→ SPACE FOR LIFE

human spaceflight science newsletter

September 2010

First photo taken of planet Earth through the windows of the ESA built Cupola ISS viewing module. Courtesy of NASA

In this issue:

- ISS Science Incr. 23-24
- MAXUS-8 science
- ILSRA 2009
- AMS testing
- Artificial gravity
- **Upcoming topics**

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Increment 23 & 24 Science Programme - ISS produces valuable data

Increment 23 started early April 2010, and immediately after ISS had another full crew occupation , as both the STS-131 and the Soyuz TMA 18 crews arrived with an interval of a few days. Increment 24 is now slowly running out and a substantial and ambitious science programme with it.

Onboard the ISS

With almost 2 months still remaining of their planned 164 days on ISS, the residing ISS crew - Kotov (RUS), Noguchi (JPN), and Creamer (US) - on 4 April welcomed Kornienko (RUS), Caldwell Dyson (US) and Skvortsov (RUS), the 22S crew launched 37 hours earlier from Baikonur Cosmodrome, Kazakstan. Around 36 hours later, the crew of seven - Poindexter, Dutton, Mastracchio, Metcalf-Lindenburger, Wilson, and Anderson, all representing NASA, and Yamazaki, representing JAXA - started their journey to the ISS from Kennedy Space Centre, Florida, USA, onboard US Space Shuttle Discovery, STS-131. When Discovery docked 2 days later with the ISS, the total number of residents on the ISS was brought to thirteen for a period of more than one week. Increment 23 was in full swing.

Science planned for Increment 23 & 24

With them onboard the STS-131 crew brought the sample material for the WAICO-2 experiment to be started up in Biolab. The WAICO-1 experiment took place early 2008. The first step towards starting the experiment was made on 8 April. WAICO is looking at the effect of gravity on plant root development.

Work in April 2010 - Increment 23

The following actions of importance for the experimental programme were undertaken in April:

- Biolab SW was upgraded in preparation of the WAICO-2 experiment.
- The gloves in the Biolab glovebox were exchanged, in order to ensure continued sterility.
- Error finding and analysis of problems related to the PADIAC experiment. The anomaly was in fact at the level of the stand alone KUBIK-3 Centrifuge/Incubator, which was attempted reactivated. That failed. ESA launched a spare KUBIK E-Box on 23S, and KUBIK-3 was repaired in Columbus on 23 June. A subsequent check-out test confirmed that KUBIK-3 got its full capabilities back. PADIAC is now manifested on 24S ascent.
- On 26-28 April JAXA astronaut Noguchi installed the sample material in the experiment containers and

equipment for start of the WAICO-2 experiment.

WAICO-2 was started on 28 April by placing seeds and growth medium into dedicated experiment containers. All containers were first spun for 3 days at 1-g level to properly orient the root of the germinated seeds. On 02 May the 1-g regimen was switched off to allow for a 0-g regimen for the remainder of the experiment on half of the containers. WAICO-2 was completed on 10 May.
On 26 May, the samples landed onboard STS-132 Shuttle Atlantis and were handed over to the scientists.

May 2010- Increment 23

After WAICO has been completed, the TripleLux-A experiment will be the next experiment even if that will be a while, and tentatively be launched on Shuttle ULF-6 (STS-134). It is planned to be performed in the Biolab facility during Increment 26, i.e. after March 2011.

What is TripleLux?

The 'triple-' indicates that three different cell types are flown to be exposed to space radiation onboard the ISS. The long standing suspicion that radiation and g-level could be complementary factors in generating the difference in response compared to Earth samples will be tested by having half of the samples inserted in an onboard 1-g reference centrifuge. The rest will remain in weightlessness. The cell types flown are 1) a bacterium, that is the 'bate' so to speak for the immune cells, 2) an invertebrate immune system cell, and 3) a rat macrophage cell type. The strategy used for detection of the function of the cell response - bioluminescence - has earlier been described in Newsletter March 2010, p.9, where one parabolic flight experiment used yeast cells to demonstrate the effect of gravity on phagocytes on cell level - basically the same case.

The European Drawer Rack, EDR, is ESA's flexible 'work horse' type on the ISS, allowing for accommodating any payload, as long as the power, cooling and other resource interfaces are respected.
EDR housed the Protein Crystallisation Diagnostics Facility, PCDF, experiments over a period of 3 1/2 months until July 2009.
Now EDR is prepared for housing the Kubik-6 incubator, but in preparation of the next activity some maintenance has been necessary as there were faulty indications of temperature data from KUBIK-3 instruments.
Due to past problems, the start of the PADIAC experiment ("Pathway Different Activators") has been deferred six months, during the subsequent Soyuz flight 24S in October.

June 2010 - Increment 23/24

Undocking and Landing

Following Soyuz activation and routine safety checks, undocking of Soyuz TMA-17 with Kotov, Noguchi and TJ Creamer, occurred just after 02:04 (CEST) on 2 June, followed by a 15 sec separation burn three minutes later. The parachute over Soyuz TMA-17 allowed for a soft landing at 05:25 CEST (09:25 local time) near the town of Zhezkazgan in Kazakhstan. This defined the end of Increment 23.

Kotov, Noguchi and TJ Creamer had spent almost 163 days in space. From here the crew was flown to Karaganda in Kazakhstan by helicopter. Kotov was flown on to Star City in Moscow, while Creamer and Noguchi were flown onboard a NASA plane directly to Houston. Undocking of Soyuz TMA-17 marked the end of Increment 23 and the start of Increment 24.

Soyuz TMA-18/23S, Expedition 24 arrives

The Soyuz 23S Mission Crew - Yurchikhin representing the Russian Space Agency, RSA, together with Walker and Wheelock, both representing NASA, arrived on 17 June.

Experimental activities

On 3 June NASA astronaut Tracy Caldwell-Dyson performed a session of the THERMOLAB experiment, which shares data with the complementary NASA experiment 'VO_2 max'. The THERMOLAB experiment utilises the Portable Pulmonary Function System, or Portable PFS, a miniaturised version of the earlier version PFS, accommodated in the NASA Human Research Facility 2 (HRF-2). Portable PFS is 4th generation of breathing gas analysers built under ESA development contracts. The first breathing gas analyser was flown onboard the Spacelab-D2 mission in 1993.

The COLLOID experiment will be launched onboard Progress 39P and is planned be performed during the month of September. COLLOID is a continuation of the earlier Fluid Sciences experiments that were performed in the Microgravity Science Glovebox, MSG, albeit with a rather different focus.

What is COLLOID?

Colloids are mixtures of fluid and firm parts - particles or other matter that are evenly distributed in the fluid. In this case the focus is on nano-scale charged components. It is attempted among others to build colloidal aggregates from this mixture, to investigate how the very small forces of attraction and repulsion[1] play into this dimensional regimen.

Material Science Lab

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

MSL with CETSOL and MICAST

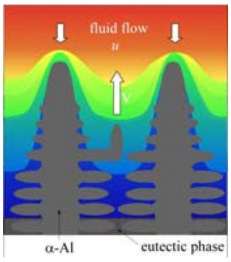
Planned for processing in June were the Material Sciences samples for CETSOL. The last MICAST sample is now planned for processing not earlier than December 2010. Installed within NASA's Material Sciences Research Rack, MSRR, ESA's Material Sciences Lab, MSL and the mentioned CETSOL and MICAST cartridges were brought to the ISS during last fall.

What is CETSOL?

CETSOL (Columnar to Equiaxed Transition in Solidification processing) looks at the microstructure of growth appearances as indicated above. It is supposed to study the transition from columnar growth to equiaxed growth that

1. Van der Waals and Casimir forces are the focus. Van der Waals are forces of attraction or repulsion between molecules other than those due to covalent bonds or to the electrostatic interaction of ions with one another or with neutral molecules. The term includes:
- force between permanent dipole and a corresponding induced dipole
- instantaneous induced dipole-dipole forces (London dispersion force).
Van der Waals forces are relatively weak compared to normal chemical bonds, but play a fundamental role in fields as diverse as supramolecular chemistry, structural biology, polymer science, nanotechnology, surface science, and condensed matter physics. Source: http://en.wikipedia.org/wiki/Van_der_Waals_force . For explanation of Casimir forces please go to http://en.wikipedia.org/wiki/Casimir_effect

occurs when crystals start nucleating in the melt and grow independently.



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

What is MICAST?

MICAST (Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions) looks at the microstructure of growth appearances as indicated in the image above.

