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bulletin

SPACE FOR EUROPE

Ministers Secure Europe's Access to Space

European Space Agency
Agence spatiale européenne

european space agency

The European Space Agency was formed out of and took over the rights and obligations of, the two earlier European Space Organisations – the European Space Research Organisation (ESRO) and the European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO). The Member States are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Canada is a Cooperating State.

In the words of its Convention: the purpose of the Agency shall be to provide for and to promote for exclusively peaceful purposes, co-operation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

(a) by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
(b) by elaborating and implementing activities and programmes in the space field;
(c) by co-ordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
(d) by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

The Agency is directed by a Council composed of representatives of the Member States. The Director General is the chief executive of the Agency and its legal representative.

The ESA HEADQUARTERS are in Paris.

The major establishments of ESA are:

THE EUROPEAN SPACE RESEARCH AND TECHNOLOGY CENTRE (ESTEC), Noordwijk, Netherlands.

THE EUROPEAN SPACE OPERATIONS CENTRE (ESOC), Darmstadt, Germany

ESRIN, Frascati, Italy.

Chairman of the Council: P. Tegnér

Director General: A. Rodotà

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agence spatiale européenne

L'Agence Spatiale Européenne est issue des deux Organisations spatiales européennes qui l'ont précédée – l'Organisation européenne de recherches spatiales (CERS) et l'Organisation européenne pour la mise au point et la construction de lanceurs d'engins spatiaux (CECLES) – dont elle a repris les droits et obligations. Les Etats membres en sont: l'Allemagne, l'Autriche, la Belgique, le Danemark, l'Espagne, la Finlande, la France, l'Irlande, l'Italie, la Norvège, les Pays-Bas, le Portugal, le Royaumi-Uni, la Suède et la Suisse. Le Canada bénéficie d'un statut d'Etat coopérant.

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(a) en élaborant et en mettant en oeuvre une politique spatiale européenne à long terme, en recommandant aux Etats membres des objectifs en matière spatiale et en concertant les politiques des Etats membres à l'égard d'autres organisations et institutions nationales et internationales;
(b) en élaborant et en mettant en oeuvre des activités et des programmes dans le domaine spatial;
(c) en coordonnant le programme spatial européen et les programmes nationaux, et en intégrant ces derniers progressivement et aussi complètement que possible dans le programme spatial européen, notamment en ce qui concerne le développement de satellites d'applications;
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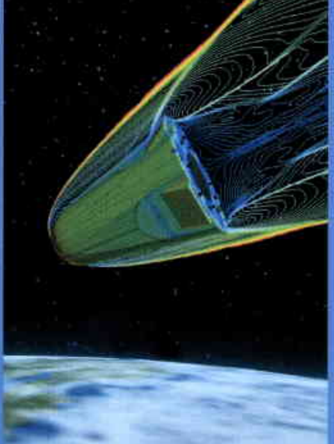

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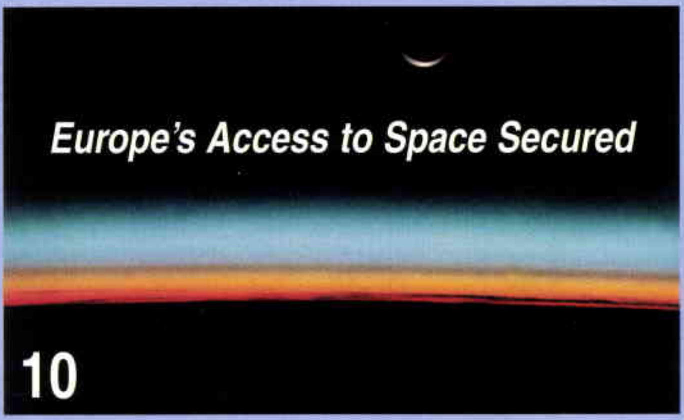

Preparing for Atmospheric Reentry

News from the Sun's Poles

Tomorrow's Space Weather Forecast

Medical Care from Space

esa bulletin 114 - may 2003

Contents

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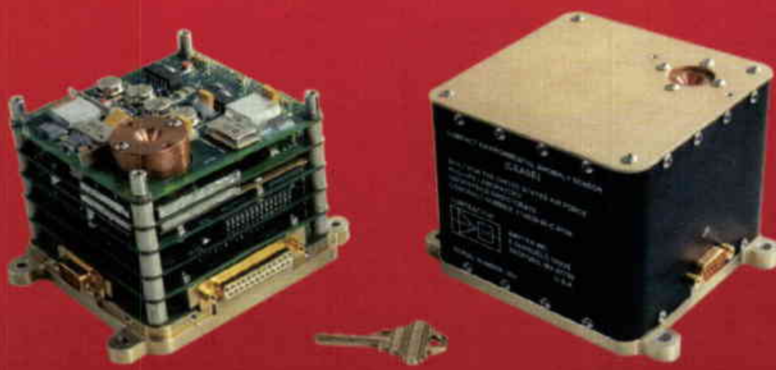

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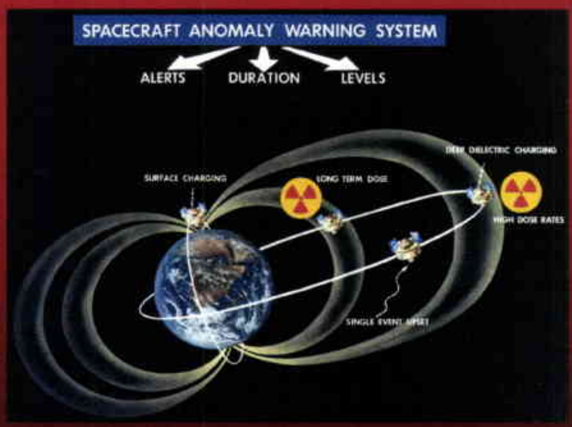

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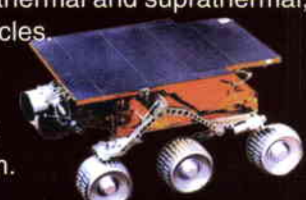

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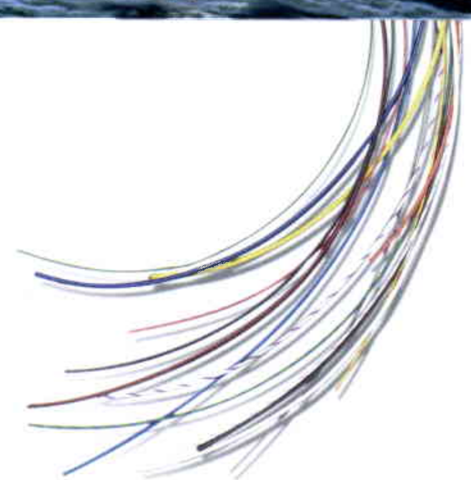

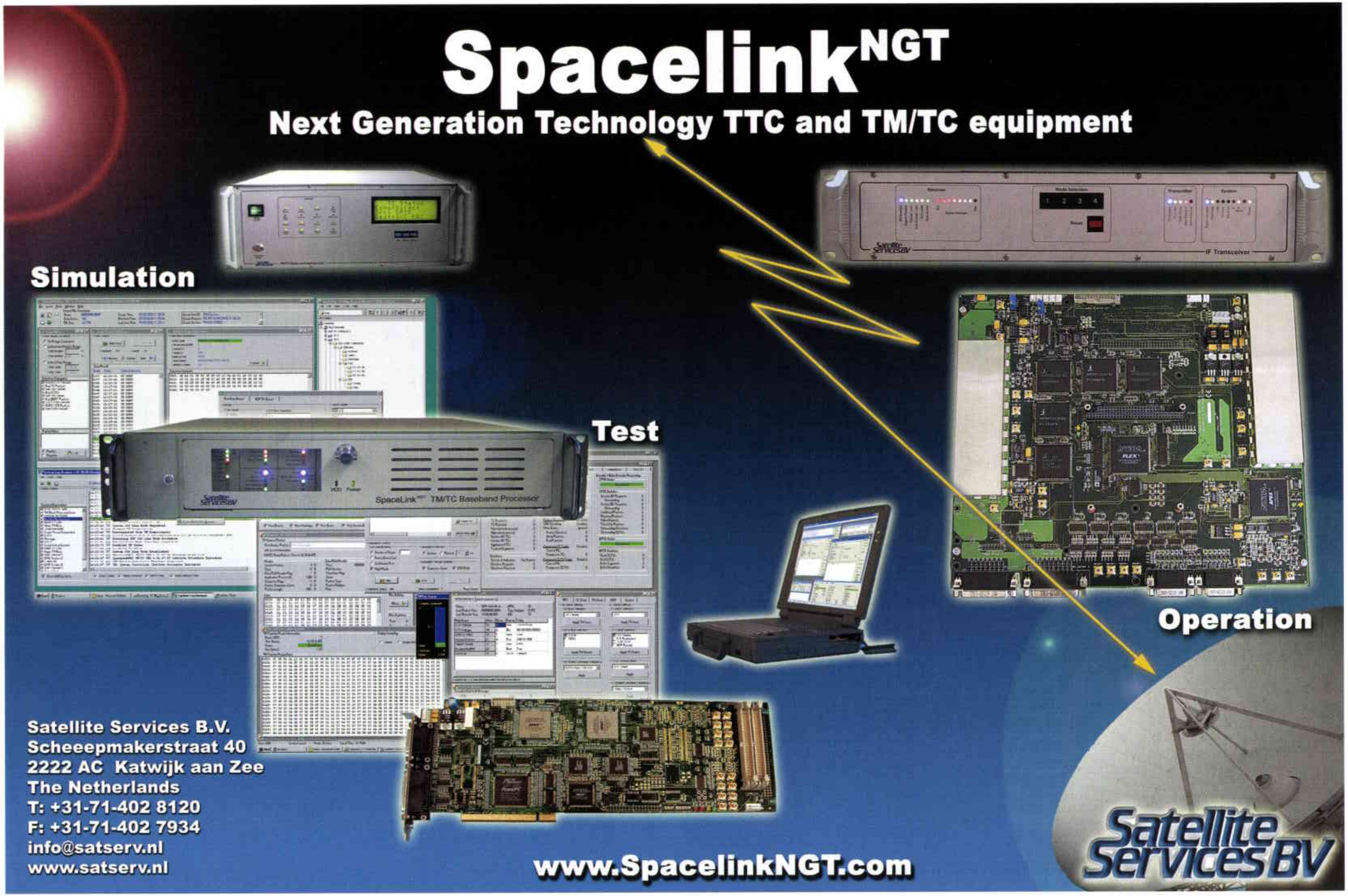
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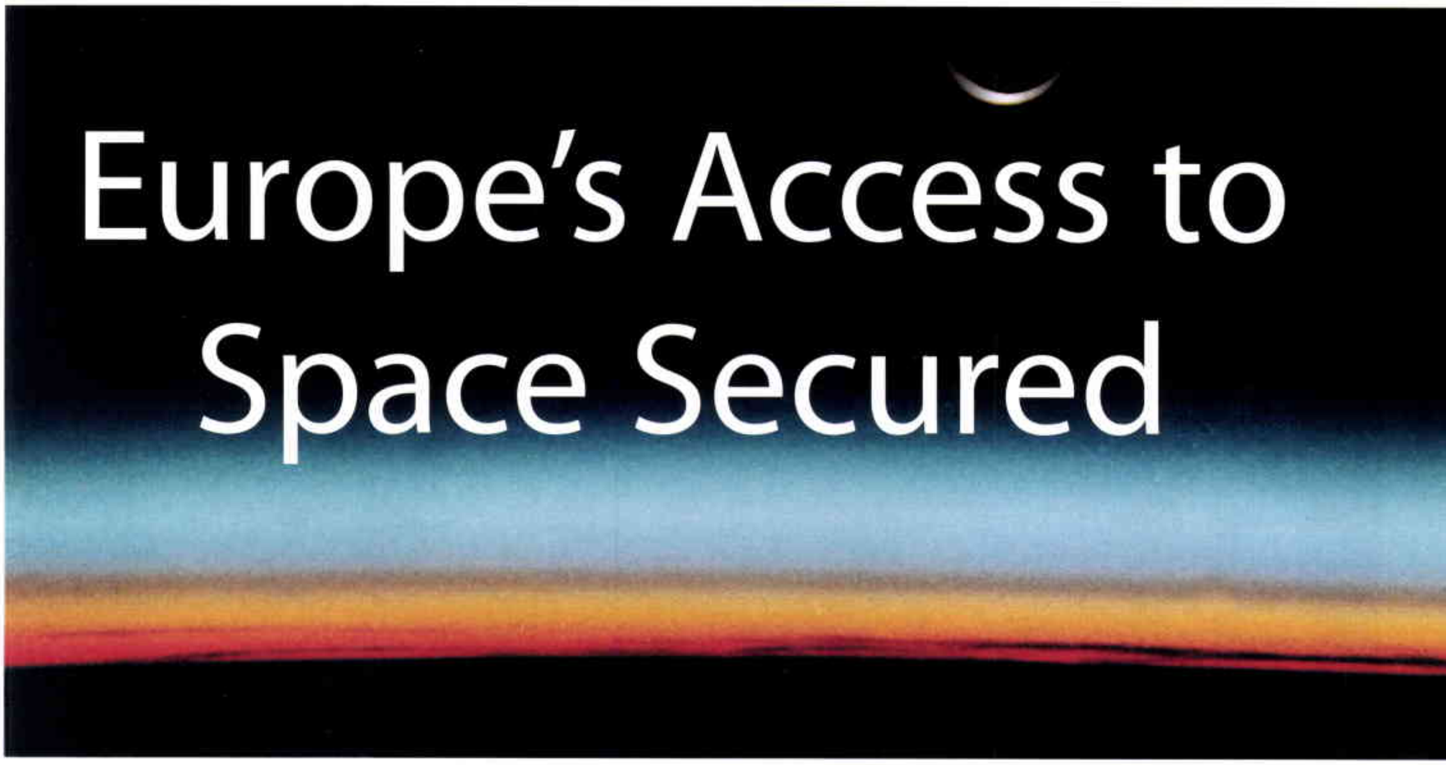


Europe's Access to Space Secured

Meeting at ESA's Headquarters in Paris on 27 May, the Ministers responsible for space matters in the Agency's fifteen Member States and Canada agreed on a series of measures to put Europe's Ariane-5 launcher programme back on track and set up the development of future launchers within a reorganised launcher sector, to free funds for the International Space Station, and to strengthen relations between ESA and the European Union.

This ESA Council Meeting at Ministerial Level was a follow-on from the gathering of Ministers that took place in Edinburgh (UK) in November 2001, where they had taken a number of important decisions on current programmes and new initiatives, with the overarching ambition of putting space at the service of European citizens. The Edinburgh decisions having been implemented, new decisions were now required to help ensure that Europe remains at the forefront in space, especially in the field of launch systems, and that space is fully recognised as a key to efficient implementation of major European policies in such areas as transport, environment, science, and security in the broadest sense.

The decisions taken in Paris are critical to safeguarding Europe's guaranteed access to space. The Ministers have helped ESA restore the competitiveness of Europe's launcher system, restructure its launcher sector and prepare the future generation of launchers. In addition, they agreed to unblock funds for exploitation of the International Space Station and reaffirmed their commitment to closer cooperation with the European Union.

In particular, the Ministers decided to support Europe's commercial launch operator, Arianespace, in the resumption of production of the 'generic version' of Ariane-5 in order to guarantee continuity of launcher operations. At the same time they decided to support the qualification of the new and more powerful version (ECA, for a 10t lift-off capacity) by means of two flights in 2004 and to reduce production costs further. In order to sustain Europe's guaranteed access to space, the Ministers also agreed on a specific programme over the period 2005-2009 aimed at intensifying the institutional use of Ariane-5.

In addition to this first set of measures to resolve present difficulties in the launcher sector, which is undergoing a severe worldwide crisis, structural measures have been agreed to secure the robustness of the overall European launcher sector, demonstrating the political will to strengthen the sector. Firstly, the Ministers supported the need to reorganise the launcher sector so as to establish a strong link between production and development. They also decided to prepare for development of the next generation of launchers, thereby improving Europe's competitiveness in the field, and to build up international cooperation. This cooperation, initially with Russia, includes operation of the Russian Soyuz launcher by Arianespace from the Guiana Space Centre, Europe's spaceport in Kourou, French Guiana, from 2006 onwards.

Another subject dealt with by the Ministers was Europe's exploitation of the International Space Station. At the previous Ministerial Council in Edinburgh, part of the funding necessary for European exploitation of the Space Station had been blocked pending confirmation that the American partner would honour commitments it had given previously, showing that Europe was indeed willing to cooperate, but not at any price. The Ministers agreed in Paris to unblock a first part of the ISS Exploitation Programme funds, to cover time-critical activities related mainly related to the availability of ESA's Automated Transfer Vehicle (ATV) and to the European ISS ground segment. Timely availability of the ATV will help to make up for a reduced Shuttle fleet following the tragic loss of 'Columbia'.

The Ministers also addressed the relationship between ESA and the European Union, which has become a regular agenda item at the Ministerial Councils. The first Resolution adopted at the Edinburgh meeting in November 2001 had reflected a very positive outcome with respect to this relationship, calling in particular for a framework agreement to formalise cooperation between the two organisations. Since then, this subject has received attention at the highest political level, as seen in the cooperation between the European Commission and ESA on drafting the Green Paper on European Space Policy and also in the possible inclusion of space matters within the revised terms of reference currently under consideration for the European Union.

Credit: ESA-P. Sebirot

Ministers and Senior Representatives of the ESA Member States at ESA Headquarters on 27 May.
Back row, from left to right: Mr J.H. De Groene (Netherlands), Mr K. Tilli (Finland), Mr J.P. Jacobsen (Denmark), Mr C. Kleiber (Switzerland), Mr P. Lynce (Portugal), Mr C. Anskrand (Sweden), Mr V. Gomez (Spain), Mr C. Hicks (United Kingdom), Mr M. Garneau (Canada).
Front row, from left to right: Mr F. Fahey (Ireland), Ms H. Hammer (Norway), Mrs L. Moratti (Italy), Mr A. Rodotà (ESA), Mrs E. Bulmahn (Chair), Mr Y. Ylieff (Belgium), Mrs C. Haigneré (France), Mr W.D. Dudenhausen (Germany).

New steps have therefore been taken towards achieving a closer relationship between ESA and the Union. The Ministers expressed their wish to see it deepened and developed further, and urged the Agency to complete, before the end of 2003, the framework agreement that will form the basis upon which ESA and the EU will work together permanently.

In addition, the Ministers noted that Europe is now in a position to finalise the conditions for participation in the Galileo navigation programme. The agreement reached between ESA Member States on 26 May has cleared the way for the official launch of the Joint Undertaking between ESA and the European Union, the legal entity that will have the task of coordinating their cooperation on Galileo, the European initiative to develop a global satellite navigation system for its citizens.

Regarding ESA's Science Programme, the Ministers welcomed the Science Programme Committee's decision on the new mission baseline for Rosetta. The spacecraft will now be launched in February 2004 from Kourou, French Guiana, using an Ariane-5 launcher and will rendezvous with the new target comet, Churyumov-Gerasimenko, in November 2014. The cost of the Rosetta launch delay has created a cash-flow problem for the science programme, which was already operating under tight budgetary restrictions, but this problem will now be resolved by the ESA Council, through the approval of greater financial flexibility at Agency level.

The texts of the four Resolutions that were adopted at the Paris Ministerial Conference are reproduced in the following pages.

Describing the outcome of the Ministerial Council, Mrs Edelgard Bulmahn, the German Minister who chaired the meeting said:

"The decisions reached are among the most important in years. The ESA Member States have provided the Ariane launcher system with the structures it needs to deal effectively with competition in a keenly disputed market. Thanks to the agreement on restructuring, policy-makers and industrialists alike can rely on planning stability over the years ahead. Responsibilities have been clearly established and price stability has been secured".

Antonio Rodotà, ESA's Director General, also expressed his great satisfaction with the outcome, commenting that:

"This is a great day for Europe in general and its space community in particular. Conscious of the economic, industrial and strategic importance of guaranteed access to space and applications such as satellite navigation, our Member States have given fresh momentum to European space activities, demonstrating Europe's continued resolve to remain at the forefront".

ESA/C-M/CLXV/Res. 1 (Final)

RESOLUTION ON THE RESTRUCTURING OF THE ARIANE LAUNCHER SECTOR

(adopted on 27 May 2003)

Council, meeting at Ministerial Level,

RECALLING the purpose of the Agency as outlined in Article II of the Convention,

HAVING REGARD to the Resolution on Directions for the Agency's evolution and Policy: "Space Serving European Citizens" (ESA/C-M/CLIV/Res.1(Final)), adopted by Council meeting at Ministerial Level on 15 November 2001, and in particular Chapter VI thereof on the Evolution of the European Launcher Sector,

HAVING REGARD to the Resolution on the Creation of a Council Working Group on the Long-Term Perspective of the European Launcher Sector (ESA/C/CLIX/Res.1 (Final)),

HAVING REGARD to the Director General's proposal for the strategy for access to space 2003-2009 (ESA/C-M(2003)10),

HAVING REGARD to the Director General's proposal for the Ariane-5 Recovery Plan based on requirements (ESA/C-M/R(2003)1),

HAVING REGARD to the Director General's proposal for the restructuring of the Ariane sector (ESA/C-M(2003)11),

HAVING REGARD to the Resolution on the preparation of an Ariane-5 Recovery Plan (ESA/C/CLXII/Res.2 (Final)), adopted by Council on 27 February 2003,

HAVING REGARD to the Declaration by certain European Governments on the Ariane Launcher Production Phase (the "Production Declaration"), which entered into force on 20 December 2001 and is applicable until the end of 2006,

HAVING REGARD to the Resolution on the renewal of the Ariane Launcher Production Phase, adopted by Council on 11 October 2001 (ESA/C/CLII/Res.1 (Final)), by which Council has accepted that the Agency should fulfil the mandate entrusted to it by the Governments party to the Production Declaration,

HAVING REGARD to the Convention on the Ariane Launcher Production Phase concluded between the Agency and Arianespace on 8 February 2002,

HAVING REGARD to the Resolution on the CSG (2002-2006) adopted by Council on 15 November 2001 (ESA/C-M/CLIV/Res. 3 (Final)),

ESA/C-M/CLXV/Res. 1 (Final)

TAKING INTO ACCOUNT the Resolution on European Strategy in the launcher sector adopted by Council on 20 June 2000 (ESA/C/CXLVI/Res.2 (Final)), and STRESSING that, in order to develop that strategy, Europe needs to maintain capabilities that support unrestricted use of space, the foremost of which is guaranteed and affordable access to space with launchers developed within the framework of the Agency programmes whose reliability must be improved and supported,

CHAPTER I
ARIANE 5 : RATIONALE FOR EXCEPTIONAL MEASURES

RECOGNISES that the success of the Ariane launcher on the worldwide commercial market has significantly lightened the financial burden on Governments and industry of guaranteeing access to space, given that the European institutional market is still today far from capable of sustaining such a guarantee, DRAWS ATTENTION to the current situation of this market, its detrimental effects on the economic outlook for the European launcher sector, in particular for Arianespace, and its potential consequences for the sustainability of guaranteed affordable access to space, and CONCLUDES that this situation requires Governments and Industry to take exceptional measures designed to:

(a) sustain such guaranteed access to space with the Ariane-5 launcher;
(b) stabilise the economics of Ariane-5 launcher production; and
(c) improve the competitiveness of the Ariane-5 launcher.

CHAPTER II
IMPROVING THE COMPETITIVENESS OF THE ARIANE-5 LAUNCHER

A. Qualification of the Ariane-5 ECA launcher

1. AGREES to proceed with qualification of the Ariane-5 ECA launcher and DECIDES that the qualification process will comprise:

   (a) completion of the development of the Vulcain-2 engine and consolidation of the ESC-A stage;
   (b) a dedicated qualification flight of an Ariane-5 ECA, to be carried out in March 2004; and
   (c) launch of the ATV-1 by an Ariane-5 ES version to be carried out in September 2004.

2. INVITES the Director General to support within the existing Ariane-5 launcher programmes:

   (a) continuation of the Ariane-5 launch service using Ariane-5 Generic versions until Ariane-5 ECA versions are qualified and are ready for commercial exploitation; and
   (b) definition of a cost-efficient back-up, the GCA version, in the event that major difficulties hamper the qualification of the Ariane-5 ECA version.

3. WELCOMES the endorsement of this approach by the Ariane-5 Participating States concerned by the qualification of the Ariane ECA version as proposed above, through implementation, within the framework of the relevant programmes, of the following measures:

   (a) preservation of the qualification status of the Ariane-5 generic launchers through a contribution to non-recurring costs according to the geographical distribution of industrial activities, within the framework of the Additional Ariane-5 ARTA Programme Declaration (ESA/PB-ARIANE/CLIV/ Dec.3, rev.9(Final)), for a maximum amount of 72.5 MEuro at 2003 economic conditions to be borne by that programme within its subscribed financial envelope;
   (b) execution of Vulcain-2 development activities within the framework of the Additional Ariane-5 Evolution Programme Declaration (ESA/PB-ARIANE/ CLIV/Dec.1, rev.3(Final));
   (c) blocking of financial contributions within the framework of the Ariane-5 Plus Programme for an amount of 315 MEuro at 2003 economic conditions, corresponding to activities referred to in document ESA/PB-ARIANE(2003)41 until a further, unanimous decision of the Participating States is taken which might include a resumption of Ariane-5 EC-B activities. Such a decision is currently planned to be taken after the completion of the in-flight demonstration programme, it being understood that if no such decision has been taken at that time, the contribution scale referred on the Ariane-5 Plus Programme Declaration will be adjusted in line with the achieved industrial return. The additional Ariane-5 Plus Programme Declaration will be amended in due time as necessary;
   (d) consolidation of the Ariane-5 ESC-A and ECA system activities through a contribution to relevant development costs according to the geographical distribution of industrial activities, within the framework of the Additional Ariane-5 Plus Programme Declaration (ESA/PB-ARIANE/CLXXI/ Dec.1, rev.7(Final)) for a maximum amount of 72.5 MEuro at 2003 economic conditions to be borne by that Programme within the non-blocked part of its subscribed financial envelope; and
   (e) execution of a new Ariane-5 ECA in-flight demonstration programme with a financial envelope of 228 MEuro at 2003 economic conditions, within the framework of the Additional Ariane-5 Slice-9 Programme Declaration (ESA/C-M(2003)5) to be entered into force on this day, the applicable scale of contributions and schedule of payment being reproduced in Annex 2 hereto.

4. NOTES the exchange of letters between the Agency and CNES on the savings of CNES/CSG expenditure over the period 2003-2004 (ESA/C-M(2003)13), and INVITES the Director General to submit to Council by September 2003 proposals to modify the Resolution on the CSG (2002-2006) (ESA/C-M/ CLIV/Res.3(Final)) accordingly.

5. AGREES that the above-mentioned decisions taken by Member States, including in their capacity as Participating States in the Ariane-5 programmes, are tied to the corresponding commitments taken by Industry (ESA/C-M/R(2003)2).

B. Reorganisation of the Ariane Launcher Sector

1. DECIDES that a single launcher system prime contractor shall be responsible for Ariane-5 launch-vehicle design, development and manufacture and shall commit to the Agency on manufacturing objectives consistent with a business plan jointly agreed with Arianespace and to be submitted at the beginning of any new development of the Ariane-5 launcher, and AGREES that this new industrial

organisation shall apply to the manufacture of the Ariane-5 batch PA expected to begin in June 2003, and at a later stage, to new developments expected to start in early 2005.

2. RECALLS that Arianespace has, through the Convention concluded with the Agency referred to in the preamble, been entrusted with execution of the Ariane launcher production phase and RECOMMENDS that Arianespace shall:

   (a) remain in charge of execution of the Ariane launcher production phase;
   (b) bear overall responsibility and liability in relation to Ariane launch service customers;
   (c) commit to a business plan jointly agreed with the launcher system prime contractor; and
   (d) procure Ariane launchers from the launcher system prime contractor.

3. DECIDES, with immediate effect, that all future Ariane launcher programmes and activities, including the expected resumption of ECB development, will be executed and managed by the Agency in conformity with the provisions of the ESA Convention and with the Agency's applicable rules and procedures, including the Code of Best Practices.

4. INVITES the Director General to take all necessary measures in a timely fashion to implement this new managerial approach, and to report to Council on the Agency's organisation he will put in place to be able to fulfil its new responsibilities and to work with all the players of the launcher sector; in doing this, the Director General will make best use of all existing management and technical capabilities in CNES (ESA/C-M(2003)14), DLR, ASI and other national space agencies, under contracts or arrangements to be concluded between the Agency and the national agencies concerned, with a view to excluding unnecessary duplication of expertise.

5. INVITES the Director General to introduce in all new contracts with industry for the implementation of Ariane launcher development programmes and production activities including the expected resumption of ECB development, specific provisions concerning:

   (a) incentives and penalties based on performance and results;

   (b) commitments by industry to production objectives and appropriate risk sharing consistent with a business plan to be jointly agreed between Arianespace and the launcher system prime contractor;

   (c) full visibility on all development and production costs, to be subject to audits, and on the relevant business plan,

   and further INVITES the Director General to present reports on the implementation of the above-mentioned provisions to the appropriate Council subordinates bodies.

6. INVITES the Director General to submit to Council, in consultation with CNES and in connection with the submission of his proposal on Agency funding of CNES/CSG beyond 2004, a proposal for a new organisation of launch operations at the Centre Spatial Guyanais (CSG).

ESA/C-M/CLXV/Res. 1 (Final)

7. INVITES the Director General to submit to Council by 11 December 2003, a report covering the following :

- an assessment by Arianespace of the worldwide commercial market for launch services and options for extending its range of services for optimising its commercial exploitation;
- a proposal for a long-term industrial policy of the Agency for the entire launcher sector, in particular considering issues such as enhancement of industrial competitiveness ensuring a balanced distribution of roles and tasks between the launcher system primes and suppliers;

and INVITES the Director General to report on a regular basis to Council on the implementation of the above-mentioned reorganisation and industrial policy.

CHAPTER III
SUSTAINING GUARANTEED ACCESS TO SPACE WITH ARIANE-5

A. The European Guaranteed Access to Space (EGAS) Ariane Programme

1. NOTES that the consequences of the downturn of the commercial market require measures in order to secure the availability of Ariane-5 for the launch of the European institutional missions.

2. AGREES that the objectives of the EGAS Ariane programme are to:

(a) place industry on a level playing field compared to competitors through to 2009 by covering selected fixed costs activities; and
(b) foster the creation of a European institutional market through the conclusion between the Agency and European institutions of bilateral agreements whereby these institutions will use the Ariane launcher and benefit from launch priority and the best market prices for their missions.

3. DECIDES that, in order to proceed with the necessary preparations, the EGAS Ariane Programme shall be carried out as an Optional Agency Programme governed by the ESA Convention and the Agency's rules and procedures, with complete visibility on, and critical analysis of, all costs, including all EGAS production costs, on the basis of the programme proposal (ESA/PB-ARIANE/R(2003)2, rev. 1 and addendum 1).

4. INVITES the Director General to implement the EGAS Ariane Programme, in accordance with the provisions of Chapter II. B of this Resolution.

5. DECIDES that the EGAS Ariane Programme's financial envelope amounts to 960 MEuro at 2003 economic conditions, NOTES further that the indicative contribution scale for the EGAS Ariane programme contained in Annex 1 hereto, corresponds to the distribution of the weighted amounts of industrial activities within the Ariane-5 production and NOTES that these contributions will be reduced if the net result of Ariane-5 batch PA exploitation exceeds the forecasts in the Arianespace Business Plan referred to in ESA/C-M/R(2003)3.

6. DECIDES that the provisions of Article II of the Resolution on the reform of the Agency's Budget Structure and Charging Policy adopted by Council on 18 December 1996 (ESA/C/CXXVII/Res.1 (Final)) shall be applied to the EGAS Ariane Programme.

7. INVITES the interested Member States to draw up by 9 October 2003, and to subscribe by 11 December 2003 to a Declaration setting out their undertakings in respect of the content of the EGAS Ariane Programme, which will be forwarded to Council along with the draft Implementing Rules.

8. AGREES that the commitments made by Member States through the EGAS Ariane Programme are tied to commitments made by industrial suppliers of Arianespace (ESA/C-M/R(2003)2) and commitments made by Arianespace (ESA/C-M/R(2003)3) through its business plan 2003-2010 adopted by the Board of Directors of Arianespace, and INVITES the Director General to present to Council, on a regular basis, progress reports on the implementation of the above-mentioned commitments made by Arianespace and Industry.

9. NOTES that the above-mentioned Arianespace business plan presents a balanced economical situation from 2010 onwards without the EGAS Ariane Programme, assuming no significant changes in market conditions.

B. Arianespace

1. NOTES the commitment by industry (ESA/C-M/R(2003)2) to implement at the latest at the end of 2004, the recapitalisation process of Arianespace reflecting the distribution of the Ariane-5 development and production activities.

2. INVITES the Director General of the Agency, in pursuance of the mandate given to the Agency by the Governments party to the Ariane Production Declaration (the Participants) referred to in the preamble, to engage in consultations with Arianespace through the establishment of a High-Level Board meeting preferably at least once a year, to be chaired by the Director General of the Agency and bringing together representatives of Member States and members of the Arianespace Board of Directors, with a view to jointly assessing the consequences, for participants, of strategic decisions to be taken by Arianespace, and further INVITES the Director General of the Agency to report to Council on the outcome of these meetings of the High-Level Board.

3. INVITES the Director General on the basis of the elements contained in the present Resolution to propose the corresponding amendments to the Convention between the Agency and Arianespace referred to in the preamble for the endorsement by the other Party, Arianespace, and further INVITES him to submit this amended Convention to Council for approval on 11 December 2003.

4. RECOMMENDS that the Director General propose the necessary amendments to the Production Declaration referred to in the preamble to the States participating in that Declaration, so as to permit full implementation of the decisions referred to in the present Resolution.

ESA/C-M/CLXV/Res. 2 (Final)

RESOLUTION ON THE UNBLOCKING OF THE INTERNATIONAL SPACE STATION EXPLOITATION PROGRAMME PERIOD 1, SUB-ENVELOPE 2002-2004

(adopted on 27 May 2003)

Council, meeting at Ministerial Level,

HAVING REGARD to the Resolution on the Agency's programmes (ESA/C-M/CLIV/Res. 2 (Final)), adopted at Ministerial Level in Edinburgh on 15 November 2001, and in particular sections 1(d) and 3 of Chapter II therein,

HAVING REGARD to the Resolution on the International Space Station (ISS) Programme ESA/C-M/CLIV/Res. 4 (Final)), adopted at Ministerial Level in Edinburgh on 15 November 2001,

RECALLING that NASA, working together with the other ISS Cooperating Agencies, has taken significant steps to restore stability to the US part of the ISS Programme over the last 18 months, including (a) consolidation of its research priorities on ISS, through the REMAP exercise, (b) reorganisation of its senior ISS management, and (c) the return to a higher degree of transparency and credibility in its programme costs, while remaining within agreed spending limits,

EXPRESSING satisfaction that "Option Path 4" agreed by the Heads of Agency at their meeting in Tokyo on 6 December 2002 is a promising way of consolidating the ISS scenario and is the basis for unblocking funds from the ESA ISS Exploitation Programme in accordance with Chapter II.1.d of ESA/C-M/CLIV/Res.2 (Final),

RECALLING that the agreed Option Path is expected to enable the European Partner to meet its utilisation and resource requirements within the existing programmatic and budgetary framework, by providing inter alia for: (a) rescue capability for a six-person crew, using two Soyuz capsules docked to the ISS from 2006/07 onwards, and for a crew of at least seven through a combination of a NASA Orbital Space Plane (OSP) and one Soyuz capsule docked to the ISS, when the OSP becomes available (currently planned in 2010), (b) accommodation and life-support corresponding to the crew size, and (c) a transport scenario based on a combination of transportation vehicles (ATV, HTV, Progress, Shuttle) providing for the necessary upload and download logistics,

RECALLING the findings of the Working Group on the evolution in the situation of the International Space Station contained in its final report (ESA/C(2003)16, rev.1), and NOTING the Report of the Director General to Council concerning the overall ISS situation (ESA/C-M(2003)19),

RECALLING the deep sadness caused in Europe and elsewhere by the loss of the 7 crew members caused by the destruction of the Space Shuttle 'Columbia' during its return to Earth on 1 February 2003, and CONSCIOUS of the impact of this tragic event on the overall ISS Programme,

ESA/C-M/CLXV/Res. 2 (Final)

1. CONSIDERS with satisfaction that the ISS configuration resulting from the process pursued by the Partners to restore stability to the US portion of the International Space Station Programme complies with the objectives defined in the ISS Agreements (IGA and MOUs).

