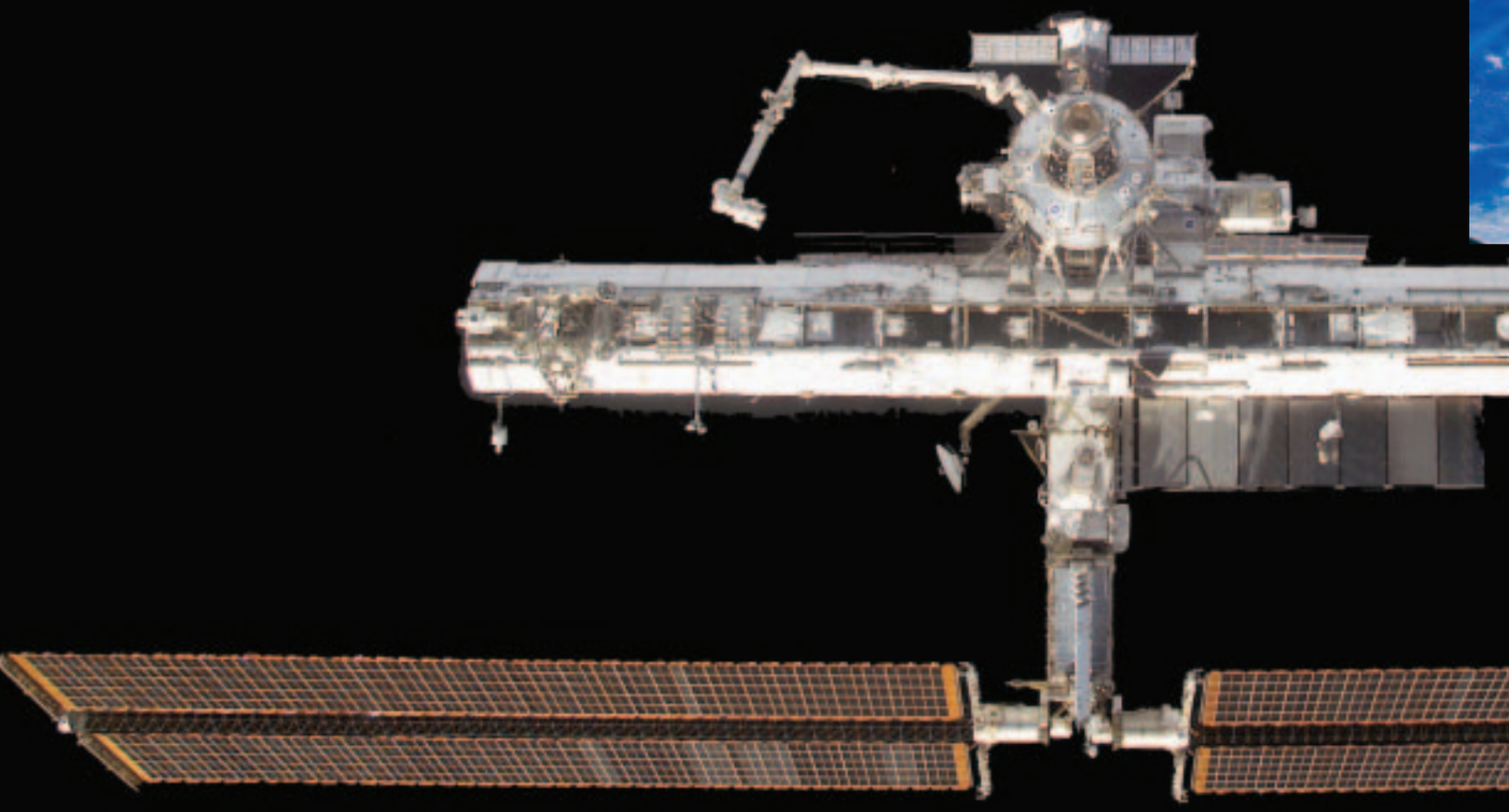
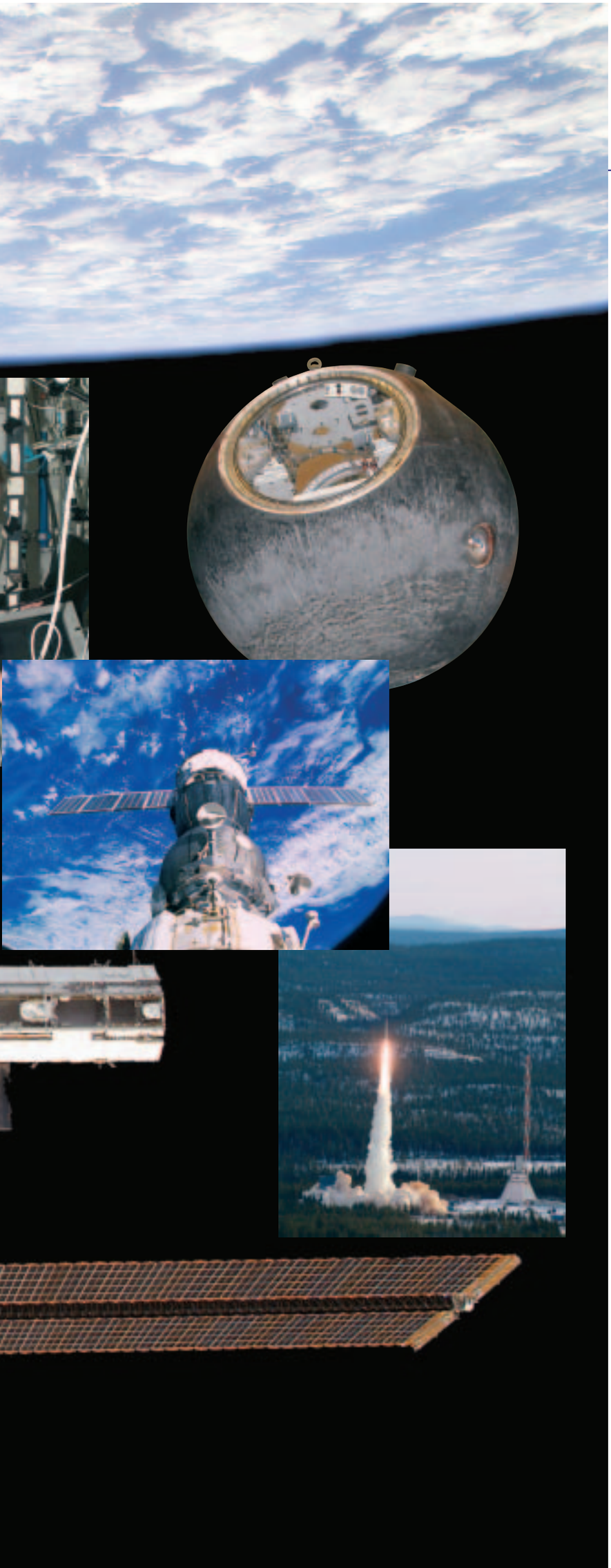
Sharing ESA's Knowledge and Experience

