→ SPACE FOR LIFE

human spaceflight science newsletter

July 2011

NASA Space Shuttle STS-134 Endeavour as the last Shuttle mission with an ESA astronaut, Roberto Vittori onboard. STS-135 Atlantis closes the Shuttle era with its 8 July launch. Courtesy of NASA.

In this issue:

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Paolo Nespoli's MagISStra mission has come to an end, Roberto Vittori (ESA/ASI) has accompanied the AMS into its location on ISS

Paolo nespoli touched down in Kazakhstan, together with his crew mates NASA astronaut Cady Coleman and Russian Space Agency cosmonaut Dmitry Kondratyev in their Soyuz capsule, on 23 May after a bit more than 5 months onboard the ISS, after an eventful science mission and more images of Earth taken than by any earlier ESA astronaut. ESA's Roberto Vittori was visiting with NASA's Space Shuttle Endeavour and the largest ISS payload ever. The Shuttle era has come to an end with the landing of STS-135 Atlantis in Florida, USA, on 21 July 2011.

Paolo Nespoli started his 5 months mission to the ISS mid December 2010 and concluded it with a smooth landing on 23 May 2011. Behind him Nespoli left a very well done and productive job, in many cases yielding more than what had been expected, and not the least producing a host of Earth images taken from the ISS. A very large number of these were finding their way into fans' and followers' electronic platforms via Twitter. More than 48.000 people followed Nespoli on Twitter.

A multitude of tasks, serving the interests of the ISS partner space agencies from Europe, the US (NASA), Canada (CSA) and Japan (JAXA) were executed.

In the following a condensed record of activities on behalf of ESA over Nespoli's last two and a half months on ISS is provided.

Physical Sciences activities - last 2 months

GeoFlow-2 experiment

The GeoFlow-2 experiment, a simulation model of the movements of fluid magma near and in the crust of the Earth, was under some time pressure, as the last mandatory run would have to be performed in time before the Fluid Science Lab (FSL) Video Monitoring Unit would have to be removed, and to be returned to Earth onboard the last Shuttle flight STS-135/ULF-7 (or otherwise end 2011 with new SpaceX cargo courier)

On the way, the experiment was put on hold for 2 weeks due to technical problems, which largely could be recovered by the engineering team. GeoFlow-2 nevertheless produced very useful data and therefore it was decided to extend the experiment execution by two to three months with further scientific parameters.

ESA Life Sciences experiments

Paolo Nespoli performed several experiments in physiology on their way to becoming completed. In order to be completed the experiment needs 8-10 test subjects for medical statistics reasons.

CARD

The experiment tests two hypotheses that are based on a more than two decades long research in understanding the reaction of the cardiovascular system to exposure to microgravity. The responses that can be observed in Space in the areas of adjustment of blood pressure, resistance in the circulation, tissue fluid filling and urine excretion, etc. do not fit completely with theories. Thus, the new theories for how the observable reactions could be brought about.

De Winne with a PFS kit folder.

A more detailed description of this experiment and the background can be found in Newsletter no.1 2010.
Nespoli performed this experiment twice in March and May time frames.

NEUROSPAT

NEUROSPAT is an experiment concerned with the human spatial and visual perception. The first experiment run of EPM/NEUROSPAT that makes use of EPM rack equipment for electroencephalogram recording was performed short time after arrival, in January 2011, and the second and last run was done in February.

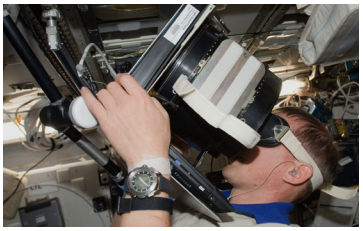
The same experiment will be performed by ESA astronaut Andre Kuipers late this year or early 2012. A further description of the experiment is provided on p.16 of this Newsletter as well.

PASSSAGES

PASSAGES is another experiment to be continued by coming onboard crews. Nespoli performed his second run mid April, after the first had been done early January. A description of the essence of the experiment is provided later under outlook to Andre Kuipers' mission, on p.15 in this volume.
Preliminary data indicate that there seems to be an altered perception of height, width and orientation in orbit.

3D SPACE

This was the first experiment in the discipline neurosciences that was performed in Columbus. Until Nespoli's flight, seven test subjects had performed the experiment, and completion is therefore nearing.
The second run was done by both Nespoli and Cady Coleman already late January, and a further run one month later. Finally Nespoli made a last repeat in April.
The 3D SPACE experiment setup was described in Newsletter February 2009. It has some relations to the PASSAGES experiment in, that it is concerned with the subjective perception.
Whilst PASSAGES deals with the judgement of dimensions relative to own-body size, 3D-SPACE is concerned with the distance and 3D perception.



In June 2009, ESA astronaut Frank de Winne was performing the 3D SPACE experiment. The adaptor ensures that the test subject cannot register any visual inputs apart from those coming from the laptop screen.

SOLO

The first repeat of this, time-wise rather demanding experiment was done mid February. The character of the experiment (special diet over a number of days) often makes it difficult to schedule without conflict with other activities.

Nespoli with Italian food onboard.

SOLO investigates the influence of salt intake on bone metabolism and is based on a decade long array of experiments relating to type of nutrition and its effect on bone metabolism. In Newsletter February 2009 a comprehensive background for the experiment is given.

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 Pulmonary Function System (PFS). Cady Coleman performed the experiment four times between January and May. The experiment was not part of Nespoli's experiment complement for this flight.

Coleman with the Pulmonary Function System, PFS. (View this 3D image with red/cyan glasses. Enlarge on your screen for better viewing).

Biology:

Biolab troubleshooting.

Biolab has been through extensive troubleshooting earlier, and during Nespoli's flight preparations were made for returning certain parts of the facility to Earth for examination- the gripper and the microscope - and potential repair. Experimentation using Biolab has been postponed until the microscope will be available for the Triplelux experiment.

Technology demonstrations

ERB-2

With this second generation 3D camera system, Nespoli produced extensive material, that serves for building 3D footage and mapping of the entire ISS.
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.

VESSEL ID SYSTEM

This ship identification and tracking system, part of a larger project leading up to a future global sea coverage via a satellite system, is being extensively tested onboard the ISS. The system continues to provide high-quality data as a test bed for future full-scale implementation. The project recently had an extension due to the successful and already practically useful performance onboard the ISS. The March 2011 Newsletter brought a comprehensive article on the topic.

Education programme

Nespoli played a key role in the following education activities:

CEO - Crew Earth Observation.

The amount of Earth photos produced by Nespoli is staggering. Evidently a large proportion of those will serve as documentation of changes in certain regions, when compared to earlier and later taken photos.

ESA Education - 'Mission-X - Train like an astronaut'

ESA together with the other ISS partner agencies launched this physical exercise initiative for children on 14 January 2011. Nespoli is the official ambassador of Mission X and in this role officially started the mission in a video address to the worldwide participants. Later, on 31 March at the end of Mission X, where the winning schools shared their results, Nespoli was speaking to the children from ISS. The project was a considerable success and a continuation is planned for later. Visit the site here.

ESA's 'Greenhouse in Space'

This educational project started on 17 February in four locations throughout Europe and on the International Space Station. Eight hundred school children together with Paolo Nespoli planted *Arabidopsis thaiana* seeds and grew them for 15 weeks.


The first tiny plant ... whilst things still looked very promising ...