2. CONFIRMS the European commitment to the ISS Programme, in particular by:

   (a) the timely development and operational availability as early as possible of the ESA Automated Transfer Vehicle (ATV), launched by Ariane-5, this being an objective also supported by NASA;

   (b) the consolidation of adequate Ariane-5 launcher capabilities, so as to permit the timely fulfillment of the ATV mission;

   (c) the timely availability of operations and utilisation means for Columbus; and

   (d) continuity in astronaut training and flight operations preparation activities.

3. NOTES the decision taken by the States participating in the European participation in the International Space Station Exploitation Programme (ESA/PB-MS/XXIX/Dec.1, rev.1 (Final)) to proceed in a phased approach and therefore:

   (a) unblock a part of the firm financial sub-envelope of Period 1 specified for the activities to be carried out from 2002 to 2004 blocked at the time of subscription, this corresponding to an amount of 124.1 MEuros out of the total blocked amount of 296.0 MEuros at 1998 economic conditions, and

   (b) decide, on the basis of the report referred to in Section 4, on the unblocking of the remaining 171.9 MEuros at 1998 economic conditions before the end of 2003, recognising that this is critical for ensuring continuity in the implementation of the ISS Exploitation Programme, including the fulfillment of existing programme obligations.

4. INVITES the Director General to report, in preparation for the unblocking decision to be made before the end of 2003, on:

   (a) progress made in the implementation of "Option Path 4", with particular emphasis on the finalised ISS configuration option and the common systems operations costs, including the conclusion of the corresponding arrangements among the Partners;

   (b) negotiations with NASA on conditions for the termination of the X-38 ESA/NASA Memorandum of Understanding and CRV activities;

   (c) ATV/Ariane-5 launch configuration in the context of the consolidation of the Ariane-5 Programme; and

   (d) industrial implementation of the operations phase of the ISS Exploitation Programme.

ESA/C-M/CLXV/Res. 3 (Final)

RESOLUTION ON RELATIONS BETWEEN THE EUROPEAN SPACE AGENCY AND THE EUROPEAN UNION

(adopted on 27 May 2003)

The Council, meeting at Ministerial Level,

HAVING REGARD to the Resolution on the Reinforcement of the Synergy between the European Space Agency and the European Community (ESA/C/CXXXVI/Res. 1 (Final)), adopted on 23 June 1998, and a similarly worded Resolution adopted by the Council of the European Union on 22 June 1998,

HAVING REGARD to the Resolution on Shaping the Future of Europe in Space, adopted by the Council of the European Space Agency meeting at Ministerial Level in Brussels on 11 May 1999 (ESA/C-M/CXLI/Res. 1 (Final)), and to the Resolution on developing a Coherent European Space Strategy, adopted by the Council of the European Union on 2 December 1999,

HAVING REGARD to the Resolution on a European Strategy for Space, adopted by the Council of the European Space Agency meeting at Ministerial Level in Brussels on 16 November 2000 (ESA/C-M/CXLVIII/Res.1 (Final)) and a similarly worded Resolution adopted by the Council of the European Union on the same day,

HAVING REGARD to the Resolution on Directions for the Agency's Evolution and Policy: "Space Serving European Citizens" (ESA/C-M/CLIV/Res. 1 (Final)), adopted by the Council of the European Space Agency meeting at Ministerial Level in Edinburgh on 15 November 2001, and in particular Chapter I thereof,

RECOGNISING that, through adoption of the above Resolutions, the Councils of the European Union and the European Space Agency have laid the basis for enhanced cooperation between the two organisations, taking into account their distinct missions and institutional bases, with the aim of strengthening the efforts devoted to space-related activities in support of policies,

WELCOMING the efforts made by Member States to the benefit of the European Space Policy developed within the Agency, thus reaching the final agreement among them for the launching of the Development and Validation of the Galileo Programme in cooperation with the European Union,

NOTING the Director General's Report to Council concerning relations between the Agency and the European Union (ESA/C-M(2003)20),

1. REITERATES its determination that space-related matters be addressed at the highest political level in Europe, thus confirming that space capability is a critical tool, through its many applications, in the context of the European Union's major policies such as transport, environment, information society and security.

ESA/C-M/CLXV/Res. 3 (Final)

2. REAFFIRMS that close cooperation between the Agency and the European Union seeks to foster European capabilities in space-related technologies and their applications, including Europe's ability to benefit from affordable, guaranteed access to space, and to develop an appropriate regulatory framework to support European commercial operators and industrial entities active in the space field.

3. RECALLS the extensive discussion in various forums over recent months of the case for including space-related matters in the renewed competences (see note) of the European Union; WELCOMES the opportunity given to all interested participants to contribute to a strengthening of Europe's capabilities and standing in the development and operation of space infrastructures and INVITES the Member States to consider, together with the Director General, appropriate initiatives leading to:

   (a) the possible inclusion of space-related matters within the renewed competences (see note) of the European Union in order to contribute to enhanced cooperation among the European States in space research and technology and their space applications, in the widest possible sense;

   (b) the Agency being consistently recognised as providing the broadest competence (see note) and the most suitable organisational structure for continuing its role in the definition and implementation of Europe's involvement in the space field, also ensuring the coordination of national centres in pursuing the network of centres initiative;

   (c) appropriate mechanisms being defined and adopted to optimise coordination between the European Union and the Agency with a view to maximising benefits and fully exploiting the complementarity and synergies between the two organisations.

4. NOTES the Green Paper initiative launched by the European Commission, in collaboration with the Director General of the European Space Agency, and INVITES the Director General to pursue that collaboration with the European Commission in drafting the White Paper and developing a subsequent plan of action which should assess the role of the various players involved in space-related activities and policies in Europe and the interaction between them, to examine possible reforms of the current institutional framework and to regularly consult with the Council.

5. NOTES the work being done on drafting and negotiating a Framework Agreement between the European Community and the European Space Agency; STRESSES the need to conclude such an Agreement, of an appropriate duration, by the end of 2003 at the latest in view of the White Paper, as a step towards the progressive development of a space policy in an integrated European perspective, with due regard for the complementarity of the two organisations, in order to achieve efficient and mutually beneficial cooperation; WELCOMES the inclusion in such an Agreement of appropriate provisions identifying the possible forms of cooperation, including the management by ESA of space research and development pertaining to European Community initiatives and participation by the European Community in ESA Optional Programmes, the respective roles of the Parties, and the inclusion also of implementing rules providing for monitoring of the cooperation by high-level representatives of the Member States of the two organisations and for joint implementation of the external dimension of the cooperation; and INVITES the negotiating parties to regularly inform the Joint Space Strategy Advisory Group on the progress of the negotiations.

ESA/C-M/CLXV/Res. 3 (Final)

6. INVITES the Director General to:

   (a) take appropriate steps, on conclusion of the negotiation of the Framework Agreement, to arrange for a coincident meeting of the Council of the European Union and of the Council of the European Space Agency at Ministerial Level to approve the Framework Agreement;

   (b) draw up, in consultation with the European Commission, a report identifying possible areas in which the European Community, in pursuance of the Framework Agreement, could contribute to the space sector in response to public and private needs, and to present that report at the above meeting.

7. INVITES the Director General to ensure, in applying the Framework Agreement and in the context of the future strengthening of cooperation between the Agency and the European Union, that States which are Members of the Agency but not Members of the European Community or European Union are not placed at a disadvantage compared with States which belong to both organisations.

8. INVITES the Director General to pursue his discussions with the European Union with a view to extending the cooperation envisaged in the Framework Agreement to other matters falling within the competences (see note) of the Union, thus fulfilling Council's recommendations in ESA/C-M/CLIV/Res.1 (Final).

Note: In accordance with the relevant applicable treaty.

ESA/C-M/CLXV/Res. 4 (Final)

RESOLUTION ON 2010 PERSPECTIVES FOR THE EUROPEAN LAUNCHER SECTOR

(adopted on 27 May 2003)

Council, meeting at Ministerial Level,

RECALLING the purpose of the Agency as outlined in Article II of the Convention,

HAVING REGARD to the Resolution on Directions for the Agency's Evolution and Policy: "Space Serving European Citizens"(ESA-C-M/CLIV/Res.1(Final)), adopted by Council meeting at Ministerial Level on 15 November 2001, and in particular Chapter VI thereof on the Evolution of the European Launcher Sector,

HAVING REGARD to the Resolution on the Creation of a Council Working Group on the Long-Term Perspective of the European Launcher Sector (ESA/C/CLIX/Res.1 (Final)),

HAVING REGARD to the Director General's proposal for the strategy for access to space 2003-2009 (ESA/C-M(2003)10),

HAVING REGARD to the Resolution concerning cooperation between ESA and Russia in the field of launchers (ESA/C/CLIX/Res.3 (Final)), adopted by Council in Montreal (Canada) on 13 June 2002, and in particular the provisions granting highest priority to the launchers developed within the framework of the Agency under the payload allocation policy to be implemented by Arianespace in respect of the exploitation of Soyuz from the CSG and the provision concerning the visibility to be provided by Arianespace to the Agency on such exploitation,

HAVING REGARD to the Resolution on the Renewal of the Ariane Launcher Production Phase, adopted by Council on 11 October 2001 (ESA/C/CLII/Res.1 (Final)), by which Council has accepted that the Agency should fulfil the mandate entrusted to it by the Governments party to the Production Declaration,

HAVING REGARD to the Convention on the Ariane Launcher Production Phase concluded between the Agency and Arianespace on 8 February 2002,

HAVING REGARD to the Resolution on the CSG (2002-2006) adopted by Council on 15 November 2001 (ESA/C-M/CLIV/Res. 3 (Final)),

HAVING REGARD to the Resolution on the Restructuring of the Ariane Launcher Sector (ESA/C-M/CLXV/Res.1(Final)) adopted on 27 May 2003 by Council meeting at Ministerial Level,

1. STRESSES that the restructuring of the Ariane sector must be associated with a perspective for the European launcher sector for the 2010 timeframe, integrating within an overall coherent strategy:

ESA/C-M/CLXV/Res. 4 (Final)

(a) an affordable access to space ensured for the long-term;

(b) a response to growing European institutional launch-service needs stemming from the building-up of the European Union and the implementation of European policies in such areas as environment, security and defence;

(c) action to enhance the competitiveness of the European launcher sector, in particular by widening the range of launch services offered by Arianespace;

(d) a strengthening of the launcher Research and Development base in Europe through the development of technological capabilities.

2. WELCOMES to this effect the strategy for 2003-2009 and the associated Long-Term Plan (LTP) for the launcher sector, proposed by the Director General in ESA/C-M(2003)10 as the appropriate framework for determining the actions and programmatic measures required to implement that strategy.

FUTURE LAUNCHERS PREPARATORY PROGRAMME (FLPP)

3. UNDERLINES the need to implement the FLPP in parallel with the restructuring of the Ariane sector in order to:
   (a) develop European technological capabilities and hence enhance the long-term competitiveness of European launchers;
   (b) avoid the risk of Europe having to respond, from an inadequate technological base, to a major non-European technological breakthrough;
   (c) permit the progressive restructuring of the industrial organisation for the next-generation launcher; and
   (d) develop system-level capabilities lacking in Europe but necessary for assessing the risks inherent in developing and operating reusable launch vehicles.

4. REAFFIRMS the importance of initiating international cooperation as a source of added value for technology development and in the perspective of launcher developments undertaken in cooperation.

5. WELCOMES Russia as the first partner in long-term cooperation on access to space, that partnership to begin the preparation of future launchers within the FLPP and the exploitation of Soyuz.

6. WELCOMES the preparatory work achieved by the FLPP potential participants which has resulted in a programme proposal (ESA/PB-ARIANE(2001)112, rev. 2), NOTING that the full implementation of this programme is being affected by the Ariane-5 Recovery Plan and STRESSING, however, the need to start in 2004 activities defined in the programme proposal, NOTES that the FLPP 1 will start in 2004 with early activities covered by a financial sub-envelope amounting to 24 MEuro at 2003 economic conditions.

ESA/C-M/CLXV/Res. 4 (Final)

7. NOTES the indicative scale of contributions for the FLPP 1- Early Activities set out in Annex 1 hereto and INVITES the participating States to draw up by 9 October 2003 and subscribe in time for the subscription of the Soyuz at the CSG Programme Declaration referred to in paragraph 14 of this Resolution, a Declaration setting out their undertakings in respect of the early activities and, including provisions for deciding on the continuation of FLPP 1 following the completion of the Ariane-5 ECA qualification flight mentioned in Chapter II A.1.b) of the Resolution on the Restructuring of the Ariane Launcher sector referred to in the preamble, and to transmit that Declaration to Council, and in due course, to draw up for approval by Council draft Implementing Rules containing specific provisions on the management and execution of the Programme.

SOYUZ AT THE CSG PROGRAMME

8. NOTES that the Soyuz launcher operating from the CSG complements the GTO and non-GTO launchers and that its exclusive exploitation by Arianespace enhances the competitiveness of the entire launcher sector.

9. DECIDES that the Soyuz at the Guiana Space Centre (CSG) programme shall be carried out as an Optional Programme within the framework of the Agency in conformity with the provisions of the Convention and with the Agency's rules and procedures and on the basis of programme proposal ESA/PB-ARIANE (2003)29 and add.1, which in particular defines the breakdown of the costs of investments required for the exploitation of Soyuz at the CSG for a total amount of 314 MEuro.

10. NOTES the commitment by Arianespace (ESA/C-M/R (2003)4) to contribute, from the profits on Soyuz launcher exploitation, to the funding of the Soyuz at the CSG Programme for a minimum amount of 121 MEuro covering at least all Russian deliveries.

11. NOTES that the financial envelope for the Soyuz at the CSG Programme amounts to 314 MEuro at 2002 economic conditions and NOTES further the first indications on intended subscriptions to the Programme expressed by some Member States as indicated in Annex 2 hereto, and the further interests expressed by other Member States on their possible participation to the Programme, in particular based on their potential industrial return during the corresponding development and exploitation phases.

12. UNDERLINES that the financial contributions of the Participating States indicated in Annex 2 hereto will be reduced by the financial contributions to be made by Arianespace as provided for in paragraph 10 above and ACKNOWLEDGES that no financial contributions of the Participating States will be called up before 2006.

13. INVITES the States participating in that programme to: (a) include provisions in the Declaration aimed at ensuring that the costs of the Programme stay within the 100 % of the subscribed financial envelope, (b) accordingly, instruct the Director General to keep the costs at completion of the Programme within the 100 % of the subscribed financial envelope, including by means of fixed-price contracting with the Programme prime.

ESA/C-M/CLXV/Res. 4 (Final)

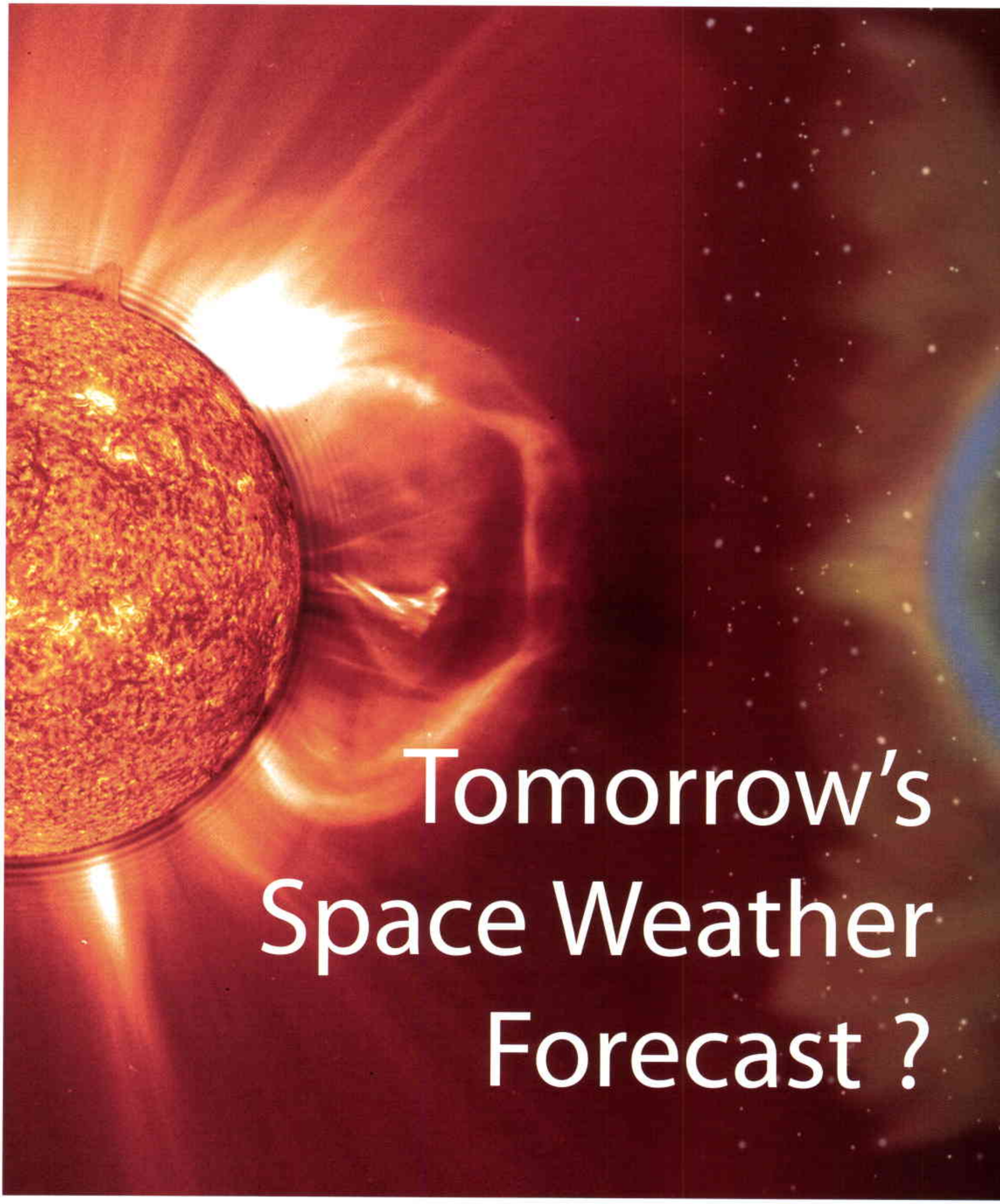
14. INVITES the interested Participating States to draw up by 9 October 2003 and subscribe by 11 December 2003 a Declaration setting out their undertakings in respect of the content of the Programme, to be fully covered by their financial commitments, and to transmit it to Council, and in due course, to draw up for approval by Council draft Implementing Rules containing specific provisions on the management and execution of the Programme.

15. AGREES that the Ariane Launcher Programme Board shall monitor the execution of this Programme and take the relevant measures, in particular approval of the annual budget.

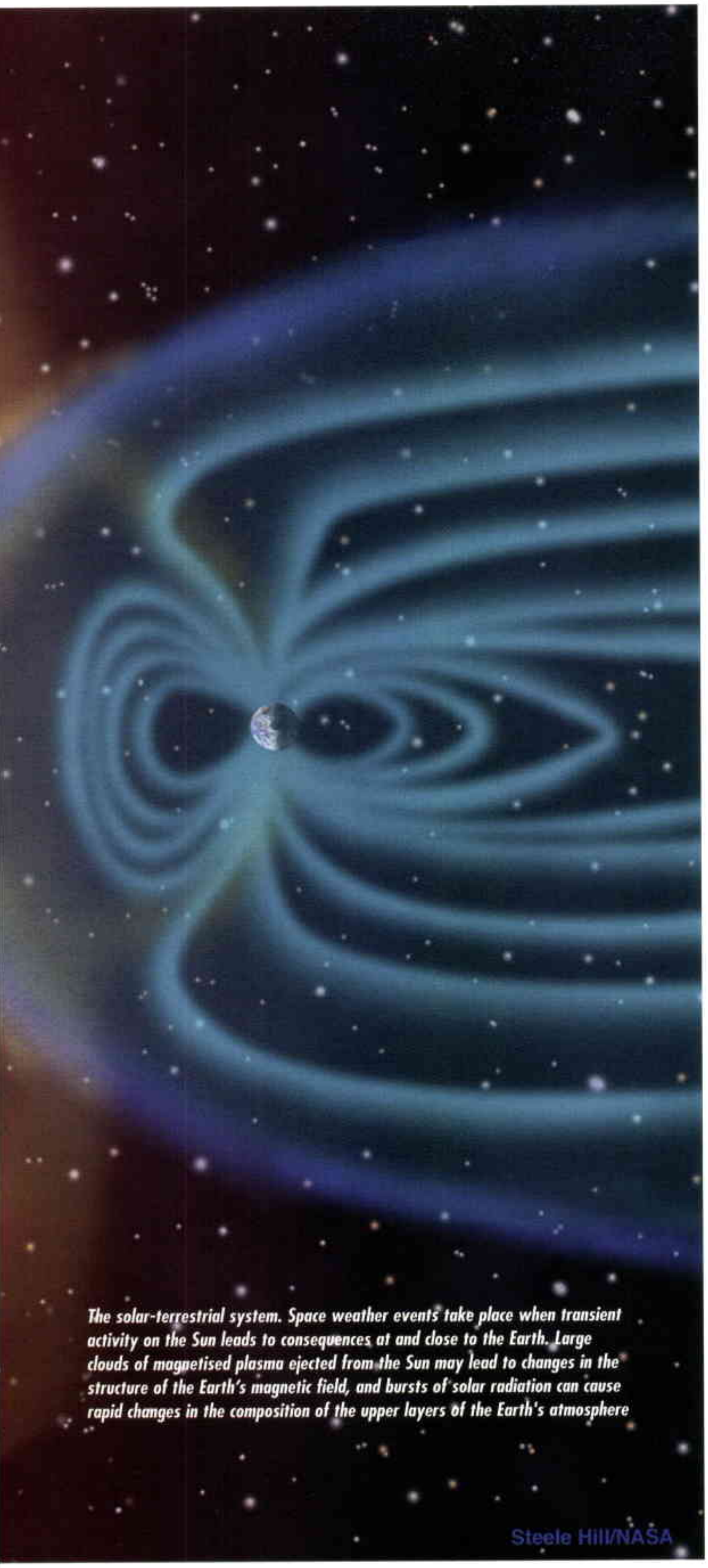
16. STRESSES that implementation, within the framework of the Agency, of the Soyuz at the CSG Programme will call for the following additional legal instruments:
    (a) the Agreement between the Agency and Rosaviakosmos on Long-Term Cooperation and Partnership in the Field of Launchers;
    (b) the Agreement between the Agency and France concerning Soyuz at the CSG.

17. INVITES the Director General to submit drafts of these Agreements to Council for approval in good time for subscription of the Soyuz at the CSG Programme.

18. INVITES the Director General to take the present Programme into account in his proposal, to be submitted to Council in 2004, concerning the CSG Resolution (2005-2009) and further INVITES him on the basis of the elements contained in the present Resolution to propose the corresponding amendments to the Convention between the Agency and Arianespace referred to in the preamble, for endorsement by Arianespace, and to submit the amended Convention to Council for approval in the course of 2004.



Tomorrow's Space Weather Forecast ?



The solar-terrestrial system. Space weather events take place when transient activity on the Sun leads to consequences at and close to the Earth. Large clouds of magnetised plasma ejected from the Sun may lead to changes in the structure of the Earth's magnetic field, and bursts of solar radiation can cause rapid changes in the composition of the upper layers of the Earth's atmosphere

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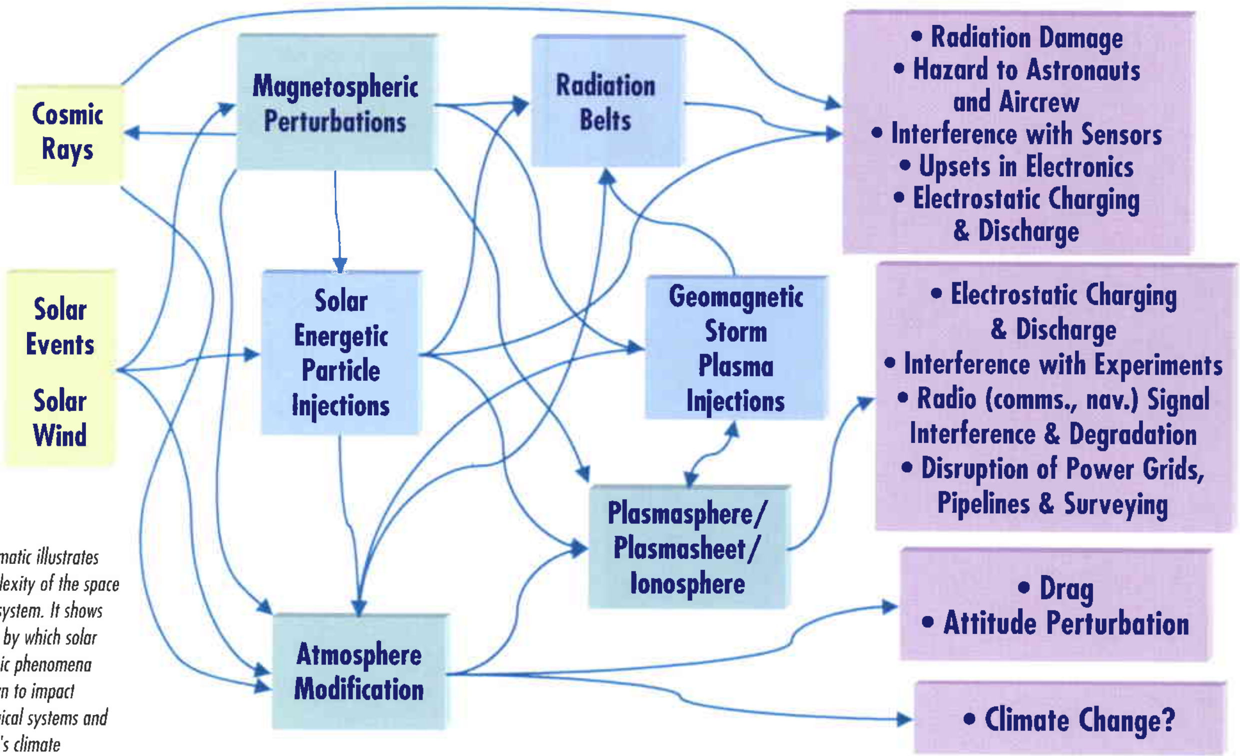
What is Space Weather? The definition most frequently quoted is that of the US National Space Weather Programme:

"conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health".

This definition demonstrates that space weather encompasses a collection of physical phenomena having their origin at the Sun and which give rise to effects that are of concern to society. The two accompanying figures illustrate the solar-terrestrial system and the complexity of the phenomena that lead to space weather effects. Much of the science that underpins space weather is part of the larger field of solar-terrestrial physics. Here we focus on some of the main aspects of the system - the Sun, heliosphere, magnetosphere and ionosphere - and the key space weather phenomena that can affect us here on Earth.



This schematic illustrates the complexity of the space weather system. It shows the route by which solar and cosmic phenomena filter down to impact technological systems and the Earth's climate

The Sun and Its Surroundings

The Sun is the primary driver of space weather phenomena. Most space weather events have their origin in the solar corona: the Sun's 'atmosphere'. The corona, which is normally visible only during a solar eclipse, is a hot (>10^6 degrees Kelvin) tenuous plasma extending away from the solar surface and out into the heliosphere. The dominant feature controlling the corona is the Sun's magnetic field. To the naked eye, the Sun appears as a constant bright yellow disk. However, in reality, the Sun is far from unchanging. This is dramatically shown by the images and movies produced by the joint ESA-NASA SOHO science mission. Viewed in these other wavelengths, the Sun is seen as a boiling cauldron of magnetic fields and plasma. Sudden changes in these coronal magnetic fields can result in explosive solar 'flares' and 'Coronal Mass Ejections' (CMEs).

Solar activity is usually classified in terms of the number of sunspots seen on the solar disk, and the frequency of occurrence of flares and CMEs. This activity shows cyclical behaviour, with a typical period of 11 years. This results in a similar variation in the number of large sporadic space weather events. These events are most frequently observed around the time of solar maximum. The most popular and visible consequences of these large events here on Earth are the spectacular aurorae or 'northern/southern lights', which may be observed at lower latitudes than normal during very disturbed space weather conditions.

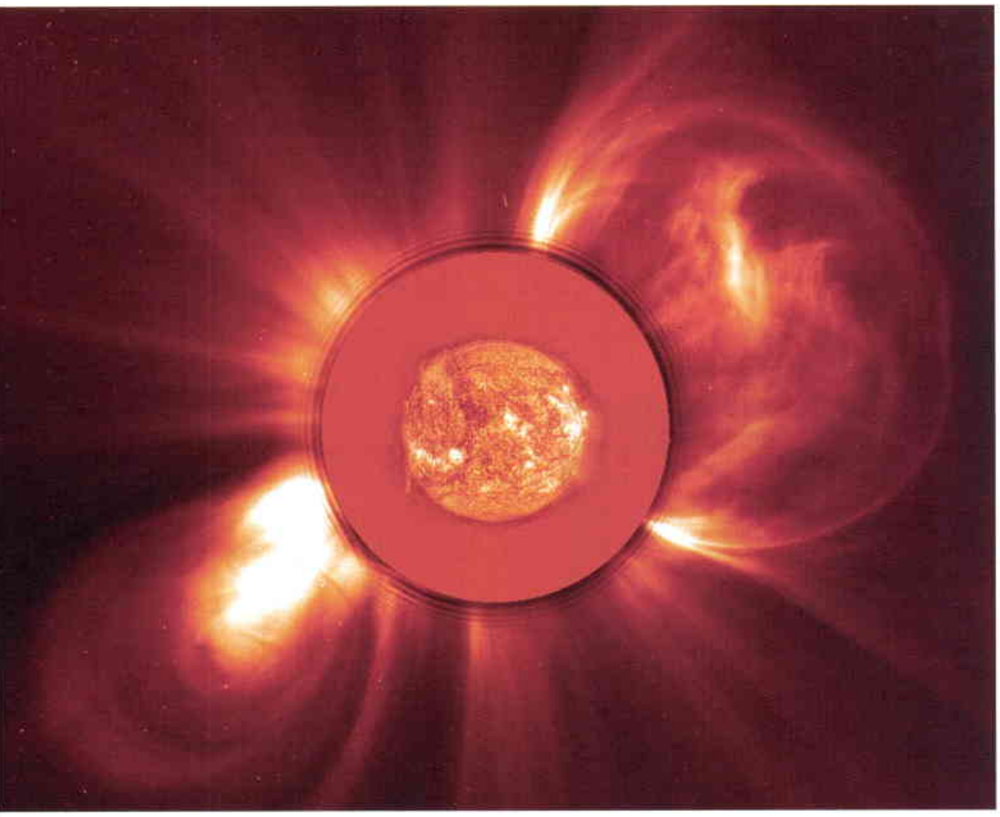
The solar wind

In addition to these transient phenomena, charged particles are constantly streaming away from the Sun in the form of the magnetised solar wind. The magnetic field lines that are carried into space by the solar wind remain tied to the Sun at one end and stretch into space at the other. Solar rotation pulls these field lines into the shape of an Archimedean spiral. During solar minimum, when the level of solar

Aurorae are caused when electrons precipitate from the magnetosphere into the atmosphere by spiralling around magnetic field lines. At altitudes of 90 to 5000 km, electrons will hit atmospheric atoms and molecules. These atoms and molecules will be given energy in the collision and will emit light. The colour of this light depends on the atom or molecule and the energy of the electron involved in the collision. Oxygen atoms will emit green and red light, whereas nitrogen atoms will emit violet and blue (Image courtesy of J. Manninen)

activity is low, the Sun's magnetic field resembles that of a bar magnet, and field lines open out into space at the northern and southern polar regions. Coronal material escapes in high-speed streams from these regions, which are known as 'polar coronal holes'. The boundaries of these polar coronal holes can extend to quite low latitudes in places, even crossing the solar equator on occasion.

Compression regions form at the boundaries between these high-speed streams and the slower solar wind ahead. Here charged particles can be accelerated to higher energies. The interaction between these compression regions and the Earth's magnetic field can lead to space weather effects occurring on an almost regular time scale. Coronal holes are long-lasting features and may endure for many weeks, rotating with the Sun every 27 days. This leads to recurrent space weather activity on a similar time scale. This pattern can be seen most clearly during solar minimum. During solar-active years, the changing magnetic field at the Sun disrupts this pattern, and the coronal holes become smaller and move to lower latitudes rather than remaining close to the poles.



CMEs as seen by SOHO/LASCO. CMEs are huge clouds of magnetised plasma that erupt from the solar corona with speeds of up to 2000 km/s. This figure shows two CMEs expanding simultaneously in the coronagraph image. One expands to the northwest and the other to the southeast. Note how the size of these clouds appears to dwarf the solar disk. This image of the solar disk was taken by the SOHO EIT telescope and shows solar features at temperatures of about 80 000 K

Coronal Mass Ejections (CMEs)

CMEs are huge clouds of magnetised plasma that erupt from the solar corona at speeds of up to 2000 km/s. These clouds carry a mass of the order of a billion tonnes – more than the mass of Mount Everest! – and are superimposed onto the expanding background solar wind.

The Large Angle Spectroscopic Coronagraph (LASCO) onboard the SOHO spacecraft allows us to see CMEs more often and in far greater detail than ever before. Like the Moon during a solar eclipse, a so-called 'occulting disk' is used to block out light from the bright solar disk (indicated by the central circle in the accompanying images). These particular CMEs were not directed towards the Earth, but illustrate the spectacular nature of such eruptions in the corona.

Most CMEs that lead to Space Weather effects at the Earth are called 'halo' CMEs. The Earth-directed plasma is observed as a bright halo completely surrounding the occulting disk and expanding radially outward in all directions from the Sun.

In order to be able to predict space weather effects, we need to be able to predict not only *what* will happen, but also *when*. CMEs can take several days to reach the Earth after we see them leave the Sun. Predicting whether a halo CME will lead to strong effects at the Earth, and when these effects will begin, remains a major challenge in space weather research.

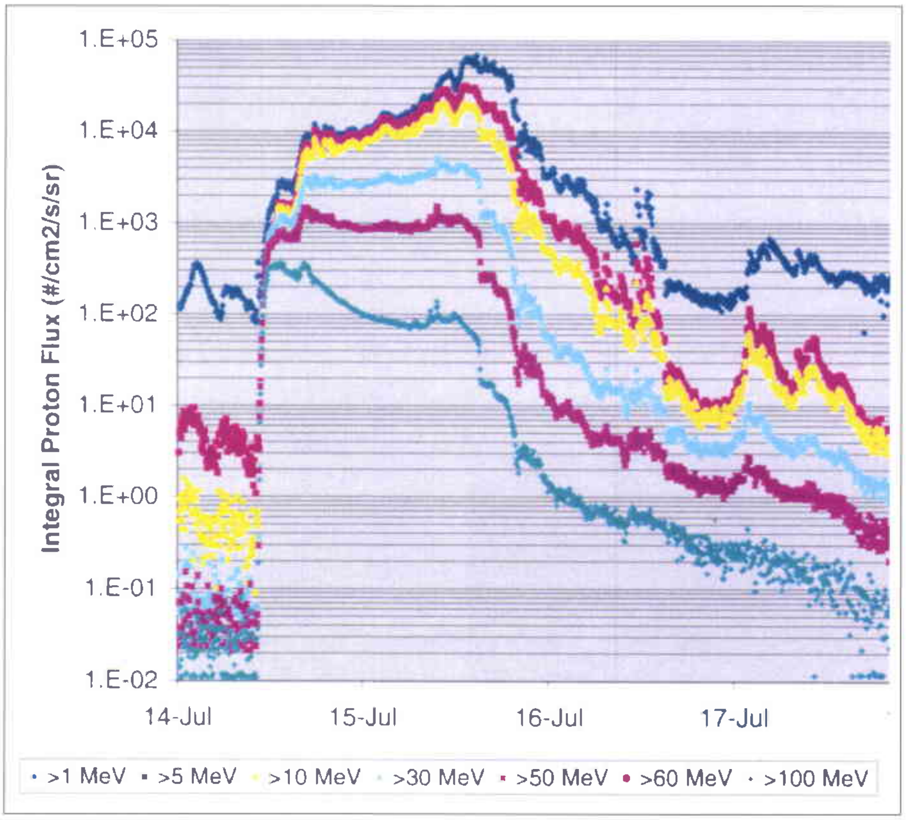
Solar flares

Solar flares are sudden and rapid releases of magnetic energy in the solar atmosphere. They are most commonly observed from sunspot regions where magnetic loops interact, with explosive consequences. Flares can last for a few minutes to several hours, releasing energies of the order of 10^{25} joules – fifty billion times the energy released by a 50-megaton H-bomb! The radiation from these events covers a wide range of wavelengths, from radio waves to gamma rays. This radiation reaches the Earth in a matter of minutes, making advance warning extremely difficult.

