esa

→ SPACE FOR LIFE

human spaceflight science newsletter

December 2011

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Hands and arms of ESA astronaut André Kuipers training in his space suit, for his December 2011 launch - in the Soyuz Training Assembly at the Gagarin Cosmonaut Training Centre near Moscow, Russia. Courtesy of Stephane Corvaja.

Launch of Dutch André Kuipers 21 December 2011 - Another ESA astronaut onboard the ISS again after a 6 months break.

ESA astronaut André Kuipers will be launched on 21 December from the Baikonur cosmodrome, in Kazakhstan, on board a Soyuz spacecraft, as flight engineer for Expeditions 30 and 31. With him in the Soyuz capsule Russian cosmonaut Oleg Kononenko and NASA astronaut Don Pettit will go to the ISS. They are scheduled to remain in space for about five months, on ESA's fourth long-term ISS mission, this one named PromISSe.

ESA astronaut Andre Kuipers flew for the first time onboard the Dutch Soyuz mission DELTA in 2004. At that time he stayed a bit over at week in Space, but this time he will remain onboard the ISS for about 5 months, until mid May 2012. During Kuipers' mission, increment 31&32, more than 25 experiments will be conducted. Kuipers, a medical doctor, will perform experiments in both human physiology disciplines and physical sciences. Also biology and radiation monitoring and technology experiments will be performed, as well as educational activities. A condensed record of the planned activities on behalf of ESA can be found in this Newsletter after p.3.

Kuipers will be the next ESA astronaut on the ISS after the station has had no ESA astronaut for more than six months, since 24 May 2011, when ESA astronaut Paolo Nespoli landed.

In the meantime, other astronauts from NASA, the Russian and the Japanese Space agencies have 'had the guard' onboard, and as a part of their activities they have performed ESA experiments. Here is an account of the last months of activity onboard the ISS.

Onboard Science activities - last 3 months

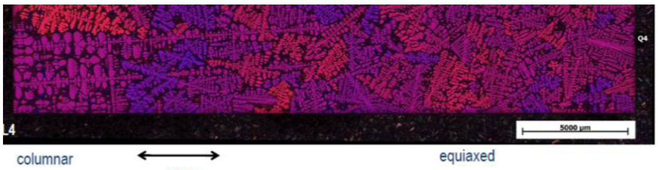
Events during September 2011

GEOFLOW-2

The GEOFLOW-2 experimental programme was significantly impacted by anomalies related to the Fluid Science Laboratory (FSL) on the ISS. Engineering efforts have been made to better understand the current anomalies, before resuming the experimental runs. Several troubleshooting activities have been successfully performed on the FSL Video Management Unit (VMU) subsystem. The outcome has been positive, as the FSL VMU has now been upgraded with new hard-disks of much bigger capacity. Additional effort has been made to acquire the micro-g levels during the GEOFLOW-2 science runs with the CSA-provided FSL Microgravity Insulation Vibration System (MVIS). The GEOFLOW-2 science programme has been successfully resumed on 26 September, but needed to be temporarily put on hold due to limitations from the Ground Operation User Centres, the USOCs coverage. The overall science planning has been re-assessed and the experiment completion is now planned in early 2012.

Material Science Laboratory - September

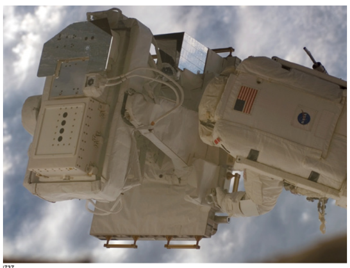
For the Material Science Laboratory (MSL) Facility, the first two Sample Cartridge Assemblies (SCA's) were processed for the CETSOL-2 and MICAST-2 science projects, described in earlier Newsletters, and on p. 7 in this one. An unfortunate event happened during the processing of the SETA-2 Sample Cartridge Assembly (SCA), however: Due to the temporary failure of a central component of the US LAN, the MSL was automatically switched off during the critical solidification process. This had negative impact on the science, as the processing was interrupted before having been completed, and on the furnace insert, due to the lack of appropriate cooling.



CETSOL solidification sample.

Radiation and solar activity

The cumulative radiation monitoring of the ALTEA-SHIELD experiment, that monitors the radiation spectrum and energy inside the station, has been fully accomplished at the last location in the US-Lab.
The science team has now gathered enough science data to terminate the ALTEA-SHIELD Survey experiment.
The measurements from this payload (provided by ASI) will be compared with those made outside of the ISS, in order to judge aspects such as radiation protection value of the materials used, as well as comparing spectra and energy levels.
The experiment registers cosmic particle flux and can discriminate the type of particles and determine the trajectories and energy level.
Presently in NASA's Destiny module, the instrument has been mapping the radiation impact in 3 dimensions.



The SOLAR facility, here held by a NASA astronaut. Courtesy of NASA

The SOLAR external platform continues to monitor the changing Sun spectral activity. Recently the SolACES instrument has encountered a decrease in its measurement efficiency, likely due to some hydrocarbons or water vapour-based contamination on the optical elements. While the root cause is still under investigation, the science and engineering teams have tested a work-around solution, which consists in heating up the instrument during the periods of no measurement of the Sun, and during any ISS manoeuvre events involving Russian vehicles arriving/docked/departing from the MRM-1/MRM-2/DC-1 docking ports. This strategy seems to work and instrument measurement efficiency could be recovered.

Technology demonstrations

ERB-2

Finally, the Erasmus Recording Binocular (ERB-2) experiment hase taken place with NASA astronaut Mike Fossum, as part of his Voluntary Science activities.
ERB-2 is a stereoscopic camera with an improved resolution, 1280 x 720 pixels, corresponding to the HD 720p standard, and it is used both for live broadcast of stereo films as well as for down-linking files of recorded video sessions.

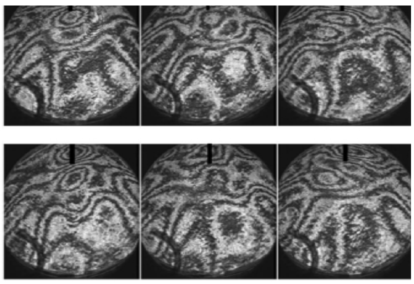
Recorded material is stored on a hard drive in the camera and, when full, these drives are from time to time sent down, last time with the Space Shuttle STS-134, that landed on 1 June. In addition, the European Drawer Rack, a multi-purpose versatile rack is used for down-linking video sequences.

Events during October 2011

General perspective

The cargo ship Progress 44P mishap for a while upset the planning, as the very much needed supplies had to come with the following cargo ship, Progress 45P. Further, the next crew launch with Soyuz 28S was put on hold for a while, whilst the investigations were running.
A potential de-crewing of the ISS by Soyuz 27S return was considered in case Soyuz 28S would be further delayed. All ESA critical activities with JAXA astronaut Satoshi Furukawa and NASA astronaut Mike Fossum were in the week-by-week plan, but several objectives were delayed for NASA astronaut Dan Burbank. Some of the physiology experiment planned with him had to be slightly adapted, given the unexpected on-orbit duration of his stay (i.e. four months instead of six). All in all, therefore, October did offer very limited science opportunities, as indicated here after.

GEOFLOW-2



GEOFLOW images from diverse experiments runs. See also Newsletter February 2009: GEOFLOW - The miniature Earth model (click here)

The GEOFLOW-2 science programme was successfully resumed on 26 September after the upgrade of the FSL Video Management Unit (VMU). In October the science acquisition was put on hold for roughly a month due to limitations from the USOCs ground coverage.
On the way to completion, COLLOID-2 offered an opportunity for the science team to study the ageing effects on the samples, and to gather additional data from the COLLOID-1 experiment performed end of 2010.
With Progress 45P, the samples of the next SODI experiment (DSC) have been delivered to ISS.

ESA Life Sciences experiments

The IMMUNO experiment, has been resumed as a joint Russian-European physiology experiment. Russian cosmonauts have started the pre-flight BDC sessions.

Events during November 2011

GEOFLOW-2

The GEOFLOW-2 science programme has been resumed in November, and is progressing well, despite some operational limitations related to ageing / degradation of the Experiment Container. The end of the science programme is projected to end of January 2012.

Material Science Laboratory - November

For the Material Science Laboratory (MSL) Facility, the sample cartridge could be removed, a health test of the SQF Furnace has been performed after the removal. The outcome of the detailed engineering assessment is still awaited.

SODI-COLLOID-2 and Microgravity Science Glove Box (MSG)

ESA astronaut Frank de Winne installing the SODI equipment on an earlier mission. Courtesy of NASA.

Early November, the SODI-COLLOID-2 experiment, performed in the MSG was successfully completed: The science outcome was very satisfactory as all objectives could be met, even complemented by bonus science runs. The next ESA experiment is currently hosted in the MSG, the SODI Diffusion and Soret Coefficient (DSC) could be started with the delivery of the samples with Progress 45P. After some delay to optimize the quality of the science acquisition, this experiment is currently on-going and will continue until early January 2012.

Physiology experiments resumed with NASA astronaut

The first experimental sessions for the physiology experiments targeting the NASA astronaut Dan Burbank (PASSAGES, THERMOLAB, VESSEL IMAGING), have been successfully performed in November, upon his arrival onboard 28S flight. A short description of these experiments is given below.

- PASSAGES

One of the images used to evaluate if the astronauts' dimension perception in relation to own body dimensions is changed in microgravity.

PASSAGES is an experiment to be continued by coming onboard crews. A description of the essence of the experiment is provided later under outlook to Andre Kuipers' mission, on p.4 in this volume.
Preliminary data indicate that there seems to be an altered perception of height, width and orientation in orbit.

- THERMOLAB

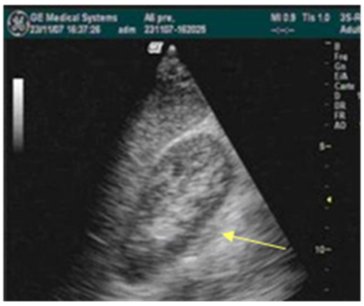
THERMOLAB is a Human Physiology experiment looking at core temperature changes in humans before, during and after exercise performed on ISS. It uses the ESA-built Portable Pulmonary Function System (PFS).
Cady Coleman performed this experiment 4 times between January and May 2011.

