# Human Spaceflight

# SCIENCE NEWSLETTER

FEBRUARY 2009

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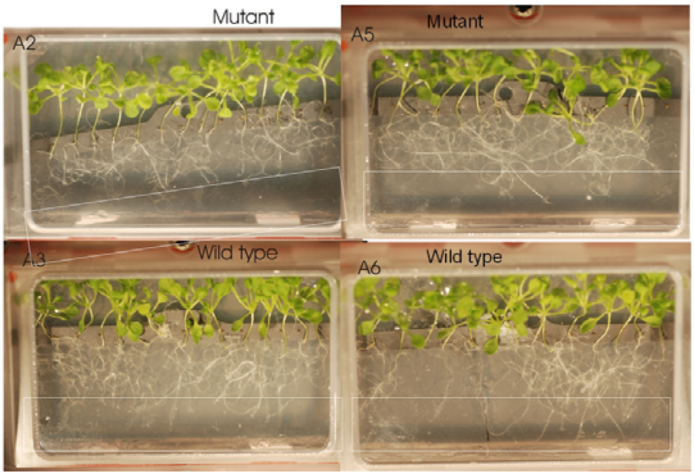
editor: B. ELMANN-LARSEN, ESA/ESTEC-HSF-US



# WAICO-1 – How the 'Waving and Coiling' experiment developed onboard the ISS

(Science Team: G. Scherer, University of Hannover, Germany)

All A-Boxes growth in µg, recovered from orbit, fotos in Hannover (watch difference in quality as compared to fotos from astronaut)




WAICO-1 was flown early 2008, as the first experiment to be performed in BIOLAB. The experiment was awaited with excitement but unfortunately technical problems in the early phase indicated a not perfect experiment run. Photos could not easily be taken as planned, due to moisture building up on the inside of the incubator door, and the planned fixation of the plants at the completion of the experiment could not be performed. Instead the plantlets were 'parked' in a dark, cool place in order to stop further growth. In this state they were finally returned to Earth and the originating scientist.

A disastrous and failed experiment, it seemed. However, the scientist has put together a report with surprisingly positive results, which may lead to a new angle to the underlying research question.

## Background

The WAICO experiment has as scientific objective to study the effect of gravity on the growth pattern of plant roots, in this case of Arabidopsis thaliana (tale cress), the most used model system in plant biology, see also earlier Newsletters.

On Earth a standard test to examine the growth pattern of Arabidopsis roots is to germinate the seeds on a flat surface with an inclination of about 45 degrees to the horizontal. Under such conditions, when the roots are not allowed to penetrate the soil, they exhibit a characteristic waving pattern. When the same experiment is repeated with a mutant of Arabidopsis, where a specific gene believed to be responsible for gravity-sensing has been made non-functional ('knocked-out'), the root growth is modified into a more coiling pattern.

In short, these experiments hint that the final 'waving' pattern is a result of the interaction between the inherent (endogenous) 'coiling' pattern and the effects of gravity, mediated through the gravi-sensing elements of the roots.

A natural follow-on experiment is therefore to test this hypothesis in a weightless environment on board the ISS, to study the waving and coiling behaviour of both the 'wild-type' natural variant and the mutant Arabidopsis. And this is exactly what the WAICO-1 experiment intended to do.

The experiment hypothesis of WAICO-1 was that,

- If the coiling of the roots increases, this would indicate that the endogenous processes which drive coiling become dominant, as the gravity influence is reduced to zero, basically.

– If the roots grow straight, this would suggest that the gravitropic stimulus provides a dominant input to the coiling process (as a profound change seen when it is gone). This would be interpreted as the coiling process is not endogenously driven, but dependent on gravity.

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ESA astronaut Hans Schlegel assembling the BIOLAB incubator that houses the WAICO experiment

### How the WAICO-1 flight experiment: was designed

The WAICO-1 experiment was using 8 containers (like the one depicted in the photo above) that fit in the BIOLAB facility on the ISS. The contents and location of the containers are chosen such, that both the 0g and (through the BIOLAB centrifuge) the 1g condition can be tested for both the wild-type and the mutant Arabidopsis variant, with, for statistical and redundancy reasons, 2 containers for each condition. Apart from insertion of the containers in BIOLAB, the taking of high-resolution pictures and the storing of the containers in a conditioned environment at the end of the experiment, all other actions are performed automatically by BIOLAB. This includes the conditioning of temperature and humidity levels, regulating the day-night light cycle, setting the centrifuge parameters and taking automatic pictures of the growing plants, as well as the final fixation of the plants at the end of the experiment.

While the initial steps of WAICO-1 worked well, it became soon clear that more humidity was condensing on the container windows than expected, thereby obscuring a bit the automatic pictures. This was not a major science set-back, but did handicap the real-time monitoring of plant growth. What was more unfortunate was that, after an otherwise more or less nominal experiment execution, the final fixation step of the plants could not be performed. Whereas this was a real set-back, it was decided in discussion with the science team that nevertheless 4 containers would be taken out of BIOLAB and stowed at low temperatures in order to preserve the experimental results as much as possible. These unfixed containers were then transported back to Earth with the next Shuttle flight and handed over to the science team for further analysis in the laboratory.

### Preliminary WAICO-1 results

While of course the condition of the samples upon return to the laboratory was not as optimal as planned, still some scientific analysis could be performed. This analysis focused on a photographic analysis of the plants and roots obtained during the flight. From this analysis, the following features emerge:

- The difference in growth between wild type (WT) and mutants (M) is less obvious in the 0-g samples than in those that have grown in 1-g, but not absent either.
- The plants in 0-g give longer stems than in 1-g.
- The roots appear more branched in 0-g than in 1-g, in particular for the mutant type.

- The difference between wild-type and mutants grown under 1g can be seen as having longer stems and smaller leaves. In micro-g however, this difference is not seen, but leave size is basically similar in WT and M.

These results seem to indicate that gravity has an effect on both the wild-type (expressed in stem and leave sizes) and on the mutant type Arabidopsis (expressed in root growth pattern). This might even constitute an example of gravimorphogenesis where plant morphology is directly influenced by gravity.
Of course, further experiments are needed to verify these potentially exciting results. Luckily, a second run of WAICO was already foreseen. Based on these findings, the experimental protocol for WAICO-2 has been significantly adapted in order to confirm the WAICO-1 findings in a controlled way. At the same time, some hardware modifications have been introduced in the WAICO containers and Biolab itself in order to avoid some of the technical issues in WAICO-1. WAICO-2 will be carried out in spring 2009.