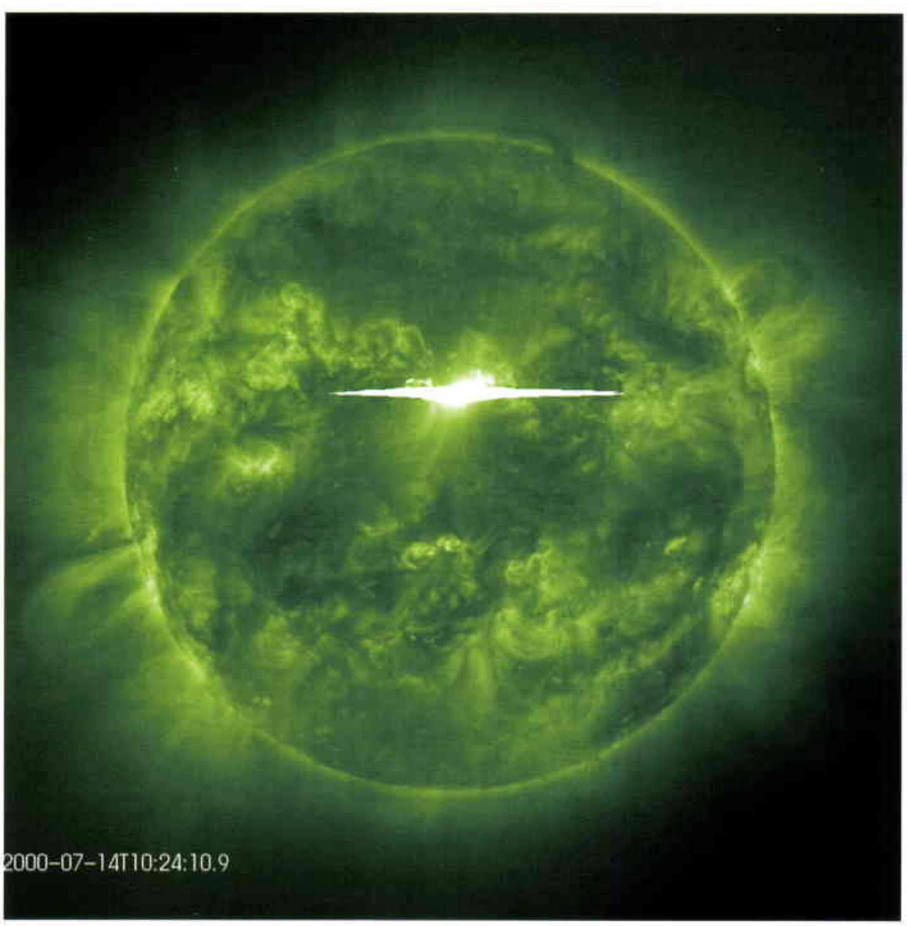
Solar Energetic Particles (SEPs)

Another key aspect of space weather is the arrival at Earth of sudden bursts of highly energetic particles originating from the Sun. The largest such events can enhance the radiation intensity in near-Earth space by several orders of magnitude.

Solar energetic particles can either originate from a solar flare or from acceleration at interplanetary shocks driven by fast CMEs. High-energy SEPs can arrive at the Earth within tens of minutes of the flare onset, and SEP events can last for several days.



A solar-particle event seen by the NOAA GOES spacecraft on 14 July 2000. This particle event followed the solar flare shown below by about 30 minutes. Note the speed with which the particles arrive and the steep increase in particle flux.



A solar flare, as seen by the Extreme Ultraviolet Imaging Telescope (EIT) onboard SOHO. This image shows solar emission in the extreme-ultraviolet (EUV) wavelength range. Features in the solar atmosphere seen here are heated to a temperature of approximately 1.5 x 10^6 K. Note the bright magnetic loops punctuating the solar disk

Because they carry an electric charge, SEPs can only propagate along magnetic field lines. Therefore, the importance of these particles at the Earth depends not only on the characteristics of the flare or shock from which they originate, but also on the structure and behaviour of the interplanetary magnetic field. Particles most readily reach us if the Earth and the source region are magnetically connected.

The Magnetosphere and Near-Earth Environment

The region surrounding the Earth that is dominated by its magnetic field is called its 'magnetosphere'. The interaction of the solar wind with the Earth's magnetic field leads to a complicated system of plasma convection and electrical currents which form within the Earth's magnetosphere and determine its entire geometry. The energy loaded into the magnetosphere is related to the local solar wind density, speed and magnetic field. This energy is stored in the geomagnetic tail in plasma and magnetic flux and is released intermittently in events known as 'substorms'. During such substorms, most energy is released in a direction pointing away from the Earth, but a significant part is accelerated towards us, leading to particle precipitation at high latitudes and hence to aurorae.

Substorm development involves dramatic magnetospheric changes, which have clear electromagnetic signatures in terms of waves or magnetic oscillations that are even detectable on the ground. Geomagnetic perturbations have been recorded by a worldwide network of magnetometers on a continuous basis for many decades in the form of so-called 'geomagnetic indices'. These observations provide an invaluable means of assessing the short- and long-term effects of space weather.

Earthward-directed CMEs, or solar wind stream boundaries, often interact with the magnetosphere, leading to the onset of space weather effects such as magnetic storms and enhanced aurorae. CMEs that interact with the magnetosphere are termed 'geo-effective'. It is not yet possible to predict which CMEs will be the most geo-effective before they reach the magnetosphere. However, we do know that if a CME is fast and has a strong southward magnetic field component in its magnetic structure, there is a strong probability that it will lead to geomagnetic activity. In this orientation, the magnetic field of the CME is able to connect with the Earth's magnetic field and solar wind energy can easily be transferred to the magnetosphere. The geomagnetic storm that may result from this is, however, a result of the explosive release of energy from the magnetotail: the extended, anti-sunward-pointing part of the magnetosphere. This follows some time after the CME impact.

Radiation belts

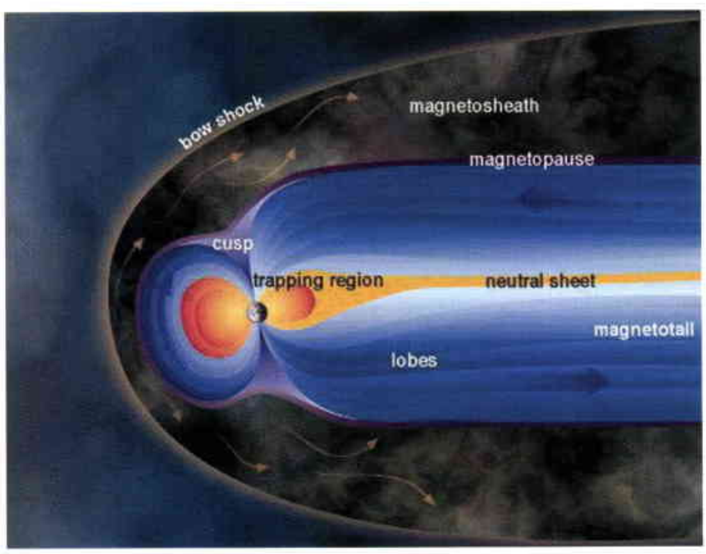
Some of the solar wind material may eventually become trapped and accelerated in the Earth's magnetic field, contributing to the filling of the radiation belts. These radiation belts are layers of intense particle fluxes in the magnetosphere. Within these belts, particles can be accelerated to high energies. High concentrations of energetic (MeV) electrons often appear in these belts after storms. These particles are often referred to as 'killer electrons', because of the effects they are known to have on spacecraft electronics. The highest concentrations of these killer electrons occur at altitudes of between 10 000 and 30 000 km. At the geostationary orbit of 36 000 km frequently used by communication and navigation satellites, the flux levels are still hazardous.

At low altitude, the major source of radiation hazards is the inner radiation belt consisting of energetic protons. This is a relatively stable population due to the decay of atmospheric neutrons created by cosmic rays.

Atmosphere and aurorae

The ionosphere is the ionised part of the Earth's atmosphere. It is composed mainly of atmospheric molecules that have been ionised by solar ultraviolet (UV) radiation. However, it also contains some particles originating from the solar wind.

Direct electrodynamic coupling between space and the upper atmosphere exists due to the magnetosphere-ionosphere coupling through precipitation of magnetospheric particles, field-aligned currents and the electric coupling along the magnetic field lines connecting the magnetosphere to the ionosphere.



Artist's impression of the Earth's magnetosphere. Close to the Earth, the field lines resemble those of a large bar magnet. However, at large distances, the influence of the solar wind results in the sunward side of the field being compressed. In contrast, on the anti-sunward side, field lines are extended to form the magnetotail, which can stretch to several hundred Earth radii

Increased numbers of charged particles can penetrate to atmospheric heights of about 90 – 130 km at high latitudes during disturbed space weather conditions. In addition to causing spectacular visible aurorae, these particles lead to an increase in heating and, therefore, ionisation at these heights.

The increased density of electrons produced by ionisation is known as an auroral E-layer. The high conductivity of this layer means that currents can flow. These are known as the 'auroral electrojet' and can reach as much as 1 million amperes, with dramatic effects on our electrical systems on the ground below.

In addition, these sudden changes in the electron content of the ionosphere may cause sudden and unpredicted changes in signal propagation paths through the ionosphere. This effect is important for both our navigation and communication systems that make use of the ionosphere for signal propagation.

Shielding the Earth from harmful cosmic rays

Geomagnetic shielding is the term given to the diverting effects of the Earth's magnetic field on cosmic-ray particles and solar energetic particles. These particles are prevented from penetrating to low altitudes above equatorial regions of the Earth's surface by the Earth's magnetic field. During disturbed space weather conditions, however, this geomagnetic shielding is weakened, leading to larger fluxes of these particles than would otherwise be the case. This may lead to an increased radiation dose being received by the passengers and aircrew onboard aircraft flying at high altitudes. While the increase is usually negligible for passengers making a single journey, it may accumulate towards the maximum permissible dose for regularly flying aircrew.

An Applications Perspective

Space weather affects a broad range of our technologies and activities, through radiation, plasmas, ionospheric currents, particulates, etc. The resulting economic

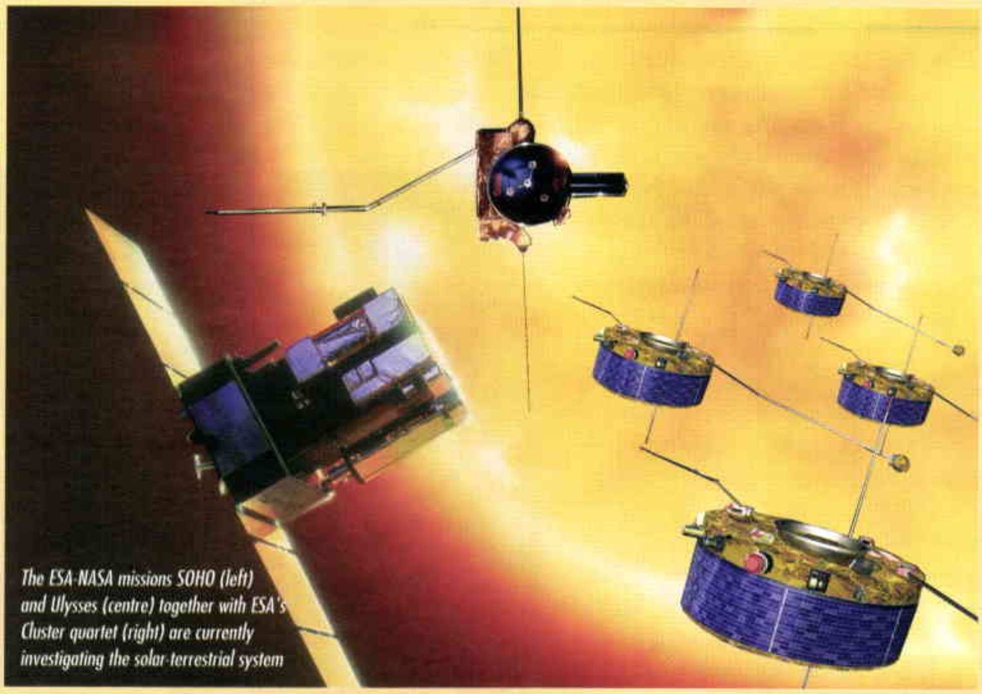
Interactions with Other Entities

The science underpinning ESA's space weather activities will remain a priority of the Agency's Science Programme, as highlighted by its future missions such as the Solar Orbiter and BepiColombo. In addition, ESA has recently announced its participation in the new International Living with a Star programme. ILWS is a new initiative in which space agencies worldwide are coordinating their activities to investigate how the Sun's variations affect the environments of Earth and other planets in the short and long term. In particular, ILWS will concentrate on those aspects of the Sun-Earth system that lead to space weather effects. The programme is a major collaborative initiative benefiting from the involvement of Europe, the United States, Russia, Japan, Canada and possibly other nations.

ESA's missions form a vital part of ILWS. SOHO, Ulysses and Cluster are already providing unprecedented data, helping us to understand the Sun, heliosphere and magnetosphere. In 2003, in collaboration with China, the Double Star mission will be launched to complement ESA's Cluster mission. In a decade's time, ESA's Solar Orbiter will follow. This spacecraft will travel closer to the Sun than any solar mission ever before. ESA will provide ground stations for Japan's Solar-B mission (launch 2005), and there is considerable European participation in NASA's STEREO (launch 2005) and Solar Dynamics Observatory (launch 2007) missions.

In addition, ESA's missions to the other terrestrial planets – Mars Express (launch 2003), Venus Express (launch 2005), and the BepiColombo mission to Mercury (launch 2011/2012), will carry experiments that look at solar-wind interactions with their respective planets.

ILWS builds upon a previous international framework between Europe, Japan, Russia (formerly the Soviet Union), and the United States established to study the Sun and its effects on the Earth. That framework was the International Solar Terrestrial Physics (ISTP) programme, in which the SOHO and Cluster missions were part of ESA's contribution. The Canadian Space Agency has joined this collaboration with the start of ILWS.



The ESA-NASA missions SOHO (left) and Ulysses (centre) together with ESA's Cluster quartet (right) are currently investigating the solar-terrestrial system

In terms of space weather applications within Europe, ESA is not alone in recognising the need for further research into the applications of space weather. Two European Commission funded COST (Coordination in Science and Technology) Actions have been initiated, focusing on increased understanding of the science behind space weather through international collaboration. Both aim to create a network of scientists and engineers with the common goal of understanding the impacts of space weather on the environment.

Monitoring of the space environment currently takes place within the framework of the International Space Environment Service (ISES), which encourages near-real-time monitoring and prediction of space weather and the space environment. Data are exchanged between several regional warning centres (RWC) distributed around the globe. The NOAA Space Environment Center plays a key role as the 'world warning centre', acting as a hub for data exchange and forecasts. ESA has recently become a member of ISES and will be responsible for creating a working group on the effects of the space environment on spacecraft.

Space weather as an application area has also recently been recognised in the European Union's Framework-6 Programme. The term 'space weather' is included under the heading of GMES (Global Monitoring for Environment and Security) 'risk management', within the thematic priority of aeronautics and space. While 'risk management' encompasses only a small subset of space weather issues, it is hoped that future EU collaborative projects will raise awareness of space weather and its impact on society.

Clearly, the scientific aspects of space weather are already well coordinated. It is hoped that through coordination of European initiatives and collaboration with the US and other national programmes such as those of Japan, Russia and China, a similar level of coordination in space weather applications can be achieved.

The Space Weather CDF Study

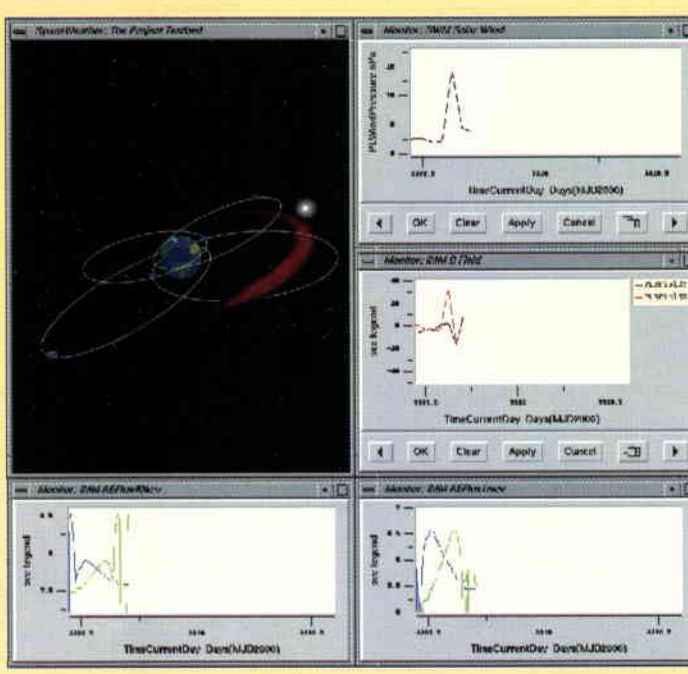
Following on from the two parallel ESA Space Weather Programme Feasibility Studies, ESA carried out an additional study to consider possible elements of a future space segment for an operational, service-oriented, European space weather system. The study was carried out using the Concurrent Design Facility (CDF) at ESTEC. Its main starting points were the space- and ground-segment recommendations proposed by the two consortia taking part in the feasibility studies.

Both the RAL and Alcatel consortia proposed several interesting options for a space weather system. As a result, it was decided that some of the proposed options should be analysed and further developed by ESA through the CDF, to establish their feasibility and cost. While a comprehensive space weather system should include elements beyond those studied by the CDF, following consultation with the consortia, it was decided to study the following demonstrator elements:

- an element for continuous monitoring of solar features that are important in ultimately causing space weather hazards near and on the Earth
- an element for continuously monitoring the solar wind upstream of the Earth, and
- a fleet of inner magnetospheric monitoring spacecraft which would observe changes taking place within the terrestrial radiation belts, the magnetosphere and partly the ionosphere.

The study was conducted between October and December 2001. The accompanying figures illustrate the space segment studied and the type of data that would be retrieved.

Elements of the space weather system studied within the Concurrent Design Facility (CDF) at ESTEC. This proposed space segment consisted of a solar monitor, a solar wind monitor and a fleet of four inner magnetospheric monitoring spacecraft. Both the solar and solar wind monitors would be permanently situated in the solar wind, in a halo orbit around the L1 Lagrangian point between the Sun and the Earth. The magnetospheric monitors would be located in a series of elliptical orbits within the magnetosphere, taking them though the Earth's radiation belts



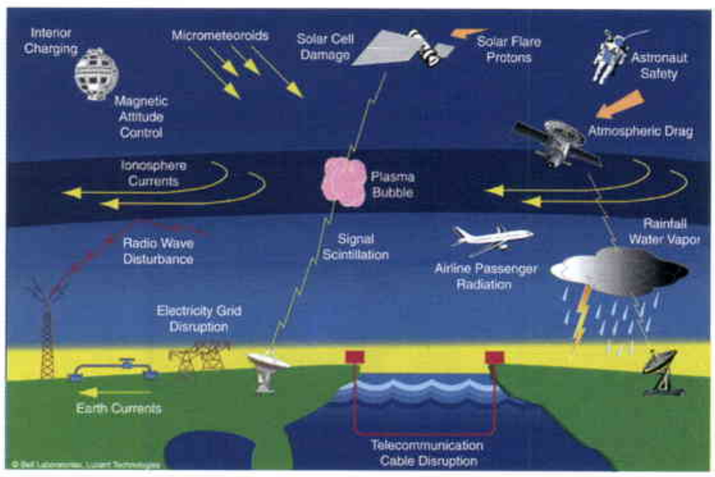
A simulated space weather event in the Earth's magnetosphere. This screen shows the type of data that would be retrieved from the magnetospheric monitors examined as part of the space weather CDF study. The red arc in the top-left panel indicates the injection of energetic particles into the radiation belts. This is confirmed by the sharp deviations in the measured quantities indicated in the other four panels impact is estimated to be some tens of millions of Euros per year for those sectors that are traditionally influenced by space weather. Since society's dependence on spaceborne technology such as communication and navigation systems is continually increasing, the economic impact of space weather may grow considerably in the future.

The known 'victims' of space-weather effects already include:

- *Terrestrial power distribution grids:* These are affected by additional current flows in cables induced by currents in the Earth's ionosphere. The resulting current surges can destroy equipment, necessitate operational system reconfiguration or special designs.
- *Terrestrial communications:* Some systems that make use of transmission via the ionosphere are seriously affected. Many of these systems are military.
- *Users of space-based trans-ionospheric services:* Radio propagation through the ionosphere can be perturbed by changes in the electron content. Ground-space communications and navigation services such as GPS and the future Galileo can be disrupted, as well as radar-based remote sensing.
- *Oil and mineral prospecting and operations:* Geomagnetic field variations can perturb magnetic readings routinely used in these fields.
- *Defence:* The defence sector makes increasing use of communications and navigation services which are affected. Space systems are important to this sector. Over-the-horizon radars are also adversely affected.
- *Airlines and aircraft developers:* Advanced avionics systems are becoming susceptible to cosmic radiation effects. Aircrew are exposed to doses of cosmic radiation, for which European legislation now requires monitoring.
- *Space agencies and commercial space system operators:* Space systems are subject to numerous types of serious radiation damage and interference. Radiation hazards to astronauts are significant. Spacecraft can discharge following plasma-induced charging, causing anomalies. Rapid atmospheric variations can affect spacecraft orbits and stabilisation.
- *Climate:* Recent research has indicated that space weather may have important effects on climate. Global surface temperature is thought to vary with the solar cycle and the level of cloud cover is also thought to vary in accordance with cosmic ray flux. Clearly, these effects need to be accounted for in global change programmes.

users to take appropriate action if a space weather event is predicted/detected.

Continuity of observations and longevity of the mission might also be considered less important in terms of scientific mission objectives, whereas these would be of key importance in terms of a monitoring mission. Indeed, science missions are normally unique and have a finite expected lifetime. In contrast, a space weather monitoring system should have a replacement procedure built in such that, as one element begins to fail, a replacement can be called into operation at short notice to maintain an operational service.



An overview of space weather effects, showing the wide range of domains that it influences. Not only space-borne systems are affected: terrestrial systems such as electrical power distribution grids and telecommunication cables also feel the effects of space weather (Image courtesy of Bell Laboratories, Lucent Technologies)

Service requirements

Regarding space weather as a hazard and developing strategies and systems to circumvent the problems that it can cause gives a very different perspective from the scientific investigation of the solar-terrestrial system. These different perspectives frequently mean that the requirements of scientific and service-oriented missions are not the same. For example, any monitoring service will require real-time or near-real-time data downlinking, together with a negligible delay in data processing and supply of data to the relevant users. In contrast, scientific measurement of the same system may require observations made at unprecedented resolution for a short period of time with no real-time constraint on data acquisition.

Availability of data may also prove a problem when instrument teams with scientific goals wish to restrict data access prior to publication of scientific results. In the context of space weather monitoring and prediction, the availability of real-time data is of paramount importance to allow

ESA Initiatives for Space Weather Applications

A European Space Weather Programme?

In 1999, ESA embarked on an investigation into the feasibility of a coordinated space weather programme. Contracts were placed with two consortia consisting of experts in the fields of engineering, solar-terrestrial science and space weather effects. These consortia were led by Alcatel Space (F) and the Rutherford Appleton Laboratory (UK).

The consortia performed wide-ranging analyses of the need for a European space weather programme and the possible content of such a programme, including:

- analysis of space weather effects
- analysis of the requirements of a space weather system

- definition of a service including prototyping aspects of this service
- definition of the space segment
- analysis of programmatic and organisational issues.

These studies were supported by a Space Weather Working Team consisting of external experts who provided input to the studies, analysed the work of the consortia, and advised ESA on its future strategy.

Together, the studies identified a wealth of expertise in space weather already existing within Europe. Key strengths were identified in the areas of scientific research, modelling and observatory infrastructure. It was stressed that federation of these activities, which are currently spread throughout Europe, would strongly benefit the space weather community, both in terms of the development of an applied service and in terms of coordinated research into the solar-terrestrial system as a whole.

It was noted that, at the present time, many European space weather applications are based on a US service. It is frequently the case that tools developed in Europe to mitigate space weather effects rely heavily on a US service provision infrastructure based at the NOAA Space Environment Centre in Boulder, Colorado. Consequently, they receive data via an Internet link, which may be subject to disruption. Security of this data may also become an issue in the future due to military involvement in US space weather data measurements and the increasing dependency of society on systems affected by space weather.

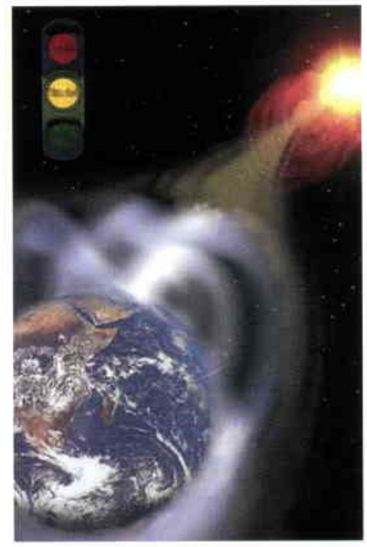
The results of these studies are accessible via ESA's Space Weather Applications website at:
www.estec.esa.nl/wmwww/wma/spweather/esa_initiatives/index.html.

At present, most space weather data is provided by scientific missions and the US NOAA meteorological spacecraft. However, useful space weather information is also provided by small, low cost 'hitchhiker' instruments, of which the Standard Radiation Environment Monitor (SREM) is an example. This instrument, which provides data on the space weather conditions in the vicinity of the spacecraft, has been flown on several ESA missions including Integral (shown here in the ESTEC Test Centre prior to launch) and Proba. Future missions that will carry SREM monitors include Rosetta, Herschel and Planck. The SREM was developed under the ESA Technology Research Programme (TRP)

The Space Weather Applications Pilot Project

This two-year Pilot Project follows on from the two parallel space weather studies described above. It seeks to expand the results of these studies and further develop the community of space weather service users and developers in Europe. It will focus on the development of targeted space weather services based on existing or easily adaptable sources of data, but there will also be a strong emphasis on outreach activities, collaboration, and the coordination of existing activities. A quantitative evaluation of the benefits that a future coordinated space weather service would bring to European industry and society will be carried out in parallel. This evaluation will independently assess the benefits of a service devoted to space weather across the wide range of domains that it affects.

The Pilot Project will focus on the development of a number of space weather applications projects in key areas. These will be integrated into a common network, which will be developed in parallel. This network, in turn, will provide support to the individual service development activities and will create a space weather application service provision infrastructure.



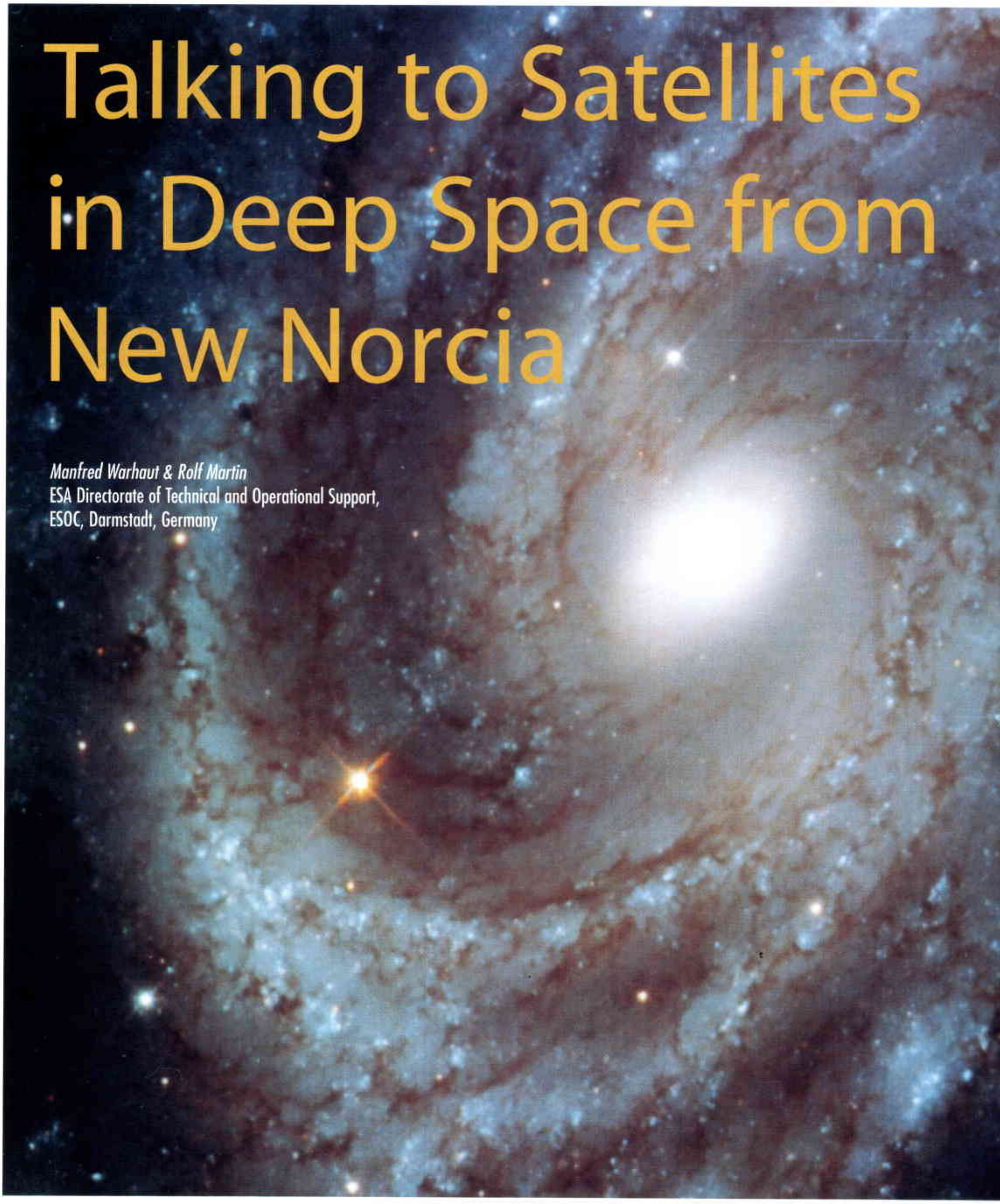
Space weather services are often targeted at users who are not specialists in space weather effects. These users require that the complex space weather system and how it affects their interests be interpreted by the service provider and converted into a format that is easily understandable. This might take the form of a 'traffic light' system

Areas in which service activities will be developed include (but are not limited to):
- Ground-based power distribution systems
- Space-based communication services
- Space-based navigation services and users
- Spacecraft development and operations (including drag effects)
- Scientific spacecraft users (instrument interference and campaign planning)
- Aircrew radiation-exposure monitoring
- Public outreach and tourism.

It is anticipated that this network of pilot services will pave the way for a future coordinated European Space Weather Applications Service.

Acknowledgements

Sincere thanks go to the RAL and Alcatel-LPCE consortium leaders during the ESA Studies for a Space Weather Programme: M. Hapgood (RAL) and B. Huet (Alcatel Space), and also to A. Santovincenzo, H. Opgenoorth, F. Ongaro, S. Coulson, M. Aguirre, and M. Verbauwhede. esa



Talking to Satellites in Deep Space from New Norcia

Manfred Warhaut & Rolf Martin
ESA Directorate of Technical and Operational Support,
ESOC, Darmstadt, Germany

To control and operate its spacecraft, ESA maintains a network of ground stations, which consists of several stations with 15 metre antennas using S-band frequencies for telemetry, command and tracking. This network has recently been augmented, in November 2002, with a ground station with a 35 metre-diameter antenna at New Norcia in Western Australia. The new station can transmit and receive at both S-band (2 GHz) and X-band (8 GHz) frequencies, and its mechanical structure will allow later upgrading for data reception in the Ka-band (32 GHz), which become the future international standard for deep-space missions.

The New Norcia antenna is one of the largest in the world for telemetry, tracking and command (TT&C) applications and represents the jewel in the crown for the ground-station network operated by the European Space Operations Centre (ESOC). This new antenna is essential for high-performance communications with spacecraft in far out in space and missions in highly elliptical orbits which take them far from Earth. ESA's Rosetta and Mars Express scientific missions fall squarely into that category.

Reliable 'long-distance communications' between the New Norcia ground station and the Rosetta spacecraft, now due for launch in early 2004, will be essential to acquire the scientific data being collected by its instruments and to allow ESOC to remotely control both the spacecraft and its payload when it is up to 900 million kilometres away from Earth – more than six times the distance from the Earth to the Sun.

Communicating with spacecraft over these huge distances puts very stringent radio-frequency (RF) requirements on the ground station's antenna system, as weight and energy constraints limit the size and transmitting power of the antenna onboard the spacecraft. The ground station therefore needs very sensitive receivers and powerful transmitters, coupled to a high-gain antenna of its own, in order to ensure reliable communication with the spacecraft. This in turn means a large antenna with a narrow beam width, and hence a high pointing accuracy also. The provision of smooth motion by the antenna's servo subsystem and high stiffness of the antenna's mechanical structure under the prevailing local weather conditions are also required to achieve optimal overall performance (i.e. a main-reflector surface accuracy of 0.3 mm, and a tracking error of no more that 0.006 deg in the Ka-band).

Like all of ESA's other outlying ground stations, the New Norcia antenna will be remotely controlled and operated from ESOC in Darmstadt. This avoids the needed for permanent manning of the station and limits the need for maintenance staff to visits on a weekly basis. The

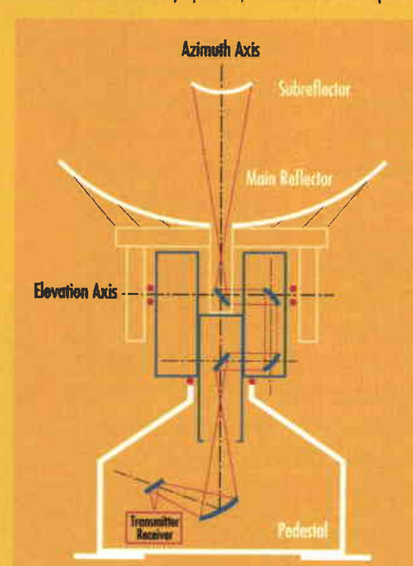
ESA's new 35 metre deep-space antenna at New Norcia in Western Australia

Technical Features of the Station

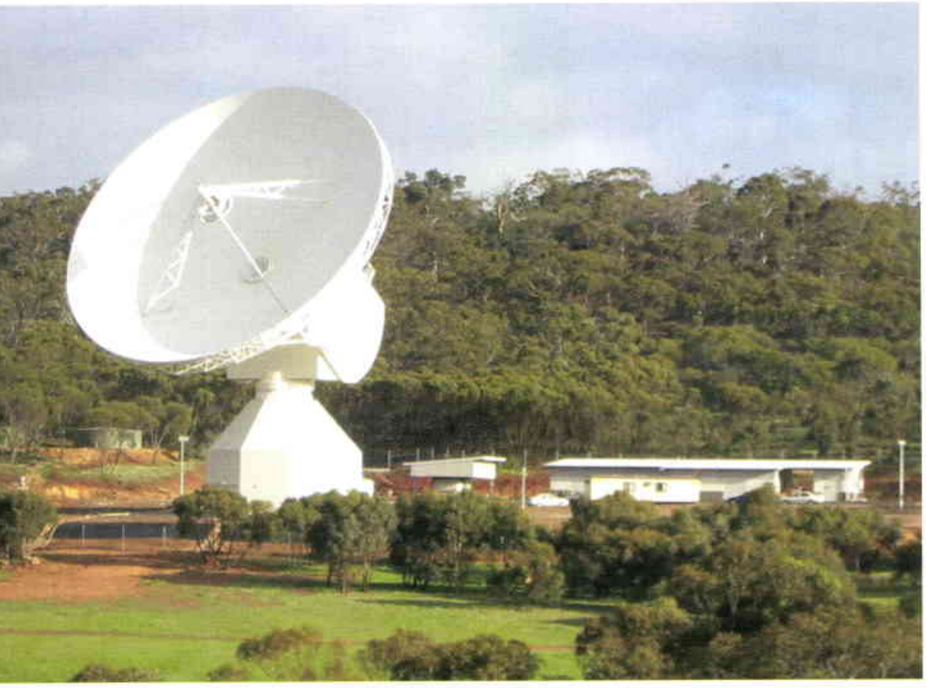
The New Norcia deep-space ground station consists of the antenna front-end, the site infrastructure facilities, the antenna back-end, and a high-precision frequency and timing system based on hydrogen masers. The 35 m antenna is mounted on a full-motion, turning-head pedestal. There is a beam waveguide feed system, cryogenically cooled S-and X-band low-noise amplifiers, and 20 kW S- and X-band transmitters, together with all of the other typical support equipment for an antenna front-end. The overall height of the antenna is around 40 m, and the structure and equipment above the antenna pedestal weigh approximately 630 tons.

