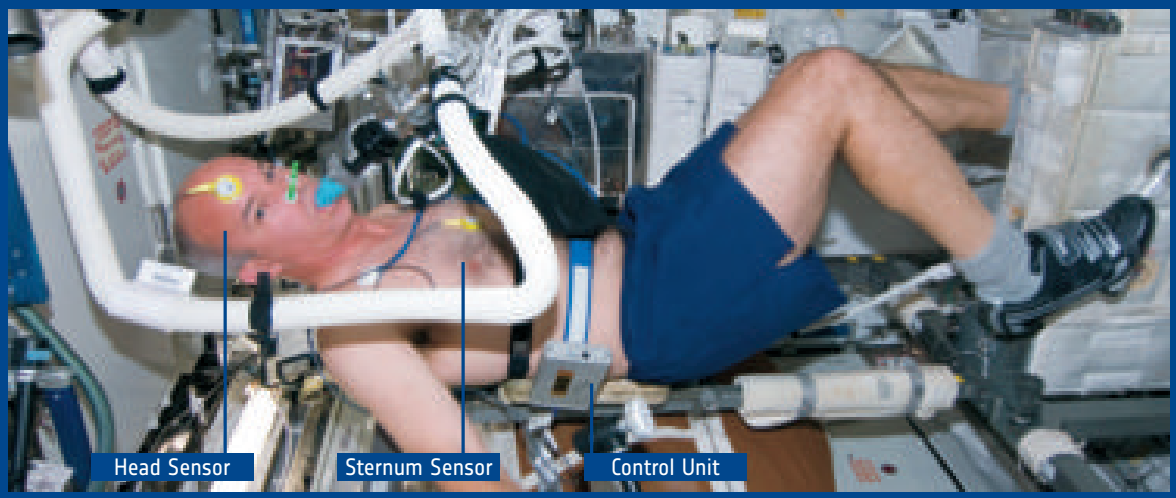
Monitoring patients is not exclusive from planet Earth. In orbit, astronauts have been using the HealthLab system to record a set of various highly upmarket physiological parameters and to evaluate them.

HealthLab implements a specific diagnostic method as well as space-specific training methods for docking manoeuvres. Due to its modular design – it is compactly integrated and portable in design – the system meets the requirements of the majority of different applications, and it is also universally available for other scientific purposes.

The monitoring system HealthLab is used since 2006 as a permanent equipment of the Russian module of the International Space Station, and successfully delivers physiological parameters from the cosmonauts from space. Still in use, since 2009, is also the ThermoLab system, another variant of the HealthLab technology in the U.S. Destiny module.

ZENTRUM FÜR WELTRAUMMEDIZIN BERLIN

CENTER OF SPACE MEDICINE, CHARITÉ BERLIN, DRAEGER WERKE

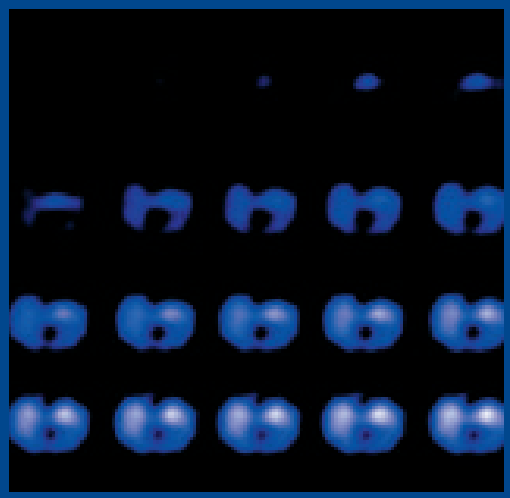


Thermolab: Space fever

Humans have an autonomous endothermic system that ensures a balanced body core temperature of 36.7°C. When the environment alters the relationship between our skin and that temperature, our body activates thermal regulation systems. During spaceflight this changes dramatically. The first studies were already planned 40 years ago, but due to the low acceptance among astronauts to use rectal tubes to measure their temperature, no valid data could be collected. The development of a non-invasive sensor has made these measurements possible. The Double Sensor works via a heat flux technology that gives excellent correlations when compared to the rectal probe. It finally became possible to measure the forehead, near to the temperature regulation center (hypothalamus).

The Thermolab project started in 2009. In conjunction with NASA, astronauts were examined during a maximal bicycle test. Ten subjects participated in the protocol before, during and after their spaceflight. The results confirmed the hypothesized alteration in temperature regulation during weightlessness: all subjects had a higher basal body core temperature in orbit. During exercise, that temperature increased faster and higher, with a prolonged cool down phase compared to exercise on Earth.