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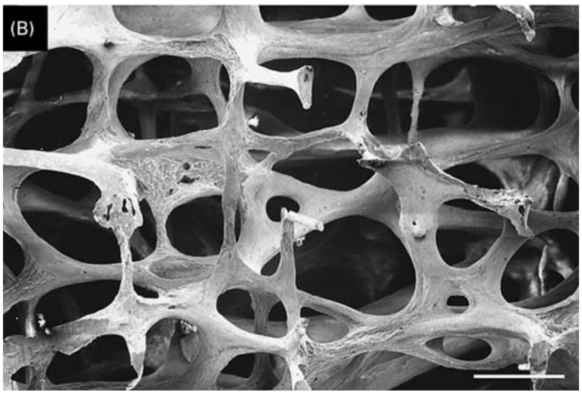
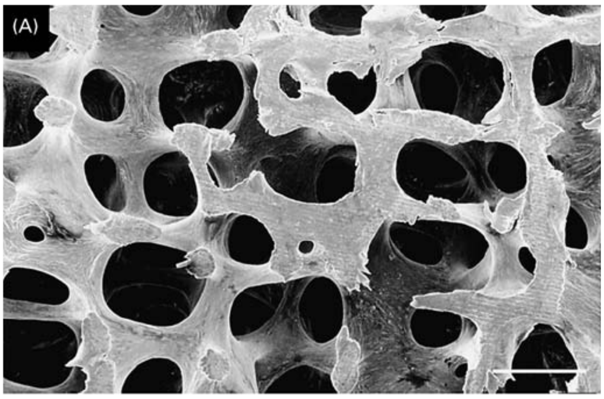



Above: A segment of a vertebra from a 71-year-old woman (with osteoporosis), as it looks after all soft tissue has been removed.
Below: A similar segment of a vertebra from a 31-year-old woman (healthy), Note the thickness-difference of the beams (trabeculae) and the fragility of the trabeculae in the top image. Courtesy of Tim Arnett (2)




# SALT LOADING IN MICROGRAVITY (THE SOLO EXPERIMENT) – WHAT DOES THAT HAVE TO DO WITH BONE HEALTH?

(Science Team: M. Heer, DLR, Cologne, Germany)

Astronauts loose bone mass in Space - that is old news in a way - but the mechanisms behind this detrimental phenomenon are complex – very complex.
It has been studied under normal gravity conditions whether special diets would be an effective therapy against bone loss, but this did not lead to significant results.
There are, however, serious reasons to suspect that nutrition for some reasons is more important when we are in a weightless environment. This is one of the central themes that is addressed in this SOLO experiment, in which a very accurate account of the diet, particularly salt intake and excretion, are being monitored.
Salt intake is known e.g. to be linked to development of high blood pressure – hypertension - but how can it have an effect on the amount of calcium we loose from the skeleton?
The scientists behind the SOLO experiment have an intriguing theory, based on recent exciting findings – and on some very old ones!

## Earlier experiments and how the idea was created

It actually all started with the investigation of how the body handles large amounts of salt, a continuation of experiments in Space that started as early as 1993 onboard the Spacelab D2 mission. At that occasion the first experiments were done investigating whether there would be a difference between Earth and weightlessness, in the way the body handles infusion into the blood stream of two liters of isotonic[1] saline fluid.

While this experiment mainly focused on how the circulation and the kidney respond to this overloading, related salt experiments gradually entered different experiment regimes. In one 'milestone' short term bed rest study beginning in 2001, the response to different levels on food intake was tested in bed rested and ambulatory test subjects.

[1] Isotonic = same concentration as in the human body. The definition says: ...of equal tension, i.e. the resulting pressure attracting of driving water across a semi permeable membrane is zero. This quality is obtained with 0.9% NaCl (natural salt) in demineralised water, relative to the red blood cells in the circulation. Large amounts of isotonic saline can therefore be infused into the blood stream without hazardous effects. The kidney will take care of the increased volume by excreting more of both NaCl and water.

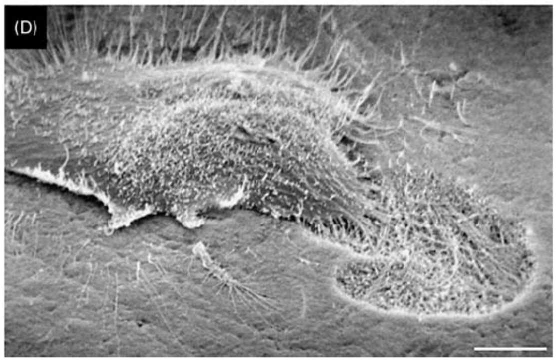
Based on findings from that study, a further salt concentration intake manipulation study was constructed, also with the two basic situations, bed rested[2] and ambulatory, but now varying the salt intake from under-normal concentrations to several times normal concentration. In both studies, markers[3] in urine and blood for bone metabolism were monitored.

According to classical theories regarding response to excessive intake of salt, the body should as an effect retain large amounts of water, in order to keep the salt concentration in the circulation constant, i.e. by thinning the blood so to speak – more salt would need more water, in order to maintain the same concentration. And this would be registered as a rapid increase in bodyweight, as an effect of reduced water excretion via the urine.

## Salt intake, water retention and acidity

In the mentioned - extremely well-controlled - metabolic study[4], the expected water retention did not happen, and that was the point where detective work was triggered, to find out – as the salt concentration in the blood seemed stable in these excess experiments – where the salt then could have gone. It was assumed that the salt would be bound in an inactive form, so that it would not act on the body water balance, as it apparently didn't.

A number of old findings helped in trying to unravel this research 'mystery'. The first related to the finding that acidifying the blood, via the type of food ingested (studies in 1918 and forward), leads to bone loss in test animals. The second was that increased salt excretion as an effect of increased salt intake, is accompanied by an increase in calcium excretion from the body in the urine (a 100 to 1 relationship – 1 unit calcium lost for every 100 units salt excreted). These two findings stimulated a renewed focus on the acidity issue, in an attempt to find out which role exactly salt would play in that context.[5]



Scanning electron microgram of an acid-activated osteoclast ('bone eater') on cultured cow bone. Scale 10 microns (10/1000 of a mm). Courtesy of Tim Arnett, (2)

The role of the acidity (pH) of the fluid around the bone has gained new attention over the last 3-4 years. Good quality studies demonstrate that even quite minor pH changes have dramatic effects on bone break-down (bone resorption). Would salt, therefore, have an effect on acidity of the fluid, or of the blood? If so, salt could be seen as a mediator of the initiation of bone decay. On the other side, if it could be

[2] Bed rest studies have for a few decades already, been used as a way to simulate in particular the fluid redistribution in the body, that takes place in weightlessness (in Space). But in addition, many other factors, such as lower energy demand and off-loading of the skeleton are consequences of the horizontal position, which in turn can be used as a test bed for such phenomena.

