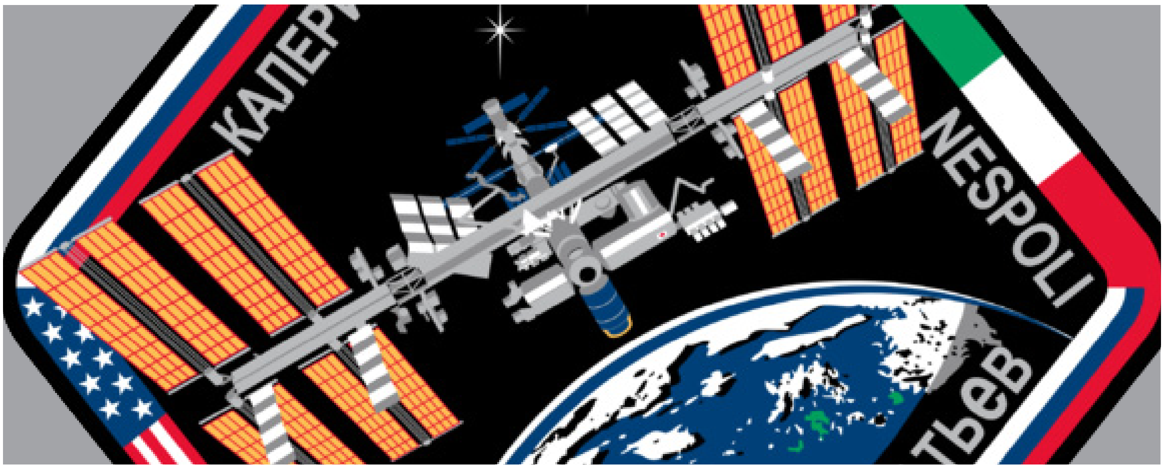
→ SPACE FOR LIFE

human spaceflight science newsletter

March 2011



TMA-19/25S Soyuz mission patch. ESA astronaut Paolo Nespoli was launched to the ISS on Dec. 15 2010. Courtesy of NASA.

In this issue:

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Increment 25 & 26 science programme being conducted - ESA astronaut Paolo Nespoli's new experiment package

On 15 December 2010 ESA astronaut Paolo Nespoli flew to the ISS, onboard the TMA-19/25S Soyuz launcher from Kazakstan, together with his crew mates, from the Russian Space Agency, commander Dmitri Kondratyev, and NASA astronaut Catherine Coleman. The crew will stay onboard the ISS for 5 months, identified as the Expedition 26/27 crew.

Paolo Nespoli started his 5 months stay onboard the ISS mid December 2010. A multitude of tasks, serving the interest of the partner space agencies from Europe, the US (NASA), Canada (CSA) and Japan (JAXA) are to be worked.
As is the case for all onboard crew, ongoing scientific and infrastructure maintenance programmes need to be served. This is the case also this time.
Experiments that Nespoli will perform on behalf of the science community fall under the following areas:
In Physical Sciences, in the disciplines Fluid Physics and Combustion.
In Life Sciences experiments are planned in Cardiopulmonary research, nutrition and metabolism, neuro-muscular research, immunology, cognition and psychology, biology of gravity-perception.
In addition, cosmic radiation recordings are monitored, as well as demonstration of diverse technologies and Earth monitoring will be performed, and finally a set of educational activities originating from ESA are planned, as normally when an ESA astronaut goes onboard the ISS.

Physical Sciences

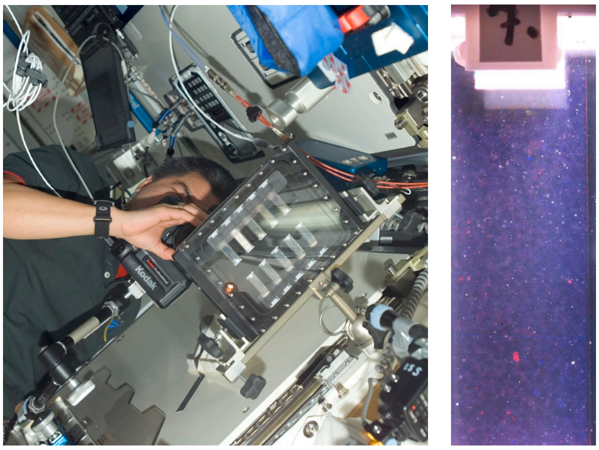
Paolo Nespoli will work the following experiments:

Geoflow-2

Geoflow is a simulation model of the geo-physical flows under the crust of the Earth. The hardware modifications on the experiment cell assembly for the implementation of the GeoFlow-2 experiment are concluded. It has now been launched onboard ATV-2. This experiment will start very soon, and the execution of a wide science parameter range will last about 3-4 months.

MICAST

MICAST (Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions) looks at the microstructure of growth appearance. The experiment was described in more detail in Newsletter September 2010 after the successful commissioning of the SQF insert. MICAST has already one more sample processed during Nespoli's stay, which will return on ULF-5.



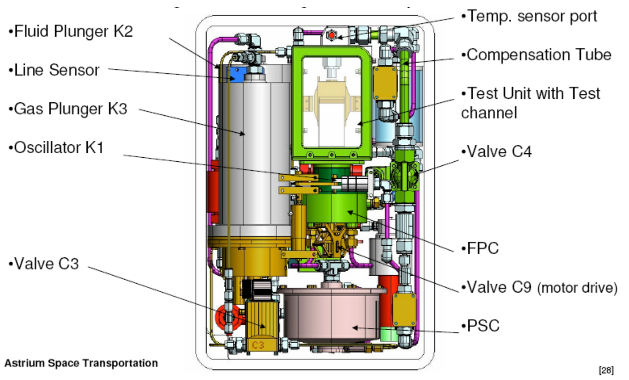
NASA astronaut Dan Tani working the BCAT-3 Sample Module in Node 2 of the International Space Station (left). Sample image of a BCAT-5 colloid sample no. 7 (right). Courtesy of NASA.

BCAT (Binary Colloidal Alloy Test).

NASA's BCAT Experiments have been performed since 2006 onboard the ISS. They focus on the physical properties of colloids, investigated by means of simple tools, at this point in time high resolution cameras and basic microscopes. Colloids used here are tiny nano-scale spheres of plexiglas suspended in a fluid.
The 10 samples used are made from the same ingredients, each with different proportions of the components. They are grouped in three categories for the investigation of 1) critical point, 2) binary alloy, and 3) surface crystallization.

BCAT-5 that was launched last summer is the batch now to be operated. It will take place in the Japanese module, JEM.

MSG/CCF (Capillary Channel Flow)



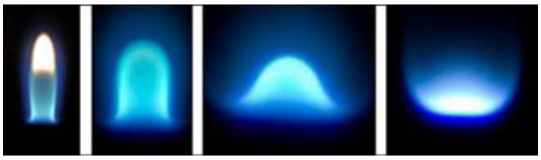
See an account of the arguments and application for these experiments here[1]. See also Newsletter September 2009, 'Fluid Science', for further theoretical reasoning.

A precursor facility of this joint DLR/NASA experiment with DLR provided Experiment H/W, CCF has been flown on ESA Sounding Rocket flight TEXUS-37 and this long-duration ISS experimentation is a logical continuation of that: Fluids behave differently in Space where no gravity can influence. The small forces, such as capillary forces take over.
The objectives of the MSG/CCF experiment are
1) to find limits for capillary forces in systems that are based on passive fluid management, simply as an effect of geometry of the containers,
2) to describe the effect of geometry for capillary forces controlled multi phase flow regimes, and
3) to define critical numerical data for these low-g inertial forces capillary regimes.
See a short TEXUS video recording of some the dynamic phenomena investigated here.[2]

MSG/SHERE (Shear History Rheology Experiment)

The main hardware for this NASA experiment was launched onboard STS-120/Discovery in October 2007. Since then and until January 2009 a thorough test period has been run and completed.
SHERE is dealing with very special fluids, the so-called Boger fluids (BF). These are fluids that behave differently from standard fluids, like water or oil (so-called Newtonian fluids (NFs)) in the way that they respond to pressure changes in a different manner[3]. NFs are fluids where there is a linear relationship between force and velocity. BFs do not fulfill this criteria, see footnote. Boger fluids used in BCAT are among others containing nano-spheres. High resolution photo images are taken of the samples with certain intervals.

MSG/SPICE (Smoke Points In Co-flow Experiment) and



Examples of flame behavior under different SPICE and SLICE circumstances. Courtesy of NASA

MSG/SLICE (Structure & Liftoff In Combustion Experiment)

The SPICE experiment (NASA) studies soot production and oxidation in flames, and the equipment will be used for the SLICE experiment as well, with some extra features added to it. The experiments are in terms of procedures very similar. The extras needed are more fuel bottles, more fuel and electronic data storage as well as minor equipment adaptation. Then SLICE can be performed.
The SPICE experiment looks for relations between fuel flow smoke points. The SLICE experiment will have a fixed fuel flow with the air velocity gradually until the flame lifts off from the nozzle.

ESA Physiology experiments

Paolo Nespoli will perform experiments in physiology that are on the way to becoming completed. Those are:

ESA astronaut Thomas Reiter operating the Pulmonary Function System (PFS) in preparation of the CARD experiment. Reiter has experience with an earlier generation of the gas analysers, the RMS-2 which he used onboard the Euromir 95 mission.

1. http://spaceflightsystems.grc.nasa.gov/Advanced/ISSResearch/MSG/CCF/

2. http://eea.spaceflight.esa.int/attachments/soundingrockets/ID4c581f9c6f2c7.mov

3. Take as an example a mix of cornstarch and water: with little water the starch does dissolve. When stirring slowly the mix moves along. When trying to stir more powerfully, the mix sticks and cannot be moved. Ketchup is another example of a non-Newtonian fluid.

