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on station

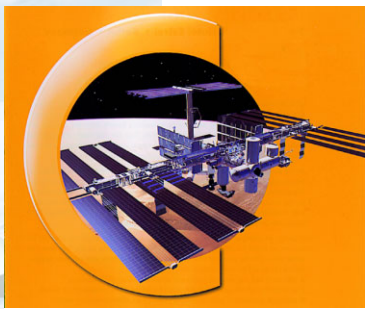
The Newsletter of the Directorate of Manned Spaceflight and Microgravity

http://www.esa.int/export/esaHS/

Special Issue: ISS Forum 2001

This issue of On Station is devoted to the ground-breaking ISS Forum 2001. During 5-7 June , Berlin became the focal point for the International Space Station (ISS) when 800 leaders of industry, government officials and scientists from 22 countries gathered at the first international conference on Station utilisation. They discussed R&D, industrial applications and commercial opportunities, explored the Station's potential and explained the opportunities available to users. NASA, Rosaviakosmos, NASDA, CSA and ESA outlined for the first time their approach to commercialisation of the Space Station. A live TV link-up with the Expedition 2 crew aboard the Station was a highlight of the Forum, and showed potential users the extensive facilities already in orbit. Participants also met the Station 'builders' – the companies developing the modules and other hardware – and current 'users' – companies in areas ranging from hi-tech to media that are already benefiting from being onboard. The final day was largely devoted to roundtables on access policy for institutional users and commercial customers, and the handling of payloads.

Mrs Edelgard Bulmahn, Germany's Minister of Education and Science, is welcomed to ISS Forum 2001 by ESA Director General Antonio Rodotà and (right) DLR Chairman Walter Kröll.



A Successful Utilisation Milestone

Antonio Rodotá

ESA Director General

I have been asked if the goals of *ISS Forum 2001* have been achieved. I feel very confident that these have indeed been successfully accomplished primarily because of the number of participants attending, the high interest in the many presentations made and, last but not least, in the extent and quality of the exhibition displays about potential Space Station utilisation. I am still receiving very positive reactions to the *Forum* but, in the final analysis, the best demonstration will be the clear build-up in the number of Station users.

We have started very early in preparing for Station utilisation in order to make potential users aware of its features – exactly as we have done for other scientific programmes – as a fundamental objective. Certainly the *Forum* was another important step in that familiarisation process and now we have a large consensus about the scientific and industrial utilisation of the Station, and that will be our planning basis for the next few months. As far as the application of education to utilisation, we will begin to seek a concept for educational activities so that we can make younger people aware of what they can do onboard. Such a new line of activities could, in due course, become another important utilisation discipline of the Station. So far, education has not been one of our first priorities, but we are gradually paying greater attention to it. The Station is indeed a very useful tool because it has an intrinsic appeal of its own, so people are already interested.

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European Space Agency
Agence spatiale européenne

Directorate of Manned Spaceflight and Microgravity
Direction des Vols Habité et la Microgravité

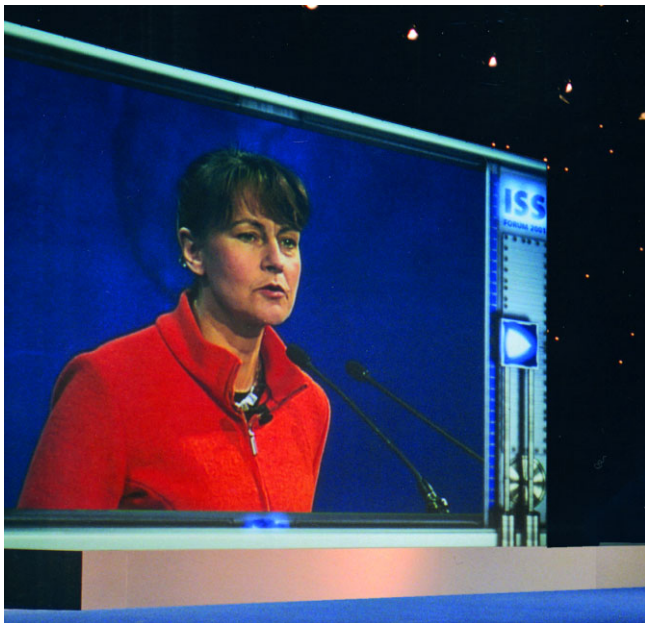
After all, it is basically a flying outpost for us to live and work in, and this provides an ideal opportunity for youngsters to see how they can use the Station and even how they can become the next generation of scientists, engineers or even space travellers in this new and exciting field.

As far as attracting new users, *ISS Forum 2001* provided a very good first step in 'bonding' traditional developers and users with potential new users who are reflecting on how they can use it. The newcomers were not in the majority at the *Forum* but I think that they should be at the next. Enthusiasm is building and we as an Agency need to devote more attention to these newcomers in order to produce more successes for Station utilisation.

Shortly after the *Forum*, I was honoured to receive a letter on behalf of ESA and the other Station Partners from Their Majesties the King and Queen of Spain informing me that we had won the celebrated Prince of Asturias prize! This is the highest prize in Spain, awarded yearly to a select number of personalities in different fields. We have been so honoured as a sign of international cooperation – it is testimony to the fact that the Station is becoming a reality. It is very much appreciated that we have received one of the most coveted prizes in the world. This is further confirmation to my colleagues in D/MSM for all their years of hard work in preparing for the Station. It is also a sign to our citizens of what Europe can really achieve in space – and that is second to none!

Mrs Bulmahn with ISS Expedition-1 crew (from left) Sergey Krikalyov, Yuri Gidzenko and Bill Shepherd.

The Forum was opened by Edelgard Bulmahn, Germany's Minister of Education and Science, followed by keynote addresses from Prof. Alain Bensoussan, President of CNES and Chairman of the ESA Council, and Prof. Dr. Walter Kröll, Chairman of the Board of Directors, DLR. These speeches are presented in the following pages.



Edelgard Bulmahn

German Minister of Education and Science

Today, the industrial and commercial utilisation of the ISS begins. Since the beginning of mankind, we have gazed up to the sky to understand the secrets of the stars. The beauty of our own planet, however, became clear to many of us only after we were able to see the 'blue planet' with all its fascination, but also all its vulnerability.

Our Earth is an ecologically, economically and politically closed system. We have to understand this system and the interactions between the various factors better if we want to conserve and shape it not only as a habitable place, but also as a place worth living in. We rely on a politics that is global and lasting, that secures the foundations of life for generations and that improves the quality of life for all of mankind.

Our knowledge-based society depends on the ability to receive information independent of place and time. Increasingly, communication uses satellite-driven systems. Live TV transmissions via satellite and intercontinental mobile communications are only the first important steps.

The same is true for satellite-based navigation, which has a huge potential. With the development of the Galileo civilian European satellite navigation system, which we vigorously support, we will be able to improve the navigation of ships and cars, and the flow of traffic so that traffic jams do not emerge in the first place.

If full use is to be made of the opportunities offered by space exploration and research, then science and industry must be given planning security and a reliable framework in which to work – something they did not have in the

1990s. This is why the German government approved a new space programme three weeks ago. This is the first German national space programme for almost 20 years. For the next four years alone, space and space science will receive DM8 billion, DM7 billion of which will come from the Ministry of Education and Research.

Since November 2000 we have had a permanently manned laboratory in space – the International Space Station (ISS). The ISS is mankind's largest scientific and technical project of collaboration. The 15 nations involved will develop the ISS further, and Europe's Columbus module will dock to the Station in 2004.

Here at the *ISS Forum 2001*, discussion in the next few days will centre on the kind of opportunities the ISS can offer science and industry and how its potential can be exploited for scientific progress, economic development and the creation of new jobs.

One very promising field is research under microgravity conditions. We are talking here about laboratories 'transferred' to space in order to carry out experiments that cannot be performed on Earth. Our scientists also have great hopes for experiments in the life sciences. They are confident that new discoveries will be made about the workings of cells and organs, providing us with a basis for new diagnostic and therapeutic developments in medicine.

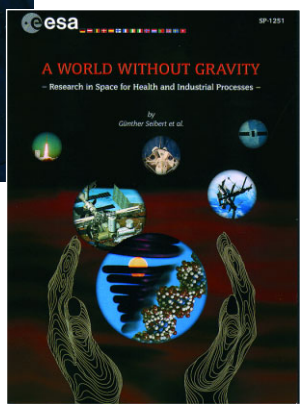
State-funded human space activity is a service provided to users – nothing more and nothing less. The challenge now is to make use of the facilities developed in this way.

I know that many of you come from companies for whom space practically lies in their backyard. Others consider space and spaceflight mostly as unknown territory. But all of you have one thing in common: you will hear terms at this Forum that you know from everyday business. Terms such as 'end-to-end service' and 'customer service' belong to your daily vocabulary. In the past, these terms were unknown in industrial utilisation of manned spaceflight. Now there is a change of paradigms that tells us: customer orientation is very important for the future industrial and commercial utilisation of the ISS!

Where scientific use of the ISS is concerned, we intend above all to focus on projects directed at solving specific problems on Earth and with a potential for new products and applications. This will involve tying space research projects into the wider area of terrestrial research and the particular mother disciplines concerned. The ISS has to demonstrate its specific capabilities in competition with terrestrial scientific resources. utilisation of the Space Station must be science-driven, not glamour-driven.

Here in Germany, we are looking above all to public-private partnerships to take ISS utilisation forward and seek in so doing to help industry increase its share of worldwide scientific use of the space resource. Small & Medium-sized Enterprises (SMEs) in particular are well placed to occupy attractive niche markets – which is why they are given special encouragement.

Mrs Bulmahn is presented with copy #1 of ESA's new book on microgravity research by Mr Jörg Feustel-Büechl (ESA Director of Manned Spaceflight and Microgravity; right) and Mr Antonio Rodotà.



You will not find it too surprising perhaps that I, as Research Minister, give priority to scientific use of the ISS. But even outside the research domain, many parties have an interest in utilising the ISS – in the media, the entertainment industry, the world of art, and marketing. The development and market potential is enormous. That is why I believe we should leave scope for non-scientific commercial ISS utilisation, as long as

Prof Alain Bensoussan (left) with Mr Antonio Rodotà (centre) and Prof Walter Kröll.

Prof. Alain Bensoussan

President of CNES and Chairman of the ESA Council

I am very honoured to say a few words during the opening ceremony of this forum devoted to utilisation of the International Space Station. I would like to thank the authorities of the city of Berlin for their welcome. We all follow with great interest the evolution of this newly reborn capital of Germany. My thanks go also to ESA and DLR for the outstanding organisation of this symposium, as well as to all the important personalities I see here. I say hello in particular to our colleagues from the other space agencies, partners in the Space Station programme.

The topic of this symposium is particularly relevant since the Space Station is now a reality. Today, the ISS is the only permanently-manned orbital infrastructure, and while we are still building it the time has come to optimise its utilisation. I would like to underline some of the essential aspects linked to this important process.

First of all, the biggest world-class technological project ever undertaken is under close scrutiny by the media. Every project carried out onboard the Station will be highly visible to the public and policy-makers all over the world. Covering the whole spectrum of space activities – scientific and technological research, space applications for everyday life, discoveries and human endeavours – the Space Station, well utilised, may represent a fantastic promotional tool for space as a whole. In this regard, what is at stake with Space Station utilisation is much more than the future of manned spaceflight.

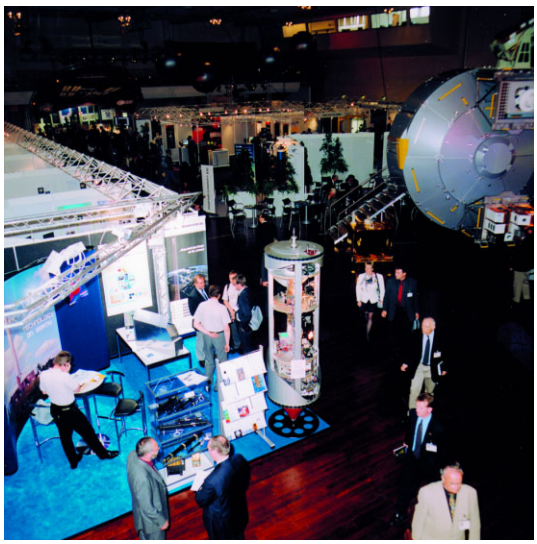
Secondly, the Space Station will be used by men and women from various countries working together in orbit, and it is a fact that such a human endeavour unites people much more than any other type of cooperation in science and technology. Thus, using the Space Station together is a way to strengthen international cooperation on space activities, and a source of progress and enrichment.

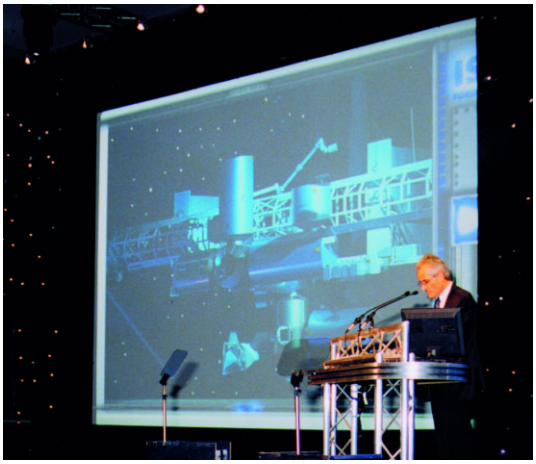
Europe made a commitment to participate in the ISS programme. For the ten participating states, this means a tremendous amount of money: more than €3 billion has already been spent. ESA's manned spaceflight and microgravity programme is one of the agency's biggest. We must now benefit from this it does not hamper the scientific effort.

I can also well imagine the ISS being used for educational purposes. We should be using the fascination exercised by space to get young people interested in scientific questions. Schoolchildren should have the opportunity to ask space travellers and researchers questions about their work. Many youngsters will give up their dream of becoming astronauts once they have seen the reality from closer up. But many others – once they have 'got the bug' – will look for and find their professional futures in space, space science or the natural sciences in general.

Some members of the first ISS crew have already visited a number of schools. Here in Germany, DLR has opened its doors to school groups. This gives me great pleasure and I very much hope this initiative will be taken further.

Ladies and gentlemen, I wish you three eventful and informative days here in Berlin, and many new ideas and proposals for projects for the ISS.





investment made by European taxpayers, beyond the political benefit that we can get from Europe's active participation in an international space endeavour.

Along this line, the European Space Strategy, jointly elaborated by ESA and the European Commission, and adopted on 16 November last year by the European space ministers, states that Europe should now optimise the use of the ISS as a European research infrastructure for all disciplines in space science – especially life and physical sciences, applied research,

technology development and validation – and as a powerful educational tool and a testbed for the 'next step' in human space exploration: the exploration of the Solar System.

These potential applications will be discussed during the next three days. You will also discuss the opportunities offered by the Space Station to private companies that would like to use this infrastructure on a commercial basis. This topic should not be taboo – business activities on the ISS might even represent a powerful tool for development of the space programme. We have to talk about it and quickly establish 'rules of the road' in order to go ahead in this direction.

I am personally convinced that this type of symposium, where specialists from all over the world gather to discuss Space Station's utilisation, is a very good opportunity to pave the way for new developments. I am sure that the results of your work will provide precious input for the decisions to be made on 14/15 November in Edinburgh, during the next session of the ESA Council at ministerial level, when Europe has to decide about the next phase of the Space Station exploitation programme.

I wish you an excellent symposium and I thank you for your attention.

Prof. Dr. Walter Kröll

Chairman of the Board of Directors, DLR

I would like to welcome you on behalf of the German Aerospace Center DLR, one of the organisers of the ISS Forum 2001.

Recently, a new star has appeared in the sky and is constantly gaining visibility: the ISS. Almost two years ago, the directors of the space agencies involved in the ISS had the idea of holding a global conference about the industrial and commercial utilisation of the ISS. It was intended to be a conference that would transmit an international signal; a new 'market place' offering a wide spectrum of new business opportunities is opening up with the ISS.

We want to firmly establish industrial-commercial utilisation in parallel to the research financed by public resources. We have gained a leading position in research in weightlessness with the Spacelab missions D1 and D2 and through the partnership with our American friends. We have also carried out missions to the Mir station with our Russian colleagues. What is more, we have built up infrastructures and gathered management expertise (control centres, user support, payload processing). We would like to make this vast expertise, which we have gained through public investment, available to the private sector. We have to change paradigms: we have to change our orientation from a publicly financed aerospace infrastructure to one of satisfying demand. The space agencies have to develop, by integrating potential users, services that are interesting not only to science and space industry but also to non-space industries. If we want to commercialise Station resources, we have to create clear general legal and user-oriented access conditions: easy, fast, safe and affordable.

During this spring's meeting of German industry, we began a dialogue with various organisations, including the Federation of German Industries (BDI) and the German Association of Chambers of Industry & Commerce (DIHT). Through this we have started, here in Berlin, to build the bridge between public research and market-oriented

ESA Astronaut Thomas Reiter and cosmonauts Sergey Krikalyov and Yuri Gidzenko (on stage, with moderator Claus Kruesken at right) link up live with the ISS. The Expedition-2 crew are (from left) Yuri Usachev, Susan Helms and Jim Voss.

industrial research, between research on Earth and the integration of the ISS as an efficient laboratory under the specific conditions of space.

The representatives of trade and industry among you will ask how involvement in the ISS can be useful, what competitive advantage it has, and what the cost-bebefit ratio would be. It is the aim of this conference and of our promotion programme to provide convincing answers to these justified questions.

Industrial-commercial utilisation of the ISS will aim mostly at optimising commercial processes and developing better products using the specific conditions in space, especially weightlessness. Switching off gravity also means switching off effects such as sedimentation, convection and hydrostatic pressure. Under these circumstances, specific phenomena can be made visible which are masked on Earth. What is more, researchers will use the Space Station as a testbed for systems and technologies destined for spacecraft that cannot be serviced, such as telecommunication satellites.

The market place still needs to be developed and the market segment opened up. This is possible only if we manage to overcome the understandable scepticism and caution among non-space industries. Market studies and analyses show a good potential for this development. Without anticipating future results, one could imagine important developments: for example, of material science or life sciences, where many experiments have already been run successfully. Let me just point to the growth of large protein crystals for crystal structures or experiments on water distribution in the human body in connection with the development of oedemas.

Of course, other areas such as the services sector or advertising and entertainment could be opened up as long as they do not impair the Station's primary research function.

Commercial use of space with its tantalising potential is possible only in a reliable and uniform legal frame. The space law treaties of the 1960s and 1970s are still valid today and efficiently regulate state activities in space. But the increase of space utilisation by private parties means they need to be updated by rules at international and national levels, and especially by harmonised licensing processes. For this goal we have – in collaboration with the Institute for Aviation and Space Law of Cologne University – run an international project with the title 'Legal Frameworks for the Commercial Use of Outer Space – Project 2001' for the last three years. More than 100 of the most distinguished experts from almost 20 countries have sketched the future path of space law in different themed workshops.

The formulation of a 'code of conduct' for ISS commercial activities has been proposed, linking settlements of competition law with measures for the protection of intellectual property and establishing an arbitration mechanism.

More than 30 years ago, Stanley Kubrick created a cult with his film masterpiece *2001: A Space Odyssey*. It is a search through our Galaxy for alien life. Today, in the year 2001 of space-faring reality, the mission of our outpost in space, the ISS, is much more Earth-bound: a new 'star' close to Earth, integrated in our terrestrial infrastructure, to enrich life on our planet.

I am happy that you all want to take part in and co-create the 'liftoff' of the industrial-commercial use of this mission. ■

The ISS is Open for Business

Liz Wright
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The International Space Station has arrived. A rare combination of technology, human endeavour and cooperation has turned the dream into a reality. But we are only at the beginning of the story. Huge investments have been made and many problems have been overcome to get to this point. Now we must see that it achieves its full potential. It is time for industry to participate, to make use of this extraordinary resource to improve the lives of ordinary people on Earth.