[3] 'markers' in urine are in principle the waste product of a certain chemical process in the body - the left-overs that are excreted into the urine. The waste products are – under certain conditions - 100% specifically related to one particular process. So when a certain compound or waste product is found in the urine, one can say that e.g. bone break-down has been taking place in the body.

[4] In metabolic studies flown by ESA, pioneering work has been done regarding demonstrating the crucial importance of controlling the essential variables with the highest accuracy. This is done by applying strict dietary regimes to the test subjects. It started in the early studies with a strict control of salt-intake and balance (Norsk et al.), and this present SOLO study (Heer et al.) profits from the very high accuracy standard this group is known for. Without this, experiments are often useless and give no clear results.

[5] The complexity in bone metabolism is the large amount of factors that can influence it on diverse levels; this mentioned acidity is just one, but probably one of the more effective ones, as we might find out.

demonstrated that salt indeed acidifies the arterial blood, this would be an indirect proof of this effect of salt intake.

### Ground experiments preceding the flight

The SOLO group recently conducted a study on the ground (3), testing if indeed arterial blood would become acidified by intake of increasing amounts of salt. They could in fact very elegantly demonstrate that salt intake in excess did have a significant – albeit minor - impact on acidity levels, such that on average the pH in the arterial blood was lowered to a level, which would be considered sufficient for stimulating initiation of bone resorption (2).

This effect was demonstrated as an increase in calcium excretion in urine, with increasing levels of salt intake. That the calcium indeed seemed to originate from the break-down of bone was supported by other indicators – markers - in urine. But how salt in particular effectuates acidification of the blood is still to be understood. Above all, however, an even light acidification of the arterial blood does indicate that the acid potential - the $H^+$ ions that need to be neutralized chemically in order not to change pH downwards – is not sufficiently neutralized in cases of high salt intake.

### Importance and effect of pH changes in the body

Normally $H^+$ ions are buffered out, i.e. neutralized via several systems. pH buffering is a central physiological parameter, well understood overall and crucial for the functioning of the body. When one of the several buffer mechanisms does not work properly, blood goes more acidic.
But even when all systems seems to work, it seems as if the sodium ($Na^+$) part of salt could be involved in some sort of ion-exchange, with excess of salt intake stimulating increased acidification through increased release or maintenance of $H^+$ in the system. How and where this particular effect takes place is unknown.

Bone resorbing cells – the osteoclasts - need an acid environment in order to be activated. At the same time, the low-grade metabolic acidosis we discuss here – the mild fall in pH – probably reflects a much more significant acidity locally e.g. around the bone cells (2), which comfortable would justify the seen bone break-down effect under high salt intake regimes.

Excess salt intake is therefore very likely harmful to the bone health, unless it is counteracted. At the same time, several studies demonstrate a beneficial effect of intake of potassium ($K^+$) that will counterbalance this adverse effect of acidity. Good potassium sources are fruit and vegetables, moderate amounts of milk and vegetable proteins (4).

The skeleton contains an enormous capacity to buffer acidity in principle, by releasing calcium into the blood stream. And this seems to be a profound mechanism, that has been there since early evolution, which may also indicate a reasoning for the intriguing effect we see excess of salt intake having.
That this effect has a negative secondary consequence, that, if persistent, will lead to fatal effects for the skeleton, is something the body apparently accepts. But overall it makes a lot of sense that the skeleton in this manner can give off or take up calcium dependent on pH in the surrounding fluid, thereby keeping the crucial pH fairly constant.

### How is the SOLO experiment done on the ISS?

Diet is standardised for the duration of the experiment, that runs over five days, each time it is performed. This means that the crew will eat meals that 1) are specially prepared for the experiment in terms of composition, and 2) in terms of composition are known in all details to100 percent.

As indicated, samples of urine but also blood will be taken. These will be frozen and analysed when back on Earth after the study. In addition one fingertip blood drop will be analysed onboard, for 5 parameters, amongst those pH, using the SOLO Portable Clinical Blood Analyzer (PCBA).

### Status SOLO Experiment right now:

- SOLO experiment equipment was uploaded with 30P, docked to ISS Wednesday 17 September, 2008
- SOLO Portable Clinical Blood Analyzer (PCBA) Consumable kit has been transferred from 30P on 18 September, 2008
- PCBA Pouch 1&2 (incl. control solution and cartridges) have been inserted in MELFI freezer and its +2/+8 degrees Celsius drawer (in US Lab Destiny).
- First SOLO experiment execution was 3 till 14 October, 2008, performed by Greg Chamitoff.
- Next SOLO experiment runs:
    - Test subject no. 2, NASA astronaut Mike Fincke, experiment has started on 7 February, 2009
    - further 1-2 subjects during Incr. 20, and
    - completion of the experiment for a minimal number of subjects to allow acceptable medical statistics ca. 2011.

NASA astronaut Greg Chamitoff preparing the SOLO experiment). Courtesy of NASA

References:
1. Fuller, K. et al.: Murine Osteoclast Formation and Function: Differential Regulation by Humeral Agents.
2. Arnett, T.: Regulation of born cell function by acid-base balance. Proceedings of Nutrition Society (2003) 511-520.
3. Frings-Meuthen, P, et al: Low-Grade Metabolic Acidosis May Be the Cause of Sodium Chloride-Induced Exaggerated Bone Resorption. Journal of Bone and Mineral Research, Vol 23, number 4, 2008.

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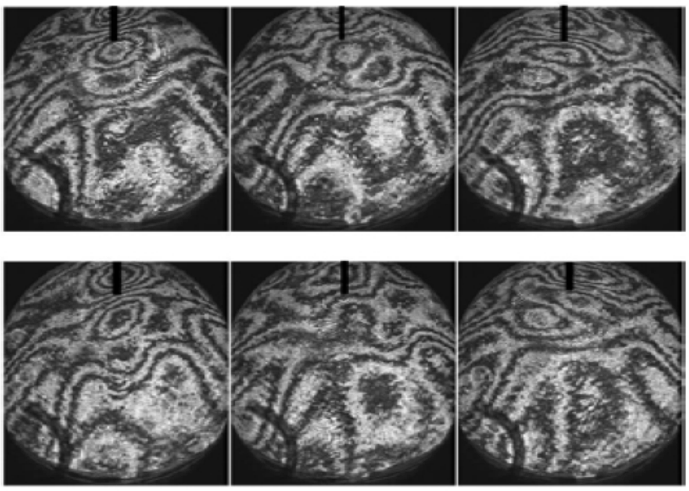


Figure 1: Interferometry picture array of a situation with a 1.6 rotations per minute in one of the early GEOFLOW experiment runs onboard the ISS. What we see is not a model of continents and oceans, but rather streaming patterns of the fluid between the two hard shells. Courtesy of C. Egbers, TU Cottbus, Germany.