CARD

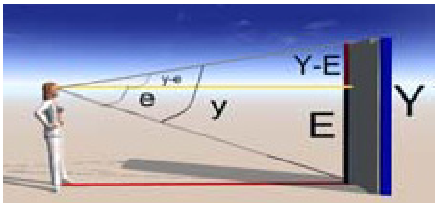
A description of the experiment and the performance status was given in Newsletter no.1, 2010. The experiment needs 8-10 human test subjects for medical statistics reasons, for it to be completed. This number of repeats has not yet been reached. Due to time prioritisation it now appears that CARD might have to be postponed to next increment.

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 explained.

NEUROSPAT

EPM/NEUROSPAT is the second neurosciences experiment performed in Columbus. It makes use of EPM rack equipment for electroencephalogram recording. NEUROSPAT is an experiment concerned with the spatial and visual perception. The experiment was described to some detail in Newsletter September 2010. Nespoli and Cathy Coleman will perform another set of scientific sessions of this experiment. As can be seen from the image Nespoli has been test subject for the first NEUROSPAT experiment, here being kitted up with the EEG cap for registration of his brain activity during the NEUROSPAT tasks performance.

PASSSAGES



Paolo Nespoli will perform in total three sessions of this experiment, one early in-flight, one in the middle of his stay and one before he returns. 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 first PASSAGES session has already been performed.

3D SPACE

ESA astronaut-Frank de Winne 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.

This was the first neurosciences experiment in Columbus. Till now seven test subjects have performed the experiment, which means that it is almost complete.

The experiment seeks to identify differences in perception of dimensions and depth (3D) between the normal gravity on Earth and the 0-gravity onboard the ISS.

The 3D SPACE experiment setup was described in Newsletter February 2009. It has some relation to the PASSAGES experiment in the way, that it is concerned with the subjective perception. Whilst PASSAGES deals with the judgement of dimensions relative to own-body size, 3D-SPACE deals with the distance and 3D perception.

Nespoli has already performed his second 3D-SPACE session on 21 January. His third session took place during his time for voluntary science on 12-13 February.

SOLO

As was the case in the August – September time frame with NASA astronauts Doug Wheelock and Shannon Walker, Paolo Nespoli is to do the SOLO experiment after having been one month in Space, as the experiment needs a Space adapted state. For a while the specific food containers for this experiments could not be found, but now the first SOLO session is done. It is foreseen to have another crew person performing SOLO during spring, after Soyuz 26S has arrived. SOLO investigates the influence of salt intake on bone metabolism. The background for this experiment has been spelled out in detail in Newsletter February 2009.

THERMOLAB

The THERMOLAB experiment was started in 2009 and was also performed by the the Expedition 24 crew members NASA astronauts Doug Wheelock and Shannon Walker. THERMOLAB is a Human Physiology experiment looking at core temperature changes in humans before, during and after exercise performed on ISS. It uses the Pulmonary Function System (PFS), and is performed in conjunction with NASA's VO_2 max experiment.

ESA Biology and Exobiology experiments

BIOLAB Trouble Shooting.

Biolab has experienced problems in May 2010 in conjunction with the WAICO-2 experiment, and thorough trouble shooting has been performed. It has been decided to return certain vital parts of the facility, such as the syringe gripper mechanism and the microscope, for repairs on the ground. This has delaying effect on the TRIPLELUX experiment described in last Newsletter.

GRAVI-2

The experiment is looking for 'Threshold Acceleration for Gravisensing' . It is performed with lentil seedling roots and the direction of root growth is monitored as a an effect of g-level and direction.

Artificial gravity of between 0.1 g and 0.01 g is used, as it is known from earlier experiments, that the threshold lies within this interval. The European Modular Cultivation System (EMCS) is used to create the stimulus.

Sample return from earlier experiments

Genara-A (Gravity Regulated Genes in *Arabidopsis thaliana*) is completed and samples will go back with STS-133/ULF-5.

CFS-A (Growth and Survival of Coloured Fungi in Space) will have 75% of the samples ready for return on the same flight.

EXPOSE-R, the external exposure facility has been recovered via a Russian EVA in time for return of sample trays on the same flight.

NASA Life Sciences experiments

Reaction Self Test

Two times a day, every fourth day throughout the mission this 5-minute Reaction Self Test panel is performed using either the NASA Human Research Facility (HRF) laptop or the Station Support Computer (SSC). Reaction Self Test examines the influence on performance of ISS crew of fatigue originating from too little sleep and/or changes in the normal day-night rhythm. As the ISS orbits Earth 16 times per day, there is no natural light-dark cycle on board.

Sleep Long

Full title: Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Long.
This experiment registers the distribution between activity and rest. Acti-watches automatically register sleep patterns and the crew keep sleep logs. The influence of light exposure on the diurnal rhythm of the ISS crew is logged as well.

Nutrition

NASA astronauts Shane Kimbrough and Sandra Magnus, onboard STS-126 Shuttle mission brought fresh fruit to the ISS.

This study investigates the effect on bone metabolism and other metabolic values of the sort of food ingested. Numerous experiments looking into the effect of composition of the nutrition on physiological parameters such as bone and muscle loss have lead up to this present one, among many others looking at the potential importance of certain vitamins and fatty acids.

Pro-K

Full title: Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism during Spaceflight and Recovery.
The hypothesis suggests that a decreased ratio of animal protein to potassium will lead to decreased loss of bone mineral. The experiment is related to the Nutrition experiment and forms one of the many logical steps in trying to discern which metabolic compounds could influence bone metabolism.

Repository

This experiment implements the dream scenario of all physiologists: To take body fluid samples for analysis of parameters in the future, not known at this time. In this manner one will in the future be able to have a solid statistical material for factors to come up as crucial for certain mechanism, parameters for which our knowledge today is absent. An easy to understand example of the value of such samples is the analyses done today on 10 years old samples from elite sport persons, in the search for doping compounds.
Blood samples are collected routinely. A 4.5 ml blood plasma sample and a 5 ml serum sample are taken from each participating crew person. The sample points are in addition to pre-flight samples done on flight days 15, 30, 60, 120 and within two weeks after return to Earth.

Technology demonstrations

Nespoli will perform the following technology demonstrations:
- SPHERES
- ERB-2 (Erasmus Recording Binocular).

This is a stereoscopic camera with an improved resolution: 1280 x 720 pixels corresponding to the HD 720p standard. It is the intention to use this for both live broadcast of stereo films as well as down-linking files of recorded video sessions. It uses the connections available in the European Drawer Rack (EDR) for downlink purposes.

VESSEL ID SYSTEM

This is an ID system presently mounted on ESA's ISS module Columbus. It monitors sea traffic and provides important safety information. This newsletter has a special article on that tecnological demonstrator.

Education outreach programme

Nespoli will perform a number of education activities with different objectives:

CEO (Crew Earth Observation)

The human eye and brain with its real time evaluation capacity to distinguish important from unimportant is the background for the CEO activities: In this manner development on Earth, such as city growth, agricultural expansion, and other natural appearances like volcanoes and hurricanes are observed and the important aspects also photographed.
Comparing such material from the last decades form an invaluable basis for judgement of how activities and life on Earth develops, prospers and suffers over time. Deforestation is only one such important aspect.

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

ESA together with the major ISS partner agencies of the world launched an exercise initiative for children on 14 January 2011. ESA astronaut Paolo Nespoli is the official ambassador of Mission X and in this role officially started the mission in a video address to the worldwide participants. Nespoli will be speaking to the children live from the Station on 30 March at the end of Mission X where the winning schools will be able to share their results.

ESA's 'Greenhouse in Space'

This educational project started on 17 February in four locations throughout Europe and on the International Space Station. 800 school children together with Paolo planted Arabidospis seeds and will grow them for 15 weeks.

The first tiny plant ...

NASA EPO (Education Payload Operation)

This kit that is always onboard contains several gadgets that are useful for demonstrating diverse aspect of physics in weightlessness or in the universe. It includes among other things a gyroscope, a ruler, a string, and soft Earth, moon, and Mars scale models for demonstrations and live ISS education downlinks.

Radiation detection and Space environment monitoring

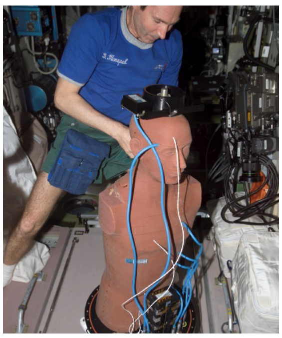
Five different devices and facilities are concerned with monitoring different aspects of the Space environment. These facilities typically do the work themselves without much intervention from the crew. Data is stored in diverse manners and read out or downloaded with certain intervals.

ALTEA-DOSI (Anomalous Long Term Effects in Astronauts' - Dosimetry)


The ALTEA-SHIELD facility

This experiment among others focus on the light flash phenomenon, that crew experience onboard, light flashes that you register as visual events closed eyes. Further it aims at assessing the effect of cosmic radiation on the central nervous system in general. The facility registers radiation particle flux and can discriminate the type of particles and determine the trajectories and energy level.
The equipment is moved around onboard the ISS, and the next two locations have been identified. These will be used somewhat later than planned due to the onboard stowage situation.
The ALTEA-DOSI facility provided by ASI registers the radiation spectrum internally in the NASA Destiny ISS module. These measurements will be compared with those from an external facility, in order to judge aspects such as radiation protection value of the materials used in the following ALTEA-shield experiment, as well as comparing spectra and energy levels.

MATROSHKA-KIBO


Russian cosmonaut Valery I. Tokarev, Expedition 12 Flight Engineer works with the European Matroshka-2 experiment in the Zvezda Service Module of the ISS.

MATROSHKA is the model of the upper half of a human, filled with dosimetric equipment, that has been placed also on the outside of the ISS. Now, for a long time it has been monitoring inside the ISS, in different modules. The facility is presently placed in the Japanese module, KIBO.
MATROSHKA has since its placement in the Japanese module used passive radiation dosimeters plus the of PADLES type from JAXA which were installed inside the Matroshka.
MATROSHKA will be disassembled and the dosimeters returned by Soyuz in March.

DOSIS (Dose Distribution Inside the ISS)

The present configuration is a double set of the DOSTEL instruments which are also used in MATROSHKA. Now these are oriented such that they register in two directions perpendicular to each other.