July 2010 - Increment 24

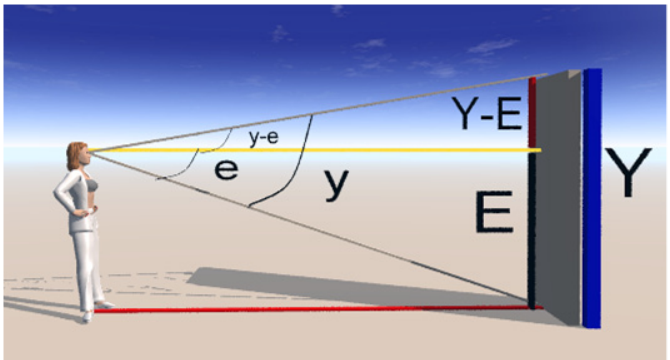
Progress 38P arrived with cargo on 28 June. During its final approach to the ISS Progress 38P lost contact with its automated docking system and the docking approach was automatically aborted. After specialist had investigated and tested the KURS navigation system, it was concluded to be fully functional and as effect of that fact, Progress 38P reacted correctly. It was further concluded that interference between the KURS system and the TORU manual docking TV viewing system was the reason for the automatic docking abort.

The experimental programme in July counted the following:
Genara-A (Gravity Regulated Genes in *Arabidopsis thaliana)* was the next ESA experiment to take place in the European Modular Cultivation System, EMCS. This experiment was activated on 09 July completed on 23 July. Four culture chambers contained a total of around 1600 seeds, half of which have been exposed to 1-g (centrifuge) in EMCS and half to 0-g. Analyses will focus on the relation between the original genetic material in the plant and the expression in the form of root growth parametres of same.

IMMUNO was planned to be performed by the 22S crew, Skvortsov and Kornienko but has been postponed. This experiment is looking into the effect of the cumulative stress factors onboard, on the immune system.

MARES - the Muscle Atrophy and Exercise Research System - is planned for a first rack-level check-out in the fall timeframe Commissioning is planned for February 2011.
MARES is the ESA built most advanced muscle research facility ever flown. Controlled by a comprehensive SW package, MARES will be 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 eventually be able to provide tailored training programmes for each individual astronaut.
MARES now goes through initial check and commissioning phases and experimental activities for the Sarcolab experiment will only start beyond Increments 23 & 24.

PASSSAGES is illustrated for one aspect in the next image. The experiment was performed by Doug Wheelock on 24 June and by Shannon Walker on 02 July.
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. "Can I pass this door without having to duck?" is a question that we do not ask each time. We simply just do it, because of our self-image, that has given us the experience that dimensions do or do not fit.
The question investigated is, if this self-image is influenced by gravity and thus changes in Space.



The SOLO experiment will have two other human test subjects during this period. It is planned during end of August – September time frame with NASA astronauts Doug Wheelock and Shannon Walker. This will be one of the last repeats before the experiment has been completed. 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.

The TASTE experiment will be started in this period as well. TASTE is an educational experiment, the outcome of which is going to be used in primary and secondary education.
It has to do with changes in the subjective taste of some food items in Space and on Earth, of which we have many records.

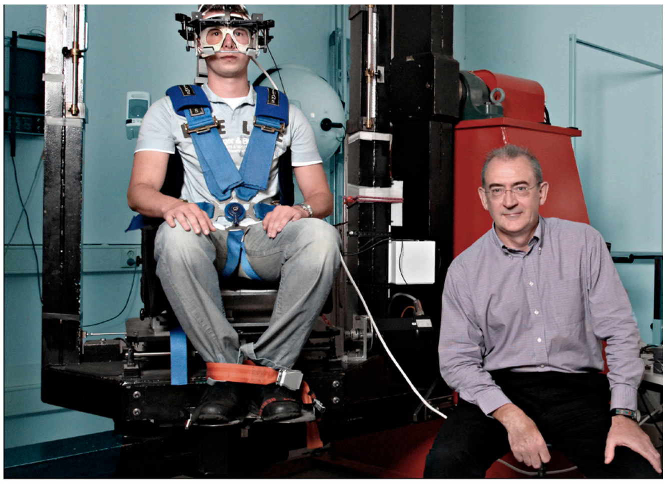
The THERMOLAB experiment was started last fall and will have a next repeat with the Expedition 24 crew members NASA astronauts Doug Wheelock and Shannon Walker.
THERMOLAB is a Human Physiology experiment looking at core temperature changes in humans before, during and after exercise performed on ISS.
Many factors relative to heat balance in humans are different from when on Earth: Weightlessness offers no natural convection, which would normally help getting rid of excessive heat. Likewise, evaporation from the skin is impaired on ISS, as sweat tends to stick to and cover the body - an effect that is aggravated by absence of convection.
One additional essential difference between Earth and ISS conditions is, that a larger proportion of the body fluid is accumulated in the upper body in Space than on Earth.
These factors and a few more give reason to believe that the heat balance regulation is disturbed in Space to the extent that the temperature control system is overloaded during and after exercise.

August 2010 - Increment 24

THERMOLAB had optional slots for session repeats foreseen during August. The PASSAGES experiment has the requirements for the first session to be performed not later than FD21 and second session not earlier than FD120, thus looking at an early and a point as late as possible in the fully adapted 0-g phase

Before and after flights

Around times before launch and at certain intervals after landing of the manned missions, a number of physiology experiments are planned on the ground, i.e. the experiments looking at human bone status, EDOS, the endurance capacity in exercise by analysis of gas exchange and heart rate kinetics, EKE, and SPIN, which uses a rotation chair to evaluate the status of the balance system after flight, and its potential impact on the cardiovascular control. Due to among others the present 'direct return' of NASA crews to Houston, TX, neither SPIN nor EDOS have been performed,



however. Finally, ZAG & OTOLITH, another rotating chair experiment set, that looks at how the perception of the vertical is influenced by microgravity, is using an off-center rotation approach, letting the axis of rotation pass exactly through one of the two vestibular organs in the inner ear. This allows for e.g. side-wise differential measurements which differentiation is crucial for understanding the physiological mechanisms involved.

September 2010 - Look ahead to Increment 25

The PADIAC experiment is using both the Kubik-6 incubator inside the European Drawer rack as well as the stand-alone Kubik-3 incubator connected to the rack. The Kubik incubators are transportable incubators with centrifuge accommodations, that were designed in the frame of the ISS Soyuz missions for biology experiments processing. Planned for launch on Soyuz 24S, the goal of PADIAC is to determine the different cellular activation pathways used for activation of T cells, which play an important role in the immune system.

Geoflow-2 experiments

The hardware modifications for the implementation of the GeoFlow-2 experiment are concluded and bench testing performed in order to launch it on ATV-2 at the end of 2010.

Finally, further planning will allocate time for ESA experiments to take place on the ISS from September 2010 / Increment 25.

Summary and outlook

Increments 23 & 24 have had an ambitious experimental programme, not the least seen in the light of the phase the ISS programme is in at this time: Overall the last Space Shuttle flights have been re-scheduled and are approaching rapidly, and with that the need for up and download of a multitude of sample material. In addition the long term future of the ISS has now been defined up to even 2020 which opens up for different options, both for the scientific programme as well as for logistics to and from the ISS. As the Space Shuttle has been the major work horse in bringing large payloads to the ISS, 2011 and onwards will see changes to that scenario. ESA's Automated Transfer Vehicle, ATV, which will be sent to the ISS at regular intervals in the future has a significant volume capacity as well.

Back to top

The Maxus-8 mission - Twelve minutes of microgravity above the polar circle

The Maxus-8 mission marked another important success of ESA's Sounding Rocket Programme and confirmed the merit of self-standing scientific investigations that do not require long microgravity periods, but still have demanding mission logistics, safety and/or hardware requirements.

The latest Sounding Rocket mission MAXUS-8 was successfully launched from Esrange, Sweden, on March 26th, 2010 to an altitude of 700 km over the surface of the Earth. That is roughly twice the altitude of the orbit of the International Space Station. MAXUS-8 carried three of four experiments for research into material sciences. Of these, one experiment studied directional solidification of new alloys of titanium-aluminium, the second investigated agglomeration of nickel particles by synthesis of its vapour. The third monitored liquid diffusion in metallic alloys by means of in-situ X-ray imaging. The fourth experiment in the field of biology was attempting to identify the cyto-skeletal forces that are assumed to be the basis for the gravi-sensing mechanisms in roots of plants and fungi.
In addition to the scientific experiments, aboard MAXUS-8 was also a technology demonstrator: the SHARK (Sounding Hypersonic Atmospheric Re- entry Kapsule) project was to deploy and drop a secondary capsule that separated from the payload still during the ascent phase after motor separation, approximately at an altitude of 150km. SHARK is a fully autonomous system aimed at proving the feasibility of dropping a "black-box" from outside the Earth atmosphere.

> Four Experiment Modules onboard MAXUS 8
>
> → **Solidification of new titanium-aluminide alloys**
> Science Team: Y. Fautrelle, O. Budenkova, S. Rex, D. Browne, S. McFadden, L. Froyen, A.Kartavykh
>
> → **Agglomeration of nickel nano-particles**
> Science Team: B. Günther, S. Lösch.
>
> → **X-ray monitoring of liquid diffusion in metallic alloys (XRMON)**
> Science Team: A. Griesche, R. Mathiesen
>
> → **Cytoskeletal forces underlying gravity sensing mechanisms of Characin cell**
> Science Team: M. Braun, B. Buchen, N. Vagt

MAXUS-8 flight analysis

The ignition of the Castor-4B motor occurred at the end of the 1st hot countdown that lasted for 7 hours and 13 minutes. The outside temperature was -20°C over the snow-covered Northern Sweden.
After motor separation, the MAXUS-8 Rate Control System (RCS) operated some low thrust manoeuvres, in order to reach and maintain the correct flight attitude of the payload and to zero all residual angular speeds in roll, yaw and pitch.