The Greenhouse experiment aboard the International Space Station unfortunately developed a potentially hazardous fungus. Since the Station's ecosystem is particularly fragile, it was decided to dispose of the plants.
The project's closing event was held in Lisbon, Portugal, at the Ciencia Viva science centre.
Ciencia Viva invited 173 children and 20 teachers from eight schools from all over Portugal to present their findings on 12 May.
In parallel with the ISS and school projects, the Mars500 crew in the Moscow isolation facility grew the same plant, and with significantly more success than onboard the ISS.

Radiation and Space environment monitoring

Five different instruments are concerned with monitoring different aspects of the Space environment. These instruments typically do the work themselves without much intervention from the crew. Data is stored and read out or downloaded with certain intervals.

ALTEA-SHIELD

The Anomalous Long Term Effects in Astronauts' - Dosimetry experiment.
This payload (provided by ASI) presently registers the radiation spectrum internally in the NASA Destiny module. The measurements will be compared with those from an external facility, 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 radiation particle flux and can discriminate the type of particles and determine the trajectories and energy level.
Presently in NASA's Destiny module, the instrument continues the mapping of the radiation impact in 3 dimensions. It is the intention in the future to use the instrument for examination of the radiation protection effect of different materials. (ALTEA SHIELD experiment)

DOSIS

This "Dose Distribution inside ISS" experiment has been using the DOSTEL-2 detector, located inside the European Physiology Modules (EPM) rack. The experiment was disintegrated on 17 June, which marks the end of an experiment period that started in July 2009. The DOSIS experiment determines the dose and fluence of the radiation field inside ESA's Columbus laboratory.
Radiation exposure being one factor higher on ISS than on Earth needs to be monitored carefully, both for real-time protection of the crew, but also in order to gain experience that can lead to better radiation protection means and materials in the future.

Roberto Vittori's ISS visit onboard STS-134 Endeavour

STS-134 launched from Kennedy Space Center on 16 May to go to the ISS with the two big payloads, the Alpha Magnetic Spectrometer-2 (AMS-2), described in Newsletter September 2010, and EXPRESS Logistics Carrier 3 (ELC3). In addition Vittori brought a science programme that he performed during the mission. His central tasks included the controlling of the Shuttle robotic arm to grapple the AMS-2 and bring it to its installation position on the ISS truss. Three days after the arrival of Endeavour, Nespoli and his crew mates landed with the Soyuz capsule in Kazakhstan, whilst the Endeavour crew stayed for another good week.

ESA astronauts on ISS in 2011

In 2011 a total of three ESA astronauts will visit the ISS. The last one to come is the Dutchman Andre Kuipers, on his second flight and first long term mission. Kuipers is now in the final stage of his training for ISS expedition 30/31, which will commence with the Soyuz start on 30 November 2011.

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Maser 12 in preparation - Mission overview at a glance

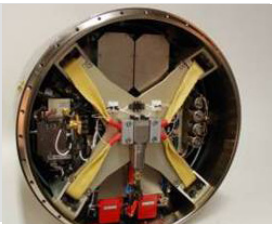
The MASER 12 launch is planned for late November 2011, from Esrange Space Center, Kiruna, Sweden. The mission is carried out by the Swedish Space Corporation (SSC) for the European Space Agency. MASER 12 will have a payload, consisting of four experiment modules (17" diameter), in the 13-metres long rocket offers 6-8 minutes of high quality microgravity, normally better than 10^{-5} g in all three axes. Real-time interaction during the flight, high-speed telemetry, tele-commands and real-time high resolution digital video transmission are amongst the services provided.

In collaboration with Swedish Space Corporation

RECOVERY SYSTEM

European Recovery System (ERS)

The ERS is designed to recover payloads up to 450 kg. It features a separating ogive (pointed tip, ed.) nose fairing with forward deploying recovery parachute. Further, it includes a GPS tip antenna. Activation of the ERS at the appropriate point in time is controlled by barometric switches in combination with electronic timing activation unit.

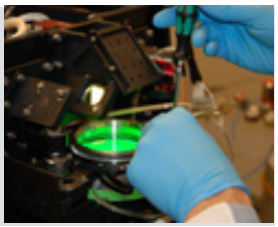


BIOMICS-2

Experiment: Dynamics of cells and Biomimetic Systems

Science Team:
T. Podgorski, CNRS and Université J. Fourier, Grenoble

BIOMICS-1 flown onboard MASER-11 in 2008, gave experience in particular regarding the behaviour of vesicles in a fluid stream, as an effect of shear forces, mimicking blood. A parabolic flight experiment later did the same with real blood.

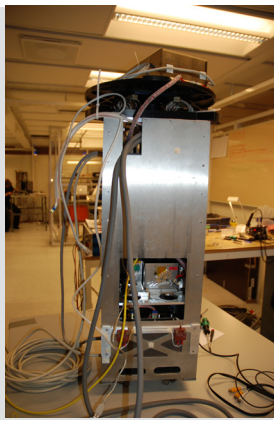


XRMON-GF

Experiment: In-site X-ray monitoring of advanced metallurgical processes under microgravity and terrestrial conditions

Science Team:
Henri Nguyen-Thi, L2MP, Univ. Paul Cézanne Aix-Marseille III

The XRMON facility - the X-ray monitoring of metallic fluid samples on Sounding Rockets - is on MASER 12 used for a new aspect, namely directional solidification. The latest application concerned monitoring the development of metallic foam during the solidification process.



SOURCE-2

Experiment: Convective boiling and condensation: local analysis and modelling of dynamics and transfers

Science Team:
C Colin, P Behruzi, J Lacapère, M Dreyer ,

As the earlier experiment, SOURCE-1 flown onboard MASER-11 i May 2008, pressurised gaseous nitrogen was used as atmosphere over the fluid - the fluid used was a low-boiling point technical liquid HFE7000, which has very attractive characteristics, such as freezing at -120°C and boiling at 34°C. As well it is nontoxic, non-flammable and non-corrosive.

BIM-2

Experiment STIM: *Science Team A Cogoli et. al, Zero-g LifeTec GmbH, Zurich*
Signal transduction in human T-cells in microgravity: Expression and function of chemokines, cytokines and their receptors, epigenetic alterations.

Experiment MicImmun: *ScienceTeam: Maikel Peppelenbosch, Univ. of Delft*
Influence of Microgravity on the Activation of NF-kB / Micro- gravity in adaptive immunity.

SERVICE MODULE

SERVICE MODULE

The service module is handling services related with flight. Thus the telemetry function is located there, as well as an S-band transmitter for video, a rate control system, and a GPS sensor and emitter for accurate indication of position, necessary for quick recovery.

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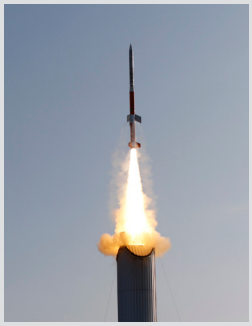


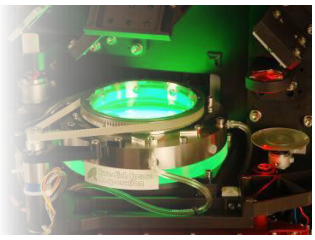

Launch and Recovery of MASER rockets in in Northern Sweden.