MARES (Muscle Atrophy and Exercise System)

is the ESA built most advanced muscle research facility ever flown. Controlled by a comprehensive SW package, MARES is fully programmable and will be able to analyse almost any thinkable aspects of muscle mechanical action. It will store personal data profiles from exercise sessions and will monitor the effectiveness of muscle training programmes for each individual astronaut. MARES now goes through initial check-out and commissioning phases and experimental activities will only start during the mission of ESA astronaut Andre Kuipers.

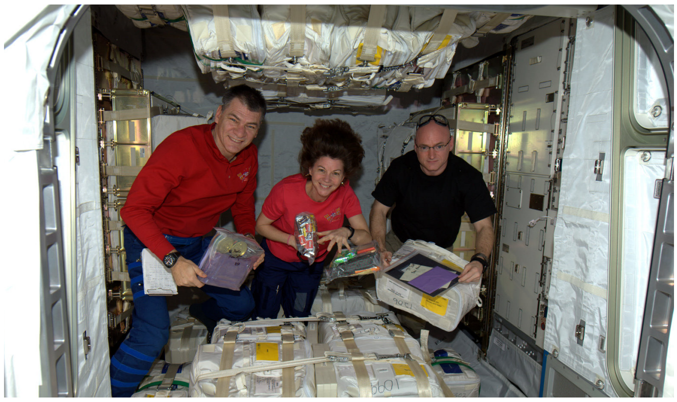
Summary

Increments 26 & 27 are characterised by a fairly complex scheduling task, as a multitude of vehicles come and go during a very short period, to mention some: HTV-2 in January, Progress 41P 28 January, ESA's ATV-2 docking on 24 February, NASA's STS-133/ULF-5 on 26 February. During the month of March STS-133/ULF-5 will depart, then a Soyuz, after which ISS for two weeks will have only a 3-person crew, followed by the departure of HTV-2.
ATV-2 will be unloaded and the MPLM Leonardo, that now will become the Permanent Multipurpose Module, PMM, will be outfitted. Finally on 1 April Soyuz 26S will be docking. The potentially one but last Shuttle flight STS-134/ULF-6 is now scheduled for a not earlier than 29 April launch.

On-board Life

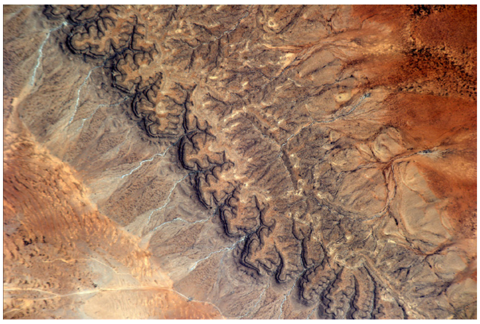
Onboard life has many faces, and indeed a lot other than experiment activities are going on onboard the ISS. The images below give some impressions.


This image gives a unique impression of the dimensions in ESA's Columbus module. It shows the significant extent of the MARES facility.


The Japanese Transport vehicle HTV-2 brought food en masse.

Nespoli's Earth from Space .....

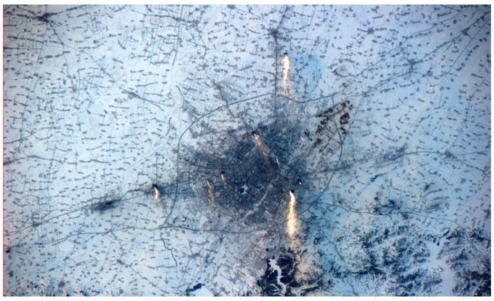
Since 15 December 2010, ESA astronaut Paolo Nespoli has been onboard the International Space Station, ISS. Apart from the very busy scientific programme Nespoli has been supporting, he has been an eager photographer during his free time. Some of the unique examples of what Earth offers in terms of visual impressions from 350 km above the surface you see here.



Desert. Somalia

Paolo says: "I wish that everybody could have a possibility of being up here and looking down to Earth, but as this is not possible so far I'm happy to provide these views and feelings to people."

"Flying in space and locating the objects around is not easy. The main reason for Cupola is doing robotics, moving cargo with the Station's robotic arms, and in this Cupola really enhances our capability of being very efficient in space."

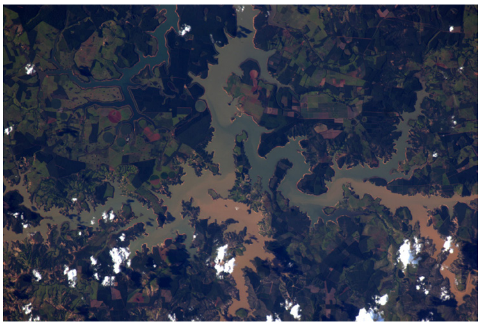


Capital of Jilin province in China

"It is amazing, because I find constantly something new. As the Station is moving very fast, the view is changing all the time and the lighting conditions, season, position of the Sun and the whole situation is never the same."

NASA astronaut Tracy Caldwell looking down on Earth through Cupola (from earlier increment)

"I have managed to get most of the targets I wanted to photograph, like the pyramids of Egypt or the Great Wall of China, but there are still a few things I would like to catch. Like the Nazca Lines in Peru. I really would like to see those!"



Rio São Francisco, Brazil

"Earth is a beautiful subject and one of the most magnificent models that a photographer can have," says Paolo, but confesses: "It is also an easy target if you are up here and you have a good camera with a few lenses."

"But it is also a challenging model, because we are flying so fast, the view changes continuously, the situations are practically never the same, the angle of the Sun varies, the clouds are moving, and so on.
"Earth is different every single moment – and that is really the beauty of this model."

Moon-rise as it looks over the horizon from the ISS

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ATV-2 launch on 16 February 2011 - seen from the ISS ...

... and Space Shuttle Discovery's last flight

Launched from Europe's Spaceport in Kourou, French Guiana, at 21:50 GMT (18:50 local) on Wednesday 16, the second Automated Transfer Vehicle ever, ATV-2, named Johannes kepler, was viewed by ESA astronaut Paolo Nespoli. A bit to the right of the middle of the ISS structure in the right side of the picture the condensation trace of the Ariane-V rocket carrying ATV-2 can be seen. On 24 February NASA's Space Shuttle Discovery's launch for the last time ever, after almost 27 years of service. It docked with the ISS two days after ATV-2.

The trace of the ATV-2 launch can be seen in the right hand side of the image taken by the ISS crew.
ATV-2 docked on 24 February as planned with the ISS, after having been hovering 10-15 meters away from the docking port at the Russian Zvezda module, and thereafter making the final approach with a velocity of around 10 cm per second until a flawless docking was a reality.

Later that day, the third-last Shuttle flight, STS-133 Discovery , that had been delayed significantly from last autumn due to technical problems relating to the external tank, launched from Kennedy Space Center in Florida, USA, at 3:53 CET from launch pad 39A.
Space Shuttle Discovery flew its first flight as mission 41D in August 1984. It has spent 351 days in Space and orbited the Earth 5628 times. It has docked with the Russian Space Station MIR once and with the ISS 13 times including this last flight.

'Parking' space at the ISS becomes scarce

The shuttle docked with the ISS on Saturday 26 February. This brings the number simultaneously docked vehicles with the ISS to six:

- Soyuz TMA-18/24S launched on 8 October 2010. This Soyuz capsule is due to return on 16 March 2011
- Soyuz TMA-19/25S mission that brought Paolo Nespoli and his crew mates to the ISS on 15 December 2010,
- Japanese cargo ship HTV-2, that docked on 27 January,
- Russian cargo ship Progress 41P, that docked on 30 January,
- ESA's ATV-2 that docked on 24 February and finally
- NASA's Shuttle Discovery STS-133 that docked on 26 February.

The ATV-2 has several tons of propellant to boost the ISS in total to a 50 km higher orbit. This is done by the ATV boosters and it was moving the ISS with a velocity of 0.5 m/sec. The duration of the boost, performed on 25 February was 3 minutes and 18 seconds, which all in all elevated the ISS to an orbit around 1.5 km over the initial orbit, from 352 to just under 354 km altitude. This exercise cuts in half the amount of fuel the ISS would have to use to retain its orbit.

What ATV-2 brings to the ISS

With a total mass of just over 20 tons, the ATV can bring significant amounts of supplies to the ISS. ATV-2 Johannes Kepler brought more than 5000 kg of propellant, 102 kg of oxygen and 1400 kg of dry cargo. Despite the fact that it can carry over 600 kg of water in three tanks, this was not necessary this time due to the onboard potable water regeneration system.

ISS expansion and the first robot onboard

As an unusual thing, the former Multipurpose Logistics Module Leonardo, MPLM, will now stay attached to the ISS for the future - renamed to PMM or Permanent Multipurpose Module - providing considerable extra storage space for the ISS. On all earlier flights the MPLM has been brought back with the Shuttle as a pressurised carrier. As a new thing NASA brings an advanced robot to the ISS, that is supposed to assist the crew in cleaning and on EVAs.

After the main cargo items have been unloaded, ATV-2 will over the next months gradually be filled up with material and items not any longer useful on the ISS, including general trash. It is thereafter the plan to undock ATV-2 from the ISS on 4 June and let it perform a controlled entry into the Earth atmosphere and where it will burn up over the Pacific Ocean on the way down.

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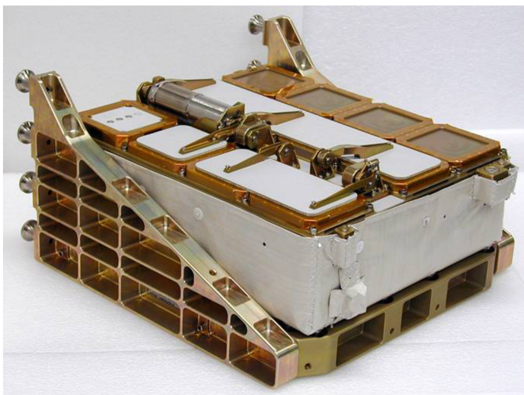
EXPOSE-URE OF BIOLOGICAL MATERIAL TO 5 SPACE FACTORS

NASA astronauts Olivas and Stott retrieved the European Technology Exposure Facility (EuTEF) that housed the EXPOSE-E facility. Courtesy of NASA.