NASA astronaut Jeff Williams performing the THERMOLAB experiment onboard the ISS. Courtesy of NASA..

- VESSEL IMAGING

By means of ultrasound waves, images can be formed of structures in the body. In a certain frequency band, the higher the frequency used, the more shallow the image will be formed. This offers the opportunity to investigate the dimensions of both superficial as well as more deep lying structures in the body. Thus heart, brain circulation and superficial vessels are examined.

Ultrasound image of the portal vein, one of the structures looked for



Ultrasound image of the kidney

In response to gravitational stress and exercise, the blood vessel diameters change. After spaceflight it seems that vessels that normally should contract to maintain the blood pressure do that less well than before the flight. Onboard, gravitational pull can be created artificially by exposing the lower body to negative air pressure, thus testing in microgravity, to which extent these reflexes are changed.
The effectiveness of the Lower Body Negative Pressure exposure, that is used as a countermeasure against the negative effects of Space, is likewise tested in this manner.

Present outlook.

ISS research activities were reduced for a while until the full crew complement of six was reestablished for a few days with the arrival of three ISS Expedition 29/30 crew members on 16 November. After a few days of handover the three Expedition 28/29 crew members returned to Earth. The next big event is now the 21 December launch of Andre Kuipers, as a member of the Expedition 30/31 crew Their arrival on ISS on 23 December will again re-establish a permanent six-person crew on the ISS.
With the NASA Space Shuttle fleet retired, Soyuz will continue to launch and retrieve the long duration crews from the International Space Station.

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André Kuipers during the 2004 DELTA Mission to the International Space Station between 19 and 30 April 2004. ESA photo.

André Kuipers preparing ISS expedition 30/31 for a long-term stay

The fourth European long-term mission will launch to the International Space Station (ISS) on 21 December 2011 and will last 5 months until mid May 2012. ESA astronaut André Kuipers will conduct this mission - increments 30 and 31 in 'ISS language'. Kuipers will launch from Kazakhstan in a Soyuz capsule, and come back as well in the same capsule. A preliminary programme of about 25 experiments is waiting for Kuipers - a medical doctor - in human physiology disciplines and physical sciences. Also biology and radiation monitoring and technology experiments will be performed, as will the compelling educational activities.

Here is an account of the planned experiment package that André Kuipers and his crew mates will perform during their mission on ISS.

Human Physiology

SOLO - Sodium (salt) Loading in Microgravity

Astronauts loose calcium from the skeleton when they are in space, most likely because of immobilization of the weight-bearing bones. As a result, bone density decreases during microgravity.

It has been known since early last century that decalcification of the skeleton is stimulated by shifting of the blood and surrounding fluid pH in direction of acidity. At the same time, increase in salt intake is known both to accompany increased calcium excretion marginally and to stimulate light acidity in the blood. And finally, earlier experiments in space indicate a higher degree of salt retention in the body than in normal gravity.

This complex of facts is the basis for the SOLO experiment to compare bone degradation markers in urine to different levels of salt intake. Bone markers are the metabolic waste products found in the urine.

The question raised represents a sharp focus on, when bone degradation (resorption) starts as an effect of pH and to which extent it can be linked to the salt level in the body. Findings in this area are crucial for understanding one of the central processes in the balance in bone formation and bone resorption.

Kuipers will at a few occasions follow a special 5-day diet of constant low and normal sodium intake, high fluid consumption and iso-caloric nutrition, i.e. he will eat daily the same amount of carbohydrates, protein and fat.

PASSAGES - do I fit through the door?

This experiment has been performed already a number of times onboard the ISS, latest by Paolo Nespoli and his crew mates, and will be repeated by Kuipers. Normally at least eight different test subjects need to do such experiments, for the necessary statistical calculations.

Each test subject has to do three sessions of this experiment, one early in-flight, one in the middle of the stay and one before return.

The experiment is based on the concept, that in order to plan appropriate actions relative to dimensions in our direct environment, it is necessary that each individual has a self-image of his/her own dimensions, velocity etc. The question investigated is, if this self-image is influenced by gravity and thus changes in space. The image above is illustrating the judgement our brain does unnoticed every time we need to pass through e.g. a door.

THERMOLAB - Monitoring long-term exposure to microgravity

The THERMOLAB experiment uses the ESA-developed Portable Pulmonary Function System to investigate thermo-regulatory and cardiovascular adaptations during rest and exercise in the course of long-term exposure to weightlessness. The portable PFS basically uses data from


Kuipers testing the Portable PFS training Model at ESTEC, in Noordwijk, Netherlands. ESA photo.

breathing gases as indirect and/or direct measure for the sought values. The Maximum Volume Oxygen (VO_2 Max) is aimed at measuring oxygen uptake and cardiac output in particular, during various degrees of exercise.

EKE - Aerobic responses in space

The preservation of astronauts' aerobic capacity is a major goal of exercise countermeasures during space missions. As one of the parameters indicating exercise capacity and indirectly of endurance, maximal oxygen uptake during exhaustive exercise, the VO_2 max, is measured.
As exhaustive exercise is not under all conditions what you want to do on orbit, an alternative is to check changes in oxygen transport at a certain heart rate. Reduced oxygen uptake relative to the earlier measurement will then indicate a deterioration or the opposite in work capacity. The protocol uses a stair-case step function, pre-programmed into the exercise ergometer, so that you exercise for a fixed time on a certain level, and then step up to next level. Also this experiment makes use of the Portable PFS.

IMMUNO

The messaging mechanism on the immune cell surface seems weakened in space. Internally in the cell, changes also take place in the way that the actions of critical enzymes apparently are less effective.

Earlier studies on diverse animal species indicated that circulating levels of the stress hormone cortisol, coincides well with the immune response weakening, and it has been shown that cortisol is back to normal level after 1-2 weeks in space. Also other studies indicate that the concentration of cortisol is important.

Recent studies continue along these lines in pursuit of a better understanding, in preparation of longer space journeys and with a clear clinical spin-off for terrestrial conditions. In cardiovascular studies it has been established that catecholamines[1] are higher than normal in space. This seems to act in the same immuno-depressing direction.

Which of these, or combination of which are the important ones impairing the immune system, at least for a while? Are the immune cells indeed susceptible to lack of gravitational impact? The IMMUNO experiment is trying to find answers to these questions.

VESSEL IMAGING - The blood flow

By means of ultrasound waves, images can be formed of structures in the body. In a certain frequency band, the higher the frequency used, the more shallow the image will be formed. This offers the opportunity to investigate the dimensions of both superficial as well as more deep lying structures in the body. Thus heart, brain circulation and superficial vessels are examined.
In response to gravitational stress and exercise, the blood vessel diameters change. After spaceflight it seems that vessels that normally should contract to maintain the blood pressure do that less good than before the flight. Onboard, gravitational pull can be created artificially by exposing the lower body to negative air pressure, thus testing in microgravity, to which extent these reflexes are changed. The effectiveness of the Lower Body Negative Pressure exposure, that is used as a countermeasure against the negative effects of space, is likewise tested in this manner.

SPACE HEADACHES - Incidence and characteristics

The origin of headache can be many, as most people are aware. This experiment will screen astronauts for symptoms and development characteristics etc. in order to understand better the reasons for developing headache in space, a frequent occurrence amongst astronauts. Headache characteristics will then be analysed and classified according to the International Classification of Headache Disorders.

ENERGY

Being in space evidently loads the body far less on average than on Earth because of the lack of gravitational pull. Exercise is prescribed to increase the necessary loading, and astronauts exercise almost every day in order to keep muscles and skeleton in good condition.
Astronauts' body mass in almost all cases is reduced during a long-term flights, and the reasons are not well understood.

Monitoring of energy consumption as compared to energy intake in the form of food, is tedious and complex, but this experiment tries to get as complete a picture of this relation as possible.
One of the several complicating factors for these measurements is the fact , that the body is composed of around 70% water, so that even small changes in body water will have a significant effect of the body mass measurements. The systematic ongoing negative energy balance observed in flight also contributes certainly to such a loss, in addition to the effect of disuse of muscles, that leads to lower overall muscle mass.
This experiment therefore focuses on:
1. Measuring changes in energy balance due to long term space flight, and
2. Monitoring adaptation in the components of the total energy expenditure.
3. Finally, these data are hoped to contribute forming an equation for the reel energy requirements of astronauts.

NEUROSPAT


Andre Kuipers in NEUROSPAT training.

EPM/NEUROSPAT started out as the second neurosciences experiment performed in Columbus, and the experiment is near its conclusion.
It is an experiment concerned with the spatial and visual perception. The experiment was described to some detail in Newsletter September 2010. The test subject for the NEUROSPAT experiment, will wear an EEG cap for registration of brain activity

1. Catecholamines is the common name for a group of physiological chemical compounds with the same basic chemical structure, that profoundly impact factors such as heart rate, blood perfusion, and nerve traffic in the body. Adrenalin or epinephrine is one well known of those. Most commonly they work via receptors in the blood vessel walls. They are produced in the body.

during the NEUROSPAT tasks performance, supported by ESA's European Physiology Modules rack.

The experiment examines changes in spatial orientation and perception during spaceflight. These changes will be assessed by recording behavioral measures (speed and accuracy) as well as neurophysiological signals (EEG, EMG) during performance of a series of visuo-motor tasks. The pre-frontal part of the brain is of particular interest, as this is the part of the brain where the effect of stressors such as fatigue, sleep deprivation or hypoxia can be seen.

MARES-SARCOLAB

The **Muscle Atrophy Research & Exercise System - MARES,** is the most advanced muscle research system ever flown in space. It was conceived starting in 1993 and is able to give values for all components in the muscle-tendon system, in almost unlimited experiment settings. All muscle researchers involved with space are excited to see the outcome of the first experiments.

NASA astronaut Shannon Walker, Expedition 24 flight engineer, with the voluminous MARES hardware during installation in the Columbus laboratory. Courtesy of NASA.