The ISS is a major achievement and it is time for industry to participate, reap the benefits and contribute to improving life on Earth. ESA is allocating 30% of its resources on the Station to industry for commercial use and has developed commercial conditions that meet industry's needs. Opportunities include R&D, marketing, entertainment and service provision...

Opportunities for Business

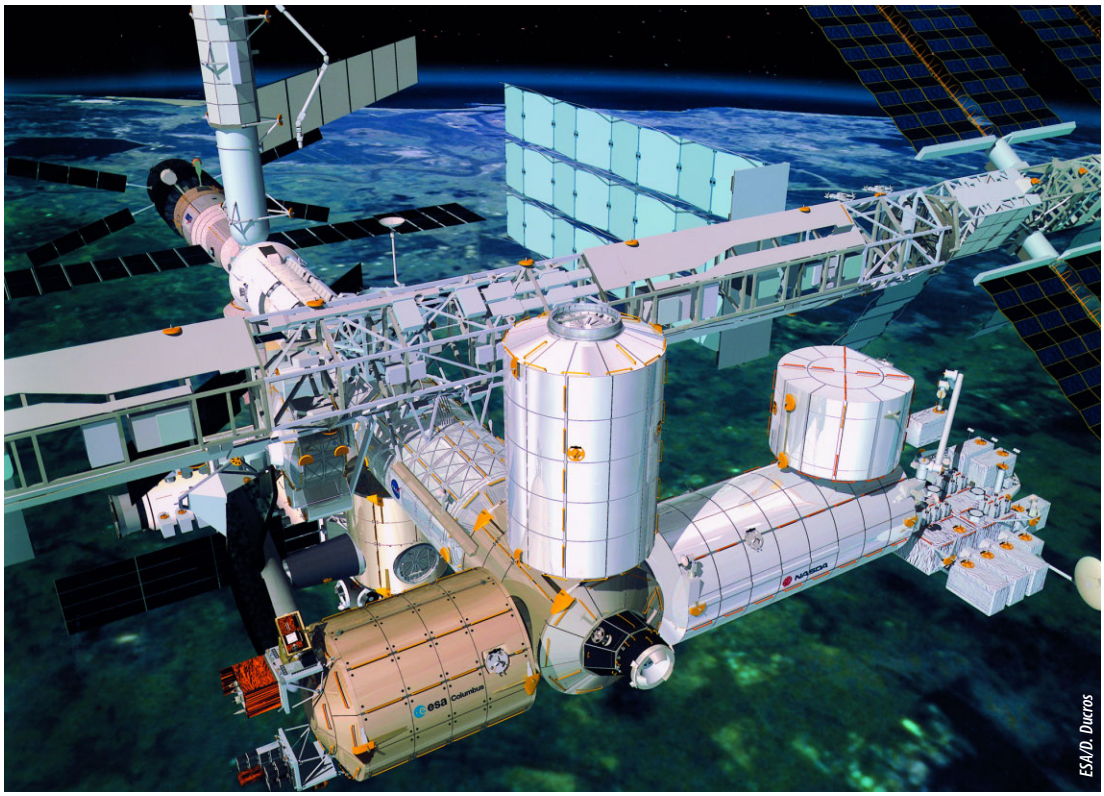
At the beginning of the 20th Century Tsiolkovsky wrote, 'Mankind will not remain on Earth forever. It will penetrate beyond the atmosphere and conquer all the space around the Sun.' His prediction came true in that century. Today, at the beginning of the 21st Century, we are at the forefront of a new challenge – using space not purely for science and research but for commercially viable investment that will benefit humankind.

In the past, industry has not made significant investments in space-based programmes, partly because there have been few opportunities for industry to participate but also because the conditions have not been attractive to industry. Investing in space-based research has been considered a risky business with a long payback time. The Station is set to change this pattern. The International Space Station is open for business. ESA is allocating around 30% of its resources on the Station to business for commercial use. It has recognised the need to become more industry-friendly and has set up commercial conditions that will make it easier for industry to reap the benefits from investing in space. The commercial conditions include shorter lead times, regular access flights, the potential for continuous use and protection of Intellectual Property Rights. Although ESA's main facility, the Columbus laboratory, will not be available until 2005, earlier opportunities may become available, so now is the time for industry to plan for commercial activities in space.

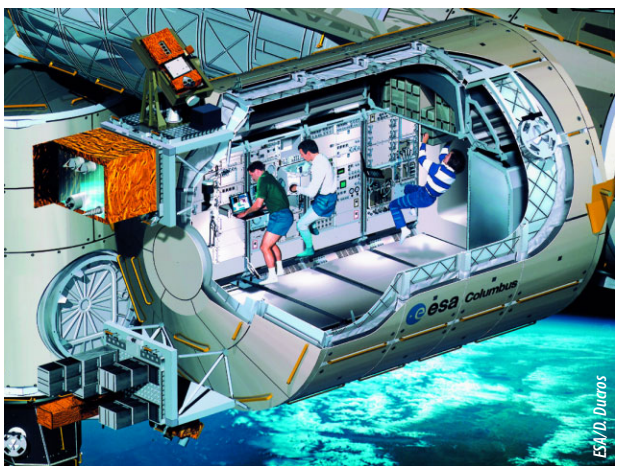
What does the Station have to offer businesses? Firstly, there are the impressive research facilities and the microgravity environment on the Station. Together, these make it possible to do things that cannot be done on Earth. R&D in space has the potential to improve terrestrial production processes, to contribute to the development of new advanced materials and to help design and test new drugs in the battle against disease.

The ISS also offers opportunities for introducing new services on a commercial basis, for example for communications and navigation, imaging and environmental monitoring. The watch manufacturer, Fortis, is planning to use the Station's Global Transmission Service to develop an accurate time-setting service for its watches.

ESA astronaut Claude Nicollier at work. (NASA)



Clearly, R&D is the primary purpose for the Station, but its existence in space opens up opportunities for businesses to use the Station in other ways. The eyes of the world will be on the Station as it develops and contributes to society. Companies can associate their name with the biggest achievements in our time. There are many possible ways for companies to get involved, perhaps through placing products on the Station, through sponsorship of research or through support of educational programmes linked to the Station. One of the top-10 global communications companies, Bikker Euro RSCG, is setting up a programme to match sponsoring companies with research projects. The programme will allow the companies to use public relations opportunities to maximise the benefits from an association with ISS.



The Station could also be a focus for entertainment and education. It is the perfect setting for attracting and fascinating large audiences. Broadcasters could transmit from space making use of stunning images of Earth and deep space. Other possibilities include science and geography lessons transmitted from space – an opportunity to see space-based science as it happens.

The companies that use the Station will need support services, and a number of companies are investing in developing commercial services for the Station's industrial users. Intospace (R&D and marketing opportunities) and Astrium (communications) are two of the first companies to introduce such services. Other companies are already investing in the development of facilities on Station for commercial users.

Conclusion

The International Space Station is an extraordinary resource that has the potential to make a significant impact on the lives of ordinary people on Earth. ESA has listened to industry and has set up conditions that will make it attractive for industry to make use of the facilities offered by ISS. It is now time for industry to play its part in realising the full potential by investing in space-based business opportunities.

The human achievement of putting the Station into space is enormous. The dream has become a reality. What happens now is up to us. The International Space Station is open for business and some companies have already seen the potential for using it to grow their own business.

For further information on the opportunities of doing business on ISS, visit the ISS commercialisation web site at *<http://www.esa.int/spaceflight/isscommercialisation>*

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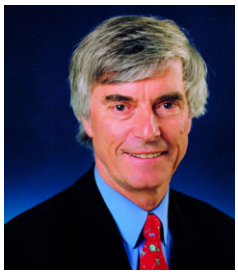
Research on the International Space Station



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The International Space Station (ISS), with its permanent human presence in space and its numerous research facilities, offers a wide scope of opportunities to research institutes and industry as well as for services and innovative commercial use. Here, I focus on research and development, as ISS is a laboratory with unique features:

- microgravity (physical sciences, life science, synergetics);
- no atmosphere (astrophysics, plasma physics);
- a global view (Earth observation);
- a testbed and an engineering workshop in orbit.

The ISS provides unique conditions for research...

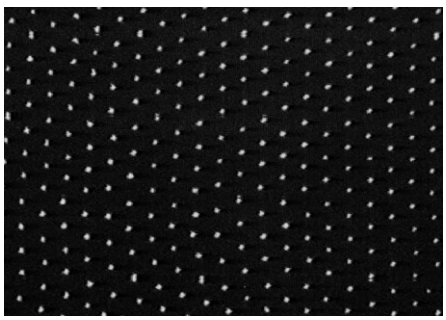
In order to illustrate what can be done on the ISS for science and technology, I would like to present a few research projects planned for the new station.

Improvement of Casting Processes

Even today, a significant part of the world's economy is built on the casting of metals. For instance, European steel production alone yields a financial turnaround of €18 billion annually. Although casting was invented at least 3000 years ago, its technology has been improved considerably in recent years. Despite that, progress calls for more reliable and more specialised materials. The challenge and economic implications make this one of the most active fields of research. Turbine blades are a high-value example. The mechanical and thermal properties of such highly stressed parts strongly depend on their microstructure, including grain boundaries, texture and segregation of alloys. The microstructure in turn is determined by the solidification process. Computer-based simulations are now commonly used to optimise this process and hence the microstructure. The quality of these simulations strongly depends on how accurately we know the thermophysical properties such as surface tension, viscosity, density, specific heat and thermal conductivity. The experiment of Prof Hans Fecht at Ulm University (D) to measure the thermophysical properties in microgravity will be ready to fly in 2004. The samples will be held away from the container walls by electromagnetic levitation to avoid contamination and thus reduction in data accuracy. Microgravity is ideal for these measurements because high-temperature metals react with most materials.

Plasma Crystals in Microgravity

There are numerous kinds of plasmas, such as stellar atmospheres, the aurora borealis, fluorescent light tubes, cometary tails, ionosphere and arc discharges (plasma welding). The sizes of the charge carriers – electrons and ions – mean that their motions cannot be observed directly. Prof Gregor Morfill of MPI Garching (D) discovered that microparticles with diameters of several microns injected into a plasma can be used to visualise it. Owing to the much higher mobility of



Plasma crystals can form in microgravity.

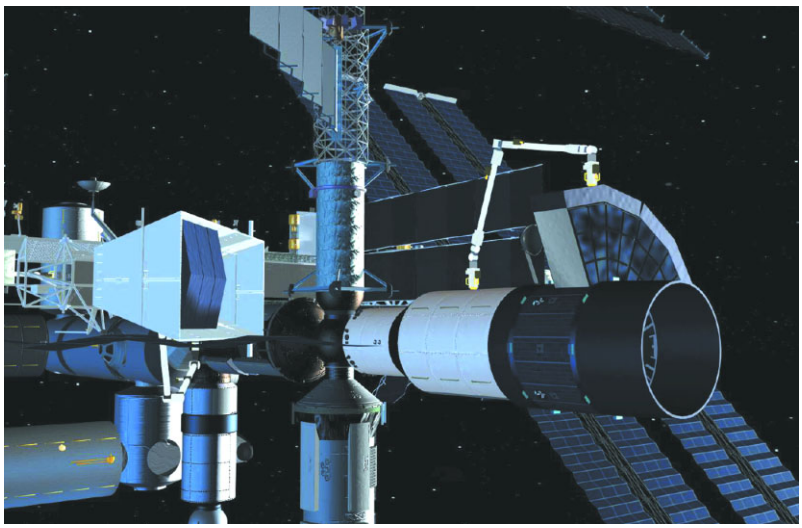
Sergei Krikalev with the plasma crystal unit – the first European experiment aboard the Station.

the electrons, the microparticles are struck by electrons far more often than by ions, so they charge up negatively (1000 to 10 000 electron charges) and move like charge carriers. Illuminated by laser, they become visible.

At high density, the microparticles begin to interact. Under the influence of electric and magnetic forces they form a 'complex plasma' in which a 3D lattice structure equivalent to a crystal can be formed. In these 'plasmacrystals' the microparticles are separated typically by 100 µm. Even solid-liquid phase transitions are observed.

Because the microparticles are 50 billion times heavier than the plasma ions, gravity is a dominant force in complex plasmas. In fact, gravity significantly disturbs the formation of the structured state. In order to eliminate this effect, the experiment is being performed aboard the ISS under microgravity conditions – the first European experiment on the Station, under a German-Russian agreement. It was delivered by Progress on 28 February 2001 and first activated 3 March in Zvezda's aft transfer compartment, with most of the work performed by Sergei Krikalev. A second run in May could be followed by another in October.

A deep knowledge of plasma physics is important for many high-technology processes. It is expected that the know-how garnered from the ISS will advance plasma and colloid technologies on Earth.



The initial XEUS observatory (right) is expanded by adding mirror segments while attached to Zvezda.

Diagnostics of Heart and Lung Performance

Microgravity produces significant effects on the human body. Almost immediately after orbit insertion, extracellular liquids such blood and lymph fluids shift upwards from the lower body. Blood circulation changes considerably, as the heart no longer has to fight gravity.

To find out how the heart works in weightlessness is of fundamental relevance and important for the health of astronauts. Cardiac output is one of the most important parameters, but high-accuracy measurements have so far required invasive techniques. Research groups in the US and Europe (Dag Linnarsson, Karolinska Institutet, Stockholm, S; Manuel Paiva, Univ. Libre, Bruxelles, B; J.B. West, Univ. California at San Diego, US) have developed a non-invasive method based on rebreathing a gas mixture. It will be tested in October 2001 during a parabolic flight campaign for space application. Although measuring gas concentrations is a sophisticated process (the heavy mass spectrometer is replaced by a novel photo-acoustic method), it is fast and simple for the test subject. The apparatus is light and power-efficient. For these reasons, this innovative technique is now used in hospitals. In other words, on top of the new system's high potential for human physiology research aboard the ISS, there is an interesting spin-off for health care on Earth. Considering that heart diseases are the primary cause of death (>50%) in most industrialised countries, the system's importance is evident. Developed over several generations within ESA's Microgravity Programme, the equipment is being commercialised through Innovision.

XEUS – ISS takes Astrophysics into a New Era

Although it is fortunate for life on Earth that ultraviolet, X-rays and gamma-rays are blocked by the atmosphere, it is a serious constraint for astrophysicists. For them, only spaceflight opens the window to the Universe.

XEUS is Europe's latest and most ambitious X-ray astronomy project. One objective is the detection of black holes in the early Universe.

XEUS will be launched with a primary mirror 4.5 m in diameter, the largest that can be carried by current launch vehicles. Later, XEUS will dock with the Russian Segment of the ISS and mirror segments will be added to grow it to 10 m. The ISS is a cost-effective assembly site for this exciting upgrading job.

ARES – An Air Revitalisation System

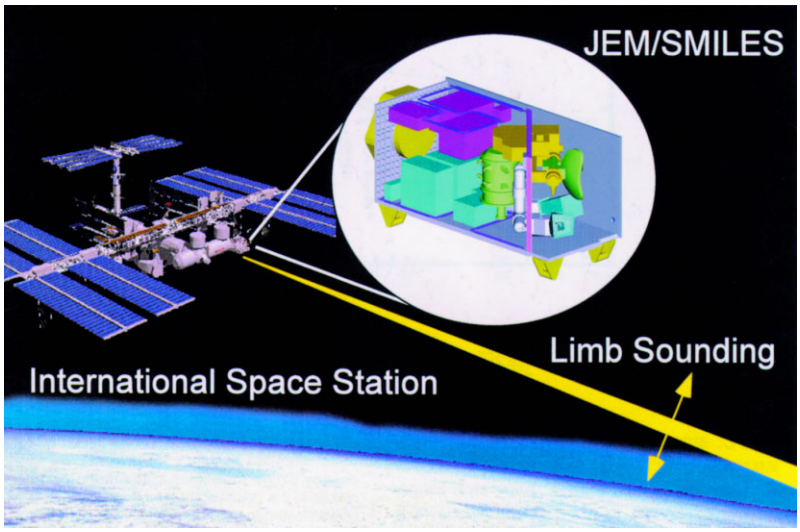
Each human needs 2 litres of drinking water per day to keep the body going, so six people aboard the ISS require 1 t every 100 days. Oxygen, food, spare parts and clothing also have to be supplied, and carbon dioxide and water vapour have to be removed from the cabin atmosphere continually. It is a logistics challenge and a significant contributor to the operations costs. For these reasons, operating a space station as a closed-loop system is highly attractive. On Mir, water was recycled from 'condensate' and oxygen from urine. ARES is even more sophisticated: it recycles oxygen from waste water and carbon dioxide. This ESA-funded project is being performed by Astrium, with the intention of demonstrating it in space in about 2006.

For the future exploration of space, like the mission to Mars, closed-loop life support systems will be indispensable.

SMILES: Superconducting Submillimetre-Wave Limb-Emission Sounder

Given that there are now 6 billion people on Earth, space technology has an important role to play in supporting and cleaning up our planet. Spaceborne systems help us to monitor the environment and throw light on global processes such as the effects of greenhouse gases on our climate, the problem of ozone depletion, and the question of why many forests are in bad condition. The ISS orbit with an inclination of 51.6° covers most of the globe's inhabited areas, making it ideal for Earth observation.

The major cause of atmospheric changes like global warming and ozone depletion is the release of man-made gases into the atmosphere. NASDA's SMILES can monitor critical trace gases and radicals in the stratosphere day and night. By looking at the Earth's limb, it provides altitude profiles of molecular abundances for many species. Since it works by observing the thermal emission, it can monitor the stratosphere irrespective of its orbital position relative to the Sun. It will survey the latitude range between 65°N and 38°S.



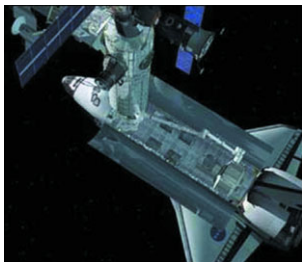
SMILES is currently planned for launch in August 2005 for operation from the Exposed Facility of NASDA's Kibo module.

Atomic Clock

Today, atomic clocks provide the international time standard. Specifically, the frequency of an emission line of atomic caesium is the basis for the time measurement. Accuracy is improved by using lasers and atom-photon interaction to cool these atoms to very low temperatures, slowing them to a few mm/s. But weight injects a major perturbation: the atoms fall like any other object under gravity and in 0.1 s acquire a velocity more than a hundred times larger than cancelled by laser cooling. On the ISS, gravity forces are reduced by a factor of 100 000, so the Atomic Clock Experiment in Space (ACES) will provide unprecedented accuracy. Launch is currently planned for November 2005 on UF-6. The Principal Investigator is Prof Christophe Salomon of Univ. Pierre et Marie Curie (F).

Accurate clocks are the key element for the new methods of global navigation: GPS and Galileo. New ways of using satellite navigation data emerge almost every day. With more precise clocks, the higher navigational accuracy make it conceivable to predict volcanic eruptions and earthquakes. ACES will be a unique platform for testing fundamental physical laws with enhanced precision, such as the equivalence principle and the physics behind Bose-Einstein condensation. For long-baseline interferometry, one of the most powerful methods of modern astronomy for resolving distant objects, the precise synchronisation of the clocks in two widely separated observatories is of paramount importance. ■

The 'ISS Owners'



ISS Forum 2001 allowed the five International Partners to describe their roles in the ISS. Here are edited highlights of the 'ISS Owners' roundtable...

The panel of 'ISS Owners' comprised Dr. Kathie Olsen, NASA Acting Associate Administrator, Office of Biological & Physical Research and Chief Scientist; Mr. Valery Alaverdov, Rosaviakosmos First Deputy Director General; Mr. Kaname Ikeda, NASDA Executive Director, Mr. Mac Evans, President of the Canadian Space Agency, and Mr. Antonio Rodotà, Director General of the European Space Agency.