The antenna is complemented by standard ESA ground-station back-end equipment, installed in a separate building. Advanced digital technology has been used in the receivers, the demodulators and the ranging equipment used to determine the position and orbit of the spacecraft being operated.

The project to build the station began in 1998 and the industrial team contracted for the work involved several companies from European countries, Canada, the United States and Australia. The prime contractor was SED Systems of Canada. Major subcontractors were: Bovis Lend Lease of Australia (site infrastructure), Nortel DASA SatCom of Germany (back-end equipment), Vertex Antennentechnik of Germany (mechanical and servo system), and Vertex Antenna Systems of the USA (passive radio-frequency system).

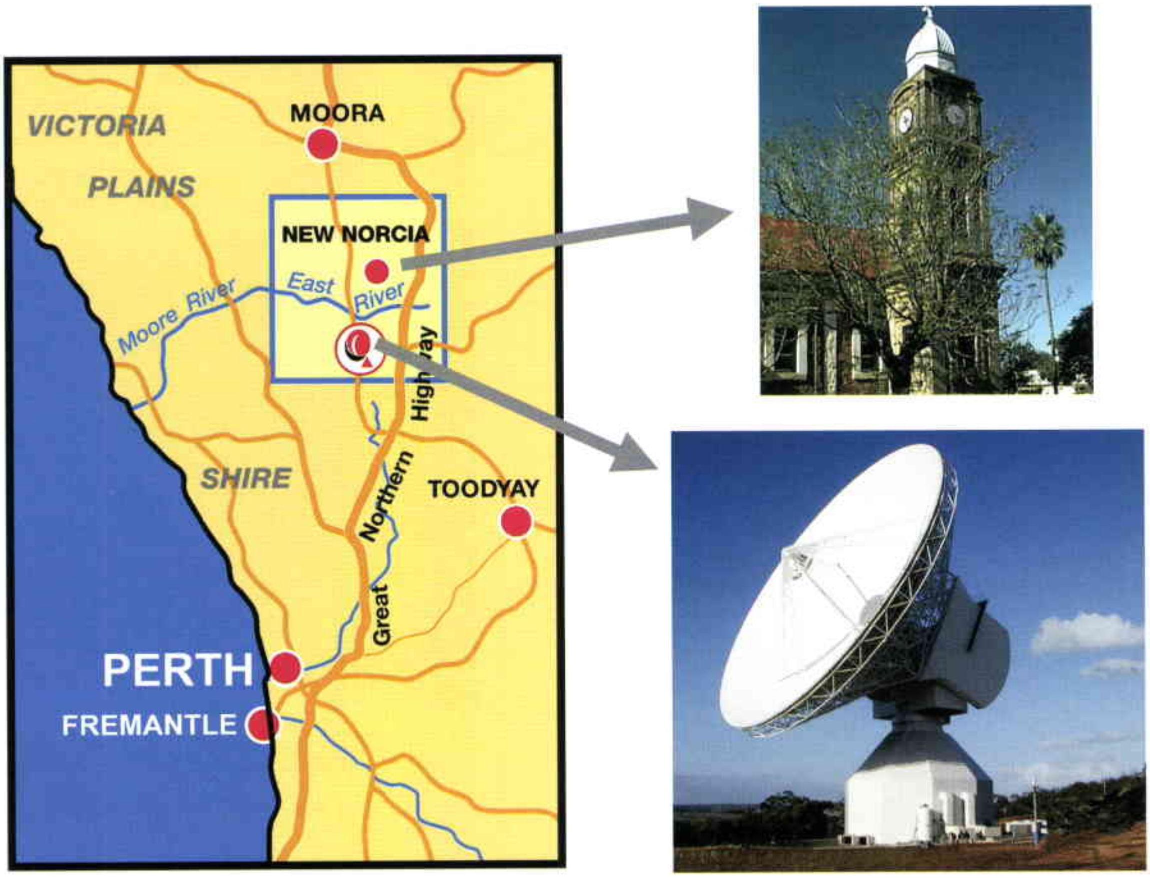


Incoming signals are collected by the main 35 m dish and guided via the sub-reflector and various mirrors down to the receiver



station's location has been carefully chosen to provide the necessary satellite visibility, the required radio-frequency clearance for data transmission and reception, the best-available weather conditions, which influence station performance (rain attenuation, wind speed), and to satisfy the need for cost-efficient operation and maintenance.

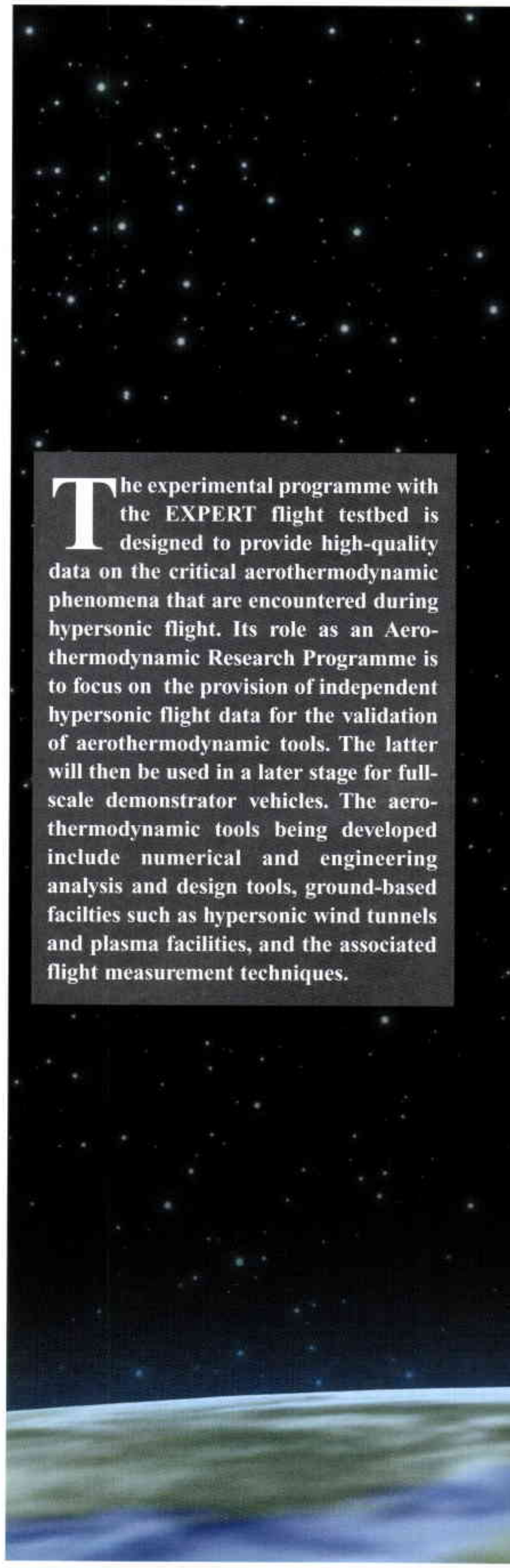
New Norcia is a small historic town about one and a half hours north of Perth, where the new ground station provides a 'bridge' between the 150 year old traditions of its Benedictine Monastery and the high-tech world of operations in deep space!



The geographical location of the New Norcia ground station

Preparing for Atmospheric Reentry with EXPERT's Help

- An Aerothermodynamic In-Flight Research Programme



The experimental programme with the EXPERT flight testbed is designed to provide high-quality data on the critical aerothermodynamic phenomena that are encountered during hypersonic flight. Its role as an Aerothermodynamic Research Programme is to focus on the provision of independent hypersonic flight data for the validation of aerothermodynamic tools. The latter will then be used in a later stage for full-scale demonstrator vehicles. The aerothermodynamic tools being developed include numerical and engineering analysis and design tools, ground-based facilties such as hypersonic wind tunnels and plasma facilities, and the associated flight measurement techniques.

Jean Muylaert, Francesca Cipollini, Giorgio Tumino, Willi Kordulla, Giorgio Saccoccia, & Constantinos Stavrinidis
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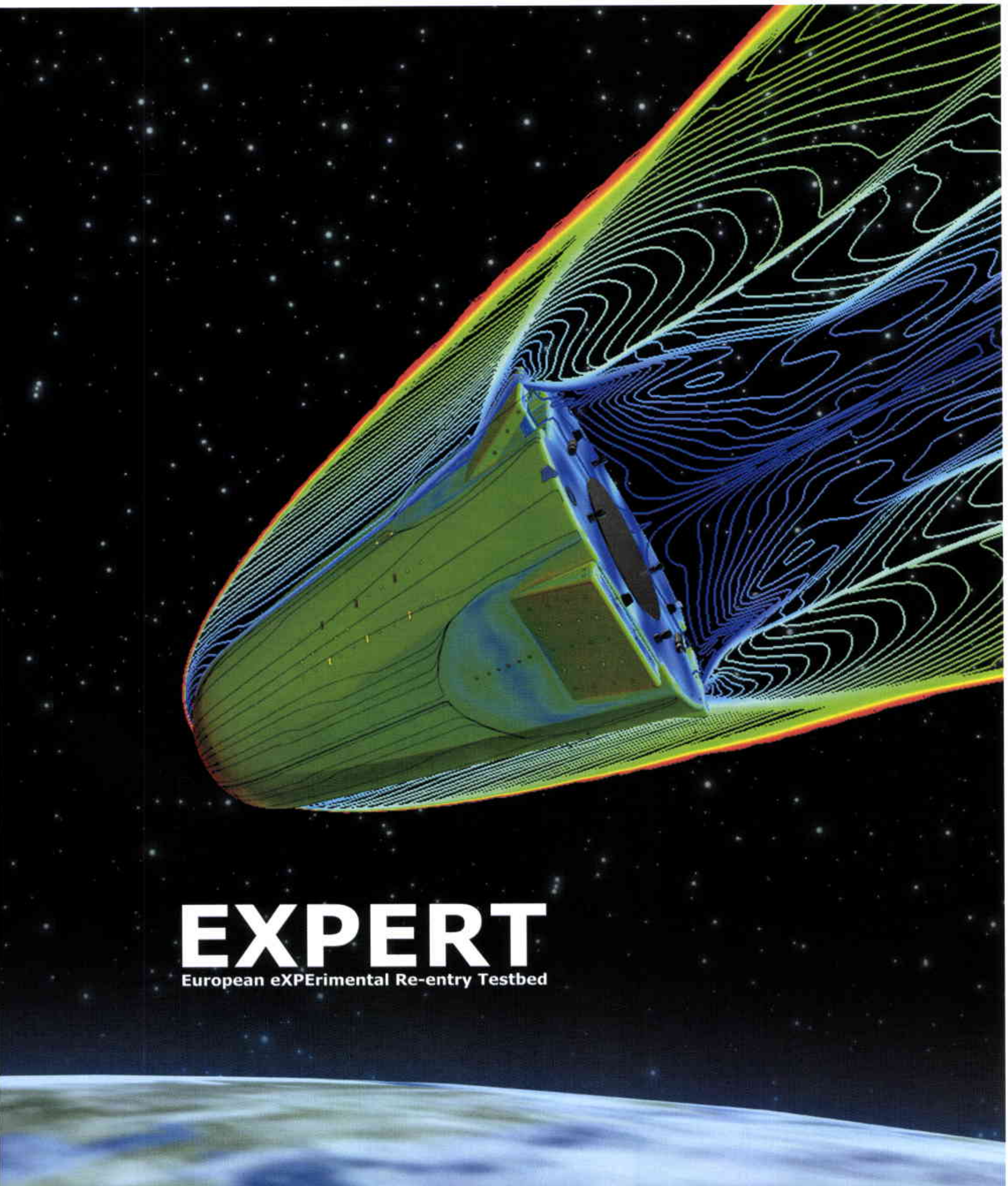


EXPERT

European eXPERimental Re-entry Testbed

The Rationale for Advancing Europe's Aero-thermodynamic Knowhow

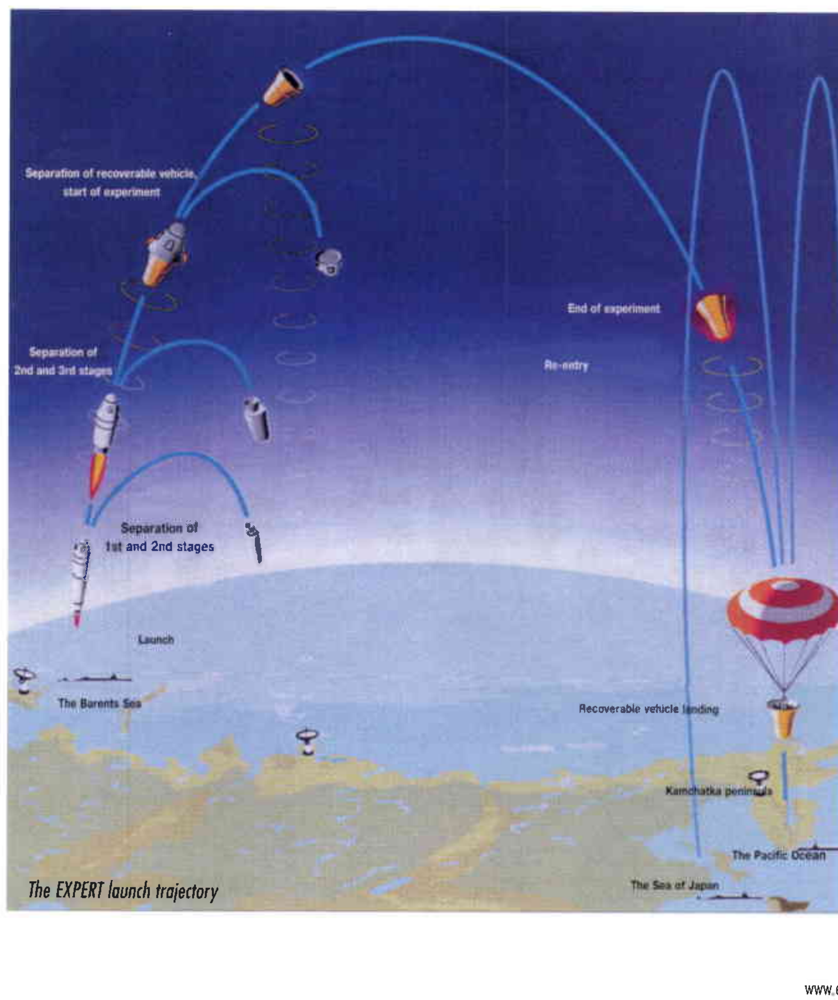
The aerodynamic knowhow needed to design and safely fly future hypersonic space vehicles is generally obtained via ground-based experimental simulations, computational predictions and ground-to-flight extrapolation methodologies. However, unless these tools have been validated by comparison with relevant wind-tunnel and flight data, they lack the verification needed to ensure optimal engineering margins. The best approach for establishing that confidence in the aerothermodynamic design tools is therefore to validate both the tools and the design approaches against flight experiments. In the past, however, such attempts have often been hampered by serious deficiencies such as poor measurement accuracy and resolution, flow contamination, limited/isolated single-point measurements and, last but not least, the high costs and risks associated with achieving a successful flight.

Lessons learned from past European flight-test programmes, such as ESA's Atmospheric Reentry Demonstrator (ARD), and development work on lifting-body vehicles such as the X38 crew-return-vehicle prototype, have underlined the need for more accurate hypersonic flight data to benchmark the quality of today's computational tools and design approaches. This is particularly the case for the most challenging problems of hypersonic flight, such as flap efficiency and heating, boundary-layer transition, high-temperature or chemistry effects, and gas-surface interaction effects such as catalysis and oxidation.

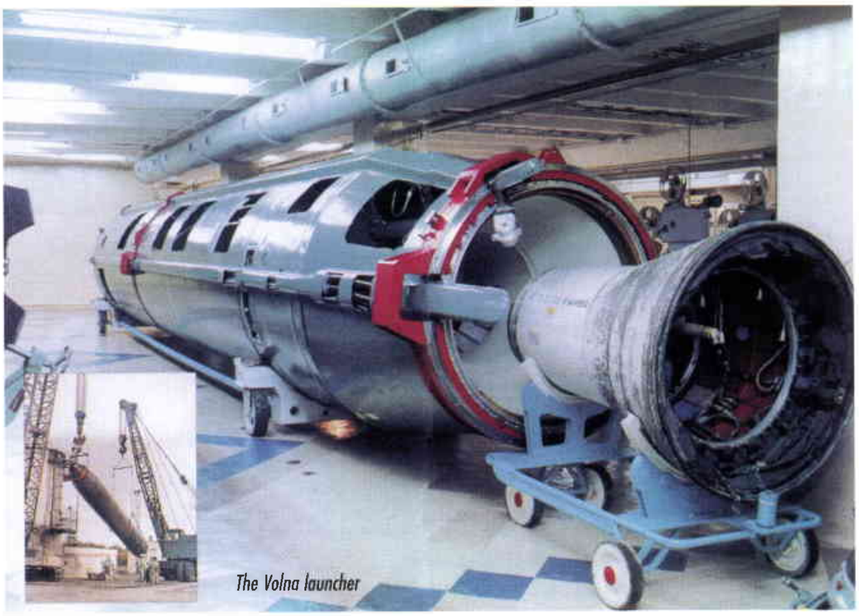
The EXPERT flight test programme addresses the current shortage of hypersonic flight data and at the same time will provide the data needed to improve wind-tunnel to flight extrapolation, by flying at speeds ranging from 5 km/sec, corresponding to today's ground-based hypersonic testing capabilities, up to 7 km/sec, which is approaching the reentry flight conditions of interest for future space transportation system design. This provides a unique opportunity in that the hypersonic facilities can partly duplicate

IN-FLIGHT EXPERIMENTATION STRATEGY – CLASSES 1-3

CLASS 1.	FULL-SCALE DEMONSTRATION AND QUALIFICATION, WHEREBY PERFORMANCE ENVELOPES ARE GRADUALLY EXTENDED: e.g. – SHUTTLE, BURAN, APOLLO, ARD, ARIANE-5 – X38, HOPE, HERMES, OSP – HERCULES, SOCRATES	PROGRAMME
CLASS 2.	EXPERIMENTAL VEHICLES FOR IN-FLIGHT QUALIFICATION OF SYSTEM/SUBSYSTEMS: e.g. – BOR4 for TPS ; BOR5 for GNC; – HYFLEX for TPS; ALFEX for GNC – IRDT for INFLATION SYSTEM – PHOENIX 1 and 2 for GNC – IXV (SPHYNX – PRE-X – USV)	
CLASS 3.	IN-FLIGHT RESEARCH FOR DESIGN TOOL/PHYSICAL MODEL VALIDATION IMPROVEMENTS: e.g. – SHARP B1, B2 FLIGHTS, HYSHOT, – MIRKA, EXPRESS – EXPERT multiple flights for aerothermodynamic research	R & D



The EXPERT launch trajectory



The Volna launcher

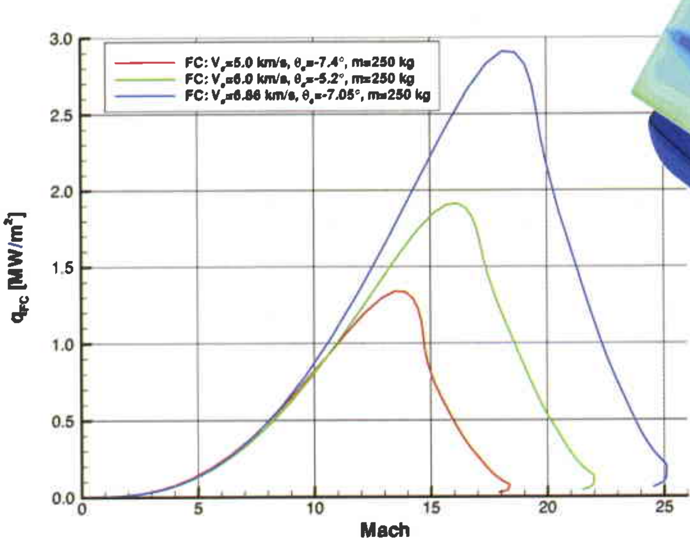
scaling parameters such as Mach number (compressibility), Reynolds number (viscosity) and high-temperature effects (real gas effects).

Thanks to the launch flexibility of the Russian Volna rocket selected, the EXPERT test vehicle will be able to make controlled ballistic suborbital flights to study all of the most critical aerothermodynamic phenomena and then be recovered for detailed post-flight inspection.

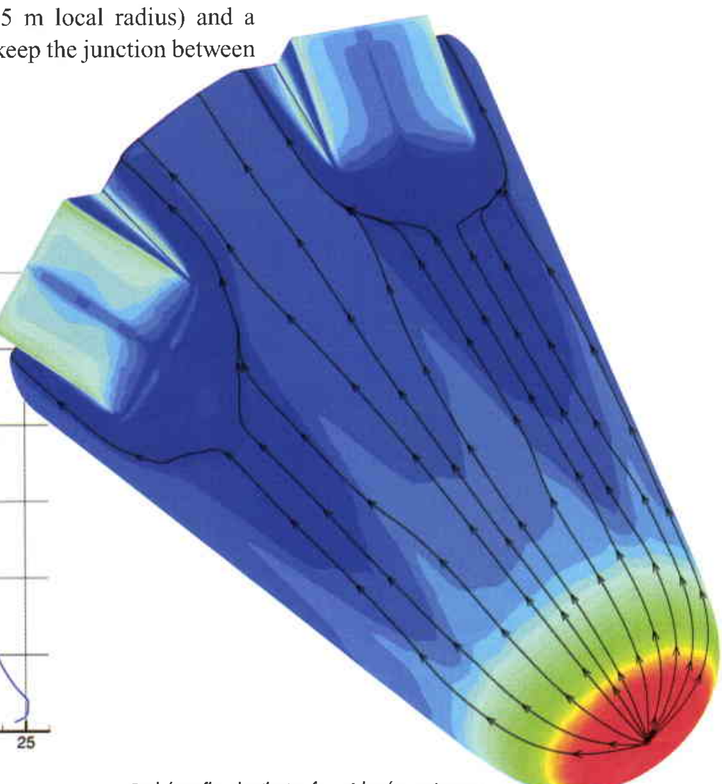
EXPERT – A Ballistic Vehicle

The configuration finally chosen for the EXPERT vehicle is the result of a feasibility study performed under ESA contract, taking into account the payload mass and volume capabilities of the Volna launcher as well as the need to provide appropriate resolution for the aerothermodynamic phenomena of interest. It is basically a 'blunt cone' with four flaps and flat surfaces ahead of them. It is 1.6 m long and 1.1 m in diameter. It has an elliptically shaped nose (0.55 m local radius) and a smooth spline to keep the junction between the nose and conical parts continuous. The 12.5-deg conical leading edges generate axisymmetric flows, enabling two-dimensional sensitivity computations. Two diametrically opposite flaps, presently at fixed angles of 20 deg, will be open to study 3D micro-aerothermodynamic effects at the corners, base flow re-circulation, and non-convex re-radiating wall effects. Two other diametrically opposite flaps will be closed to protect sensitive instrumentation such as an infrared camera or pyrometer equipment. A Reaction Control System (RCS) for attitude and spin control will keep the flight angle of attack as close as possible to the optimum (zero-trimmed incidence).

The overall shape of the EXPERT vehicle has been dictated by the maximum allowable heat flux in order to avoid possible degradation of the nose's surface material due to active oxidation, and by the need to have clean laminar attached flow over the majority of the flight path in order to study gas/surface interaction (catalytic and boundary-layer transition phenomena) in sufficient detail.



Heat flux versus Mach Number for different trajectories – 5, 6 and 7 km/sec



Peak heat-flux distribution for a 6 km/sec trajectory

The Scientific Payload

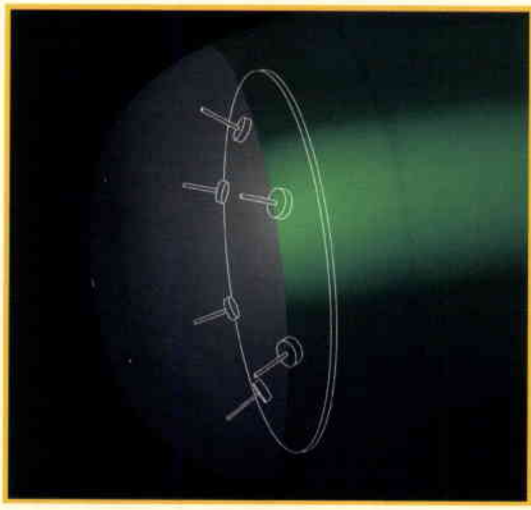
The EXPERT vehicle will carry state-of-the-art instrumentation for in-flight measurement of the critical aerothermodynamic phenomena: transition, catalysis, real gas effects on shock interaction, as well as shock-layer species partial densities and temperatures. Special attention will be paid to the design of measurement sensors, as well as to measurement of the free-stream parameters during re-entry (i.e. the design of the ADS).

Payload 1

Free-stream tracking

A pressure-based Air Data System (ADS) mounted on EXPERT's nose cone will be calibrated so that it can track the free air stream throughout the atmospheric portion of the flight. Lessons learned from past flight programmes have shown the importance of knowledge of this stream's density for the improved interpretation of onboard measurements.

Positions of Payload Elements



Payload 2

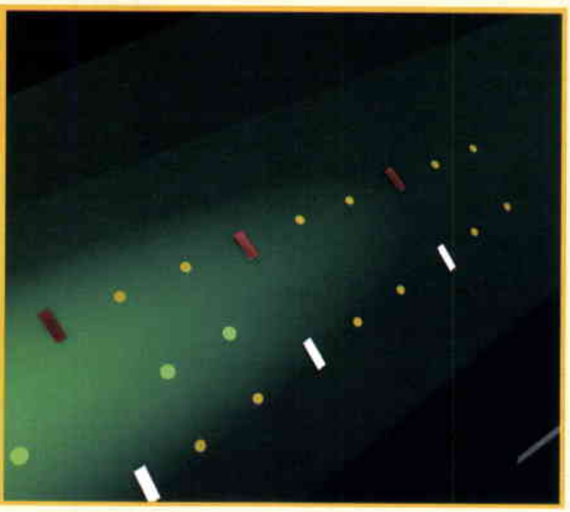
Nose heating measurements

EXPERT will take advantage of instrumentation originally developed for the X38 experimental vehicle (the forerunner of the originally planned Crew Rescue Vehicle for the ISS) to measure temperatures in the nose region. PYREX and possibly Raflex gauges will be mounted inside the nose.

Payload 3

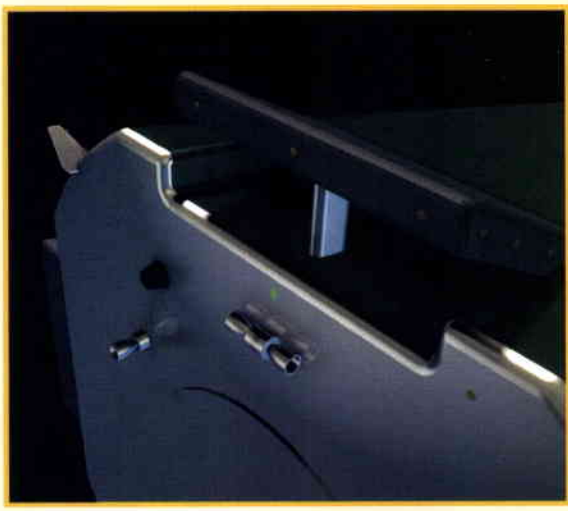
Catalysis measurements

The assessment of the catalytic gas-surface interaction is a major concern when designing a thermal-protection system. The degree of catalicity of a material affects the heating of the surface (the higher the degree of catalicity, the higher the wall heat flux), and thus the design of the protection needed. Understanding this phenomenon calls for very complex modelling at the molecular level, which can be only partly validated in ground-based plasmatron facilities. A series of temperature gauges, each covered with coatings with different degrees of catalicity, are foreseen to be flown on two diametrically opposite leading edges of EXPERT to study the phenomenon.



Payload 4
Roughness-induced transitions

Laminar to turbulent boundary-layer transition is considered one of the most critical aerothermodynamic phenomena due to the associated local temperature peaks. Most of the data obtained in ground-based hypersonic test facilities are contaminated by acoustic effects emanating from the wind tunnel itself. Roughness-inducing boundary-layer transition elements will be mounted on the leading edges of EXPERT in diametrically opposite locations. Their position, size and number will be chosen such that transition occurs in the lower altitude, higher Reynolds number part of the flight.

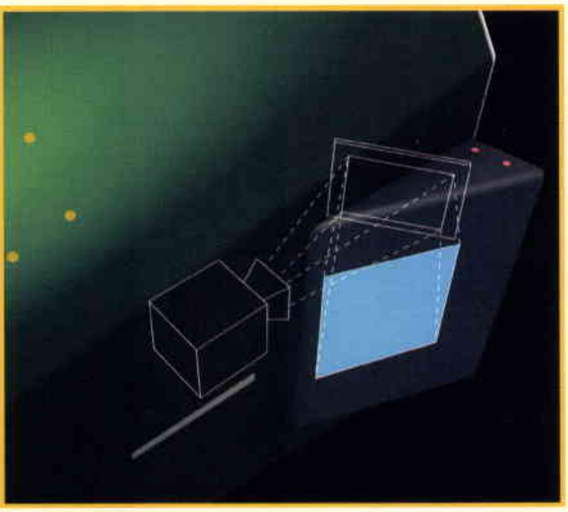


Payload 5
Shock interactions around open flaps

Boundary-layer separation effects in front of a deflected flap affect not only the efficiency of the flap for control purposes, but also the heating associated with shear-layer reattachment. Three-dimensional effects, corner and gap heating, base-flow circulation and wall cooling are all critical issues that need to be addressed in the design of control flaps. Specific pressure, heat-flux and force (moment) measurements will be performed using EXPERT's fixed open flaps to investigate these effects.

Payload 6
Heat fluxes inside closed flaps

Taking advantage of today's capabilities for measuring time-dependant 3D phenomena using non-intrusive techniques, an infrared camera will be mounted inside the closed flaps. Inverse methods will be applied to the data measured beneath the flaps in order to 'reconstruct' the external 3D heat flux during re-entry. As the deflection of all four flaps is identical, the flow results can be cross-checked with those predicted using the more classical methods.



Payload 7
Shock-layer chemistry

When computing a hypersonic flow field, the thermo-chemical model used plays a dominant role because it strongly affects the results of the numerical simulations. Unfortunately, those applicable to hypersonic flight could not yet be fully validated and hence there is an acute need for a reliable set of thermo-chemical measurements, particularly within the shock layer, which EXPERT can provide.

An instrument based on the electron-beam fluorescence technique will measure the concentrations of nitrogen and nitrous oxide, providing very valuable data for the validation of the thermo-chemical models and complementing the data obtained from ground-based facilities. The technique currently works only at high altitude, and so more work is required to improve the system.

Payload 8

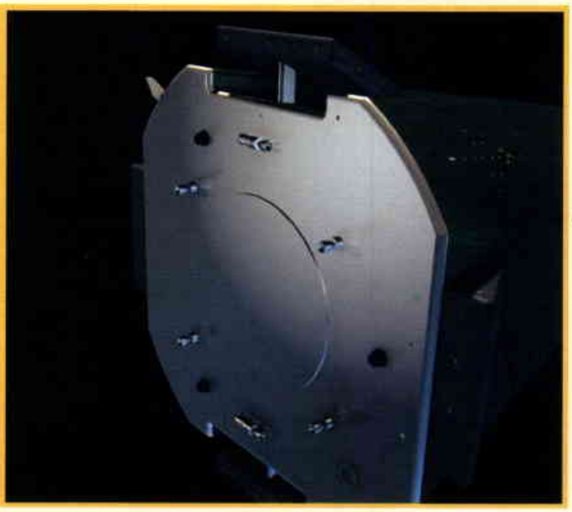
Boundary-layer measurements

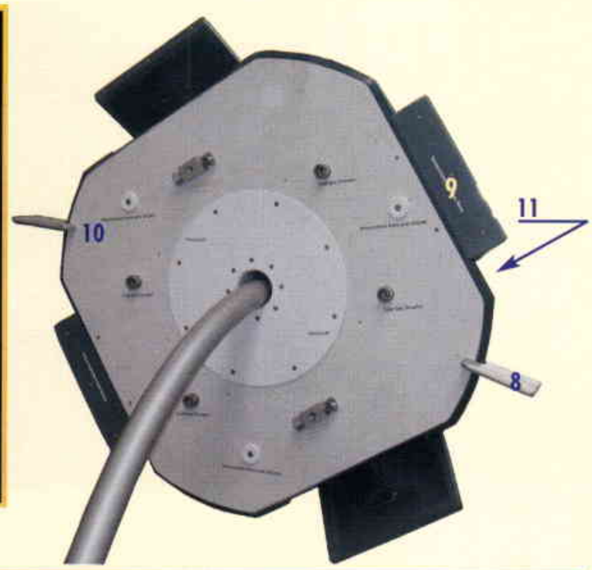
At the trailing edge, EXPERT will be equipped with a Pitot static pressure rake and a Langmuir probe in order to measure, respectively, the boun-dary-layer characteristics and the electron-density profiles close to the wall. The resulting characterisation of the boundary layer at the trailing edge of the vehicle will further contribute to our understanding of boundary-layer transition phenomena.

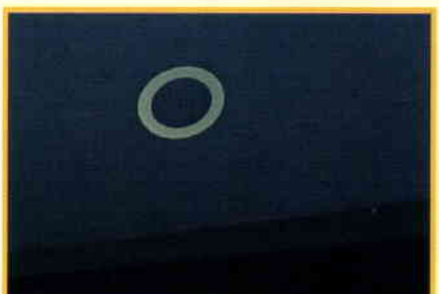
Payload 9

Base- and slip-flow measurements

Pressure and heat-flux measurements will be made at selected points on EXPERT's base. Some slip-flow gauges are to be installed at specific points on the vehicle's leading edges to provide data with which to validate the current Monte Carlo numerical simulation tools.







Payload 11

Thermal protection

It is planned to fly a small innovative water-cooled thermal-protection system as a passenger. Based on an idea emanating from the Technical University of Delft (NL), it uses the concept of forced convection through a water evaporation process.

Payload 10

Black-out measurements

EXPERT will carry some reflectometers, similar to those flown on ESA's Atmospheric Reentry Demonstrator (ARD), which combined with the Langmuir probes will deliver a good data-set for the validation of the attenuation codes describing the blackout phenomena.

Conclusion

As an in-flight research programme, the prime objective of the EXPERT testbed is to improve our understanding of such critical aerothermo-dynamics phenomena as transition, catalysis, blackout, real gas effects and shock-wave boundary-layer interactions associated with flap efficiency and heating. Multiple flights using the Volna launcher are foreseen, focusing on wind-tunnel to flight extrapolation as well as on the use of modern in-flight measurement techniques. At present, two ballistic flights are planned, at 5 and 6 km/sec. If successful, further flights at higher speed (7 km/sec) will follow for the study of aero-braking and jet interaction, and flights to study advanced materials associated with high-speed re-entry may also be anticipated. esa

Acknowledgement

The authors acknowledge the FESART team for their contributions to the feasibility study preceding the EXPERT project:

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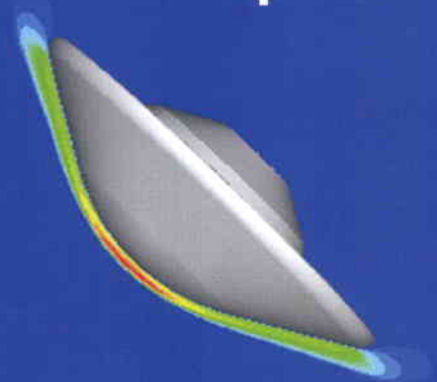
University of Delft: J Bruunsink and T. Van Baten.