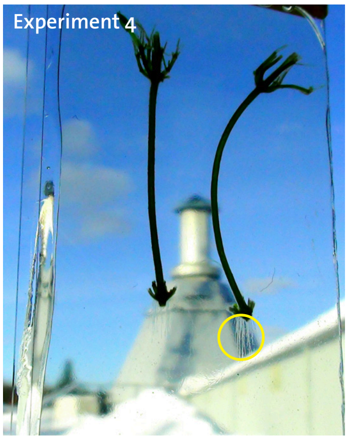
MAXUS-8 entered the free-fall conditions after motor separation and nominal ejection and release of the SHARK capsule, at approximately 91 seconds after lift-off.

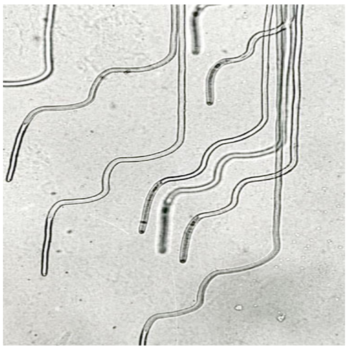
Experiment 1: Solidification of new titanium-aluminide alloys

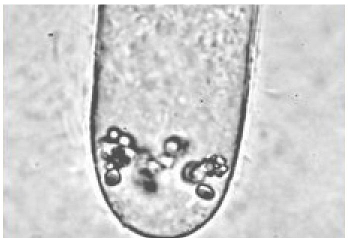
The purpose of this IMPRESS[1] related experiment was to investigate the nature of the solidification process of industrial highly relevant Ti-Al-Nb alloys with and without grain refiners. In particular, the experiments were aimed at understanding the nature of solidification in relation to both columnar and equiaxed solidification. It was proposed that the introduction of Boron would produce borides that, in turn, would promote equiaxed solidification.
A double set of samples was used, so that there were two main samples and two back-up samples.
Along the sample long axis a temperature gradient of 15 degrees per cm, or from one to the other end between 1605° and 1415° was created,

Photo courtesy of ESA

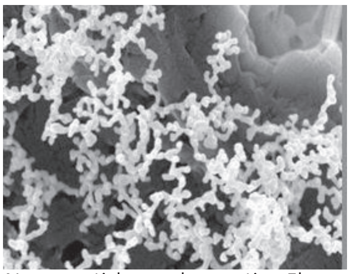
1. ESA metallurgy project in collaboration with the European Commission.



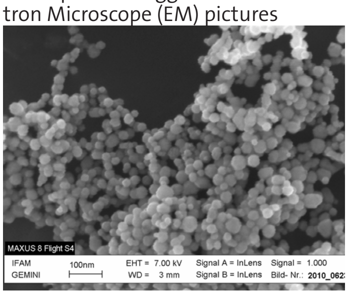




The Characin cell development in three magnifications, this image the highest - the root tip with statoliths, particle moving in response to gravity



Nano-particles agglomeration Electron Microscope (EM) pictures



and in addition a cooling rate of 18 degrees per min was applied (see sample images at bottom of page) so that the impact of different temperatures on the solidification process could be observed.

Observations: Columnar dendritic growth was observed without any evidence of equiaxed growth. The columnar growth is initially axial columnar and gradually changes to radial columnar. Hence, the tendency is for columnar dendritic solidification in the unrefined samples – even under the low temperature gradient conditions. Thus it may be concluded that there was no tendency for equiaxed heterogeneous nucleation in sample A and no tendency for dendrite fragmentation to form equiaxed crystals. Usually engineering alloys have some tendency for dendrite fragmentation.

The microstructure from sample B, the grain-refined sample, represents a significant finding: In this case completely equiaxed grain structure was observed, which indicates that the inoculants promote equiaxed nucleation and growth in the Ti-Al-Nb.

Experiment 2: Agglomeration of nickel nano-particles

The objective of this experiment was to determine experimentally the relationship between the morphology and the residence time of nickel aerosols under the sole action of diffusive and magnetic interaction suppressing convection and sedimentation effects.

Previous parabolic flight experiments with a 0-g time less than 15 sec, showed chain-like Ni-agglomerates. During the MAXUS-8 mission residence times up to 100 seconds were used, and some effect of the longer duration was expected.

The following preliminary conclusions can be drawn from typical morphologies of the Ni-agglomerates:

1. Hardly any particle-chains were obtained on the substrates, and in contrast to the results obtained from parabolic flight experiments it was expected that the chain length of the Ni-particles would increase with increasing residence time as indicated by parabolic flight results.
2. The size distributions of the Ni-particles obtained for various residence times showed a significant narrowing of the size distribution in the µg-produced samples compared to ground based experiments.
3. It was expected that agglomeration would continue with time, but durations of between 13 and 100 seconds did not have any apparent impact.
4. The amount of Ni-agglomerates on the substrate was not influenced by sampling time. Changing sampling time from 15 seconds to 5 seconds left the number density of agglomerates on the substrates nearly unchanged.

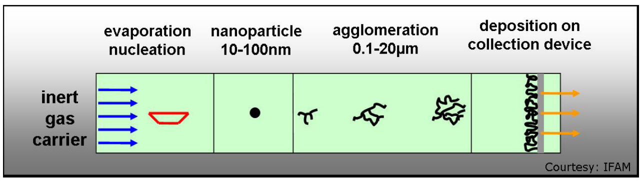
The overall number of deposited Ni-agglomerates decreases after approximately 7 minutes of continuous evaporation, which was somewhat surprising, as, in total only half of the initial Ni was evaporated from the tungsten filament. CCD-data revealed steady evaporation occurring until the very end of the experiments. Flight samples will now be compared with the ground reference experiments.

Experiment 3: X-ray monitoring of liquid diffusion in metallic alloys (XRMON)

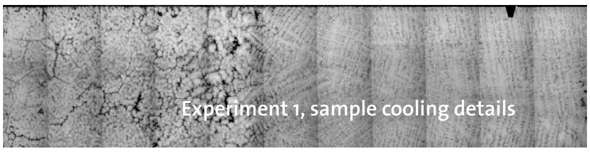
During the ascent phase of MAXUS-8 , the XRMON module suffered a sudden and abrupt loss of air pressure, which subsequently caused the automatic shut down of the X-ray source. This failure has been carefully investigated by a Material Review Board (MRB) composed by members from ESA, SSC and the science team. The work of the MRB was recently concluded and brought forward an explanation for the cause of the observed failure. Findings, structural in nature, have been taken in due account in the definition of the remedy actions needed to prevent the occurrence of similar failure in future MAXUS missions. The early shut down of the X-ray source caused loss of the main objectives of the experiment i.e. the on-line monitoring of physical effects in the molten alloys. Samples processed in the furnaces of the MAXUS-8 module have nevertheless been handed over to the scientist for post-flight analysis.

Experiment 4: Cytoskeletal forces underlying gravity sensing mechanisms of Characin cell structures

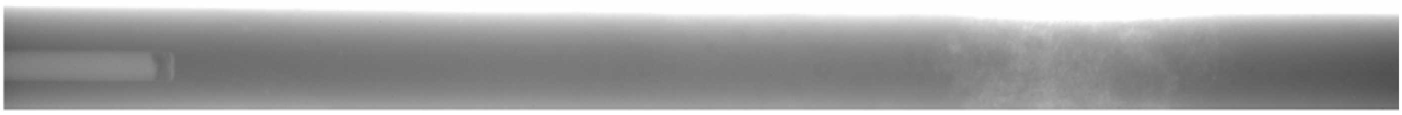
Previous experiments have been performed using Chara rhizoids over a series of sounding rocket (Texus 21, 25, 28, 29, 30, 43, MAXUS-3 and -5) and orbital experiments (STS-65, STS-81). Data from



Theory behind nanoparticle experiment (Experiment 2)



X-ray imaging (above and below) of TiAlNb sample processed on MAXUS8, courtesy: ACCESS e.V. (Experiment 1)



the experiment on Texus 43 indicated that lateral accelerations between 0.05g and 0.14g are required to displace “statoliths” (intracellular sediment particles) towards the gravity sensitive plasma membrane site, where contact of statoliths with gravi-receptors induces cell-type specific responses. It is believed that the cell cytoskeleton, i.e. the cells’s structural support, is involved in the gravity sensing process and the MAXUS-8 experiment permitted a comprehensive analysis of molecular cytoskeleton forces.
The rhizoids and protonemata - the very first development in the lifecycle of a plant - were installed onto a rotating platform inside of the MAXUS-8 experiment module permitting centrifugal accelerations to be applied to the cells stepwise from 0.05g to 0.09g for 60s each. This was followed by an initial adaptation time of about five minutes.