Dr. Olsen, how will the current budget difficulties faced by the ISS affect NASA's plans for its utilisation?

Before I answer that question, I want to thank ESA and DLR for sponsoring this meeting. I think it's the start of something I look forward to attending three or four years from now. We are now talking about the actual research and commercial activities carried out on the Station versus the potential. We are in a very exciting time. We have 16 nations coming together for the ISS. We have research on the Station right now – 18 biomedical and radiation experiments. Representatives from all the nations are working on these projects. Dr. Gunther Reitz of Germany has an experiment on dosimetry mapping and we have a Japanese colleague working on the Bonner Ball neutron radiation experiment. These experiments (<http://scipoc.msfc.nasa.gov>) are actually preparing us for future expeditions.

Now you are asking about the Space Station budget. We are facing a $4 billion overrun. We are doing this very carefully. We are on schedule on the first ten racks and for the hundred experiments selected by our peer review process. However, with the blueprint budget that was given, the research budget has been reduced by 36%. Therefore, we have to make some very serious decisions on how we are going to proceed. This is not going to be done tomorrow; it is a two-year process and we are at the beginning. Lower priority research will not be considered, but we want to keep three priorities in mind: health and safety, biotechnology and fundamental science. These are going to be the basis for all of our decisions. We are also involving scientific communities as well as international partners. With 16 nations working together, our goal is doing really outstanding scientific research. Research for the first time looking at 'how are we going to evolve in space?' Research that is going to allow us to work and live in space for the first time. Research involving atomic clocks, fundamental physics, materials etc. Working together as a team, we will be able to achieve a 7-person crew and state-of-art-facilities. We are faced with the challenge now, but I think that we will get to realise our dream.

Mr. Alaverdov, looking back at the long experience that Russia has with space stations, how do you see the ISS?

Naturally, ISS activities are taking into account

The 'ISS Owners' roundtable (from left): Dr. Olsen (NASA), Mr. Alaverdov (Rosaviakosmos), Mr. Rodotà (ESA), Mr. Ikeda (NASDA), Mr. Evans (CSA) and moderator Claus Kruesken.

the vast experience gained in 15 years of flight of the Mir orbital complex. This covers technological continuity, in particular modular construction, and the delivery and return of cargo to and from orbit. Reparability in orbit is of the utmost importance, as are cosmonaut EVAs – they spend a lot of hours out there. With Mir, we assembled and tested large-scale constructions in a very elegant manner. This is very important for the assembly of the ISS. It is worth mentioning here that our scientific, technical and manufacturing experience allowed us to develop and launch the Zarya and Zvezda modules as the core of the ISS. Also, our biomedical support allowed a super-long stay in space – over one and a half years.

The second aspect is our experience of international cooperation. It is about joint training of the cosmonauts and flawless joint operations of the international crews. Just as important, it is about coherent operations of the ground infrastructure of the participating countries – Houston, Moscow and other flight control centres. It is mainly about the flight control. Equally important is a good working relationship between the experts who handle situations and take decisions in real time.

The Station is expensive. It is important to have return. From the very beginning we have to select the fundamental-science experiments and research to obtain qualitatively new knowledge for humankind, hopefully up to the level of real discoveries. For applications research, it is necessary to select experiments that solve problems that we cannot solve on Earth. Another area is commercialisation. It is clear that everybody should have the opportunity for access. The issues of commercialisation are critical.

Mr. Ikeda, what is the purpose and motivation of Japan's participation in the ISS and what is the schedule of future Japanese missions?
It can be categorised into three areas: to strengthen the base for our space activities; to advance high-technology developments; and to contribute to society and the economy. We are developing Japan's 'Kibo' pressurised module where we can carry out scientific research and development. Additionally we would like to see applied research for industry. There is also an exposed deck for Earth and space observations and various technology developments like robotics. And we also have a logistics supply module. Through this development and the flights of our astronauts,

we are acquiring the technology and know-how of human space activities.

We also would like people to get interested in our activities aboard ISS. We have already started public campaigns in Japan looking for proposals to carry out in space, using equipment like high-definition TV. We have already sent to the Station the neutron detection device mentioned earlier, and we are about to send up a facility to examine micro particles in space. We would like to send a high-definition camera to the Russian segment even before Kibo's launch. By this sort of activity we hope to attract people's interest in what we are doing in space.

We also think it is quite important for us to play the leading role in Asia, paving the way for Asian countries to take part in the ISS. We want to exchange views and share accumulated experience.

In addition to the Kibo module, we are developing a logistics vehicle – the HTV, to send cargo to the ISS. In order to realise this programme, we need to have a successful launch of the first H-IIA rocket this summer. We are also developing a centrifuge module for life science experiments, using the very precise artificial gravity for experiments on mice and other animals to examine the influence of microgravity.

This is a very difficult task, a challenge for us and our community, but we are proud we are being part of the ISS.

Mr. Evans, Canada was one of the original ISS partners. What was Canada's motivation for taking part, what is its contribution and how do you foresee the future as regards Canada's utilisation?

This venture and its utilisation is a major milestone in humanity's exploration in space. Canada was honoured to be invited to be part of this programme for two reasons. Firstly, we believed we had something to contribute, based on the robotics we developed for the Shuttle's famous Canadarm. So we undertook the critical function of providing the new robotic arm, which is essential for the Station's continuing construction. This arm was delivered in April and it is being checked out now. In about a year, we will provide the mobile base that will allow the whole arm to move up and down the Station. In a couple of years, we will add the two-arm robot for very dextrous activities, such as changing out units that need to be replaced. So it will be essential for maintenance of the Station.

The second reason we are very pleased to part of the ISS is its utilisation. We have a unique laboratory in space and since about 1984 Canada has been preparing for this day. Since then, we have had quite an aggressive microgravity programme in our country, aimed at getting our scientific and industrial community used to doing research in that environment. Now the Station is up there, we have long-duration access and we will be able to do a lot more than on the Shuttle. We have adopted the policy of making 50% of our Station utilisation resources available to industry for commercial purposes. Recently, we had a major conference in Canada where we offered to the world's industries the opportunity to make a proposal to us on how they would pursue the commercialisation of those resources.

Mr. Rodotà, what will Europe gain from its participation in the ISS programme?

Some of the gain that Europe can get from this Station is yet to come. This Station is a big instrument for scientists, for industrialists. We hope that big, big science will come from the Station and quite a number of new improvements to benefit industry and employment. Space Station is part of the tradition of the European space sector in general where, in addition to science and applications, we have access to space and staying there. Those two pillars have been implemented on the launcher side – with the Ariane family – and initially with Spacelab and now with the ISS. This has created a high level of competence and allows Europe to play an important role commercially and in preparing technologies for use not only in the space field but also in other sectors.

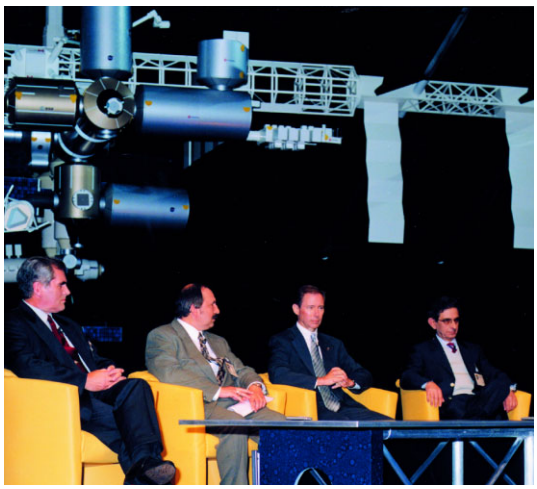
Europe's early participation in the Station focused on very specific items, but now we are using our competence to contribute hardware that was not originally foreseen – such as the Nodes, Cupola and possible participation in the Crew Return Vehicle. So I think we have already gained much from the Space Station, and we hope that we will gain increasingly in the future. ■

The 'ISS Builders'

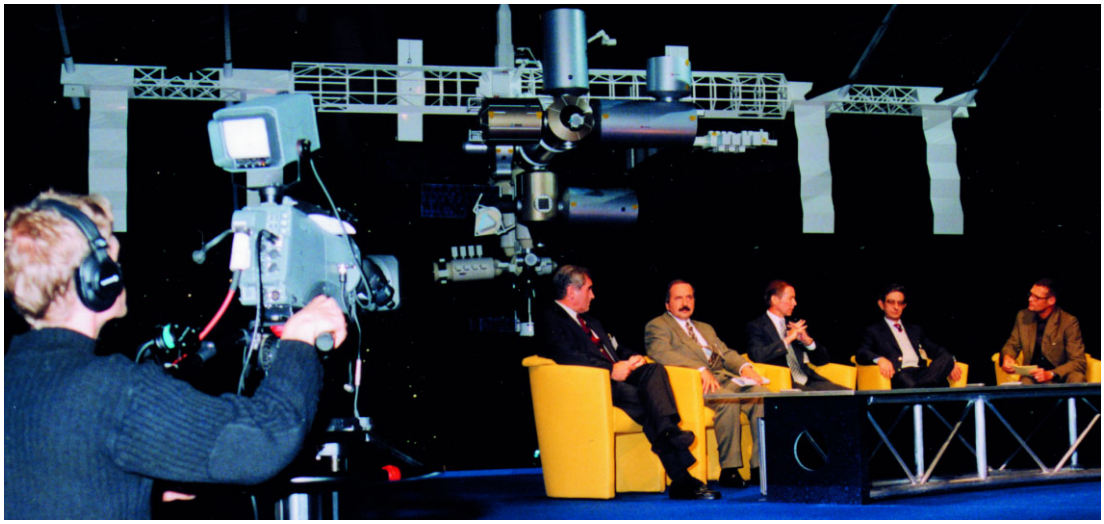
ISS Forum 2001 allowed the main contractors to describe their roles in the ISS. Here are edited highlights of the 'ISS Builders' roundtable...

The panel of 'ISS Builders' comprised Mr. Josef Kind, President of the Space Infrastructure Division, Astrium GmbH; Mr. Sergey Shaevich, Director of the ISS-FGB Programme, Khrunichev State Research and Production Space Centre; Mr. Brewster Shaw, Vice President/General Manager International Space Station, Space and Communication Group, The Boeing Company; Mr. Saverio Lioy, Space Station-related Projects and Future Development, Alenia Spazio.

Mr. Shaevich, the Russian and US elements had never met before they were mated in space but they work perfectly together. How much coordination was necessary to achieve this?
ISS history began in Crystal City, Washington DC in August 1993. The initial step of our joint activity was to define the requirements, particularly of the Zarya and Unity first elements. The current configuration has an almost equal number of Russian and American elements, totalling 140 t from seven Russian and nine US launches. These elements had never met before. We organised many technical teams to prepare the right requirements and the right approach for verifying the interfaces. We continue to have many meetings – teleconferences and face-to-face meetings on a regular basis. We paid a lot of attention to preparing the crews on the flight units and simulators, plus mission control centres and launch facilities. Of course, we had to overcome language problems and technical cultural differences. Many joint documents were created, including a huge volume of standard documentation. It took a lot of work but you can see the good results today. Our joint experience can be used for other international projects in the future.



Mr. Shaw, industry works under contract to the respective space agencies. How much coordination and cooperation is there among these industries and how did you achieve it?
Cooperation and communication is essential in an international project of this magnitude – with several space agencies, dozens of companies and thousands of workers all over the world contributing to the ISS. Keeping the teams all heading in the same direction is imperative. The cooperation we have had to achieve the success we have seen so far is outstanding, fed by the efforts of the agencies in keeping their teams together to agree on the requirements and have everyone focusing on the common goal. In industry we do the same thing. Clearly, we can build the ISS but the question is, what are we going to do with it now? Boeing, along with several of our industrial partners, has bilateral and multilateral memoranda of understanding towards helping the agencies resolve the issues associated with operations, utilisation and commercialisation of the ISS. The Station will be judged over time on what it accomplishes. Certainly, government-funded research and supporting further exploration of our solar system will be key, but I personally believe that, for the Station to be judged a great success overall, it will have to contribute significantly to the development of space commerce. And by space commerce I mean the



The 'ISS Builders' (from left): Mr. Kind (Astrium), Mr. Shaevich (Khrunichev), Mr. Shaw (Boeing), Mr. Lioy (Alenia) and moderator Claus Kruesken.

commerce that is generated by teaming an intelligent human and an intelligent machine to accomplish a goal.

Mr. Lioy, Alenia appears by the number of elements it has produced to be the world's main supplier of pressurised modules. How will Alenia deploy its workforce once the ISS hardware is complete?
As a matter of fact, we will have produced 50% of the pressurised modules by the time the Station is completed. Our experience began with the European Spacelab programme and then consolidation of Italy's participation in the Station through bilateral agreements between ASI and NASA, and, of course, through participation in the European space programmes under ESA leadership. That approach has given Alenia the opportunity to build on its Spacelab responsibility for the thermal control and manufacturing the structure. Now we are in the position of designing and manufacturing the complete system of all the pressurised elements under our responsibility. Under an ASI-NASA bilateral agreement, we developed the three flight units of the Multi-Purpose Logistics Module (MPLM). Two have already flown and the third is ready to go. Our enthusiasm in Alenia for this job was confirmed by the astronauts commenting that they found our MPLM a comfortable environment.

After that, we have Nodes 2 and 3, a joint programme between ASI and ESA. We believe our experience has been appreciated by NASA, so we have started preliminary studies on the habitation module. Working with ESA has given us the opportunity to consolidate what we have achieved with MPLM – we have a major responsibility for Columbus. We also have prime responsibility for the Cupola and the pressurised carrier on ATV.

But what will Alenia do after manufacturing these ISS elements? With this in mind, we are responsible for major microgravity facilities: the Fluid Science Laboratory, for which we are prime contractor, and the European Drawer Rack. We are thinking now how to utilise the Station, for which ASI and Alenia have created the ALTEC Advanced Logistic Technology Engineering Centre (<http://www.spacegate-altec.it>). Of course, we are convinced that the Station will expand and we hope to contribute our experience to ESA's Crew Return Vehicle project, where we have key capabilities for the pressurised compartment. Looking at missions to the Moon and Mars, we have already initiated studies on pressurised inflatable structures that will be of fundamental importance.

Mr. Kind, Astrium is heavily involved in developing hardware. How is the space industry prepared to support ISS operation and in particular to serve the commercial utilisation?
From the beginning we have had a very strong strategy for Astrium to concentrate during the development phase on both the operational task and the utilisation task. One way is that we offered ESA a high-level commitment to handle operations for the European elements via industrial consortia. We are preparing this proposal with our integrated team in Bremen, where we are also integrating Columbus and the ATV carrier. The second way is that Astrium is investing a lot of money for commercial applications – in utilisation, experiments, facilities and marketing customer-orientated infrastructure. We therefore created the BEOS centre in Bremen (<http://www.beos-space.de>) to provide all the customer end-to-end services. We offer utilisation expertise for mission preparation, the technology and put it all together to present a single interface to the customer. Astrium is ready for you, in an operational, utilisation and commercial way! ■

The ISS is a Classroom!

Dr Kathryn Clark
Chief Scientist, Human Exploration & Development of Space, NASA HQ, Washington DC, USA
Email: kclark@hq.nasa.gov

Space exploration is an exciting tool for teaching students of all ages...

People ask, 'Why use space for education?' The best reason is that the tools and technologies pace exploration are exciting to students and can be used to grab their attention. Not only can we use space exploration to teach about the Universe, but we can use it to engage students in mathematics, science, physics, social studies and languages – after all, it is the *International* Space Station. We can use space to teach about our home.

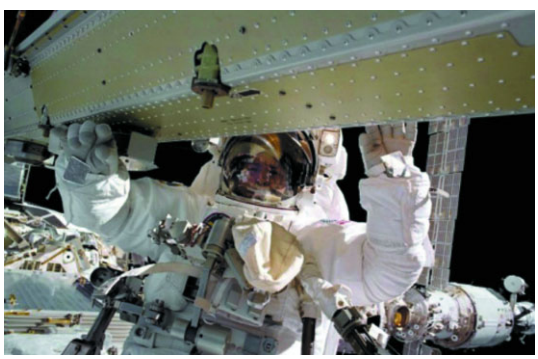
The unique perspective of images from the ISS and other space vehicles can inspire students to become rocket scientists, nuclear physicists or, perhaps, artists. Space is full of the 'coolest toys'. Kids from ages 4 to 94 love space and space toys. Once we have their attention, there is no limit to what we in the education community can teach them.

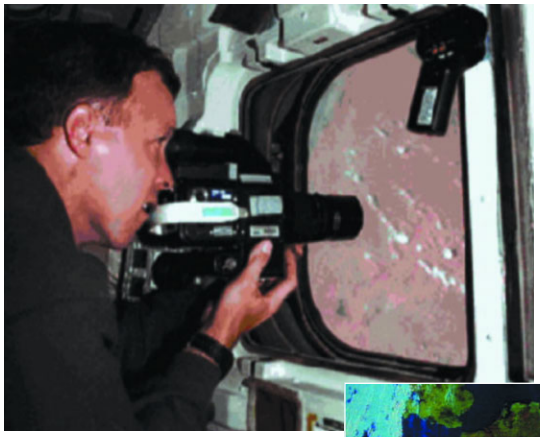
The ISS was a teaching tool before it became a space station. NASA's educational video *Meet Me at the Station* <http://spaceflight.nasa.gov/gallery/video/station/mmats/index.html>is an overview of building the ISS and the kinds of technologies required. It is similar to ESA's *Space Pinball* game, which is used to illustrate gravitational principles and orbital mechanics. <http://www.estec.esa.nl/outreach/spacepinball/>

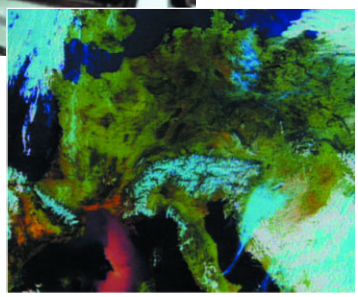
Images of astronauts and objects in orbit, coupled with educational materials, make it easy to explain such difficult concepts as the difference between weight and mass. The Italian Space Agency's *Mars* programme, like NASAs *Space Day* event, is geared towards living and working in space, a subject that fascinates people of all ages. Questions ranging from bathroom etiquette to technologies for oxygen production are commonplace at events where astronauts are available to explain the intricacies of life in the microgravity environment.

Just to embark on the greatest engineering project ever undertaken by humans is an engineer's dream. It also provides teachers with images that can be used to illustrate physical principles, real-life uses of mathematical concepts and the benefits of teamwork. In addition, as we continue to build the massive structure, it becomes increasingly visible in the night sky (<http://www.hq.nasa.gov/osf/station/viewing/issvis.html>), allowing teachers to engage students by bringing the real ISS to Earth.

The concept of microgravity is one of the most difficult to explain, and the most necessary in order to use the environment for education. 400 km up in the atmosphere is still within 90% of the Earth's gravitational field. Why, then, do objects float, and what do scientists mean when they use the term 'microgravity'? The Station and all other satellites in low Earth orbit are actually in a state of freefall, a concept that is considerably easier to demonstrate than to explain. It is as though the astronauts are in a very tall elevator, falling thousands of metres. The problem with an elevator, of course, is that it eventually gets to the bottom. The

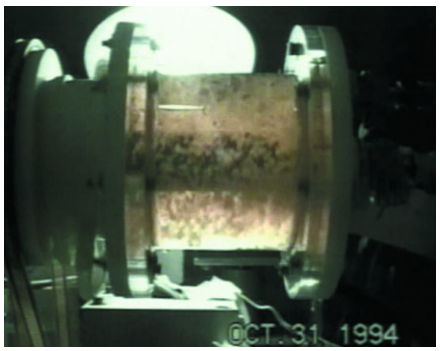






28 000 km/h 'sideways' speed of the ISS means that it falls without ever reaching the bottom. It is easy to understand why I favour a demonstration for this – it is difficult to explain but simple to show.