DRÄGER
TECHNOLOGY FOR LIFE



PulmoVista 500. Making ventilation visible

The new PulmoVista 500 is the first Electrical Impedance Tomography device (EIT) intended for everyday clinical use to assess regional distribution of lung ventilation directly at the bedside. This technology has been used on several parabolic flight campaigns in order to investigate the behaviour of the lungs under zero gravity conditions. Mechanical ventilation uses pressures that are much higher than normal breathing which creates a risk of over-stretching areas of the lung. On the other hand, if the pressure at the end of the breath is set too low, some lung areas may collapse. Both of these situations can impede the healing process of an intensive care patient.
PulmoVista 500 provides dynamic tomographic images representing the lung function. The physician can continuously track how evenly the breathing gas volume is distributed in the lungs. Measurements are performed by determining the bioimpedance inside the body. One of the primary goals in developing PulmoVista 500 was to make sure that the device was easy to use in the demanding intensive care environment. Thanks to the easy to attach flexible electrode belt the device is ready for use in just a few minutes. PulmoVista 500 does not use radiation and thus can be used for continuous ventilation monitoring without side effects.

NOVOTEC-MEDICAL, GALILEO-TRAINING

Galileo Space against muscle and bone loss

The battle against muscle and bone loss is fought not only in space, but also in bed rest studies, parabolic flights and analogues on Earth. Galileo side-alternating vibration devices have been shown to be the most effective training system to counteract this undesired effect in long term space missions.

Bed rest studies showed effectiveness of the vibration training of almost complete compensation of muscle and bone loss. Over 50 days of bed rest, volunteers just had to train with the device between 10 and 50 minutes per week.

During several parabolic flight campaigns, the decoupling of vibration from the carrier was demonstrated and fundamental research on muscle function under vibration carried out. Galileo vibration training was also seamlessly used during the whole Mars500 study.

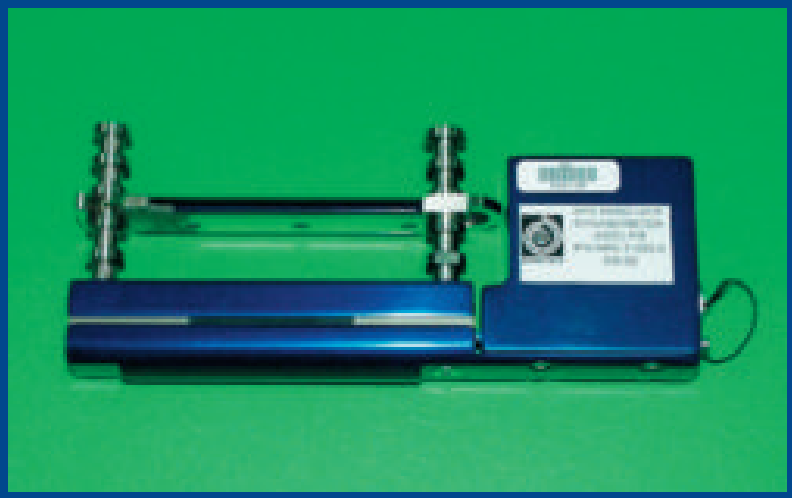
CENTRE SUISSE
D´ÉLECTRONIQUE ET
DE MICROTECHNIQUE

LTMS: Measuring critical physiological parameters

Point-of-care medical systems, continuous vital-sign monitoring at home or specialised training devices for athletes are some of the applications that the Long Term Medical Survey system (LTMS) brings to people on Earth. Non-invasive technology has been recently developed to record blood oxygen saturation, core body temperature, respiration, heart rate and electro-cardiogram. In particular, a system based on the LTMS technology but adapted for sports has been developed by CSEM for the start-up Sense-Core.

The European Space Agency, together with the other space agencies, is considering future manned missions to Moon and Mars. One way of preparing this for physiological and psycho-logical data is the exploration of simulation analogues, such as the Concordia station in the Antarctic. Currently the LTMS is set to monitor the health and adaptation of the Concordia crew to extreme environments. The objective is to continuously monitor physiological signals while wearers are performing their daily activities or during their sleep. It has been also used in other contexts, like in field experiments of the ÖWF (Austrian Space Forum) space simulation suit at Rio-Tinto, an old mine in South of Spain.