– The Erasmus Experiment Archive





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The aim of the Erasmus Experiment Archive is to make available to scientists, engineers, decision makers, students and future generations of researchers the results of low-gravity experimentation carried out under the responsibility of with the support of the Directorate of Human Spaceflight over the last 30 years, and to keep track of new experiments. The archive groups into a single repository as much information as possible regarding research carried out under these special conditions, in an effort to inspire new research and share with the science and industrial space community at large the body of knowledge acquired so far. As is well-known, the time lapse between consecutive space missions is often a major problem in retaining expertise in the scientific and industrial teams. The Erasmus Archive is another way to achieve that goal of passing knowledge across the generations.

Introduction

The Erasmus Experiment Archive is an electronic database, accessible via the Internet, that collects in a single reference repository information regarding all experiments performed to date in the facilities that fall under the responsibility of the ESA Directorate of Human Spaceflight, Microgravity and Exploration. The archive was developed and is maintained and kept up-to-date by the Erasmus User Centre, which forms part of the Directorate and is located at ESTEC in

Noordwijk (NL). Abstracts from the experiment proposals, scientific results and a list of relevant references and publications are some of the features that can be found for each experiment record.

The Erasmus Experiment Archive cooperates in this effort with the experiment archives of the partner space agencies NASA and JAXA (Japan). By means of the International Distributed Experiment Archive (IDEA), a mutually agreed standard for experiment records, the experiments contained in the databases of the three partners are shared so that users around the World can browse all experiment records through the Internet, regardless of whether they start their search via the ESA, NASA or JAXA database Internet site.