The idea of using demonstrations both on the Earth and in space has spawned a number of projects from all the ISS partner countries as well as a few not yet formal members of the partnership. Hopefully, these programmes will be catalogued in such a way that they are available to students all over the world. The international component of this will add a dimension likely to be of greater benefit than the science and mathematics combined.



The *Physics of Toys in Space* programme began back on Shuttle mission 51D in 1985 and has been expanded into an international programme on the Shuttle and ISS called *Teaching from Space*. Almost every crew carries some education projects, complemented by curriculum and demonstration materials on the ground. The DLR German space agency has produced an entire series of curriculum materials based on space images in order to engage students in physics and mathematics. Russia and Australia are working on the 'Kolibri' project, for their students to collaborate on studying Sun-Earth physics and high-energy particles in the Earth's upper atmosphere using a microgravity satellite that will be released from the ISS. In Canada, the astronauts frequently visit classrooms to engage students in problems associated with spaceflight and creative thinking. Canada's 'Canolab' project uses their museums to spread education using canola seeds flown in space that are now plants on Earth.

Older students can be pressed into more autonomous roles in data collection. In the EarthKAM international project, high-school students have to write grant applications to receive images from a camera mounted in the window of the Destiny US Lab (<http://www.earthkam.ucsd.edu/>). The project is run by university students, providing a natural mentorship that is beneficial to both groups.

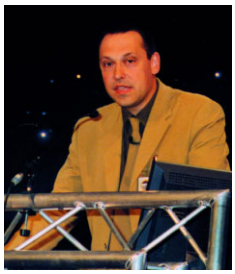
Students also have the opportunity to experience microgravity for themselves. ESA and NASA both have student parabolic flight programmes. The ESA Space Station Utilisation Contest Calling for European Student ideas (SUCCESS) offered prizes of laptops, a trip to a launch, or a fellowship at ESTEC culminating in a parabolic flight with their experiment. While the flight itself was terrific fun for all students, they also worked on creative and well thought-out experiments, learning to work in teams in the totally foreign environment of repeated bouts of 25 s of microgravity. The Orbital Liquid Experiment won the parabolic flight. Designed to study fluid phenomenon under intermediate levels of gravity, this experiment may eventually fly on ESA's Columbus module.

University and graduate students are also mentored into the field by being part of real research in space. Every space agency has programmes to allow researchers to bring students into their laboratories to participate in these experiments. The opportunities for these mentorships are limited only by what can fly on the ISS. Thus students can become engaged in astrobiology, bioastronautics, fundamental biology, gravitational biology, biotechnology, materials science, combustion, fluid physics, fundamental physics, Earth science and space science.

The unique International Space University in Strasbourg (F) brings together students from diverse cultural backgrounds, both with respect to nationality and to education. The students of business, engineering, policy, law and science will lead the next generation of space explorers, entrepreneurs and researchers.

That is our future. ■

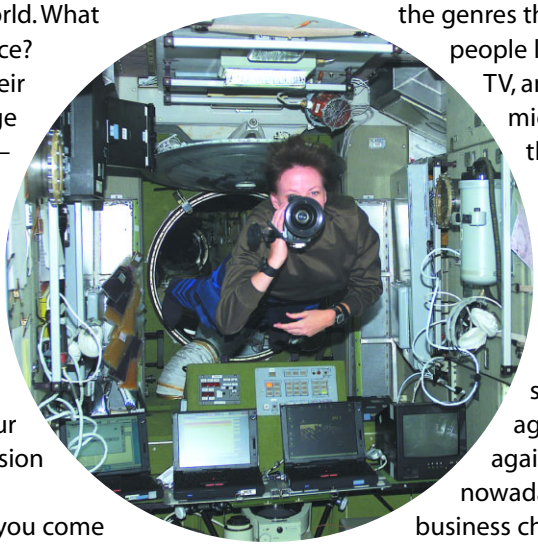
Discovery Inside the Space Station



Patrick Hörl
Discovery Channel Betriebs GmbH, Robert-Buerkle-Str. 2, D-85737 Ismaning, Germany
Email: Patrick.Hoerl@discovery.com

It is a great honour for me to speak in front of the people who are building the ISS. Let me share some of our industry's thoughts with you, because the key to any good science content on TV is gaining a better understanding of each other's perspectives on the world of science.

As the leader in reality-based programming around the world, the Discovery Channel continuously has to re-evaluate and re-think its mission in a changing world. What can we do for the audience? How can we appeal to their curiosity? It is our privilege to take viewers seriously – television is more than entertainment. Even if we use the tricks of any good entertainer, we believe that TV first and foremost has its potential in the opportunity to enrich your lives. If we succeed, television can give you a better understanding of where you come from, and where our world is going. Whatever your idea of the future is, and wherever you want to be in the future, television has a bigger impact than any other medium on forming these perspectives.



For us, it is your world of space research and exploration that provides the building blocks for an accurate picture of our future. For the world of science television, the number of stars attending the ISS Forum might be bigger than the number of stars currently involved in filming new movies in the studios of Babelsberg at the other end of town. We depend on communicators, who can talk about their science. We are looking for scientists who can excite, people who can guide our perception of the future, who can help us to understand the implications of new developments. The scientists and researchers of today are the adventurers of the 21st century.

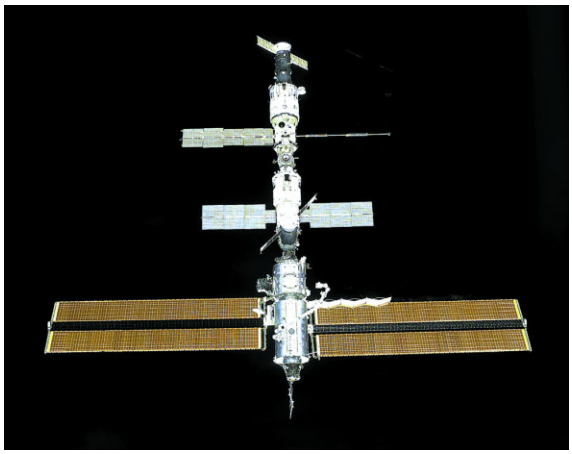
Recent studies show that the appetite for films about science and technology has grown. Recently, ARD, the German public broadcaster, researched the genres that people like on TV, and you might be surprised to hear that they prefer films dealing with science and technology against films on regional issues, and even against popular music channels like MTV. They prefer science and technology against game shows, against films on politics and, nowadays, certainly against business channels.

The ISS provides a unique meeting point for the worlds of space and television...

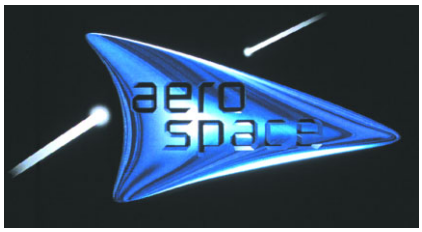
What conclusion should we draw from that? We started to look into the potential of the ISS as early as two years ago, and Discovery was probably the first channel worldwide to dedicate a high-budget documentary special to the ISS. We aired *Inside the ISS* in December 2000 in 150 countries in 32 languages.

Television was not made for space, just as astronauts were not. Taking cameras into

space requires a huge effort well beyond the typical budget of a TV film, and of a non-fiction film in particular. So, if we really want to bring some of these great stories down to Earth, a joint effort is needed. TV companies, broadcasters, the space industry and space agencies need to team up. We must face this reality. Television from space is not a likely revenue source in business models for the commercialisation of space. It is rather a precondition for such a commercial approach. Any perspective for commercialisation is minimal if nobody understands and knows what the ISS is good for. But once we agree that there are relevant stories to be told about the scientific and industrial efforts in space, we will be able to catch the attention of a large audience. It is really a question of what we want to tell and how it can be told. It has to become our common goal to figure out new ways capturing the imagination of a bigger audience. What you can do in space has a lot to do with what ordinary people believe you can do up there.



The Discovery Channel has begun two initiatives in Europe, which will help us to tell stories about the ISS on a more continuous basis. We are running the regular *Aerospace* TV magazine dealing solely with aviation and space issues. Its studio host show is ESA Astronaut Thomas Reiter. A reason we began this show is because we are deeply convinced that the ISS will continuously deliver interesting stories about manned spaceflight, science, progress in science, interesting research and all the imagination that goes into what ESA and the other space agencies and the industry are coming up with. We regard *Aerospace* as a contribution to the overall effort that ISS represents.



And a new initiative has just started. We are asking independent filmmakers in Europe for proposals on subjects relating to the ISS. We want to encourage young storytellers and journalists to identify gripping supjects, dealing with the ISS and the people living and working up there. The films we are planning to commission should ensure that the ISS stays in the mind of the public, and that it will be perceived as an interesting place in space, as an interesting outpost for learning and the quest for understanding, and for new discoveries in the world around us.

Many proposals have already been submitted. It is obvious there is a keen interest in your work. Help us, so that the adventure doesn´t stop with the experience of penetrating your large organisations. Allow us outsiders to become part of your efforts. In return, we will help you to identify stories in your midst that can become valuable experiences for a wide audience.

You are the people who take the astronauts up there. Consider us as your partner when it comes to bringing them down to a wider audience. ■

The Mir Experience and Commercialisation of the Russian Segment of the ISS

Prof. Nikolai A. Anfimov
Director of TsNIIMash (Central Research Institute of Machine Building), Korolev-city, Moscow Region, Russia
Email: anfimov@mcc.rsa.ru

The 40-year history of space exploration, beginning with mankind's first spaceflight – by Yury Gagarin – is a vivid illustration that manned space exploration is a driving force for all space activities. Manned flight is a rather expensive area of space activity, so commercial activities aboard a space station should be a major incentive for its further development and a means for covering costs in the near future.

The experience of Mir's utilisation

Assembly of the unique Mir station began in February 1986 with the launch of its core module. Mir operated in orbit for 15 years, achieving a final configuration of six principal modules.

A large integrated research programme was performed aboard Mir, resulting in valuable practical applications that are also of interest to non-space industries. More than 20 countries participated in research aboard Mir. Many organisational and technical approaches required for international collaboration were developed and tested there. Because of this, Mir was actually the first international space station and the first phase of the ISS programme.

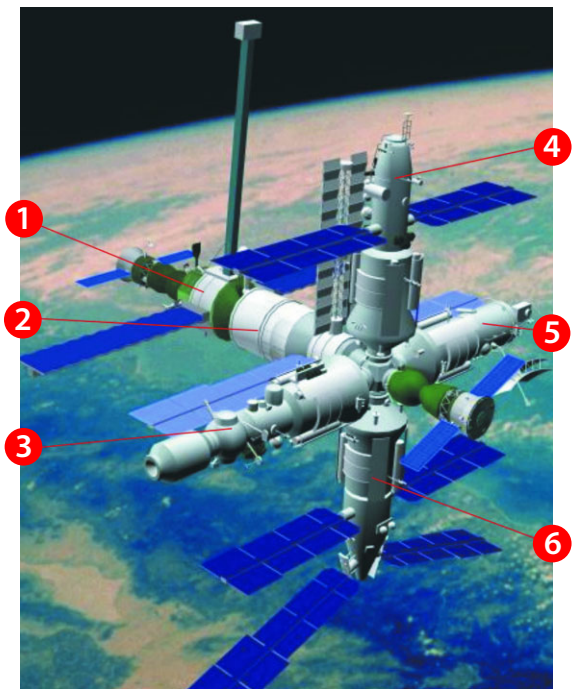
The most important achievements in Mir's utilisation are outlined below.

In space technology and material sciences, Russian specialists have achieved pilot-scale production of different materials with improved properties. More than 100 experiments developed the processing technology for the materials required for highly integrated chips, solid-state lasers and highly efficient radiation detectors.

Extensive data on Earth's ionosphere and magnetosphere were gathered during Mir's geophysical studies. Interaction of the ionosphere and magnetosphere with the solar wind and their relation to processes on Earth's surface and in the atmosphere were studied. Our scientists achieved promising results in detecting ionospheric precursor events a day before powerful earthquakes.

In life sciences and biology, Mir research revealed the mechanisms of how the human body adapts to space and allowed us to create a medical support system to support flights of up to 1.5 years. In particular, these results allow us to support flights by non-professional astronauts and to form a basis for missions to Mars.

Russia offers a wealth of experience in manned spaceflight and orbital facilities...



The Mir space complex. 1: Kvant astrophysical module. 2: Core module. 3: Kristal docking & technology module. 4: Kvant-2 resupply module. 5: Priroda remote sensing module. 6: Spektr research module. Orbital mass ~130 t, power ~26 kW, pressurised volume ~300 m³, 2-6 crewmembers. Number of research sessions >22 000; basic expedition crews 28, international visiting crews 26, total crewmembers103 (including 62 foreign), total time of international crews onboard >3 years.

MIR SPACE COMPLEX: RESEARCH RESULTS

The unique Mir research complex included 6 modules containing 240 items of scientific equipment with a total mass of 11.5 t, manufactured in 27 countries. More than 22000 experiments were performed 1986 - 2000. New knowledge and results of significant practical importance were obtained in the areas of medicine & biology, astrophysics, material sciences, geophysics, biotechnology ecology, power engineering and technology.

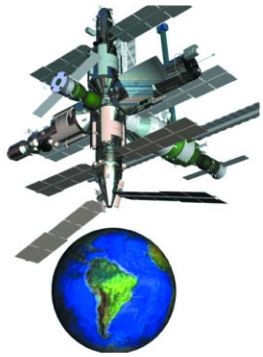
TECHNOLOGY

- More than 4000 sessions of experiments performed onboard the station
- Unique technology for large-scale truss and film-based structures assembly and deployment
- Methods and means for repair and recovery to prolong the station and equipment lifetimes

INTERNATIONAL COOPERATION

- More than 7000 sessions of experiments carried out on medicine, biology, technology, biotechnology, technical research
- 26 international missions implemented, 21 of which were on a commercial basis
- Representatives of more than 11 states worked on the station (USA, Germany, UK, France, Japan, Austria, Bulgaria, Syria, Afghanistan, Kazakhstan, Slovakia

1986-2001



BIOTECHNOLOGY

- About 120 experiments performed
- Possibility demonstrated for the fine purification of biological protein products, with the output purity hundreds of times higher than on Earth
- New knowledge obtained on cells, proteins and viruses

EARTH OBSERVATION

- More than 1000 sessions of observations
- 125 million sq. km of Earth's surface photographed in different spectral ranges
- Equipment perfected for operational measurements and data transmission
- Photo-, video-, spectrometric information data bank created

SPACE TECHNOLOGY AND MATERIALS

- More than 1900 experiment sessions performed
- Basic technologies worked out for semiconductor production and samples obtained that exceed their ground-produced equivalents by specific physical properties
- 5-10 times output increase confirmed for valid devices manufactured from materials obtained
- Selected materials properties confirmed for long-duration operating spacecrafts

MEDICINE

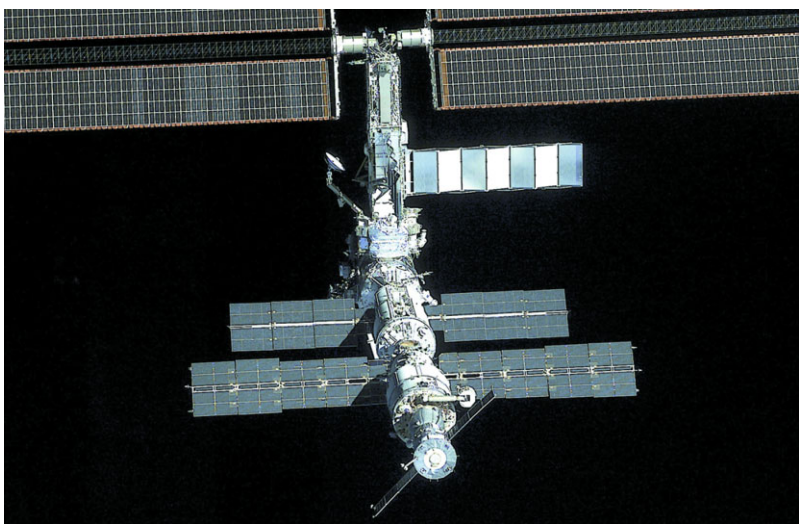
- More than 2000 experiments performed
- Medical maintenance system created to support spaceflight of up to 1.5 year duration
- Techniques developed for specialist selection and training for working under extreme conditions
- A number of techniques applied to general medical practice

ASTROPHYSICS AND GEOPHYSICS

- More than 9000 experiment sessions performed
- Unique observations carried out, and hard X-rays from supernova SN1987A detected
- X-ray sources (named KS: Kvant Sources) disclosed and studied in details
- Detailed research of the Galactic Centre
- Detection of Earthquake precursors under development

Studies of Earth's natural resources and ecological monitoring included detection of volcanic eruptions, forest and grass fires, contamination of the land, ocean and atmosphere, and natural and man-made disasters. Numerous technical studies and experiments produced new space technologies, including repair techniques.

The state of Russia's national economy during the last decade meant that Mir's commercial utilisation was limited to seeking non-governmental financial resources – mainly funding from international partners interested in project implementation. This approach is also being taken during the initial deployment of the ISS Russian Segment.

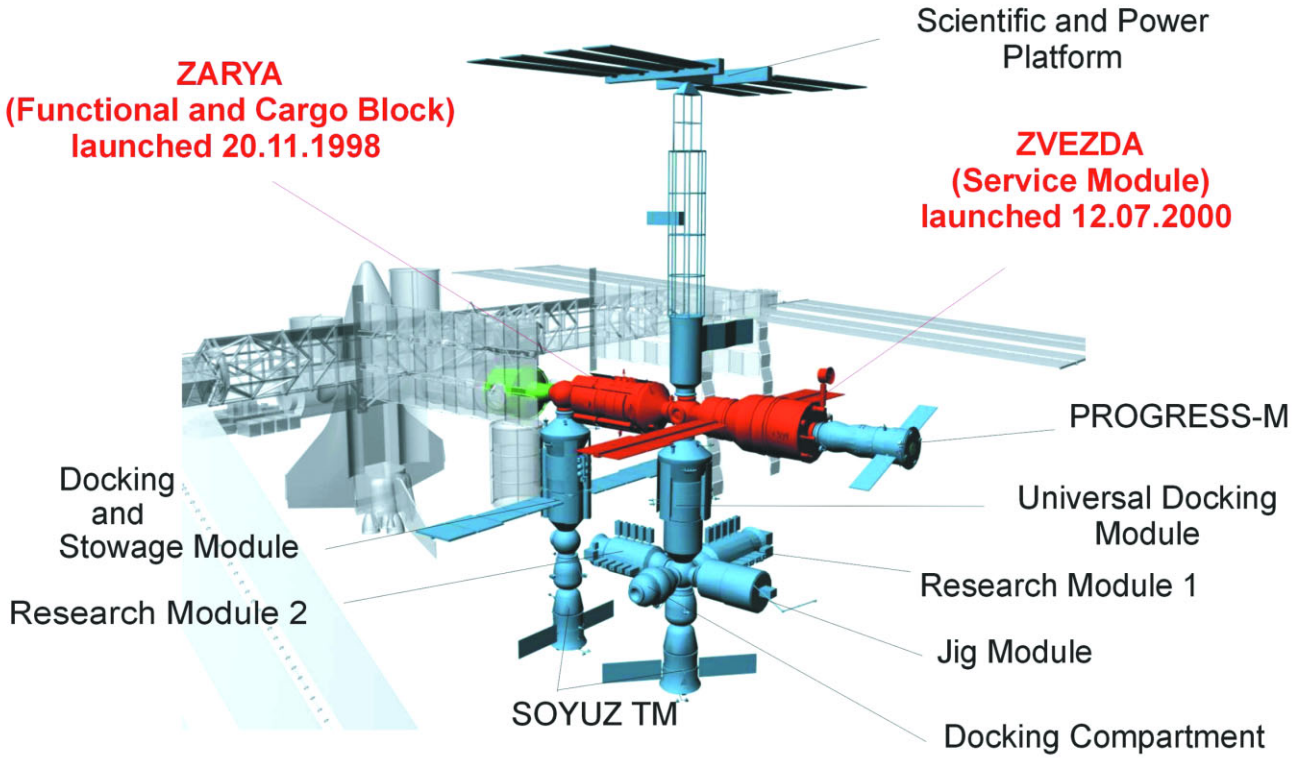


Commercial Perspectives of the Russian Segment of the ISS

The ISS allows us to expand commercial opportunities and stimulate private investments in different areas of space activities. Implementation of the first commercial projects on the Russian Segment has already started, during the first two Expedition missions. Zvezda, Docking Compartment-1, the Science & Power Platform and the Universal Docking Module can accommodate about 180 items of scientific equipment totalling more than 3000 kg. About 160 experiments are proposed in 11 areas, including commercial contracts and international cooperation:

- Space biology and life sciences
- Space biotechnology
- Space technology and materials
- Geophysical studies
- Earth remote sensing and ecological monitoring
- Extra-atmospheric astronomy
- Studies of planets and small bodies of the Solar System
- Studies of cosmic rays

The planned Russian Segment of the ISS. Mass 133 t (out of ISS total 408 t), including 26 t of science equipment. Number of planned experiments 295, power supply 19 kW, crewmembers 3-6.