# GEOFLOW – THE MINIATURE EARTH MODEL IN ITS RIGHT ELEMENT

(Science Team: C. Egbers, Cottbus University of Technology, Germany)

The GEOFLOW experiment, with the original title "Simulation of Geophysical Fluid Flows under Microgravity" is the first experiment performed in ESA's Fluid Science Lab (FSL). It was activated onboard the ISS late last year, and the first data is being analysed by scientists. The experiment continues to book the large number of needed experiment runs. GEOFLOW is simulating specific physical phenomena that govern the movement in fluids in planetary bodies, such as the Earth. Especially aspects related to the way liquid flows and moves as a result of temperature gradients, rotation and gravitational forces are focused on.

In order to create a simulation model that is not disturbed by the comparably strong gravitational field on the surface of the Earth, the set-up is flown onboard the International Space Station. Since 7 August GEOFLOW has completed several runs and produced valuable data. The total number of runs will be achieved over the next year.

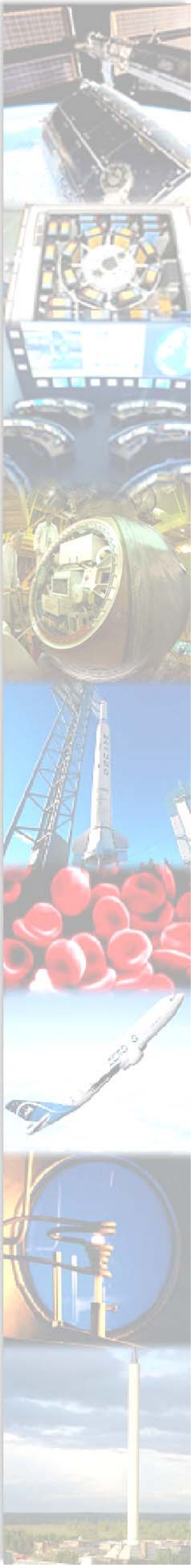
## Background

In this Newsletter we are used to deal with GRAVITY as a phenomenon that we all believe we know pretty well, but in this article we will go a level deeper, in order to explain what the GEOFLOW experiment is out to do.

We normally characterize the Earth's gravitational acceleration level as being in the order of 9.8 m/s$^2$, or 1g. That is the ballpark figure that is a good average value and deviations are small from location to location, as they only show up at the second or third decimal place. Gravity force, coupled with the strong temperature non-homogeneities present inside the Earth, is the cause, among others, of intriguing and complex phenomena like the movement of tectonic plates and oceanic and atmospheric circulation.

## Structure of the Earth

The Earth has a layered composition in direction of the centre, which one can partition roughly in the crust, the mantle and the core. The crust is defined to be around 35 km thick. This is the layer we know best, and which can exhibit large changes over time, in terms of moving tectonic plates, which are moving away from the areas where liquid magma (molten rock) erupts and solidifies to form solid rock. And earthquakes are created in zones where one plate moves in under the other, deep into the crust. Theories for plate tectonics deducts among others, that a layer of liquid material underneath makes these movements possible, this layer is assumed to be located on the border between the crust and the upper mantle.



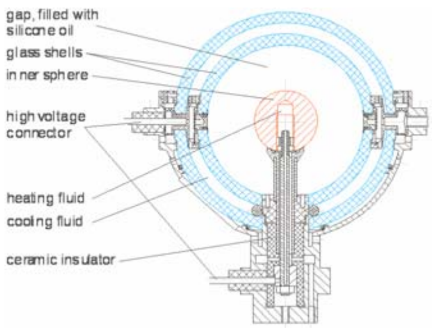
In addition to the non-solid material in the crust, another layer of liquid material of high significance for the Earth, is the outer core, around 3000 km deeper, in direction towards the centre of the Earth, which, in contrast to the solid inner core forming the central mass, is non-solid.

In the core, Earth's rotation is assumed to influence the convective[6] structures. The interplay between rotation and buoyancy driven convection seems to be extremely complex and, as the reader will understand, the system lacks a direct access to experiment observation.

The purpose of the GEOFLOW experiment, which will be described in more detail in the next section, is to observe the convective platform generated in the spherical cell designed as a scaled-down, simplified version of the Earth's outer core, in order to test numerical models and substantiate of reject theoretical predictions that have been made.

### The GEOFLOW experiment

Notwithstanding the fact that the first scientific experiment on thermal convection date back to the end of 19th century, no experiments have ever been performed on a spherical cell with a central force field, due to the presence of uniaxial terrestrial acceleration. The purpose of GEOFLOW is to take advantage of reduced gravity conditions to achieve a central simulated gravity field. The setup basically consists of two spheres entrapping a liquid. The two spheres can be set at different temperatures and they can rotate at the same angular velocity, and an artificial, dielectrophoretic[7] central gravity force can be added by applying an electrical field to the two spheres (see drawing). GEOFLOW is placed inside the Fluid Science Laboratory on board the ISS, where it will operate without the interference of external forces.



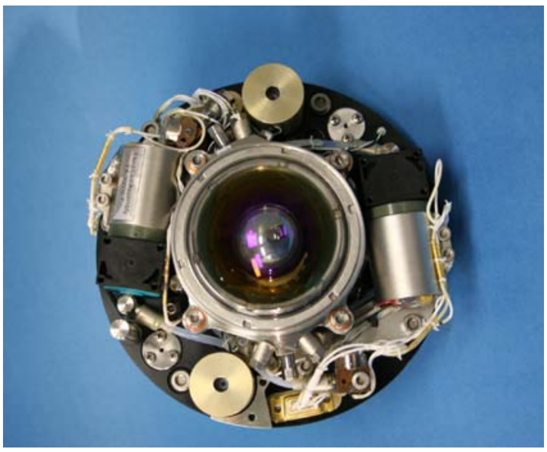



Figure 2: Schematic drawing of the GEOFLOW experiment cell (left) and the flown experiment-cell (right)

[6] Convection is a central issue in this experiment. Convection can be defined as the movement created by gravity, when a fluid or gas does not have same temperature homogeneously. Colder (and therefore denser and heavier) parts of the fluid or gas will sink as an effect of gravity pulling is downwards, leaving lighter volumes to raise.

[7] Dielectrophoretic force is a force created by a difference in electrical field or voltage between two entities.