Many muscle status and performance experiments have been performed over the last two decades, but sophisticated measurements were mostly made before or after the flights. This has been interesting enough, and the many experiments have given good information, but measuring the same parameters under weightlessness conditions will yield information that cannot be achieved in normal gravity on Earth.
MARES will be commissioned by Kuipers and experiments following could well result in a new phase in the understanding of how muscle function adapts to space conditions - a world without gravity, and in addition to which extent muscle function is related to the sensing of gravity. These things we simply do not know yet. So MARES will be a 'first' via the experiment activities of Kuipers in 2011-12, and probably one of the most prominent ESA physiology experiments for a long time.
Kuipers, before he became selected astronaut, for a time was Project Scientist on MARES and therefore has an intrinsic knowledge of the facility.

Ground based human studies

In relation to every flight with astronauts, a ground-based programme is performed, partly as a way to harvest control data, that can form the basis for an evaluation of the data that is obtained on ISS, and partly as a set of experiment activities, which - in particular after the return from a stay in space - can ascertain which effect weightlessness has had on different body functions.

It is therefore natural to focus on areas where experience tells us that we have 'problems', and as such a programme been conducted over a large amount of years involving a large number of flown astronauts, we are building up a significant experience database.
The data collection sessions connected to Kuipers' flight are identified in the following.

EDOS - Early detection of osteoporosis in space

"Early Detection of Osteoporosis in space" (EDOS), is one of the post-flight activities.
Now, loss of bone mineral density in space is not to be categorised as osteoporosis per se, and probably has a more straight forward reason - etiology - than osteoporosis on Earth (the evident central difference is the change in gravity regime, but how exactly it works on the skeleton is what we are looking for).
Nevertheless, space as such in this manner offers an observation window for what happens when otherwise healthy persons are exposed to lack of gravity for a shorter or - in particular - longer period of time.
Loss of bone mineral can not easily be measured by scanning methods and the like, as significant changes are needed before such methods reveal the change. On the other hand, we now have significant experience with the so-called bone markers from space crews - the metabolic waste products that in particular can be observed and measured in the urine, but also, and for other informative factors, in the blood.
Bone markers reveal as early as 24 hours after a change in the constant gravity direction, that something has changed in that respect, and we do in this manner get a picture of the biochemical reality in bone under such conditions, and as a very early indicator of a shift in the status quo.

The EDOS experiment uses a computer tomography (3DpQCT) scanning method - a device that has a very good measurement resolution - one of the key problems in all scanning methods. With increased resolution we will be able to see ever smaller changes, so a development in this sector is of utmost interest.
Space-based loss of bone mineral and osteoporosis evidently must share a number of characteristics, as well as a significant part must be different, and it is this distinction between the observations in a person that has been diagnosed with osteoporosis, and that in healthy astronauts, which eventually may give us a clue as to why bone mineral is lost overall.

Top osteoporosis researchers claim, that as much as 75% of the findings in osteoporotic patients may be caused by their unfortunate genetic profile. In most cases, space based bone mineral loss must be explainable in rather different terms.

SPIN

Another area that is of concern and high interest is the effect that lack of gravity has on the balance organs.

In daily life on Earth, we always know the direction of the gravity vector, as all movements we do, happen against that force. Onboard an orbiting spacecraft there is no gravity to be sensed, so when astronauts close their eyes, they cannot tell what is up and down. Gradually therefore vision takes over the control whilst in space.
Coming back to Earth after a longer stay in space is therefore a subjectively violent experience, as the exposure to sensing gravity has been 'forgotten' to a significant degree. Even though turning, and accelerating onboard the ISS does give information to the sensory organs, so that astronauts feel that, this happens without the presence of the

very strong Earth-gravity component, we normally have as background. The way the body 're-learns' to deal with gravity, and in particular how the relevant sensor organs register it, is what the SPIN experiment is after.

Measurements done, address if e.g. the sense of the natural vertical is disturbed. This could indicate asymmetry in the balance system, which in itself is an interesting and important observation. Diverse tests challenging the balance system are performed, such as tilting the body on a stretcher, standing upright for a certain period, etc.

Two basic aspects are of interest, namely to gain a better understanding of the sensor functions, and an operational one, which for the future astronauts will be of importance, namely how one prepares in the best way for a landing on another planet after maybe six months in space. Understanding the basic mechanisms better will give us better possibilities for designing efficient countermeasure programmes in such situations. In parallel with findings in space, daily clinical practise can profit from the same improved knowledge.

Biology

The biology facility that will be used for experiments during Kuipers' mission is the self-contained KUBIK, which is accommodated in the European Drawer Rack (EDR) incubator.
KUBIK has housed a very large number of experiments lately, and will during Kuipers' stay be housing the experiments KUBIK-ROALD2 (ROle of Apoptosis in Lymphocyte Depression).

KUBIK-ROALD2

ROALD-2, ROle of Apoptosis in Lymphocyte Depression forms an important continuation of the immunology research that has been performed in space for more than 2 decades. ROALD-2 will in particular look at the life cycle of cells to determine if the have a tendency have a shorter life in space than on Earth. The investigation is targeted on finding possible reasons for impaired T-Lymphocyte function that has been observed in space.

Physical sciences

GEOFLOW-2

Andre Kuipers will continue the execution of the GEOFLOW-2 experiment, now the facility has been upgrade with more capacity. The experiment is described on p.2 here.

MSG-SODI/DSC

The Selectable Optical Diagnostics Instrument (SODI), supports research in the field fluid physics.
SODI has at several occasions been in action. It is located and operated in the Microgravity Science Glovebox (MSG) in order to provide containment, as fluids worked with theoretically could escape.
One earlier experiment was IVIDIL, an experiment that investigated the influence of vibration and temperature gradient regimes on the fluid observed.

A further experiment was COLLOID, investigating phenomena linked to colloid solutions. That experiment was performed in October 2010 and will be done again around October 2011, prior to the arrival of Kuipers.
During his stay, Kuipers will be performing the DSC experiment - Diffusion Soret Coefficient - in the meantime upgraded and now called DSC/DSCMIX or DCMIX. The experiment will investigate the physics of a mixture of three different fluids, so-called ternary fluids. The objective is to test thermo-diffusion theories and develop physical and mathematical models for the estimation of (thermo) diffusion coefficients.

MSL-BATCH 2A: CETSOL-2 and MICAST-2 and SETA-2.

CETSOL and MICAST were earlier discussed in Newsletter September 2010, which was the time for uploading sample material for these experiments to the ISS. SETA-2 is explained on p.2 here.

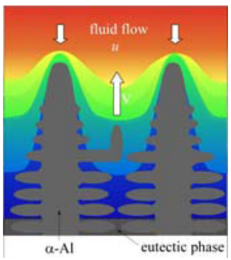
The samples will be processed in the Materials Science Laboratory
CETSOL - Columnar-to-Equiaxed Transition in Solidification Processing, and MICAST - Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions are two central experiments that examine different growth patterns and evolution of microstructures during crystallization of metallic alloys in microgravity.

Typical parametres looked for in solidification in the CETSOL experiment:

Dendritic columnar growth ...
- Nucleation of equiaxed grains
- Sedimentation, rotation of equiaxed grains
- Blocking of columnar structures

CETSOL looks at the microstructure of growth appearances as indicated above. It is supposed to study the transition from columnar growth to equiaxed growth that occurs when crystals start nucleating in the melt and grow independently. These are parameters that are essential to understand for the casting industry.

MICAST looks at the microstructure of growth appearances as indicated in the image below.



Typical parametres looked for in solidification in the MICAST experiment:

Dendrite tip shape ...
- Primary dendrite spacing
- Secondary dendrite arm spacing
- Macro- and micro-segregation
- Mushy zone morphology

Radiation

Radiation detection and recording is a standard component of modern space missions, due to the fact that radiation is health endangering for space crews. Monitoring and recording can be done in many ways and constellations and different parts of the radiation spectrum can be of interest.


The ALTEA-SHIELD instrument

Onboard the ISS, presently the ALTEA instrument is monitoring radiation events in different locations.
Further, the SOLAR facility with its external instru-

ments will continue observations and registration of solar events.

As of September 2011, yet another radiation detector **TRITEL** (name indicating the presence of three dosimeter telescopes) will be onboard. This is an active dosimeter with quite some built in data processing electronics, that will process the counted radiation hits and give real-time dose indiction in three axes. It will in this way be able to provide the interpretation and conversion into absorbed dose values for crew onboard the ISS.
TRITEL will distinguish between contributions from galactic radiation and solar radiation, and is supposed to offer improved dose indications to the ISS crew.

Even though the radiation load environment onboard the ISS is fairly well known by now, it is of utmost importance to continue this monitoring, not the least to gain experience with the effect of the occasional, dangereous solar flares.

NASA astronaut Randolph Bresnik on 21 November 2009 with the unfurled AIS antenna, attached to Columbus to be used for experimental tracking of VHF signals of ships at sea. Courtesy of NASA.