The archive was established by ESA to facilitate access to the results of experiments performed under microgravity conditions with the objectives of providing experienced and potential European scientists, via a user-friendly reference tool, with:

– An overview of European experiments carried out on space platforms and ground-based facilities.
– Coverage of the ESA Research Cornerstones.
– The scientific results of the experiments, wherever possible.
– References for further details and results.
– As much multi-media material relating to the experiments as possible, including images, videos, audio, graphs, tables, animations, etc.

With the growing use of the Internet and the progress in Internet technology, particularly in the field of database-driven web applications, and with the advent of streaming video broadcast techniques, it was decided to substantially re-engineer and upgrade the existing Microgravity Database to form the 'Erasmus Experiment Archive'.

The technology of streaming video recordings stored on an Internet server which has been incorporated into the new Erasmus Experiment Archive lets the scientists behind each of the experiments explain the rationale of their experiment and the results to be expected, in small video clips that can be accessed over the Internet. Video recordings and other photographs and illustrations of the experiment's execution can be archived and made available online using the same techniques.

Experiment Facilities Covered by the Archive

The ESA Directorate of Human Spaceflight, Microgravity and Exploration facilitates and coordinates the access of European users to a number of experiment facilities that provide a very particular physical and operational environment that other facilities cannot offer. They include the International Space Station, recoverable Foton satellites, Maser and Maxus sounding rockets, the Airbus A3000 Zero-G aircraft for parabolic flights, as well as various ground facilities in Europe.

Most, but not all, of these facilities are characterised by a 'weightlessness environment', which is why they are commonly called 'facilities for microgravity research'. This term is a little misleading, however, in that microgravity is a tool, not a scientific discipline as such. In fact, these 'microgravity facilities' are not used by 'microgravity scientists', but by researchers from scientific disciplines as diverse as biology, human physiology, physics, material science, fluid science, combustion science, as well as more application-oriented engineering sciences, and for the evaluation and demonstration of innovative techniques and industrial processes and of new commercial services.

The use of these facilities is intended to increase our collective knowledge in the scientific and technical arena. It has in fact already led to many new discoveries, new insights into physical processes and phenomena, and increased confidence in new manufacturing processes.

The Beginning

In the early 1990s, ESA set up a catalogue of the experiments performed in the various facilities for research under microgravity conditions. This catalogue started as a collection of printed fact sheets, developed into a computer-based database that was distributed on floppy disc and later CD, and finally evolved into an online database that could be accessed through the Internet. This became known as the 'Microgravity Database'.

The Target Groups

The Erasmus Experiment Archive primarily addresses the following large and diverse audience:

– Scientists interested in utilising experiment facilities for their own research activities.
– Project engineers and managers involved in developing, building or operating similar facilities.
– Scientists and engineers at the European User Support and Operations Centres (USOCs), who support users in the preparation and utilisation of their experiments.
– Political decision makers and project managers from governmental services who decide on the funding and orientation of research programmes.
– University students in search of reference material for their studies or for information that can guide them in their study, and later professional career, choices.
– Public and private education and information-dissemination institutions and centres that focus on the popularisation of science and technology activities in space.
– Media representatives and other lay people with an interest in space research and technology.

The major vehicles for the dissemination of scientific findings are publications in scientific journals and presentations at scientific symposia. The only problem is that both are usually very focused on a given discipline, whereas the utilisation potential of the research facilities with which the ESA Directorate of Human Spaceflight, Microgravity and Exploration is dealing is of a very multidisciplinary nature.

This scientific diversity means that a special effort is necessary to ensure that the results of the work performed in the said facilities and their scientific returns not only benefit the specific community of the scientists directly involved in an

The Archive's Content

The information contained within the archive is collated in individual experiment records. Their structure has been carefully chosen to capture and retain the most important knowledge concerning any one experiment, without overwhelming the user querying the system with excessive information. Each record has a primary and secondary field set: the primary set assists in the definition and recovery of the specific record, while the secondary set covers the core knowledge associated with the experiment.