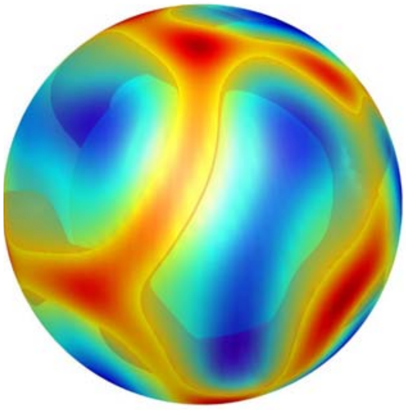


Figure 3: false colour, synthetic interferogram of the temperature field in a spherical shell with high Rayleigh and Taylor numbers.

The experiments will be carried out by varying the temperature difference between the spheres and their rotation rate. This will allow exploring a wide range of condition, expressed by the Rayleigh[8] and Taylor[9] numbers, from the pure Rayleigh-Benard[10] thermal convection case of non rotating spheres to the intriguing interplay of buoyancy driven and rotation driven forces in the case of rotating spheres. By progressively increasing Rayleigh number (influenced by temperature difference) and Taylor number (influenced by rotation), the scientists expect to observe a transition from more stationary spatio-temporal structures, to chaotic-like, three dimensional convection typical of "extreme" systems like planet interior. The convective patterns will be visualized by means of an optical Interferometry technique, that gives a quantitative map of the refractive index (in turn influenced by the local temperature) of the fluid, similar to the one depicted in figure 1. Such interferograms, after a dedicated image processing, will be compared to synthetic temperature patterns generated by sophisticated, state of the art numerical models (see figure 3), to test for the first time ever, the predictive power of such models in earth-like spherical geometry.

In conclusion, the GEOFLOW experiment is trying to elucidate how heat is transferred, how the Earth rotation influences the flow in the outer core zone and how the system undergoes a transition to chaotic states. These experiments, carried out in a miniature and simplified "Earth system" will give experimental evidence to test current numerical predictions, and will contribute to the challenging task of predicting and understanding the incredibly complex geophysical processes that take place deep inside our planet.

NASA astronaut Greg Chamitoff with the GEOFLOW experiment unit. Courtesy of NASA

Links: See an animation of the continental drift as an effect of plate tectonics in the form of 'continental drift' here:

References: A recent account of numerical and experimental studies related to GEOFLOW can be found in B. Futterer et al., "Thermal convection in rotating spherical shells: An experimental and numerical approach within GEOFLOW", Acta Astronautica, 62, 300, 2008.

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[8] The Rayleigh number basically describes the degree of disorganisation or chaos in a non-solid medium, regarding buoyancy driven flow. The higher number, the more disorganised and energy-rich the status of the medium is, as an effect of that energy (heat) is transferred via convection. Viscosity (higher viscosity describes a less fluid medium) plays a role: In a more viscous medium a higher Rayleigh number is seen in order to create disorganisation or chaos in the medium.

[9] The Taylor number comes into play when two cylinders or two spheres (as here) entrap fluid, AND these containers rotate, relative to each other. The value is constructed as a relation between rotational speed, radius of the system and viscosity. Based of factors in the equation, fluid streaming becomes 'irregular' over a certain Taylor value.

[10] Rayleigh-Bénard convection, describes a specific scenario, where the convecting fluid is contained by two rigid horizontal plates. This is a convenient for observation as a 'pattern formation system'.

# 3D SPACE: How gravity influences the accuracy of our perception of dimension and depth.

(Science Team: G. Clement, University of Narbonne, France)

NASA astronaut Gregory Chamitoff prepares the 3D SPACE experiment inside Columbus

RECENTLY A NEW ROUND OF EXPERIMENTS IN HUMAN PHYSIOLOGY STARTED ONBOARD THE INTERNATIONAL SPACE STATION.

AS A CONTINUATION OF A VERY LONG ROW OF SOPHISTICATED EXPERIMENTS ON HUMAN PERCEPTION AND ITS DEPENDENCE ON GRAVITY OVER THE LAST TWO DECADES, THE EXPERIMENT 3D SPACE IS USING THE NEWEST TECHNOLOGY – VIRTUAL REALITY – TO PRODUCE MORE SOLID AND CONSISTENT DATA ON HOW WELL HUMAN PERCEPTION CAPABILITIES ARE CONSERVED AFTER SHORT OR LONG TIME SPENT IN SPACE.

THE UNDERLYING ISSUE IS WHETHER THERE IS A NEED TO TAKE INTO ACCOUNT POSSIBLE SHORTCOMINGS IN HUMAN PERFORMANCE IN THIS RESPECT ON FUTURE LONG-TERM SPACE MISSIONS.

"When we look down from the top of a 100-m tall building, people below look noticeably small. But when we look 100 m "down" the street, people don't look small.

The reason is we have learned the "rules" for scaling people at a horizontal distance, but not from a height" (Clément & Reschke 2008).

With these statements, the scientists behind the 3D SPACE experiment express the focus of their research – depth and dimension perception in space.

So what is perception actually? Well, in a way it is the end-result of how our nervous system interprets the visual and other inputs to form of a 'final judgement'. Judge yourself what you want to conclude based on the image to the left here.

This interpretation of inputs makes it possible for us to judge how far away things are, if they are symmetric, if two figures are identical or not, and if we move or stand still, etc. All these 'final judgements' are crucial for how well we manage our way through the environment, and this process takes place constantly.

One very simple and easy-to-understand situation is the ability to judge how far away things within our immediate reach are. Visual images from both eyes are necessary to judge this accurately, with the effect that we normally grab the coffee cup where we intended to. We can do this repeatedly without any mistakes. But if only one eye sees, depth perception deteriorates sharply and we act with far less accuracy.

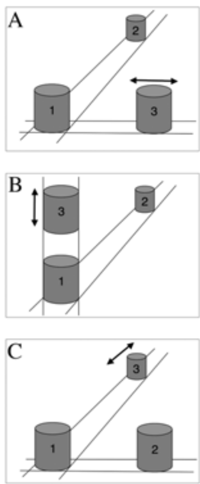
'According to some astronauts, accurate binocular depth perception is limited to 25-30 meters' in space (Clément 2005). Astronauts also frequently report that spacecraft interiors look longer and higher than they actually are (Lathan et al. 2000). In particular, the vertical dimension relative to our own long axis seems to be influenced by gravity. There is not yet a full understanding of this phenomenon today. Let us therefore see if we can get a bit closer to the essentials, and investigate what scientists currently think is happening.