The authors are also indebted to Dr. Danilkin and his team from SRC for providing the Volna launcher specifications.

1ST Announcement and Call for Abstracts

International Workshop on Radiation of High Temperature Gases in Atmospheric Entry



8-10 October 2003
Instituto Superior Técnico, Lisbon, Portugal

esa Aurora Programme
European Space Agency

http://www.esa.int/export/esaMI/Aurora/index.html

esa
www.esa.int

cnes
CENTRE NATIONAL D'ETUDE SPATIALES
www.cnes.fr

INSTITUTO SUPERIOR TÉCNICO
www.ist.utl.pt

In the framework of ESA's Aurora programme and with the support of CNES, the Working Group "Radiation of High Temperature Gases" (WG RHTG) is organizing a workshop on Radiation of High Temperature Gases in Atmospheric Entry.Topics of interest include:

- Non Equilibrium Chemical Kinetics
- Hypersonic Flow
- Plasma Emission and Absorption
- Computational Fluid Dynamics
- Instruments and Facilities
- Flight Experiments
- Radiation Transfer
- Radiation emission & transfer database and models
- Re-building of selected radiative emission and absorption experiments
- Numerical axially-symmetric test-cases for flow and radiation emission and absorption calculations

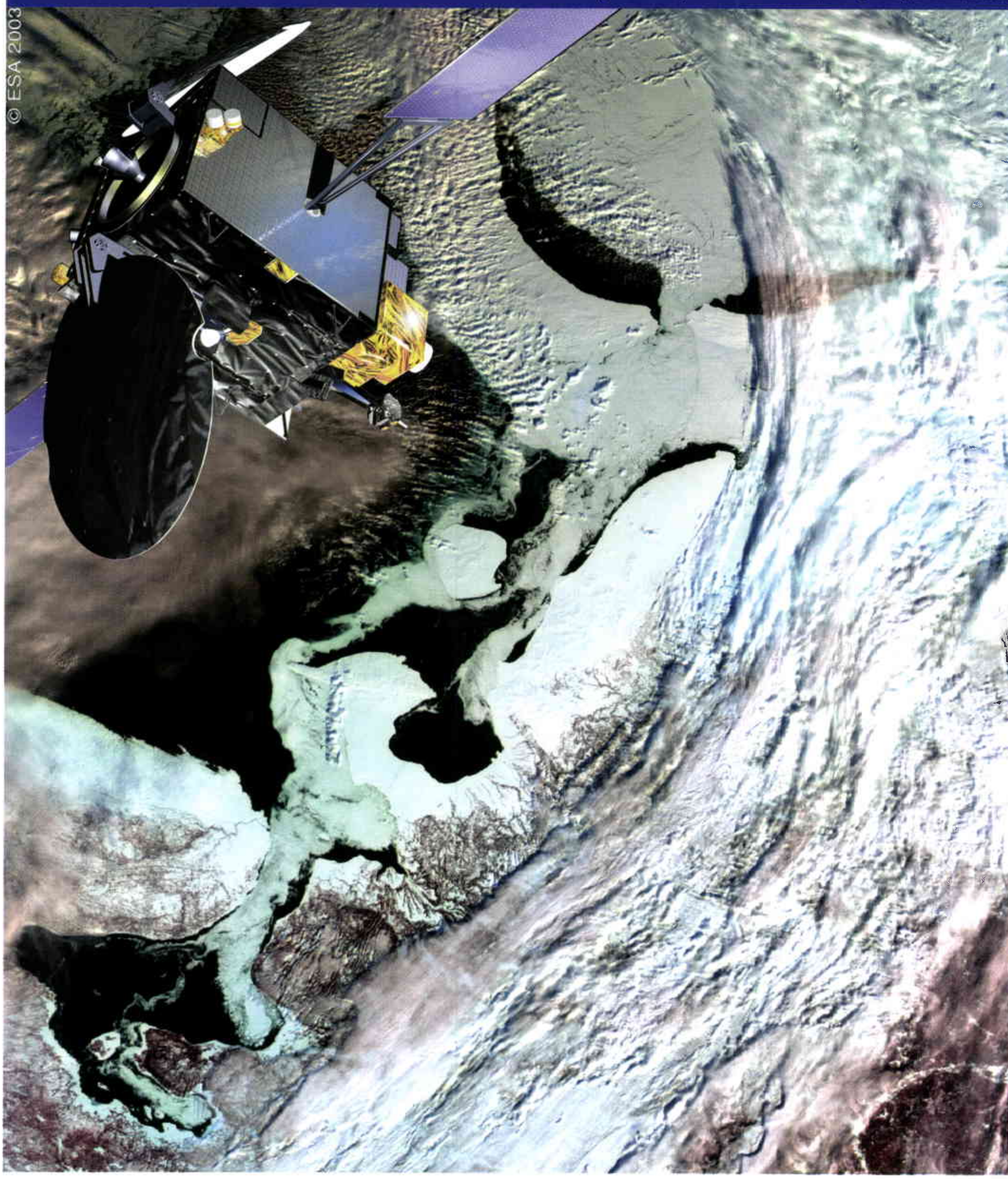
For further information see the Workshop website at:

www.estec.esa.nl/conferences/

or contact

Prof. Paulo Gil
email: p.gil@dem.ist.utl.pt
Tel: +351 21 841 71 96 (direct)
Tel: +351 21 841 71 97 (secretariat)
Fax: +351 21 841 94 68

The first Envisat image transmitted by Artemis on 13 March 2003, showing Archangel in Northern Russia



Artemis Finally Gets to Work !

Gotthard Oppenhäuser & Aneurin G. Bird
Artemis Programme Office,
ESA Directorate of Applications,
ESTEC, Noordwijk, The Netherlands

After a remarkable recovery operation lasting 18 months, ESA's latest telecommunications satellite Artemis finally reached its assigned position in geostationary orbit on 31 January. Launched on problematic Ariane-5 flight 142 on 12 July 2001, which experienced a malfunction in its upper stage, the satellite was injected into an abnormal, low-energy orbit with an apogee height only half that of the standard geostationary transfer orbit (GTO). For any conventional communications satellite, this would have resulted in the total loss of the mission. Thanks, however, to the combination of technologies onboard Artemis and the innovative control procedures devised by the spacecraft control team, the satellite has been coaxed into the correct final orbit and is now able to provide the operational data-relay, land-mobile and navigation services for which it was designed.

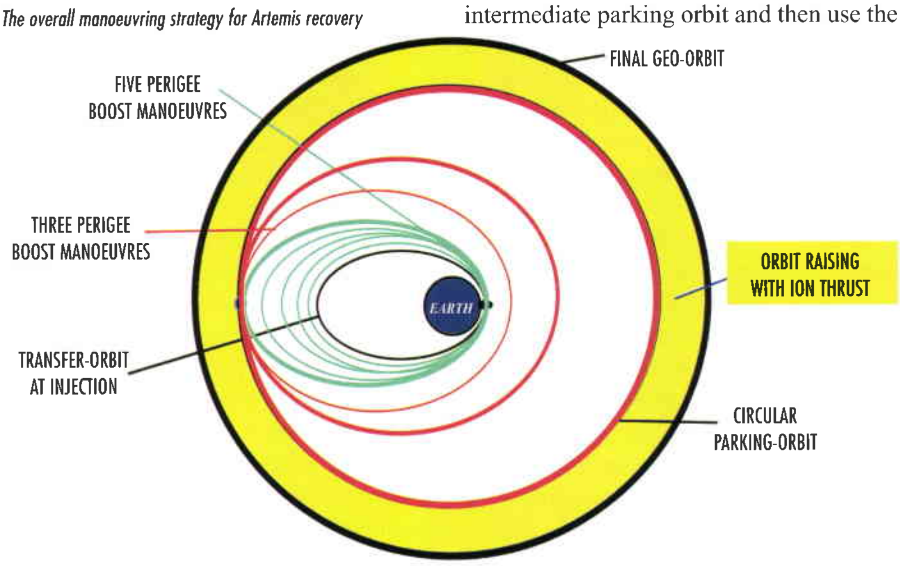
The Recovery Concept

Although Artemis carried a significant mass of chemical propellant, it was judged after the launch mishap that this was insufficient to reach geostationary orbit (GEO) and still have sufficient fuel available to provide a useful station-keeping function. It was therefore decided to use chemical propellant to reach an intermediate parking orbit and then use the satellite's experimental ion-propulsion system, together with a new attitude-control mode, for the transfer to GEO.

A favourable balance was found between the mass of chemical propellant remaining for operations in GEO and the time taken for the final transfer using the ion-propulsion system. The intermediate parking orbit was chosen to be about 5000 km below GEO. This required 200-300 days of ion-propulsion operation but still left sufficient chemical propellant to meet the basic satellite-control requirements in GEO.

The first and most urgent phase of the recovery was to make a series of engine burns at perigee to lift the orbit of Artemis beyond the Earth's destructive radiation belts. It was by no means straightforward to adapt the control modes of the liquid-fuelled engine to operate in eclipse, and in the absence of telecommand contact. Operation of the satellite's infrared earth sensor well below its specified altitude limits was also a critical element in achieving success with these early operations.

The overall manoeuvring strategy for Artemis recovery



There followed more conventional chemical-engine burns at apogee to raise and circularise the orbit at the chosen parking-orbit altitude and reduce its inclination. All of the manoeuvres executed proved to be successful and were also highly efficient. Within a few days of launch, therefore, Artemis was safely under control in its parking orbit, circling the Earth every 5 days. A new global ground-station network was arranged to monitor and control it.

The Ion-Thrusting Solution

Up to that point, the possibility of using the ion-propulsion system with a new attitude-control mode had been only the germ of an idea. The four ion engines are mounted in pairs (for redundancy) on the corners of the satellite, providing thrust both perpendicular to and in the orbital plane. As originally designed for control of the satellite's orbital inclination, the in-plane component was unused. However, this was the very component needed for the rescue operation, which required thrust to be generated in the orbital plane to increase the radius of the orbit. Harnessing this in-plane thrust in the direction of motion required rotation of the satellite in the orbital plane by 90 degrees.

Thus just a few weeks after launch, the serious design work was started to devise, test and program the new attitude-control laws, data-handling modes and new flight-control procedures. In all, about 20% of the original spacecraft control software had to be modified. Thanks to the re-programmable onboard control concept used on Artemis, these modifications could be uplinked to the satellite as 'software patches', amounting in total to 15 000 words – the largest reprogramming of flight software ever implemented on a telecommunications satellite.

By the end of December 2001, work on the new software had been completed and it was subsequently validated using the spacecraft simulator. Once the new flight-control procedures had also been validated, all preparatory activities were complete, and on 19 February 2002 the orbit-raising manoeuvres were commenced. The ion engines started to expand the orbit with their almost imperceptible thrust, but with good efficiency, and more than 20 km/day could be achieved by using two thrusters simultaneously.

Two ion thrusters on the south face of Artemis

The RITA ion-propulsion thruster

The first few months, however, brought many new problems to be resolved, related to the daily passages through eclipse, tuning of engine performance, and experimentation with different attitude-control techniques to orientate the satellite for optimum propulsion from the engines. These activities took time and sometimes resulted in an interruption in effective thrusting, slowing progress. The greatest concern was the failure by July 2002 of three of the four ion-propulsion units. At that time Artemis was barely half way on its 5000 km route to GEO. The ensuing months were a very tense period, but the one remaining thruster unit continued to perform well, providing an average rate of climb of 15 km/day.

In evaluating the performance of the ion-propulsion system, we have to remember that two different, experimental technologies were being flown and tested in-orbit for the first time, and used in operational modes for which they had not been intended. In practice, all four ion thrusters worked successfully for periods ranging from a few hundred to several thousand hours, during which they exhibited a robust, stable performance and high efficiency. The three engines that failed did so for reasons unrelated to the fundamental ion-propulsion process or the design of the thruster assemblies (possible breakdown of high-tension insulation; sticking of a thruster flow-control valve). These anomalies are still under investigation, and those three thruster units may yet be reactivated. Still, the ion-propulsion subsystem has already operated for the equivalent of 4 years of geostationing lifetime, and the remaining operable thruster has so far logged no less than 6000 hours of in-orbit operation.

The Artemis experience therefore represents a major step forward for ion-propulsion technology, by dramatically demonstrating not only its impressive performance, but also the practicality of low-thrust orbital transfer. The feasibility of many of today's planned missions relies on ion propulsion and they have been eagerly awaiting the Artemis demonstration, albeit not in such a spectacular fashion!

The Commissioning Phase

When Artemis at last reached its assigned slot in geostationary orbit on 31 January 2003, there was hardly time for congratulations, let alone a well-deserved rest for the operations teams. Within hours of its arrival, the spacecraft had to be reconfigured for geostationary operations using new attitude-control laws and new operational procedures.

Although many spacecraft modes had been exercised during the recovery process, and although payloads had also been checked out, the most remarkable being the first optical data-relay link in November 2001 with SPOT-4 (reported in ESA Bulletin No. 108), Artemis had finally arrived in orbit just when a significant community of users was waiting for it. It was therefore imperative to complete formal commissioning and performance assessment as quickly as possible. An intensive measurement campaign was conducted using the test facilities at ESA's Redu station in Belgium, followed by interface tests with Artemis users. This campaign thankfully demonstrated that the spacecraft and its payload were both performing according to specification.

The 50 Mbps optical data-relay link with SPOT-4 was again established with the same high quality achieved in November 2001. The particularly exacting 100 Mbps Ka-band data-relay link with Envisat was also acquired at the first attempt and image transmissions and subsequent tests have shown this link to be of very high quality. The first Ka-band and S-band links between Artemis and NASDA's ADEOS-II satellite were also realised first time without a problem, and the whole test plan with ADEOS was completed within three days.

Upon completion of these commissioning tests, formal reviews have been held and Artemis has been declared fully operational and cleared for routine service operations starting in April 2003.

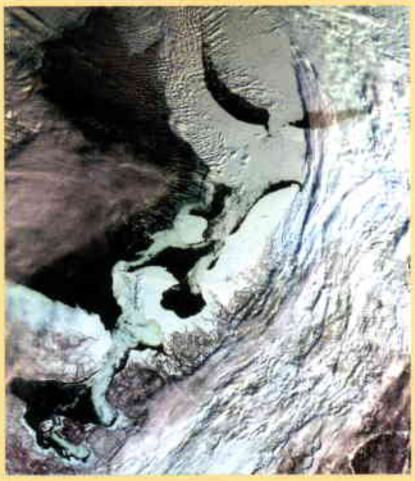
The Services Provided by Artemis

Data-Relay Services

Routine use of the data-relay links by SPOT-4 and Envisat started in April.

SPOT-4 will make operational use of the SILEX payload to transmit high-resolution image data via Artemis to the SPOT Image data-processing centre in Toulouse (F). Several optical passes per day will be used. Occasional use will also be made of the S-band data-relay link for SPOT-4 telemetry reception at the SPOT-4 Control Centre.

Envisat will use up to two Ka-band channels with one link every orbit. Its global, background, ASAR and MERIS instrument data will be transmitted via Artemis to the Envisat data-processing centre at ESRIN in Frascati (I).



Space-based data relay offers a number of benefits to Earth-observation missions: longer contact times, real-time transmissions, higher volume of data, improved reliability, and greater flexibility of data selection. When the first real-time images are received in Europe following an environmental incident, the full potential of data relay will be apparent. Data-relay users need extensive in-orbit experience with this new form of data collection to adapt their control and operations philosophy, and the future of European data relay will very much depend on the Artemis experience.

Other users planning to the Artemis data-relay services are the Automated Transfer Vehicle (ATV) and Columbus element of the International Space Station (ISS).

Land-Mobile Services

From April until the end of the year, the L-band payload of Artemis will carry the European Mobile System (EMS) service provided by Telespazio/Eutelsat. This provides low-data-rate and voice services to small mobile users (trucks, boats). It is expected that under future contracts the volume of the service will steadily increase to take advantage of the greater capacity of the Artemis payload.

Navigation Service

The European Geostationary Navigation Overlay Service (EGNOS) is currently in prototype operation using navigation transponders on Inmarsat satellites. The navigation payload on Artemis will be integrated into the EGNOS system in the course of 2003 without interruption of current service. When EGNOS goes live around April 2004, the Artemis transponder will form an invaluable element of the operational system, providing the additional coverage, precision and reliability needed to meet the system performance requirements.

Conclusion

The Artemis mission has encountered many programmatic and practical problems during its development, culminating with the unfortunate launch failure. Thanks, however, to the satellite's novel ion-propulsion and re-programmable onboard control technologies, and the ingenuity of its engineers, a unique recovery operation has been possible. As a result, the satellite is safely in orbit, having already fulfilled its technology demonstration mission admirably. Despite the long and arduous recovery action, Artemis is now ready, on time, to provide the services it was designed for, both demonstration and operational, with the potential to promote and stimulate further space-enabled data-relay activities in Europe.

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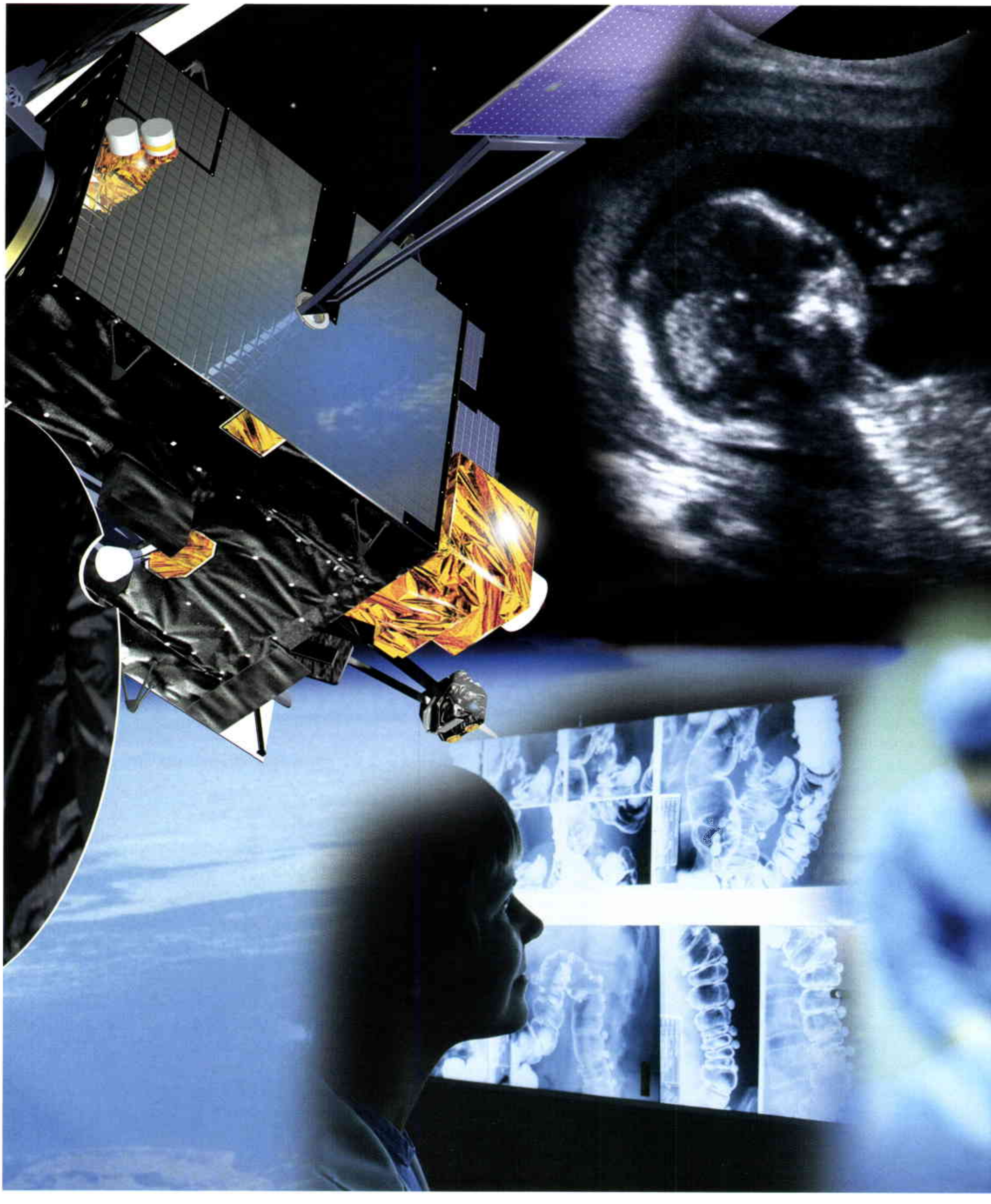
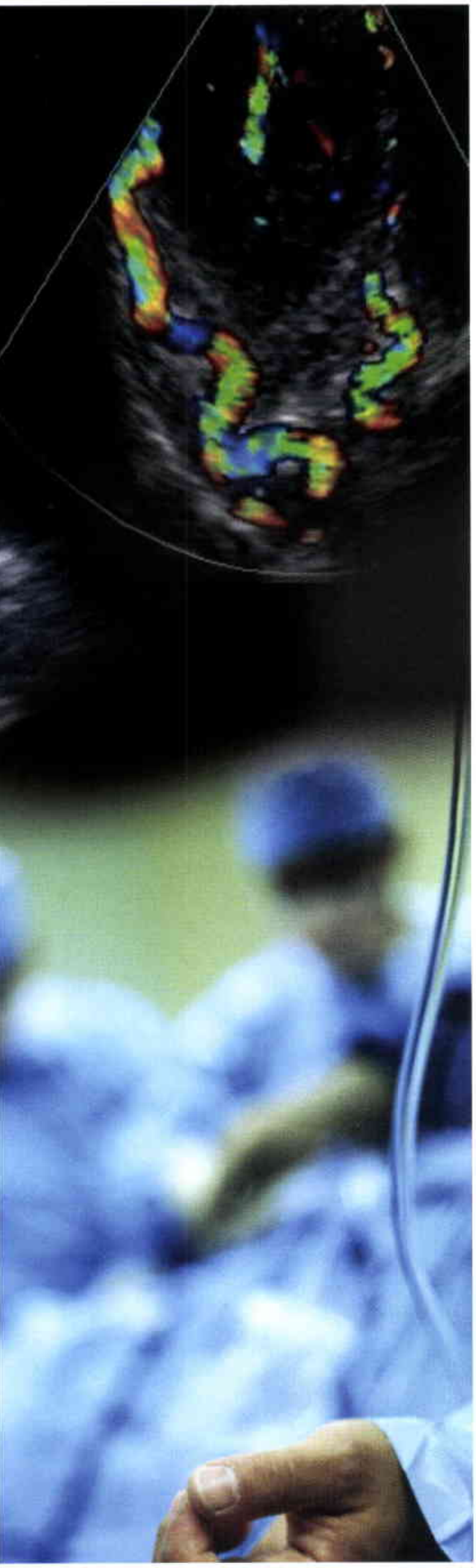




Medical Care from Space: Telemedicine

Francesco Feliciani
Telecommunications Department, ESA Directorate of Application Programmes, ESTEC, Noordwijk, The Netherlands

'Telemedicine' can be defined in various ways, but the underlying concept is based on the simple fact that, thanks to modern telecommunications links, diagnostic and therapeutic medical information can be passed between patient and doctor without either of them having to travel. Initially and for quite a long period, voice communication, via telephone or radio, was used to solicit the opinion of a doctor in the case of an emergency, but the potential of Telemedicine was boosted dramatically by the widespread introduction of modern information and communication technology (ICT) into the healthcare sector. Today we are at the point where the boundary separating Telemedicine and medical ICT is somewhat blurred. The prospect of using satellite communications technologies and associated connectivity services to support even wider application of the benefits of Telemedicine was the reason why ESA began actively pursuing activities in this challenging domain back in 1996.

Activities to Date

The opportunity for ESA to promote satellite communication in the field of Telemedicine with pre-operational systems first arose in 1996 when, in support of the humanitarian mission in the former Yugoslavia, a consortium of space industry and two major Italian hospitals asked the Agency to provide support in setting up a satellite-based pilot communication system between hospitals in Italy and a field hospital in Sarajevo. At that time, a videoconferencing system, developed a few years earlier in the context of the Agency's Olympus Utilisation Programme with associated Local Area Network connections, was installed. The possibility to exploit the expertise of medical specialists located hundreds of kilometres away helped to reduce the feeling of professional isolation experienced by the doctors in the field hospital, particularly when faced with medical problems that were new to them.

The Telemedicine system hosted at the Sarajevo field hospital was mainly used to support tele-consultations concerning both military and civilian patients, both on-line (e.g. live video conferences) and off-line (e.g. by sending medical images for later diagnosis). Thanks to the availability of satellite broadband connections (384 kbit/s to 2 Mbit/s), the system proved effective in providing video links with acceptable quality and speed to transfer medical images. Medical peripherals such as an X-ray scanner and cameras in the operating theatre were connected to the system, opening new ways to exploit the Telemedicine setup and to provide remote assistance.

In parallel with the tele-consultation activity, a group of doctors from the University of Sarajevo started to use the system as a learning platform, presenting and discussing clinical cases such as vitreo-retinal surgery techniques and pathology microscope images with medical teachers located in the hospitals on the Italian side.

After the initial running-in period, the system was progressively enhanced and new functions added in response to the explicit needs of the medical community. Two additional satellite terminals and the associated Telemedicine systems were added to the satellite network, one in Pec and one in Tirana. This method of working has been readily accepted, to the point where today, more than six years after the initial installation, the network of hospitals is still routinely using the system every week.

The field hospital in Sarajevo which hosted the ESA Telemedicine Facility from 1996 to 1999

The Contribution of ARTES

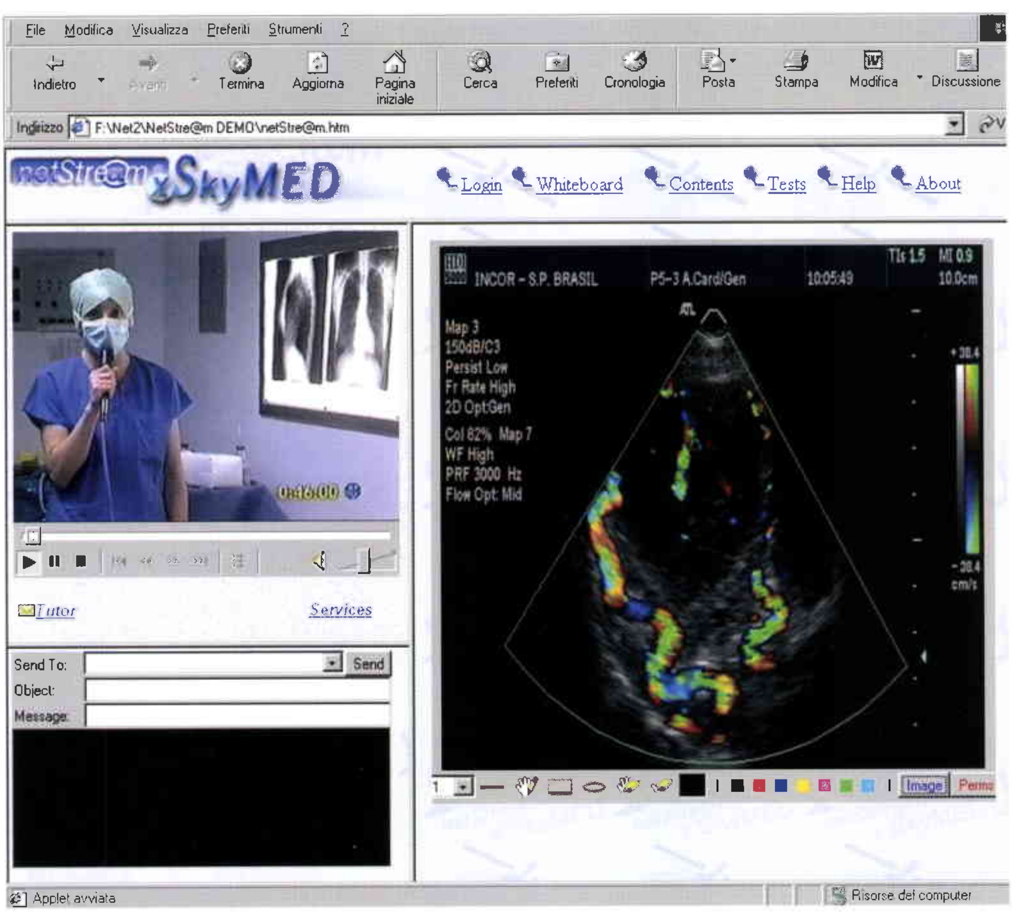
With the launch of the Multimedia Element of ESA's ARTES programme – Advanced Research in Telecommunications Systems, dedicated to promoting and enhancing the competitive position of European and Canadian industry and operators in the field of satellite-based multimedia – Telemedicine quickly became a hot topic for that part of the programme dedicated to the development and validation of innovative applications and services.

Between 1997 and 2002, 20 different projects have been undertaken within the ARTES programme to explore and promote the different facets of Telemedicine via satellite, taking a pragmatic approach (see accompanying table). These projects have been targeted at developing the hardware, software and content elements required by the specific Telemedicine applications and then using the resulting system in a pilot utilisation phase with real users and under truly operational conditions.

Telemedicine-related Projects initiated through ESA's ARTES Programme
(with participating countries in brackets)

- Broadband, Highly Interactive Applications: DELTASS - 3D Simulation component (F, D)
- Distributed Environment for Medical Simulation: MULTIMED (UK)
- Emergency Consultation: SECOM (UK), IEMN (CDN), MIST (CDN), DELTASS - Mobile Field Hospital and Search & Rescue component (F, D), TELANY - Emergency component (I, N), I-DISCARE (F, I, N)
- Tele-Consultation: SHARED (I), EUROMEDNET (I), RCST (CDN)
- Clinical Research: WEBGMS (I)
- Access to Patient Multimedia Data Base: HERMES (I), TELANY - Medtronic component (I, N)
- Continuing Medical Education: EMN (CH, D), SANTTSUR (UK), MAYFLOWER (I,N), SM@RT (I), SKYMED (I), HPS In-Surgery and In-Home (UK)

Project DELTASS: the portable terminal used by the Search & Rescue (SAR) teams to fill in the electronic patient record card. The link with the coordination centre is via the Globalstar satellite system



Project SKYMED: the multimedia interface used for the on-line distribution of a course on ambulatory surgery. The signal is transmitted via satellite using the Internet Protocol and DVB-S (Digital Video Broadcasting – Satellite) technology

The inherent global capabilities of satellites make them the most suitable tool for communication applications involving high mobility, emergency and disaster situations, broadband access from underserved areas, multicasting and dissemination of multimedia contents, high capacity and fast deployment for temporary use. For some of these applications, satellites are the only solution. A summary of the particular relevance of satellite communication for the different areas of Telemedicine is given in the accompanying table.

Towards Sustainable Telemedicine

An important aspect addressed by the Telemedicine activities hosted within the ARTES programme is the sustainability of the various operations after completion of the contract with ESA. In this respect, from the very early phase of the programme it was evident that these exploratory activities with new satellite-based applications and services could have ended up merely as demonstrations of new technologies, unable to progress beyond 'showcase' status. This risk is particularly relevant in the field of Telemedicine, where a number of operational, organisational and regulatory aspects have a strong influence on what has to eventually become accepted practice within a given healthcare system.

To prepare the different projects to deal with such a risk, strong emphasis was put on ranking the proposed opportunities on the basis of their strategic merits. In a very early phase, therefore, the projects were forced to face the question of how the initiative would be sustained following the completion of the contract with ESA. In pursuing this challenging objective, all of the Telemedicine-related projects have foreseen from the outset strong participation by the user community, as a representation of the target customer base to which the system will be exposed in the pilot utilisation phase.

Of course, a number of critical factors are still to be resolved before Telemedicine can be deemed a consolidated opportunity, of which three seem to play a major role. The first is the lack of coordinated and solid regulation at international level concerning Telemedicine services. The second is the fact that costs incurred for accessing Telemedicine services are not eligible for reimbursement by the national healthcare systems (with very few exceptions, such as Norway). The third is the lack of a clear process of certification for distance-learning systems, to validate the credits required by the Continuing Medical Education programmes, which are becoming mandatory in many countries.

It is only matter of time before these questions will be sorted out, by which time the mechanism, the technologies and the services for Telemedicine must be in place. This is why ESA's role is both crucial and timely in providing the opportunity for such ventures through its ARTES programme.

Some Lessons Already Learned

Although each ARTES project explores a particular strategic opportunity in Telemedicine, a number of recurring critical features would seem to characterise the current situation of Telemedicine as a whole. They can be summarised in terms

Satcom Aspects / Telemedicine Areas	High Mobility Communications in Emergency and Disaster Situations	Broadband Access from Underserved Areas	Multicasting/ Dissemination of Multimedia Contents	High Capacity/Fast Deployment for Temporary Use
Broadband, Highly Interactive Applications		+	+	++
Distributed Environment for Medical Simulation			++	++
Emergency Consultation	++	+		+
Teleconsultation		++		++
Clinical Research			+	
Access to Patient Multimedia DataBases	+	++		
Continuing Medical Education		+	++	

Relevance of satellite communications in different areas of Telemedicine: + important, ++ decisive of the following lessons learned:

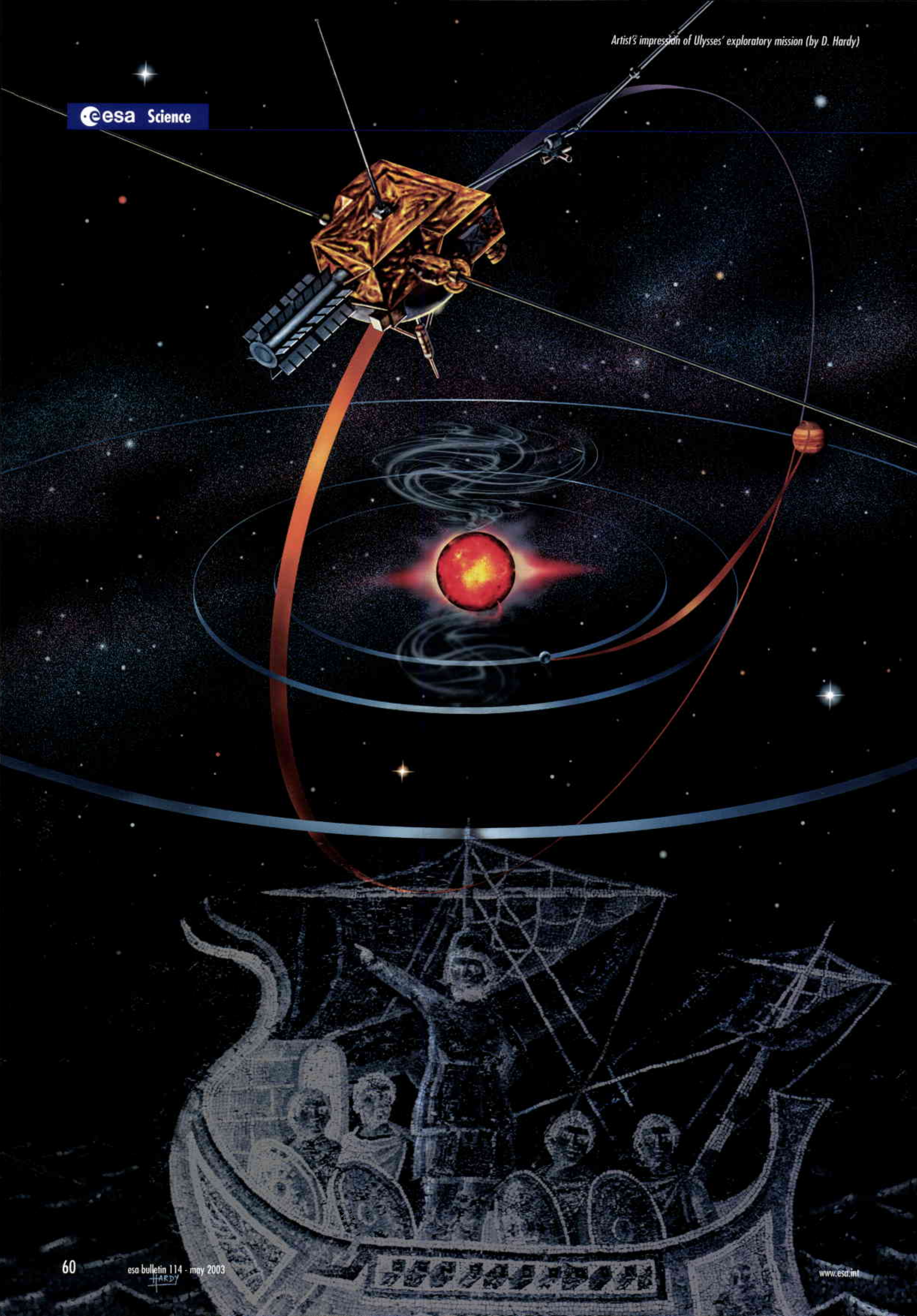
- Telemedicine is still at an early stage of maturity. The process of gathering the user requirements has in many cases to be assisted by a process of awareness-building devoted to preparing the user community for making the most of the Telemedicine opportunity.
- Telemedicine brings changes in the organisational environment of any health-care system. As these systems are often already very complicated, Telemedicine can be successfully introduced only if conceived and proposed in a proper context, and not imposed on the basis of a technological push.
- In essence, Telemedicine is primarily an information flow between healthcare professionals. As such, it should not try to impose new communication paths, but rather enhance and empower the existing ones.