DESPITE BEING EXPOSED TO FULL-SPECTRUM SOLAR LIGHT INCLUDING THE LIFE-ERASING UV-C, COSMIC RADIATION, VACUUM, FREEZING/THAWING AND MICROGRAVITY FOR MORE THAN 18 MONTHS, BIOLOGICAL LIFE IN SOME CASES CAME BACK ALIVE. EXPOSE-E CARRIED A LARGE NUMBER OF SAMPLES INTO SPACE AS A PART OF THE EXTERNAL EUROPEAN TECHNOLOGY EXPOSURE FACILITY, EUTEF, THAT WAS BROUGHT BACK TO EARTH ONBOARD THE SPACE SHUTTLE STS-128 MISSION IN SEPTEMBER 2009. NOW THE FIRST SCIENTIFIC FINDINGS REPORT THAT SOME LIFE FORMS INDEED SURVIVE THESE HARSH CONDITIONS IN SPACE.

With the dimensions 440 x 380 x 250 mm and a mass or 30 kg, EXPOSE-E housed 408 samples, distributed over 11 sample carriers, in seven separate sample-type sets. 'Compartments' in the following correspond to one of the four regular square structures per 'tray' - see sketch at opposite page.
Samples were housed in two separated sample container layers of 204 samples, the top layer being exposed to the full solar spectrum, with the other 204 placed underneath, completely shielded from the Sun.

The seven separate experiments each had their own objective. One of these DOSIS/DOBIES - was an accurate registration and storing of the radiation spectrum data, necessary for good interpretation of the findings, once the samples would be retrieved. It was representative of the exact dosis the experiments ADAPT, PROTECT and LIFE received, and thus their reference.



THE SEVEN EXPERIMENTS:

ADAPT
(Using 3 compartments)

Aim: Molecular adaptation strategies of micro-organisms to different space and planetary UV climate conditions.
Science Team: P. Rettberg DLR (Germany)

DOSIS/DOBIES
(Using 1 compartment)

Aim: Monitoring of Radiation Dose Distribution inside EXPOSE.
Science Team: G. Reitz DLR (Germany) / F. Vanhavere SCK-CEN (Belgium)

R3D
(Using 1 compartment)

Aim: Active monitoring of UV and ionising radiation.
Science Team: D-P. Haeder University of Erlangen (Germany)

PROTECT
(Using 3 compartments)

Aim: Resistance of spacecraft isolates to outer space for planetary protection purposes.
Science Team: G. Horneck DLR (Germany)

LIFE
(Using 2 compartments)

Aim: Resistance of lichens and lithic fungi to space conditions.
Science Team: S. Onofri Tuscia University (Italy)

SEEDS
(Using 1 compartment)

Aim: Testing the plant seed as a terrestrial model for panspermia[1] vehicle and as a source for universal UV screens.
Science Team: D. Tepfer INRA (France)

1. Panspermia is defined as the potential, natural way that biological material could have spread between planets.

PROCESS
(Using 2 compartments)
Aim: Investigation of PRebiotic Organic ChEmistry on Space Station.
Science Team: H. Cottin LISA Creteil (France)

Preliminary Results

ADAPT

The scientific objective of ADAPT was to investigate the capability of micro-organisms to adapt to UV levels like those on Earth and on Mars. Due to the different composition of the Martian atmosphere and its low pressure, the Martian UV radiation climate is significantly different from that on Earth. The hypothesis to be tested was whether longer-lasting selective pressure by UV radiation of different quality would results in a higher UV resistance as well as in a higher resistance against the simultaneous action of further extreme environmental factors that exist in space or on other planets, like vacuum or cosmic radiation.
As a result of this experiment additional organisms to the ones that were known to be resistant to space conditions have been found.

DOSIS/DOBIES


One of four DOSIS sensor cells

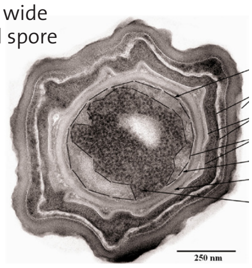
A total dose of about 200 mGy[2] was accumulated over the whole mission. DOSIS/DOBIES functioned as reference for the experiments ADAPT, PROTECT and LIFE.

R3D

The R3D (Radiation Risks Radiometer-Dosimeter) is a device which records, with time resolution, the dose of solar light over four wavelength ranges (UV-A, UV-B, UV-C and photosynthetic active light) as well as the flux of cosmic particles. The R3D supported the biological and biochemical EXPOSE-E experiments by delivering the history of solar irradiation and cosmic radiation as experienced during the mission.
Already published data show[3], that, the radiation measurements from R3D were made at a shielding depth of 0.4 g/cm2, which is very close to the shielding levels provided to the plant seeds (SEEDS) and the organic molecules (PROCESS). Total radiation dose was 245 mGy, with approximately three quarters of the dose delivered while passing the South Atlantic Anomaly (protons) and the remaining quarter by Galactic Cosmic Rays.

PROTECT - Bacterial spores

1 micron wide bacterial spore



Scale bar 250 nm

PROTECT resorts under a special niche of astrobiology known as Planetary Protection. Some microorganisms can resist all sterilization procedures applied nowadays and therefore represent a serious hazard for the in situ search for extraterrestrial life, contaminating the planetary bodies the probes are sent to. It is of crucial importance to measure the resistance of such organisms to space conditions in order to develop adequate decontamination procedures.
The PROTECT experiment demonstrated that the hazard represented by space contamination is real. Bacterial spores were able to survive a simulated journey to Mars except if fully exposed to solar light. At the surface of Mars, they may survive for several years if shielded against direct solar irradiation.

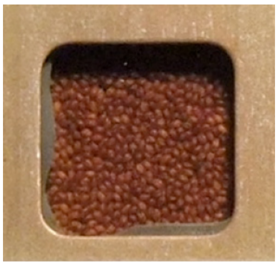
2. Definition of 1 gray (Gy): One gray is the absorption of one joule of energy, in the form of ionizing radiation, by one kilogram of matter

3. Dachev Ts. et al. (2009) Space Shuttle drops down the SAA doses on ISS, Fundamental Space Research, Suplement of Comptes Rend. Acad. Bulg. Sci., ISBN 987-954-322-409-8, 69-72, 2010. + four additional articles

LIFE

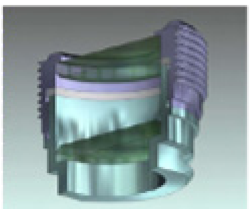
Lithic fungi and lichens, thriving on Earth in extreme environments, were tested for their rate of survival in open space, with a subset of samples exposed to simulated Martian conditions. Previous ESA experiments in 2005 and 2007 demonstrated surprising robustness of lichens during two-week exposure to the harsh space conditions – including solar UV.
The LIFE experiment was a logical long-duration follow-on to these initial Space studies, with the exposure duration, this time extended from 2 weeks to 18 months.
At this point in time photosynthetic activities, growth tests, and DNA tests have been performed and analyzed. Vital staining tests are still in progress and electron microscopy will be performed. The experiment was successful and reached interesting results as space and Mars-like conditions resistance was observed for some new organisms, and especially eukaryotes[4] for a long period of time.

SEEDS

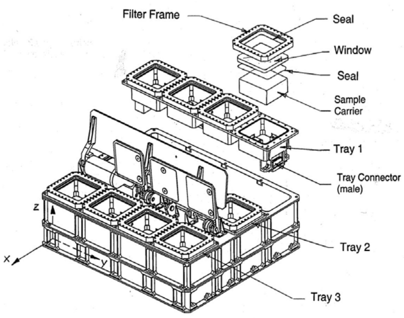

Sun-exposed SEEDS container

Plant seeds have evolved to conserve the species and its genome under extreme stress conditions (cold, desiccation[5], etc.) The objective of SEEDS was therefore to determine the resistance of plant seeds when exposed to the open space environment. Plant seeds have in fact frequently been tested in space, mostly as part of microgravity and radiation studies, but never with full exposure to solar UV-C on a long-duration flight. The panspermia hypotheses are tested in this experiment.

PROCESS


One cm^3 chemical/organics sample material container for PROCESS

PROCESS is the investigation of the chemical nature and evolution of organic molecules involved in extraterrestrial environments and exposure to full-spectrum solar light.
Results from this experiment are not yet available, as analyses are still ongoing.



Sketch of the EXPOSE facility indicating the arrangement of compartments.
One vertical entity (container+seal+window etc.) corresponds to one 'compartment'.

4. Eukaryote: A cell with a nucleus.

5. Desiccation: Extreme dehydration

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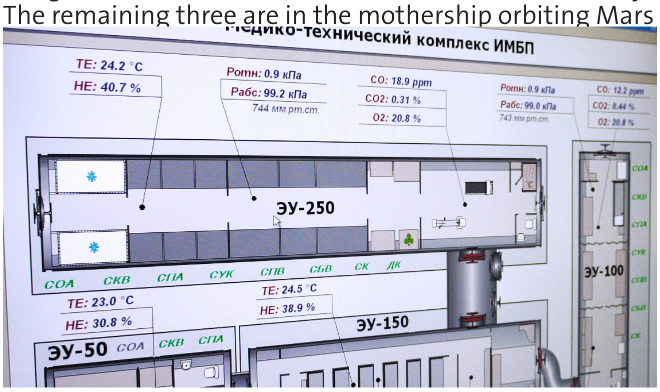
One month on Mars .....

Resulting graphics from "Mars 500" 'crew member Diego Urbina's calculation of the trajectory and coding scripts in a planetarium software.

A bit more than eight months ago, an international crew of six entered the "Mars 500" simulation facility in Moscow, Russia. The journey to Mars has now been accomplished, the mother-ship has remained in orbit and half of the crew has set foot on Mars on 12 February.