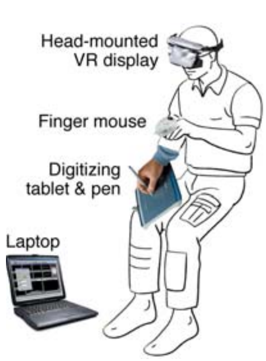
Here are some basics:
Any higher organism is equipped with a significant ability to survive even if one or more of the essential orientation cues would be eliminated. Thus, we can balance ourselves as long as we can see, but we also can balance ourselves in the standing position, even if we cannot see. In these situations the inner-ear balance organs perform the job fairly accurately[11], as long as all active systems function optimally, and as long as signals from these systems 'fit together'- and make sense to the brain. In this case the resulting reaction, if one is needed, most often is appropriate. But when we have a CONFLICT between these cues – balance organs, eye vision and input from joint and foot soles, THEN potential errors or inaccuracies arise.
We will give examples of 'conflict' situations in the following.

Remember that the brain at all times has to *interpret* the different signals it receives in order to make sense of it[12], and it can only make sense of it by comparing to what has been learnt during our own personal development - the experience that is stored in the brain in some form. So when this interpretation cannot be made to make sense against experience, the brain has to improvise, based on the second best data set, so to speak, which by the way very often is a good enough interpretation, but mostly less accurate and appropriate.

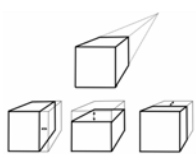
A well known phenomenon related to *conflicting inputs* is the development of motion sickness, which occurs based on a mismatch between what the eyes see and what the balance organs sense – we develop nausea and un-wellness as an effect. This is the short version of a much more complex story, but it gives the picture.

In space, on the other hand, the conflict is represented by the fact that no gravitational pull is experienced. The reference frame – gravity – is gone. In the early phase of the flight this definitely corresponds to a conflict, as in the case of first time space travellers, this cannot be a part of their experience 'data bank'. Therefore a large number of the astronauts experience this special form of motion sickness, called space adaptation syndrome or SAS, and some still experience problems with this on consecutive flights, despite the experience from having flown in space before.

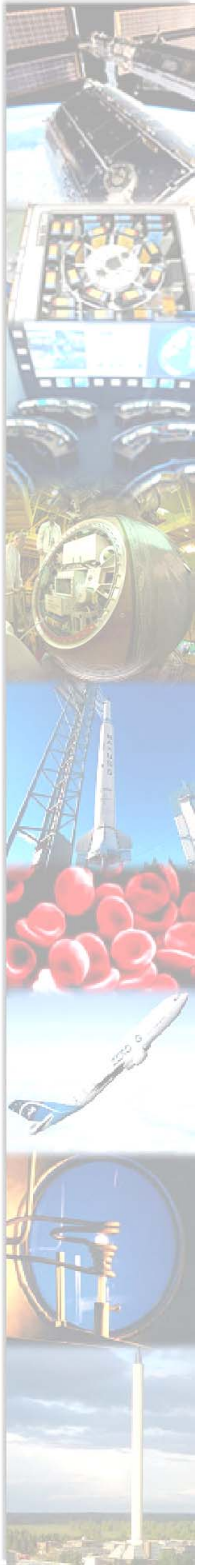



On the other hand we now know, that the central nervous system adapts very well to the lack of gravity after a number of days, such that the missing gravitational reference frame seems to be ignored in the sensory integrative process, and visual input becomes the dominating factor. This eliminates in principle



[11] This is a reduced version of the truth, in fact: The major role is played by the inner ear, but signals from joints and pressure sensors in the foot soles are very important inputs as well.
[12] 'Make sense' is here to be understood NOT as something we notice, but rather something that results in appropriate reactions / responses. This is also the basis for the phenomenon called 'illusions', which can be defined as something that only seems to be happening, as our senses are being fooled. Very trustworthy illusions are created in flight simulators that play on our movement and position sensors in the inner ear, challenging the visual input.



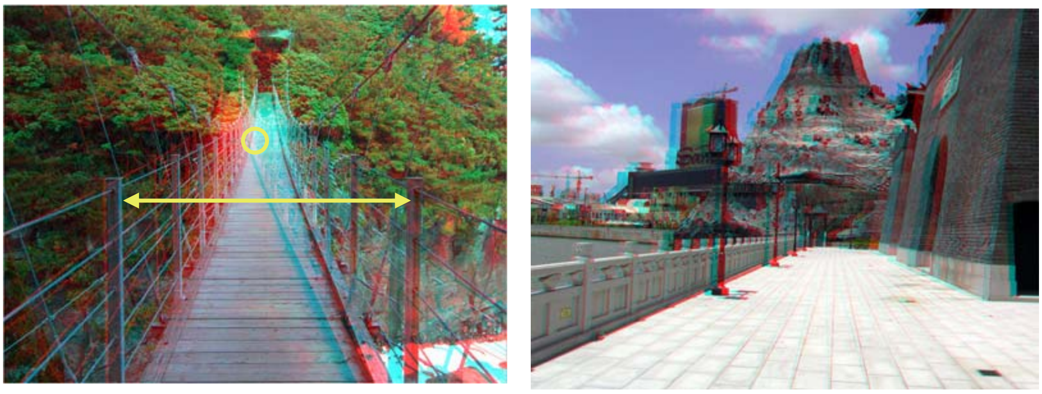
the *larger* conflict. But could it lead to some residual impairments as a result?

The experiments performed here are very much focusing on this *remaining conflict* theory as a basis for when problems do and when they do not develop. The focus of the experiment is the mentioned 3D perception.

The experiment is performed involving the entities indicated in the figure above. Here are some of the tasks the astronaut will have to perform:

- Geometric visual illusions with or without perspective (see examples to the right)
- 3D cube in perspective with one vanishing point
- Adjust the length of a vertical, horizontal, or oblique segment so that it matches a reference length
- Measurement: Size differential between adjusted length and actual length
- Adjust distance between blocks 1-3 so that it is equivalent to the distance between blocks 1-2
- Natural 3D scenes:
- Estimate absolute distance between two landmarks or between self and one landmark

The latest 3D SPACE tests were performed onboard the ISS by NASA astronaut Gregory Chamitoff in July, August and September 2008. The results are not yet fully analysed, but the indications go in the same direction as earlier similar experiments. For example, the subjects seem to underestimate horizontal distances in weightlessness, and the 3D objects look compressed (Clément et al. 2008). In order to reach firm conclusions, however, at least 8 experiment data sets need to be collected. Therefore, ESA plans to execute the 3D SPACE experiment on several subsequent ISS crewmembers, including ESA astronaut Frank de Winne who will be flying in 2009.



Example of scenes the astronauts are asked to use for judging dimensions and distances. The blurred appearance of the images is due to the fact that these are supposed to be viewed with 3D spectacles, in which case an illusion of 3D perspective will be created in the observer.

The above images will give you the 3D perspective if you apply simple red-green 3D spectacles. You are invited to request a set by sending your return address to the:
ERASMUS User Centre using the email address: massimo.sabbatini@esa.int.