The Next Step

Telemedicine is an innovative field of application where satellite communications can play an important role, and where associated technology, applications and services can quickly be turned into concrete benefits for mankind. In this respect, the several activities launched within ESA and the European Union have already contributed to the process of bringing Telemedicine from demonstration to operational reality. Such realities have not only to coexist with, but also to become part of the 'traditional' healthcare system.

The integration of Telemedicine into the working environment of healthcare professionals can only be pursued though an intensive process of awareness building among the user community and the stakeholders in the healthcare system. The projects launched so far have provided a valuable contribution in this direction and have allowed us to identify and explore new technical solutions and applications with the clear potential to become part of the future Telemedicine practices.

ESA Telecom is continuing to play an active role in encouraging and promoting the use of satellites for Telemedicine. A Symposium at ESRIN in May 2003 will bring together communications specialists and healthcare professionals to review the current status of satellite-based Telemedicine services and technologies in monitoring, diagnosis, therapy and medical education, and to identify possible guidelines that should be taken into account in defining future programmatic actions for the further development of Telemedicine via satellite.



Artist's impression of Ulysses' exploratory mission (by D. Hardy)

News from the Sun's Poles Courtesy of Ulysses

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True to its classical namesake in Dante's Inferno, the ESA-NASA Ulysses mission has ventured into the 'unpeopled world beyond the Sun', in the pursuit of 'knowledge high'!

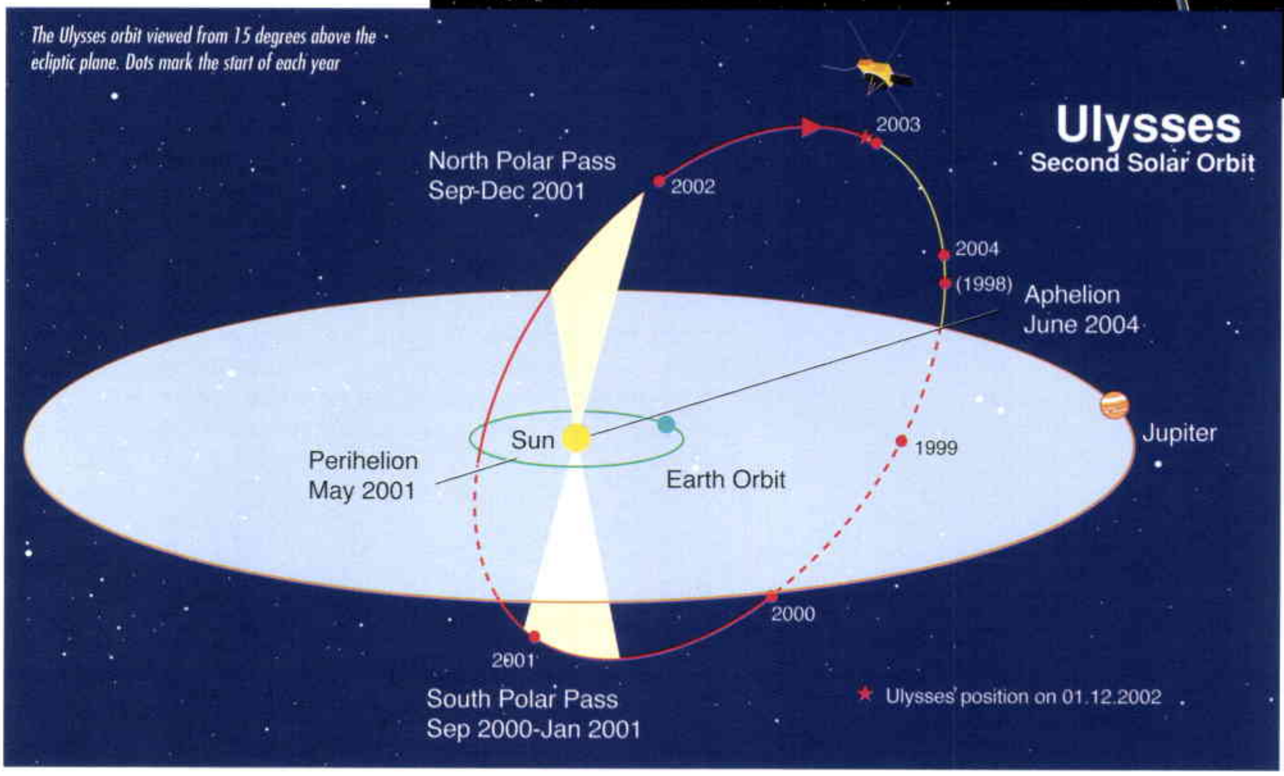
Introduction

Launched from Cape Canaveral more than 13 years ago, Ulysses is well on its way to completing two full circuits of the Sun in a unique orbit that takes it over the north and south poles of our star. In doing so, the European-built space probe and its payload of scientific instruments have added a fundamentally new perspective to our knowledge of the bubble in space in which the Sun and the Solar System exist, called 'the heliosphere'.

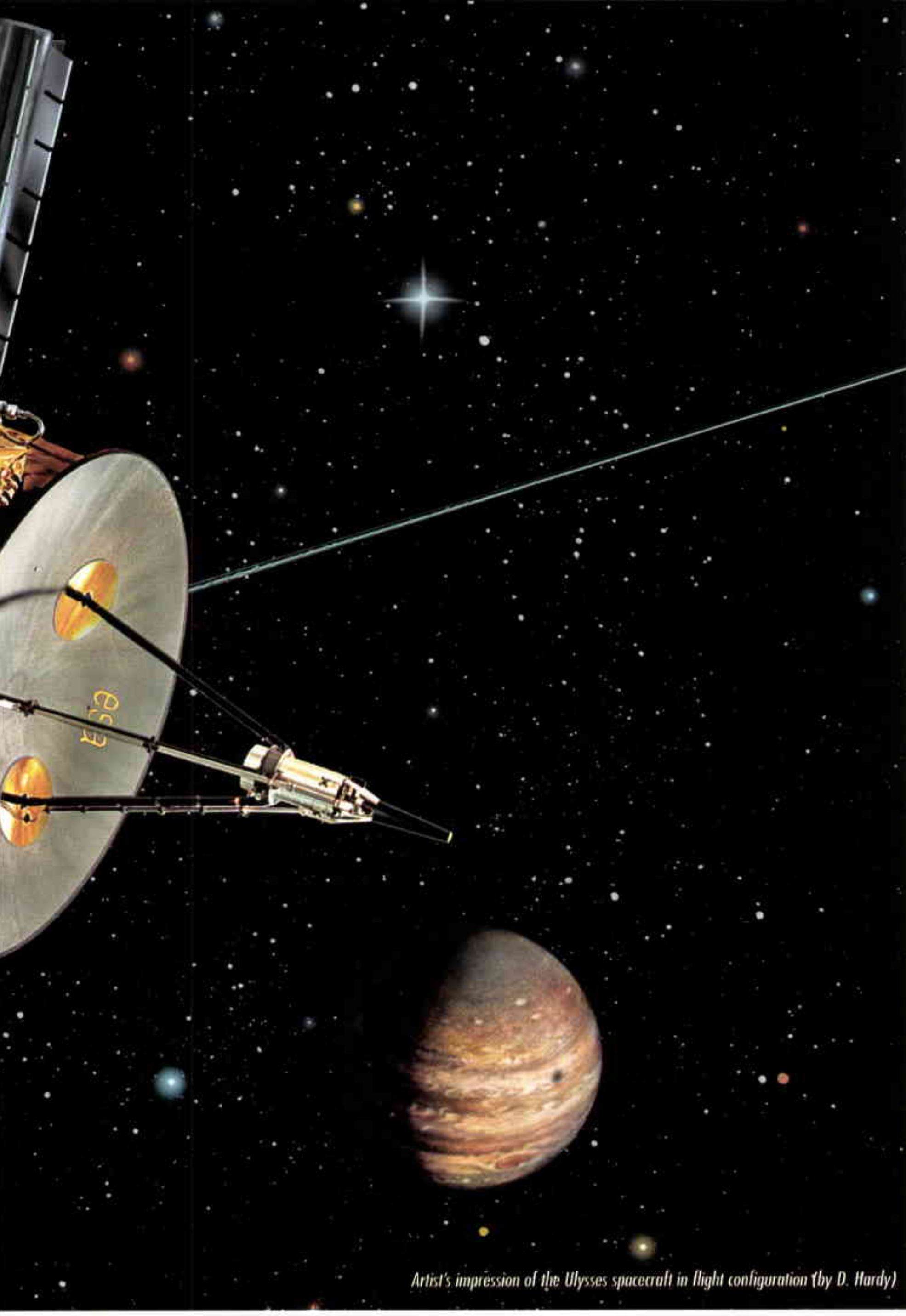
A small spacecraft by today's standards, Ulysses weighed just 367 kg at launch, including its scientific payload of 55 kg. The nine scientific instruments on board measure the solar wind, the heliospheric magnetic field, natural radio emission and plasma waves, energetic particles and cosmic rays, interplanetary and interstellar dust, neutral interstellar helium atoms, and cosmic gamma-ray bursts. The Ulysses science team responsible for the instruments is truly international, with investigators from many European countries, the United States, and Canada.

Following its initial exploration of the solar polar regions in 1994-95, when the Sun was in its most quiescent state (known as 'solar minimum'), Ulysses returned for a second look in 2000-2001. This time, however, solar activity had reached the peak ('solar maximum') in its 11-year cycle, presenting scientists with a unique chance to compare conditions at these two extremes in stellar behaviour.

With a journey of well over 6.5 billion kilometres already under its belt, the intrepid European-built Ulysses spacecraft is still in excellent health, and continues to deliver first-class science.



The Ulysses orbit viewed from 15 degrees above the ecliptic plane. Dots mark the start of each year



Artist's impression of the Ulysses spacecraft in flight configuration (by D. Hardy)

History of the Mission

This joint ESA-NASA collaborative mission, the first ever to fly over the poles of the Sun, was launched by the Space Shuttle 'Discovery' on 6 October 1990, using a combined IUS/PAM-S upper-stage to inject the spacecraft into a direct Earth/Jupiter transfer orbit. Arriving at Jupiter in February 1992, Ulysses executed a gravity-assist manoeuvre that placed it in its final Sun-centered, out-of-ecliptic orbit. With a period of 6.2 years, the orbit is inclined at 80.2° to the solar equator, the perihelion (point of closest approach to the Sun) is at 1.3 AU (1 Astronomical Unit is the mean Sun-Earth distance, equal to 150 million km), and the aphelion at 5.4 AU (the most distant point in the orbit).

Ulysses' primary objective is to explore the heliosphere in four dimensions: three spatial dimensions plus time. Although Ulysses has made ground-breaking discoveries at many points along its unique trajectory, the 'polar passes' (the segments above 70° heliographic latitude in each hemisphere) have attracted special interest. The first such passes took place in 1994 (south) and 1995 (north), as the Sun's activity was approaching a minimum. Ulysses arrived over the Sun's south polar regions for the second time in November 2000. Solar activity reached its maximum in 2000, so that Ulysses experienced a very different environment from the one it had encountered during the first high-latitude passes.

With the completion of the second northern polar pass in December 2001, Ulysses provided the first, and for the forseeable future only, survey of the high-latitude heliosphere within 5 AU of the Sun over the full range of solar activity conditions. The spacecraft is currently heading away from the Sun once again, on its way towards aphelion at the end of June 2004.

The results from the first set of polar passes, in 1994-95, have been described in earlier Bulletins (e.g. ESA Bulletin 103, pp. 41-47), and in particular in the recent book 'The Heliosphere Near Solar Minimum: the Ulysses Perspective' (published by Springer-Praxis). We therefore focus here on just a few of the scientific highlights from the recent 'solar maximum mission'.

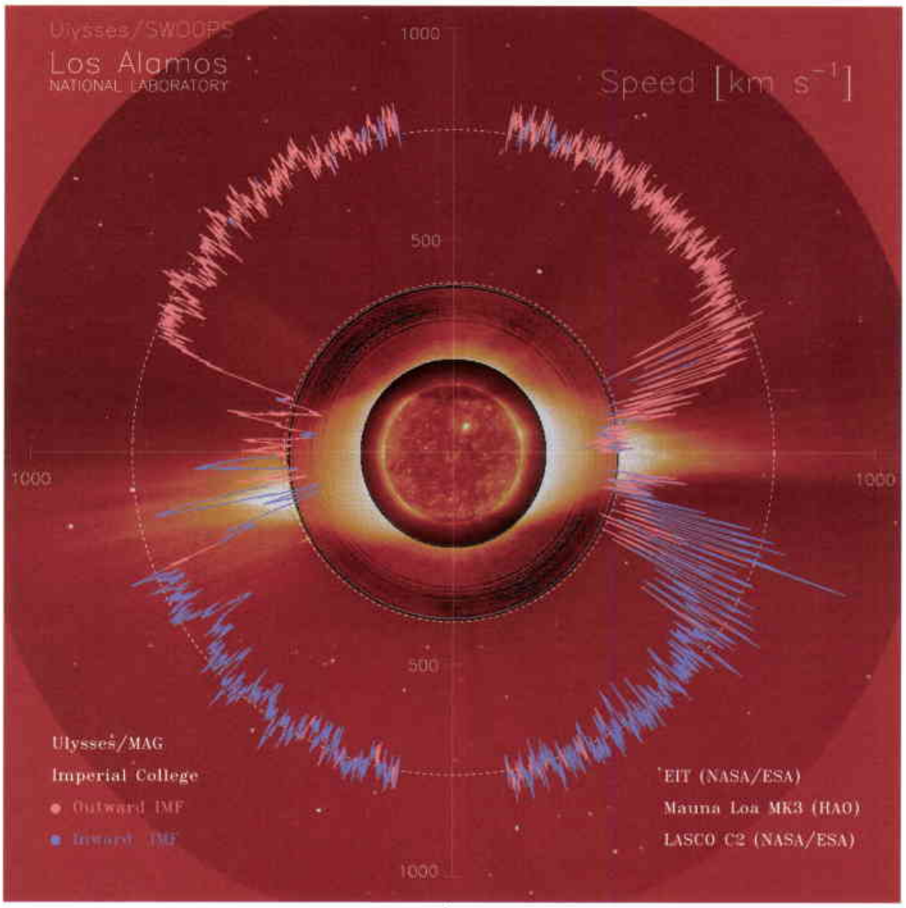
Scientific Highlights

Solar wind and magnetic field

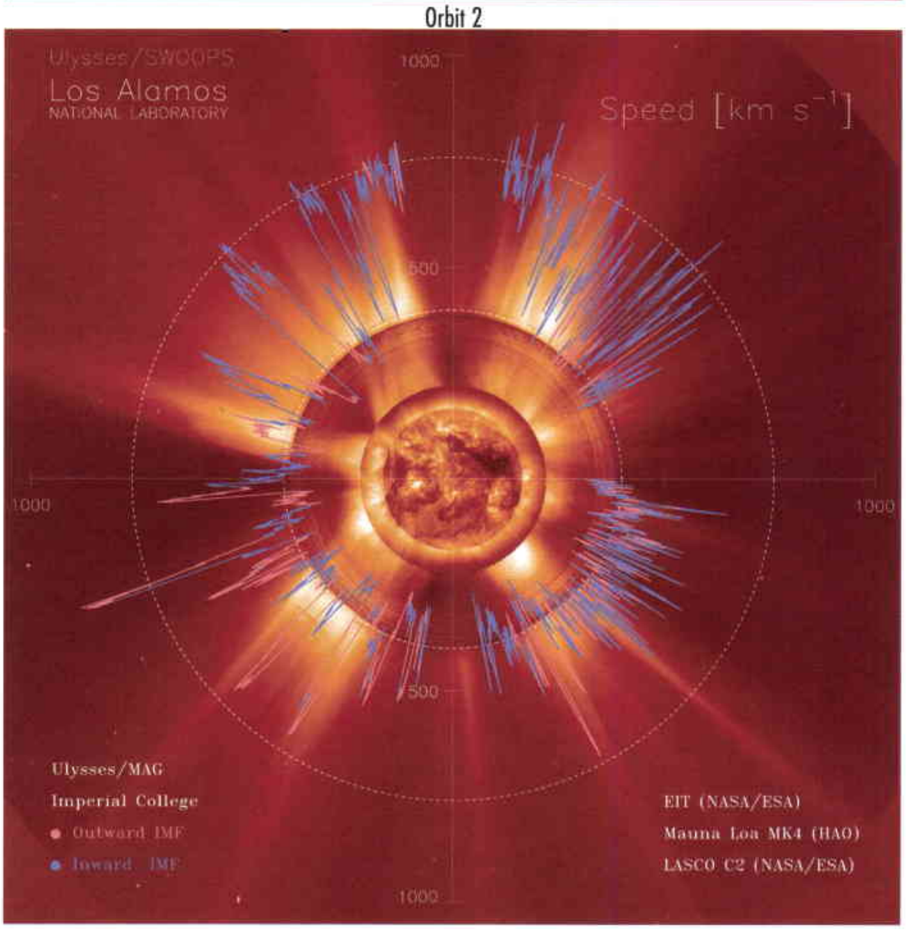
Ulysses' exploration of the solar wind and its physical characteristics – speed, temperature and composition – during maximum solar activity has revealed an entirely different configuration from that observed near solar minimum. Then Ulysses found a heliosphere dominated by the fast wind from the southern and northern polar coronal holes* (not unlike the Earth's ozone holes), but during solar maximum those large polar coronal holes had disappeared and the heliosphere appeared much more symmetrical. The solar wind flows measured throughout the south polar pass, and much of Ulysses rapid transit from south to north, showed no systematic dependence on latitude. At all latitudes, the wind itself was generally slower and much more variable than at solar minimum.

** Coronal holes are extended regions in the Sun's atmosphere, or corona, that appear dark in X-ray images of the Sun (hence the name). This is because they are cooler, and less dense, than the surrounding corona. Coronal holes are largest and most stable at or near the solar poles, particularly near solar minimum, and are known to be the primary source of high-speed solar wind.*

Orbit 1



Orbit 2

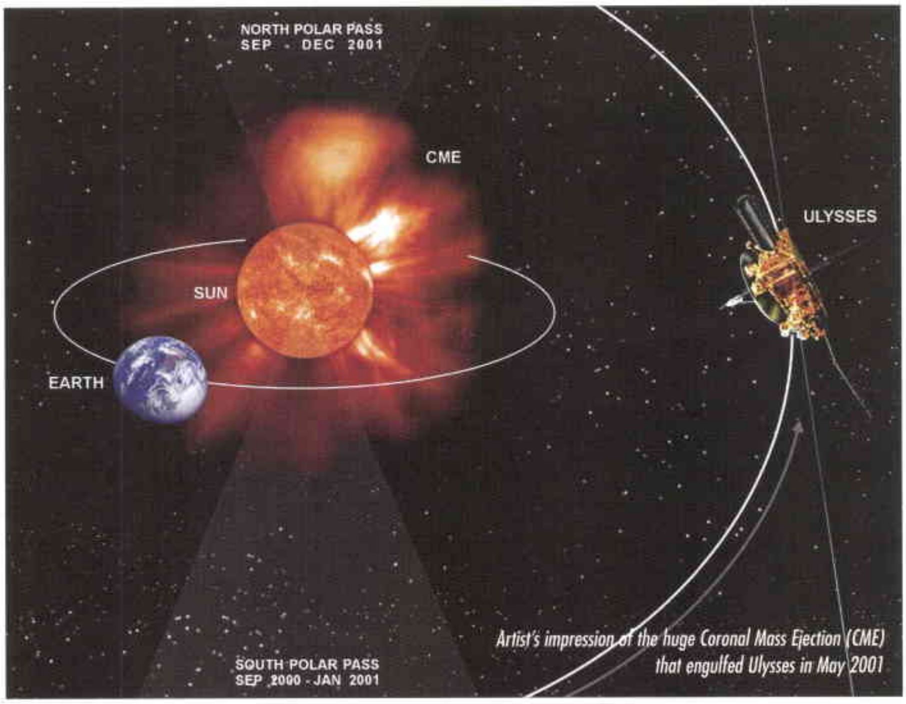


A comparison of solar-wind observations during the first (solar minimum) and second (solar maximum) orbits. The coloured traces show solar-wind speed as a function of Ulysses' latitude, against a background image of the Sun from SOHO/EIT/LASCO (Courtesy of D.J. McComas, SWRI / P. Riley, SAIC)

When Ulysses reached high northern latitudes in late 2001, however, it witnessed the formation and growth of a new polar coronal hole. This clearly marked the start of a return to more stable conditions. The solar wind became faster and more uniform, resembling the flows seen over the Sun's poles at solar minimum. By the end of 2001, regular excursions into variable, slower wind were once again the order of the day for Ulysses. The explanation for these differences can be found in the fact that the Sun had only just begun its transition to more stable conditions during the second northern polar pass, whereas solar-minimum-like conditions were already well-established in 1994/95.

A characteristic feature at times of enhanced solar activity is the frequent occurrence of so-called 'Coronal Mass Ejections, or CMEs'. These violent eruptions from the Sun are often associated with solar flares, and are one of the principal drivers of 'space weather' (on which there is an article elsewhere in this Bulletin). A typical CME can involve as much as 10 million million kg of ionized gas – equivalent to 25 million fully-loaded 747 jumbos! – travelling away from the Sun at speeds up to 1000 km/sec. When a fast-moving CME encounters the Earth's magnetosphere, the latter becomes compressed, resulting in magnetic storms that in turn are the source of many space-weather effects. A CME-driven shock wave that swept past over Ulysses in May 2001 was responsible for the most intense interplanetary magnetic field, and highest solar wind density, ever observed by the spacecraft.

The development of the global solar-wind characteristics discussed above was reflected in Ulysses' magnetic-field observations. One of the many questions that has been investigated is how the high solar activity level affected the structure and dynamics of the heliospheric magnetic field. Although the solar magnetic field, corona and solar wind were highly variable, the magnetic field at Ulysses



Artist's impression of the huge Coronal Mass Ejection (CME) that engulfed Ulysses in May 2001

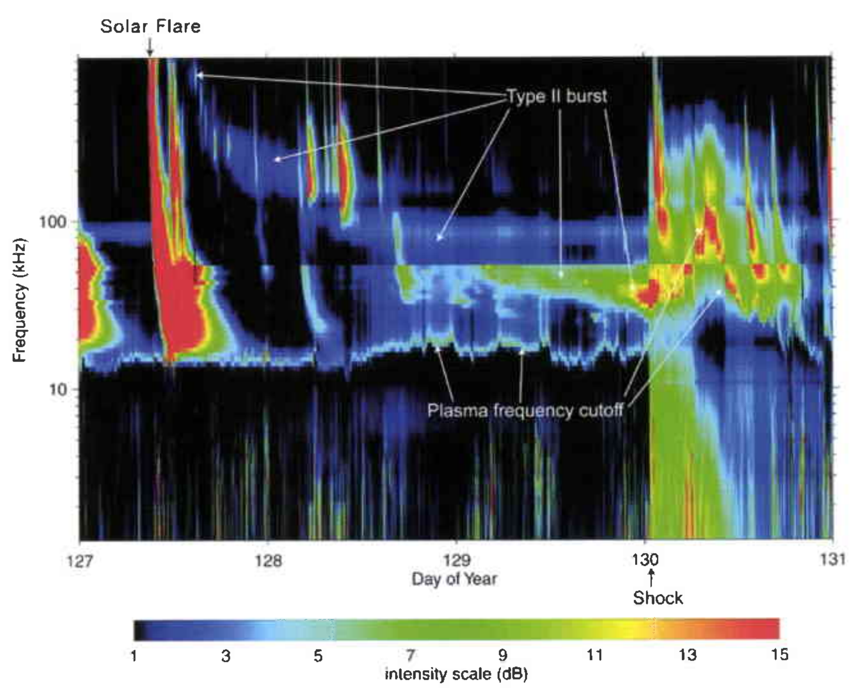
(~1.5 – 2.5 AU from the Sun) maintained a surprisingly simple structure, rather like a bar magnet. In contrast to the situation at solar minimum, however, the equivalent magnetic poles were located at low latitudes rather than in the polar caps. This is consistent with the presence of coronal holes near the Sun's equator, and their absence at the poles. The spreading out of the field lines from these equatorial sources to high latitudes, in turn, caused the solar wind to be deflected poleward.

Another phenomenon of great interest was the reversal of the Sun's magnetic polarity that occurred during the 2000 and 2001 polar passes. It was found that the reversal process is a complex one that takes several months, while the corona evolves to reflect the changes occurring at the Sun's visible surface, or 'photosphere'. This meant that although ground-based observations showed that the reversal of the surface magnetic field in the southern polar cap had already taken place when Ulysses was at high southern latitudes, the heliospheric field measured at the spacecraft still had the 'old' (negative) polarity. A year later, when Ulysses reached high northern latitudes, both the surface and heliospheric magnetic fields had the same 'new' (negative), polarity. Presumably, the newly formed fields in the south polar cap had not yet been carried out into space by the solar wind, suggesting that the open fields measured by Ulysses in fact originated at lower latitudes. In contrast, the polar cap fields in the north had evolved sufficiently by the time Ulysses was at high northern latitudes for them to be carried out by the fast solar wind.

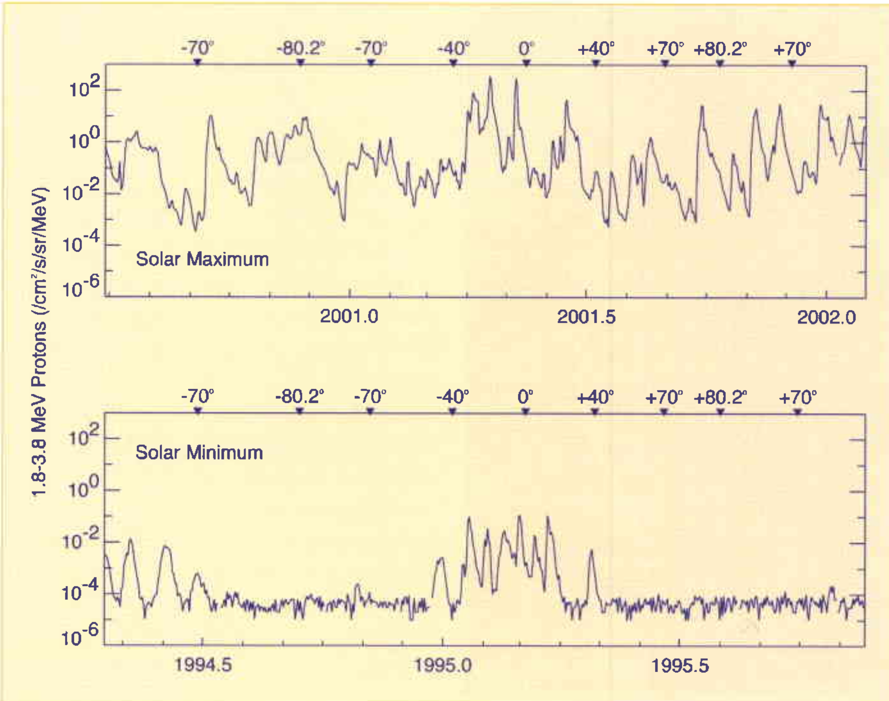
Energetic particles

One of the key discoveries made during the high-latitude passes of Ulysses at solar minimum was the unexpected ease with which energetic charged particles, mainly protons, were able to gain access to the polar regions of the heliosphere. This was surprising because the source of these particles was known to be confined to much lower latitudes. This discovery prompted theorists to re-assess existing models of the heliospheric magnetic field, and even led to new suggestions regarding the source of the solar wind itself. An obvious question, then, when Ulysses returned to high latitudes at solar maximum, was: Do energetic particles have the same easy access when the heliosphere is much more chaotic? Ulysses provided an unequivocal answer: Yes. In fact, the intensity profiles of energetic particles recorded at all latitudes were very similar to measurements made near the Earth, close to the solar equator.

Scientists knew that the source of energetic particles at solar maximum and



Radio and plasma wave measurements of the May 2001 Coronal Mass Ejection (CME) (Courtesy of R.J. MacDowall, GSFC)



Energetic-particle flux at solar maximum and solar minimum. In the lower panel, energetic particles are generally absent above ± 40°. The periodic flux increases on the left-hand side are part of a long sequence that began at the Sun's equator and extended to the south polar cap. No such increases are seen in the northern hemisphere. By contrast, at solar maximum (upper panel), elevated fluxes are present at all latitudes

solar is not the same. As noted earlier, fast CME-driven shock waves give rise to the numerous large increases in particle flux that are characteristic of solar maximum. In addition to revealing the presence of large fluxes of energetic particles over the poles, the Ulysses measurements indicate that the number of these particles in many events is comparable to that measured simultaneously in the ecliptic near 1 AU. This has led to the idea of the inner heliosphere near solar maximum acting as a 'reservoir' for solar energetic particles.

The precise mechanism by which the particles fill this reservoir is still being debated. It is certainly different from that in operation at solar minimum. Whatever the mechanism, however, Ulysses has shown that energetic charged particles can gain access to all regions of the heliosphere during all phases of the solar cycle far more easily than expected. This in turn has consequences for our ability to predict the 'space weather' that astronauts venturing far away from Earth are likely to encounter.

Cosmic rays

Galactic cosmic-ray particles moving through the heliosphere are affected by a combination of processes that include scattering by small-scale twists and turns in the heliospheric magnetic field, and drift motions caused by the large-scale pattern of field lines. The direction in which the cosmic rays drift depends on the electric charge carried by the particles, and on the Sun's magnetic polarity.

At the time of the Ulysses solar-minimum high-latitude passes, the Sun's field was such that the predicted flow direction of positively charged cosmic-ray particles entering the heliosphere was inward over the poles. By the same token, these particles were predicted to leave the heliosphere along the helio-magnetic equator. Under these conditions, Ulysses was expected to observe more cosmic-ray nuclei over the poles. Such an increase was indeed found, but was smaller than expected, suggesting that charged particles of all energies are less restricted in their motion by the heliospheric magnetic fields than previously thought.

With the Sun returning to a more stable state following the solar-maximum activity, the associated reversal of the dominant magnetic field polarity provides a unique opportunity to test our understanding further. Now we expect positively charged particles to flow into the heliosphere along the helio-magnetic equator, and be transported outward via the poles. There should be fewer cosmic-ray nuclei at high latitudes than near the equator. The expectation is that these patterns will soon become established, enabling Ulysses to add another chapter in the investigation of global particle transport in the three-dimensional heliosphere.

Local Interstellar Medium

Ulysses science does not focus exclusively on the Sun. Observations made by the instruments on board have also added significantly to our knowledge of the Interstellar Medium (ISM) surrounding the heliosphere. The Sun has recently entered a rather small, but relatively dense, warm cloud – the Local Interstellar Cloud or LIC – with profound consequences for Earth that are not yet fully understood. The physical characteristics of the LIC have a strong influence on the heliosphere, determining its size and shape, and Ulysses is unique in having the right orbit and instruments to measure the properties of this LIC gas. The Ulysses GAS instrument, for example, provided the first and most comprehensive direct measurement of interstellar helium. As a result, we now know precisely the relative velocity between the Sun and the LIC (26.4±0.5 km/sec), the temperature of the LIC gas (6480±400 K), and the density of interstellar neutral helium (0.015±0.002 cm^{-3}). On an even grander scale, measurements of the chemical and isotopic composition of the LIC permit us to make inferences about the history of the Universe.

Other Results

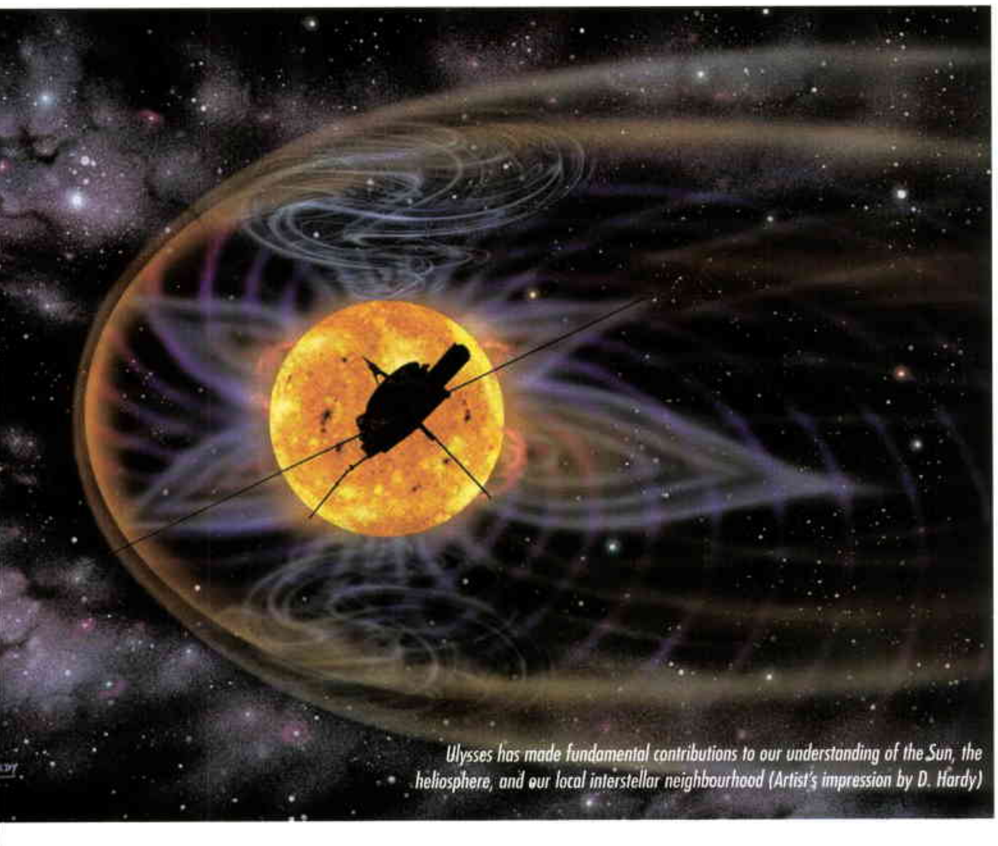
The above highlights represent only a small fraction of the new scientific insights being provided by the unique data sets acquired by Ulysses' instruments. Other areas of research to which the mission is making valuable contributions include the search for the origin of gamma-ray bursts, the nature of the interstellar dust grains that enter the heliosphere, and the source of the solar wind itself.

In all of these areas, the combination of a unique orbit that takes the spacecraft to high latitudes and also allows it to 'dwell' for extended periods at distances of several AU from the Sun, and the technical excellence of the scientific instruments on board, makes Ulysses a remarkable research tool. Add to this the unprecedented data coverage provided (a better than 95% average throughout the mission), and it is clear that the mission to date can be qualified as an outstanding success. This success has been augmented in recent years by the role that Ulysses plays in both the interplanetary network of gamma-ray detectors, and especially within the fleet of solar and solar-terrestrial missions that includes SOHO, ACE, Wind, and Voyager-1 and 2. Many multi-spacecraft studies rely on Ulysses' unique capabilities.