Preliminary analysis of video microscopy images obtained in-flight shows that the threshold for lateral statolith displacement to occur was approximately 0.07-0.08g, see also third image from the top on opposite page. This corresponds to a minimum force of 1.14 x 10-14 N being required to initiate the gravisensing cascade. These data are important for understanding the mechanisms of gravity perception, in particular the link between physical susception of gravitational acceleration and initiation of molecular signalling processes within the cell.

Back to top

Historical: What TEXUS-1 flew in 1977 ....

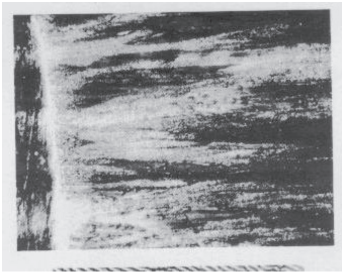
On 13 December 1977, the first TEXUS rocket was launched from Kiruna, Sweden. One of the experiments flown was defined by H. Fredriksson and T. Carlberg from Department of Casting of Metals, Royal Institute of Technology, Stockholm, Sweden.
The question examined was expressed in the title:
“Study of the structure of eutectic[1] and hypereutectic alloys solidified in the absence of convection and sedimentation”.

In the experiment the following findings and derived conclusions were made:
1. Sn-Zn eutectic[2] isothermally processed: (......) When compared with the reference sample processed on the ground, the space sample exhibited in its centre a larger proportion of this normal eutectic structure (90% instead of 60%) and a coarser arrangement. **It is therefore concluded that convection influences strongly the formation of such structures.**
2. Al-Al2Cu eutectic solidified directionally: **no significant differences between the structures of the space and reference samples were observed** as the solidification rates were rather high and the accuracy of the measurement of the fault density in the cellular structures obtained was low.
3. Al-15%Cu (hypereutectic) solidified directionally: the transition between a columnar and an equiaxed structure was observed. **The length of the zone with directed columnar dendrites was 38 mm long in the space sample and only 25 mm in the ground reference sample. This is thought to be due to the more stable conditions in microgravity with a reduced convection in the melt.**

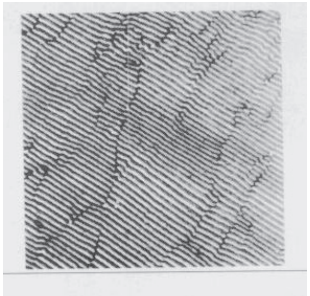
These were some of the first observations of the effect of the low gravity environment, on which later experiments have built their research.
Imaging capabilities have advanced tremendously since then, which is apparent from the images inserted here,from the 1977 experiments onboard TEXUS-1, when you compare to the MAXUS-8 images on p.6 and further Material Sciences images on p.8.

The experimental procedure was described as follows:
“Various samples were either processed isothermally in mirror furnaces (sample size : 7 mm diam., 12 mm length) or solidified directionally in gradient furnaces (sample size : 8 mm diam., 80 mm length).”

For comparison, present flights under the Sounding Rocket Programme fly X-ray and interferometry based imaging facilities, high speed video recordings, real-time interaction with the payload and storage of gigabytes of data if necessary. In 1977 the first desktop computer had not even been sold, it was not introduced as a commercial device until 1983.



Longitudinal section of the start of the unidirectional solidification in the eutectic AlCu sample solidified in Space. Magnification 40 X.



Transverse section 1.9 mm from the start of the unidirectional solidification in the eutectic AlCu sample solidified in Space. Magnifiction 1900 X.

This and much more you can find in the Experiment Archive of the Human Spaceflight Directorate, the EEA (click).

2 A eutectic system is a mixture of chemical compounds or elements that has a single chemical composition that solidifies at a lower temperature than any other composition. Not all binary alloys have a eutectic point. Source: http://en.wikipedia.org/wiki/Eutectic_system

Back to top

Outcome of the 2009 Research Announcement - 23 experiments in physical sciences and 39 in life sciences pass sciences merit and feasibility screening successfully

An International Life Science Research Announcement (ILSRA-09) was released last year in co-ordination with NASA, CSA, JAXA and the European national space agencies ASI, CNES and DLR. ESA in addition issued an invitation for biology experiments on sounding rockets, as well as a general invitation for physical sciences on ISS. Now a selection into the Elips Research Pool has been put together.

ESA's Directorate for Human Spaceflight solicits the best science possible via offering research opportunities to the scientific community. The evaluation process is independent of ESA via reviews performed by reviewers with the highest personal scientific merit in their respective disciplines, under the guidance of the European Science Foundation, ESF. Once recommended on the basis of scientific quality and a number of related criteria, experiment proposals of the best segment are forwarded to the international (between Space agencies), or ESA internal technical feasibility evaluation. Experiments passing this process successfully are then recommended for final selection.

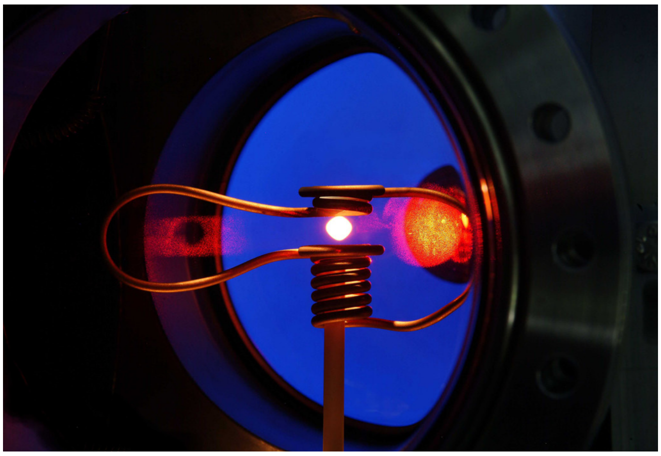
The selected-list for Physical Sciences (22 experiments) indicated in Table 1, below, also including which flight platforms would be foreseen for their implementation. One additional experiments needs further maturation before being selectable.

PHYSICAL SCIENCES

Table 1. AO 2009 **Physical Sciences** experiments and distribution on target platforms, in descending score order

Exp. Code	EML	MSL	SR	FSL or MSG	Non-ESA Facility	Name and Remarks
-1020	•	•	•			THERMOLAB-ISS, follow-on 1999-022
-918					•	PERWAVES
-1051	•					SISSI
1050					•	EUSO
-1082				•		CHYPI
-858				•		TRIMIX Merge w - 1056
-959	•					ICOPROSOL
-1056				•		TRIMIX Merge w - 0858
-1105		•	•			GRADECET
-1136	•					OXYTERM
-1000						PLASMALAB
-898	•					PARSEC
-1014				•		SELENE
-813				•		PASTA
-1153			•	•		DOLFIN-II, follow-on 2004-132
-894	•					LIPHASE
-943			•	•		COMPGRAN, follow-on VIP-GRAN
-1061				•		VIPIL, follow-on IVIDIL 2000-096
-1094		•	•			DIFFSOL
-1113						Topical Team for maturation
-829	•					NEQUISOL- III, follow-on 1999-023
-1055		•	•			LIPIDIS
-997				•		VILMA

Legend. EML: Electromagnetic Levitator, MSL: Material Science Lab, SR: Sounding Rockets, FSL: Fluid Science Lab, MSG: Microgravity Science Glovebox.

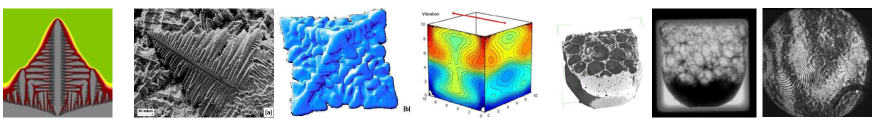


Seven projects are foreseen for the Electromagnetic Levitator (EML), see 2nd column in table.

Five of the EML experiments on the list represent scientifically the 'next logical step' based on earlier experiments. Four of these projects also require experiments that can be performed using ESA's Material Science Laboratory (MSL) onboard the ISS, see column 3 in Table 1.
Experiments typically represent several sub-experiments, and one frequently changing parameter between sub-experiments in materials sciences is the furnace temperature. As MSL is defined at present, only part of these new objectives can be served. The solution for the rest may be to utilise e.g. a furnace to be launched by JAXA in 2011, and further a Russian furnace is planned to be launched in 2013, that could serve two further sub-aspects of these experiments.

For aspects of X-ray diagnostics in materials samples, upgrading of the existing sounding rocket facility is in preparation by ESA. In this area still some work is to be done before an ISS facility can be defined.

Fluid Science: The last year onboard the ISS has seen experiments in fluid science performed in the Microgravity Science Glovebox, MSG. Eight new experiments would need a similar scenario, see column 5 in table 1. As MSG basically offers a volume in which one can mount equipment and perform experiments under double or triple containment, there is relative freedom to define the detailed equipment, as long as the given interfaces are respected. Such consideration is ongoing for the above experiments, but it is premature to identify any solutions for how eventually these will be performed.