- Technical studies and experiments
- Space power and propulsion
- Programme integrated analysis and formation.

Of the highest interest to industry and business are:

Biotechnology. Space biotechnology provides a solid base for producing substances that greatly exceed the quality of their terrestrial equivalents or that have no terrestrial equivalent at all.

Production of advanced materials. The goal is small-scale production of complex monocrystals for micro- and optoelectronics, doped garnet monocrystals for lasers, and general materials with properties that cannot be obtained on Earth, as well as optimisation of ground-production techniques.

Earth remote sensing. It is planned to develop and apply methods for natural-resource exploration and early forecasting of disaster phenomena and their spatial and temporal scales and consequences.

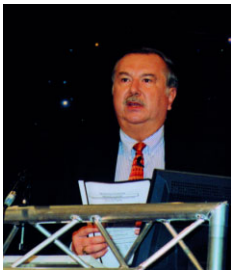
Non-traditional utilisation areas. During these early days of the Station, when the project is attracting the attention of the whole world, the most interesting activities for business users can be in the 'non- traditional' areas of space utilisation. They may include advertising, branding, sponsorship, entertainment, and educational and outreach programmes. We expect that the most advanced telecommunications and multimedia tools will be used for these commercial projects.

We believe that 'guest' missions of non-professional astronauts to the Station should be possible. Spaceflight is a dream for many people who chose other professions. Of course, these flights must be regulated by specific documentation approved by all of the International Partners.

We are ready to provide the resources, hardware and other opportunities offered by the Russian Segment, as well as to offer our unique experience for projects proposed by the users themselves. Of course, we will create a user-friendly environment by providing:

- minimum time from user's proposal to project implementation,
- simple and clear process for proposal review and selection,
- transparent pricing policy;
- confidentiality and intellectual property rights, etc.

The NASA Commercial Space Centers



Dr Frederick Best
Director of Center for Space Power, A&M University, Texas, USA
Email: FRB4492@teesex.tamu.edu

The US Commercial Space Centers play an important role in developing space products. They are poised for major expansion now that the ISS is available for full-time orbital research...

The 17 US Commercial Space Centers (CSCs) unite industry, universities and NASA for commercial product development. This industry-driven programme uses leading research professionals from their host institutions, other universities and the industry affiliates to develop technologies. With over 163 industry affiliates currently working in the programme, the CSCs have access to researchers and facilities that would normally be out of reach. Cash and in-kind investments from industrial partners allow the CSCs to leverage their NASA base grant funding, which provides for a more robust research and product development organisation. When required, space-oriented research and technology development activities are supported with existing flight hardware, tested in zero-gravity using NASA's KC-135 aircraft and, if programme criteria are met, provided with access to space.

Commercial Space Centers are:

- non-profit organisations that lead consortia of commercial, academic and/or government entities in space research and development projects;
- established by cooperative agreements with NASA. NASA provides base funding at about $1 million per centre per year plus ISS funding for hardware. Industrial partners with cash and in-kind investments are required;
- providing an interface to space for industry. They market the advantages of space research, provide expertise and flight hardware to support industry-driven research, cooperatively execute the research, and cooperate in mutual technology development for commercial products.

With a combined total funding from NASA, industry and universities of $96 million, this programme has fostered spin-off companies, and developed commercial technologies that encompass many different fields.

The Center for Biophysical Sciences and Engineering, University of Alabama at Birmingham, is partnered with pharmaceutical companies that are developing drug treatments of cancer, immunological, inflammatory and viral diseases.

The Center for Advanced Microgravity and Materials Processing's research involving ambient-condition hydrogen storage could impact the transportation market and significantly reduce pollution and dependence on foreign oil. Fire suppression technology is being developed by the Center for Commercial Applications of Combustion in Space. This new water-mist fire suppression technology will provide an inexpensive, non-toxic alternative to Halon. The Center for Space Power at Texas A&M University is developing magnetic bearings for aerospace flywheels. These bearings will provide increased energy storage density to save mass, and the long cycle life enables low Earth orbit missions (reducing cost of ISS). The Commercial Space Center for Engineering (CSCE) is working with industry to develop, design and prove space technologies that enhance commercial markets. The Express Pallet testbed on the ISS will provide industry with short- and long-term access to space for testing products and processes in zero-gravity.

The Wisconsin Center for Space Automation and Robotics partnered with International Flavors and Fragrances to identify the new 'Space Rose' fragrance for a rose in zero-gravity. The fragrance has been incorporated into *Zen* perfume and marketed..

'Kibo' and its Diverse Utilisation

Hideshi Kozawa
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The construction of the International Space Station (ISS) began in November 1998, and the assembly of the 'Kibo' Japanese Experiment Module in space will start in 2004. At last, utilisation of the space environment is becoming a reality.

NASDA wants to make full use of Kibo, not only promoting it as a traditional onboard laboratory but also diversifying its utilisation to users in various fields, including private companies. As part of this effort, NASDA is creating more friendly user guidelines.

Possibilities for the non-traditional utilisation of Kibo include space movies, on-air events, educational experiments, experiments using the airlock, sponsorship of commodities for living aboard the ISS, and an external video camera viewing the Earth.

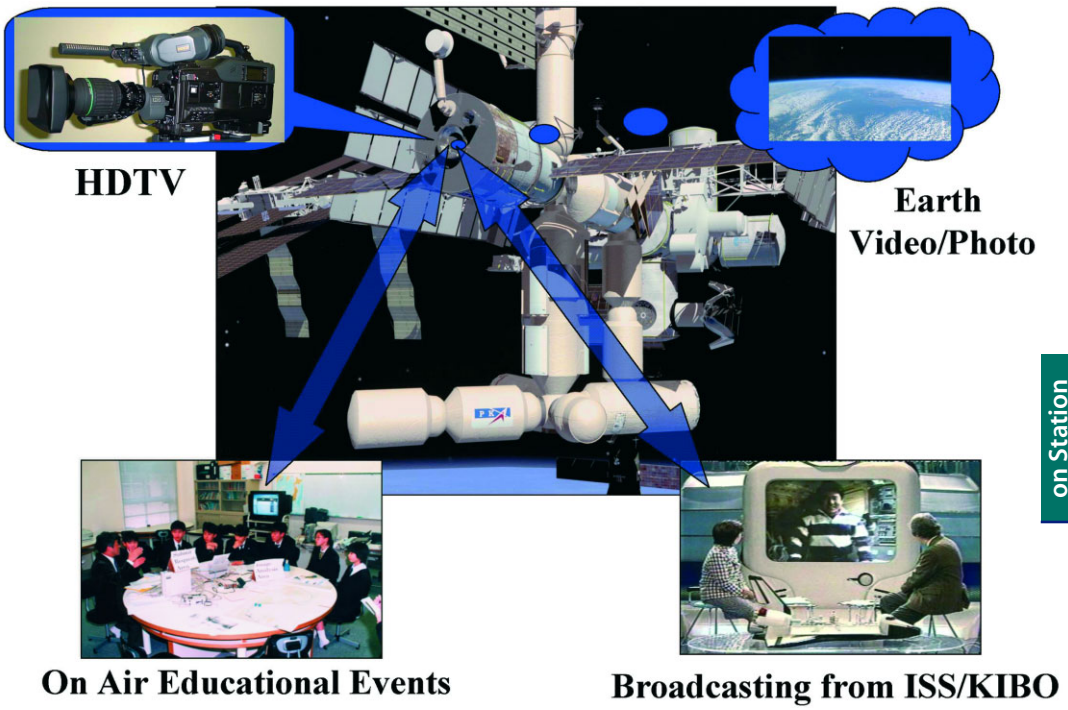
NASDA is beginning a series of a new type of pilot project to widen the scope of Kibo's utilisation. The first project began in mid-2001, based on an idea proposed by the public to make use of NASDA resources aboard the ISS. These resources include a high-definition TV camera delivered to Russia's Zvezda Service Module in August.

NASDA will develop each pilot project in turn to gather data to help establish a user-friendly approach for future Kibo utilisation.

To promote diverse utilisation, NASDA is emphasising the following public relations activities:

- symposia for new communities. The first symposium on Kibo diversification was held this March, and the concept of the first pilot project was unveiled;
- a network of future user communities in various fields;
- using pilot projects to highlight the range of possibilities for using Kibo;
- practical experiments through a series of pilot projects to help develop user-friendly guidelines.

Japan's 'Kibo' module will host a range of pilot projects...



NASDA believes that the diversification of Kibo's utilisation will help to open the door on mankind's use of the space environment and the creation of new culture. ■

The Promotion of Industrial Users by DLR

Hartmut Ripken
Coordinator for Space Station Utilisation Preparation, German Aerospace Center (DLR)
Email: Hartmut.Ripken@dlr.de

DLR has developed a concept for promoting German industrial utilisation of the ISS. Close cooperation with non-space industrial mediators, outsourcing of marketing activities and the best possible customer care are key elements of the DLR initiative. Pilot projects by German industry are in their definition stages...

In the past, the German Aerospace Center (DLR), acting as the German Space Agency, has conducted extensive market studies in Germany's non-space key business areas, in order to measure the awareness and perception of exploiting the International Space Station (ISS) and microgravity. It was generally found that microgravity research and the use of in-orbit infrastructure was largely unknown. ISS utilisation clearly is an underdeveloped market segment.

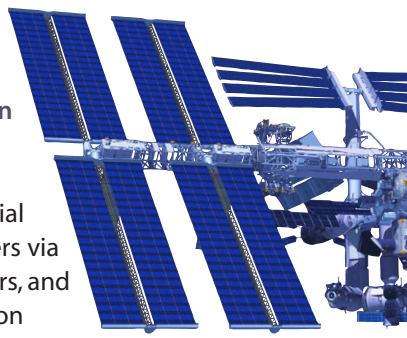
Evaluating the research advantages and potential of the ISS, DLR found indications that a strong interest in using Station resources can, if nurtured properly, emerge in key business areas worldwide within the next decade. Also, Station utilisation for private-sector research will be a high priority. In anticipation of this market change, DLR has developed an initiative to promote industrial ISS utilisation nationally and to assist German industry in accessing ISS for research purposes.

The ISS User Community

European ISS users will be predominantly researchers in basic science, gaining access to the Station via ESA's peer review process (principle of 'best science'). Further user groups include public service providers and users in applied research. Industrial and commercial users and non-scientific enterprises will form approximately a third of the ISS user community.

Here, 'industrial users' are customers engaged in potentially profit-making research, partly supported by national or international promotional programmes. In contrast, the term 'commercial users' refers to fully paying customers predominantly unconcerned with research.

The DLR initiative to promote industrial use of the ISS will focus exclusively on industrial research using the Station as a testbed or exploiting its microgravity conditions. In order to overcome the strong bias of this user group against a manned space infrastructure, DLR has developed a concept for ISS utilisation offering solutions that can be implemented by non-aerospace companies.



The Concept of Industrial ISS Utilisation Promotion

Key elements of the concept are:

- addressing potential industrial customers via industrial mediators, and
- focusing strongly on industry-standard customer care (key account, 'one face to the customer').

This promotion concept is atypical not only for government space agencies, but also for space companies.

Industrial mediators charged with market development include contractors (outsourcing of tasks), Chambers of Commerce, industry associations and transfer centres. They are in a uniquely qualified position to perform customer analyses, to address market-relevant terrestrial topics and to establish a dialogue between space representatives and potential industrial users. DLR has selected Kesberg, Bütfering and Partners to be the prime contractor for industrial promotion and promotion project management.

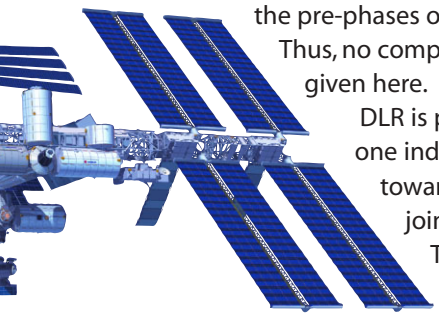
The prime tasks are the description of Station utilisation potentials, the clarification of relevant boundary conditions and access procedures, and the initiation of necessary cooperation in the area of user support. Tools to perform these tasks are the 'Information Service ISS' with newsletter and website (<www.raumstation.dlr.de>), and the implementation of a virtual 'Service Center ISS' formed by DLR, space industry, academia and national user support centres.

This Service Center ISS focuses on customer-oriented activities, identifying potential advantages for industrial users, offering expert rounds and contacts with institutes and support centres, and providing – if requested by the user – a professional 'end-to-end service'.

DLR will coach this process. It is the intention to initiate pilot projects to demonstrate the feasibility of industrial ISS research, to enable pre-experiments, to use precursor flights (eg sounding rockets, Spacehab) and to commit to an ISS engagement.

Evolving Pilot Projects

DLR is working with several industrial companies to open ISS research for the private sector. Common to all these companies is their insistence on absolute confidentiality, even in the pre-phases of the projects. Thus, no company names can be given here.



DLR is proceeding with one industrial company towards establishing a joint pilot project. This global player is engaged in materials research, specifically in metal alloys. Currently, financial and user support packages are being prepared with the help of DLR-external expertise. It is the clear goal of this company to perform long-term research, to use microgravity as a tool and to embed it in terrestrial company research. If precursor activities are successful, building an experiment facility for metal alloy research onboard the Station is contemplated.

In the field of biotechnology and medical diagnostics, DLR is assisting three medium-size enterprises in forming a research consortium. In a 'bundling of performance', project development, scientists, user support and financial specialists are brought together to implement a pilot project. The three companies intend to use the Station as a testbed, in order to develop miniaturised diagnostic tools and thus reform terrestrial and spaceborne point-of-care diagnostics.

Funding Policy and Access Conditions for Industrial Users

DLR has established a funding policy for German industrial users, ie companies performing research on ISS:

	Experiment Costs	*Mission Costs*
Phase 1	partly private	fully public
Phase 2	fully private	fully public
Phase 3	fully private	partly public

This policy is intended to promote industrial utilisation and will gradually reduce public funding. Pilot projects as described above will be in Phase 2: no funds from national space budgets will be used to subsidise experiment costs.

Industrial researchers can gain access to the Station either via ESA (selection by means of a special review) or their national agency (selection based on national priorities, eg industrial policy). In Germany, DLR is the prime focal point of contact for industrial users. (Fully paying commercial users must apply at the ISS partner agencies, such as ESA.)

It is of vital importance to make the access conditions user-friendly. Currently, space agencies are defining short access times, user-oriented procedures, transparent pricing and selection criteria, ensured confidentiality and proprietary rights, and liability regulations.

Conclusion

DLR has developed a promotion concept for German industrial users of the International Space Station. Close cooperation with non-space mediators and actively listening to the needs of potential industrial customers has proved to be very successful; pilot projects to demonstrate the feasibility of industrial research on the Station are in their definition stages. A funding policy for an interim promotion phase is intended to strengthen the engagement of the private sector.

NASA

In this way, although it is not one of the IISS partner agencies, Germany strives to be part of the global effort to create a 'New Marketplace' in space. ■

Marketable Services and Commercial Initiatives

ISS Forum 2001 allowed different business sectors to discuss marketable services and commercial initiatives for the ISS.

Public Private Partnerships in Space

Paul A.T. Davies, PricewaterhouseCoopers

For the past few months, PricewaterhouseCoopers has been working with ESA to develop Public Private Partnerships (PPPs) to maximise the commercial utilisation of the ISS. Why is commercial utilisation needed? Although the ISS infrastructure itself is funded, there is no committed public sector funding in place to ensure full utilisation of ESA's available ISS resources. Viewed narrowly, ESA needs commercial utilisation to ensure that the ISS is used to the full. But ESA's real motivations are much wider than that. The ISS offers commercial opportunities that are the springboard for far wider economic development – a development that can only go ahead with the full participation of the private sector. ESA's objectives therefore are much more far-reaching. They want to:

- maximise commercial utilisation of the ISS;
- develop a wider commercial market in space;
- encourage the competitiveness of Europe's space industry;
- promote industrial research in life and physical sciences in space.

In ESA's view, therefore, the ISS opportunities are the beginning of much wider commercial development in space.

But does a commercial market exist? In theory, space is the ultimate commercial market, with limitless opportunities and potential. In practice, the commercial development of space is in its infancy. Satellites aside, there has been very limited commercial activity, and the likely growth and size of that market cannot be forecast with any degree of accuracy.

Also, in theory, with the opening of the ISS, there is a unique opportunity for commercial research and development. But again, in practice, the market is very uncertain. There are a large number of studies that examine why. In essence, the problems preventing commercialisation boil down to two:

- structural impediments, including the high cost of research in space, long lead times and the long time between R&D and the realisation of commercial profits back on Earth;
- an undeveloped market – potential users are unaware of the ISS opportunities, the benefits of a microgravity environment for research, or the price of accessing the Station.

ESA intends to introduce PPPs to remove or mitigate these two problems. Consequently, two forms of PPP are under development:

- a Cooperation and Services Framework;
- a European Business Developer (EBD).

The Cooperation and Services Framework is an overarching framework in which key industry players, both public and private, work together to offer services to reduce those structural impediments. These services will make it cheaper, faster and easier for each user to access the Station.

Under the framework, specific PPPs will be established to offer joint services. In the short term, the most significant of these will be a 'Partnership for Promotion' between ESA and ISS industries. This is intended to be an agreement under which funds and services can be made available on attractive terms to promote R&D projects of high potential. This

could prove to be a substantial contribution to getting commercial research and development underway.

Further down the line, a European Business Developer will be a new PPP specifically incentivised to develop the market and seek out commercial opportunities. It will have an explicit objective of promoting the European space industry and use of the ESA portion of the ISS.

There is already a growing number of regional and independent commercial agents whose business is promoting and arranging the commercial utilisation of space. The European Business Developer will work closely with them to ensure the most efficient development of the market, acting as a central mouthpiece of ESA policy, and in return giving centralised private sector feedback. The key decisions going forward for ESA to resolve are, first, the current balance between the resources needed in the EBD to complement the activities of the commercial agents, and, second, the best time and method to introduce private sector skills, experience and capital into the EBD.

The ISS is up there and the commercial opportunities exist. Using the skills and know-how of both the private and public sectors, ESA intends to reduce the structural impediments to commercial utilisation and ensure the market is developed to the full. The development of the Cooperation and Services Framework and the PPPs sitting under it, as well as the European Business Developer, will create structures to do precisely that.