References:

Clément, G. : Fundamentals of Space Medicine. Dordrecht: Springer, 2005.

Clément, G. & Reschke, M.F. : Neuroscience in Space. New York: Springer, 2008.
Clément, G., Lathan, C.E., Lockerd, A. : Perception of depth in microgravity during parabolic flight. Acta Astronautica 2008; 63: 828-832.
Lathan, C.E. Wang, Z, Clément, G. : Changes in vertical size of a three-dimensional object drawn in weightlessness by astronauts. Neuroscience Letters 2000; 295:37-40.

Contact Science Coordinator: gilles.clement@cerco.ups-tlse.fr

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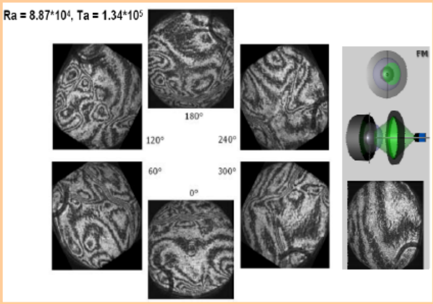
# INCREMENT 18 EXPERIMENT OVERVIEW

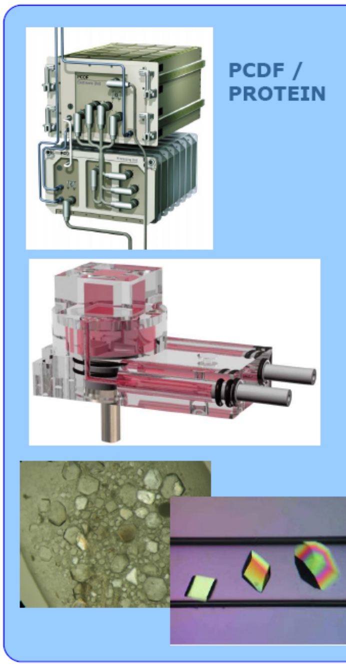
Increment 18, in the period October 2008 till April 2009, has the following experiment objectives running or upcoming before the end of the Increment:

**BIOLAB**

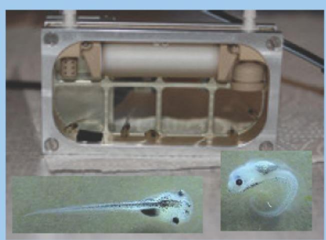
**Troubleshooting / Corrective Maintenance**



**FSL / GEOFLOW**

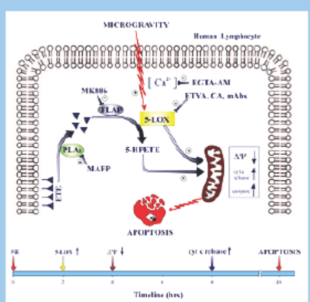


**PCDF / PROTEIN**



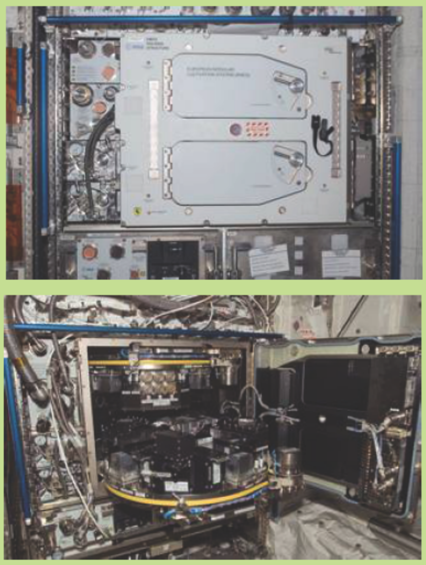
**XENOPUS**

**BASE-B / BASE-C**

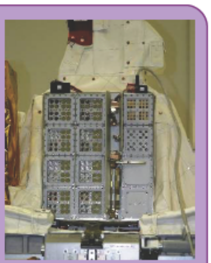


**ROALD**

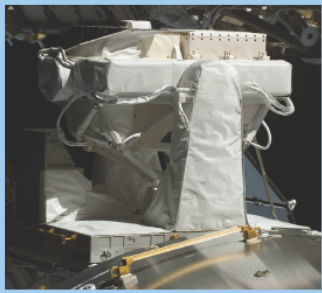
**KUBIK BIO#4**



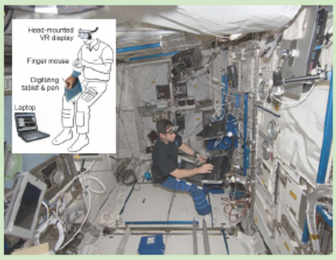
**EMCS Troubleshooting / Corrective Maintenance**


**EuTEF**
**(8 technology instruments + 5 exobiology experiments)**

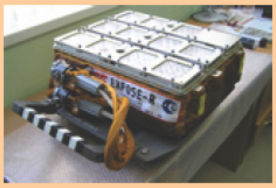


**SOLAR**
**(3 experiments)**



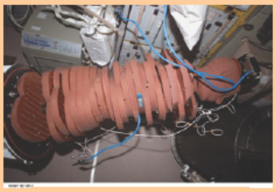

**3D-SPACE**

**SOLO**



**EXPOSE-R**
**(8 ESA expts. + 1 IBMP)**

**ALTCRISS**
**(IBMP)**

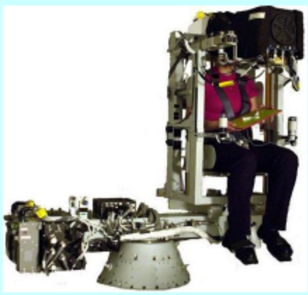


**MATROSHKA-2**

**MOP**

**LOW BACK PAIN / MUSCLE**

**OTOLITH**



**ZAG**


**VLE-1**

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# 50TH ESA PARABOLIC FLIGHT CAMPAIGN MAY 2009