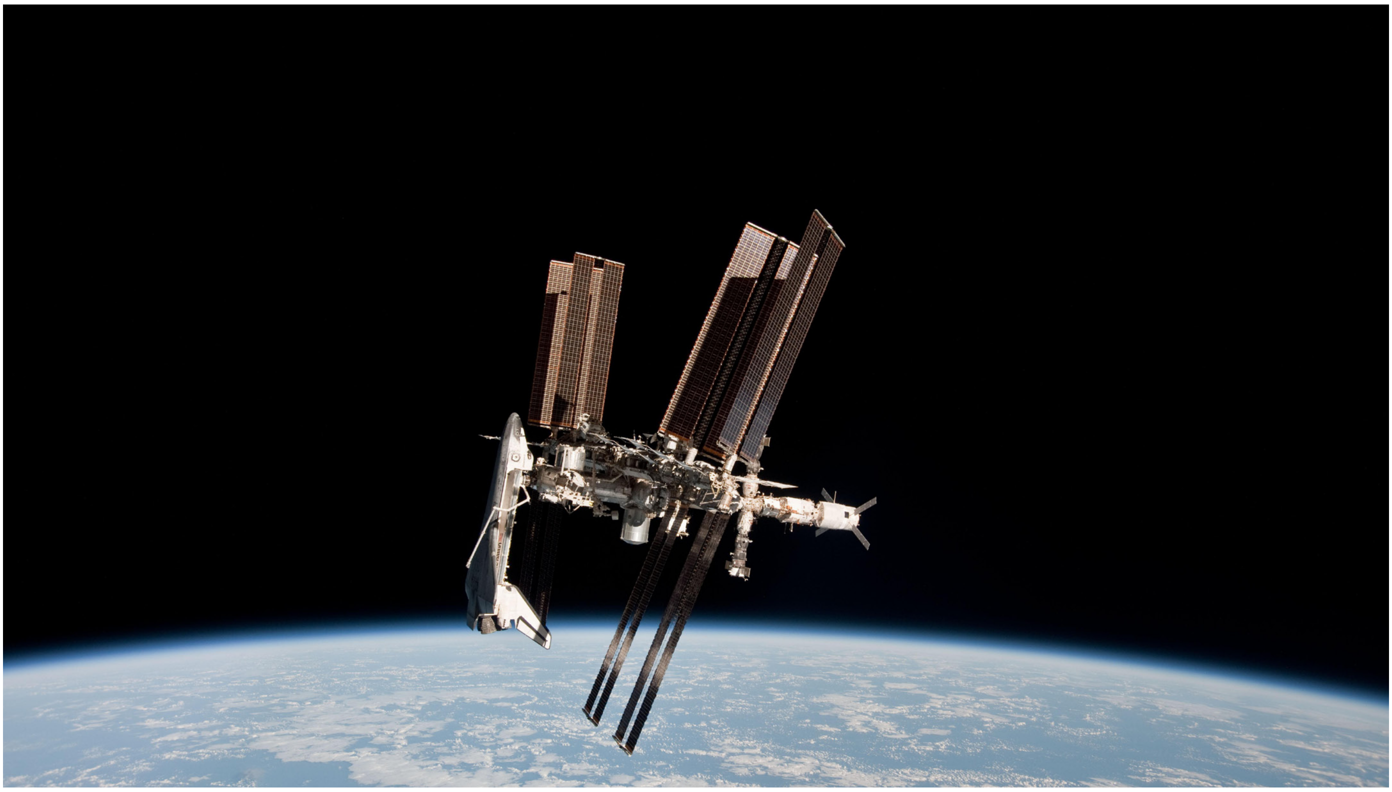
Technology demonstrators

The successful **VESSEL ID** instrument is a technology demonstration test case that will continue during Kuipers' flight. A comprehensive account of that was provided in the March 2011 Newsletter.
in addition the **METERON** experiment will be initiated. METERON = Multi-Purpose End-To-End Robotic Operation Network is a platform to provide 'educated answers' to the question of how future "operator in space" robotic mission architectures need to be implemented.
Finally, the **NightPod** is a device to support and improve digital photography for Earth observation at night. In particular, making use of the Cupola's Nadir window, it will be possible to mount a digital camera on the device and support the task of taking pictures of a specific ground target with long exposure time, compensating for the ISS/Earth relative motion.

Education

Two educational experiments as part of André Kuiper's spaceship Earth educational programme are planned:

1) One experiment on the behaviour of foam under microgravity, the **EPO-FOAM-S** experiment. On Earth, the fluid phase of the foam will drain due to gravity, and that will not happen in space. This and many other fundamental characteristics of foam will be examined and demonstrated.
2) Another experiment (**EPO-Convection**) will demonstrate the role of gravity in the process of heat convection. Didactic links will be made between the small scale convection experiment and the large scale convection patterns on Earth, with particular attention to the Earth's atmosphere and oceans.



This unique photo of the ISS with Space Shuttle Endeavour docked was taken by Paolo Nespoli from the Soyuz capsule at a few kilometers distance from the ISS. Courtsy of ESA/NASA.

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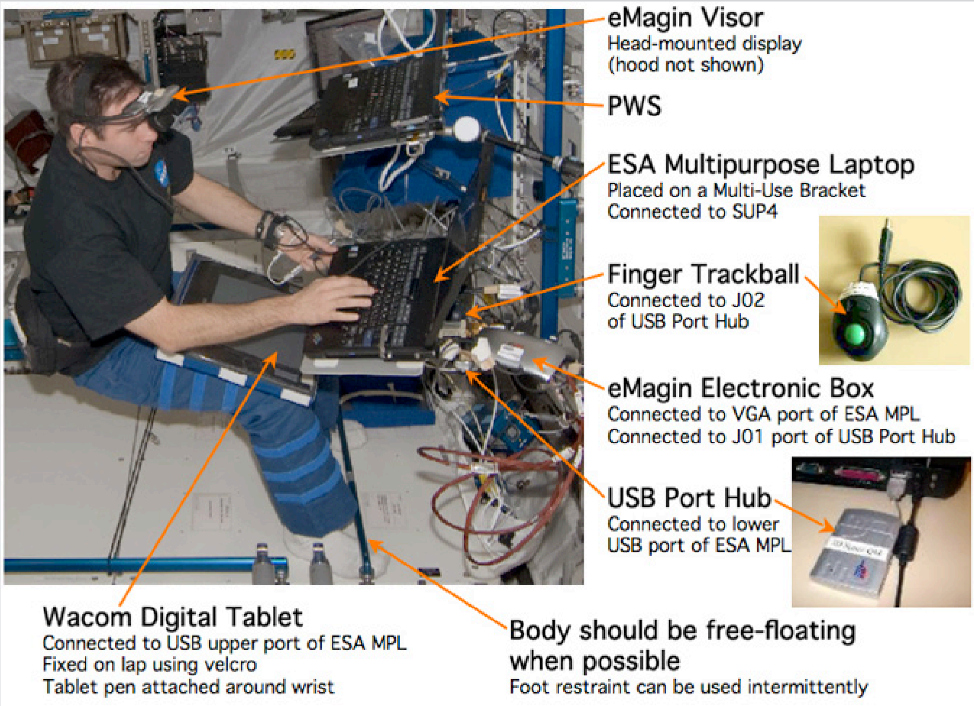
Weightlessness is tricking our senses - ESA's three separate ISS experiments in Neurosciences reveal some of the secrets

Born and living in a world of constant gravity, our organism does not know a world without it. We can get a little taste of it whilst being relatively weightless when diving in the sea. But the complete absence of gravity and buoyancy is only experienced onboard an orbiting spacecraft, like the ISS. There, lack of gravity input influences our ability to orient ourselves optimally in some situations. ESA has now completed three experiments focusing on the balance and orientation system in Space.

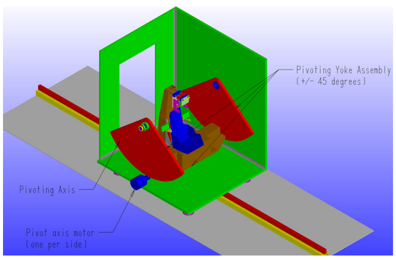


Careful experiment design

Neuro-vestibular experiments in Space require careful equipment design and consideration of the experiment protocol, as the human senses are not easily fooled. Onboard the ISS, even being blindfolded, test subjects still can orient themselves via the hearing, at least if there is a directional difference in the environmental sound patterns. Some experiments are sensitive to this, others are not.
Experiments that ask the subject to identify a direction (up and down and the like) *do* need the hearing to be shut off, by means of ear plugs.
Experiments that play on the visual perception, mostly make use of the fact that, if the full field of view is covered by what a head mounted display shows, hearing plays a minor role. Such experiments specifically play on the interaction between the eye-vision and the balance organs located in the inner ear.

NASA astronaut Greg Chamitoff engaged in preparing for the 3D SPACE experiment. When set up and ready to start, the test person will pull a blindfolding hood over the head and start the experiment, free floating.

Three experiments have been designed to investigate the effect of gravity, on our ability to orient our selves relative to our environment. The experiments and some of the results are described in the following.



In this sketch of the ZAG experiment set-up, the blue central part is the seat where the subject is located. The red pie-segment-shaped parts form the cradle that can swing back and forth. The entire structure can move back and forth along the red-yellow track. See also text. Source: ESA Experiment Scientific Requirement Document (ESR) ESA-HME-ESR-OTO-I1R0.

Experiment 1: ZAG - Z-axis Aligned Gravito-inertial force

We have all experienced feeling dizzy for one or the other reason, the feeling of being out of balance and maybe even falling over, without any exterior signs of this dizziness. As an effect of the **feeling** of imbalance we need to correct, in order not to fall.
An observer will not register that anything is wrong.

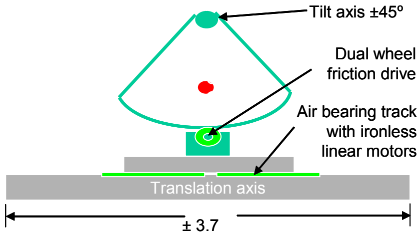
Likewise do astronauts, returning from Space often have movement illusions, that can be ascribed to similar mechanisms - they experience impaired movement coordination, vertigo and spatial disorientation - situations and perception that are caused by inappropriate impulses from the balance sensory organs to the central nervous system (CNS). When the brainstem has to bring order in and organise these signals relative to other balance signals, there is a mismatch and the resulting conclusion may be, that 'I move.. ' whilst the body in reality is stationary.

This kind of movement illusions is what the ZAG experiment is trying to decipher, and in order to do that one needs as a minimum two things, namely 1) an accurate registration of the movements and position of the test subjects, in addition to a constant registration of the eye movements, and 2) an accurate synchronised reporting possibility from the test subject, of what kind of movement and direction he/she feels is taking place at all times during the experiment. To this end the subject has a joystick similar to those used for controlling a helicopter.

But the experiment goes further:
Imagine, that you as a test subject want to report a movement in a certain direction on the joystick. This is the basic request, but in another test-mode, you can control the movement and velocity of the experiment machinery - you have the ability to make the system do what it takes to give you the feeling of standing still - that you and the machinery do not move anymore ....

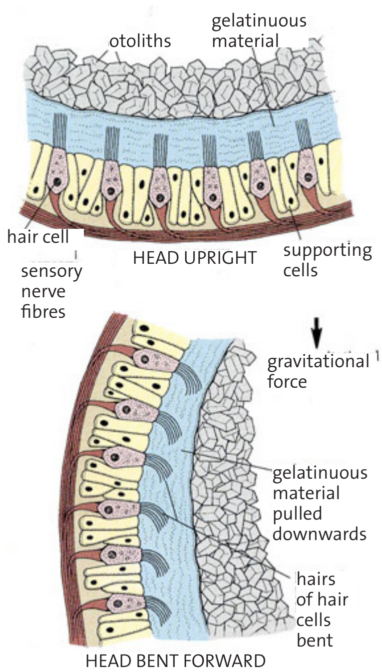
Without movement illusions you would with high likelihood make the facility come to a standstill, but if you do have movement illusions, the facility might de facto still move when you as a test subject think you have made it stop. This experiment however only works, if you can not orient visually.
This is the ingenious way in which the design of the ZAG facility at any time will allow to demonstrate the movement illusion the test subject has, which will be the inverse of what mechanically is being registered.