The Future

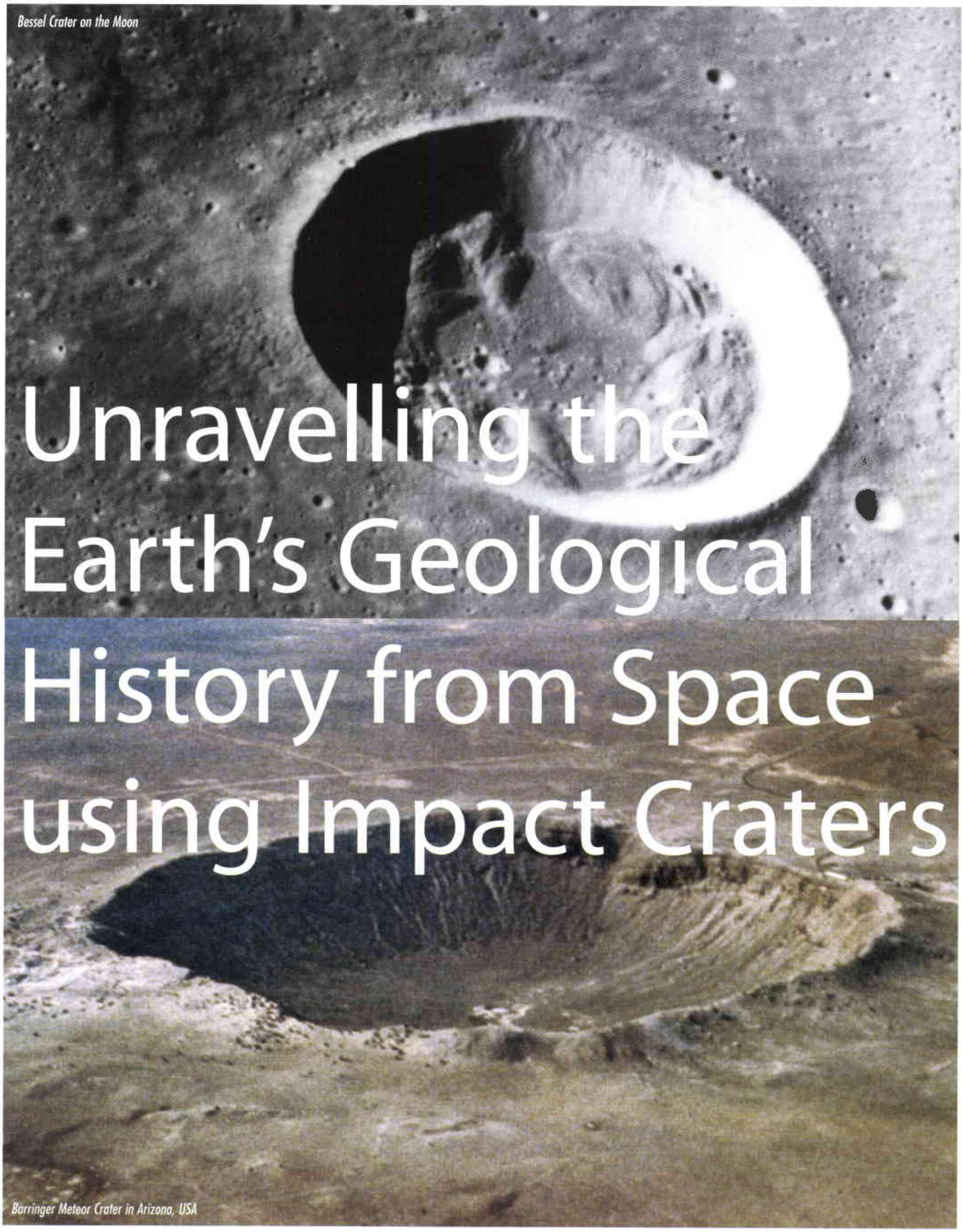
The Ulysses mission was originally foreseen to end in October, 1995. Owing to the outstanding scientific success, and equally, to the robustness of the spacecraft and its scientific payload, ESA and NASA have already approved two mission extensions. The first, until December 2001, enabled comprehensive observations to be made over the Sun's poles at both solar minimum and solar maximum. The second, with funding for spacecraft operations until September 2004 and archiving activities within ESA until December 2006, is providing the opportunity to observe the initial effects on the global heliosphere of the Sun's magnetic-field reversal.

So what does the future hold for Ulysses? Many questions still remain to be answered concerning the heliosphere and its many constituents. Plans for follow-up missions to Ulysses exist, in particular ESA's Solar Orbiter. With a likely launch in 2011-2012, Solar Orbiter will extend the range of out-of-ecliptic measurements to include imaging and spectroscopy of the Sun's polar regions, but from lower latitudes than Ulysses. On the NASA side, a mission called Telemachus (son of Ulysses) is being studied, which will also carry remote-sensing instruments and will use the same Jupiter flyby technique as Ulysses to reach the highest latitudes, but with perihelion much closer to the Sun (0.2 AU). If approved, Telemachus will be launched in the 2010-2015 time frame. In the meantime, Ulysses remains the only spacecraft able to sample the Sun's environment away from the ecliptic plane.


Ulysses has made fundamental contributions to our understanding of the Sun, the heliosphere, and our local interstellar neighbourhood (Artist's impression by D. Hardy)

Global coverage of the inner heliosphere between the Sun and the Earth is a key element of the recently launched International Living With a Star (ILWS) initiative, the principal goal of which is to stimulate, strengthen and coordinate space research in order to understand the processes governing the Sun-Earth system as an integrated entity. Among the space missions expected to make major contributions to ILWS is NASA's STEREO, planned for launch in December 2005. By putting two space probes at different locations in the ecliptic plane, in heliocentric 1 AU orbits that will lead and trail the Earth, the STEREO mission, together with Ulysses at high latitudes, could form part of a valuable ILWS network to further extend our three-dimensional studies of the heliosphere. Such a network would also include SOHO, and possibly NASA's ACE spacecraft.

Even without this network, there are many important contributions to our knowledge of the heliosphere that only Ulysses, with its extended record of continuous observations, and unique orbit, can make. From a technical point of view, extending the mission beyond 2004 with a core payload able to acquire a meaningful set of scientific measurements is a possibility. To this end, the NASA project has submitted a proposal for review by the Sun-Earth Connections Senior Review panel in mid-2003. If successful, this could open the way to a continuation of the epic journey on which Ulysses set out in October 1990, with the possibility of a third set of polar passes in 2007/2008. esa



Bessel Crater on the Moon

Barringer Meteor Crater in Arizona, USA

USGS

Unravelling the Earth's Geological History from Space using Impact Craters

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Magellan/NASA

Mead Crater on Venus (diam. 200 km)

Why are Impact Craters of Fundamental Importance?

Impact craters are ubiquitously present on the Earth, the Moon and Solar System's planets. Logically, therefore, the identification of impact craters can help us deepen our knowledge of the geology of the Earth in the context of our Solar System. The terrestrial cratering record is unique in providing a detailed picture of the history of our Solar System over the last few billion years, as well as its celestial environment. The search for the scars of ancient cosmic impacts is therefore of fundamental importance from both the astronomical and geophysical points of view. Firstly, we can obtain an estimate of the flux and size distribution of the impactors – meteoroids, asteroids, comets – that have hit Earth during the last few billion years. Secondly, the identification of impact craters can improve our detailed geological knowledge of the Earth's surface.

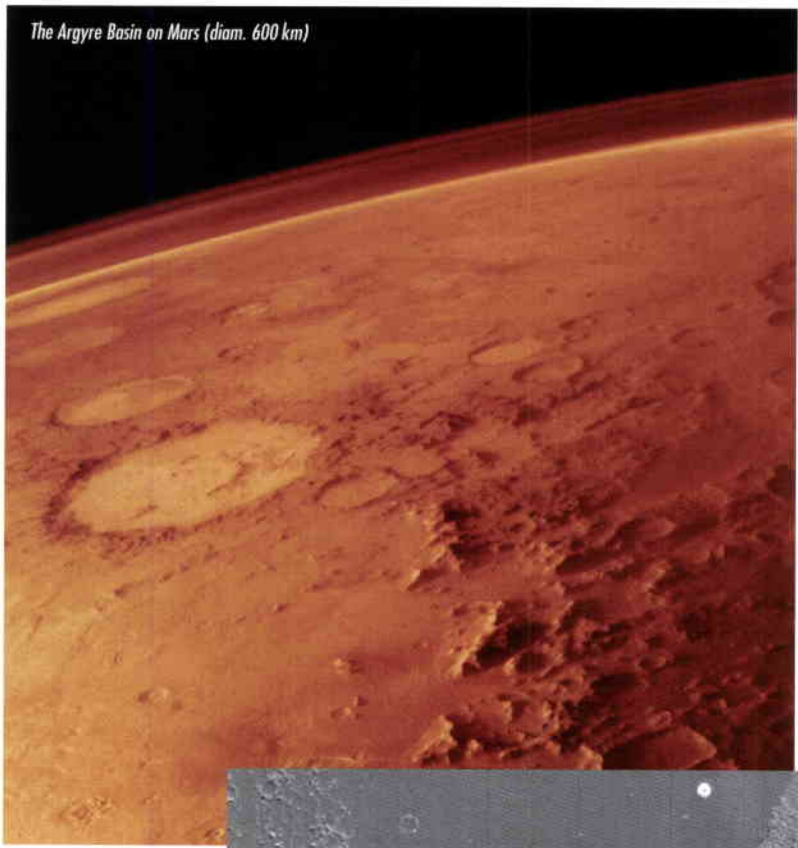
Impact Craters in the Solar System

Impact craters are the geological structures formed when a large meteoroid, asteroid or comet hits the surface of a solid planetary body. Impact cratering has marked the surfaces of all these bodies over the last 4.5 billion years and given them their most characteristic features. During this period, the Earth has been hit by countless asteroids, comets and meteoroids. Study of the resulting impact craters is an important field of space-science research, as they constitute an important link between planetary studies and geoscience (geology, geophysics, geochemistry) investigations of our own planet.

Impact craters occur throughout the Solar System and they hold precious information about the impacting body, about the surface conditions of the impacted body at the time of the collision, and also about the body's interior if the crater is sufficiently deep. Rather than being just passive remnants of planetary collisions, impact events have driven the geological evolution of many solid planetary bodies, especially in the early days of the Solar System.

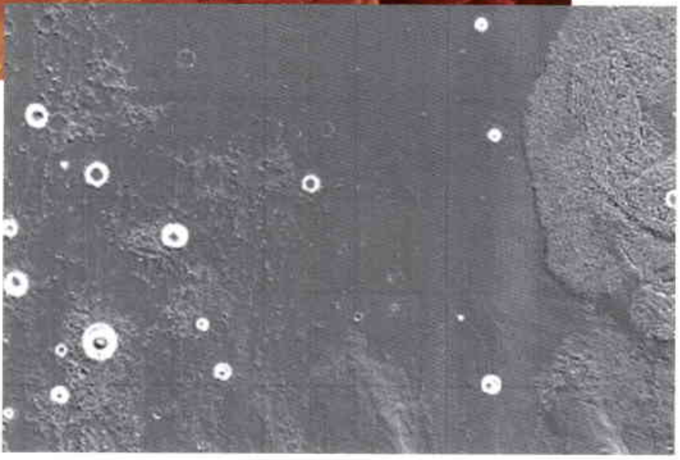
Following the condensation of the primitive solar nebula and the accretion of the different planetary bodies, a period of heavy bombardment followed, which lasted until about 3.9 billion years ago. The surface of the far-side of the Moon, for example, is covered with craters of all sizes, produced by a cratering rate perhaps 100 times higher than today. All of the planetary bodies have experienced bombardment, but only those having solid surfaces still show the scars of even minor body collisions throughout the lifetime of the Solar System.

However, the impression left by the first Mars fly-bys was somewhat disappointing since the images sent back were morphologically similar to those of the Moon. These observations covered the older, southern hemisphere of the planet, which is indeed dominated by impact craters. When the Mariner-9 orbiter finally provided global coverage of the planet, it revealed the majestic volcanoes and canyons that characterize the northern hemisphere. The Pioneer, Voyager and Galileo missions to the outer planets have observed enormous impact features, such as the Valhalla basin on Jupiter's moon Callisto. At the other end of the Solar System, Mercury was revealed as a near twin of our Moon, its surface being pock-marked with craters of all sizes. More recently, close-range observations of asteroids have shown craters with sizes larger than 60% of the diameter of the body.



The Argyre Basin on Mars (diam. 600 km)

Viking/ NASA / Calvin J. Hamilton



Craters on the Martian surface detected with parameter resolution scaling

Other observations have shown that several planetary bodies have much lower impact-crater densities. This is certainly the case for Venus, Io, Europa and icy satellites such as Enceladus (a satellite of Saturn) or Miranda (a satellite of Uranus). The example of the Earth suggests that this situation arises when resurfacing processes have erased all but the latest impact craters, i.e. when the surface is younger than some hundreds of millions of years.

Years ago impacts by extraterrestrial bodies were regarded as an interesting but certainly not an important phenomenon in the spectrum of geological processes affecting the dynamic evolution of the Earth. However, the perceived relevance of these processes has changed radically as planetary exploration has progressed. It is now clear that impact cratering was the dominant geological process during the growth of the planetary bodies of the Solar System. Consequently, the role of impacts in the Earth's evolution is now receiving much greater attention. The space exploration programmes of the last four decades have changed our perception of planetary bodies in our Solar System from 'astronomical' to essentially 'geological' objects. This 'extension' of knowledge has provided new insights into the nature and the importance of impact cratering in planetary evolution.

The Moon, for example, which has experienced limited internally driven geological activity and lacks an atmosphere and hydrosphere, exhibits striking evidence of impacts. The scale of this process is extremely variable, from more than 1000 km-sized impact basins, dating back more than 4 billion years, down to micron-sized impact pits on rocks and minerals. By contrast, the Jovian satellite Io, exhibiting a high rate of resurfacing due to the constant volcanic activity driven by tidal forces induced by Jupiter's presence, has no apparent impact craters whatsoever.

Impact Cratering and Space Science

Impact cratering is increasingly being recognized not as the passive record of marginal events in the early history of the Solar System, but as one of the driving mechanisms of planetary geological evolution even on our own planet. The following are some of the most striking examples where impact cratering has helped to explain major scientific phenomena:

- The early heavy bombardment of the Moon, resulting in the excavation of large impact basins subsequently filled by lava flows, accounts for the asymmetry between the near and far sides of the Moon.
- Stresses induced by the formation of the Caloris impact basin on Mercury resulted in a major global compressive tectonics episode unlike its subsequent history.
- The dichotomy on Mars between the northern plains and the southern highlands is possibly explained in terms of several major impacts early in its history.
- On Earth, the heat generated by impacts is believed to have led to outgassing and dehydration of its volatile-rich early crust, thus contributing to its primordial atmosphere and hydrosphere.
- Major impacts may have guided the break-up of the Earth's crust, thus contributing to the opening of oceanic rift zones and possibly the formation of anomalous continental crust, as in the case of Iceland.
- The rims and central uplifts of several impact structures in sedimentary deposits have provided oil and gas reservoirs suitable for economic exploitation, and the extensive copper-nickel deposits of the Sudbury Basin in Canada are related to a huge Precambrian impact (1850 million years ago).
- A number of animal and plant extinctions throughout the Earth's history, such as that of the early Triassic (250 million years ago) and in particular that of the late Cretaceous (65 million years ago), when the dinosaurs became extinct, are linked to global effects resulting from major impacts. In the latter case, this was the impact that produced the Chicxulub crater in Yucatan, Mexico.

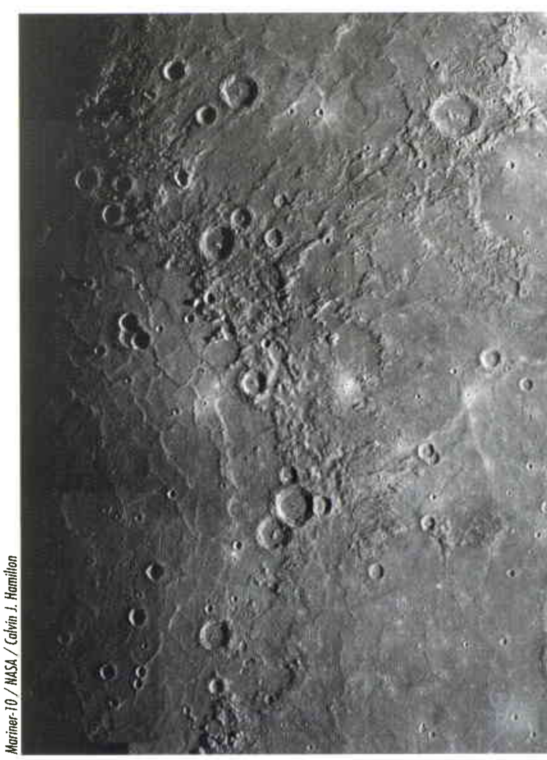
Apollo-11/NASA

This image, taken by the Apollo-11 astronauts in 1969, shows a portion of the Moon's heavily cratered far side

The Morphology of Impact Craters

Studies of the Moon have demonstrated that the morphology of its impact craters changes systematically with crater diameter, which in turn depends largely on projectile size, type, velocity and trajectory. Small lunar craters (about 15 km in diameter or less) display a simple bowl-shaped cavity. Above 15 km in diameter, the complexity increases to include terraced walls and then a flat floor and a central peak in the range of several tens of km to more than 100 km in diameter. The next incremental step above 175 km in diameter is to get a ring-shaped uplift, which develops into a full size concentric ring, thus becoming a multi-ring impact basin, typically between 300 and over 1000 km in diameter. The largest lunar basins have often been filled by volcanic lavas well after the impact occurred.

The different gravity fields on other bodies, however, lead to different diameter ranges for each morphological type of crater. On Earth, the higher gravitational acceleration produces smaller versions (compared to the Moon) of the three main types of crater: 'simple', 'complex' and 'multi-ring basins'. Also, the crater morphology reflects certain characteristics of the target planet at the time of the impact, such as the fluidized ejecta craters on Mars indicating that water or ice-rich materials were excavated, or the pancake-shaped craters on Venus bearing witness to the high atmospheric pressure of the planet, which concentrates the ejecta blanket close to the crater rim.



Mariner-10 / NASA / Calvin J. Hamilton

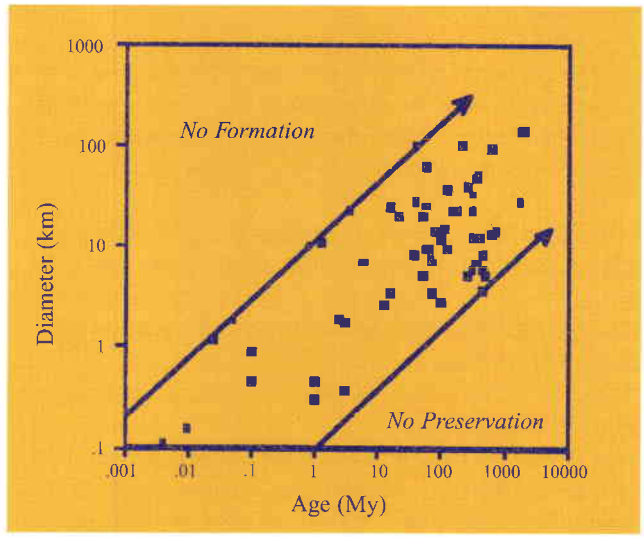
The Caloris Basin on Mercury (diam. 1300 km)

Impact Craters on the Earth

The dynamic processes occurring on Earth 'hide' most of the collision records. Erosion, sedimentation and volcanism quickly remove impact structures: approximately 30% of the known terrestrial craters are buried beneath post-impact sediments. The detection of these impact craters is therefore more challenging and complex. Luckily, however, Earth-observation satellites provide an extremely rich variety of images that can be used in the search.

There are currently about 160 known impact craters on our planet, with diameters ranging from a few hundred metres to several hundred kilometres. This low number is due to the relatively young age and the dynamic nature of the terrestrial geosphere. We also have to take into account the fact that two-thirds of the Earth's surface is covered by oceans, and that the tectonic movements of continental plates, as well as erosion, volcanism and sedimentation processes, have erased and/or hidden most of the original morphological effects of impact-cratering. On the Moon there are over 300 000 impact craters, with sizes greater than or equal to that of Meteor Crater in Arizona, which is approximately 1 km across. If we assume a similar flux of asteroids and comets for our own planet, the total number of impact events that have affected the Earth is estimated to be about twenty times greater. If no surface renewal and reworking had occurred, the Earth's surface should appear at least as scarred as the Moon's, and so the relatively small number of known structures represent a small sample of a much larger population.

The known impact craters on Earth are concentrated in the Pre-Cambrian shields of North America, Europe and Australia (see accompanying figure), for perhaps two reasons. These areas have been relatively stable for quite long periods in geological terms and may be considered the most reliable surfaces for preserving impact craters. They are also regions where past scientific activity has been concentrated. The 'scarcity' of known craters in other areas such as Africa and



The relationship between the diameters and the ages of the Earth's impact craters

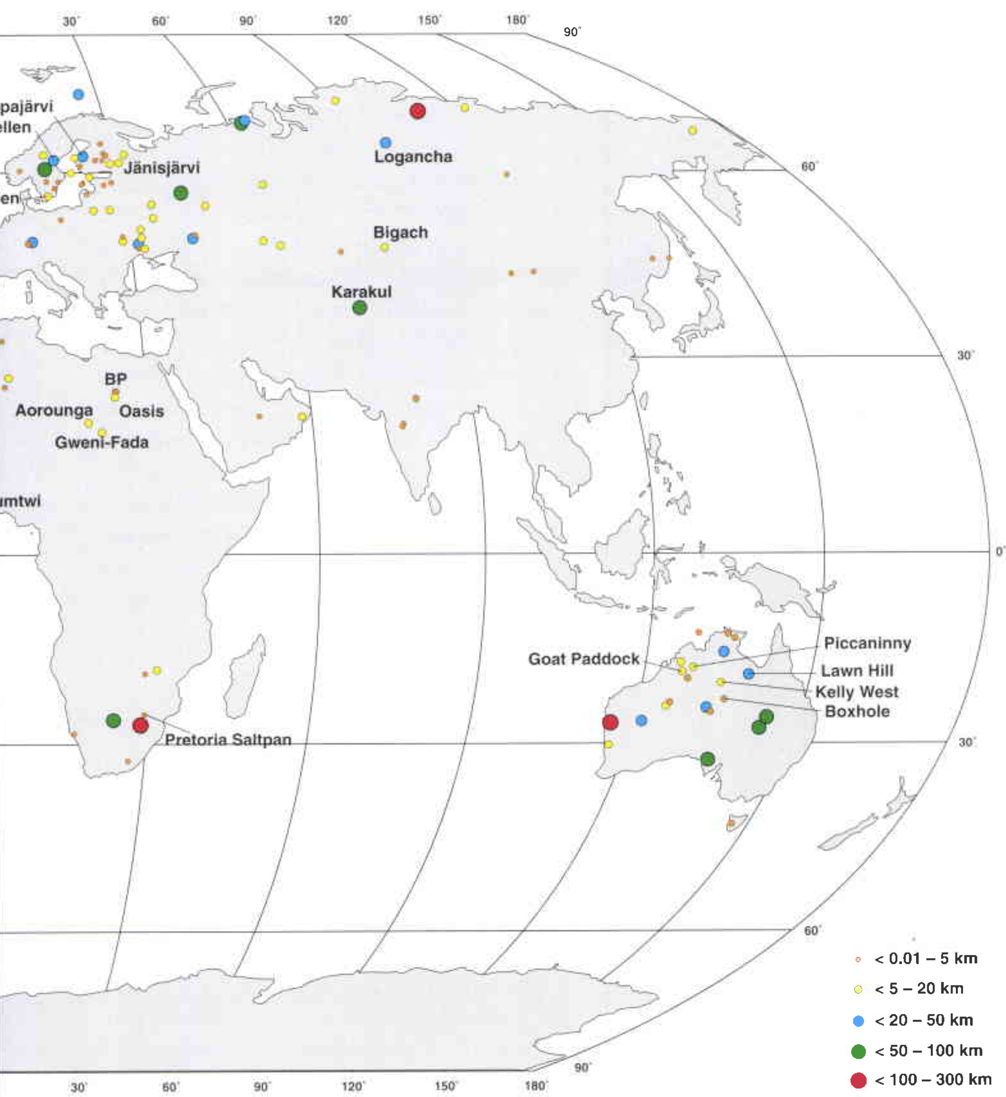
The locations of the largest impact structures on the Earth

South America seems to be due to the lack of geological information as well as the absence of active systematic search programmes.

Terrestrial geological processes also introduce a number of biases into the known terrestrial impact record. Firstly, it is temporally biased, with over 60% of the known terrestrial impact structures being younger than 200 million years. This reflects the greater probability of removal of impact craters by terrestrial processes. In addition, there is a deficit of known craters having diameters smaller than about 20 km. This deficit increases with decreasing diameters and reflects the greater efficiency of terrestrial processes in removing smaller craters. There is also an atmospheric shielding effect at work in the rare formation of terrestrial impact craters with diameters of less than about 1 km.

With a few exceptions like Mjölnir in Norway and Montagnais in Canada, located in relatively shallow waters, all known impact structures on Earth are completely or partially on land. No impact structures are known from the true ocean basins, partly reflecting their relative youth, but also our lack of detailed knowledge of the ocean floors. Progress can be made here also with the help of space technology, by analysing gravimetric and radar data collected by satellites.

The Earth's known impact craters range in age from recent craters, formed during the last century, like Sikhote Alin in Eastern Siberia, to the highly eroded billion-year-old ancient structures like that at Acraman in Australia. In dimensions, they range from a few metres in diameter like the Kaalijarvi (Estonia) and Henbury (Australia) crater complexes, to a few hundred kilometres, like the Vredefort (South Africa), Sudbury (Canada), and Chicxulub (Mexico) impact structures. Those that remain have been preserved either because of their young age, large size, occurrence in a geologically stable region (Precambrian shields), or through rapid burial by younger sediments subsequently removed by erosion. The smaller and more recent craters (less than a few million years old) are best preserved in the desert areas of the World. In any case, orbital satellite imaging at radar and visible-infrared wavelengths, and satellite radar altimetry, are ideal tools with which to find and explore impact craters.



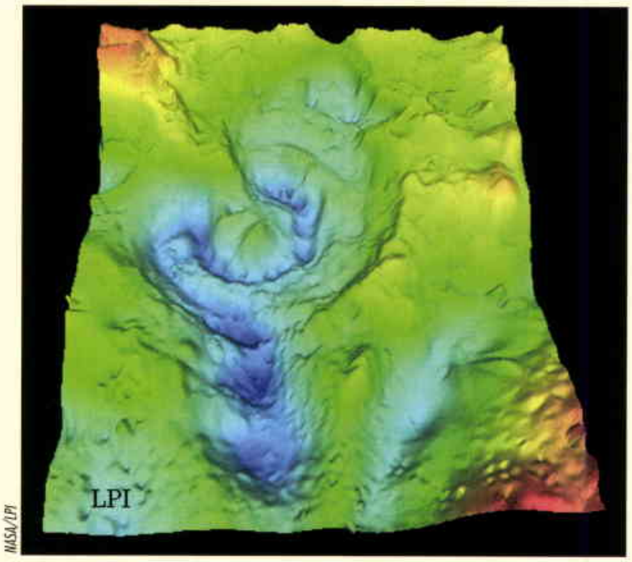
How Best to Recognise the Craters on Earth?

Impact craters have an approximately circular shape (possibly elongated), although the remnants may have become so irregular that it is hard to see a circle. Therefore, to define a model that represents a crater, the circular shape, being the feature most relevant, is certainly a good candidate and, for particular recognition techniques (optical and radar), can be effective. The adoption of such a simplified model has the obvious advantage of allowing recognition under a variety of circumstances (although the number of false identifications will increase), while a more complex model would allow more refined recognition, but needs to be modified for different cases.

Having analyzed various techniques that did not need to consider separately different image types or different crater morphologies but would still deliver robust results, an algorithm based on the so-called 'Hough transform' was developed. The Hough algorithm exploits a geometric model of the crater's shape and allows the

Aorounga Crater in Chad, Africa (diam. 17 km)

Manicouagan Crater, Quebec, Canada (diam. 70 km)



Chicxulub Crater, Yucatan Peninsula, Mexico (diam. 170 km)

detection of craters in images from different types of sensors - a Martian crater in an optical image can be very different from a crater on Earth seen by a synthetic-aperture radar (SAR). While on planets like Mars impact craters can be well-preserved, on Earth they can be highly modified by erosional and tectonic processes and thus representation by a complex model is often impossible.

The use of the Hough transform in circular-shape identification and in crater-detection algorithms is not new, but the development of an algorithm robust enough to cope with multi-sensor images (optical and radar) is far from trivial. The natural digitization of the image and the quantification of the parameter space can introduce a loss of precision, so it is necessary to use special techniques to cope with the irregularities in crater shape due to erosion and other factors.

The results of tests on Martian surface images running the Hough algorithm indicate that craters with a wide range of radii are clearly detected. The Hough transform algorithm can also be improved by introducing an adjustment in order to be able to detect highly degraded craters, sometimes called 'ghost craters'. It certainly improved the detection of such craters on Mars, and can also be used for the Earth. While for the surfaces of Mars and the Moon, a simple classification with a few patterns covers all types of craters, the situation on Earth is more complex, because of the degradation due to tectonic processes and erosion of old impact structures. Study of ERS SAR, MODIS and Landsat images has shown that degradation, as well as vegetation coverage, can make crater recognition a challenge even for an expert image analyst.

The work done so far has focused on automatic recognition of clearly visible craters, which is the 'classical' recognition approach. However, this has shown clearly that the detection of craters not revealed by simple visual inspection can be further pursued only by exploiting data from multiple sensors, i.e. optical, multi-spectral, radar, altimetry, magnetic and gravity data. The contribution from space-based remote sensing is becoming more

The Hough Transform

The Hough transform allows the detection of simple geometric objects of known parametric form, like lines, circles and ellipses. The main idea is to build a parameter space in which the detection is computationally easier. The coordinates of the parameter space are the parameters that define the sought curve in the image space.

The fundamental algorithm consists of three basic steps:

- Each pixel of the image space is transformed into a curve (or surface, depending on the number of parameters) in the parameter space. The curve in the parameter space is defined by the same equation that defines the sought curve in the image space, by considering the parameters as variables.
- The space of parameters is divided into cells. Each pixel of the image contributes one vote to the cells lying on the transformed curve.
- The cell with maximum number of votes is selected and its coordinates in the parameter space are used to identify the curve to be found in the image space.

In the case of crater recognition, the parameter space has three dimensions - the parameters are the two coordinates of the centre and the radius of the crater - and its size depends on the image size. To improve efficiency and allow the processing of large images, techniques for speeding up the recognition process and for reducing the memory requirements are needed. A decisive saving in computational time can be obtained by exploiting the knowledge of the direction of the gradient at each point of the image. Moreover, statistical techniques (e.g. Monte Carlo simulation) can be applied to improve the computational efficiency.

Preliminary test results showed a dependency on the size of the craters. Large craters tend to have more irregular rims than smaller ones. In addition, the rims of the smaller craters are 'smoothed' by the limited resolution of the image. Consequently, when uniformly sampling the parameter space, the algorithm works well only for a small range of radius values. The algorithm can therefore be improved by scaling the resolution of the parameter space with the radius value. A shape is recognized as a circle when it fits a perfect circle within a certain tolerance. In particular, this error can be quantified as an increasing function of the radius, thereby allowing larger circular structures a higher radius error than small circles. A similar mathematical argument can be made for the position of the crater's centre.

and more important due to the vast amount of data and computational power now available.

A remote-sensing-based catalogue of the features of all known terrestrial impact craters (about 160) still does not exist. Previous compilations (by Grieve in 1988 and Hodge in 1994) are now incomplete, because 30% of the craters known today have been discovered in the last 15 years, thanks in part to the increased availability of remote-sensing data. The availability of multi-sensor data from ESA's latest Envisat satellite should provide the necessary material for such a comprehensive cataloguing activity.

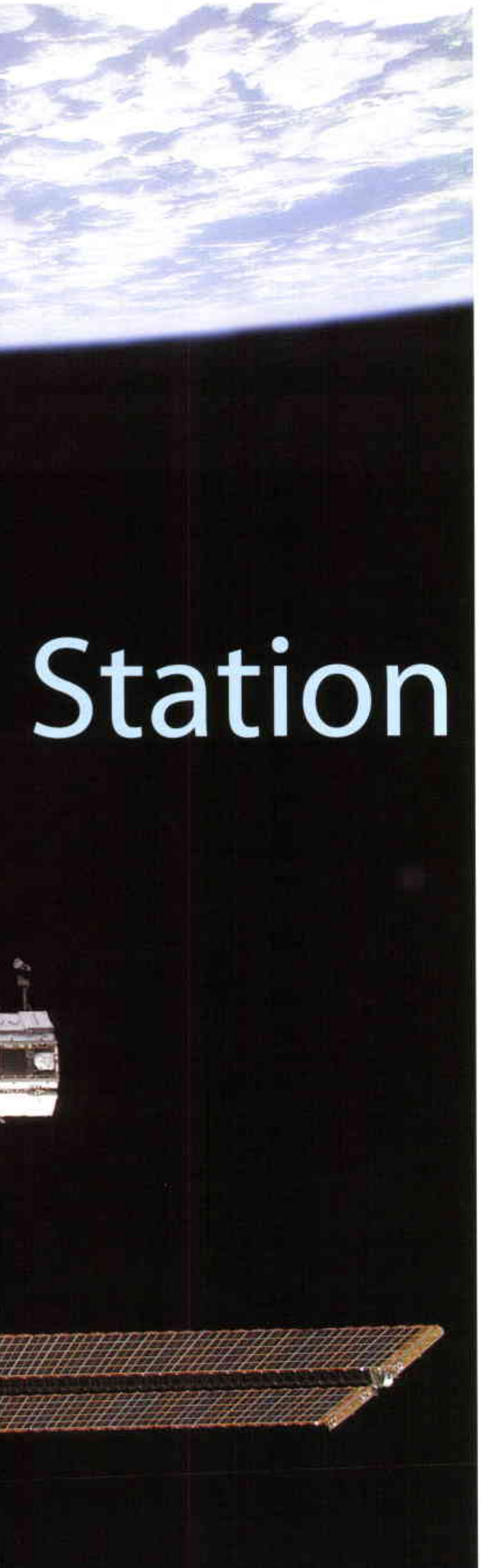
Concluding Remarks

The work done so far shows that, by their nature, impact-crater studies call for a very interactive research process, requiring a multidisciplinary team effort, which in turn necessitates perseverance and a global approach to local problems. However, terrestrial impact-crater research is a broad scientific topic with far-reaching implications in such diverse fields as meteorite and asteroid research, Solar System evolution and even the search for life beyond our planet. Comparison of the cratering records and crater morphologies on different planets represents a fruitful field of investigation for reconstructing the history of our Solar System. Moreover, the algorithms developed for impact-crater recognition from space may well provide the methodologies that will make it possible to respond successfully to the challenge of automatically recognizing even more complex structures on our fragile planet in the future.

Acknowledgements

The work reported here is the result of the continuation of a specific collaboration between ESA's Science and Earth-Observation Directorates, which began a few years ago when detailed studies and the compilation of a new catalogue of our home planet's craters were initiated, using data from ESA's ERS-1 and 2 satellites.

Branding the International Space



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The work to create a successful strategy for the commercialisation of the International Space Station (ISS) has reached a critical juncture. The International Partners in the ISS - NASA, CSA, RSA, NASDA and ESA - have recognised that one of the platforms for a successful commercialisation strategy is the development and exploitation of a coherent, powerful and global ISS brand.

Why have its Partners decided that the ISS needs to be marketed in this way and why is branding important for commercial success? This article seeks to answer these questions and to describe the process and organisation that two of the Partners, ESA and the Canadian Space Agency (CSA), have already initiated.

What is a 'Brand'?

A quick rummage through the on-line bookshelves of Amazon throws up more than 60 articles with the words 'brand' or 'branding' in their titles. Through this fog of often-conflicting guidance one single truth emerges. This is that brands are different things to different people. Now, this may appear rather trite, but contained within this conclusion is the key insight to revealing the answer to the question, 'What is a brand?'.

Before going on to reveal what this insight is, perhaps we should start by saying what a brand is not. A brand is not a logo or a slogan, although these are important tools for communicating about a brand. A brand is not a static commodity, product or idea. It evolves constantly, as frequently as consumers change their minds, their opinions and attitudes, which is frequently. A brand is not an advertising campaign, although advertising and other forms of brand communication are essential tools for building and maintaining a brand's presence in the minds of consumers.

So if a brand is none of these things, what is it? There are many definitions, but two of the best known will give us the start we need to answer the question. The first is that 'a brand is a promise delivered', and the second is 'companies make products, but consumers own brands'.

A 'promise delivered' seems pretty clear. The essence of what a brand is concerns the trust that is built up over time between consumer and manufacturer or service provider, and the belief that this trust will be 'repaid' each time the two interact. As someone who enjoys a non-alcoholic, sugary, fizzy drink you know that 'Coke' will deliver this experience each time you buy a can. For the car driver who prizes safety, reliability and engineering expertise, the chances are that buying a 'Mercedes' will deliver what you expect. And in the non-commercial world which is perhaps more relevant to the ISS, we instinctively know what the Red Cross is for, we have a feel for its values, and maybe even empathy with these values also.