KAYSER ITALIA



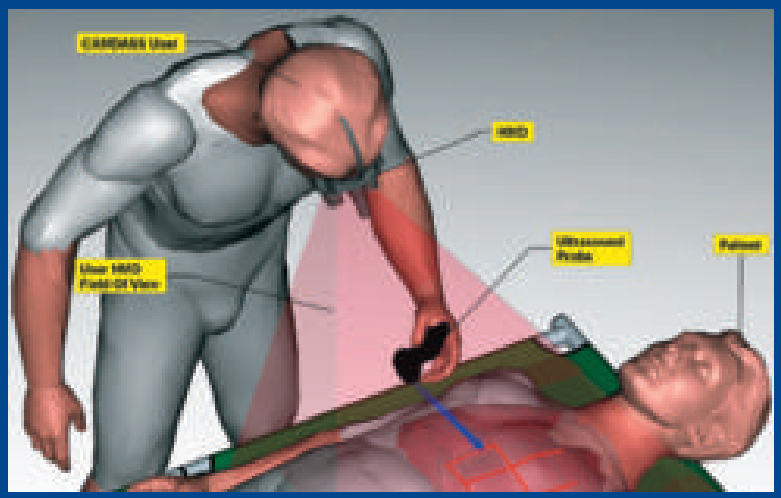
Hand Grip Dynamometer

During spaceflight astronauts are subjected to motor control and postural diseases, as well as to loss of calcium and muscle atrophy. These changes are used as models for the study of usual diseases on Earth such as osteoporosis and other age-linked conditions.

A set of instruments for the ISS have been developed in order to quantitatively assess the performance degradation of upper limbs. In particular, a decrease of Maximum Voluntary Contraction (MVC) has been demonstrated with four astronauts.

The Hand Grip Dynamometer is one of those instruments. It has an accuracy of 0.7%, and it it is complemented by an instrumented glove with 15 degrees of freedom, the inertial tracking system for the wrist in order to reconstruct trajectory of the hand, and a pulse and blood pressure monitor.

SPACE APPLICATIONS SERVICES: AN SME IN HUMAN SPACEFLIGHT



CAMDASS: Augmented Reality for Ultrasound Diagnostics

Soon it won't be necessary to be a doctor to diagnose a sick person when there is no hospital around the corner. The Computer Aided Medical Diagnostics and Surgery System (CAMDASS) uses augmented and virtual reality to provide medical guidance and diagnostic support to astronauts (or other non-expert users) through a database of medical procedures. Focusing on non-invasive diagnosis using ultrasound, procedures are broken into sub tasks such as probe guidance, image acquisition and image analysis and measurement. A stereoscopic see-through head mounted display is used to present guidance cues directly in the astronaut's field of view.

The 3D guidance cues are registered to the patient's body, providing the 'in-situ' information on placement of the probe, as well as additional information to assist in the successful completion of the diagnosis. Data recorded during diagnosis can be compared with the medical history of the patient. Speech recognition driven interaction allows the system to be used in a hands-free manner. These two features allow the astronaut to efficiently perform on the medical procedure. Such technology could help to provide critical assistance to patients in emergency situations on Earth.

ADECHOTECH & MAGELLIUM: 2 SMES IN BIOMEDICAL RTD

ROBOTIZED TELE-ECHOGRAPHY. How to diagnose remotely?

In isolated and/or underserved situations on Earth, carrying out an ultrasound exam is often hampered by the lack of a specialist radiologist. The first diagnosis is critical in order to facilitate the choice between a local treatment and a transport to a dedicated medical centre. Such contexts are for instance peacekeeping operations, support to relief operations to natural disasters, isolated and mobile contexts or even the fight against the worldwide unequal redistribution of healthcare. Long-duration stays on the International Space Station and future manned exploration missions will require the use of medical tools in order to diagnose potential crews' health problems. Among various medical imaging techniques, echography has been identified as promising since it is non-invasive and compact.

Different ESA sponsored activities in the field of robotized tele-echography have demonstrated that such a diagnostic technology has a clear dual interest: it is not only useful for diagnosis or scientific investigations during crewed Earth-based precursor missions (e.g. in space analogues) or for International Space Station crews, but also for terrestrial telemedicine applications.

TECHNISCHE UNIVERSITÄT DRESDEN AND UNIVERSITÄT STUTTGART

Gas Sensors for Atomic Oxygen & Respiratroy Breath Analysis

The key is not to miss a breath. Based on the success of sensor systems for atomic oxygen in space, a miniaturised version for human respiratory analyses (mRSS) on Earth is now under development. The sensor system FIPEX for atomic oxygen has been in operation on ESA's external platform EuTEF on the International Space Station for about 18 months.