ZAG Experiment setup



On the sketch the test subject will be placed more or less where the red dot is. See also the previous figure.
The gondola with the test person can swing around a horizontal axis and the entire mass can in addition move back and forth along a 3.7 meter long track. This latter happens on an aircushion, in order to eliminate orientation cues in the form of vibrations, and the like.

The astronauts report the perceived motion in response to different combinations of body tilt and translation in darkness, and by manually controlling their own orientation the resulting position of the movement-generating devices reveals to which extent you are able to judge whether you move or stand still. In turn, the deviation will give an indication of the error in this judgement, and thus a value for the distortion in the perception organs. This 'error' value is then inserted into the algorithm for calculation of the expected output.
Science Coordinator: G. Clement et al., International Space University, Strasbourg, FRA



Source: Cornell University

Experiment 2: OTOLITH

The word otolith is derived from Greek and means 'ear stone'. The schematic on the left illustrates the principle details and function of the otolith sensory organ, situated in the inner ear, as part of the balance organ. The otoliths, or otoconia, are tiny $CaCO_3$ grains that rest on top of a gel-like mass with nerve-connected hair cell sensor organs in-layered. Holding the head in different positions deviating from normal vertical will displace the otoliths which in turn stimulate the sensory hair-cells in the gel. This stimulus changes the electrical signals to the brainstem, where all orientation signals are integrated to form meaningful messages regarding position or type of movement at any point in time.
As the principal sensor for gravity and linear acceleration the otolith organs provide essential information for spatial orientation. In particular, gravity represents the central reference for spatial orientation, as indicated in the figure. In the absence of gravity, - as is the case onboard the ISS - the sensory hair cells are no longer biassed, or loaded, by gravity and the associated signals to the brain indicating head position and movement no longer correspond to those in the familiar repertoire 1-g Earthbound environment.
A "sensory mismatch" arises - contradictory and confusing processing of spatial orientation.

This gravity-sensing role of the balance organs has enjoyed particular attention from Space neuroscientists since more than two decades, and the possible origin of the so-called Space Adaptation Syndrome - the nausea and vomiting that many astronauts experience during the first days of a spaceflight - is related to the sensory mismatch experienced on entry into microgravity.
In particular the potential asymmetry in the function of the organ in each inner ear is in focus as a location where a possible explanation could be found (each ear has one set and these may not register all situations identically, thus asymmetrically).
As the otolith signals are also utilised to stabilise the static position of the eyes - their signals influence the tonus control of the extraocular muscles – the measurement of eye position and movements provide an inroad to the assessment of the otolith function.

A test subject in the rotator, adjusting the red line to what is felt to be vertical.
Source: ESA Experiment Scientific Requirement Document (ESR) ESA-HME-ESR-OTO-I1R0.

One hypothesis is that the symmetry of the signals from the right and left inner ear organs may be disturbed in the absence of gravity, resulting for example in an incorrect judgement of vertical, perception of what is truly vertical. Normally we are able to identify the vertical with an accuracy of less than a few degrees.

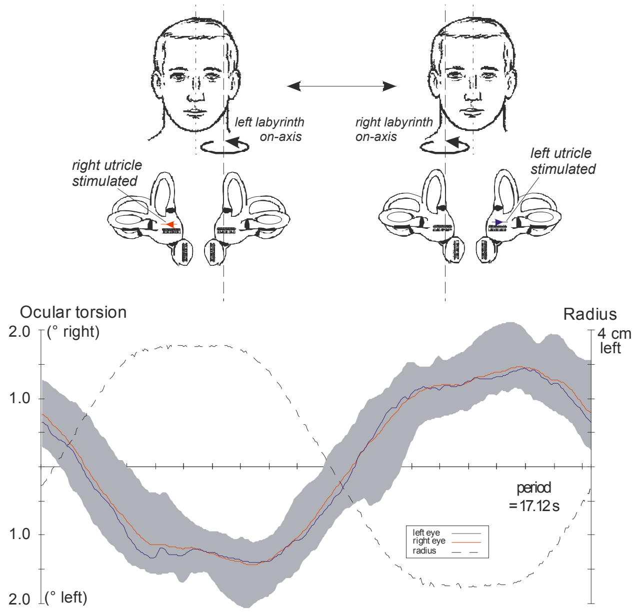
Earlier studies by this group, performed with cosmonauts and astronauts onboard MIR and the ISS have provided evidence that the signals from the otolith organs or lack thereof, influence the coordination of eye movements.

In accordance with what seems to be a general characteristic of our sensory systems, an adaptation to the altered gravity conditions – as a result of the plasticity of the brain – occurs, the sensitivity, or 'gain' (the relationship between stimulus and response) is re-adjusted to accommodate to the prevailing conditions.

The former ISS experiments, conducted over six month missions, demonstrate that systematic changes in eye-head coordination and stability of eye position control persist throughout spaceflight. For example the so-called ocular-counter-rolling (OCR) reflex, which – under 1-g conditions on Earth – causes a compensatory rotation of the eye in the opposite direction to head rotation, is near-absent in 0-g.
The present experiment examines, amongst other things, how this OCR reflex re-adapts after re-entry into 1-g conditions. Such adaptation processes in the brain represent the essence of the experiment.

A relatively new test of otolith function, based on the measurement of Vestibular Evoked Myogenic Potential or VEMP, derives from the response of the otolith organs to acoustic stimuli. The stimuli consist of a sequence of loud clicks - similar to those widely used in clinical hearing tests. In addition to the hearing organ, the otolith organs respond by sending a signal to the lateral head-mover muscle on the side of the neck - the sternocleidomastoid muscle. This response can be recorded by surface electrodes, providing a measure of the otolith response.

How are the investigations done?



Source: ESA Experiment Scientific Requirement Document (ESR) ESA-HME-ESR-OTO-I1Ro.

In order to investigate the aspects described, two tests are used before and after the flight.

1 ▸ An asymmetric rotation paradigm (figure above) is applied to investigate the Otolith Ocular Reflex (OOR) i.e. the reflex connection between the otoliths and the muscles controlling the eye movements. The axis of rotation is in the rotator set to go exactly through, first the otolith organ on one side, and thereafter similarly in the other side. This has the effect that one side is neutralised, as no sidewards effect is experienced, and one can then comfortably observe the action of the other side . This allows for a judgement if both sides separately give the same response, and thus if any aspect of asymmetry can be identified.

2 ▸Applying the mechanisms of the VEMP described above. Here, the electromyogram (EMG) i.e. the electrical activity of the Sternocleidomastoid is registered during the acoustic stimulus.

Of critical importance is that all three of the employed approaches - eye movement measurement, estimation of vertical and VEMP measurement constitute unilateral tests, i.e. the function of the right and the left ear organ is evaluated individually.
The experiment is designed as a pre- to postflight comparison of otolith function. Accordingly, the changes in otolith function after spaceflight microgravity are monitored and the re-adaptation to 1-g Earthbound conditions is tracked.
Science Coordinator: A. Clarke, Charité Medical School, Berlin, GER

Experiment 3: 3D SPACE

Our ability to judge accurate distance to an object, be it an object within reach or much further away, is based on binocular vision. Each of our eyes actually see the world in 2D. As the eyes are placed a distance apart in our head, the direct line from one eye to an object forms a small angle with the same line to the object from the other eye. The resulting images at the retina in each eye are not quite identical, and this difference enables our brain, that computes the images to allow us to see them as one, but as an effect of the angle, also to determine the distance to the object.
Is the object very close to our eyes the angle - the parallax - is large. Is the object very far away, the angle is very small. This is the tool for the brain to make us judge distances very accurately.

Early on, this group of scientists noticed, that this depth perception was impaired when examined with the head tilted. With their intrinsic knowledge of how the complex apparatus is composed, that is controlling balance and movement accuracy in all contexts, they hypothesized, that the finding they made was a proof that not only gravity but also the direction of the gravity vector plays a role for depth perception.
Logically, therefore, they hypothesized, that depth perception would be impaired in Space where no gravity influences the individual. But how it would be influenced still was to be seen.

The 3D SPACE experiment was conceived as looking at exactly these aspects.

Preliminary results of the 3D SPACE experiment

Based on initial experiments performed onboard one of ESA's Airbus 300 Parabolic Flight Campaigns, the team could make interesting conclusions regarding differences between depth perception in normal gravity and the same observation during the weightlessness period of around 20 seconds on each parabola at the PF campaign.
What they saw was, that when test subjects were asked to adjust the sides of an initially not quite regular three-dimensional cube, to what they would perceive as correct (all sides should end up being of identical length), on ground both height and depth were adjusted on average to a correctness within 0.5%, whereas the width of the cube in all cases was underestimated by around 4%.

Performing the same tasks onboard the Airbus under microgravity, the estimation of the width actually was significantly better - 0.56% accuracy - than on ground, whereas they set the height to be around 3% smaller, and the depth to be around 3% longer. Turning this around, describing how test subject see a regular cube under microgravity, it can be concluded that a cube to them looks around 3% taller, 4.5% thinner, and 3.5% less deep than on the ground.
Science Coordinator: G. Clement et al., International Space University, Strasbourg, FRA

Conclusion

The hypothesis, that perception of 3D objects is changed during microgravity as compared on the ground was thus proven. In addition to the indications above, the depth aspect of an object is also altered in Space.

As mentioned under the OTOLITH experiment, an intrinsic reflex connection exists between the muscles that control eye movements; i.e. the otolith organs which sense linear acceleration and the semicircular canals, which sense rotation of the head. Above all, the sensing of gravity (where is up and down !) represents the central reference for our brain throughout life, whether this be stabilization of eye control or complex cognitive tasks of spatial orientation.
One interesting finding is that there appears to be a dominant balance organ, similar to handedness or eyedness.
The above conclusions have been confirmed in the ISS experiments, but full conclusions from the these, now completed experiment will have to wait for final scientific publications to appear.