BEOS: an International Gateway for ISS Operations and Utilisation

Manfred Jaumann, Head of Astrium BEOS Operations & Utilization Center and CEO BEOS GmbH

BEOS was born as a joint initiative between Astrium, OHB System and ZARM to combine the unique capabilities of space industry, science and research facilities in Bremen, Germany. This endeavour began in 1996 with the objective of improving services to customers by combining the different capabilities of the BEOS partners. The BEOS GmbH legal entity was founded in 1998 and the first pathfinder projects were set up. With the strong support of the Bremen local authorities, Astrium and its partners established the BEOS Operations & Utilization

Centre with all the required Simulation and Diagnosis Facilities. In addition, the Centre is open to the public and already attracts more than 20 000 visitors per year.

The final setup of Astrium/BEOS will be international in order to be competitive in the global market for utilising and commercialising the ISS. This imminent new market can be divided into three main sectors:

- *New Institutional Markets*: education, Earth observation and Station enhancements, with public funding;
- *Industrial R&D Applications*: engineering research, technology development, life sciences, materials science, fluid science and combustion science, with a mixture of public and private funding;
- *Commercial Utilisation*: Earth observation services, communication services, space tourism, advertising and media, with purely private funding.

To prepare Astrium/BEOS to serve its customers, the partners early on started numerous projects in technology R&D. Astrium already has more than 60 projects under way to strengthen the capabilities needed to serve future customers in ISS utilisation and commercialisation.

The business architecture must establish a front-end that acts as the only partner for commercial customers and takes care of all their needs. To guarantee excellence, this front-end needs a strong backbone – a powerful network of cooperation with the Space Agencies, external investors and partners inside and outside the space community to provide the

necessary rights of access, use of ISS facilities and equipment, the necessary funding and additional know-how.

Astrium and its partners developed BEOS as this front-end partner for commercial customers. This is reflected by the investment of more than €50 million in technology R&D, and by the numerous activities and initiatives around the world in setting up partnerships and cooperative efforts.

BEOS provides a 'one-stop' service for commercial customer by providing the necessary logistics/administration, flight opportunities, optimised lead time, confidentiality, verification, technical consultancy and cost-effectiveness. Through its industrial characteristics and its strong relationships with the Space Agencies and industrial partners around the world, Astrium/BEOS is an international gateway for ISS operations and utilisation.

For further information, see <www.beos-space.de> or contact +49 421 539 5905/4250.

ALTEC: the Italian Gateway to ISS

Ernesto Vallerani, President, ALTEC

Early this year, the Advanced Logistic Technology Engineering Centre (ALTEC) was established to support ISS activities and to offer a full range of services to its users and customers. ALTEC is a Public Private Partnership, with Alenia Spazio, a Company of Finmeccanica, as majority shareholder (51%) and the Italian space agency (ASI, 29%) and Icarus (20%) as strategic partners.

The decision to create a ground centre dedicated to supporting onboard activities, logistics and maintenance complements the major participation of Italy in ISS construction.

In addition to its ISS involvement through ESA, ASI agreed with NASA to provide the Multipurpose Logistic Pressured Modules (MPLMs) to service the ISS. In exchange, ASI acquired rights to utilise the Station for its own scientific and commercial activities. At the industrial level, Alenia Spazio is the leader in pressurised module design and manufacture, with 30 years of industrial experience in manned infrastructures.

ALTEC operates in Torino, Italy, on the premises of the Centro MultiFunzionale Spaziale (CMFS), realised by Icarus, a Consortium of Local Government Entities and Alenia Spazio with an initial investment of about €20 million; additional investments are planned, under ALTEC responsibility, to begin operating. ALTEC's core business covers:

- operation and logistic engineering support to ISS related to MPLM and Italy's share of Columbus and of all the other ESA-provided elements.
- technical and engineering support to users for integration of the Italian payloads originated by ASI and the Italian share of European payloads originated by ESA.
- commercialisation of the Italian opportunities for ISS utilisation.

ALTEC's strategic plan foresees enlargement of the core business to cover additional activities, all related to ISS utilisation. Two main fields have been so far identified:

- technology and application initiatives,
- education and recreation initiatives, for developing activities that will also interest non-space professionals.

The user support services that ALTEC intends to offer are:

- marketing of ISS opportunities for users and customers,
- provision of ISS-related information,
- project management, including financial and legal advice,
- flight activity definition, manifesting and planning,
- flight and ground system development and verification,
- ground operations and logistic support, including launch and landing site activities,
- flight/ground crew and user training,
- mission operations, including infrastructure set-up and validation, access to control centres, participation in mission planning activities, troubleshooting, etc,
- data acquisition, processing & distribution,
- PR management and organisation of media events.

For further information, see <www.spacegate-altec.it> or contact info@spacegate-altec.it.

Spacehab: We Mean Business in Space

Michael Kearney, President, Spacehab

In the early 1980's, when aerospace companies were content with bidding on cost-plus government contracts, Spacehab, Inc. took an unprecedented path by leasing products and providing services while maintaining ownership of flight assets. Seeing a growing government and commercial need for more research capability onboard NASA's Space Shuttles, Spacehab raised $100 million to design and develop flight hardware to satisfy this need. And this was only the beginning.

Today, with more than $100 million in annual revenue and over $250 million in private assets, Spacehab is a leading provider of commercial space services. Offering a fleet of research and logistics carriers, the company has anticipated the needs of NASA and the space community as commercial and industry demand for space access has increased. And with the development of Enterprise, a commercial module that will be attached to the International Space Station (ISS), Spacehab will establish the first permanent commercial presence in space.

Spacehab research and logistics services bolstered the ability to reach out to a larger customer base and make huge strides in space commerce. In 1999, Spacehab announced an historic agreement with RSC Energia of Korolev, Russia, to establish the first commercial outpost in space. This partnership is the first big step off Planet Earth for private enterprise in space, once again independent of government funding, with expected investment costs of about $150 million.

Enterprise will become part of the ISS configuration on the Russian segment, replacing the Docking & Stowage Module. This module is being developed to meet research, stowage, crew support, habitation and multimedia needs. The partners approved the baseline design following a joint review concluded in December 2000. Spacehab and Energia are already at work on detailed design and procurement of long-lead-time materials and components. The partners plan to launch Enterprise to the ISS in 2003 on a Russian Proton vehicle.

Enterprise will include habitability systems that can support additional crew in orbit. With cancellation of the US Hab module, this private initiative will enable the ISS to maintain a crew of six instead of the potentially reduced capability of only three. This doubling of crew support, through the use of Enterprise, means that foreign space agencies and potentially other visitors to space can be accommodated. This commercial platform also offers a variety of marketing, advertising and content development options currently unavailable on the US side of the ISS because of government restrictions.

Spacehab is setting the pace for space commerce initiatives. Private citizens and private enterprise will use this somewhat uncharted territory for private purposes. Space will be a venue for commercial activity, a site for recreation and entertainment, and a wellspring of prosperity in ways that are not currently imagined. Spacehab is the bridge from the current age of public space exploration and experimentation into this future of private space utilisation.

For further information, see <www.spacehab.com> or contact +1 713 558-5000.

15 years of Intospace Space Services

Jürgen K. von der Lippe, President, Intospace

The Integrated ISS Marketing Programme

Intospace draws its experience from marketing manned and unmanned space systems for utilisation by industry over the last 15 years. Sales and services have been provided for Spacelab, Eureca, Spacehab, Mir, Foton and Texus/Maxus and dedicated experimenting facilities.

The focus is now on the ISS, which presents a high-tech research centre and a most attractive media platform. Using and maintaining this for commercial business is the objective of the 'Intospace Integrated ISS Marketing'.

The use of the ISS for industrial research requires a business environment that must also allow for product placement and advertising. In turn, commercial product placement and advertisement must not interfere with the ISS being used for top science and high-technology development. Non-R&D (media, consumer goods presentation, etc.) and R&D activities need to be compatible and to support each other.

Mr Von Der Lippe (right) and Mr Jörg Feustel-Buechl, ESA Director of Manned Spaceflight & Microgravity, sign the €2 million contract for the Agency to supply a proportion of its Station resources to Intospace.

Research Management

The origin of commercial space activities aboard manned vehicles lies in the utilisation of microgravity for applied research, developed by Intospace with the concept 'Microgravity, a Tool for Research'. Our experts analyse industrial research for processes involving gravity, with the objective of implementing projects with industry making use of microgravity.

Marketing and Sales

Its attractiveness to the media makes the ISS an ideal platform for presenting new consumer goods to the public by including them in the crew's daily activities. Intospace develops product placement projects for customers with consumer goods, medical instruments, tools and measurement equipment by providing the full range of onboard activities, preparation support, space certification, and support for press conferences and industrial fairs, including complementary merchandise.

Flight Opportunities

The Intospace business section 'Infrastructure Sales and Services' has flown hardware on European, American, Russian and Chinese space platforms. We are committed to providing the most cost-effective flight services and related ground services, including the utilisation of facilities for science and technology development. Although we now focus on ISS utilisation, we also offer complementary flight opportunities on sounding rockets, capsules and micro-satellites.

The Business Environment

Although it benefits from the exceptional media interest and the microgravity environment, the Space Station faces strong competition from terrestrial opportunities. Therefore:

- commercial access conditions must be at least user-friendly, if not competitive with the terrestrial approach;
- the astronauts must be familiar with commercial activities;
- programmatic constraints (schedule, risk, proprietary rights) must match the needs of the terrestrial programmes.

Intospace picked up the business opportunities provided by the ISS as soon as they became available and has implemented the first industry-financed projects. The company has entered into an agreement with ESA for purchasing ESA resources and services for commercial utilisation of the ISS.

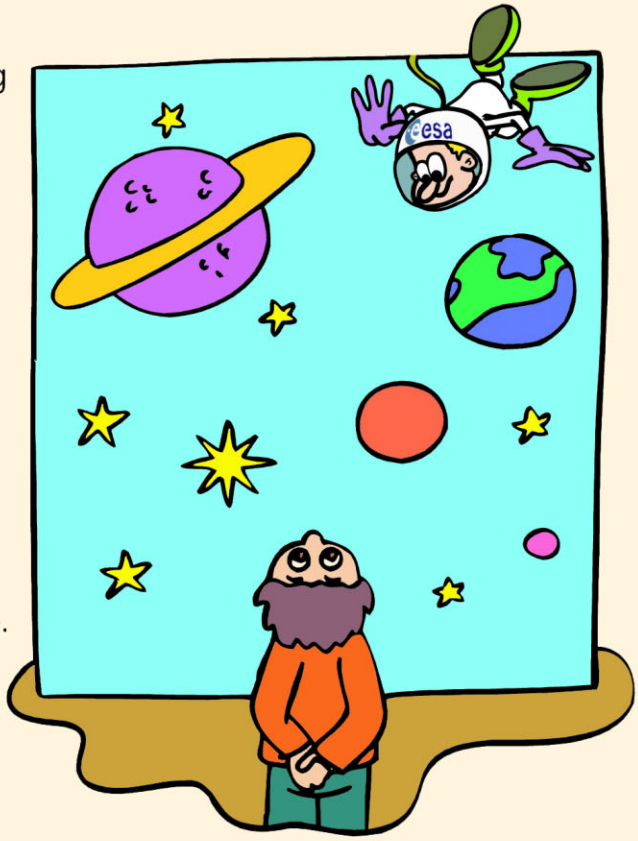
TEACH SPACE 2001

International Space Station Education Conference

26 - 28 October 2001

The European Space Agency (ESA) is inviting teachers of children aged 6 to 18 across all subject areas to the first International Space Station (ISS) education conference at ESA/ESTEC in the Netherlands.

Objective: to develop educational material using space as a tool for teaching.



'Space' is not only about science,
it is a vision,
a subject without boundaries

Conference Highlights:

- Exchanging ideas for using space as a tool for interdisciplinary teaching.
- Opportunity to see projects by teachers, for teachers.
- Network with teachers from all over Europe.
- Meet and greet European astronauts.
- Visit ESA/ESTEC's space facilities and visitors centre.

Open call:

Do you run a space-related teaching project ?
Are you developing an idea for one ?
Then send your proposal to us before
21 September 2001.

- Proposals could range from hands-on experiments to shows, films, CD ROMs or websites.
- Proposals sent by teachers will be entered in a competition for the most inspiring project.

For more information, support possibilities and registration
visit our website at http://www.estec.esa.nl/TEACHSPACE_2001
or send an e-mail to barber.uijl@esa.int

esa

ISS Project Implementation – Factors for On-Orbit Payload Operations

Thomas Reiter
ESA Astronaut, European Astronaut Centre, Cologne, Germany
Email: Thomas.Reiter@esa.int

To date, implementing research projects on manned space missions, either on the US Space Shuttle or the Russian Mir station, has required a considerable number of steps. In general, these steps were:

- the definition of a research project,
- its selection by a peer-group,
- the ground processing of the experiment, including development of the hardware and software, its production, integration into the space vehicle and functional check-out,
- the crew training,
- the research activities during the mission,
- and, finally, the processing of the experiment data and production/publication of the experiment report.

Optimum utilisation of the ISS resources for payloads requires careful planning...

Against the background of a growing, high-tech research facility in space, it is the objective of all ISS Partners to reduce the time and organisational overhead to bring an experiment from conception to execution aboard the ISS. In addition to public-funded research projects, the Partners want to attract commercial customers.

ESA has gathered technical and operational experience from its participation in short missions aboard the Shuttle and longer missions aboard Mir (Fig. 1). Based on this experience and in view of ESA's contribution to the ISS programme, the agency is ready to make full use of the research capacities.

Payload operations in orbit are influenced by various factors (Fig. 2). These factors determine mainly how efficiently the astronauts do their work and how much time they have available for all the different types of activities.

Onboard systems

Functionality, reliability and maintainability of onboard systems determine the suitability of the space infrastructure as a research platform, and consequently the effort the crew has to make in order to keep this infrastructure operating. ISS systems exhibit a high level of redundancy and are integrated into a complex command and control structure. Consequently, onboard systems can be operated autonomously to a large extent, mainly by the Mission Control Centres (MCCs).

Additionally, a 'new' maintenance concept has been introduced, based on the modular design of onboard systems: Orbital Replacement Units (ORUs). The maintenance concept foresees the replacement of ORUs that show off-nominal behaviour or have failed, rather than performing on-orbit repair. This concept saves crew-time to the benefit of payload operations.

Payload characteristics

The integration of research facilities into racks significantly alleviates their handling by the crew, as compared to the standalone design of payloads used during European missions aboard Mir. Some laboratory equipment can be used for a wide range of experiments and different 'users', thus increasing operational flexibility. Once the crew is trained on these Multi-User Facilities, the training time required for preparing multiple experiments can be significantly reduced.

Communications

Communications are a key asset for successful operation of payloads and the Station as a whole. With three US TDRS geostationary satellites in operation today, and three more systems to be installed (ESA's Artemis, Japan's DRTS and Russia's Luch), the coverage for the downlink of telemetry data, uplink of commands, and the exchange of voice and video will improve.

Fig. 1

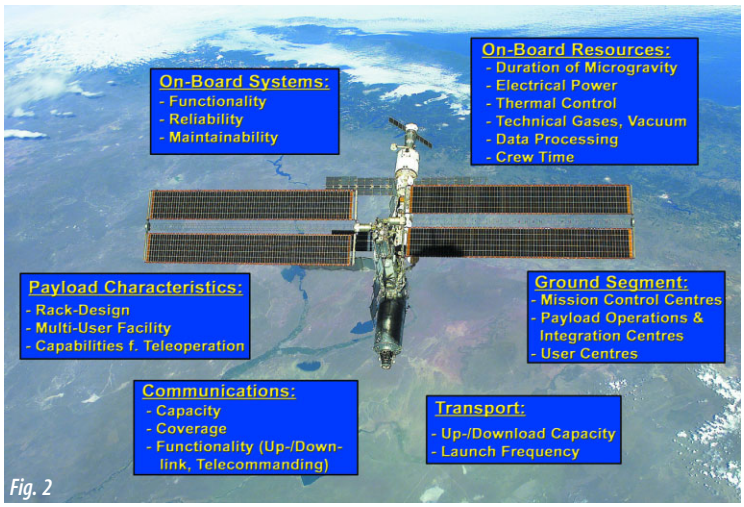


Fig. 2

Ground segment

The network of MCCs, Payload Operations and Integration Centres, User and Support Centres – with all the specialists distributed around the world – supports the Station's efficient operation. Instead of moving into mission operation centres, investigators on Earth can stay in their usual working environment but still have access to all the information necessary to operate their payloads.

Transport

Three vehicles for uploading hardware are in service: Shuttle, Soyuz and Progress. The first two also provide download. Currently under development, Japan's HTV and ESA's ATV will increase the upload capacities and frequency. Reducting the current reaction time (the time between the demand for a specific item aboard the ISS and its delivery) requires access to the ferry vehicle as close to launch as possible.

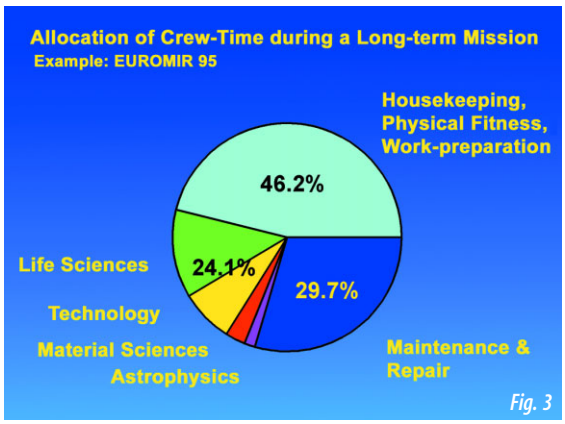


Fig. 3

Onboard resources

Besides resources like electrical power, thermal control, data processing, technical gases, vacuum and pointing support for external payloads, microgravity is a very elementary resource for research projects in orbit. It is foreseen that the Station will be maintained in a 'torque equilibrium attitude' for a total of 180 days per year in 30-day increments, thus granting undisturbed conditions for microgravity experiments of the order of weeks rather than hours or days.

Finally, crew time is one of the most critical resources, as payload operations depend on crew interactions. Three generic areas of crew activities can be distinguished:

- the operation and maintenance of the orbital infrastructure (i.e. the onboard systems),
- an 'operational overhead' such as time for housekeeping, work-preparation, operation of Station systems (e.g. during rendezvous & docking), physical fitness and meals,
- the time allocated to research tasks (i.e. payload operations).

Allocation of crew-time to the different day-to-day activities requires intensive coordination between the Partners operating the infrastructure, and the scientific community. The daily scheduling aims to generate a flawless crew-activity plan that makes best use of their work capacity.

Despite their numerous and complex tasks in activating, checking out and validating ISS systems, the Expedition-2 crew may spend up to 10% of their working time on payload operations. In total, the crew has worked on 18 US and 12 Russian research projects. Compared with a long mission aboard Mir (Fig. 3), even with a crew of only three members, this is already a clear indication of the Station's capacity as a state-of-the-art multidisciplinary laboratory. As assembly approaches completion, crew tasks will increasingly shift towards payload operations, thus making full use of the Station as *the* research facility in space. ■

ISS Payload Accommodation, Integration and Processing

The 'Roundtable on Physical Accommodation, Integration and Processing of Payloads' brought together Mr. Richard Nygren, Head of Space Station Payloads Office, NASA; Mr. Rolf-Dieter Andresen, Head of Space Station Utilisation Division, ESA; Mr. Susumu Yoshitomi, Deputy Director, Space Utilisation Research Centre, NASDA; Mr. Lawrence Vézina, Manager, Payloads & Integration, CSA; Mr. Valery Panchenko, Head of Payload Department, RSC-Energia.