Eight months have passed since the hatch was closed between the Mars 500 crew and friends, colleagues and family on Earth. Since quite some time Mars has grown in the distance, every day conquering a gradually larger share of the visual field. Days ago the red planet took up almost the entire field of view - so close to the final stage were the six in the Mars 500 'vehicle'.
The crew has now since some time been split in two: Three staying in the Mars orbiter (French Romain Charles, Russian Sukhrob Kamolov,, and likewise Russian Alexey Sitev), and three now forming the landing team with the Mars lander as their home for two weeks. Russian Alexandr Smoleevskiy, Italian Diego Urbina and Chinese Wang Yue, boarded the lander on 8 February, descended to the surface and the great unknown, and 'landed' on Mars on 12 February. The remaining three are in the mothership orbiting Mars



Housekeeping data screen for the Mars 500 'vehicle'.

waiting for the landing crew in about two weeks' time will leave Mars' surface . Then the return journey back to Earth will start.

The health has been maintained quite well. Time has occasionally been long and monotonous, despite the busy training and health maintenance programme, but computer programmes have made it possible at least to experience the sounds of Earth nature, whilst wandering through the artificial landscape on the screen.
Now the crew is focusing on the other planet, Mars, which half of them are now exploring during their Mars flight simulation, as the first humans to set foot on it - more than 40 years after man set foot on the Earth-moon.
But a main part of this story is fiction: The crew has indeed been isolated for the period, and they have split up in two 3-crew teams, but they have all the time remained on Earth, in an isolation facility built for the purpose - a Mars mission simulation - in Moscow in Russia.

Study of the impact of long isolation

One of the biggest concerns on long duration space missions are of psychological character. On a human mission to Mars, real-time communication with Earth gradually becomes impossible due to radio transmission delay. In addition the space is limited, food is pre-defined and stored, and monotony is unavoidable daily routine. In addition, apprehension regarding the potential dangers during the inter-planetary journey, not to mention that long trip back, are aspects for which we have no experience basis yet. The "Mars 500" study has many of these and many other themes on the experimental programme.

Experiments - in more detai

Mainly, the experiments will provide insights on how the crew reacts to the stress of a long flight, especially to isolation and confinement. In fact, the human factor itself will be an incalculable risk during a long-duration spaceflight mission.
There has been an episode in 1967 where the commander of the U.S. mission "Apollo 7 ", instead of following orders from Houston, got into a massive fight with Mission Control because he had "not eaten" and had "a cold" . The rebellious crew removed all the measurement sensors, which were used for medical monitoring.
In 1988, the cosmonauts Gennady Titov and Musa Maradow broke a new record of being - for the longest time ever- on the space station "Mir" - , but completely stopped communication between each other because of disagreements. The ground control centre diagnosed "certain personality changes" in the men in orbit. Only the wives brought the men back to their senses after involving Titov and Maradow in a radio cross-examination.

In "Mars 500", the crew is therefore under constant

observation - more than 40 cameras monitor the lives in the pseudo-space ship. A team of psychologists is available around the clock and monitors and analyses the crew member's well-being and reactions, thus drawing valuable conclusions for future long-duration space missions..
But "Mars 500" will also provide lots of other - in particular medical - results, all with benefits for Earth. "'Mars 500" is

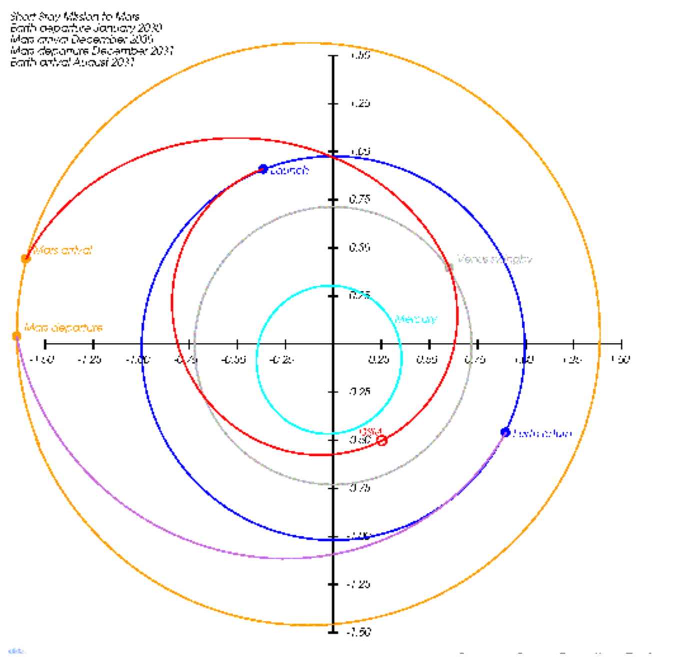
"Mars 500" crew member Inspecting the modules before transfer of half the crew to the lander.

a paradise for researchers," says Alexander Chouker of the Ludwig-Maximilians University in Munich.
His team, for example, studies how isolation weakens the immune system of the crewmembers. Already now, there are indications from the first preliminary results of the study that point towards a modulation and inhibition of certain cellular responses that are important in the immune response. The aim of his research is to better understand the interplay between brain and immune system in stress responses.

Initial findings also concern changes in biological rhythms. Researchers had assumed that this would be affected especially for long-duration flights due to reduced physical activity, the cramped confinements of the station and also the change of the light-dark cycle. This has been confirmed, in that the circadian rhythm remains initially retained, but that the range of fluctuations in body temperature are substantially reduced.

Peculiarities of a travel to and from Mars

The mission this crew is on is a so-called "short-stay" mission. This type of mission requires a gravity-assisted



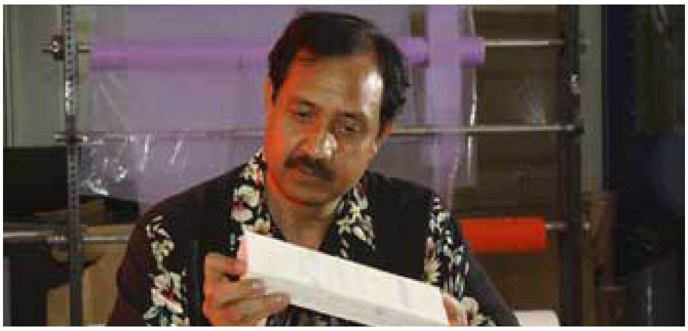
'Short stay' Mars mission orbital mechanics. Courtesy of Michael Khan, ESOC

swingby at Venus - at an altitude of only 550 km over the Venus surface. This kind of mission has one short transit leg, which can be outbound or inbound, and one long transit leg, the latter requiring close passage by the sun that is 70% of the normal Earth distance to the Sun.

Missions to Mars take the crew out of the radiation-protective magnetic field that surrounds Earth and fends of large parts of harmful cosmic radiation. On the way to Mars you leave that magnetic field at a point and on Mars, where no protective magnetic field is present, the full thrust of radiation is loaded on the crew, so radiation protection remains one of the main issues for a safe Mars mission. Enough resources - food, energy and water - is the other, and finally orbital mechanics and safety of same is the third.

Radiation protection options

Materials examined for their radiation protection value are in addition to the borated polyethylene shown by the NASA engineer below, pure polyethylene, but also others: One of the best radiation protection materials is liquid hydrogen. However, water is also very useful.
Carbon-based nano material may offer an improvement for hydrogen storage and finally palladium alloys are recommended to be investigated as well for hydrogen storage.



Borated polyethylene material for radiation protection - is this the solution? Several times more protecting than aluminium and already approved for spacecraft construction.

None of the electromagnetic concepts - where basically a strong magnetic field is created around the spaceship - have till now been found promising, but a concept that uses cold plasma for expansion of a magnetic field possibly could be a future solution[1]. The current concept for the spacecraft transfer phase seem to fall out in favour of hydrogen. But this still leaves the question of radiation protection at the surface of Mars, not to mention what options could be conceived for the crew suits to be used for crew moving around of the Mars surface.
But for now, the "Mars 500" study is just that - a full duration mission simulation.
Finally, designing new advanced technology launchers could reduce the importance of the radiation load by simply cutting down on the transfer time, bringing the travel down to weeks rather than months.

Two "Mars 500" astronauts on 'Mars'