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The MagISStra and STS-134 missions post-flight tour - connecting with scientists who's creations finally flew

Visit to the Natioanl Laboratories of Gran Sasso underground facility, at the National Institute of Nuclear Physics (INFN), near L'Aquila.

Postflight tours are often the completion of a more than a decade long effort to finally accomplish, that complex facilities and instruments have been brought into action in Space. A deep feeling of team accomplishment is often experienced and demonstrate the dedication and commitment both scientists and astronauts have for the work they perform.

Being IN the heart of a mountain, 1,400 meters under the rock, was something quite unusual for those, who are more used to work onboard the International Space Station.
ESA astronauts Paolo Nespoli and Roberto Vittori, accompanied by their respective ISS and Shuttle crews, visited the National Laboratories of Gran Sasso at the National Institute of Nuclear Physics (INFN), near L'Aquila.
Lucia Votano, director of the Laboratories, guided the astronauts through the underground tunnel to introduce some of the world's best experiments tracking neutrinos, dark matter and antimatter - all elements which the present astronauts had to deal with during their space flight since the STS-134 Mission's main purpose was to install the Alpha Magnetic Spectrometer -2 (AMS-2) onto the ISS.

Audience in the auditorium at La Sapienza.

Nespoli, who welcomed the STS-135 Crew onboard ISS as an ISS Expedition 27 crew member recalls "When the AMS-2 arrived on the ISS we had reflected over all the efforts made by many scientists from many countries for more than 15 years to conceive and design AMS and bring it into orbit" and "it's touching to see these many young scientists here who work with great passion".
The astronauts presented their mission to the universities of Pisa and Rome, Sapienza. There they had the opportunity to meet some of the high level Italian physicists involved in the projects.

Nespoli listening to questions from the auditorium at La Sapienza.

Both events gathered over 2 000 students and professors to listen to the report of and extra-ordinary mission bringing the AMS-2, a unique instrument onto the ISS in order to learn more about our universe. These encounters were perfect occasions to bring together the scientists and engineers designing the experiments prior to the spaceflight and the astronauts, who fly the payloads and sometimes conduct the experiments in space.

Weightlessness on Earth - there is no such thing.....

But how close can one come? And why is that interesting? Transitory exposure to weightlessness-like situations have no permanent effect on humans. Mostly any effect goes away within 24 hours. The permanent lack of gravity exposure onboard the ISS does however impose more permanent effects. This is on one side a problem and on the other an advantage - to researchers who want to understand how our body responds to lack of gravity. Understanding that, allows us to better understand the effect of gravity. Keeping people bedridden permanently for a number of months creates similar effects.

The model and the effects

In bed rest studies, healthy human test subjects are put to bed in a head-down tilt position (-6°, i.e. level of the feet higher than level of the head). They remain in that position 24 hours per day for durations between 5 to 60 days or longer, depending on the study aims. Remaining in this horizontal position takes away the normal daily rhythm of getting up and being vertical for the major part of the day, a position that due to gravity, loads the body in the long axis every day. When this does not happen, we see changes in the skeleton (bone loss) and loss of muscle mass, in addition to cardiovascular deconditioning. These appearances are due to what one could term 'disuse'. Onboard the ISS we see similar changes. Bed rest studies are therefore a relevant and useful model for testing mechanisms of physiological changes. As an effect we can deduct what to do to avoid these negative effects and define countermeasures.

ESA has been organising bed rest studies since many years, the first longer studies being performed during the mid 1990'ies.
On the basis of the early experience, it was in 2005 decided to define the strategy for the coming 10 years. With the future long-duration exploration missions coming up, all what had been learned in early studies now needed to be used in the definition of future countermeasure models.

Prior to any upcoming study period, a 'Call for Ideas' is being announced by ESA.
Such a call for ideas does not mean that well-established models do not exist, but they are rather a necessary step to ensure that the latest novel ideas are being considered, so that these can play a role in defining study designs, for studies that often start years later.

The Call for Ideas forms a part of the basis for defining the final Announcement of Research Opportunity for the next coming bed rest study.
Study activities and experiments are always defined on the basis of these external proposals. Proposals are taken through a lengthy evaluation process, that considers, medical, technical, and ethical aspects of acceptability for being performed in the context of a bed rest study.
When scientists define their individual experiment, they need to take into account what they need of equipment, measurements, and biological samples, but when a number of similar, partly overlapping experiment proposals have been accepted, synergies are found and a streamlined set of experiment protocols defined. As an effect individual scientist almost always end up needing less sample material than initially requested, as data and samples asked for overall often can be shared.

A typical study operates with one control group and one or two intervention groups. The control group participating without any form of experimental intervention, another may do regular exercise, and a further group may be asked to ingest medicine of one or the other kind.

Studies can as well be defined with one group being exposed to a certain, promising countermeasure approach, that has been defined as a part of the programme, whilst one other will function as control.

Standardisation between studies

As bed rest studies are logistically complicated, costly and require a long preparation period, it has over the years made streamlining of these studies mandatory:

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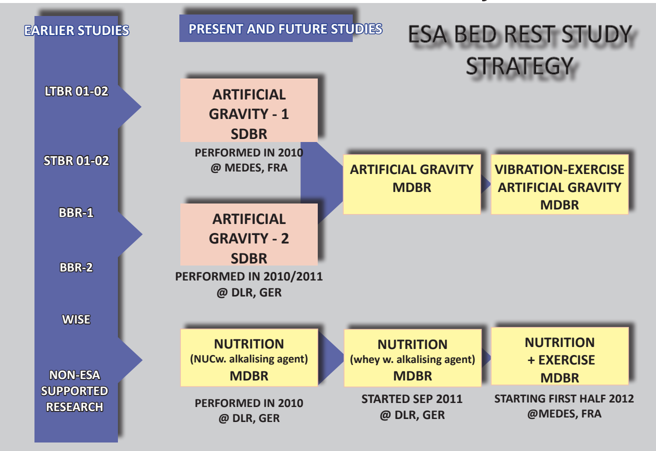
To a certain extent, each study will have a set of 'core data', i.e. data, that are always necessary. These have to do with the standard health monitoring of the test subjects, but in addition experience has shown that a large number of required parameters repeatedly are being asked for in each study. A large number of these parameters are nowadays a built-in component of each study. This does not only have the effect that the way they are harvested is standardised and can be simplified, but also, and more importantly can be compared between studies, to the extent that they can form the basis for common statistical analyses.



The current version of ESA's bed rest strategy. Studies in yellow are Medium Duration (21d) Bed Rest Studies (MDBR). In pink Short Duration (5d) Bed Rest Studies (SDBR).

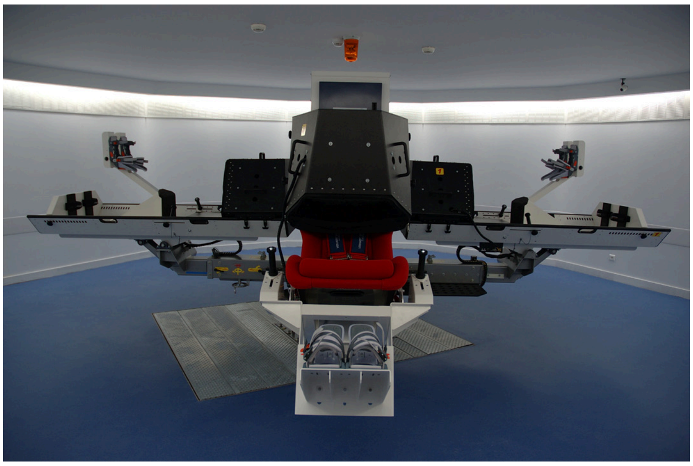
Standardisation efforts

There are two aspects to standardisation on which a lot of work has been done by ESA in recent years:

- standardisation of study conditions and
- standardisation of measurements.

The definition of a set of standardised measurements ensures that independent of the selected experiments, one can always be sure to have a minimum of data available to characterise the functional effectiveness of the tested countermeasure.
As standardisation of these studies is so essential, a study group in the frame of the International Academy of Astronautics is working since a couple of years in order to define similar standards on an international level.

In the figure above the current ESA bed rest strategy is illustrated.



The ESA short-arm human centrifuge. Two are available, one in each of the main centers used by ESA for bed rest studies, the space clinic Medes in Toulouse, France, and the DLR Institute for Aerospace Medicine in Cologne, Germany.

Focus of next studies

Two main countermeasures are given priority in the current bed rest strategy: Artificial Gravity (AG) and nutrition.

Artificial Gravity in this context means spinning the test subjects on a short arm centrifuge (image), head to the center, feet pointed outwards. This model has been chosen as the one that - under the given conditions - gives the best mimicking of the way gravity normally influences our body.

Preparation for the real study

In preparation of the next upcoming bed rest study, two short duration studies, with head-down tilt periods of 5 days, have been performed, investigating different AG protocols, as well as pilot testing an exercise regime that could be performed on a centrifuge. Two more medium duration studies (defined as a 21-day head-down tilt period in the ESA standards) are planned.
Both studies involve exercise during centrifugation. Modifications to the ESA centrifuges, required to make this exercise feasible, are being currently being studied.

Nutrition interventions - why?

Loss of bone and muscle mass is one of most critical physiological changes induced by spaceflight. In order to at least partially counteract these changes, astronauts exercise every day on board the ISS.
In order to induce muscle growth on Earth, people often increase their protein intake. This allows a faster muscle tissue anabolism. A downside of proteins is however, that it adds acidity can lead to what is called a mild "metabolic acidosis" - a slight change to the pH of the fluids in the body. This in turn has a theoretical, negative effect on the skeleton, by stimulating increase of the breakdown of bone tissue. So while protein intake may be good for the muscles, it may aggravate the known problem of loss of bone mass in Space.
But potassium bicarbonate added to the diet is supposed to counter the metabolic acidosis created by the increased protein intake.
In the NUC (NUtritional Countermeasure) study, which took place in 2010, the effects of pure potassium bicarbonate in bed rest were studied. This study is now followed by a recently initiated study that combines potassium bicarbonate with whey protein, which in itself already produces less acidity than the animal protein normally used in supplements.
A study planned to start during the first half of 2012 will investigate the ultimate aim, adding exercise to the nutritional supplementation, in order to verify the hoped-for positive effects.
As an effect of these studies addressing the areas indicated, the ESA bed rest strategy will soon be updated. Still within 2011, a new call for countermeasure ideas will be published.