PRELIMINARY LIST OF EXPERIMENTS (status 09/02/2009)

| Experiment ID | Experiment Title | Experiment Coordinator |
|---|---|---|
| PS-50/A AO-2004-111 | Boiling on a flat surface: convective boiling and condensation | Prof. C. Colin (IMFT, Toulouse, F) |
| PS-50/C AO2004-113 | Dynamics of cells and bio-mimetic systems | Prof. C. Misbah, (Univ. J. Fourier, Grenoble, F), Prof. F. Dubois (Univ. Brussels, B) |
| PS-50/D AO2004-132 | Drop impact and hydrophobic surfaces (DOLFIN experiment) | Prof. C. Tropea (Technical Univ. Darmstadt, D) |
| PS-50/E) AO-2000-096 | Soluto-vibrational convection in reduced gravity (SOVICON) | Prof. V. Shevtsova, (Univ. Brussels, B), |
| PS-50/F AO-99-0 | Multi scale boiling investigation under micro gravity conditions (RUBI expt) | Prof. P. Stephan (Technical Univ. Darmstadt, D) |
| PS-50/G | Test of convection generation in dense samples of sand using vibration | Dr P. Evesque (CNRS Ecole Centrale, Paris, F), |
| PS-50/H AO-2004-130 | Agglomeration studies in nanoparticulate metal aerosols | Prof. B. Guenther (IFAM, Bremen, D) |
| PS-50/I AO-2004-111 | Mass diffusion-induced bubble growth in supersaturated solutions at temperatures bel boiling: the role of g-jitters to heat conductio | Prof. T. Karapantsios (Aristotle Univ. Thessaloniki, GR) |
| PS-50J (PS-49/K) | Foam stability in microgravity | Prof. N. Vandewalle, (Univ. Liege, B) |
| PS-50K IAO-99-018 | PROGRA2-Visible domain sample testing | Dr J.B. Renard (LPCE-CNRS, Orleans, F) |
| LS-50/A | Influence of gravity on the percept reversal o ambiguous figures | Prof. G. Clement (Univ. P. Sabatier, Rangueil, F) |
| LS-50/B | Gravity induced changes of neuronal excitat in the human brain measured by changes in slow cortical potential electroencephalography (SCP-EEG) | Prof. W. Hanke, (Univ. Hohenheim, D) |
| LS-50/C | Effect of different gravity conditions on Ion-channel parameters in patch-clamp experiments in cell cultures | Prof. W. Hanke, (Univ. Hohenheim, D) |

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# DATES FOR THE AGENDA …

## – UPCOMING MILESTONES, STATUS 10 FEBRUARY

- 15 March (3. rev.) Kennedy Space Center: 15A launced, STS-119 to bring truss segment S6 but also PCDF to be installed in EDR. (not earlier than now 22 February, due to check of external tank hydrogen gas flow controlling valves)

The Protein Crystallisation Diagnostics Facility, PCDF, integrated in the European Drawer Rack,

STS-119 Crew, courtesy NASA

The STS-119 Crew counts:

Lee Archambault (2) - Commander
Dominic A. Antonelli (1) - Pilot
Joseph M. Acaba (1) - Mission Specialist 1/Educator Astronaut
Steven R. Swanson (2) - Mission Specialist 2
Richard R. Arnold (1) - Mission Specialist 3/Educator Astronaut
John L. Phillips (3) - Mission Specialist 4
Koichi Wakata, mission specialist, Japan Aerospace Exploration Agency astronaut

- 25 March, Baikonur, Launch of the18S Soyuz mission, with the crew M.Barratt (NASA), G, Padalka (RSA), and C. Simonyi (participant)

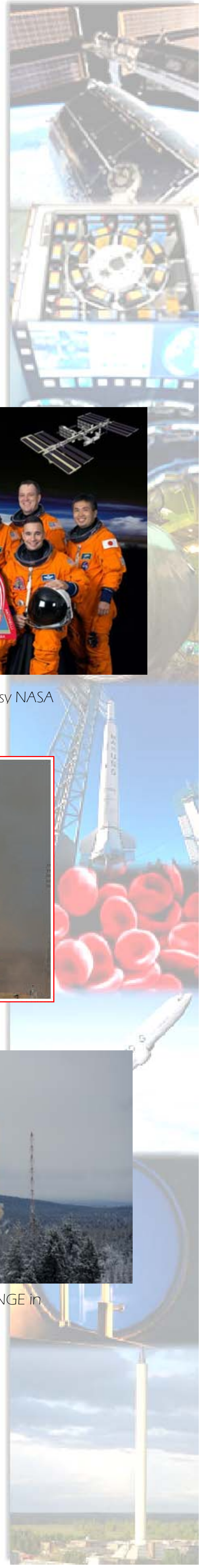
The Crew of Four to go into the Mars-500 pre-study for 105 days

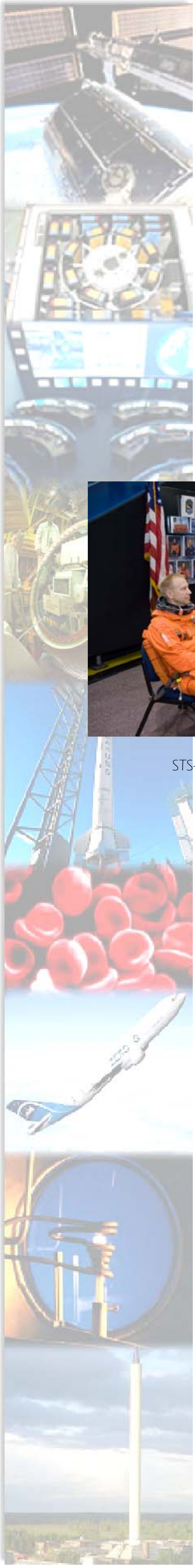
- 31 March, IBMP, Moscow: Start of first Mars 500 study (105 days)

TEXUS 45 launching from ESRANGE in Kiruna, Sweden in 2008

- 14 April - 26 April, ESRANGE, Kiruna: Texus 46 Two experiments in EML-3 and two combustion experiments.

- 11-15 May, Bordeaux: The 50th Parabolic Flight Campaign





- **27 May, Baikonur: Soyuz 19S launch** of Frank de Winne, long duration flight and first European commander of the ISS (from October 2009). Together with de Winne,, R. Romanenko (RSA) and B. Thirsk, (CSA) are launched

ESA Astronaut Frank de Winne training in the Soyuz capsule for an earlier flight

- **13 June: Launch of STS-127 (2J/A)** brings PCDF back to Earth. The STS-127 Crew counts:

STS-127 Crew, courtesy of NASA

Mark L. Polansky (3) - Commander
Douglas G. Hurley (1) - Pilot
Christopher J. Cassidy (1) – Mission Specialist
Thomas H. Marshburn (1) - Mission Specialist
David A. Wolf (4) - Mission Specialist
Julie Payette (2) - Mission Specialist - Canadian Space Agency

- **6 August: 17A, STS-128** brings ESA Astronaut Christer Fugelsang, the MPLM and MELFI-2, As well as MSL inserts to the ISS.
The same mission returns EuTEF


The Microgravity Multi-Purpose Logistics Module, MPLM, in the Shuttle cargo bay, courtesy of NASA

NASA astronaut H. Williams with a MELFI-1 insert

The European Technology Exposure Facility, EuTEF

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