Physical Sciences images obtained onbaord diverse ESA platforms, via use of state-of-the-art imaging techniques

Finally, a small number of experiments, suggest to use non-ESA facilities. An experiment that needs broad international funding of the equipment is no. 1050, which is related to the Extreme Universe Space Observatory or EUSO. Despite the high scientific merit of this experiment, the challenging implementation would be a truly international undertaking, involving all identified Space partners and funding plus flight segment resources from these.
Another experiment, no. 1000 PLASMALAB will be based on pre-development of the hardware by DLR. In the meantime ESA will in that area concentrate on the collaborative efforts undertaken for the PK-4 project, which is nearing development conclusion at this time.

ESA's Sounding Rocket (SR) Programme - a close collaborative effort in terms of missions with Germany and Sweden - is a frequent and highly successful programme. Eight of the listed experiments are identified for one or more SR flights, mostly as a precursor step for full implementation onboard the ISS. Four of these eight experiments can make use of the existing SR experiment modules for high temperature solidification or X-ray diagnostics. One further experiment will make use of the existing CDIC facility, see Newsletter January 2009 - that newsletter in addition gives a good account of some of the facilities mentioned above as well.

Conclusion

All in all 203 scientists from 25 countries in Europe, Russia, USA, Japan, China, Korea and India make up the science teams in the selected Physical Sciences projects.

LIFE SCIENCES

Preamble

ESA Life Sciences derives science proposals from three separate calls i.e. from the International Life Sciences Research Announcement, ILSRA-2009, from the special call for Biology research onboard ESA's Sounding Rocket platform, and finally under the specific invitation to submit proposals for Bed Rest Studies, AO-09-BR.
These three areas will be reported in the same sequence below.

ILSRA-2009

The 39 Life Sciences experiments result from a total of 148 received proposals. Of the 70 proposals receiving a science merit score of 70 points or more (of 100), 51 were European. Out of these, 39 passed successfully the scientific selection as well as the technical feasibility review.
Further, it has been agreed with the international partners, that as many as 15 of the 39 experiments may become subject to international cooperation regarding requested implementation resources.
All experiments are listed in Table 2. These will now enter a definition phase, which represents the process of matching the experimental requirements with diverse requested resources, such as number of repeats, total crew time needed, up and download to the ISS, etc.
Some of the experiments may still be eliminated during the definition phase, due to incompatibility with

ESA astronaut Frank De Winne, Expedition 21 commander, readies Portable Pulmonary Function System (Portable PFS) in preparation a breathing gas analysis experiment

available resources, even though the present assumption is that all in principle could be implemented in the 2011-2016 time frame. Unlike what is the case for the Physical Sciences experiments, no decision has been made yet regarding which carrier

Table 2. ILSRA-2009 Life Sciences experiments, in descending score order

Exp. Code	Flight	pre / post	Experiment Topic	LS Discipline
-1080	•		Bone & Muscle & Countermeasures	Bone & Muscle
-1102	•		OREOCUBE	Exobiology ??
-870	•		Global Tracking System for small animals	Navigation
-1135	•		Oxygen demands in Space	Cell and molecular biology
-966	•		Planarians regeneration in Space	Exobiology ??
-1047	•		Neurosciences and Perception	Neurosciences
-994	•		Cartilage morphology and biology	Bone
-1062		•	Neuroplasticity insight with NMI	Neurosciences
-834	•		BIOMEX - Biology and Mars	Exobiology
-890	•		PSS - Photochemistry on ISS	Radiation
-952	•		Extraterrestrial Geomicrobiology Package	Exobiology?
-1067	•		Endothelial cell-cell junctions	Cell and molecular biology
-1121	•		Immune system response to stress	Immunology
-398	•		Cytoskeleton dynamics and its regulation	Cell and molecular biology
-778	•		Radiation dose distribution inside ISS	Radiation
-801	•		Airway Nitric Oxyde in Space	Cardiopulmonary
-1001	•		Radiation effect,mutants in photosynthesis	Radiation
-976	•		Bone recovery and impact of exercise	Bone
-1048	•		Navigation and acceleration	Neurosciences
-1093	•		Straight ahead perception	Neurosciences
-836	•		Biofilm organisms on surface in Space	Microbiology
-1053	•		Extremophiles onboard the ISS	Radiation
-989	•		Reaching and Grasping	Neurosciences
-395	•		Circadian rhythm in humans in Space	Circadian rhythm
-932	•		Arabidopsis Thaliana, light and growth	Plant
-1142		•	Skin changes in Space	Tissue
-1149	•		Immune cell response, by new assay	Immunology
-1156	•		Cellular microarray for system's biology	Cell and molecular biology
-729	•		3-D Ballistocardiography	Cardiovascular
-1034	•		Bone turnover in early Space phase	Bone
-1026	•		Genome-transcription DNA damage in cell	Genetics
-860	•		Whole genome model - small fish	Genetics
-950	•		Space Headache - incidence and character	neurovascular
-1017	•		Osteogenic cells' response to low gravity	Bone
-1045	•		Immune system adaptation / re-adaptation	Immunology
-928	•		Lymphocytes and endocannaboid effets	Immunology
-1078	•		Stemcell research in Space	Cell and molecular biology
-922	•		Bone and muscle inflight density by qCT	Bone & Muscle
-873	•		Exercise, metabolic and cardiovascular	Cardiovascular

or facility would apply to each experiment.

AO-09 Sounding Rockets

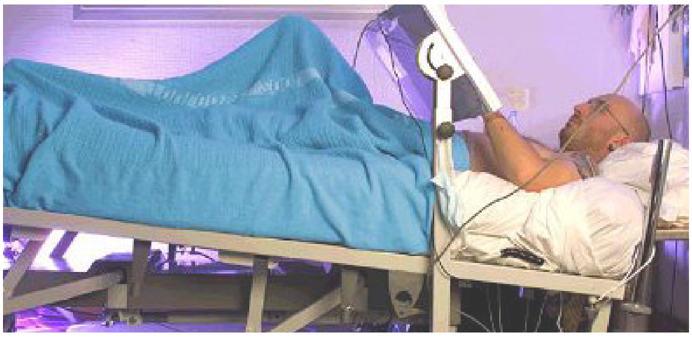
Four experiments in Biology have been identified for inclusion in the Sounding Rocket experiment pool. As is the case for the other experiment categories, a definition phase shall show if and how these experiments could be implemented. Only after definition studies have been finalised will a firm selection and flight assignment be decided.

Table 3. AO-09 **Life Sciences / Sounding Rockets** experiments, in descending score order

Exp. Code	Experiment Topic	LS discipline
SR-0910	Assay for role of cAMP in Euglena gracilis	Cellular and molecular
SR-0912	Gravitactic threshold in Euglena gracilis	Cellular and molecular
SR-1161	Cell viscoelasticity and gravisensing	Cellular and molecular
SR-1057	Effects of microgravity on Thyroid function	Endocrinology

AO-09-Bed Rest

Bed rest studies play a major role in elucidating mechanisms of physiological changes as a result of immobilisation or low gravity onboard spaceflights, as well as in developing improved countermeasures against them. This will be useful for current, and mandatory for future human space exploration.



ESA, typically in cooperation with European national space agencies or sometimes also non-European space agencies, has been conducting bed rest studies since many years.
On the basis of the first Bed Rest study phase, the bed rest programme was reorganised in 2005 creating a long-term strategic plan.
The selected experiments from the bed rest AO-2006 are now fully allocated to ongoing studies for which reason it is necessary to invite experiments for the next phase of bed rest studies.
In April 2009 a bed rest workshop was held to try to define the best strategy further. One of the outcomes of this workshop was the recommendation to study: (1) Resistive vibration exercises in combination with artificial gravity, and (2) Exercises with nutritional supplementation (whey protein + alkali salt) as interventions in two medium duration bed rest studies.
In total 29 proposals were received, of which 20 received a score of 70 points or more. The list of the 20 experiments from the 2009 AO, given in table 4 reflects this recommendation indicated above. A further definition study will now be initiated to decide which and how many of these experiments eventually can be implemented.