Clinical aspects for benefit to patients

The knowledge from studying healthy persons confined to bed for extended periods of time, will have consequences for bed ridden patients in general. Healthy subjects offer the advantage, scientifically, that changes are not influenced by diseases, whilst patients are hopitalised because they have a health problem. Today's society is much less physically active than earlier, and the ageing population is more sedentary, leading to metabolic and other changes similar to what we see in bed rest.
ESA's approach described here is supposed to enable us to maintain the leading edge of current scientific knowledge, as a basis fot taking further steps into space, while at the same time contributing to addressing societal challenges here on Earth.

→ SPACE MEDICINE 2011 Workshop for Students 4 - 8 July

European Space Agency, European Astronaut Centre, Cologne, Germany

Students' new ideas for solution of medical problems in Space

Members of the 3rd prize winning team practising Cardio-Pulmonary Resuscitation to devise a new CPR method suitable for microgravity.

ESA's Crew Medical Support Office (CMSO) at the European Astronaut Centre (EAC) in Cologne, Germany and the Human Spaceflight Promotion Office, ESTEC, the Netherlands, welcomed the group of 28 students from eight different ESA member states to the EAC for a workshop on space medicine. CMSO in this manner seeks to stimulate interest and educate students in relation to the "human" aspect of human spaceflight.
With the next generation of missions in mind, Bachelor and Master level students of medicine, physiology, sports science, biomedical engineering and other life science related fields were encouraged to come up with new concepts for solving medical problems on future human spaceflights.

Announcement of Opportunity

The standard approach used by ESA Human Spaceflight to recruit proposals for experiments and science activities is by issuing so-called Announcements of Opportunity (AO) for research. The same approach was applied in recruiting teams and individuals for the Space Medicine Workshop.

Proposals

Proposals received in response to such AOs have to follow strict guidelines to be accepted, and they are reviewed by a panel of specialists, specifically selected to judge the particular scientific disciplines in question.
In this manner students immediately got a taste of what is expected when proposing experiments to ESA for e.g. the International Space Station or other microgravity platforms.

Leading Space agency specialists support

The reward for being selected for this student workshop was the direct contact with, and advice during the workshop week, from some of the leading experts in Space Medicine, Dr. Jeff Davis, NASA Life Science Director, Dr. Jean-Marc Comtois, CSA Life Science Director, and Dr. Volker Damann, head of ESA Crew Medical Support Office, CMSO.

Workshop topics

The 'AO' used in this context identified three areas of activity to propose for, namely

1) Off-world Cardiopulmonary Resuscitation (CPR),
2) Artificial Gravity and
3) Medical Data Management.

In order to pass the first selection criterion, students and team proposals would therefore have to address one of the three topics above. The AO further gave guidelines regarding context, aspects to address, etc.

Human Spaceflight director welcomes

The selected 28 participants from eight ESA member states were welcomed by the ESA Director for Human Spaceflight and Operations Mr. Thomas Reiter. Mr. Reiter is a former astronaut who flew long-term missions both onboard the Russian Space station MIR, as well as onboard the ISS.

A week packed with specialists and information

Also supporting the activities during the workshop week were additional experts from ESA, the German Space Agency, DLR, and from the French Institute for Space Medicine and Physiology, MEDES, Toulouse, France.
These experts assisted during the week in providing background knowledge on the three workshop topics, in addition to space medicine in general.
The programme provided a complete package covering all aspects of crew health support and maintenance, by involving relevant experts from the European Astronaut Centre in general, as well as a programme demonstrating diverse test and intervention facilities, such as the ESA Short Arm Human Centrifuge, a Lower Body Negative Pressure device and tilt table at DLR's Institute of Aerospace Medicine, located close to EAC.

Student tasks

After the thorough introduction to what space medicine and astronauts entail, small teams of student participants were formed, with the task of jointly devising, preparing and delivering solutions to the topics of their proposals.

Not restrained by existing concepts and do's and don'ts student worked up solutions in line with their own ideas and in that process defined the best compromises between several, topic-wise related proposals from the individuals.

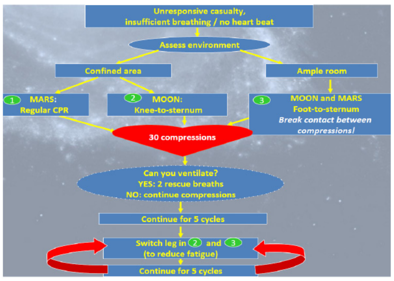
On the last day eight group presentations were given by the participating students - the results of the hard work over the preceding days, and the three best ideas were identified.

Eight teams offered a broad span of interesting and insightful proposals, some from perspectives not normally pursued by incumbent professionals.

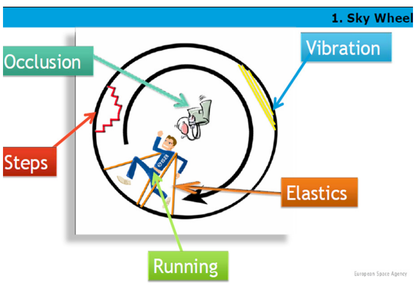
The winners

The judges granted the **third prize** to one of the teams working on off-world CPR. The three students had devised a new method for CPR in hypo-gravity, which they had named the "Seated Arm-Lock Method". Their prize for winning third place was an annual subscription to Space Flight Now Plus, a web service providing space related video footage.

The second prize went to another off-world CPR teams, who had tested a number of unconventional CPR methods, concluding that their foot-to-sternum technique could be effective in hypo-gravity, but providing a decision flow chart to enable future astronauts undertaking planetary exploration to decide which form of CPR would be most appropriate in their given situation. They were awarded the text book "Fundamentals of Aerospace Medicine", written by Dr. Jeff Davis (Director, NASA Life Sciences) who personally signed each copy. Both second and third place awards were provided courtesy of Wyle GmbH.



The first prize went to one of the teams solving the artificial gravity task. The four students of that team had devised a new countermeasure system that consisted of an exercise course taking advantage of the typically circular shape of space craft modules. The system was termed "Sky Wheel". They returned to the concept implemented by Pete Conrad in Skylab in the early 70ies, where he was running around the circumference of the module, generating centrifugal force through his own speed of movement. For their innovative idea and creative presentation, the team was awarded fully funded participation in the European Low Gravity Research Association Symposium that took place in Antwerp, Belgium, in September 2011.



General observations

The workshop was a fantastic experience for participants, who up to that point in time had only had marginal contact with Human Spaceflight. The themes and content of the week were seen to offer useful and valuable learning experience for the students.
Workshops of this nature, when part of a wider health education programme, offer an effective method of transferring knowledge and expertise from today's space professionals to Europe's youth, and vice-versa, the latter likely becoming tomorrow's human space flight managers, scientists, doctors and crew.
Events like these form the development of next generation specialists, building on the experience that has been harvested over the last many decades. Space agency experts in the instructor-teams are crucial for identifying the many reasons why research into and health maintenance of space travellers is a very unique branch in the Environmental Medicine and Physiology.
Finally, the very particular aspects of maintaining physical and mental health of Space crews were brought across to the 28 person strong, highly motivated student group.
If you qualify, consider applying for the next Space Medicine Workshop for Students!

Winning team with the 'Sky Wheel' - From bottom clockwise: Gunnar Erz, Gaël Boivin, Chan Sivanesan, Andrew Winnard.

Student participants and EAC experts and specialists in front of the European Astronaut Centre.

Student winners and EAC Head of CMSO, Dr. Volker Damann (left) and Chairman of ESA Medical Board, Dr. Bernard Comet, from MEDES (3rd from left).

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Physical Sciences in Space: 4th ISPS Symposium, 11-15 July 2011, Bad Godesberg, Germany

Group picture with all ISPS-4 participants.

The International Symposium on Physical Sciences in Space returned to Europe after visiting Canada in 2003 and Japan in 2007. This fourth occurrence took place in Bonn on 11-15 July 2011, co-organised by ESA and the Institute for Materials Physics in Space at DLR Cologne, Germany.

Addressing the 240 participants from 18 different countries with this citation of Henry Ford "Coming together is a beginning; keeping together is progress; working together is success", Prof. J-D. Woerner, Chairman of DLR's Executive Board set the tune of the Symposium. M. Zell, Head of ESA's Astronauts and ISS Utilisation Department then emphasized how intensive international cooperation and coordination enables the partners to the ISS project to select and realise series of experiments in many different domains, both internally and externally to ISS.

The Symposium programme

The programme was engineered by the international scientific committee under the coaching of the co-chairs A. Meyer, I. Egry (DLR Cologne), S. Takeuchi (Univ. Tokyo) and V. Fortov (JIHT Moscow) with the ambitious objective of promoting synergies and hopefully original research between sometimes not so close disciplines.

Main topics addressed

Several keynote lectures introduced most of the main topics that are currently addressed in the ISS programme.

- C. Salomon (ENS, Paris) introduced atomic sensors and clocks in particular for high precision relativity tests. ACES is in the final phase of manufacturing and testing. Considering the blatant perspectives with space in this field, further projects are already well advanced, a fact that E. Rasel (Uni Hannover) demonstrated later in the week.
- O. Petrov (JIHT, Moscow) described how fluid physics studies at virtually the molecular level can be performed using complex plasmas and how much science has already been generated by the series of PK instruments in space including on the ISS; no doubt that the next generation will bring this science to yet another level of similarity with molecular dynamics.
- S. Matsumoto (JAXA, Tsukuba) presented the results from long series of fluid dynamics experiments using a liquid column configuration.
- Finally N. Mangelinck (Uni. Marseille) reported on a wealth of detailed in-situ observations of cellular growth experiments in transparent alloys.

These four first keynote lectures very well illustrate the breadth of science covered by the ISPS participants, at the same time showing that the ambition of the scientific committees in each area could be met.