ISS Forum 2001 allowed the partner agencies to describe the process of flying payloads on the Station. Here are edited highlights of the roundtable discussion...

Mr. Nygren, what is the selection process for non-commercial payloads?
There are different ways but all of the Partners use similar approaches. We all start with Announcements of Opportunity, where anybody interested in flying a payload can apply. After going through that selection, they are peer-reviewed to make sure they have scientific merit. Then a feasibility assessment makes sure that the payload is safe for the vehicles and crews, what hazards it might present, the resources required and whether there is a flight opportunity. The Safety Review Panel, chaired by NASA, is responsible for certifying that payloads are safe.

Mr. Vézina, what product assurance requirements are applied?
Some vary between Partners but essentially we apply industry standards. Because space experiments are a very expensive business, we we also make risk and benefit analyses. Maybe the cost of developing a piece of equipment is too much for the benefits it would bring. The risk analysis makes sure that whatever money is invested in the development, it works.

What microgravity disturbances will a payload experience?
The environment you see on the Station is, at this moment, determined by analysis. But we have a lot of experience gained during experiments on the Shuttle and Mir. It varies from location to location and I can give you numbers like 10^{-6}-10^{-5} *g* but they do not mean anything. In reality, you have to assess the effect of microgravity for different types of experiments. We will have good conditions depending on the location in the module, and when a payload requires better conditions then you can always use isolation systems that each Partner is developing.

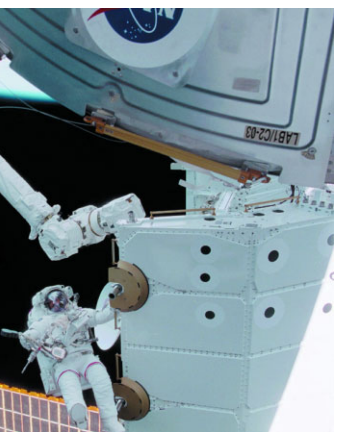
Mr. Nygren, what about refrigeration, freezing and the general support aboard the ISS? And the multi-user facilities?
A number of refrigerators/freezers are being developed. They start at +10°C and go down to cryogenic temperatures of –180°C. ESA's MELFI has +4°C and –80°C capabilities. And smaller ones go from +10°C down to –20°C and –30°C. There is a wide range to support the science community.

Almost all the ISS facilities are multi-user. On the US side we have eight planned multi-discipline Express Racks. Then there are multi-user experiments in combustion, human research and so on where you are looking at specific disciplines. In the Russian modules, where the facilities are not yet developed, all of the capabilities are multi-user and can support almost any discipline.

Mr. Yoshitomo, how many pressurised and external payload locations are there, and what resources are provided for the payloads?
There are currently 38 allocations for the International Standard Payload Rack (ISPR). NASA has 13 in Destiny, we have 10 in JEM,

The roundtable on payloads. From left: Richard Nygren (NASA), Rolf-Dieter Andresen (ESA), Susumu Yoshitomi (on screen; NASDA), Lawrence Vézina (CSA), Valery Panchenko (RSC-Energia) and moderator Claus Kruesken.

Columbus has 10 and the Centrifuge Accommodation Module (CAM) has five. Externally, we have 19 on the Truss, 10 JEM, four Columbus and four Zvezda. The Russians are planning to add 20 locations on the future module, so there will be 57 locations on the Station. For the pressurised payloads, most of the locations will be provided with power, vacuum/venting, video, data and thermal capabilities. For external payloads, resources are more limited – they will have power, video, data and passive thermal capabilities.



Mr. Andresen, how will the payloads be exchanged at the different locations?
For the pressurised modules, the crew is the key resource for exchanging payloads. For external payloads, the non-Russian payloads go up with the Shuttle and are transferred robotically to their ISS destinations. Russian payloads are exchanged by the crew via EVAs. The consequence is that we are limited to certain payload sizes and certain ISS attitudes.

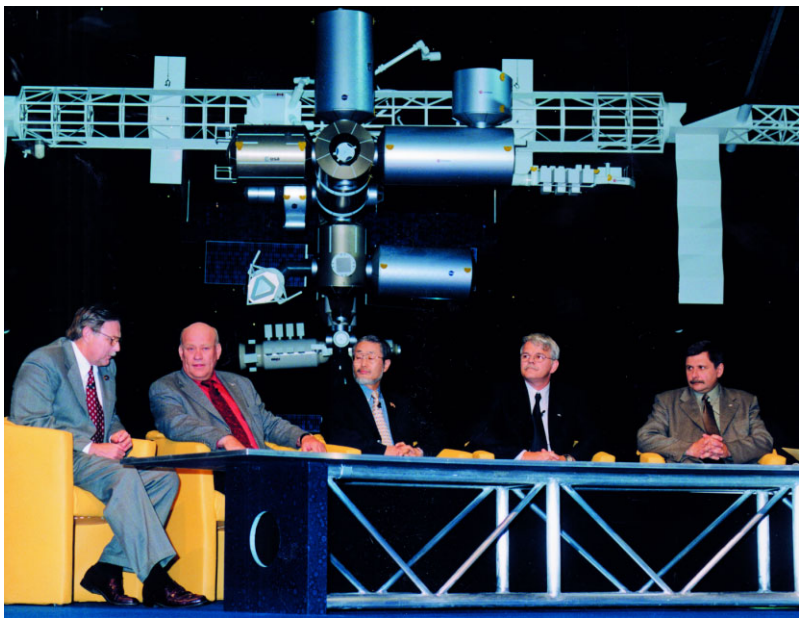
Payloads can be moved. On Columbus we use the Express Pallet system and adapter, so we can move. The key point is not really the specific location, but the resources you get out of the module, and there are slight differences between locations.

Mr. Panchenko, how long does it take from payload selection to flight? How late can I deliver my payload to the launch site, and how soon after a flight can I get my samples?
Payload complexity is the most important factor. For simple payloads, 12-18 months is reasonable, while the development can take several years for very complex payloads.

For the Shuttle, payloads are delivered to the launch site typically 6-9 months before launch, but some can be processed in a few days. For Progress, a payload is delivered to Baikonur a month before launch, although for biological small items it can be as short as 1-2 days.

Payloads returning on the Shuttle middeck can be returned to their experimenters within hours after landing. Those returning in the Shuttle cargo bay can be retrieved in a few days depending upon complexity, size and location. For Soyuz, those payloads with special handling requirements can be accessed within a few hours and returned to their investigators within 2 days, while non-time-critical payloads are handed over between a week and a month after landing.

Mr. Vézina, what kind of payloads are currently onboard the ISS? What is the principal mode of payload operations?
There are about 30 payloads on the Station covering a wide range of scientific experiments in biology, medicine and other branches. Each Partner is responsible for operating its own payloads. At the moment, there are only Russian and US payloads aboard, so their centres are the focuses of operations, but each



Partner is planning or building an operations centre.

Payload data come via two routes. On the Russian Segment, data go straight to Moscow, but data flow for the other Partners is handled by NASA's Marshall Space Flight Center. Data are routed back to Japanese or ESA centres for further processing. For the CSA, we have an operations centre for the robotic arm.

Mr. Yoshitomo, where does the experimenter have to be during the operations of his experiment?
In our case, our current operations centre is at Tsukuba some 60 km north of Tokyo. Of course, experimenters want to operate from their own laboratories but, for the moment, we have centralised payload operations at Tsukuba. From there, they can access our ISS data link.

Mr. Vézina, can experimenters operate from their own institutes?
Each Partner has in mind a concept where data are centralised in its own operations centre before distribution to remote locations and access by the scientists. We cannot expect people to spend a lot of their time at centralised centres waiting for their experiments to be run. They want to stay at home and monitor their experiments, maybe even sending commands and interacting directly with their payloads.

Mr. Nygren, how are my payload data protected?
True encryption is the responsibility of the payload developer but, practically, we are shipping megabits of raw data down to the ground so there is minimal chance of them being compromised. And when they are sent from the control centre to the user, they have a standard type of Internet protection. It is like buying something securely on the internet with a credit card.

Mr. Andresen, what are the launch vehicles that can bring the payloads to the ISS? How are the payloads moved to their final ISS locations?
We will have three main routes for delivering payloads to the Station. The Shuttle is already moving a lot of cargo up and down. ESA's ATV will enter service in 2004 and Japan's HTV is also in development. For downloads, the key vehicle is the Shuttle and the Soyuz has a limited capability. Progress, ATV and HTV will be destroyed deliberately on reentry.

Once they arrive, pressurised payloads are handled by the crew. The crew unpacks each payload and transfers it to its destination. For external sites, the Shuttle and ISS robot arms grapple the payload and position it. On the Russian side, the crew first handles an external payload inside the Station and then uses an EVA to take it to its destination. That is a very flexible system.

What facilities are available to process the payloads at the various launch sites?
Mr. Panchenko: we have equipment to perform checkout, gas and liquid servicing.
Mr. Nygren: we have an extensive set of payload processing facilities at the Kennedy Space Center. We can handle animals, plants and biomedical processing. We can check things out functionally, and service them with gases and fluids during acceptance checks before putting them into the payloads. We have a number of carriers to move large cargo in and out of the payload bay. A major difference from the Russian side is that we can provide payloads with power during ascent. They are powered almost continuously even before the experiment begins on the Station.

Mr. Vézina, are payloads retrieved from space are they destroyed after their operational lifetimes?
At the moment, most are returned to the ground. But this is a very expensive business, so you might negotiate with the Partners to leave your payload in space or put it in a Progress and destroy it to save the return cost. It is a trade-off. If it is intended to fly on a regular basis, then you want it back. ■

ISS Access Policy for Institutional Users and Commercial Customers

The 'Roundtable on Access Policy for Institutional Users and Commercial Customers' brought together Mr. Jason Steptoe, Associate General Counsel Commercial and International Law, NASA; Mr. Martin Lebeuf, Manager of ISS Commercialization Office, CSA; Mr. Alexei Krasnov, Deputy Director, Department of International Cooperation, Rosaviakosmos; Mr. Hideshi Kozawa, Space Utilisation Promotion Department, NASDA; Mr. Jochen Graf, Head of Exploitation Preparation Department, ESA; and, for institutional utilisation, Mr. Karl Knott, Head of Microgravity and Space Station Utilisation Department, ESA.

ISS Forum 2001 allowed the partner agencies to describe their policies on Station access. Here are edited highlights of the roundtable discussion...

Mr. Knott, during this conference we are talking a lot about commercialisation of the ISS, but a significant percentage of the Station is allocated to institutional utilisation, isn't it?

ESA currently has 70% of its resources allocated to this institutional utilisation and 30% for commercial use. NASA has a similar figure in mind and Canada is looking at a 50/50 share. The proportion is not fixed for all time, and I expect it to change as business develops.

The best discriminator between institutional and commercial utilisation is the funding source. Everything funded from public money, from taxpayers' money, you can label as institutional utilisation. All the utilisation funded via industries, entrepreneurs, companies and so on is commercial. There is a possibility of combining the two – certainly in the beginning. Public funding requires the user to fulfil two main conditions. The first is that he has to pass a peer review by independent experts and/or scientists. The second is that the resulting data must be shared. The investigator has the exclusive right to the data for one year, but then it must be published and shared with the public.

There can also be a mixture, such as a

National Aeronautics and Space Administration (NASA)

Process

Principle Components of Offer
- Offer Description
- Technical Information
- Company Information & Management Team
- Market Analysis & Strategy Summary
- Financial Plan
- Letters of Intent/Commitment

Offer Review Steps
- Registration of Offer
- Review: Business Issues, Technical Issues, Legal/Policy Issues
- Dispositioning (Acceptance/Rejection)

Notifications to Offeror
- Registration Letter
- Evaluation Letter
- Status Letter

http://commercial.hq.nasa.gov/submit.html

Pricing

Schedule	Available Inventory (Assembly Complete)	Price Structure (per annum)
Internal Rack Bundle Site		
One 3kW ISPR Site 2,880 kWh energy 86 IVA crew-hours 2.0 Terabits, space-to-ground	8	$20.8M
External Adapter Bundle Site		
One Express Adapter Site 1,800 kWh energy 32 IVA crew-hours 2.6 Terabits, space-to-ground	7	$20.8M

Premiums
- $10,000. per lbm each way (Space Shuttle passive pressurized cargo)
- $12,000. per lbm each way (Space Shuttle passive unpressurized cargo)
- $15,000. per Space Station IVA crew-hour
- $2,000. per Space Station kWh energy
- $100. per minute TDRS transponder time

http://commercial.hq.nasa.gov/price.html

Conditions of Sale
- Term of use is up to one year from on-orbit deployment.
- Timing of use is negotiable, subject to the inventory of resources and accommodations available at each phase in the ISS program.
- Fractional bundles, as small as 1/6th of a bundle, will be priced on a pro-rata basis including pro-rata utilities.
- Re-sale or barter of unused resources and accommodations is not permitted during the ISS assembly phase if it would change the NASA interface relative to the bundle purchaser.
- Costs associated with integration, flight certification, and safety compliance are the responsibility of the buyer.
- Costs associated with all hardware and software required for operations or training are the responsibility of the buyer.
- Rack bundle includes crew training, subject to availability and scheduling, for one flight increment.

http://commercial.hq.nasa.gov/price.html

Contact Information

Director, Research Integration & Product Development Division
Office of Biological and Physical Research
Code UM
NASA Headquarters
300 E Street, SW
Washington, DC 20546
E-mail: commercial@hq.nasa.gov
http://commercial.hq.nasa.gov

The roundtable on access policy. From left: Jason Steptoe (NASA), Martin Lebeuf (CSA), Alexei Krasnov, (Rosaviakosmos), Hideshi Kozawa (NASDA), Jochen Graf (ESA), Karl Knott (ESA) and moderator Claus Kruesken.

public-private partnership. In ESA, if any public money is involved then we consider it institutional utilisation. For commercial utilisation, the entire funding must be from private sources. All the details are in our new *European Users Guide*, available online at <http://www.spaceflight.esa.int/users/downloads/userguides/ISS_European_Users_Guide.pdf>

Mr. Graf, why are the ISS Partners commercialising the Station?
First and foremost, we want to stimulate business investment into new markets and activities by using the Station and its unique capabilities in low Earth orbit. This complements the institutional R&D activities. We recognise that public funding will not necessarily be sufficient to fully utilise the Station, and we are optimistic that these activities will create revenues in the long run that can be used to support further scientific R&D.

Mr. Steptoe, what resources are allocated for the commercial user?
At the Forum, we have published sheets from each of the Partners showing what is being commercialised in terms of power resources, rack space and pricing. We should keep in mind that, when it comes to utilisation, the Partners have very broad discretion to implement their programmes differently. That does not mean we are competing on price – in fact, we are working very carefully to coordinate the pricing mechanism for the Station. But the Partners have a high degree of flexibility to exploit the particular advantages of their launch systems and of their portions of the Station.

Mr. Kozawa, are the ISS Partners working together on commercialisation?
Each Partner has the autonomy to 'sell' the Station in its own way as long as it is compatible with the Intergovernmental Agreement (IGA), but sometimes we need to discuss new situations and for that we have established the Multilateral Consultative Working Group for Commercial Programmes.

Mr. Krasnov, why is consultation and coordination of commercial use among the Partners desirable or even necessary?
The ISS is an integrated structure, so the activities of one Partner may affect all the others. Resources could be required not only from the sponsoring Partner, so there is clear need for mutual arrangements and a time plan. Coordination establishes the guidelines on how to provide the best access for commercial entities. For public acceptance of the ISS, it must be an accessible resource, perform commercial programmes along with federal

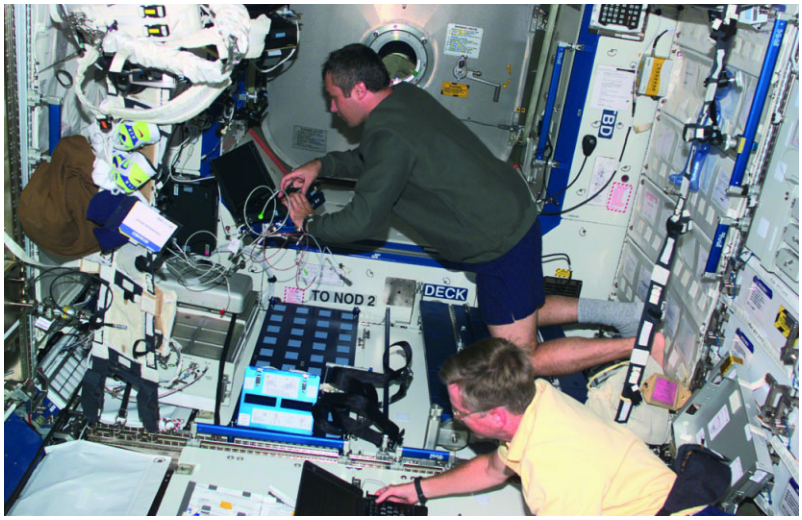
programmes and generate additional resources for the ISS cooperating agencies.

Mr. Graf, what is allowed aboard the ISS and what is not? What about logos, advertising, the whole field of entertainment, filming and space tourism?

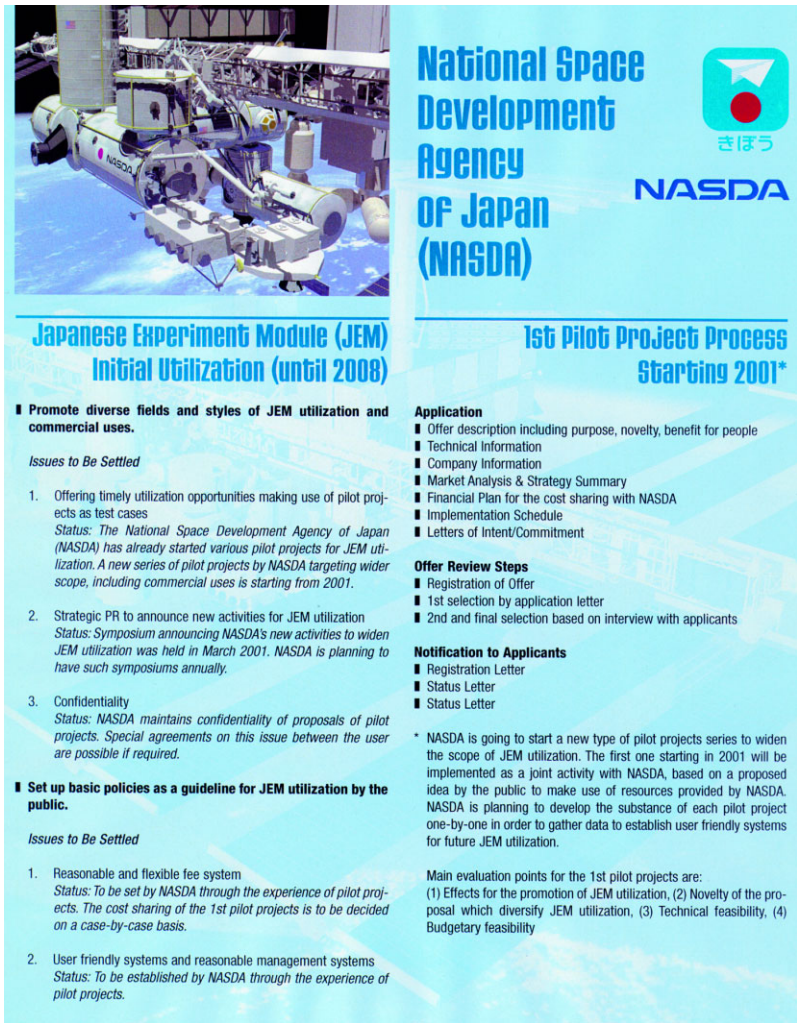
It is important to recognise the right of every Partner to exercise its autonomy to place and support commercial activities as it wishes, as long as it is consistent with the IGA. Logos, branding, advertisement and entertainment are allowed. But *how* will they be allowed? We are working on establishing the criteria. There are some high-level criteria – an activity must not adversely affect the utilisation activities of another Partner. It should not impact the institutional research, because that is the Station's primary purpose. It must be in good taste, although this criterion is subjective. It must not reflect negatively on the image of the Station. We intend to have as few rules and restrictions as possible in order to attract people. Rather than spending a year or two in working groups to decide on the rules, we invite commercial entrepreneurs to come forward now and we will learn together what we want to allow and, in the end, what to restrict.