European Recovery System (ERS)

The system was built in 2006 under an ESA contract. A separating ogive nose tip is ejected forward. The base part of the ogive holds the parachute system, an autonomous redundant pyrotechnic ignition system, housekeeping electronics, telemetry interface, a beacon system, a camera system and pyrotechnic and electronic batteries. The system is activated via a barometric pressure sensor, when the rocket has descended to an altitude of 4.6 km. First, a drogue parachute ejects, and is separated when the load is stabilised and it has extracted the main chute. In this last phase the payload sinks at 8 m/s until landing.

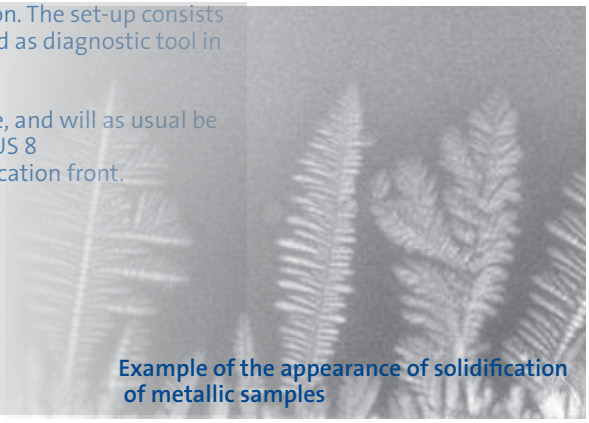
BIOMICS-2

Successfully flown on MASER 11 2008, the experiment is now followed-up by BIOMICS-2. The number of experiment samples is increased from two to six, and different from the first experiment, this now studies regimes with only one vesicle size. Further, a digital holographic microscope including camera for monitoring the experiment cell has been added to the payload.
BIOMICS-1 was successful in many ways, and one significant finding was, that vesicles tend to place themselves in the center of the fluid stream, after having lifted off from the vessel wall.



XRMON-GF represents Microgravity investigations of directional solidification. The set-up consists of one furnace that will be heated to 630° C. This is the third time X-ray is used as diagnostic tool in sounding rockets.

A new module has been designed, manufactured, and tested for this purpose, and will as usual be operated by SSC using experience from X-ray modules on MASER 11 and MAXUS 8
Live X-ray images are downloaded during flight, for observation of the solidification front.



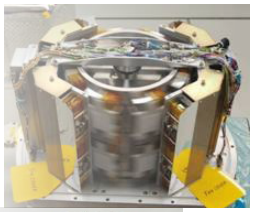
Example of the appearance of solidification of metallic samples

SOURCE-2 geometry is the same as in SOURCE-1, but the liquid HFE7000 is not pressurised by nitrogen but by its own vapour (HFE7000). The objective is to compare the heat and mass transfer at the gas-liquid interface, at the wall and on the heated plate in the two configurations (with and without condensable gas. See a more detailed description of the SOURCE experiment here.

Left image, the SOURCE-2 experiment module. To the right, an onboard video image through the transparent experiment container. See more images here.

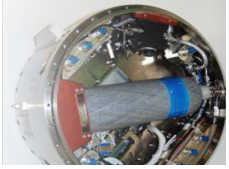

BIM-2 Module and experiment cell design is based on BIM, successfully flown on MASER 10, but destroyed at landing
MicImmun and STIM.

The module is designed to accommodate blood cell experiments (MASER 12) and plant cell experiments SPARC and GRAMAT. Samples (cells in a solution) are chemically activated at the beginning of the µg phase, and fixed before end of the µg. Reference samples, in a 1-g centrifuge included in the module experiment set-up, and 1-g reference samples in incubator on ground are run in parallel with the flight µg experiment.



SERVICE MODULE

The module is 260 mm long and weights 28 kg. The design allows for easy disassembly for adjustment and servicing purposes. Over the years, upgrades have become necessary, due to increased requirements to e.g. real-time telemetric intervention, as well as an increasing demand for real-time data and video downlink. The latter now gives the opportunity in real-time to observe experiment events.



Note: In 1986 Sweden began its own sounding rocket programme, called MASER (MAterial Science Experiment Rocket). The first successful launch - MASER 1 - took place at ESRANGE in March 1987. ESA has now participated in eleven MASER missions. MASER missions are managed by Swedish Space Corporation (SSC). From MASER 6 to 10, two stage Skylark VII rocket motors have been used. From MASER 11 and onwards, the Brazilian two-stage solid propellant VSB 30 motor is used. **Source:** Adopted from 'European User Guide to Low Gravity Platforms' - an ESA User Handbook.

ESA is introducing a new feature regarding the g-level offered on its Parabolic Flight Campaigns onboard the Airbus A300. Martian gravity (0.38 g) has occasionally earlier been offered as an exception. Now ESA goes all the way offering a full campaign with levels of 0.16 g for approximately 23 sec and 0.38 g for approximately 30 sec. These Lunar and Martian gravity levels are necessary in preparation of the Martian future reality for technology and crews. The Joint European Partial-G Parabolic Flight Campaign is a collaboration between ESA, CNES and DLR.

In June 2011, the first Joint European Partial-g Parabolic Flight (JEPPF) campaign took place. Experiments were selected from 42 proposals received in response to an international call for experiments, to be conducted at 0 g and partial g levels: Moon g level (0.16 g) and Mars g level (0.38 g).
This is the first full A300 ZERO-G campaign with such intermediate g levels, which will help scientists in obtaining results at intermediate levels of gravity and allowing to better study the influence of gravity and to prepare future planetary exploration missions.
This first Joint European Partial Parabolic Flight campaign (JEPPF) was conducted from Mérignac-Bordeaux airport between 30 May and 9 June, 2011. Three flights were performed with the selected 13 experiments onboard. Each flight performed a profile composition as indicated at the bottom of this page and the next.

The combination of three different low-g levels on the same flight is a first in this form, and offers the unique opportunity for the time to observe the reaction of samples and humans and rodent body systems to such a combination. The added value of combining these in one flight are many, not the least adaptation phenomena in biological systems, but also as g-sensitivity threshold investigation for various scientific aspects. The experiments flown are identified in the table with their sponsoring agency indicated.

Preliminary reports from the flight campaign indicate that it has been a highly successful undertaking to combine three gravity levels into the same flight. Scientists are excited to gain the next opportunity for continued partial-g experimentation.

Scientific objectives of selected flight experiments.

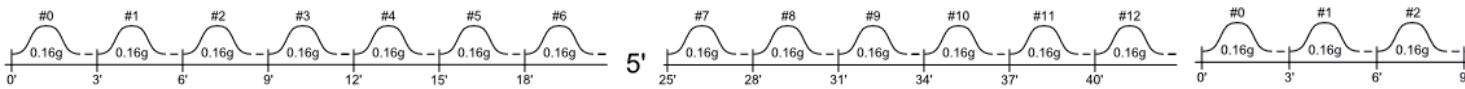
Local Heat Flux Investigation during a Single Bubble Cycle under Low Gravity Conditions

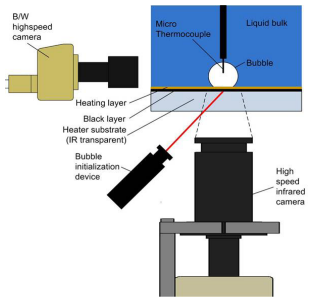
Peter Stephan et al. , Technische Universität Darmstadt, DE

Scientific objectives of this experiment were:
• Micro scale measurement of heater surface temperature distribution, bubble shape and vapour temperature during a single bubble cycle at varying heat fluxes under exactly predefined