The objectives of this project are to develop miniaturised oxygen and carbon dioxide sensors, to use their capability for simultaneous measurement of total flow rates, to integrate them into a contactless mask for the in-situ measurement of respiratory parameters, and to perform first validation and scientific tests.

As a result, new miniaturized gas sensors for in-situ measurements of residual gases in low Earth orbit, and spin-off technologies applicable for space experiments and instruments, are being developed. A small and light-weight device for astronaut fitness surveillance and scientific experiments on-board the International Space Station or other space missions may be targeted for a future development, having also a high potential for different terrestrial applications.

MDU MECÂNICA IDA, FMH, SELMATRON

A Zero-g treadmill to fight bone loss

Reducing bone density loss is particularly important for a population at increased risk, like elderly people or astronauts. Special trousers with bungees developed for the space environment help to increase muscle activity and fight bone diseases. Bone loss is a major problem for astronauts on long-duration mission under microgravity conditions. Due to the lack of gravity, their muscles don't have to support the weight of their entire legs. One of the countermeasures to mitigate this health problem is exercising, such as walking/running on a treadmill, using a special harness to hold the astronaut. However, its efficiency is lower as when compared to the same drill under normal gravity.

Covering the legs and lower torso, the trousers restrain the movements in a way that forces the posterior muscle groups to work harder. The bungees force the leg to be on a vertical position aligned to the body. In a way, they mimic the effect of gravity. The result is a stronger counterforce on the respective supporting bone and a better output from the treadmill exercise. The compression applied to the bones in the leg have a positive influence on the reduction of bone mass density loss.

WORLD LEADING MEDICAL UNIVERSITY AND EXERCISE INDUSTRY

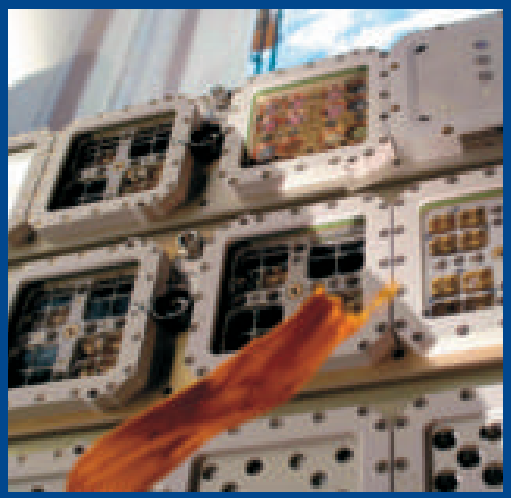
The ultimate exercise device for space travel and home use

Spaceflight certified hardware can now be used by the demanding home trainee and the astronaut. ISS crewmembers are mandated to perform regular exercise to combat muscle atrophy, bone loss and compromised cardiovascular function and stamina resulting from zero-g. Despite the confined area and small habitat on the Station, several bulky exercise tools with different functions are needed to allow for resistance and aerobic exercise training. Such equipment must be highly effective to produce the desired training effects to maintain health. Any apparatus must possess a small mass, be easy to stow, use high-end, spaceflight certified materials, require minimal maintenance, and be safe and user friendly. However, future long-duration spaceflights will only allow for one single piece of compact exercise hardware engineered for both resistance and aerobic training.

Up until now, no commercial product or known innovation could comply with these requirements. YoYo Technology AB has designed and owns rights to flywheel technology that allows for both resistance and aerobic exercise. Years of applied muscle research at the Karolinska Institute has proven that this exercise solution could be the preferred choice of astronauts and home trainees.