Mr. Knott, perhaps it would not hurt an institutional experiment to be partially funded by an advertisement. Is this something you are thinking about?
This is not at all excluded. An example might be if a company wants to sponsor a specific research project on the ISS, or use the results of research. But it should not interfere with the progress of the research. If it is done in the right way, it can be profitable for both sides.

Mr. Lebeuf, how much will commercial access to the ISS cost? What will be included in the price? Are there price differences between the Partners?
Each agency has the autonomy to determine its pricing policy. In Canada, we have our own, related to NASA's policy. It will be negotiated on a case-by-case basis. We want to stimulate the market, so, in the short term, most of the



Partners will waive part of the ISS access costs. In the early years, there will be very interesting pricing arrangements. Potential users can find more information on ISS pricing policy in the new brochure on ISS Commercial Programs prepared with the collaboration of all Partners. Any Partner can accommodate users from other countries. For instance, a Canadian company could negotiate an agreement with Rosaviakosmos. Flexibility is very important.



From left: Hideshi Kozawa, Jochen Graf, Karl Knott and moderator Claus Kruesken.

Mr. Krasnov, what legal framework is required for a commercial deal on the ISS. How will confidentiality be protected?
The legal structure is simple – an IGA among all the Partners. It outlines, for example, the sharing of onboard resources. The IGA already provides for commercial activities. The protection of intellectual rights and confidentiality is included in the agreement in general terms. It is also provided by the Crew Code of Conduct. If the customer wants, specific clauses can be included in the contract.

Mr. Steptoe, to what extent will crewmembers be involved in commercial activities, such as wearing logos on their clothing?
In general, the crew's commercial activities are in accordance with the directives and procedures of each agency. Each has its own commercial utilisation programme and the right to use a certain allocation of crew time for its purposes. The Partners do not want crewmembers exploiting their personal situation – there are rather extensive provisions in the Crew Code of Conduct to deal with that. In the case of national policies, these differ. In NASA's case, rules and federal laws prohibit government employees from endorsing commercial products, for example. So NASA would not be interested in a commercial project using astronauts this way. However, within those broad outlines of principles there is a great deal of flexibility – it will depend on what companies want to do. We are getting into new areas here. NASA has not yet decided on the question of logos on suits. Other Partners may have a different view. Issues of sponsorship, whether the Station as a whole has its own brand – all issues are under active discussion within the Partnership. There is a willingness among the Partners to engage in a dialogue with commercial industries across the World in order to make this a successful endeavour for all.

So it is an open invitation to ask questions, to come to you with ideas, and you will be as flexible as possible?
Yes. It is a dialogue. There is already extensive trading in resources between the Partners, with regard to crew time, provision of elements, subsystems and outfitting the laboratories. There is an extensive web of agreements and relationships going on for many years. The commercial operators will not see this and do not need to worry about it. It will be there, in

place and ready for business. How they exploit the opportunities is in the first instance the decision of the companies. The agencies will consult with each other and quickly arrive at an answer to satisfy the mutual interests of all the Partners. That is the model we are working on, and we hope it is the prescription for success.

Mr. Lebeuf, now that so many agencies are involved, are there plans for a single organisation for all ISS commercialisation?
There is a multitude of entrances to the Station – each agency is a door and there are others. For instance, within the US there is NASA headquarters, NASA centres and the 13 Commercial Space Centers.

Mr. Graf, how do agencies plan to stimulate commercial development in the short run?
In the near-term, we want to support and stimulate the commercial activities. In the beginning, we may provide direct financial contributions, provide services in kind and negotiate different prices. The price lists published here for the first time are not hard prices for every case. We have to look at the benefit of any commercial venture to see to what extend we have to negotiate on the prices. We must make it attractive for the user to exploit and explore what they can do on the Station. At ESA we are looking at pathfinder projects. These are co-financed activities, which are useful for us to find the right route to follow. In the long run, it is clear that we want the commercial activities to stand up on their own, creating revenues for themselves and us.

We do not want to subsidise these activities forever – we want to achieve self-standing commercial activities on the Station. ■

Karl Knott (on screen) discusses a point on institutional utilisation of the ISS.

International Space Station Commercial Program
ROSAVIAKOSMOS Policies & Procedures

Process

Principle Components of Offer	Offer Review steps	Notifications to offeror
Offer Description	Registration of Offer	Registration letter
Technical Information	Review: Business issues	Evaluation letter
Company Information/Management team	Technical issues	
Market Analysis & Strategy Summary	Legal/Policy issues	
Financial Plan	Dispositioning (acceptance/rejection)	Status letter
Letters of intent/commitment		

Commercial Development Stimulating

- minimal time from user's offer to project implementation	Depending on procedures
- simple and clear process for offer review and selection, applied criteria, existing limitations and restrictions	Depending on procedures
- transparent pricing policy, reduced prices	Depending on project specificity
- confidentiality / proprietary rights (i.e. intellectual property rights) protection	Depending on project specificity
- standard commercial contracts for standard services	Depending on project specificity
- non-standard service offer (in particular, services which can not be provided by other Partners: delivery and accommodation of non-standard equipment, user consulting based on Russian unique experience, user access to data bases on previous activities onboard Russian manned space stations, etc.)	Depending on project specificity

Available Inventory (Resources)

Category	Limitations	Pricing
Scientific and Applied Research and Experiments	Available power, volume, crew time, up and down mass delivery within a particular increment	Depending on composition (content) and required power, crew time, volume, up and down mass delivery, training
Space flight (guest mission), several days duration, including tourism	Available spare seat in transportation vehicle (Soyuz), concurrence with Partners (if needed) for non-Partner involvement	Depending on visitor (tourist) program content
Advertisement (Sponsoring, Branding)	Limited to standards of good taste, ethical norms, relevant agreements with International Partners	Case-by-case
Entertainments (including filming, TV-programs, shows, photo and video imaging, etc.)	Limited to the above of space flight and/or availability of crew time (in case of crew participation), standards of good taste, ethical norms; crew consent if needed	Depending on program and resources required (crew time, dedicated hardware, up and down link, etc.)

Price Limits for ISS Russian Segment Resources*

Resource	Price Limits
Up Payload Delivery	$10,000 - 20,000 per 1 kg
Down Payload Delivery	$ 20,000 - 30,000 per 1 kg
Crew Time	$ 20,000 - 40,000 per 1 man-hour
Power	$1,300 - 2,000 per 1 kWh
Pressurized Volume	$ 800,000 - 1,500,000 per 1 cub.м*year
EVA (1 exit)	$ 2,000,000 - 4,000,000 per 1 EVA exit
Space Flight (Guest Mission)	Over $ 10,000,000 per 1 person

* Pricing policy of Rosaviakosmos is currently under development

Conditions of Services Sale, Lease of Resources:

- Timing of use is negotiable, subject to the inventory of resources and accommodations available at every ISS Program stage.
- Re-sale or transfer of customer rights is not permitted unless specifically agreed for certain cases.
- Costs associated with integration, flight certification, and safety compliance are the responsibility of the buyer.
- Costs associated with all hardware, software and crew resources used onboard are to be covered by the buyer.
- Delivery to and from the launch site, freight, customs clearance taxes and duties are the responsibility of the buyer.

The Human Experience in Space

Prof. Hisayasu Nakagawa
Vice-Director of International Institute for Advanced Studies, Professor Emeritus of Kyoto University, Japan

The ISS Forum 2001 was not only about institutional and commercial utilisation of the Space Station, but also offered this more philosophical approach...

In the past, two types of hardships have been the prime contributors to human suffering: natural disasters, such as earthquakes, drought, famine and illness, and catastrophes created by humans, such as war. In the modern age, however, we might add to this list the category of second-hand disasters, such as the destruction of the ozone layer or the onset of global warming, which originate with human actions but have an impact far beyond our immediate control. While we have not yet figured out how to solve these fundamental problems of life on Earth, however, the world of science is advancing in leaps and bounds, as evidenced by the launching of the International Space Station. In the controlled environment of space, a variety of scientific experiments will be conducted in areas such as medicine, the life sciences and materials science.

There is still a large gap, however, between our great achievements in space and our failures on Earth. How might we bridge this gap? In the eighteenth century, the German philosopher Immanual Kant told us that in order for people on Earth to achieve lasting peace, we must establish a cosmopolitan law to be followed by all humankind. In the International Space Station, I would suggest that we have the ideal laboratory in which to develop the kind of law that Kant mentions. Life on the Space Station will necessitate the long-term cohabitation of people with different nationalities, different religions and different languages, leading to every possible type of misunderstanding, conflict and, at times, perhaps even violence. In addition to the natural sciences, we should consider reaping from this facility what might be the most valuable information of all for the future of humankind: an understanding of why people of different backgrounds fight and how they can learn to coexist peacefully. To this end, we must consider the Space Station as a place to conduct international, or rather cosmopolitan, meetings about the future of our planet.

What the Space Station has to offer to this quest for peace is the same kind of closed and controlled environment that recommends it for scientific investigations. The ability to pare away extraneous factors makes the prospects of finding peace in space much greater than would be possible amidst the complexities of life on Earth. In order for the Space Station to function as a small-scale model of the world, however, it is necessary that the people chosen to ride on it comprise not only representatives of the European Union and nations who are financing the project, but also representatives of all regions of the world. If such factors are fulfilled, the International Space Station may provide the only remaining chance to resolve conflicts among nations and to provide everlasting peace on Earth. ■

The Astronaut Roundtable

ISS Forum 2001 allowed the astronauts to describe their roles in the ISS. Here are edited highlights of the Astronaut Roundtable...

The Astronaut Roundtable brought together a cross-section of space-farers. Japan's Chiaki Mukai performed extensive microgravity research during her IML-2 Shuttle mission in 1994, followed by STS-95 in 1998. Umberto Guidoni became the first European astronaut aboard the ISS, during STS-100 in April 2001. ESA astronaut Reinhold Ewald flew an 18-day mission to Mir in 1997 and is now involved in building the training infrastructure in Cologne for ESA Station elements and payloads. NASA's William Readdy is a veteran pilot astronaut, flying first in 1992 on STS-42 and docking with Mir during STS-79, his third mission, in 1996. Julie Payette, during STS-96 in late 1999, became the first Canadian aboard the Station. ESA astronaut Frank De Winne is in training for his first flight, aboard a Soyuz mission to the Station.

Dr Mukai, how valuable was your professional background as a medical doctor during your mission?
It helped me a lot on various aspects. For example, I used my knowledge of the human body to help me understand the very complicated space systems and hardware. The brain is like the computer, the neural system is the electrical system and the heart is a hydraulic system. When you go into space, your body adapts to the new environment, and I used my medical expertise to understand what happens. Of course, I could also help the rest of the crew with any medical problem. I was the only medical doctor, so I wondered who would help me! But I was happy to see another doctor on my second flight.

Mr. Guidoni, during your flight 2 months ago, what experiment hardware did you bring up to the ISS?
We delivered four experiments, mostly biological growth experiments. One was particularly interesting because it was one of the first commercial applications, from a private company. They limited the time it was unpowered to 30 minutes because the temperature had to stay constant – and we did it in 5 minutes. The ISS crew had the Express rack ready waiting for it. It went very smoothly and we were really pleased how easy it is to work in the Lab. It is a really clean environment and we paid particular attention to keeping it that way. We had very little Station training on the ground, but when we were aboard we really worked like a 10-astronaut crew. The Station crew was busy troubleshooting the computer problems so we did the housekeeping for them, cleaning the Station and transferring items. On Shuttle missions you have only a few days to complete your work, but on the Station they have all the time they want. The schedule is more relaxed and that is important for doing science.

Mr Ewald, what is the primary use of the ISS and the astronauts' role in it?
This Forum has shown that the ISS is primarily devoted to putting the environment – microgravity, radiation and so on – to the best use. Astronauts are an intelligent resource: you interact with them

The Astronaut Roundtable (from left): Chiaki Mukai (NASDA; on screen), Umberto Guidoni (ESA), Reinhold Ewald (ESA), Bill Readdy (NASA), Julie Payette (CSA) and Frank De Winne (ESA). At far right is Forum moderator Claus Kruesken.

Umberto Guidoni during the STS-100 mission to the ISS in April 2001. (NASA)

and explain the experiment and its underlying principles to them. To understand an experiment, you have to follow the research team in their reviews and after the flight. For my 1997 Mir mission, we finally produced a number of journal articles in December 2000. I was deeply involved and literally gave my blood, so I was interested to see the results published.

Mr Readdy, what are the challenges you face flying with an international crew?
It is an embarrassment of riches! I was lucky in all three of my flights to have international crews, international experiments, investigators, control centres and so. Such talent and enthusiasm really dominate any kind of control or language difficulties. When you are flying for only 2 weeks, you rehearse everything, all the nominal procedures and the emergency procedures. You must be highly choreographed, because you have a very limited time to do the research and housekeeping. You must be focused and the training reflects that. For long Station missions, we focus on skill-based training so that we can really understand the experiment. You have time to deal with any situation and you can interact with the investigator and the control centre. It is really a luxury, a different emphasis in the training.

Ms Payette, you were involved in assembling the Station. What is the role of robots aboard the ISS?
I had the privilege of going to the ISS very early in its construction, when it was still very small and empty. There was nobody onboard, no windows, and the systems to sustain life had yet to be launched. Only 2 years later, we have a fully operational Station with three permanent crewmembers. This is quite an achievement.

Frank De Winne makes a point.

Space robotics is critical to the construction of the ISS. Operated by the astronauts from within the Station or the Space Shuttle, robot arms are used like cranes to assemble the infrastructure and help to manoeuvre equipment and crew members during space walks. Space robotics is a complex business which relies heavily on human skills, both on orbit and on the ground. Canada is proud to have contributed the main robot arm to the Station, as well as the expertise of its engineers, trainers and operators. But our technology is only a part of this extraordinary project and it is the continued collaborative effort that makes the International Space Station truly unique.

Mr De Winne, what are the major training phases for astronauts before they can fly?
The first part is the basic training where you learn all the basics of spaceflight. You learn how to operate, live and function in space. You study the space engineering that produces a facility like the ISS. Finally, we have to train in research techniques so that when we are confronted later in our careers with specific research or engineering tools, then we have the background knowledge. The second part of the training is to learn everything about the ISS in 18 months – how it functions, its resources, how experiments are conducted. This includes science, robotics and housekeeping. Finally, when you are assigned to a mission, you train for specific experiments, repairs and mission activities. It is different to a Shuttle mission, where you rehearse everything on a very restricted time-line. On the Station, you have more time. You can communicate more with the investigators and you have more time to solve problems. When you are up in space, you must relate to the researchers to do a good job.

The initial training to make you eligible to fly to the ISS takes 2-3 years, although spread out by other duties. Once you are selected, training for a specific Station missions takes another 18 months.

ISS Forum 2001: A Success

Prof Achim Bachem (right), Mr Jörg Feustel-Büechl (centre) and moderator Claus Kruesken

Prof Bachem, is there sometimes conflict between commercial and institutional use?
There is absolutely no conflict. The ISS was built primarily for scientific work and we are happy that many of the projects are done jointly with industry – this is an excellent advertisement for the Station's commercial use. We also welcome multi-media projects, because they are excellent opportunities for promoting public awareness of what we are doing aboard the Space Station.

Mr Feustel-Büechl, have we reached the commercial community at this conference?
I hope sincerely that we have reached that community and triggered their interest. We have had about 500 participants from governments, agencies and the space industry, and about 300 from other industries and media, banks and private investors. The Forum was also broadcast on the Internet, and on the second day alone we had 5000 'hits'. I am sure there were also newcomers among them who will push not only for the Station's scientific use but also for its commercial use.

Prof Achim Bachem, DLR Executive Board member, and Mr Jörg Feustel-Büechl, Director of ESA Manned Spaceflight & Microgravity, brought the ISS Forum to a conclusion...

Prof Bachem, how important is the Station for education?
Education is a very important issue for the Station. Last year we opened our doors at DLR and in just one centre we had 60 000 visitors, mostly young kids asking questions and queuing up in front of the astronaut training centre. They all asked what we are doing up there in space and afterwards they said this is really important work and they wanted to become physicians, biologists or go into medicine. The ISS is a wonderful tool and we should use it to get children and young students involved in science.

Mr Feustel-Büechl, how are the agencies coordinating themselves on commercialisation and are they all following the same path?
Of course, this Forum shows that we have a coordinated approach. In the round tables, you have seen that we are following common objectives, procedures and principles. We do not always have the same detailed approach, but we have a very good understanding on the principles and objectives. We have more work to do, but we have the mechanism in place to achieve optimum coordination. I am pleased we have the first entry in our order book by signing the contract with Intospace, and we have opened the call for commercial proposals <www.esa.int/spaceflight/isscommercialisation>. This Forum is only the first step: there will be more conferences at national, regional and global levels. We are open and flexible. All the agencies will do their best to fill the order book with private investors and commercial customers in order to demonstrate to taxpayers that it is worthwhile to use the Space Station.

I am pleased to announce that our American friends will host the next ISS Forum. This Forum took around 18 months to organise and I thank everyone involved, including Media AG for their excellent stage and web management. ■

On Station
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The Newsletter of ESA's Directorate of Manned Spaceflight & Microgravity

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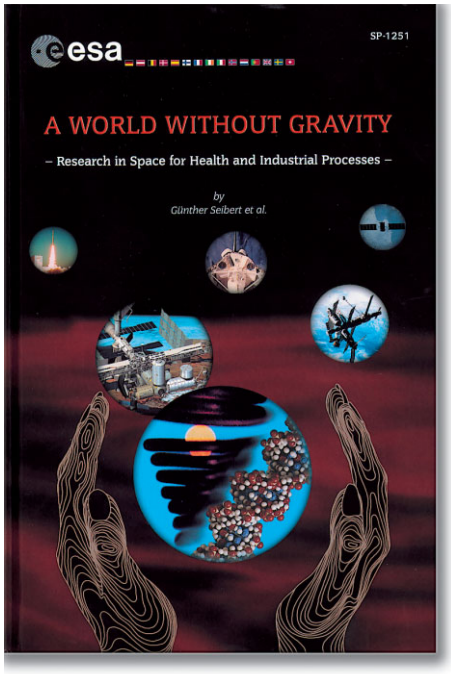
Published

A World Without Gravity

This latest book from ESA Publications and MSM highlights the activities and results of ESA's past microgravity research, hardware development and programmatic aspects, and provides an outlook on utilisation of the International Space Station.



Chapter 1 explains why this kind of research is of increasing interest, and how many questions with far-reaching implications for mankind can be answered in laboratories in space. The nine life-sciences and ten physical-sciences sections of Chapter 2 are written by more than 30 European scientists. They outline the past achievements, current status and the future importance of space in their research fields, with emphasis on recommendations for future work in those disciplines. Chapter 3 addresses the important topic of the transition from basic research to commercial applications. Chapter 4 describes the history of research under microgravity conditions, while Chapter 5 looks at the future of microgravity research. Chapter 6 provides details about the programmatic structure of ESA's microgravity activities.

The 503pp *A World Without Gravity* is available from ESA Publications by contacting Frits de Zwaan at Frits.de.Zwaan@esa.int or fax +31 71 565-5433 (quoting SP-1251). The cost is €40/90Dfl.

Author Günther Seibert autographs a copy of *A World Without Gravity*.

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