Origin	Title and Investigators
AO-PGPF-31 (ESA)	Local heat flux investigation during a single bubble cycle under low gravity conditions. *P. Stephan, S. Fischer (Techn. Univ. Darmstadt, D)*
AO-PGPF-41 (DLR)	Local erosion of (pre-)planetary bodies by light induced dust eruptions *J. Teiser, G. Wurm, T. Kelling, T. Meisner (Univ. Duisburg-Essen, D)*
AO-PGPF-39 (ESA)	Sonofluidized granular packings under reduced gravity *E. Clement (ESPCI, Paris, F), M. Sperl, (DLR-MP, Köln, D)*
AO-PGPF-38 (ESA)	Technologies for ExoMars – Preparatory activities in Martian gravity *P. Baglioni, A. Pacros, B. Bethge (ESTEC, SRE-PE)*
AO-PGPF-01 (ESA)	Alterations in autonomic cardiovascular control induced at partial g forces *S. Van Huffel, S. Vandeput, A, Aubert (Univ. Leuven, B)*
AO-PGPF-16 (ESA)	Sensorimotor coordination under partial gravity levels: movement control and adaptation *P. Lefèvre, J.L. Thonnard, (U. Louvain, B), J. McIntyre (U. Paris Descartes, F), V. Hayward (U. Paris 6, F), S. Stramigioli (U. Twente, NL)*
AO-PGPF-26 (DLR)	Orthostasis beyond Earth (ORB-Study) *F. Wappler, U. Limper, P. Beck (Univ. Witten/Herdecke, D), U. Mittag, P. Gauger (DLR, Köln, D)*
AO-PGPF-07 (DLR)	The Nintendo Wii as a training device for balance control under reduced gravity conditions *A. Gollhofer (Univ. Freiburg, D), U. Kübler (Astrium, Friedrichshafen, D)*
AO-PGPF-05 (CNES)	Influence of reduced gravity on human visual orientation determined by the rod-and-frame *G. Clement, A. Buckley (ISU, Strasbourg, F), E, Groen, J.E. Bos (TNO, Soesterberg, NL), K. de Winkel (Univ. Utrecht, NL)*
AO-PGPF-25 (DLR)	ROS (reactive oxygen species) and calcium analysis in Arabidopsis thaliana cell cultures under reduced gravity *R. Hampp (Univ. Tübingen, D)*
AO-PGPF-02 (CNES)	Role of gravitational and inertial components of the efferent copy for the control of arm movements *J. McIntyre, M. Tagliabue, P. Senot (Univ. Paris Descartes, F)*
AO-PGPF-23 (CNES)	Partial gravity and vestibular decompensation in rat *P. Denise, S. Besnard, H. Normand (Univ. Caen, F), G. Clement (ISU, Strasbourg, F), S. Wood (USRA, Houston, USA)*
(CNES)	Cryogenic - low g *J. Lacapere (Air Liquide, Sassenage, F)*

Partial-g Parabolic Flight Campaign proflie - One flight day:





thermal conditions.
• Micro scale measurement of heater surface temperature distribution, bubble shape and vapour temperature during nucleate boiling at a single artificial cavity under low residual gravity.
• Measurement of total heat flux and bubble shape during boiling on single and multiple cavities on bubble scale. • Observation of bubble coalescence on contact line and bubble scale.
• Evaluation of the influence of thermal capacity and thermal conductivity of the heater substrate onto the nucleate boiling process.

Erosion of Dust Beds by a Solid State Greenhouse Effect and Thermophoresis

Jens Teiser et al., University Duisburg-Essen, DE

This experiment investigated the light induced particle ejections under varying gravity conditions to explore their influence on the Martian dust cycle, as laboratory measurements cannot easily be extrapolated to (partial) microgravity.
This experiment was flown on the ESA PF campaign November 2009, which gave valuable experience. It led to significant changes and improvements of the experimental set-up, that could be tested on a national PF campaign. Finally, as this experiment is dealing with a theory for migration of Martian dust, the latest partial-g ESA PF campaign and the third flight of the experiment has given a significant gain in crucially important data.

Sonofluidized granular packing under reduced gravity

Eric Clement et al., PMMH-ESPCI , Paris, FR

This campaign was a first trial to explore conditions in the perspective of a future control of acoustic properties and granular flows at low g. Vibration energy was transferred to the packing by piezoelectric transducers. By direct visualization of the packing, an assessment of granular motion in response to weak vibrations could be made.

Technologies for ExoMars – Preparatory activities in Martian gravity

Pietro Baglioni et al. ESA/ESTEC, Noordwijk, NL

The ExoMars Programme is a joint ESA-NASA initiative aimed at establishing if life ever existed on Mars and demonstrating new technologies paving the way for a future Mars sample return mission in the 2020's.
The technological objectives of this activity was to investigate:
• Entry, descent and landing (EDL) of a payload on the surface of Mars;
• Surface mobility with a Rover;
• Access to the subsurface to acquire samples; and
• Sample acquisition, preparation, distribution and analysis.

Role of the gravitational component of the efference copy in the control of upper limb movements

Joseph McIntyre et al. CESEM UMR 8194 CNRS, Paris, FR

This experiment investigated the dynamics of simple pointing movements with the hand, to a memorised target. With a 3D measurement system, the trajectory followed by the hand and the movement dynamics in 0g, 1g and 2g could be studied. By measuring the muscular activity with electromyography (electrical nerve activity of muscles, ed.), the perception of the arm position and that of the command sent by the brain to perform the movement could be related, thus revealing potential differences as a function of gravity level.

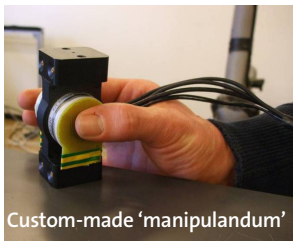
Alterations in autonomic cardiovascular control induced at partial G forces

Sabine Van Huffel et al. Katholieke Universiteit Leuven, BE

The purpose of this investigation was to study if different parameters related to Heart Rate Variability (HRV) and Blood Pressure Variability (BPV) would be linearly correlated with the gravity level.

Dexterous manipulation in microgravity

Philippe Lefèvre, Université catholique de Louvain, BEL


Custom-made 'manipulandum'

This experiment aimed at modelling certain aspects of arm trajectory planning and motor control. The first objective concerned the force applied at the fingertips, the Grip Force (GF) and the Load Force (LF). The second objective was to gain more measurements for the database concerning the hypothesis of an optimal control of the arm that is based on an energy cost function.

Orthostasis beyond Earth (ORB-Study)

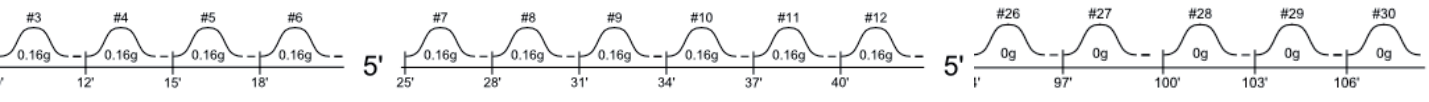
Frank Wappler et al. University Witten/Herdecke, DE

During current missions, a large number of astronauts experience warning signs and symptoms of cardiovascular (near) collapse immediately upon returning to Earth. As Martian gravity amounts to only one third of the Earth's gravity, such symptoms could occur with significant time delay. An astronaut could therefore already be involved in crucial post landing tasks when hit by a fainting spell, possibly impacting mission success and increasing the risk for injury and damage. Thus, it is considered essential for upcoming missions to Mars and Moon to understand the behaviour of the human cardiovascular system in these partial gravity environments.