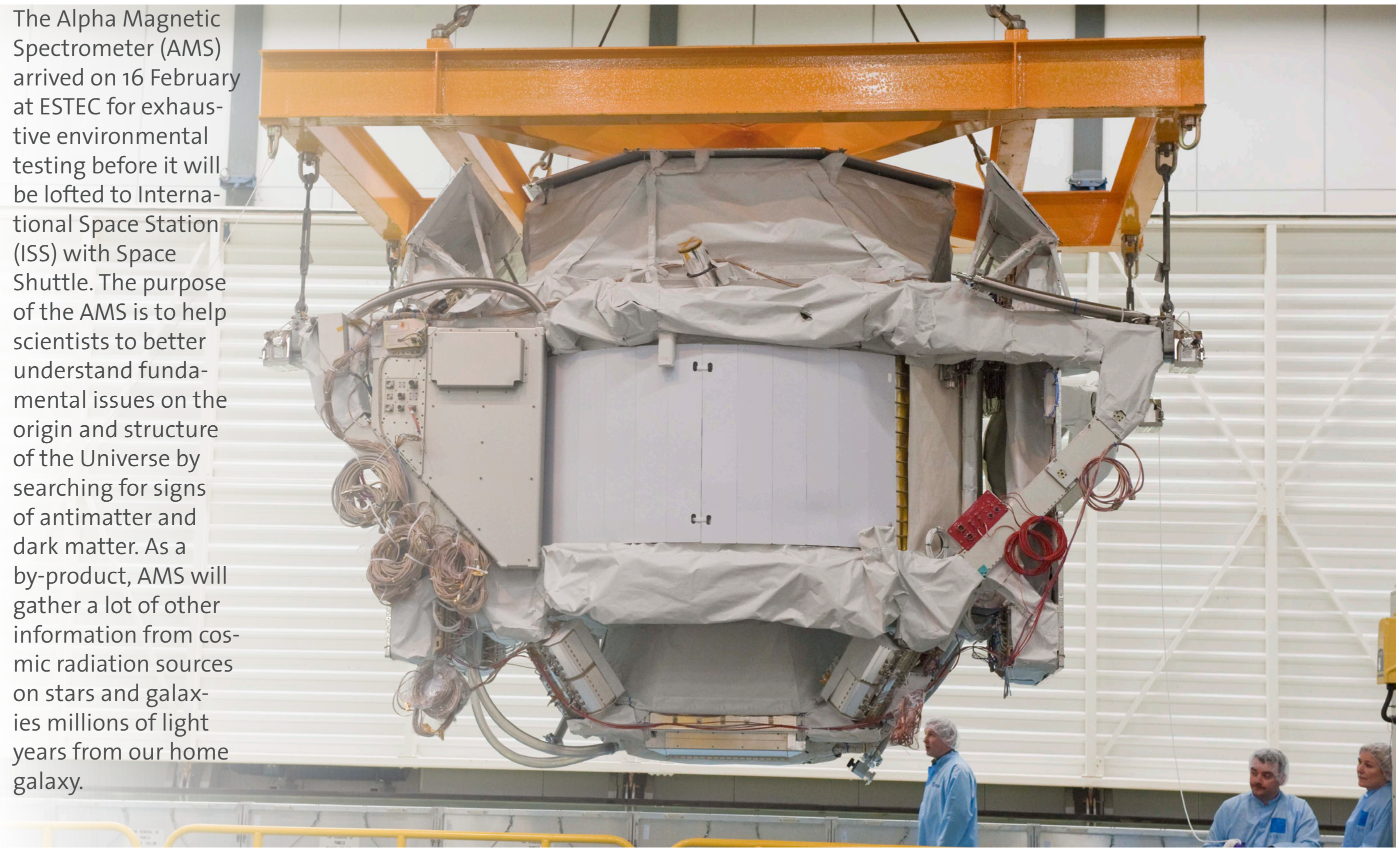
Table 4. AO-09 **Life Sciences / Bed Rest** experiments, in descending score order

Exp. Code	Experiment Topic	LS discipline
BR-0911	Heart rhythm and Bed Rest	Cardiovascular
BR-0913	Cardiovascular deconditioning	Cardiovascular
BR-0920	Artificial gravity and vibration	Bone and Muscle
BR-0968	Pro-and anticoagolatory effect of bed rest	Haematology
B R-0988	Effect of posture on glomerular filtration	Cardiovascular
BR-1015	Cardiovascular effect of bed rest	Cardiovascular
BR-1033	Mechanisms of post-ambulatory bone loss	Bone
BR-1119	Remodelling of microcirculation in bed rest	Cardiovascular
BR-1148	Neuro-physiologic control functions	Neurosciences
BR-1164	Response to orthostatic stress after bed rest	Cardiovascular
BR-1165	Bone quality by use of 3D HR-qCT	Bone
BR-0446	Automated echocardiography	Cardiovascular
BR-0880	Exercise and gas exchange kinetics	Cardiopulmonary
BR-0882	Metabolic gene expression against atrophy	Muscle and gene
BR-0884	Differential atrophy and countermeasures	Bone and Muscle
BR-0995	Cartilage morphology and biology	Bone
BR-1158	Artificial gravity against metabolic disorders	Metabolism
BR-1043	Muscle stiffness and tone	Muscle
BR-1087	Structural and biochemical properties of muscle	Muscle
BR-1117	Effects of nutritional supplementation	Nutrition

Conclusion

All in all 485 scientists from 25 countries in Europe, Russia, USA, Canada, Japan and Korea make up the science teams in the selected Life Sciences projects.

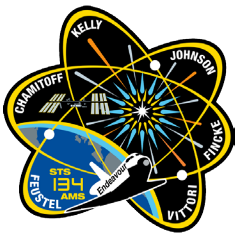
Back to top



The Alpha Magnetic Spectrometer (AMS) arrived on 16 February at ESTEC for exhaustive environmental testing before it will be lofted to International Space Station (ISS) with Space Shuttle. The purpose of the AMS is to help scientists to better understand fundamental issues on the origin and structure of the Universe by searching for signs of antimatter and dark matter. As a by-product, AMS will gather a lot of other information from cosmic radiation sources on stars and galaxies millions of light years from our home galaxy.

Courtesy of ESA / Anneke le Floc'h

A future exceptional ISS payload at ESTEC Testing Facility - the Alpha Magnetic Spectrometre, AMS-02



STS-134 Mission patch

Twelve years further

Onboard Space Shuttle Discovery on its STS-91 flight in 1998, the first version of the AMS, the AMS-01 was flown, in the form of a 3 tonnes heavy space science payload assembly. It was looking for answers to the questions "Why did the Big Bang make so little antimatter"? and "What makes up the Universe's invisible mass?"
Data were recorded 30 hours before and 105 hours after the rendezvous with the Russian Space Station MIR.
Now Space Shuttle STS-134 will bring next generation of the AMS to the ISS where it was planned to be active for three years, with a newly developed super-conducting magnet (SCM). Recently, however AMS has been given the opportunity to stay until at least 2020 due to the ISS utilisation extension. Due to this extension, it was realised that the total physics potential of AMS would be increased by an exchange of the magnet.

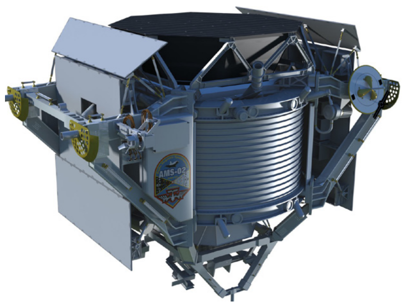
The AMS magnet and Helium

Due to the need to the intended use of a super-conducting magnet, AMS-02 had to be kept cool at cryogenic temperatures. For this reason superfluid helium (He) is used to cool it to just above absolute zero, namely to 1.8 Kelvin. Helium solidifies - or freezes - at 1-1.5 K.
AMS-02 was supposed to carry 360 kg of this ultra-cold liquid helium in order to make the project involving the super- conducting magnet arrangement possible. Over the three years on ISS, the helium would keep the super-conductor cold. And in that process it would slowly evaporate and be used up.
The needed low temperature represents a considerable practical problem regarding choice of a suitable insulation concept. For this reason, the helium/magnet assembly sits in a large vacuum enclosure.

> Says Simonetta Di Pippo, ESA Director of Human Spaceflight. "For all AMS represents to me as a physicist, as the responsible for human spaceflight in Europe and as European citizen, I couldn't wait to see it coming through the ESTEC gate, undergo the testing and head towards Kennedy Space Center to find its place on Shuttle and later on the ISS."

The AMS-02 testing

The Alpha Magnetic Spectrometer was transported by slow road transport from CERN, Switzerland to ESTEC in Noordwijk, the Netherlands, arriving on 16 February. It was the intention, when the testing had been completed at ESTEC, that AMS would be flown directly to Kennedy Space Center in Florida for start of the Shuttle integration programme for launch on



Drawing of entire AMS structure, see box 2 for details.
Source: http://ams-02project.jsc.nasa.gov/index.htm

STS-134.

Testing at ESTEC's Large Space Simulator (LSS)

At ESTEC AMS-02 was placed in ESA's thermo-vacuum chamber that simulates space vacuum, in order to test the payload's capacity of exchanging heat, necessary to maintain its thermal balance, which is essential to the functioning of the electronics.
The Large Space Simulator, located in ESA's research and technology centre ESTEC in Noordwijk, is used to test satellites and spacecraft before they are sent to space. The large vacuum chamber, complete with bright Sun and walls cooled by liquid helium, can reproduce conditions in open space with high reliability.