The primary field set consists of experiment name, research team members and their affiliations, particular mission associated (e.g. 35th ESA Parabolic Flight Campaign, Delta Soyuz Mission and Maxus 5 Sounding Rocket), and the date on which the experiment was conducted. Two other very important fields, research cornerstone and research area, complete the primary set. Two fields related to the discipline area addressed by the experiment are required as the research-cornerstone definition has only been in existence since 2001, when the following 14 Cornerstones, or 'areas of European excellence', were defined in the six major research areas:

– ***Fundamental Physics:***
  Complex Plasmas and Dust Particles Physics
  Cold Atoms and Quantum Fluids
– ***Fluid and Combustion Physics:***
  Structure and Dynamics of Fluids and Multi-Phase Systems Combustion
– ***Material Sciences:***
  Thermophysical Properties
  New Materials and Processes
– ***Biology:***
  Biotechnology
  Plant Physiology
  Cell and Developmental Biology
– ***Physiology:***
  Integrated Physiology
  Muscle and Bone Physiology
  Neuroscience
– ***Astro/exobiology and Planetary Exploration:***
  Origin, Evolution and Distribution of Life
  Preparation for Human Planetary Exploration.

http://spaceflight.esa.int/eea

The secondary field set consists of references, processing facility, experiment objectives, experiment procedure, experiment results, attachments and validation point. The attachments associated with each record may include images, PDF files, videos or sound files that help to explain the scientific objectives, particular procedures or protocols followed, and experimental results.

The validation point field contains the name and address of the person at ESA who is responsible for validating the record entry, and who may be contacted for further information regarding the experiment. It is the key field associated with the entry of records into the archive. In the past, the lead scientist for each experiment was responsible for entering the record into the archive, and this record was subsequently validated by the respective Life- or Physical-Sciences Coordinator at ESA. This process proved to be extremely time-consuming and inefficient and led to significant disparities between individual records in terms of content and style. This initial step is now carried-out by the Erasmus User Centre, which produces the initial content based on inputs provided by the scientists. A final validation by the respective science coordinator is performed prior to publishing the record. This approach results in a more timely insertion of the record, and indeed in a more homogeneous and consistent set of records, as well as in reducing the administrative task for both the research team leader and science coordinator.

experiment, but that they are also made known to scientists from other disciplines. In this way, the effects of synergy and cross-fertilisation of ideas can be promoted and exploited.

A further consideration in the design of the Erasmus Experiment Archive was the fact that the 'customers' for these facilities fall into two categories: one 'half-customer' uses the facilities and gets the benefit of their use, but does not pay for their use. This is usually a scientist from a publicly funded research institute. In addition, there is a second 'half-customer' who does not use the facilities and does not necessarily get direct scientific benefit from their use, but who pays for the use of the facilities by the researchers. This is normally a representative from a national ministry or other governmental service which is funding research projects. This 'sponsor' in turn has to explain and justify the funding of research projects to the media and the tax-paying public. Their life can certainly be made easier if they have direct access to the results and benefits of the experiments, especially if this information is presented in a form in which it can be re-used for informing other decision makers, the media and the interested public.

Retrieving the Information

The Erasmus Experiment Archive is accessible online through the Internet via a very simple web-based graphical user interface, without need for a specific user identification or password.

The main area of the opening page of the archive allows the user to make either a full text search or an advanced search. There are also links to a description of the archive, to international-partner archives and to a list of contact persons. A powerful feature is that each time the archive's Home Page is opened in the user's web browser, it automatically performs an indexing of the complete database at that instant. This means that the user will always see the most up-to-date content, even if a new record was entered only seconds before. This instant indexing is repeated each time a new search is initiated.

Full Text Searching – The archive does not use the concept of 'keywords', which are subjective and very time-dependent and may use terminology that is fashionable at the time, but soon loses its meaning. It means that records that should be found are 'lost'. A full-text search is extremely powerful in that it ensures any occurrence of the text-string within a record is not accidentally overlooked. It is similar to going into a shop where there is an assistant to help you find what you are looking for! This method is also useful when the user has limited information on which to base a search, such as an author's surname, the mission or even just the year in which the experiment took place. Although a large number of records may initially be returned, the search can be repeated and the desired information retrieved through a gradual refinement of the search criteria.

Advanced Searching – The advanced search is intended for users who have a greater knowledge of what they are looking for, and is therefore more of a self-service 'hypermarket approach', where each aisle is clearly marked and you can readily find what you are looking for.

To assist the user in searching the archive, the records have been collated into a number of groups reflecting the microgravity platforms on which the experiments have been performed, i.e. space stations, retrievable capsules, sounding rockets, parabolic flights, Space Shuttle and ground facilities. By clicking on the icon associated with a platform, the complete list of relevant missions or campaigns is listed. In addition, three 'pre-programmed' searches may be performed to show a list of records involving team members from a particular country, the number of experiments performed in any given year between 1971 and the present, and a complete list of all experiment records in the archive.