The Nintendo Wii as a training device for balance control under reduced gravity conditions

Albert Gollhofer et al., University of Freiburg, DE

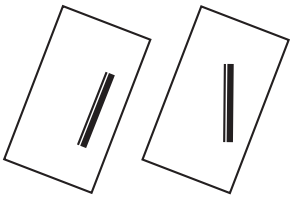
The scientific goal of this experiment was to evaluate the effectiveness of a training programme conducted under reduced gravity via water buoyancy on the motor control under actual reduced gravity. The following issues were addressed:
1) The effectiveness of a training programme performed under simulated Martian gravity on the motor performance under actual Martian gravity.
2) The feasibility of using the Nintendo Wii in microgravity under simulated terrestrial gravity (achieved by straps that



pull the subject onto the Wii balance board).
A second objective of this experiment was to evaluate the effect of reduced gravity on human balance control.

Influence of Reduced Gravity on Human Visual Orientation determined by the Rod-and-Frame Test

Gilles Clement et al., International Space University (ISU), Strassbourg, FR



Rod and Frame test - Align a rod within these frames so that the rod is vertical.

This experiment investigated whether the perception of the visual vertical is affected when the observer is in reduced gravity. The rod-and-frame test was used to investigate the role of visual and gravitational cues in judging the visual vertical, and compare normal gravity (1g) with microgravity (0g), Moon gravity (0.16g), and Mars gravity (0.38g), as well as with hypergravity during parabolic flight and in a centrifuge at TNO, at Soesterberg, the Netherlands.

ROS (reactive oxygen species) and Calcium analysis in *Arabidopsis thaliana* cell cultures under reduced gravity.

Rüdiger Hampp et al., University of Tübingen, DE

Cells were fixed chemically during the different stages of a parabola. These cells are used for total gene and (phospho) proteom expression-analyses after the campaign. Especially genes and proteins which are involved in Ca^{2+} and/or ROS dependent transduction pathways are investigated.

Partial gravity and vestibular decompensation in rat

Pierre DENISE et al., Université de Caen Basse-Normandie, FR

Rats were studied during parabolic flights, one month after unilateral vestibular deafferentation (UVD) at a time where compensation has been complete. Eye movements and neck muscle activity in restrained rats as well as motor behavior in freely moving animals were quantified.

Cryogenic low g

Jérôme Lacapère, Air Liquide Advanced Technologies, FR

The goal of this experiment was to obtain data on the thermodynamic behaviour of a fluid subjected to a low gravity environment. These data (pressure, temperature, ...) have been utilised to validate a numerical algorithm. This algorithm will be used to forecast the behaviour of propellants in microgravity for future development of launcher upper stages.

A view into the first Joint European Partial-g Parabolic Flight Campaign. ESA photo.

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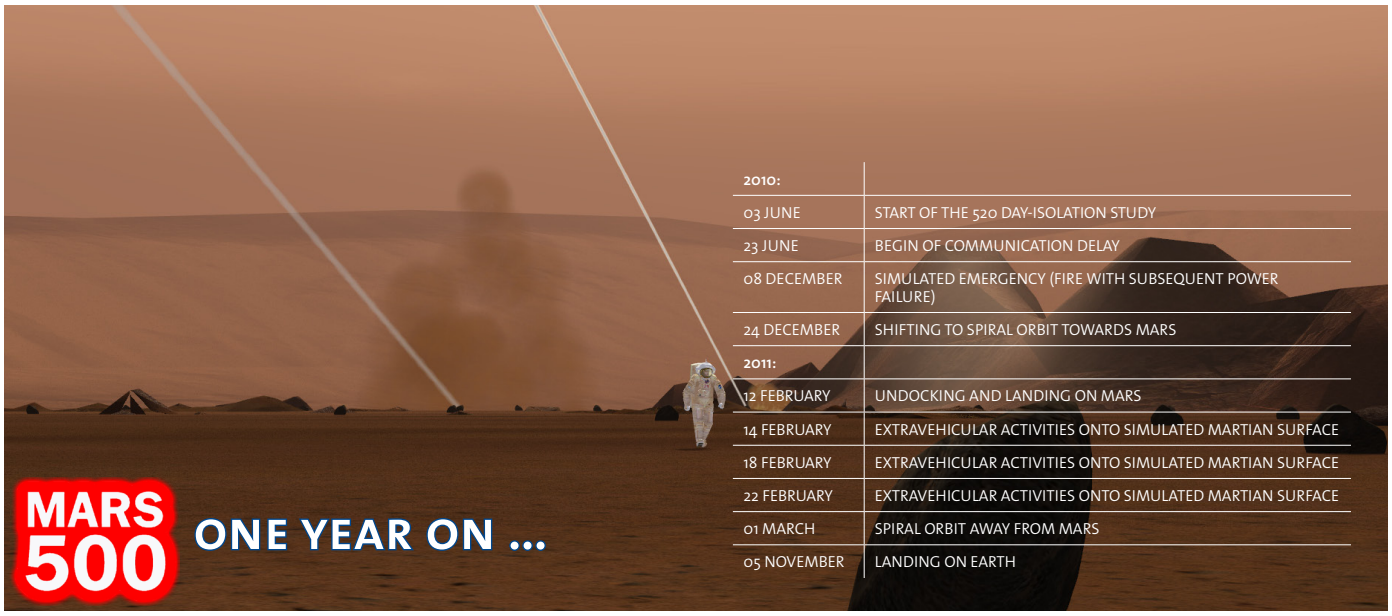

Simulation in the Mars500 simulator: One of the computer games used by the crew to look ahead towards the end of the journey.

One year on, the simulated Mars mission is moving along. Diego Urbina had his first birthday in there, turning 28, as the last of the crew to celebrate a birthday there. The mission now has less than one third of its total duration to go. On 4 November the crew will 'land' again on Earth, having been away on a trip close to one billion kilometers in simulated Space.

With the above mission schedule the crew of six started their 'journey to Mars' at little more than one year ago, 'onboard' the simulation facility in Moscow.

On 4 November 2011 the journey is over. The crew has been isolated during a period similar to the shortest possible manned mission to Mars, considering the presently available propulsion systems.

During this time the International Space Station has exchanged crews several times, ESA astronaut Paolo Nespoli has been onboard the ISS for 5 months, between December 2011 and May 2011. ESA astronaut Vittori has been on a 'short trip' to the ISS with one of the last Space Shuttles, and the ISS has since the Mars500 crew started traveled in its orbit around the Earth almost 6000 times, with another 3000 revolutions before Mars500 'lands'.

A bit more than one year on in the Mars500 facility, Diego Urbina says in his last entries in his log:

"Thank you folks on twitter!"

"Wow, it's already been a year," writes Diego in his anniversary diary and tries to visualise this by thinking "of what you were doing exactly one year ago, and then picture yourself living in a windowless metal box from then!"

"Or perhaps instead what can give you an idea of the order of magnitude involved, is that we all have had at least one birthday in isolation and the next birthdays are already coming."

"Birthdays, those complete orbits around the Sun, are particularly nice. They are moments in which you think of home a lot but it is also when you realize that there are folks waiting for you on Earth and feel a little less "lonely out in space".