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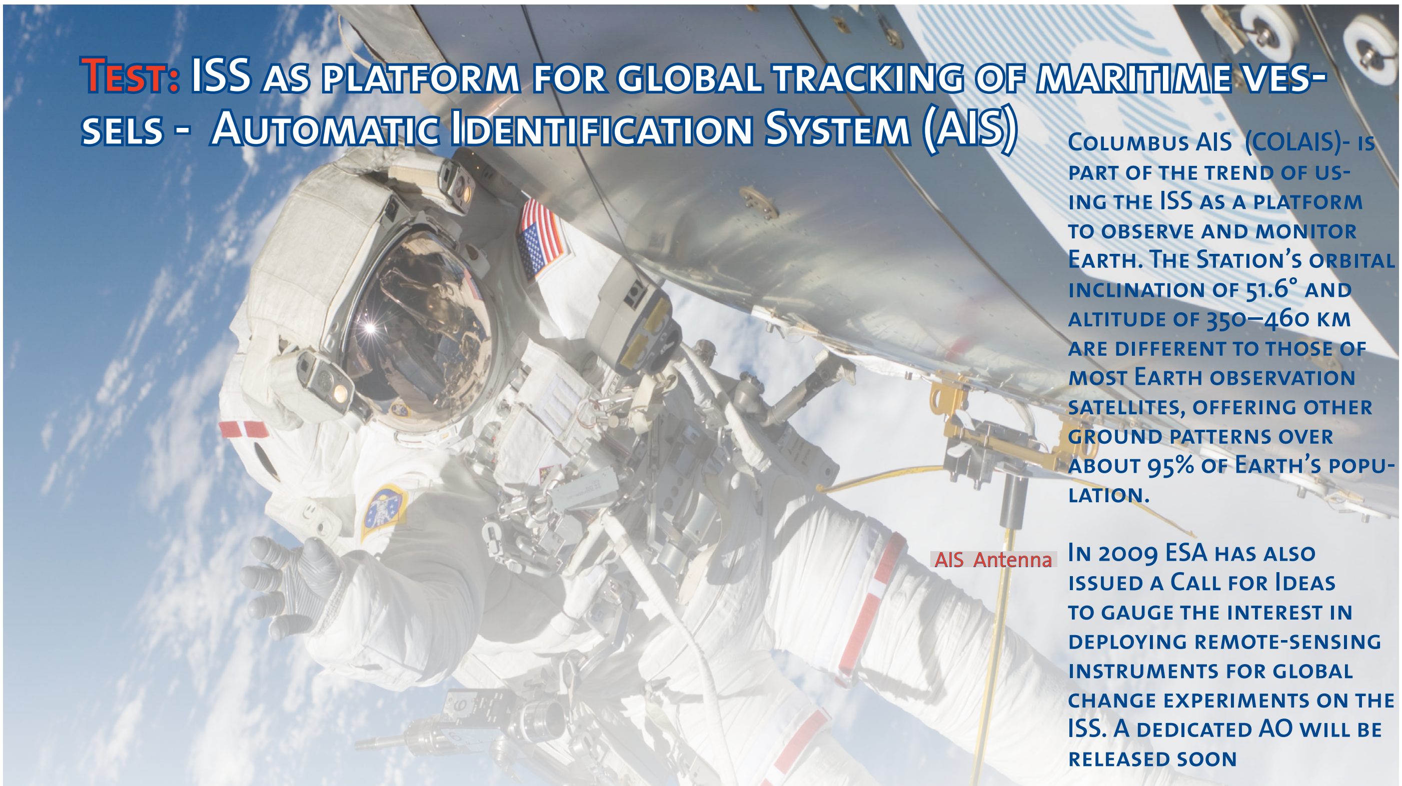
1. Source: NASA/TM—2005–213688. Revolutionary Concepts of Radiation Shielding for Human Exploration of Space



Test: ISS as platform for global tracking of maritime vessels - Automatic Identification System (AIS)

Columbus AIS (COLAIS)- is part of the trend of using the ISS as a platform to observe and monitor Earth. The Station's orbital inclination of 51.6° and altitude of 350–460 km are different to those of most Earth observation satellites, offering other ground patterns over about 95% of Earth's population.

In 2009 ESA has also issued a Call for Ideas to gauge the interest in deploying remote-sensing instruments for global change experiments on the ISS. A dedicated AO will be released soon

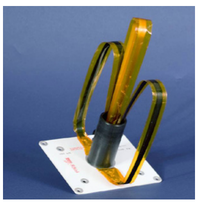
Automatic Identification System or AIS, has been around in coastal regions of the seas for quite some time. It registers and sends as a minimum basic data on identification, position and movement of the ship it is mounted on. Information is sent via a VHF transmitter that receives this information from the navigation means of the ship. Also name of the ship and tonnage etc. can be programmed to be sent as a part of the data package that is transmitted every 30 seconds or even more often. The only problem is, that this information is communicated from vessel to ground stations and therefore is limited to a range of about 40 nautical miles.

Maritime vessels larger than 300 GT (Gross Tonnage) are required to have AIS transponders installed, which give vessel name, position, speed, course and cargo to neighbouring vessels and to the shore-based AIS network.

AIS is a means to complement radar and standard VHF radio contact, for a ship to be able to identify other ships in its vicinity, and to report its own navigation data. AIS has been created as an approach to improving safety at sea and above all to help avoiding collision between ships mostly in very busy sea passages, and in coast-near waters. But it cannot - yet - be of help on e.g. transatlantic routes, when only land-based AIS receiver stations are used. For that application still complex Inmarsat communication is the system of choice.

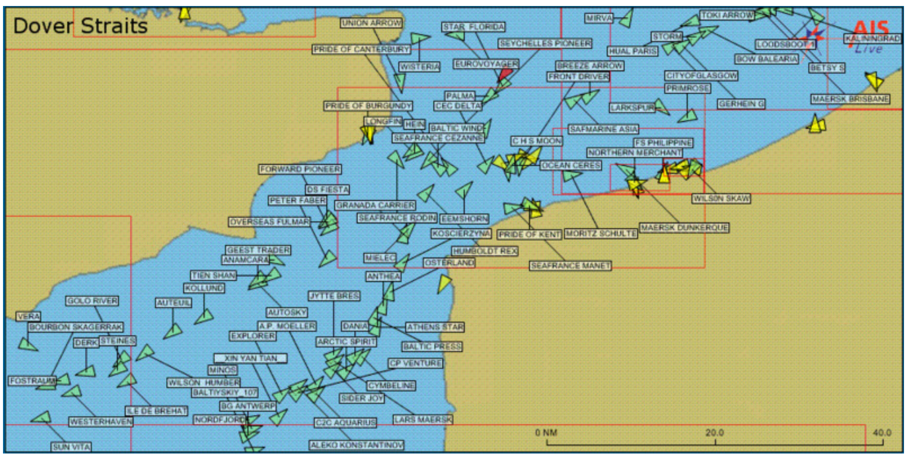
The system has evident crucial qualities but only has a geographical reach limited by the curvature of the Earth, which corresponds to a maximum reach in the order of 40 nautical miles or around 75 kilometers. This is the range and application the AIS system was designed for. Looking 'from above' and from a much longer distance is evidently attractive, but with the enormous increase of overview comes technical problems, which are the reason for using the ISS as a test-bed in the improvement process.

AIS Antenna for ISS before being unfoiled



Many factors play in: When used in its original application, looking on a range of 40 nautical miles and in one plane only, the number of vessels one can expect to see is limited. And likewise, movements take place in one plane as well, namely horizontally.
When looking down from an orbital height of about 350-800 km - the latter being the altitude that test satellites have been using - several thousands of vessels can be identified at the same time, and this enormous increase in signal traffic is one of the problems. Basically the receiver gets overloaded, and cannot distinguish between different vessels. Another issue is that any one satellite orbiting in

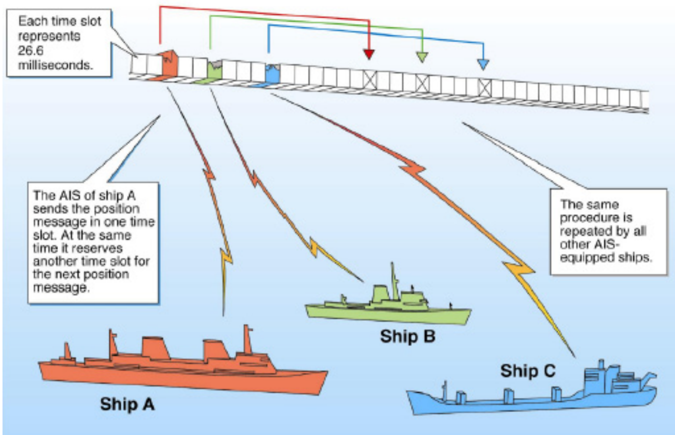
Typical AIS display onboard a ship - view here the Dover Strait



the indicated range, will need in the order of 90 minutes before it is back to roughly the same point over the Earth, and in addition the orbit will not cover exactly the same area of the Earth, but will shift a bit for each orbit. Due to the Earth's rotation, to fully cover all of Earth, a constellation of satellites is needed. Communication from the ships is transmitted at regular intervals, each 30 seconds but is not synchronised with all other ships. This means that serious collisions could arise in terms of when the AIS receiving station receives the signals. This is another significant problem to deal with.

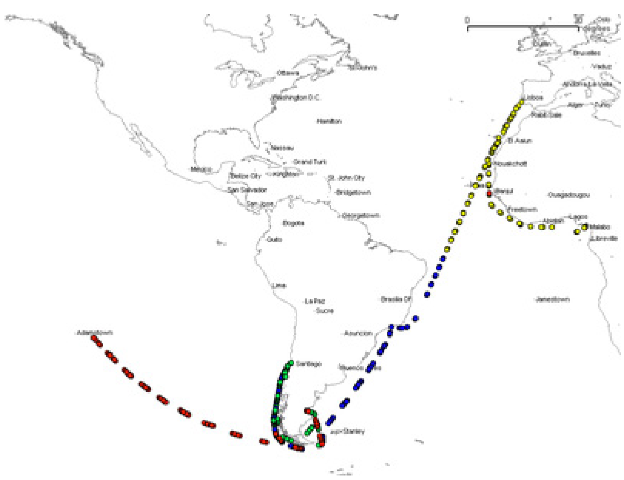
Time Division Multiple Access - TDMA

This is what the basic techncial solution is called, illustrated in the figure below: The collision of radio traffic from more ships at the same time is handled in the TDMA fashion. This means that a slot is kept open, so to speak, for the next data bit to be received by the satellite from the same ship. This is the simple version of a somewhat more complex story, but describing the basic principle.



Satellite operators and their activities

COMDEV, a Canadian provider of space based AIS by means of satellites with an orbital height of 800 km has been testing the capabilities. In the meantime the International Space Station has since June 2010 had the Norwegian and Luxemburg originating NOR-AIS and LUX-AIS receivers installed as a test-bed for their systems, with the objective of gaining data and experience with such a system placed on an orbiting station. Initially it was the plan that the project should run for one year, but it is still active.
These ESA related projects do however have a significant collaboration with COMDEV.
As the ISS is man tended and has frequent crew and material exchanges, the ISS represents a very flexible and adaptive platform, where new technology can easily be updated with relatively short notice.



ISS tracking a single ship over four months

Norwegian and Canadian development

The Trondheim-based company, Kongsberg Seatex and the Norwegian Defence Research Establishment - FFI, have in collaboration been asked to lead this study and to develop plans for the project. Kongsberg Defence & Aerospace Company (KDA) has been involved with payload manufacturing and product assurance. A Canadian satellite platform design will be adjusted to carry the Norwegian AIS receiver. The satellite dimensions are modest 20 x 20 x 20 cm. "Modern technology has made it possible to build very small and capable satellites, which reduces the launch cost considerably," says Terje Wahl at the Norwegian Space Centre.