KAYSER-THREDE RUAG

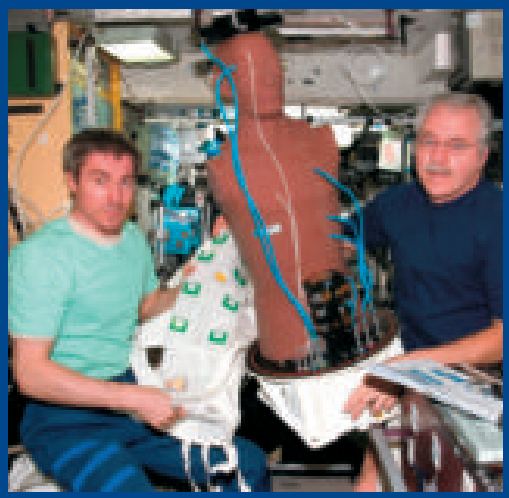
EUROPEAN SPACE AGENCY, KAYSER-THREDE GMBH, RUAG SPACE

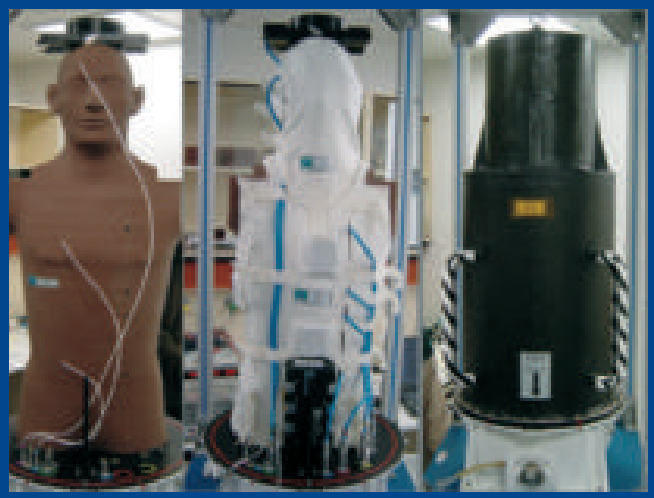


Biology and biochemistry under the harsh space conditions

What are the boundaries of terrestrial life? Is it more plausible that life could exist on some of the exoplanets detected in recent years? EXPOSE is a suitcase-sized experiment platform for astrobiology and astrochemistry. Mounted on the outer surface of the ISS, test samples can be exposed to full spectrum solar light, space vacuum, cosmic radiation, wide temperature variations and microgravity, a combination of space factors which cannot be simulated on Earth. The astrobiological experiments are intended to find out which terrestrial organisms are able to cope with the hostile space conditions. The results obtained indicate that remarkably, survivors can be found among particular microbes, plants (lichens) and even animals (tardigrades). The astrochemical experiments aim to understand the evolution of organic molecules in space. Organics are not restricted to Earth; they are abundant in deep space even when no life forms are present.
EXPOSE is equipped with 12 experiment carriers which can be individually tailored to the investigators' needs, enabling to fly a diverse set of experiments on a single mission.
EXPOSE has completed two flights: EXPOSE-E (18 months of space exposure) and EXPOSE-R (22 months). A third flight is in preparation.

DLR, AEROSPACE MEDICINE, KAYSER ITALIA AND DTM

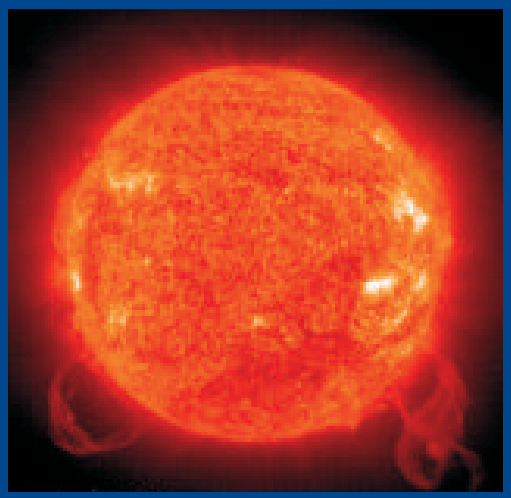




A human phantom to measure radiation hazards in space

Better understanding of the radiation impact on the internal organs of workers exposed to high levels of radiation is of prime importance for designing better protection measures. MATROSHKA is a special "astronaut", a mannequin of a human torso made up of plastic, foam, and a real human skeleton. More than thirty layers are equipped with dozens of radiation sensors that are placed strategically throughout its surface and interior to measure how susceptible different organs and tissues can be to radiation experienced by astronauts. The experiment also studies the depth dose distribution of the orbital radiation field at different sides of the astronauts' organs during an Extra Vehicular Activity (EVA). The radiation field during EVA is that of the free space environment, only modified by the space suit. Since EVA's are a substantial part of the work-schedule in the Space Station scenario, such measurements have highest priority.
MATROSHKA is one of the largest, multinational, collaborative investigations on the Space Station. Since 2004, MATROSHKA has been installed outside of the ISS, attached to the Russian segment Zvezda, and inside the Japanese module Kibo and the Russian segment. It is the longest scientific radiation experiment ever to be carried out in space.