Diego's anniversary

"I was the only one left that still had to have one, and I just turned 28 some days ago. It was fun to switch from the celebrators to the celebrated by those whom I can now call with no doubt, my friends! There were a nice couple of gifts, and, yes, just like the scientists promised...there was cake."

Diego with birthday presents.

"In between these exceptional days, there is work and work to do. Our crew has been keeping up the dozens of experiments we have to do constantly, no matter the good times or the hard times, producing data of quality that helps some of Europe's best scientists to evaluate what the space travelers of the future will go through; and allowing us to "live the future" ourselves and draw conclusions to potentially improve the conditions of life and operations in a spacecraft amidst these very unnatural and prolonged conditions."

Sharing fresh radish with precision

"Keeping steady is not simple; we as individuals have ups and downs and our mood may fluctuate, but as a group we keep level, moving forward like a flock of birds. And like a flock of birds that must look for the ascending thermal currents that keep them flying high, once one of us picks up energy and height, the whole flock knows "where the

thermal is", and all of us go up."

"The environment wants to take a piece of us, sometimes with the most lonely, stressful, or monotonous days we have experienced in our lives; and sometimes it LITERALLY wants to take a piece of us, like this experimental exercise machine that has been trying to play Dr. Guillotine with our fingers for a year. Nevertheless this crew gives all these big and little factors a hard time when they try to rain on our parade, with ingenuity, patience and hope in the future."

Simulating the Mars landing

"You naturally have to enjoy what you do in order to keep doing it. Some of the cooler things that are more likeable and never get old are the "spaceship driving lessons" where we learn to dock to a station, or the experiments in which the scientists like to share the results with us so we get to understand better the place we live in and learn some more science on the way, even eventually improving the experiments; and there are a handful of experiments instead that just do not like to be liked, such as those that involve a pain/discomfort which are OK for some months, but later can only make you wonder if you could go and pursue a career as a fakir. Nevertheless, it's all part of the package, we like to do it for the greater good and are sure that in the future the results will be worth it, and the harder it is, the more satisfactions there are."

"Free time, on the other hand, needs to be spent in an enriching way, reading, obtaining new skills, keeping the old ones, filling every possible minute in a productive manner but also dedicating some of it to relax. There is a need to be balanced and to keep improving yourself."

Diego, Alexandr and Wang 'on Mars'

"In the meantime we have learned lots about the dynamics of an interplanetary mission, the logistics, the interactions with the ground; one year of a valuable, unique, first-person perspective that has taught us a lot not only about a space mission, but about ourselves. Not to mention this is the year we walked on Mars! I mean how cooler can it get than a year in which you can say you walked on Mars."

Diego, Alexandr and Wang with flags

"I already thank all the people that have supported us thus far and that I know will continue to support us during the remaining third of the mission: family (I love you), friends who enjoy entertaining our nights with crazy earthly stories, mission support - our umbilical cord to the real world - and the folks on twitter that make us company from far away during tough times, 140 characters at a time. I also can never overstate how much I am proud of our crew, so I thank all of them too for being such good traveling partners, or sputniky, like you'd say in Russian."

- Diego.

Good spirit

The biggest problem of future exploration flights is not necessarily the technology, but the humans and interactions between the crew members. This is the main focus of the Mars500 experiment.

"Our crew has been keeping up the dozens of experiments we have to do constantly, no matter the good times or the hard times, producing data of quality that helps some of Europe's best scientists to evaluate what the space travelers of the future will go through," writes Diego.

"We still have 5 months ahead of us a lot of opportunities to make this trip to Mars even more special," adds Romain.

"We have a great crew and although our backgrounds are significantly different, we never had any conflicts between us. That's why I'm full of optimism for our last days in the Mars500 modules. We'll see you on the 5th of November when we'll land on Earth after our 520 day's journey to the Red Planet, not before!"

Dates for coming highlights

In around two months, the Mars500 crew will get close enough to Earth' that communication delay will be negligible. Therefore, 15 September will define the end of communications delay, and there will be a switch-over to voice communications.
On 13 October the 'spacecraft' will start the approach to Earth, helped significantly by the Earth gravitational pull. It will start a spiraling orbit towards Earth.
Finally, on 4 November 2011 the 520-day exploration mission will come to an end with the crew 'landing' on Earth.[1]

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1. When Diego wrote the text, 5 November still was the planned 'landing' date. Recently 4 November has been defined as the 'landing' day.

The 2010 Concordia crew and their assignments - scientists work in isolation for 8 months in Antarctica

Each year in December a new team is sent to the Antarctic Concordia base for a stay of a year, utilising the short window of a few months where one can actually physically get there. After two-three months, weather and temperature conditions make it impossible and the crew is entirely self-sufficient. Antarctica as a research location offers unique opportunities.

Part of the 2010 overwintering crew during the short summer, working with an ISS perspective on Antarctica. Courtesy of Ales Rybka.

Concordia Station

Concordia Station was conceptualised in the 1990ies as a new permanent research station for the French Polar Institute (IPEV) and the Italian Antarctic Programme (PNRA). This research facility became operational in 2005 at a location called Dome C on the Antarctic Plateau, South Pole. It is located 1,100 km inland from the French research station at Dumont D'Urville, and 1,200 kilometers inland from the Italian Mario Zucchelli Station at Terra Nova Bay. The Geographic South Pole is 1670 kilometers away.
Concordia Station is the third permanently manned research station on the Antarctic Plateau aside from Vostok Station (Russian) and the Amundsen-Scott Station (US) at the Geographic South Pole.

The high ice plateau around Concordia is an attractive place for scientific research. Studies ranging from glaciology and atmospheric sciences to biology and medicine all can benefit from the extreme environment in the middle of the Antarctic continent.

Environment

Almost total isolation and virtually inaccessible from February to November, Concordia is located at the ice plateau 3.233 m above sea level. Temperatures hardly rise above −25°C in summer and can fall below −80°C in the winter time. The annual average air temperature is −54.5°C. Humidity is low with very little precipitation throughout the year. Air pressure 645 is hPa, causing a chronic hypobaric hypoxia. Typical wind speed in winter is 2.8 m/s.
No animals or plants live at a distance of more than a few tens of kilometers from the Southern Ocean. However, bird skuas have been spotted while overflying the station, 1,200 km away from their nearest food sources.

How to get there

Access to Concordia station is limited to the austral summer (November to February) due to the extreme weather conditions. There are two different ways to access the station. Coming from Hobart, Australia, by ship to Dumont d'Urville, which take approximately 6 days. Main personnel and selected light cargo is transported by plane from

The convoy on its way ...

Christchurch, New Zealand, to Mario Zucchelli Station and then further to Concordia. This last leg takes approximately 3-5 hours. For heavy material, fluid and supplies, a convoy on caterpillar belts travel three time during the accessible season. Travel takes 10-14 days each way.
About 50 people visit during the summer and typically 12–14 crew members stay over the long Antarctic winter

(mid-February to mid-November).

ESA Interest

A stay at Concordia has many similarities with a long-duration spaceflight and with future exploration missions. ESA is cooperating with IPEV and PNRA to use Concordia's special environment to prepare for future exploratory human missions, and it provides as well an excellent laboratory for fundamental research on many subjects.

ESA also works with IPEV and PNRA in medical monitoring, operational validation of life-support technologies and psychological training of crews by personnel from the European Astronaut Centre.

A test bed for human space flight studies - how?