The technology applied

As one of the most important aspects of bringing AIS to Space has been to avoid having to impose changes to the ship-mounted transponders, which would have the effect that all transponders would have to be renewed, all changes have to be introduced on the AIS receiving and processing side.

A set of new receivers from ESA/ESTEC

The ESTEC-developed receivers to solve these technical complications, with a sensitivity three times better than the conventional AIS receivers plus a number of additional message de-colliding qualities is what is now being tested on the ISS. Additional onboard signal processing techniques are implemented, which should alleviate the problems to a large extent and allow for the massive increase of ships to send simultaneously.
One aspect of the innovative changes introduced, is the mentioned Time Division Multiple Access (TDMA), where channels are sliced in time so that each vessel is assigned an approximately 30-millisecond signal slot to transmit in sequence.

Signals from a computerised ocean

In order to arrive at a good estimation of how good or bad a new type receiver would be, a number of parameters need to be considered, e.g.

- How well one can simulate the situation where several thousand ships send signals; this requires that one tests a 'computerised ocean'. Further,
- how well one can solve the additional passing of the radio signal through the atmosphere,
- how well one can solve the signal collision issue, and
- how well one can solve the necessary latency and re-emission of signals back caused by the necessary time for processing of the received data.

These are some of the aspects being focused on in the ISS test set-up.

The time resolution model being worked with as a guideline right now has as objective of within three hours to detect around 85-90% of all ships being overflown by the satellite or the ISS.

ISS is moving at around 8 km per second and that causes significant Doppler shift on the signals and with this a frequency shift. This issue also has to be dealt with, but as it happens, this even seems to become a slight advantage, as some of the signal overlapping goes away for the same reason.

The best orbit

The ISS has an orbital height of around 350 km. This has the effect that less vessels will be in the 'area-of-sight' than from a satellite with a higher orbit. In addition the ISS does not have a limited life time issue as such, as the orbit is being boosted at regular intervals. For testing, therefore, the ISS is a comfortable place to be.

The simulation model

As indicated, the amount of single signals, i.e. ships, is the driving factor for the (over)loading of the receiver. The project team calculated that, in case 3000 ships would have to be considered within the 5000 km diameter as the maximum, all would be tracked well up to 93% confidence. In the case of 5000 ships the fraction goes down to 68%. With 8000 ships the detection fraction would be as low as 41% and multiple overpasses would be needed to get full detection.

Reality test with US Coast Guard in October 2010

During the month of October a test was performed. An AIS Search and Rescue (SART) which is a part of the standard equipment in the Global Maritime Distress Safety System (GMDSS) was placed on 27 and 28 October 2010 approximately 2 nautical miles north coast of Puerto Rico. Contrary to earlier tests, this test was setup in a very busy sea traffic zone and the objective was to test how well satellite detection on an AIS signal would be in such a situation.

The test was successfully completed, demonstrating that under these dense conditions a minimal structure could be identified by the AIS onboard the ISS.

ATV-2 - few meters before docking to the Russian module Zvezda. Part of the navigation aligment system can be seen as two dark square structures above the central circular mating ring of the vehicle. These are visual targets for crew monitoring. Courtesy of NASA.

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Anniversary for a success - 20 years of Zero-g in Bremen, Germany

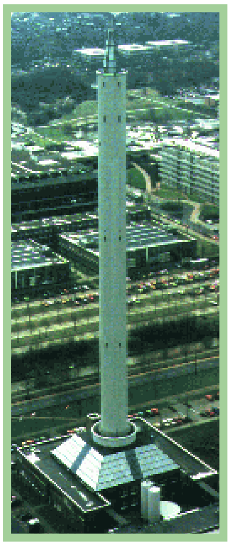
Drop capsule ready to go at the top of the Bremen Drop Tower at ZARM

The drop tower at ZARM was established based on the energy of a few enthusiastic people in 1985, as an institute under the University of Bremen, Germany. As Bremen since 1961 had industries developing from aeroplane into aerospace business, a strong basis existed in the area for creating the drop tower facility. On 19 November 2010 the 20th Bremen Drop Tower and the 25th ZARM anniversaries were celebrated

The tower has a total height of 146 metres and the fall height is 120 metres. Applying the physical equation for free fall, this all comes out as an undisturbed free fall of just under 5 seconds.
But what can one learn during such a short interval?

Well, what has developed over the years is a setup of high sophistication that actually has allowed for quite exotic observations in the Bremen Drop Tower (BDT).

As an indication of the importance the BDT has for ESA, ZARM in 2003 was introduced into the official ESA list of 'External Facilities'- a status that only very few facilities in Europe have today, demonstrating the importance the European Space agency has honoured the Bremen drop tower with.



The inspiration for the drop tower was a 145 metres deep drop tube at NASA Glenn Research Centre, Cleveland, Ohio, that was able to provide a micro-g level of better than 10^{-5} g. Europe at that time did not have any equivalent to this very attractive option for 'microgravity on Earth'.

Concept phase

The initial suggested length of the tube of a modest 73 metres quickly increased in the early discussions to 93 metres. And soon thereafter the final length of 120 metres was decided.
In 1987 ZARM started the planning and construction of the drop tower, which could take up its operation in September 1990, to which the ZARM-FAB mbH was created, the Drop Tower Operation and Service Company. The original scientific institute, now referred to as ZARM Research Institute, today consists of the departments following:

- Fundamental Physics and Space Flight Technology,
- Multi phase Flows and Measurement Techniques in Fluid Sciences,
- Combustion and Aerodynamic,
- Complex Fluids and Material Sciences

These departments together represent about 2/3 of all ZARM institutions.
The Drop Tower was finally inaugurated in 1990. In 1993, the first 1000 drops had been performed, in 1997, 2000 drops, and in 2004 the number of experimental drops had reached 4000.

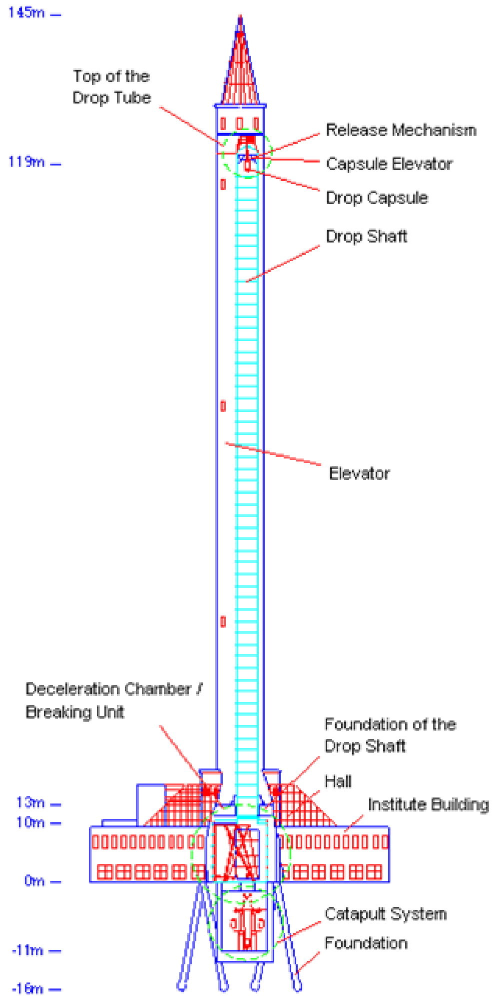
ESA's part of the BDT programme

On average, ESA funds some 70-100 drops per year, distributed on four to five campaigns, dependent on the hardware readiness and availability of the experimenter team. The experiments are usually carried out in campaigns of 15 to 25 drops each.

How to prepare an experiment?

The ESA supported drop tower campaigns can have various goals and origins. Experiments pursuing scientific goals are received by the Agency in response to ESA AOs (Announcements of Opportunity). These proposals can address "stand alone" drop tower experiments, where the drop tower is the only microgravity research platform considered to be used in the underlying science programme. Alternatively drop tower experiments complement, or serve as precursor programme to scientific investigations performed on other microgravity platforms, such as Parabolic Flights, Sounding Rocket Missions, FOTON/BION orbital flights or ISS Experiments.

The cooperation agreement between ESA and the ZARM-FAB includes experiment preparation advice by ZARM, as well as the entire chain of support from concept to finalisation. The experiment hardware itself is provided by the scientists or at least has to be procured from sources outside of ESA's drop tower utilization contract.



How does it work?

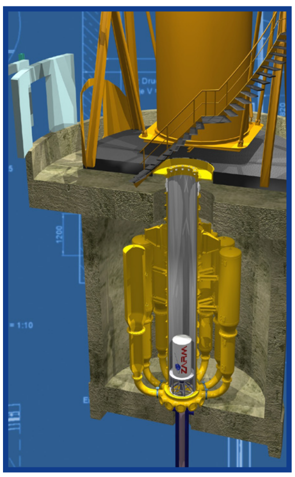
Inside the large diameter tower, a much smaller diameter drop tube - 4 metres diameter and 120 long, indicated in blue in the (fairly sketchy) figure - is the 'real' facility. In that tube a vacuum better than 10 pascal (Pa) or 10^{-5} bar can be created. A total of 18 pumps with a nominal capacity of 32 000 cubic meter/h need about 1.5 hours to reduce the shafts inner pressure to 10 Pa.

The flight ready capsule, with a diameter of 0.8 metres and lengths of 1.6 metres or 2.4 metres with a total mass of some 500 kg is ready in position before shaft evacuation. The drop capsule is winched to the top and held by a sophisticated release mechanism. The challenge of this release mechanism is the necessity to let the capsule go, avoiding the induction of any mechanical disturbance.

After release, the capsule starts a free fall of 4.7 seconds and arrives with a velocity of some 167 km/h at the 8 metres deep deceleration tank filled with polystyrene pellets. Despite of this 'soft landing' the capsule and its payload does experience a breaking impact of some 30 g.