EUROPEAN SPACE AGENCY



SOLAR. Looking at the Sun

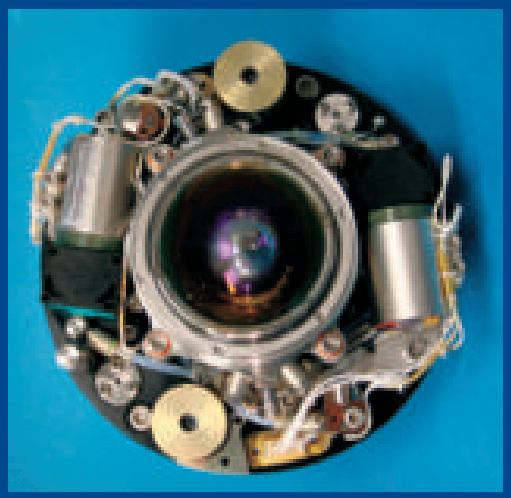
We are living now a maximum of solar activity in the Sun's normal 11-year cycle, a period that is helping to build a more detailed time-dependent picture of its sunspots and magnetic field. Extreme ultraviolet radiation emitted by solar flares, for example, can affect the Earth's ionosphere. Only by analysing the solar activity in more detail, we can understand the physical mechanisms at work in our star.

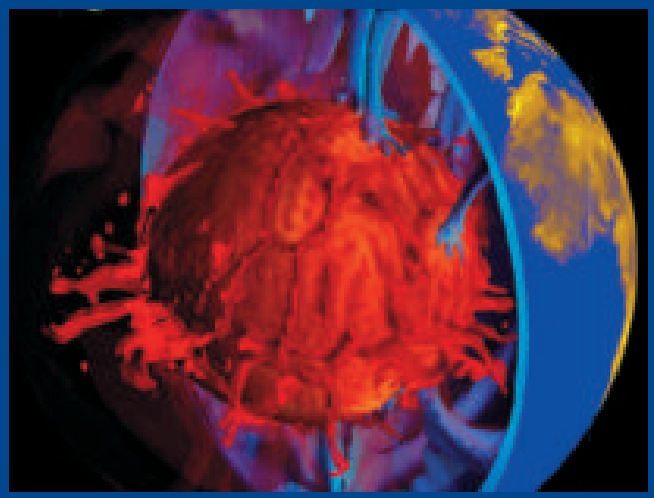
The SOLAR payload facility, located externally on the Columbus laboratory, studies the Sun's electromagnetic radiation with unprecedented accuracy across most of its spectral range. The data acquired will help scientists in improving climate models and sharpening future weather forecasts. It could also help future satellites to better tolerate the radiation effects and prolong their life in orbit.

After more than four years in orbit, the facility has so far produced excellent scientific data during a series of Sun observation cycles. SOLAR has been designed to perform its science operations automatically, minimising the need for intervention by astronauts.

ASTRIUM
AN EADS COMPANY

EUROPEAN SPACE AGENCY,
EADS/ASTRIUM





GEOFLOW. The art of simulation

Gravity makes it impossible for scientists to observe convection in a sphere without perturbations. This is of importance for astrophysical and geophysical problems such as global scale flow in the atmosphere, the oceans and in the liquid nucleus of planets.

In space, however, such convective flow can be generated by applying different gravity levels with electric fields and temperature differences. It is like creating a spherical kettle, with the heated water moving outwards from the centre.

The Geoflow-2 experiment investigates from space the flow of an incompressible viscous fluid held between two concentric spheres rotating about a common axis, as a representation of a planet. The aim of this experiment is to observe for the first time the liquid movements as accurately as possible, and compare them with computer simulations.

Geoflow-2 will give us clues about Earth's mantle convection, and an improved understanding of the global-scale flows in the liquid nucleus of planets and the outer shells of celestial bodies.