The combination of a number of research-wise attractive features are only found on Concordia:

• Prolonged isolation and confinement (typical duration of a stay in the station is 11- 12 months): the crew needs to be totally self-dependent especially from February to November where no access to and from the station is possible, even in emergencies.

• Hostile natural environment (extreme low outside temperatures, chronic hypobaric hypoxia).

• Life in a small multicultural setting (typically 12-14 crewmembers, different languages & behavioural customs).

• Limited mobility outside the station buildings, especially during winter.

• Night/daylight variations (constant light in summer, constant darkness in winter).

• Having to manage life with limited resources and with consideration for the environment.

Experiments

Together with the Concordia partners ESA's Directorate for Human Spaceflight and Operations selects experiments to be performed on Concordia by the selected crew, in the areas of medicine, psychology and physiology.
As an example, the experiment package for the overwintering period 2010 was:

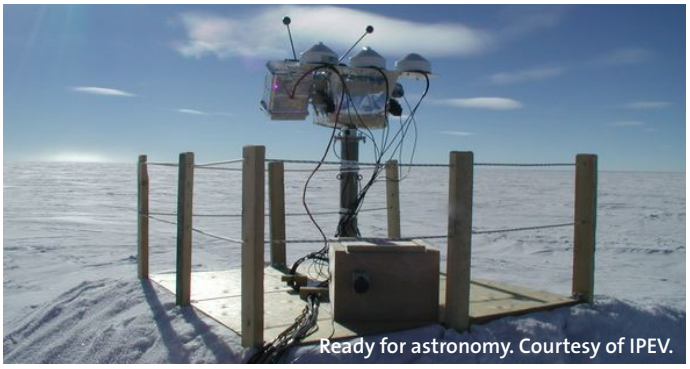
- Consequences of longterm-confinement and hypobaric hypoxia on immunity in the Antarctic Concordia environment (Choukèr)
  How: Blood, urine, saliva, exhaled air, questionnaires
- Assessment of biomarkers for behavioral adaptation and health during isolated stay in Concordia (BEACON) (de Boever)
  How: Blood, urine, saliva, cognitive tests
- Influence of physical activity on mental and perceptual motor performance and mood during long-term confinement (Schneider)
  How: EEG, exercise log, questionnaires/performance measures integrated with LTMS/BEACON protocol
- Medical skill maintenance during long duration missions (Schaefer)
  How: Simulation of medical emergencies
- Concordia microbial dynamics (van Houdt)
  How: Environment samples, faeces samples from crew members

Arrived at Concordia Station

Soon after the arrival of the new Concordia team, daylight starts becoming less, and eventually disappears for good, for a period of almost 6 months. End January-early February, summer is over. Adaptation to the new environment is necessary. It is a challenge to deal with the low air pressure that corresponds to being at an altitude of almost 4000 meters over sea level continuously. Breathlessness lasts in the order of two weeks. The air is extremely dry, occasionally as low as 6% (normally we consider 20% being very dry) which leads to occasional nose bleeding and constantly very dry skin, that easily cracks.
Available to the crew are basically two buildings, one that provides living quarters, laboratories, medical facilities and the other including kitchen, dining area, workshops and offices.

Activities and research

Many of the crew members kindly volunteer to be test subjects in the mentioned medical and psychological experiments. However, that is not the main reason that they are at Concordia.
The crew all have different tasks, such as research in the area of glaciology, atmospheric science and astronomy, for which disciplines Concordia offers absolutely unique conditions.


Ready for astronomy. Courtesy of IPEV.

One important person is the Station Medical Doctor who has to make sure that relevant actions are taken in case of sickness and the like. In addition, as the station is self-sufficient during a long period, technical engineering support and repair tasks have to be looked after. Finally, one of the most important people onboard is the cook! Some of the research indicates, that a central role for fighting mood and depression problems is played by food and meals in the isolated environment.

Daily life

Concordia probably describes the most extreme confinement one can find on Earth, and to some extent overshadows the degree of confinement astronauts experience onboard the ISS: After all, astronauts can in principle get back form the ISS within hours in case of emergency. From Concordia that is not possible after the first two months on the location, which is similar to the constraints on a Mars mission.

On the other hand most Concordia inhabitants experience a pleasant peace for the mind to work without the typical daily stresses, whilst being there. Psychologically that can be a challenge to some, whilst others thrive in the environment, enjoying having time enough to reflect over life and its positive and negative sides.

Conflicts do arise, but mostly they are kept under control, as everyone realises that an open conflict is a bad idea with the outlook of having to stay together for many months. Towards the end of the stay, any such friction case does however often flare up.


Still light over the isolated station. Courtesy of Ales Rybka.

Winter-over 2010: Self-entertainment

Looking back over the activities that the crew undertook, in particular those activities that had a self-entertaining character, it appears that the imagination seems unlimited. The crew gets into a routine where frequent highlights are created in order to break the monotony and to have fun and to laugh. All available means are used to obtain that goal, which is based on a good portion of creativity and investment of considerable time to prepare for an agreed, future special occasion, like 'Miss Concordia'(all but one of the crew were men), climbing 1000 m on Antarctica by use of the internal staircase, and loads of cultural dinners and entertainment events.
By these means monotony is broken, and time chopped up in smaller portions, to make it more bearable - a good example of the power of human adaptability.

Winter-over 2010: Psychology of isolation

A host of observations have been made during the 2010 Concordia overwintering period, among those not the least of psychological character:
One basic problem that probably had been underestimated by some crew members was the importance of language ability. Two large groups were French and Italian respectively, and not all had good English capabilities, so the more subtle communication with only English speakers in certain situations became problematic.

A further observation has been the importance of the ability to do self-reflection and perform self-control in cases of conflicts: As is expressed in a pronounced case onboard a small sailing ship crossing the Atlantic, the same is the case on Concordia, namely that you cannot walk away in case of a conflict. You can only hide for so long and eventually will have to live with the fact that all need each other in such a setting.

Winter-over 2010: Conclusions from a crew member

"I do not think one can screen very well against such situations, whilst selecting the crew for an overwintering period, or even for a Space mission for that sake, and to a certain extent it probably would be a very good idea to select space crews for long exploration missions to e.g. Mars, after they have lived at the Concordia Station during one winter period. That will show very well if they can handle the company and the confinement," says Ales Rybka, a Czech medical doctor who was part of the 2010 overwintering crew.
"The best moment on Concordia? Well, no doubt that was when light came back for the first time after the winter period. That was a fantastic experience that is difficult to describe. And the hardest part was missing my girlfriend – that was really very difficult and something I never got used to.
The stay here changed everyone, we all came back as different persons, and I personally during the stay clearly found out what is really important in life. In the daily routine, we have far too little time to keep in full contact with ourselves"

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Concordia scientific installations. Courtesy of Ales Rybka.

Monitoring Earth's climate change ...

Japan Aerospace Exploration Agency astronaut Soichi Noguchi of the space shuttle's STS-130 crew makes photos of Earth from the Cupola. Courtesy of NASA.

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. In collaboration with the Directorate for Earth Observation, Directorate for Human Spaceflight and Operations releases a research announcement soliciting activity proposals in support of improved approaches to Earth climate monitoring.

ESA's Directorate for Human Spaceflight and Operations has issued a dedicated Announcement of Opportunity (AO) for experiments studying global climate change from the International Space Station (ISS).