After this, the shaft is flooded with air and the capsule recovered, allowing the experimenters to access the payload.

A catapult almost doubles the micro-g time



In 1995 the catapult was conceived. It was a way in which to expand the micro-g period to almost the double of a simple free fall. As well as the airplane-produced micro-g via a parabola, this system should do the same.

Luckily, the idea for the catapult existed already when the drop tower was first conceived: The engineers had under the tower left a sufficiently large chamber, in which the catapult could be integrated, 12 metres underground, once the go-ahead had been given.

With this catapult payload capsules up to as much as 400 kg total mass can be launched into the evacuated drop shaft from the bottom, accelerated by a pneumatic piston elegantly exploiting the difference in pressure between the evacuated shaft and over-pressurized air tanks. The resulting gigantic acceleration - leaving any Ferrari or Porche[1] in the dust, had they been there - is adjusted by a servo hydraulic breaking system that controls the piston velocity. Without this control, the capsule would potentially be propelled through the top of the tower. For the same reason energy absorbing arrangements are activated in the tower over normal top point of the parabola, should controls fail. Considering that not even the entire shaft length is used, one in this manner achieves a free fall period of impressive 9.4 seconds[2]

Build a Drop Tower experiment !

As a basic rule, the drop tower utilisation programme of ESA's Directorate for Human Spaceflight covers only the "Flight Ticket". The experiment hardware is partially provided by industrial or academic institutions. ESA-procured hardware used in the drop tower mostly represents breadboards which are usually part of hardware-development projects covered by dedicated contracts and grants. Prior to the facility production start potential users can get advice from ZARM experts on how to construct the payload. ZARM-FAB delivers the capsule platforms for experimenters to instal the equipment in. Platforms are built as a ply-wood aluminium sandwich supposed to attenuate unavoidable vibrations upon capsule release. One to two weeks before a drop campaign the pre-mounted hardware components are usually integrated in cooperation with ZARM experts as well as additional help and service is provided as needed.

Also available for diagnostic methods is a laser, installed in the tower top, whose beam follows the experiment capsule. Also cameras, temperature control and combustion chambers are available. If one should need the incredible microgravity quality of up to 10^{-9} g, a capsule can be provided with an evacuated inner chamber, in which the experiment is free-floating during the drop.
Upon completion of all pre-flight checks and approvals, the capsule is closed gas tight by an aluminium mantle and brought into the drop shaft.
Until release of the capsule, the experiments can be externally powered . Launch is activated by the scientists themselves giving the command to perform the drop.

1. The capsule's lift off velocity from the catapult piston is about 46.9 m/s, which is reached within 0.28 seconds. As soon as the capsule has left the piston, microgravity sets in and lasts for the ascent flight and the return fall, ending in the same deceleration tank used in the usual drop mode. The fastest top sports car reaches 28m/s (100km/h) in around 3 seconds.

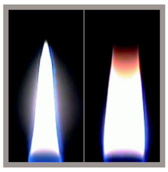
2. The free fall in principle starts as soon as the payload leaves the piston. This takes place well before the capsule reaches the top point of the parabola, which might not be evident, but in fact physically it is like that.

Experiments performed in the Bremen Drop Tower

Selected experiment types

Combustion - burning of an ethene flame:

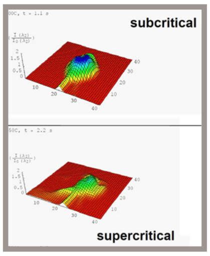
- Investigation of how conditions for soot formation and particle properties change under micro-g



Laminar ethene diffusion flame normal gravity (left) and in microgravity (right) (Courtesy of Reimann and Will)

Trans-critical droplet vaporization experiment

- Essential for investigation of the behavior of modern fuels



Vaporization of a suspended n-dodecane droplet in microgravity at subcritical conditions (upper image) and supercritical conditions (lower image). (Courtesy of ZARM).

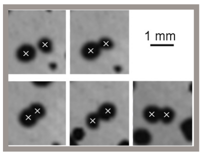
Methane flame under normal and microgravity

- Study of combustion and soot formation in low gravity

Methane flame under normal- (left) and microgravity (right). Also measured but not shown: temperature, soot volume fraction (shown here), and primary particle diameter.(Courtesy of Reimann and Will)

From dust to planets

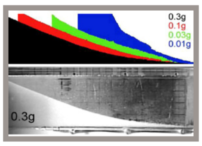
- Studying potential mechanisms of early stages of planet forming



Collision between two ~0.5-mm-sized dust aggregates at a velocity of ~4 mm/s. The two colliding aggregates are marked by an x. The time interval between the first five images (from top left to bottom right) is 54 ms, the last three images have time intervals of 850 ms between them. (Courtesy of Weidling, Güttler and Blum, unpublished data)

Avalanches of granular matter under reduced gravity

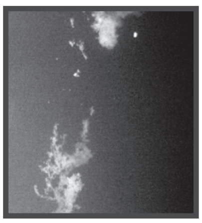
- Investigation of landscape forming as an effect of gravity



Avalanches of granular matter under reduced-gravity conditions. The image shows cuts through the run-out avalanches of glass beads at g-levels between 0.01 g and 0.3 g. The avalanche width is dependent on g-level. This figure was borrowed from Hofmeister et al.

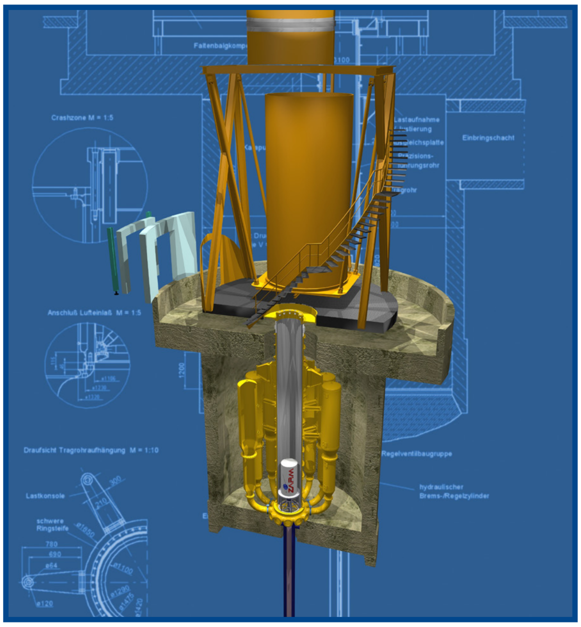
Interactions in Cosmic and Atmospheric Particle Systems (ICAPS)/ ICAPS Precursor Experiment (IPE)

- Investigation of potential cosmic dust aggregation as precursor for planet and comet forming



ICAPS/IPE generated gigantic aggregates in a drop experiment. Horizontal image size is 10 mm. (Courtesy of A. Vedernikov)

Illustration of the complexity of a fall capsule, here arranged in support of the CPS experiment: Experiment on Combustion Properties of Clouds, Particles and Spray (Courtesy of ZARM)



The ZARM Drop Tower naturally offers a maximum micro-g time of 4.74 sec. With the catapult illustrated above implemented, this can be brought to in the order of 9.3 seconds (drop capsule marked 'ZARM')

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UPCOMING TOPICS

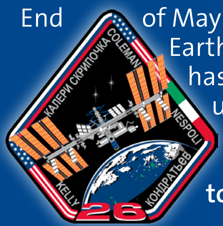
Partial Gravity Parabolic Flight Campaigns

The new parabolic Flight profiles will be offered on a campaign planned to fly in June 2011. This campaign will be a collaborative effort between ESA, CNES and DLR. There levels will be offered. Apart from the traditional 0-g, also Moon or 0.16 g level as well as Mars or 0.38 g levels will be flown.

Mars 500 Science Update

At the time for the next newsletter, the Mars 500 crew will be on their way back to Earth, as the last leg of the simulation study taking place in Moscow. Some preliminary result of the study will be provided.

MagISStra mission: Activities of ESA astronaut Nespoli onboard ISS, part 2.



End of May 2011 Paolo Nespoli will return to Earth from the ISS. The period for his stay has been remarkable in many ways. An update on his activities and achievements will be provided.

Outlook to Andre Kuipers' mission to the ISS

After ESA astronaut Roberto Vittori's short stay, ESA's next 'long-term-stay' astronaut onboard the ISS will be Dutch Andre Kuipers. Kuipers will launch together with

his crew mates Oleg Kononenko from Russia, and Don Pettit from NASA. They will go up onboard the Soyuz 29S. It will be Kuipers' second mission planned for launch 30 November 2011 from Kazakstan

The Concordia Antarctic station over-winter crew

Concordia Station, Antrarctica

Since November the new crew has been in Concordia. Data coming out from these experiments are very interesting. Updates as well as an interview with a former resident will be brought in the next newsletter

Climate Change Research Announcement

Ice-free North-west passage

The International Space Station will in the future become one of the platforms from which systematic monitoring of specific climate change aspects will be done. In close collaboration with Directorate for Earth Observation, Directorate for Human Spaceflight Operations is preparing a research announcement, to solicit proposals for how to best make use of this Space platform in a low Earth orbit (LEO), to complement satellite-based missions

MASER-12 ESA's next Sounding Rocket mission

15 May 2008 MASER-11 launched from ESRANGE in Kiruna, Sweden. Now the next in turn is made ready. It has a planned launch in November 2011.

ESA links to visit ....

- MagISStra Mission Website
- ATV-2 website
- ERASMUS Experiment Archive (EEA) - Overview of performed experiments
- HSF Science Newsletters - get electronic 'pdf' version here: http://www.esa.int/SPECIALS/HSF_Research/SEM1JV4KXMF_0.html

Contact: European Space Agency - Human Spaceflight
ESTEC, PO Box 299, 2200 AG Noordwijk, The Netherlands
http://www.esa.int/esaHS/index.html

Martin Zell, Head of ISS Utilisation Department

An ESA Human Spaceflight Programme Production

Benny Elmann-Larsen, editor
benny.elmann-larsen@esa.int

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