The archive can also help users who wish to find partners with whom to team up. Searches may be performed to find a partner in a specific country or in a specific scientific discipline, or where, for example, a complementary scientific capability is required in order to complete a team.

The advanced search is particularly useful for a user to see what capabilities are offered by a particular platform or facility.

Cooperation with International Partners

One of the major features of the Erasmus Archive is its participation in the International Distributed Experiment Archive – IDEA for short. Through this partnership with the National Aeronautics and Space Administration (NASA) and the Japanese Aerospace Exploration Agency

The IDEA search page

(JAXA), users have access to all three databases using a single search.

The problem of sharing or operating databases together is currently a very active area of discussion within the European Union, particularly with respect to cooperative policing and security, where combining Member State databases is proving problematical due to their different structures and contents, and in some instances because not all records can be disclosed to all partners. ESA, NASA and JAXA have achieved such interoperability, making records mutually accessible by means of sharing record indexes in a commonly agreed format – the IDEA concept – while retaining their own database structure.

An IDEA search will retrieve records from all three ESA, NASA and JAXA microgravity databases in the common format and the joint approach avoids overlapping information and inconsistencies between the distributed archives, and provides the user with access to a much greater bank of information.

The Technologies Utilised

The Erasmus Experiment Archive is a Macromedia ColdFusion application running on a Solaris platform, one of the Directorate's servers outside the ESA firewall. The web server is an Oracle Application server and the data are shared in an Oracle database. The application can be maintained remotely, and a ColdFusion Administrator module allows the Erasmus User Centre team to modify the content from anywhere over the Internet. The IDEA approach described in the main text provides a full-text search on experiment data that are stored in HTML files, and these HTML files are refreshed automatically once a week by the ColdFusion Administrator module.

Most records are provided with multimedia attachments that increase the usability of the archive by enlarging the range of audience that can have access to it. In particular, most new records are provided with video attachments ranging from selected scenes from the experiment itself to interviews with the team coordinator, explaining in his/her own words the scientific objectives of the experiment. Published papers, pictures, data visualisation techniques and animations are also widely used. The video products are standardised by the Erasmus User Centre team that produces them during the various launch events and makes them available a few days after in streaming-video format.

Where Do We Stand Today?

At the time of writing, the Erasmus Archive contains approximately 1200 individual records corresponding to European experiments carried out since 1971, up to the present day. Records for around 90% of all experiments conducted have been inserted to date, and the primary emphasis of present activities is on completeness of the database in terms of record content, completing the entries in reverse chronological order. A recent decision to also include experiments performed during the ESA student parabolic-flight campaigns means another 200 records need to be added to the archive to cover the 7 student campaigns flown to date.

What Does The Future Hold?

The Erasmus Experiment Archive represents one of the cornerstones of the informatics infrastructure of the Human Spaceflight, Microgravity and Exploration Directorate, and more specifically also of the Virtual Campus information framework provided to the users of the International Space Station (ISS) by the Erasmus User Centre. One major enhancement to be provided in the immediate future is improved integration of the archive with the Virtual Campus's other tools and databases, such as: the User Documentation Access System (UDAS), a system covering the utilisation and the development of scientific payloads, which narrows down the range of required documents and collects them into a single document; the MSM Photo-Video Archive; the remote collaboration tool iLinc; and the ESA Spaceflight Internet site.

Another important addition to the archive would be that of a 'lessons learned' section to each record. It is a fact that scientific journals tend to focus primarily on the scientific outcome of research, while not necessarily addressing to the same extent the technical and operational aspects of conducting the experiments themselves. Thus, it would be beneficial if a record is kept of the lessons learned with given experimental set-ups, and of the little 'tricks of the trade' that could facilitate the work of future researchers. This would allow, in particular, the introduction of young scientists more easily to the subject and would avoid each new generation re-inventing the wheel.

On the technical side, one foreseen improvement is to add the capability to conduct 'a search within a search', which is a rapid way of refining a search that has returned a high number of records.

It is hoped that within the not-too-distant future, ESA's other ISS Partners, Russia and Canada, will also make their experiment databases accessible via the IDEA system. r