The ISS is now assembled and operating with a crew of six astronauts. A variety of research activities are being routinely performed onboard the ISS by ESA and the other international partners. Historically, the main focus of European research has been in the area of life and physical sciences, taking advantage of the microgravity and exposure to the space environment provided by ISS. Furthermore, ISS can provide a multi-user platform for studies in astrophysics, solar science, fundamental physics, Earth science and climate change studies.

Use of the ISS to supplement ongoing Space based studies of global climate change

The consequences of global changes in Earth's environment are a major challenge for humanity in the coming decades and centuries. Various natural physical processes modify the atmosphere, oceans and land surfaces on short and long term scales. However, in the past 150 years human activities have resulted in significant changes in many aspects of Earth's environment, including increasing greenhouse gas concentrations, modification of the nitrogen & phosphorous cycle and major alterations of land use (e.g. deforestation). It is crucial that we understand the interaction of anthropogenic environmental changes with natural changes to predict future changes in Earth's environment.

In turn this information will assist sustainable development in relation to human activities, while minimising degradation of the environment and limiting the vulnerability of society to global changes.

Potentially, the ISS can be used as an observation platform for instruments and experiments relevant to global change studies, supplementing ongoing and planned observations from dedicated satellite platforms.
The European Columbus module has an External Payloads Facility (CEPF) which has four payload attachment sites on the end of the module, permitting nadir, zenith and side (limb) viewing.
The Cupola module, launched with Node 3 in early 2010 (image above), has multiple windows and provides a location to operate internally mounted instruments. An ISS Earth sciences instrument already under development is the Atmosphere Space Interactions Monitor (ASIM) for Columbus, planned to be deployed on the ISS in 2014.

A Call for Ideas (CFI) was issued by ESA's Directorate of Human Spaceflight in coordinaztion with Earth Observation in October 2009. A total of 45 proposed ideas were received. This input confirmed a high level of interest in the use of ISS for climate change studies and several interesting thematic areas for experiments were identified. Therefore, it was decided to proceed with release of a dedicated Announcement of Opportunity for experiments on climate change studies using the ISS. This includes research topics associated with climate change in studies of the

1) Atmosphere,
2) Oceans,
3) Land surface,
4) Cryosphere and
5) Solid Earth

The announcement of opportunity solicits proposals from scientific institutes for flight experiments on climate change studies using the ISS as a platform. Proposed projects should be consistent with the overall research goals of the ESA Earth observation programmes and should complement on-going and planned climate change and Earth observations studies from dedicated satellite, airborne and terrestrial platforms. "Fast track" experiments could be potentially developed and flown in a short time frame (<3 years).

Proposals which pass peer review selection will undergo a feasibility study (phase A), the results of which will be used to prioritise projects. Final selection and development of projects for flight (phase B/C/D/E) is contingent on available budget and ISS resources.

Visit the Climate Change Research Announcement here.
Link: http://www.esa.int/SPECIALS/HSF_Research/SEMPM17TLPG_0.html

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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 30 November 2011 and will last 6 months until May 2012. ESA astronaut André Kuipers will conduct this mission - increments 30 and 31 in 'ISS lingo'. Kuipers will launch from Kazakhstan on 30 November in a Soyuz capsule, and come back as well in the same capsule. A preliminary programme of about 25 experiments is waiting 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 tentative experiment package that André Kuipers will perform during his almost six months 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 follow a special diet of constant low and normal sodium intake, high fluid consumption and isocaloric 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 medical 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 thermoregulatory 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 hear 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 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 neuros ciences 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 during the NEUROSPAT tasks performance, and activity that is 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

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

values for all component 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.
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 commisioned 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.
A few of those data collection sessions 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 do as early as 24 hours after a change in the constant gravity direction reveal, 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. Obviously, therefore, for that reason alone, 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 available 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) and PHOTO-ISS.

Physical sciences

Miller-Urey experiment (MUE)

The MU experiment aims to investigate pre-biotic chemical pathways for the synthesis of organic compounds in the proto-solar nebula. This environment will be simulated in vials filled with various gas mixtures and solid particles. The particle material (SiO_2) and size are those suggested to be present in the solar nebulae, together with other Si-based compounds. The particles serve as surfaces on which thin water-ice mantles are formed. A high-voltage spark discharge through which particles are repeatedly moved by a shaker (as slowly as possible) injects energy into the system and causes chemical reactions analogous or closely related to the original Miller-Urey experiment. At low temperatures, a distribution of intermediates and products is expected to form that provides information about chemical reaction pathways.

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 and MICAST.

CETSOL and MICAST were earlier discussed in Newsletter September 2010, which was the time for uploading sample material for these experiments to the ISS.

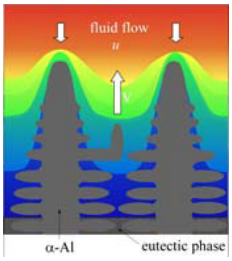
The samples will be processed in the Materials Science Laboratory
CETSOL - Columnar-to-Equiaxed Transition in Solidification Processing, and MICAST - Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions are two central experiments that 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


The ALTEA-SHIELD instrument

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.
Onboard the ISS, presently the **ALTEA** instrument is monitoring radiation events in different locations.
MATROSHKA has now been brought back onboard the last shuttle flight with the Space Shuttle Atlantis, STS-135.

As of September 2011, yet another radiation detector

TRITEL (name indicating the presence of three dosimeter telec-scopes) will be onboard. This is an active dosimeter with quite some in-built 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.

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.

With only four months to go, André Kuipers is busily consolidating all preparatory activities, including coming twice to the European Astronaut Centre in Cologne, Germany.

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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.

UPCOMING TOPICS:

Bed rest studies as simulation of Space

Bed rest studies are a well established ground-based model for some of the major changes that human bodies undergo in weightlessness. In bed rest studies, healthy volunteers are put to bed for periods from 5 days to 3 months. Following the ESA bed rest strategy, recent studies have addressed vibration exercise, artificial gravity or nutritional aspects. Currently planned studies will investigate protein supplementation to enhance the effectiveness of exercise.

Space Medicine Workshop

Bachelor or Master's level student of physiology, medicine, sports science, biomedical engineering or any other life science related field, were invited to apply for participation in Space Medicine 2011, a workshop organised by ESA's Directorate of Human Spaceflight and Operations.

The workshop took place 4-8 July 2011 in Cologne, Germany, at the European Astronaut Centre (EAC), ESA's astronaut training centre and home base of the European astronaut corps

Important experiment milestone in Neurosciences reached on ISS

Even if ESA's three now finalised experiments on human perception, balance and movement strategy in the weightlessness environment are individually designed , they share several focus areas, and as such complement each other very well. The experiments ZAG, Otolith and 3D SPACE have been completed onboard the ISS.

We will bring an account of the preliminary, promising results.

Summary of Fourth International Symposium on Physical Sciences in Space, (ISPS-4), 11-15 July, 2011, Bonn, Bad Godesberg, Germany.

ISPS-4 is the major international scientific forum for researchers in physics utilising the space environment, in particular microgravity. The symposium should inspire and encourage cross-cutting discussions between different scientific communities working in the same environment. Contributions have been discussing results of experiments carried out on drop towers, parabolic aircraft flights, sounding rockets, unmanned recoverable capsules and, last but not least, the International Space Station ISS. We bring a summary of the symposium.

ESA links to visit ....

- ESA's Research Announcement for Airbus A-300 Partial Gravity Campaign
- 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

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