New light on the processes that drive physics in Space

Numerous presentation of experiment results on diffusion in liquids with in particular the ground-breaking measurements performed by Giglio (Uni. Milano), Cannell (Uni. Santa-Barbara) and their colleagues, cast new light over the most fundamental process driving space experiments.

Solidification - use of different microgravity platforms

Solidification experiments using various platforms, alloys and techniques are progressively filling knowledge gaps in this field, as introduced by L. Ratke (DLR Cologne), P. Voorhees (North-Western Univ) and H. Henein (Univ Alberta), but as one could expect, every answer comes along with many new scientific questions.

Capillary flow - profit of latest microgravity experiments

In fluid science M. Dreyer (ZARM Bremen) had very recent results from a capillary flow in open channels to present; the long experiment time afforded by the ISS will enable adequate systematic scanning of a wide range of parameters and, thereby, the thorough testing of numerical models.

Liquid layers physics in Space

In a different configuration, and precursor to liquid layers evaporation investigations on ISS, S. Dehaeck (UL Brussels) reported on the various patterns of Marangoni-Benard convection that could be observed in space. This introduced a session on heat transfer that has become a prominent research topic on the ISS and is subject of intense and very efficient international cooperation.

Soft matter - foams, emulsions, colloids and dust

A very active domain concerns soft matter. This includes foams, about which N. Vandewalle (Univ. Liege) reported on the surprising stability in space of foams made of pure liquid; emulsions, loosely compacted grain or granular gases, colloidal suspensions and also dust in ionised or non-ionised gases as results pour in, this community co-operating more intensely as each domain can contribute a different facet to a very large problem.
P. Liu (Uni. Harvard) recalled the long list of observations made on colloidal suspensions that now call for further, more detailed studies, whereas M. Sperl (DLR Cologne) reported on quantitative stress measurements on loosely packed particles and related theories. Finally R. Schraepler (Univ. Braunschweig) demonstrated how this physics relates also to the formation of planets with the added complication that thermal gradients can represent.

Droplets for combustion studies

M. Kikuchi (JAXA, Tsukuba) explained in his keynote some remarkable droplet array combustion experiments in drop-towers and on sounding rockets. Several other investigations in the field of combustion were reported on as well, including the report on an impressive series of experiments on flame propagation in clouds of metallic particles. This presentation by F. Tang (McGill Univ) formed a true fire work that concluded this thrilling week of physics Made in Space.

Final remarks and outlook

Physical sciences has to a certain extent had to wait longer than some other disciplines, for the ISS facilities to become active, but the ISS phase is now since some time in full function. This has had the effect that experiment set rapidly gain speed and some even have been terminated or being close to termination, giving room for next generation experiments.
The road has been long to obtain full functionality of ISS physical sciences facilities, but it now gradually becomes clear that the long preparation time, involving other terrestrial platforms and short-term microgravity platforms has consisted a very important preparation of the space activities on ISS.
It is still too early to measure the full effectiveness with which synergetic research was triggered during ISPS-4, but to check on it, we propose a 'rendez-vous' at ISPS-5 about which you should be hearing soon.

ESA contributed 17 science posters to the symposium demonstrating ESA's on-going development of physics instruments. Poster headings are presented here after.

Fundamental and Applied Studies of Emulsions Stability in ISS
To reveal the properties of surfactant and particles at the interfaces

Heat transfer studies in space
To reveal the role of secondary phenomena (e.g. capillary forces) in ground applications and the nature of space systems

The GeoFlow Experiment on the ISS:
Observation of convective heat transfer in spherical geometry

The Materials Science Laboratory on the ISS
95 scientists from
EUROPE, USA, RUSSIA, CANADA and JAPAN
are involved in projects utilising the MSL

A Selectable Optical Diagnostic Instrument on ISS
6 Research groups
from Europe, Russia and Canada are currently using SODI

Complex or Dusty Plasmas in the ISS
28 Research groups from
Europe, Russia, USA and Japan are involved in this programme

FOAM COARSENING in the ISS
11 research groups involved
from EUROPE, USA and JAPAN

Atomic Quantum Sensors on the ISS
The ACES Mission and Future Perspectives
Atomic sensors as space instruments to test fundamental laws of physics and develop
applications in different areas of research

The Electro-Magnetic Levitator on Board the International Space Station
90 scientists from
EUROPE, USA, RUSSIA, CANADA, INDIA, JAPAN, CHINA and KOREA
are involved in projects utilising the EML

Adsorption and Surface TEnsion Research in ISS
20 research groups from
EUROPE, RUSSIA, USA and CANADA are involved with FASTER

"Interactions in Cosmic and Atmospheric Particle Systems" Experiment : IPE
7 Research Groups from Europe and Canada are involved in IPE

Miller-Urey Experiment: about the origin of life
7 Research Groups from EUROPE and USA are involved in MI

Atmosphere-Space Interactions Monitoring from the ISS
Unveiling the mystery of very high altitude lightning phenomena

In-Situ Observation of Metallurgical Processes in Microgravity
Dynamics and phenomena of
solidification processes, metallic foam formation and diffusion in metallic melts

VIBRATIONS IN GRANULAR MATTER
12 research groups
from EUROPE, USA and CHINA are involved in VIP-GRAN

IMPRESS Integrated Project and the Sounding Rocket Programme

German Space Day attracts more than 85.000 visitors to the European Astronaut Centre (EAC), and DLR.

European Astronaut Centre. The buildings among others house the International Space Station Training Assembly as well as an impressive 10 m deep pool, the Neutral Boyancy Facility, used for training of all aspects of space walks and handling of large equipment in weightlessness. Courtesy of DLR.

Each year in September the German Aerospace Centre, DLR, invites interested to come for an Open Day. The European Astronaut Centre (EAC) inside the DLR compound area attracts an impressive amount of visitors in that context. EAC trains European astronauts and the Open Day is an opportunity for everyone to get acquainted with how astronauts prepare for space missions.

ESA's Human Spaceflight and Operations team housed at the European Astronaut Centre (EAC) at the DLR premises in Cologne was intrinsically involved in the German Space Day.

EAC is the home-base for ESA's astronauts and at the same time the centre for a major part of their specific facility training, in support of the scientific programme that is selected for their Space missions.

The public had the opportunity on this day to familiarise themselves with ESA's ISS programme - overall as well in more detail - regarding the science the astronauts perform onboard the International Space Station.

Many of the over 85 000 visitors that took part in DLR's German Aerospace Day patiently waited in periods for long time to visit EAC to acquaint themselves on first-hand with astronauts and their activities, routines as well as more specific training activities.

Both ESA and NASA astronauts were present.

"With the direct support of our DLR hosts, ESA created a wonderful experience for several thousand visitors. While the highlight for many was simply meeting their favourite European or American astronaut, we also shared the 'passion for space' of the many engineers, scientists and others working on the Human Spaceflight and Operations Directorate team. It was, overall, an extremely effective event," said Michel Tognini, Head of the European Astronaut Centre.

On the science front, EAC had placed a joint Medical and Science Utilisation Booth outside the main entrance, to allow visitors to get some insight in to what actually astronauts do onboard the ISS. In addition the Crew Medical Support Office provided demonstrations of how ESA astronauts are supported on a personal medical level during their missions.

The open day coincided with the start of the MagISStra and DAMA/STS-134 post-flight tours - the tours that astronauts participate in, visiting selected locations and laboratories that have had a relation to the flight they have been on. ESA astronaut Paolo Nespoli, who actually spent a major part of his pre-astronaut career at the EAC as training instructor, was present, together with a part of his crew.

The international training initiative for children, with astronauts as role models, the 'Mission X: Train like an Astronaut' programme was also presented, by astronauts Christer Fuglesang and Samantha Cristoforetti.

Visitors had the opportunity to get a 'see and feel' experience with some of the large vehicles and modules that ESA has built for the ISS, the Automated Transfer Vehicle (ATV) which has been a crucial large cargo ship to the ISS over the last years, as well as the Columbus module. These reside in EAC as 1:1 scale mock-ups such that astronaut-training in these can be performed.

Finally, the educational experiments for the Dutch astronaut Andre Kuipers mission to the ISS, the 'Convection' and 'Foam stability' experiments were demonstrated.

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UPCOMING TOPICS:

MASER 12

As a consequence of the unusually mild weather conditions in northern Sweden the planned rocket launch for MASER 12 in November 2011 has been postponed until early February 2012. Next newsletter will bring preliminary results of that sounding rocket campaign.

Mission X: Train like an astronaut!

Mission X: Train like an astronaut! edition 2 is starting on 2 February 2012 with a live connection with its ambassador André Kuipers on the ISS. During the 2nd edition of this educational challenge children in more than 17 countries worldwide are participating.

Concordia Announcement of Opportunity

The Concordia Research Announcement closes on 9 January 2012. Next newsletter will bring the result in terms of submitted proposals.

Climate Change AO: Submittal status

The International Space Station ISS will be housing European activities in the future, intended to boost the initiatives taken for monitoring climate changes on planet Earth. ESA released a research announcement soliciting activity proposals in support of improved approaches to Earth climate monitoring. We will bring the first results of that announcement.

PromISSe: Mission status

ESA astronaut André Kuipers' significant experimental programme on the ISS, between December 2011 and May 2012 will be reported. Kuipers, a medical doctor on his second spaceflight will have activities broadly spread over several scientific disciplines and education.

ESA Astronaut Training: Luca Parmitano and Alexander Gerst

The first two of ESA's new astronauts have been assigned to missions in 2014 and 2015. They will soon start specific training, and we will provide an introduction and an outlook to their respective programmes.

CAVES Training - astronauts underground

We will report on the outcome of the first, ESA managed 'Cave training' for European, American, Russian and Japanese astronauts, a new way to prepare crews for space exploration.

ESA links to visit ....

- ► *PromISSe mission*: http://www.esa.int/SPECIALS/PromISSe/index.html
- ► *ESA's performed experiments* in the ERASMUS Experiment Archive (EEA)
- ► *Earlier HSF Science Newsletters* - get electronic 'pdf' version here:
  Link: http://www.esa.int/SPECIALS/HSF_Research/SEM1JV4KXMF_0.html
- ► *The multimedia streaming portal* of ESA's Directorate of Human Spaceflight and Operations:http: //wsn.spaceflight.esa.int/

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