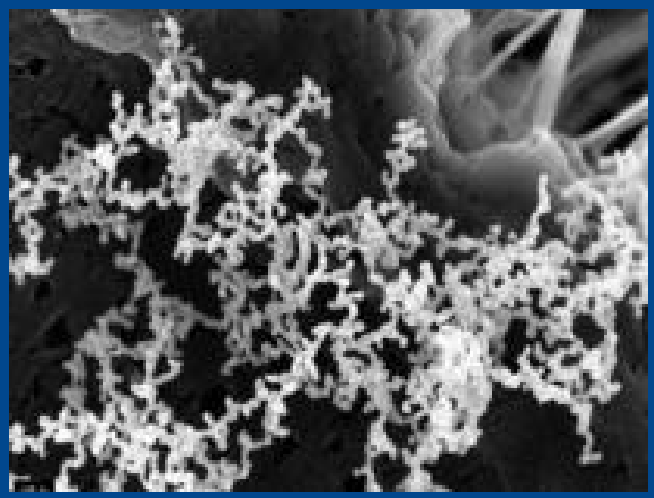
XRMON ESA MAP PROJECT

X-ray Monitoring of solidification and foaming fenomena

Automobile and aerospace industries need component reliability and well defined structures to obtain more efficient and cheaper microstructures. Sponsored by ESA, the XRMON project aims to supply knowledge to European industry that allows for solving current problems in the development and manufacture of advanced materials. X-rays are particularly well suited for in-situ studies in metallic alloys, with few demands on special sample environments and by being non-destructive to most materials. Recent advances of new and more powerful synchrotron X-ray sources as well as high resolution detectors, have revitalized the use of in-situ imaging methods also in the field of solidification science.

XRMON develops a series of systems for in-situ X-ray radiography of metallurgy experiments in order to study solidification phenomena and metal foaming in microgravity and terrestrial environments. Observations of alloy solidification or foaming processes can give hints on how to strengthen their properties in production plants. This project does not focus only on a particular material or generic science aspect. It also pays attention to the development of experimental facilities, techniques and analyses.

EUROPEAN SPACE AGENCY

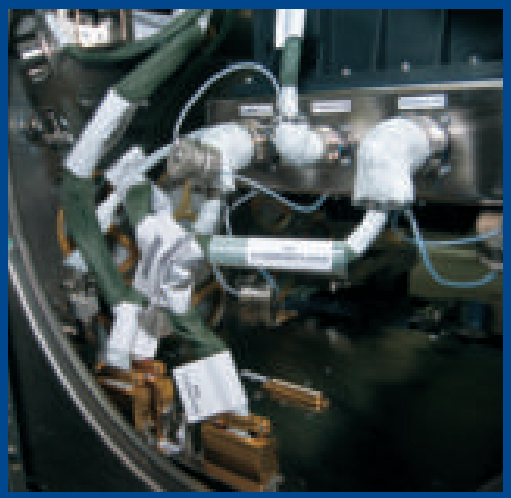


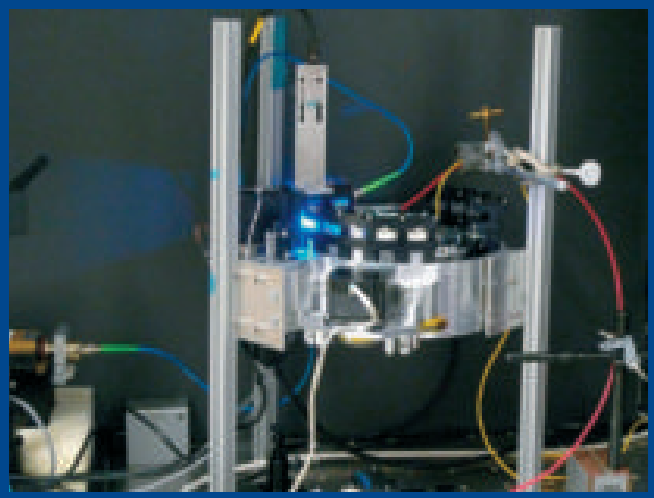
BLADES & FOAMS. Materials of the future

Lightweight and high-strength intermetallic alloys can help to improve efficiency, reduce fuel consumption and lower exhaust emissions in aero-engines. They are also important for producing advanced catalytic powders, which speed up chemical reactions, saving both time and energy for the pharmaceutical, chemical and food industries. Intermetallics are chemical compounds of two or more metallic elements. A large multidisciplinary European consortium have probed the links between the processing, structure and properties of 'intermetallic' alloys. Their wide range of potential applications in aeronautics, automotive engineering, hydrogen fuel cells and even biomedicine have placed them in the spotlight.Titanium aluminides, for example, have remarkable mechanical and physical properties. The combination of high melting point, high strength and low density make them ideal for high-performance turbine blades. Foams and emulsions are still a puzzle. Their study under weightless conditions has wide practical applications. Solid foams can be as strong as pure metal but much lighter, and they are used in advanced aerospace technology and manufacturing. Foams and emulsions are also important for personal care products and waste treatment, as well as for food and oil industries.