Even if the Large Space Simulator has seen all kinds of space hardware, the AMS payload has been something special: It is not only the biggest scientific instrument to be installed to the ISS, but also the largest magnetic spectrometer in space.

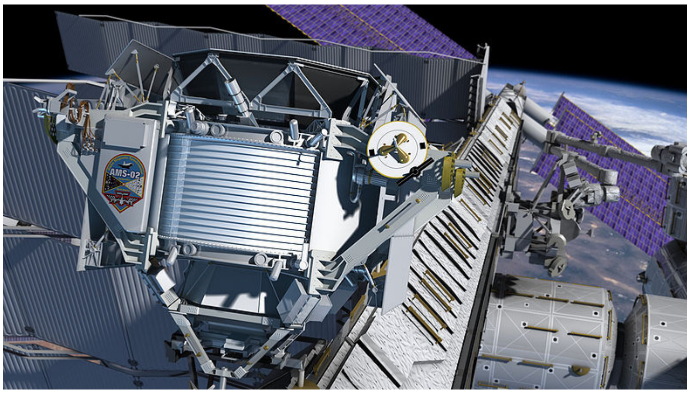
How AMS was built

The AMS detector has been built mostly by European institutes in Italy, France, Germany, Portugal, Spain and Switzerland together with the participation of China, Russia, Taiwan and US. It has been integrated at CERN, where the collaboration has built and operated a special facility. Starting 4 February 2010 until its departure for ESTEC, the detector has been exposed to a comprehensive scientific performance verification test at CERN's Super Proton Synchrotron accelerator, to check its momentum resolution and its ability to measure particle curvature and momentum. Those are some of the most central issues to be mapped by AMS-02.

With over 300,000 data channels, the detector gathers an extremely large amount of data which is then processed and sent to Earth utilising the ISS power, communication and data infrastructure.

After the ESTEC tests, AMS-02 has been back at CERN since 27 April, for a major refurbishment, however: It was concluded by the science team that the super conducting magnet will no more be the best solution, due to the limited lifetime of the helium cooling system and the additional new decision regarding the life time extension of ISS.

AMS testing revealed a likely lifetime of less than 3 years. And in addition, the recent extension of the ISS life time until 2020, has made the decision for going for a permanent magnet logic: The 360 kg Helium would have been used up within a 3-year time frame, whilst AMS now can stay onboard the ISS for 10 years.



A computer generated image showing AMS-02 mounted to the ISS S3 Upper Inboard Payload Attach Site.
Source: http://ams-02project.jsc.nasa.gov/index.htm

How well will the Permanent Magnet work?

The impact of using a permanent magnet (PM) as compared to a super-conducting magnet (SCM) is primarily the field strength. The SCM is 5 times stronger than the PM, which has been the primary motivation for choosing for a SCM. The stronger magnet bends the trajectories of the passing particles more, thereby making the determination of particle characteristics simpler. This problem can be handled by moving the last tracker in the row a bit further out in the length axis of the structure, which on the other side has a construction impact, leading to changes in the overall support structure of the AMS. Overall this approach solves the problem with the weaker magnet almost entirely, in particular when considering the PM scenario having now a 10-year lifetime instead the 3-year SCM lifetime.

On May 21 the permanent magnet from AMS-01 arrived at the CERN integration facility, ready to built in and testing was completed end of July.
AMS-02 has been shipped ship directly to NASA Kennedy Space Center, Florida,

What is AMS?

AMS is a particle detector for the International Space Station.

AMS detects high-energy particles of many types (collectively called "cosmic rays"), many of them originating in supernova explosions in distant galaxies, using a huge superconducting magnet and six highly specialized, ultra-precise detectors.

It will sit on the ISS main truss - far above the obscuring atmosphere, and making full use of the ISS's irreplaceable support systems - and gather data for ten years.

AMS is a major cosmology experiment.

AMS will observe the properties of electrons, positrons, protons, antiprotons, and nuclei in high-energy radiation from space, which-may answer important questions about the Big Bang, including "Why did the Big Bang make so little antimatter"? and "What makes up the Universe's invisible mass?"

AMS is a major particle-physics experiment.

Some types of particles - predicted by theorists, and searched for in collider experiments - may be present already in cosmic rays. AMS may observe them, thus learning about the particles themselves as well as their distant astrophysical sources.

AMS is a manifestly international, cooperative project.

Like the Space Station itself, AMS is possible only due to pooling of experience and knowledge between nations. The AMS collaboration involves over **200 people from 31 institutions and 15 countries**.

Source: http://cyclo.mit.edu/~bmonreal/frames.whatisams.html

Box 1

AMS-02 integration activities at CERN/Geneva, Switzerland

The magnet enables AMS to measure a particle's momentum and the sign of its charge. In free space, every particle tends to travel in a straight line; in a magnetic field, a charged particle prefers to move in a circle. The curvature of the particle through the magnet tells you the momentum divided by the charge, including the sign (positive or negative) of the charge. The magnet is the only tool that can separate positive from negative charges; it is the only tool for identifying antimatter.
Source: http://cyclo.mit.edu/~bmonreal/frames.det.html
Image courtesy of the Massachusetts Institute of Technology, Cambridge, MA

AMS from top to bottom ....

→ On top of AMS, **a transition radiation detector** tells us the velocities the highest-energy particles.

→ The **silicon tracker** follows a particle's path through the instrument.

→ A **superconducting magnet** makes the particle's path curve.

→ **Two time-of-flight counters** tell us lower-energy particles' speeds.

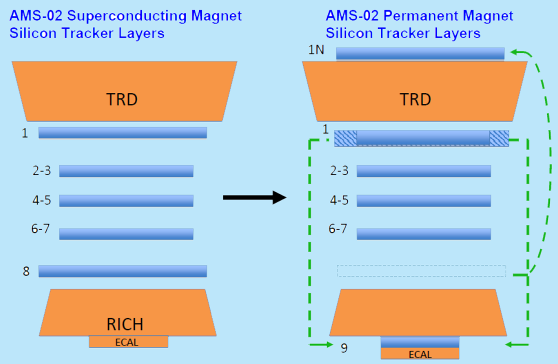
→ **Two star tracker cameras** measure AMS's orientation in space.

→ Underneath AMS, **a ring-imaging Cerenkov detector** makes an extremely-accurate velocity measurement for fast particles.

→ Some particles crash violently into **the electromagnetic calorimeter**, which measures their energy and type.

→ An **anti-coincidence veto counter** notices stray particles sneaking through AMS sideways.

Source: http://cyclo.mit.edu/~bmonreal/frames.det.html



Layer 9 comes from moving the ladders at the edge of the acceptance from layer 1. The layer 8 is moved on top of the TRD to become 1N.

Box 2

on 26 August onboard a C5 Galaxy aircraft from the US Airforce. At KSC final testing and preparation of the integration of the payload into the cargo bay of the Shuttle Endeavour will take place from beg inning of September.

In order to absorb the time impact of a so profound modification of the facility, that in turn will lead to a new round of documentation update and test and approval cycles, the STS-134 launch now has been postponed to not earlier than 26 February 2011.

The work onboard the ISS

Once docked to the ISS, AMS will examine fundamental issues about matter and the origin and structure of the Universe directly from space. Its main scientific target is the search for dark matter and antimatter, in a programme that is complementary to that of the Large Hadron Collider, a 27 km diameter tunnel more than 100 metres below the land surface in the area related to CERN, between Switzerland and France. CERN will be the detector control centre and will be supported by a number of regional physics analysis centres from collaborating institutes.

Nobel laureate as team lead

The AMS experiment is led by Nobel laureate Samuel Ting of the Massachusetts Institute of Technology (MIT) and it involves an international team composed of 31 institutes from 15 countries. ESA's partner in the AMS collaboration is the Agency's Directorate of Human Spaceflight.

Back to top

Bedrest with Artificial Gravity - What is that?

ESA has performed a number of bed rest studies over the last decade. These are crucial as simulation studies of the real Space travels, as well as for general public health.
Artificial gravity using a human centrifuge will study the effect of occasional gravity loading in this manner, on the detrimental effect of bed rest - as a simulation of Space

How does it all fit together?

When gravity is gone, as realised onboard the International Space Station and other Earth or planet orbiting vehicles, strange things happen to the human body. And the longer the exposure, the more pronounced these changes appear to be.

Long term missions onboard the ISS now routinely have activities planned almost every day with the objective of limiting the - mostly negative - effects of lack of gravitational influence on the body.
Gravity in normal life is synonymous with 'loading'- not that we always subjectively register it as such, but let us take the example of getting up every morning. After a night in horizontal position, we need to mobilise muscles and directional control to get up. Once up and functioning again, we mostly forget that we are loaded.

In Space, the term 'getting up' - if there is such a thing, as there is no 'up' and 'down' onboard the ISS - is trivial and almost meaningless. It consists of opening the eyes, looking around, releasing one self from what has been used to strap one down to the sleeping place in order to avoid floating around the ISS and bump into things while sleeping.