ASTRIUM
AN EADS COMPANY

EUROPEAN SPACE AGENCY,
EADS/ASTRIUM





Soft matter and the FOAM-C instrument

How the Soft Matter, such as foams, emulsion, granular matter and colloids are structured, and which forces control them, are a fundamental problem in physics and chemistry. The FOAM-C instrument is designed to study various phenomena in microgravity such as:
Foam coarsening: Foam coarsening is a slow process, for which a long observation time is necessary. The studies in the FOAM-C instrument will focus on very wet foams and emulsions which cannot be studied on ground, due to drainage effect.
Colloids and proteins: Controlling the crystallisation and aggregation of nanoscale systems remains an important challenge on Earth. Colloids solidification and protein aggregation will be investigated with the light scattering techniques.
Granular matter jamming: Dense granular matter is an important topic both for fundamental science (dissipative non-equilibrium systems) and for applications (handling and transport on Earth and also in future space missions). FOAM-C will provide information on the dynamics of the grains to understand the drastic change of the mechanical properties during compaction, also called jamming. FOAM-C is designed to be operated in the Fluid Science Lab (FSL) inside the Columbus laboratory on board the ISS.

KAYSER ITALIA

Cell culture chambers for life on Earth and in space

What is the signal that trigers cells to make a choice between life and death? From investigating gene expression to incubating cells, the secrets of life can be studied inside a small culture chamber.

Biology experiments require a unit consisting of a body compatible with the different fluids and cells, and adequate containment. This body includes all the necessary mechanisms and electronics in order to provide the culture chamber with nutrients, washing, fixation and collection of housekeeping data.

A fleet of experiment units have been developed during the past decade for their use in space. Plants, bacterias, yeasts or small animals have been studied in special containers adapted to cope with the science requirements, both on Earth and in space.

ASTRIUM
AN EADS COMPANY

EUROPEAN SPACE AGENCY, EADS/ASTRIUM

Improving knowledge of cultivation processes

Cultivation and production processes in different environmental conditions on Earth can benefit from the long-term research carried out in space. ESA's plant biology research is helping to determine the mechanisms behind which plants sense gravity and how this is altered in weightlessness.

The European Modular Cultivation System has been a workhorse of this research on the International Space Station. The facility has helped in determining the threshold of gravity sensitivity in lentil seedlings, the gravity response at different stages of development in thale cress with a view to producing viable seeds from multi-generation plants, and an experiment to identify gravity-regulated genes.

Research in the facility is also helping in increased knowledge of cell, molecular and developmental biology. Further development of ecosystems have potential applications in medicine, agriculture and environmental management. Biological air filters and biosensors can form part of the Environmental Control and Life Support Systems.

ASTRIUM
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EUROPEAN SPACE AGENCY, EADS/ASTRIUM

Gravitational biology experiments on plants & cell cultures

Biological investigations under microgravity on cell cultures, micro organisms, small plants and invertebrates have their place in space. The European Modular Cultivation System (EMCS) and BIOLAB are multi-user facilities which offer a complete research infrastructure with incubator for 18°-40°C, centrifuges for artificial gravity (10-3 to 2g), control of the atmosphere and observation cameras.

The BIOLAB incubator can be accessed by an automatic fluid handler with interface to integrated freezer/cooler compartments and analytical instruments for microscopy and spectroscopy for fully automated cell culture procedures. BIOLAB's glovebox also offers the possibility for manual operations by the crew.

EMCS offers photosynthetic illumination and water supplies to support specialized experiments on plants, including the growth of whole plants from seed to seed. The experiment container TRIPLELUX investigates the combined effects of microgravity and cosmic radiation on the immune defense in rats and mussel cells.

Max-Planck-Institut für extraterrestrische Physik

EUROPEAN SPACE AGENCY, MAX PLANCK INSTITUTE

Plasma Crystal and Plasma Medicine: From Space to Earth

Intriguing Plasma crystals in space

Plasma is the most disordered state of matter. Crystals are the most ordered. When charged microparticles are added to a plasma, a 'plasma crystal' forms, which allows the physicists to study physical processes in unprecedented resolution and slow motion. For large, homogeneous systems microgravity conditions are essential, and there has been a succession of Plasma Crystal Experiments on the ISS in cooperation between Russia and Germany since 2001. Currently the team is developing a plasma laboratory that will allow the study of the fluid phase of plasma crystals.

Plasma Medicine – application on Earth

From the space experiments it was a small but unpredictable step to develop cold 'atmospheric' plasma (CAP) devices. Fine-tuning of the plasma turns these into a new weapon in the fight against infections. Comprehensive tests have shown that CAP can effectively inactivate bacteria (independent of the resistance level), fungi, viruses and spores without harming human tissue and skin. In clinical trials, the CAP treatment resulted in highly significant reduced bacterial loads in chronic wounds, significantly improved healing of skin graft wounds and long-term relief of skin diseases.