Such is the reality without gravity, but is not all to be taken lightly. The lack of loading of the muscles and skeleton over time leads to decay of these, normally very active tissues, and that is why astronauts have a strict exercise plan, that has the simple objective of loading the body 'artificially' as natural gravitational loading is not available.

This is where artificial gravity comes in, but now in a more sophisticated form, namely via the use of a human centrifuge.
We all know the scenes from testing of fighter pilots where they are spun up to the magic level of 9 g, which is the order of magnitude that a fighter pilot would naturally experience in the most extreme dog fight situations. Nine g is a lot, and most humans will not last long under that regimen without passing out. That effect is mainly due to loss of conscience because the circulation is not able to maintain the minimally required blood pressure to perfuse the brain.
What we talk about in artificial gravity is something quite different, however - we try to mimic normal gravity of 1 g, as in 0-g the heart has plenty to work with and where we actually would need to pull a significant amount of the fluid in the body back to the legs and regions under normal heart level where it comes from.

So what is the larger perspective?

When we move around on Earth leading a reasonably active life, our body is in a sort of status quo, there are not the great changes to our muscular capacity and bone strength when seen on average over a longer time. Our organism has adapted to gravity during evolution such that we are in balance.
On a long term Space mission as indicated, we need to re-create this normal loading. This can be done using different exercise machines, but that is only partly solving the problem. All the rest of the body, that cannot 'exercise' still gets only a limited stimulus, such as the balance organs, and the blood circulation in general.

Bed Rest Studies and now a centrifuge

ESA has performed several long term immobilisation studies - bed rest studies - as a model for what happens in Space. We have found mostly what we were looking for, in the form of a reasonable representation of the symptoms in real Space. On that basis we can also now investigate, how much it would take to counteract these appearances in these studies, and the centrifuge is there a very interesting tool.
The Space agencies have long known of this option, and ideas of how to place such a centrifuge onboard a Space craft are plentiful, although the practical aspects till now

have been prohibitive.
Now we take the step in this direction, by applying it on individuals that are exposed to a reduced g-regimen in bed rest in order to investigate the real value.

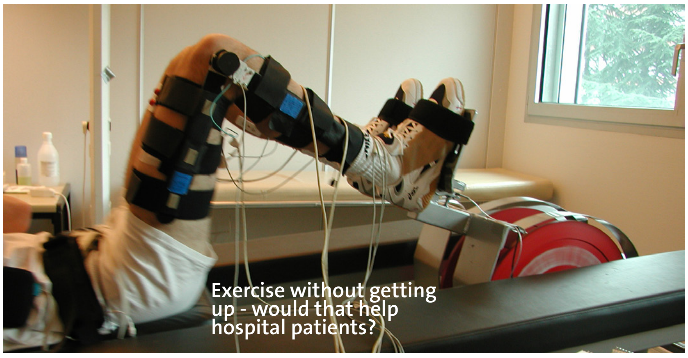
Activity profiles with the centrifuge

Many hours are spent exercising onboard the ISS for staying in a minimally good shape and to counteract the negative effects of weightlessness, but maybe a lot of these hours could be saved?
It is the intention to try finding out how little or how much time spent in such a centrifuge, still with the test person in physical horizontal position, would be enough to counteract what we see of decay in bed rest studies without exercise or any other countermeasure.
The advantages of the centrifuge stimulus are assumed to be significant: The entire body would be exposed to something that would resemble normal gravity for shorter or longer time, so the model is a more complete g-exposure than is any exercise model. It would however have to be assumed that exercise would still be necessary, but on a future mission to Mars, one could benefit markedly overall from having a centrifuge onboard.

Artificial Gravity and Bed rest scenarios

Under a new strategy for simulation studies, that was laid down by ESA originally in 2005 and which is planned to be revisited early 2011, a sequence of bed rest studies has been planned, following a logic, that was decided in terms of which direction to go.
Bed Rest studies are fairly complex arrangements already, due to duration, logistics and personnel needed, but implementing certain interventional variables, such as exercise or as here artificial gravity, have the additional practical effect that only very limited scenarios can be used in one and the same study, in order to give clear results. This is because certain regimes are counteracting each other in terms of expected effect, such that those cannot be accommodated in one study, but will need to be done in separate studies. It is therefore crucial that the right decisions are made in terms of which regimes, e.g. exercise, artificial gravity, Lower Body Negative Pressure (LBNP) or other known countermeasures, are chosen to be the leading investigation topic for a particular study. And that in turn will define a limitation to which other investigations will fit into one specific study.

The strategy laid down in 2005 defined a shorter duration study with artificial gravity to take place in 2010, as a forerunner for a longer duration study later. Further, another study planned for 2010 is looking at the difference in effect between upright exercise and standing during the same period on bed ridden test subjects.


Exercise without getting up - would that help hospital patients?

In 2011 two studies will look at the potential interaction between nutrition and exercise in a bed rest regimen, and on the effect of special food supplements regarding also the importance of the pH of the blood, respectively. The latter is specifically relevant for the effect on bone tissue, whereas the first as much is concerned with muscle tissue.

For execution in 2012 a similar set of two studies are planned, this time with focus on the longer term artificial gravity and a bed rest (21 days presently planned) and on the interaction of exercise and artificial gravity.

In this manner ESA will perform a well planned series of studies that will advance our understanding of the mechanisms involved when Space crews are onboard long term Space missions.

Flight scenarios on a mission to Mars

Flights to Mars have one crucial particularity next to a host of others, namely that Space crews will be self consistent for as long as more than 500 days and even will have to stay in good shape overall, in order to be able to help themselves when landing on Mars.
Reality for crews having lived onboard the ISS is, that travel from the ISS to Earth can be as short as a few hours, whereas the travel back from Mars may be in the order of 250 days. When landed, coming back from the ISS, a comprehensive support arrangement is in place to cater for all eventualities in terms of expected and unexpected problems, whilst this obviously will not be the case when landing on Mars. On Mars there will be no welcome party, which gives so much more reason to do all necessary efforts to ensure that these crews will be in optimal state when getting there.

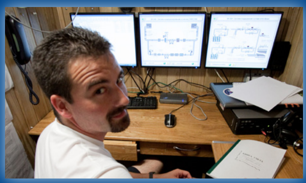
Importance for life on Earth

All the activities undertaken in the context of bed rest as a simulation of spaceflight have a potential importance for life on Earth.
Even though it is intended as simulation of spaceflight, bed rest evidently is an immobilisation form that millions of people experience every day on Earth in many sickness related or ageing situations. The studies that space agencies undertake are complementary to other clinical studies and are conducted after the same high standards. Outcomes of these studies are occasionally changing the textbooks on human physiology, as Space related studies often ask very specific questions, not normally relevant to 'Earthians' and above all the experience from these studies is an important complement to more standard clinical studies undertaken by research and hospital units.

Back to top

UPCOMING TOPICS:

Mars-500 3 months downstream



The international 7 person crew entered their simulated Mars journey on 03 June 2010. On 11 July the transfer flight to Mars has started and it will last till beginning of December 2010. During this time real time communication will change to communication with significant delay due to the distance Earth-Mars.

Partial Gravity Parabolic Flight Campaigns

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 potentially a full campaign with levels of 0.16 g for approximately 23 s and 0.38 g for approximately 30 s. Lunar and Martian gravity levels are in preparation of the Martian future reality for technology and crews.

The Concordia Antarctic station to exchange crew and science programme

ESA is participating in the Concordia Antarctic station with one crew member selected by ESA in collaboration with the French Polar Institute. Applications could be submitted until April 2010. Interviews took place in August and the new crew should optimally be selected in time for the pre-departure meeting early October.

Meanwhile, at Concordia Station, a new cold record was registered on 14 July 2010, of -84.6°C! (The circle encompasses the Concordia area).

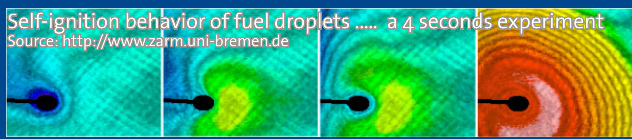
(Map borrowed from "A Vision for European Astronomy and Astrophysics at the Antarctic station Concordia, Dome C In the next decade 2010-2020". Visit http://www.concordiabase.eu/

Soyuz flight with ESA astronaut Nespoli onboard

Currently slated for a December 13 launch, ESA astronaut Paolo Nespoli will fly 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 6 months, identified as the Expedition 26 crew.

Drop Tower ZARM in Bremen exists 25 years

Six to twelve minutes on an ESA sounding rocket, 20 seconds onboard an Airbus A300 and 4 seconds free fall in the ZARM drop tower - those are the options when performing 0-g experiments with ESA on Earth. ZARM offers excellent facilities for short duration 0-g experiments.



Self-ignition behavior of fuel droplets ..... a 4 seconds experiment
Source: http://www.zarm.uni-bremen.de

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: http://www.esa.int/SPECIALS/HSF_Research/SEM1JV4KXMF_0.html

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Back to top