But it isn't that simple of course. There are tens if not hundreds of other non-alcoholic drinks that are just as sweet and fizzy as Coke and there are now many other car manufacturers with equal claims to Mercedes' safety, reliability and quality engineering. Even in the non-commercial world, the Red Cross needs to compete with other organisations for people and funds. This means that the successful brand must have other qualities and, perhaps more importantly, a special relationship with the people it interacts with.

All of us use our own experiences and knowledge to form the mental picture of what we see and experience, and we do this in wildly or mildly different ways. My chilled 'Coke' is about refreshment and energy on a hot day; your 'Coke' is about being hip and cool. Consumers therefore 'own' brands. Perhaps there is one definition that can bring all of this together. Even though it was written in the 1960s, the insight that it contains probably remains the best and most succinct answer to our question:

"A brand is a complex symbol. It is the intangible sum of a product's or service's attributes, its name, packaging and price, its history, reputation, and the way it is communicated. A brand is also defined by consumers' impressions of the people who use it, as well as their own experience."

What Has All This Got to Do with the ISS?

Successful commercialisation of the ISS means that the Station will need to have demonstrated its unique value as a research and development platform vis-a-vis other, earthbound R&D facilities.

But, as several market research studies have clearly indicated, the ISS is relatively unknown amongst the audiences it will need to connect with if commercialisation is to succeed. The research has also indicated that even when people are aware of the ISS they too frequently cannot say what it is for and why it is relevant to them. These are fundamental barriers to the ISS's commercial success.

The feedback from this research has also indicated that the ISS has great potential value as a vehicle for sponsorship, which, if fully exploited, would contribute to the ISS commercialisation process.

Building a unique brand positioning for the ISS is an essential first step in the commercialisation process. Potential customers in the R&D markets need to know why they should divert limited resources away from the traditional recipients of their budgets to the ISS. They need to know clearly and succinctly what the ISS is 'for' and what competitive advantage it will offer them.

Potential sponsors probably have different needs. They need to believe that the ISS has values with which they would wish their own brands to be associated. They are also looking for the competitive advantage that will accrue to their brands if they link themselves with the ISS, as opposed to, say, the Olympics.

For all of these reasons, a compelling, believable and relevant brand positioning for the ISS is essential. It is not enough, as has been the case until now, to communicate about the ISS from the owner's perspective. The brand positioning will provide all of these potential audiences with their own reason to believe. It will enable communication about the ISS to be user-focused, and in doing so the ISS will be able to compete successfully for the time and money that its commercial audience has available for the sort of investment that it seeks to attract (see accompanying illustration).

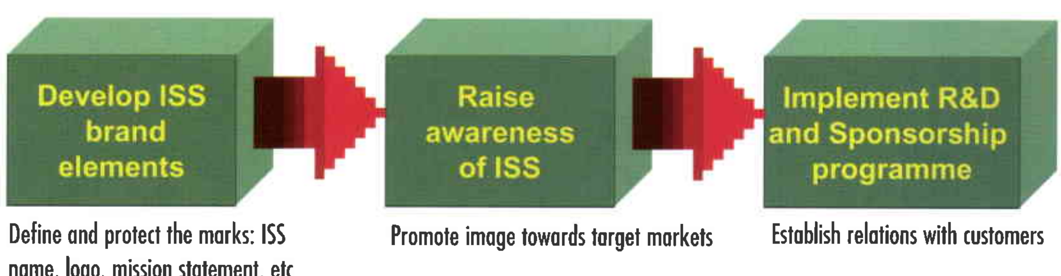
The ISS Branding Programme Content

The creation of a strong brand requires not only a smart brand definition, but also time and skilful planning. The International Partners, working together in a Multilateral Commercialisation Group, have agreed to create a global ISS Branding Programme, and have initiated the creation of an ISS Brand Management Plan, which addresses the legal, financial and organisational issues surrounding this programme.

The foundation upon which the ISS brand is built includes the creation, protection and evolution of the basic symbols and statements that encapsulate the values of the ISS, such as the logo and name.

The name of the station will remain as we know it today – 'International Space Station – ISS' – until approaching assembly completion. On the other side, the Partners are well advanced in the selection of a logo, which they will register and trademark worldwide to protect its usage, thus creating one of the platforms for the global ISS brand.

But the process of brand development doesn't stop there. The ISS brand is more than the logo, the name, descriptions and images of its physical infrastructure in space. The brand positioning must incorporate the qualitative and the emotional values of the ISS. It must also express the values of the Agencies involved. So, the process of brand creation is centred on the identification and

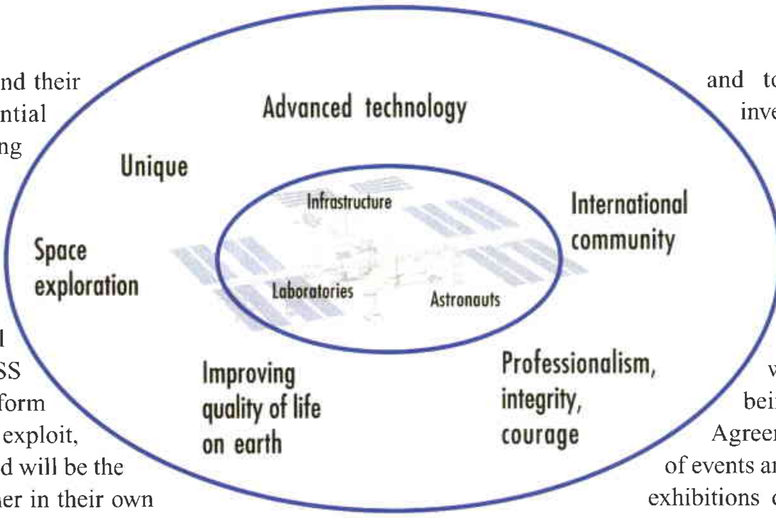


The branding programme

definition of these values and their relevance to the potential markets (see accompanying illustration).

Very few brands have attained the position where one message, one voice, one image works everywhere and with everyone all the time. So, whilst the ISS brand will be a global platform for all of the Partners to exploit, communi-cation of the brand will be the responsibility of each Partner in their own territories. Even in the globalised economy, local relevance is essential.

Of course, economies of scale will accrue if Agencies choose to work together and pool resources behind particular actions. And in this spirit of cooperation, ESA and the Canadian Space Agency have already agreed to collaborate, sharing experience, funds and resources to jointly develop and manage the ISS brand in Europe and Canada by using a specialised communication company, Ogilvy Public Relations, selected on the basis of competition.



What's in a brand

The Process

The process of Brand Definition followed three steps: Research (Brand Scan), Analysis (Brand Audit) and Development (Brand Print).

The Brand Scan helped to identify, through review and analysis of a wide range of background research material, interviews with the general public as well as Agencies' internal and external stakeholders, the key findings from which to derive the potential positioning of the Brand.

Following extensive research, a Brand Audit was performed. Three potential positioning areas have been identified and competitively tested with representatives of the R&D and corporate world – with the sorts of people who are the decision makers in relevant markets for R&D and sponsorship of the ISS.

The three positionings that were field-tested had been developed to appeal to risk-taking, idealistic, entrepreneurial leaders – who could be enticed with a product as innovative and unusual as the ISS.

The final process (Brand Print) led to the identification of a single brand positioning area, which appeals to both R&D and sponsorship targets – an ideal combination of emotional and rational values, focusing on what humans can do in space, the sense of exploration and discovery, suggesting that only human spaceflight and the ISS can offer a place beyond all boundaries.

The Brand Print was then used as guidance for developing the creative concepts, the visual identity architecture and the key messages. And the final step of this process has been the identification of the communications strategy and the tactical plan that will be used to promote the ISS brand into the market were it could compete successfully for R&D and sponsorship.

From Brand Print to Brand Presence

The core objectives of the communications strategy are to establish the ISS as the global brand of private/public partnership for the exploration of space, to create demand for that brand, and to establish ESA and CSA as the 'gateway' to the ISS brand in Europe and Canada.

Human spaceflight will be positioned as a long term strategic issue by a top-level debate about the future of human spaceflight, initiated and led by visionary business leaders, in order to attract private-sector company strategists and marketeers to the opportunities of space exploration and to guide them to concrete investment prospects.

Also, concrete opportunities for R&D in space will be communicated in order to attract the R&D community in the private sector to space research. To this end, ESA will expand its collaboration with the aerospace industries being part of the Cooperation Agreement, implementing a series of events and participating in commercial exhibitions dedicated to markets such as biotechnology, health and new materials. The Cooperation Agreement partners will also provide comprehensive 'end-to-end' services to customers under promotional conditions.

In addition, Brand Protection must be institutionalised, in order to prepare the ISS brand to face the challenges of illegal competitive exploitation.

Conclusion

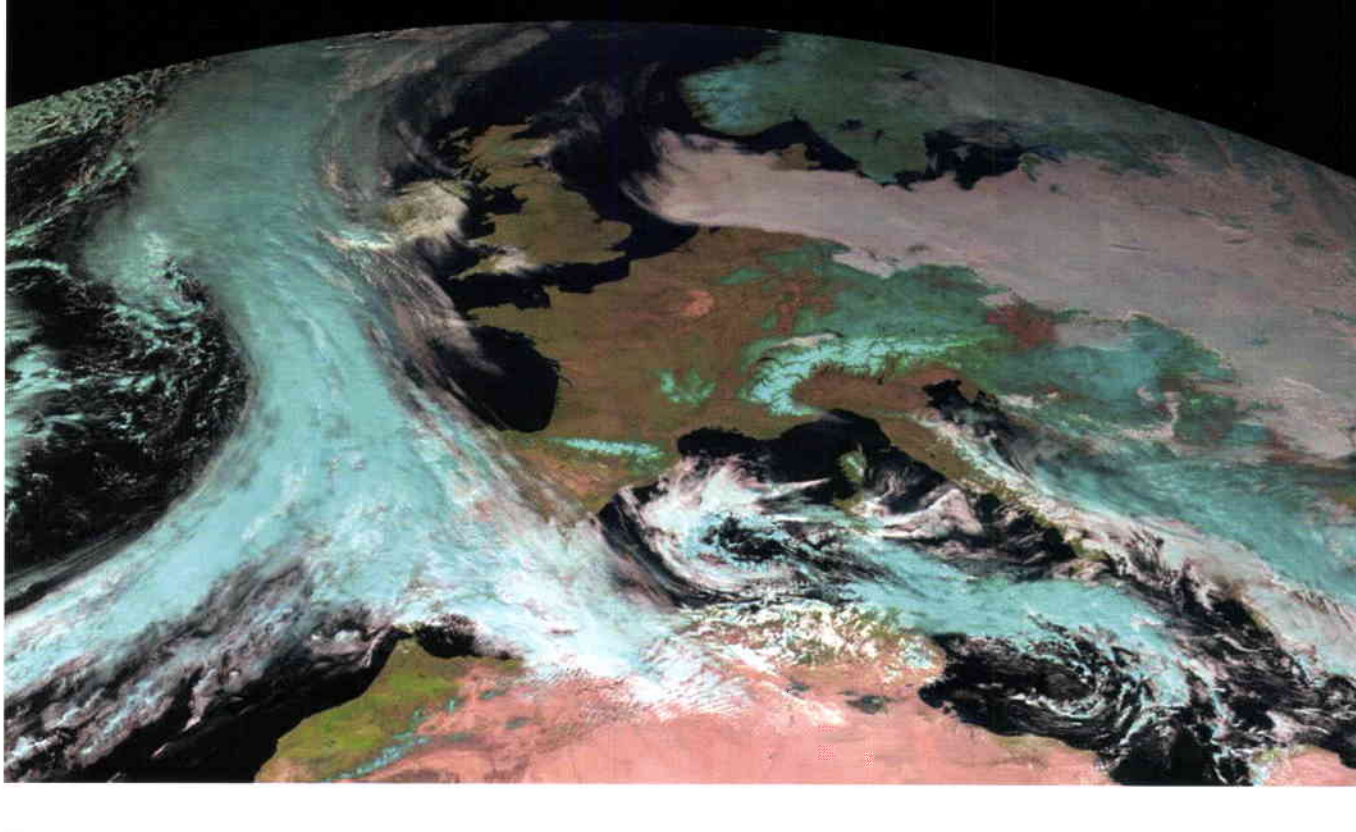
The development of an ISS brand is an essential tool for implementing any commercial activity related to the ISS, both for commercial R&D and for innovative markets such as sponsorship. It is necessary to brand and to protect the image of the ISS in order to ensure that a coherent and consistent image is presented across all activities and that the image and brand are not diluted or unfairly exploited.

The promotion of the brand will be performed with a sound communication plan whereby the potential customers will partner with human spaceflight and the ISS to explore the benefits of commercial activities in space. ESA will also leverage on the promotion and service capabilities of its Partners in the Cooperation Agreement.

The implementation of this programme is a new endeavour for the Agencies partnering in the ISS. By collaborating in this programme, the International Partners have the opportunity to open the ISS to global markets and to maximise the possibility of fully utilising the Station to perform world-class research to the benefit of the whole of mankind.

The In-Orbit Commissioning of MSG-1

MSG Project Team,
Earth Observation Projects Department,
ESA Directorate of Earth Observation,
ESTEC, Noordwijk, The Netherlands



The MSG programme is a co-operative endeavour by ESA and Eumetsat, the European Organisation for the Exploitation of Meteorological Satellites set up in 1986 to establish, maintain and operate a European system of meteorological satellites. ESA is responsible for designing and developing the first of the four satellites in the MSG programme (the fourth of which has recently been approved), whilst Eumetsat, based in Darmstadt, Germany, has overall responsibility for defining the end-user requirements, developing the ground segment, and procuring the launchers. Eumetsat, which will also operate the system, is contributing about 30% of the development costs for MSG-1 and fully financing the three subsequent flight units (MSG-2, MSG-3 and MSG-4).

The MSG-1 satellite's final inspection before launch (photo courtesy of Alcatel Space Industry, Cannes)

Following on from Meteosat, the Meteosat Second Generation (MSG) programme promises to provide advanced and more frequent data for short-range and medium-range weather forecasting and climate monitoring for at least the next 12 years. MSG will transmit more than 20 times the volume of information delivered by its predecessor, with a spatial resolution of 1 km in the visible spectrum compared to the current 2.5 km. It will therefore beam down sharper images of changing weather patterns, over an area that includes all of Europe and Africa as well as some parts of Asia, every 15 minutes instead of the 30 minutes that it now takes. MSG will help to monitor developing weather systems over areas such as oceans, where such information is normally sparse, to help predict extreme weather conditions. With its 12 channels (the current Meteosat has only 3), MSG will provide meteorologists with new insights into the condition of the Earth's atmosphere, land and ocean surfaces.

The first satellite in the new series, MSG-1, was successfully launched on 28 August 2002, and is currently in the midst of its in-orbit Commissioning Phase, during which the performances of both the spacecraft platform and the sophisticated instruments that it carries are being thoroughly checked out before putting the satellite into operational service.

Commissioning the Satellite

The results from the SEVIRI instrument (Spinning Enhanced Visible and Infrared Imager) instrument have been very encouraging. The first image was received on 28 November 2002. The basic functionalities of GERB (Geostationary Earth Radiation Budget) instrument have also been successfully tested and the first image from that instrument was received on 12 December.

On the spacecraft side, two anomalies have been detected, both of which have been thoroughly investigated and solutions put in place to mitigate their consequences. Described in more detail in the accompanying panel, they have no impact on the data acquisition or lifetime of the mission, but the onboard-amplifier (SSPA) anomaly has some repercussion for the data-dissemination scenario.

How the Instruments are Performing

SEVIRI

The SEVIRI Imaging Radiometer is the main optical payload on the MSG satellite series. Since the launch on 28 August 2002, SEVIRI has successfully undergone the un-locking of its scanning mechanism, a decontamination exercise, and has taken the first images. It has been taking images almost continuously since the beginning of 2003.

The goals for SEVIRI during the Commissioning Phase are two-fold:

- to check the radiometer's functionality against the specifications given to industry, and
- to demonstrate its imaging and radiometric performances using the Image Quality Ground-Support Equipment (IQGSE) and verify its compliance with the design specifications established by ESA and Eumetsat.

The first image taken by MSG-1 (visible channel) at 12.15 UTC on 28 November 2002 (courtesy of Eumetsat)

Two Problems – Two Solutions

The satellite Commissioning Phase identified two spacecraft-related problems:

Wobble

The Commissioning Phase started with the satellite spinning at 100 rpm and with a remaining mass of 1220 kg. After the platform and radio-frequency link validation, a 'wobble' (small regular changes in spin-axis tilt) was detected on the satellite. It was not significant, however, and the satellite performance remained well within specification. Detailed investigations were initiated and by 13 January the problem was solved. It turned out to be caused by the migration of fuel due to heating - and thus expansion - of the fuel.

An Amplifier Anomaly

On 17 October, the Commissioning Phase had to be temporarily suspended due to an anomaly in a Solid-State Power Amplifier (SSPA). SSPA-C, used for the dissemination of processed images in High-Rate Image Transition (HRIT) mode, experienced an unexplained switch-off, which is still being investigated. Although the satellite was designed with a 4/3 redundancy for the SSPA, it seems prudent not to rely on the SSPA for the high-rate and low-rate dissemination (HRIT/LRIT) of processed images. Consequently, an alternative data-dissemination scenario using commercial communication satellites is currently being investigated. The MSG-1 mission communication system will then be limited to the downlinking of raw satellite data, its Search & Rescue mission (GEOSAR) and data reception from the Data Collection Platforms (DCPs).

The MSG-1 payloads were reactivated on 26 November in a new configuration to minimise the risk of further SSPA problems. The on-going Commissioning Phase is nevertheless demonstrating that, despite the SPPA problem, the platform is working well and the predicted mission lifetime still exceeds 7 years.

The Commissioning Phase also includes optimisation of the overall imaging system to allow Eumetsat to operate MSG-1 under the best possible conditions.

The first SEVIRI image was acquired successfully in all channels at the first attempt on 28 November, with very promising quality even without any rectification. The subsequent imaging functional and performance tests conducted using the IQGSE have been proceeding successfully, giving results of a very high quality. The ground-segment's tuning has been completed satisfactorily with the IQGSE, and it is ready for 'pseudo-real-time' processing of SEVIRI's image data. The calibration trend (gain drop) exhibited by the long-wavelength

MSG-1 Event Log Since Launch

28.08.02	22.45h UTC - MSG-1 launched from Kourou
25.09.02	MSG-1 control handed over to Eumetsat
17.10.02	Commissioning suspended due to SSPA anomaly
26.11.02	Payload re-activation with new satellite configuration
28.11.02	First SEVIRI image received
09.12.02	GERB activated
12.12.02	First GERB image received
13.01.03	Wobble problem solved
End Jan. 03	First transfer of un-rectified images to Meteorological Product Extraction Facility (MPEF)
06.02.03	Mini scan functional test
12.02.03	First IQGSE rectified images
28.02.03	Start spring eclipse season, lasting until 16 April
18.03.03	Start SEVIRI decontamination
27.03.03	Successful Satellite Commissioning Results Review. Delta CCR foreseen for mid-July, after completion of SEVIRI and GERB commissioning
April 2003	First alternative dissemination trial
June 2003	Commissioning Phase-B with final Image Processing Facility (IMPF)
End 2003	Entry into operational service

channels showed signs of an increase in contamination (humidity) level, as expected. A long decontamination exercise was therefore performed during the satellite's eclipse period in March, restoring SEVIRI's full performance.

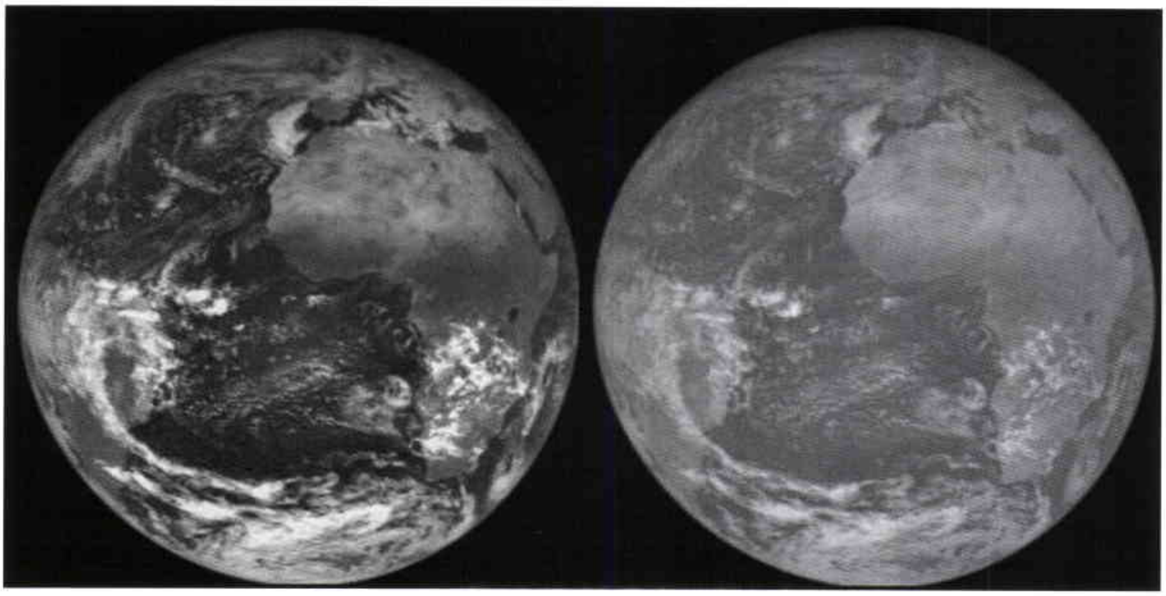
GERB

The Geostationary Earth Radiation Budget scientific instrument is accommodated on the MSG spacecraft as an Announcement of Opportunity (AO) payload. GERB is a highly accurate, visible-infrared radiometer designed to make unique measurements of the outgoing short- and long-wave components of the Earth's Radiation Budget (ERB) from geostationary orbit. The ERB is the balance between radiation coming from the Sun and the outgoing reflected and scattered solar radiation, plus thermal infrared emissions to space. GERB will also be flown on the next three satellites in the MSG programme.

The GERB measurements from geostationary orbit offer huge advantages in terms of temporal resolution compared with similar instruments in low Earth orbit. Such measurements have not been achieved previously and are extremely important because they will permit a rigorous check on our understanding of the diurnal variations in the ERB, which in turn will enable improved operational weather monitoring and permit further important progress in climate-change research. Both short-wave (0.32 - 4 micron) and total (0.32 - 30 micron) radiance measurements will be made, with the long-wave (4 - 30 micron) data being obtained by subtraction. The accuracy requirements are consistent with previous radiation-budget measurements.

The initial post-launch checkout of the GERB instrument was completed in early December and showed that all systems were working as expected. The first GERB image was recorded on 12 December. The instrument is subjected to a constant force of 16g due to the satellite's rotation, and this particularly affects the de-scan mirror mechanism. Since correct functioning of this mechanism is critical to the operation of the instrument, it has been monitored very closely during the Commissioning Phase and its performance is excellent.

GERB's image data are sent from Eumetsat in Darmstadt (D) to the Rutherford Appleton Laboratory (RAL) in the UK in near-real time, processed at RAL and then forwarded to the Royal Meteorological Institute of Belgium (RMIB) about 20 minutes later. RMIB performs further data processing, which is then available to the science team about two hours later. This system is working well and fully validated data will be available to users later this year.



GERB images taken at 12.55 UT on 1 February 2003. The one on the left shows radiances in the short- wave channel, and the one on the right radiances in the total channel

GEOSAR

The small Geostationary Search and Rescue (GEOSAR) communications payload carried by MSG will detect and relay distress signals transmitted by distress beacons to an international rescue network developed by Canada, France, the USA and Russia, and designed to assist search-and-rescue operations worldwide.

This payload's commissioning is composed of three phases:

- Phase-1: MSG-1 SAR transponder verification
- Phase-2 : GEOLUT/MSG-1 transponder compatibility (coordinated with CNES)
- Phase 3 : Demonstration and evaluation (organised by COSPAS-SARSAT).

Phase-1 has been successfully completed, with all parameters well within specified values, as confirmed by the Test Review Board on 27 February. Phase-2 began in March and is still in progress, while Phase-3 is foreseen to start this summer.

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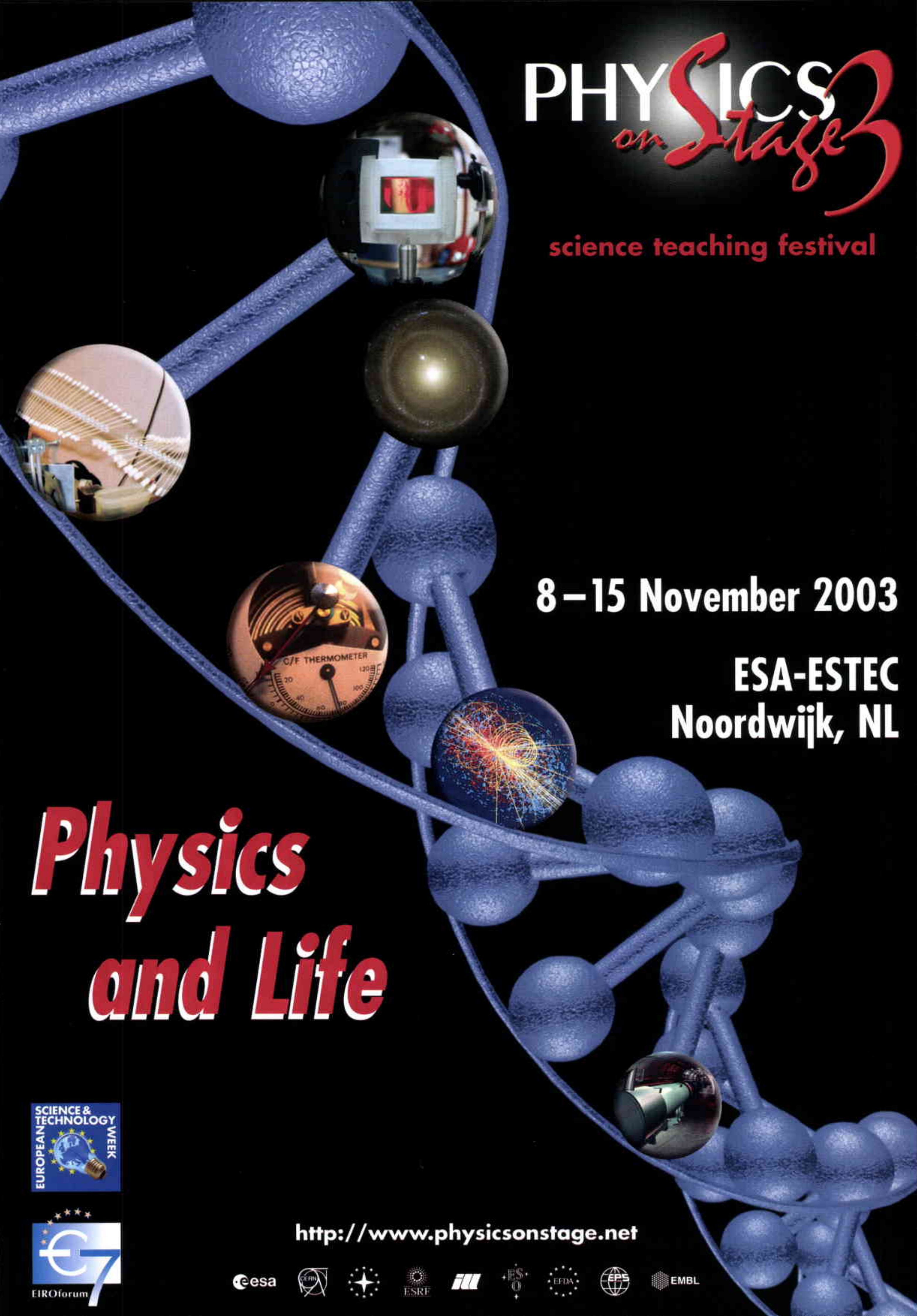
PHYSICS on Stage 3
science teaching festival
8 – 15 November 2003
ESA-ESTEC
Noordwijk, NL
Physics
and Life
C/F THERMOMETER
EUROPEAN SCIENCE & TECHNOLOGY WEEK
EIROforum
http://www.physicsonstage.net
esa
CERN
ESRF
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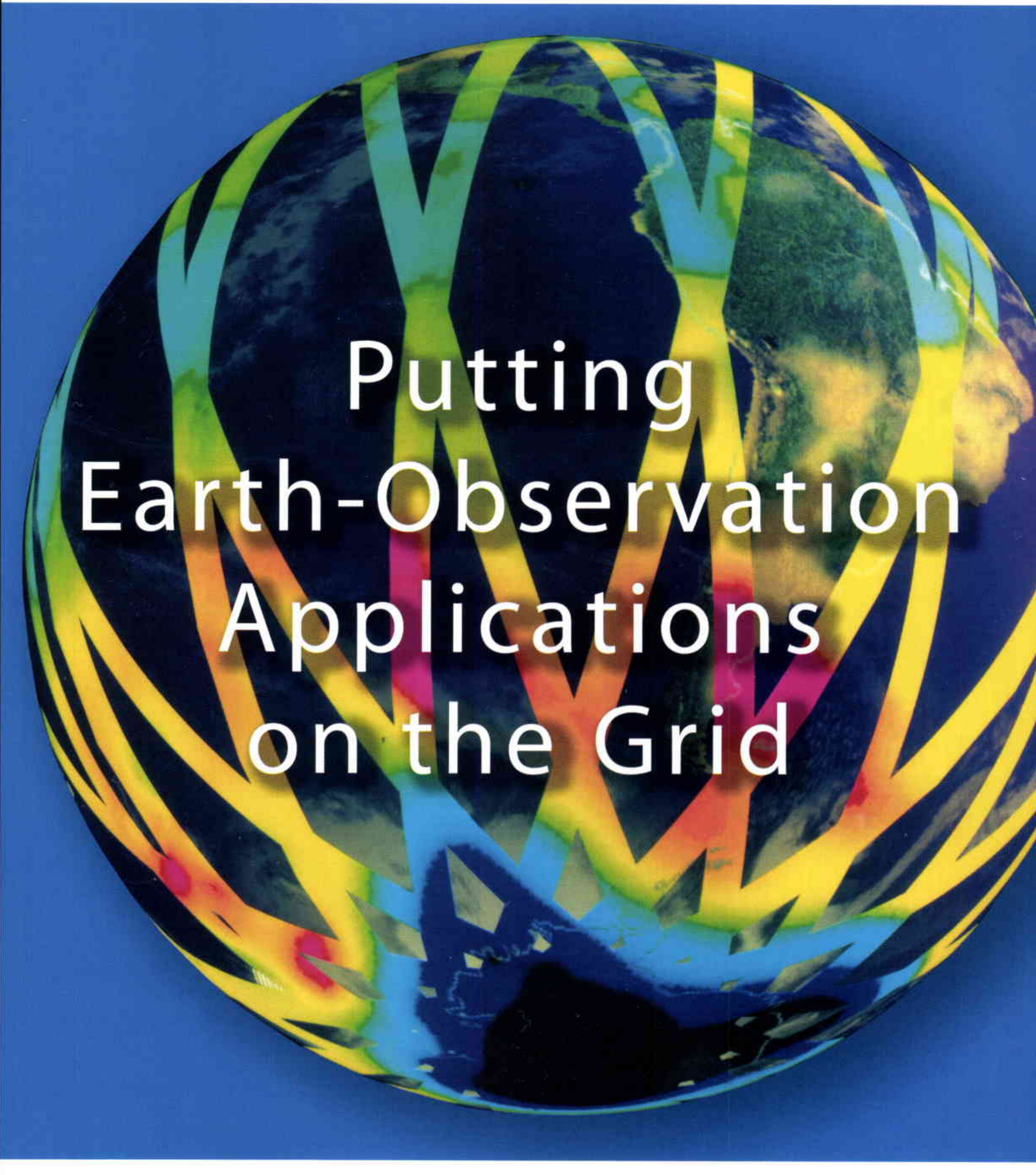
EFDA
EPS
EMBL

Putting Earth-Observation Applications on the Grid



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The rapid developments in distributed supercomputing and parallel computing in recent years have led to the high-performance computing facilities of several independent scientific research organisations being joined up via high-speed networks to construct very-large-scale distributed computing infrastructures, known as 'Computing Grids'. The aim is to eventually allow scientific researchers instant access to a multitude of distributed-processing and data-storage resources (thousands of terabytes) simultaneously, via a single log-in.

Access to high-end computer power isn't the only advantage that such Grids will offer – the ability to form Virtual Organisations (VOs), which will promote and facilitate interaction between different scientific domains, is central to the concept of Grid computing. Loosely related groups of researchers belonging to diverse organisations will be able to join groups with a common aim, to share knowledge and to undertake new forms of collaboration. There is virtually no limit as to what a 'Grid resource' may consist of; i.e. not only processing, data storage and high-speed networks, but potentially all manner of data sets, catalogues and databases, software packages, tools and environments, scientific algorithms, instruments and robotics, shared software licences, etc., all by using standard grid protocols in a coordinated way. Therefore, the Grid is often described as being the basis for the next generation of the Internet.

Grid Development Today

In the United Kingdom, Grid development is the centrepiece of a major national drive consisting of hundreds of projects and initiatives to develop the new 'e-science' infrastructures. In the United States several programmes are underway, most notably the NASA Information Power Grid, the Department of Energy (DOE) Science Grid, the National Science Foundation TeraGrid, and the Alliance National Technology Grid. In Europe, the main initiatives are DataGrid and EuroGrid (both funded by the European Commission), the Nordugrid testbed formed mainly by the Scandinavian countries, and the German UNICORE science and engineering Grid. All of these infrastructures include widely distributed resources and sites. For instance, the DataGrid, of which ESA is a member, is made up of 21 partners in 11 different countries and is currently running across many of Europe's main computing centres, e.g. CERN (F/CH), Lyon (F), RAL (UK), CNAF (I) and NIKHEF (NL), all of which are sharing their resources.

In the Grid community, the emergence of Web Services technology has not gone unnoticed, and developers have responded to the challenge by proposing an Open Grid Services Architecture (OGSA). This is expected to eventually provide a standard framework for the integration of Grid and Web Services. Technical specifications have been developed by the Globus Project and IBM, and are being put forward at the Global Grid Forum for discussion, refinement, and standardisation.

Grids and Earth-Observation Applications

For environmental Earth Observation (EO) applications, there are several benefits that a computing Grid can offer to the user community. Applications of remote-sensing satellite data are wide ranging, from studies of the Earth's mantle, atmosphere, oceans, ice and land formations, to agriculture and cartography, to name but a few. Many national and international programmes – both research and operationally oriented – build on specific application domains to provide large-scale monitoring and analysis of dynamic Earth-system interactions and to better understand and be able to predict prevailing conditions. Many of these investigations make use of large-scale, high-capacity distributed processing facilities and also involve considerable coordination and interaction between a large number of players in the scientific, operational and commercial sectors. A Grid facilitates these interactions by providing a standard infrastructure and a collaborative framework within which to share data, storage and processing resources, algorithms and data products in a coordinated way.

Satellite-borne EO sensors are capable of collecting data globally and over extended time periods, generating a huge volume of data to be catalogued, archived and processed. ESA's Envisat satellite, for example, generates some 400 terabytes of data products per year, which have to be handled by the dedicated ground infrastructure distributed across various European countries. A remote-sensing survey that needs to analyse data collected over a wide area during an extended period will consume large amounts of computing time, network bandwidth and storage space, requiring that the supporting Information Technology (IT) infrastructures be dimensioned accordingly. Where it is preferable to maintain down-sized local facilities, the Grid can provide the extra resources needed during times of peak load.

Relevant Links
- The ESA demo Web site: http:/giserver.esrin.esa.int
- ESA SpaceGrid project: http://www.spacegrid.org/
- The European DataGrid project: http://www.eu-datagrid.org
- Global Grid Forum Web site: http://www.ggf.org/
- CEOS Grid WGISS: http://ceos.esa.int/ceos_wgiss_grid/
- Astrophysical Virtual Observatory: http://archive.eso.org/avo
- GREASE: http://tphon.dutchspace.nl/grease/public/
- ESA Grid Initiative: http://esagrid.esa.int/index.html

European DataGrid sites (at the beginning of 2003)

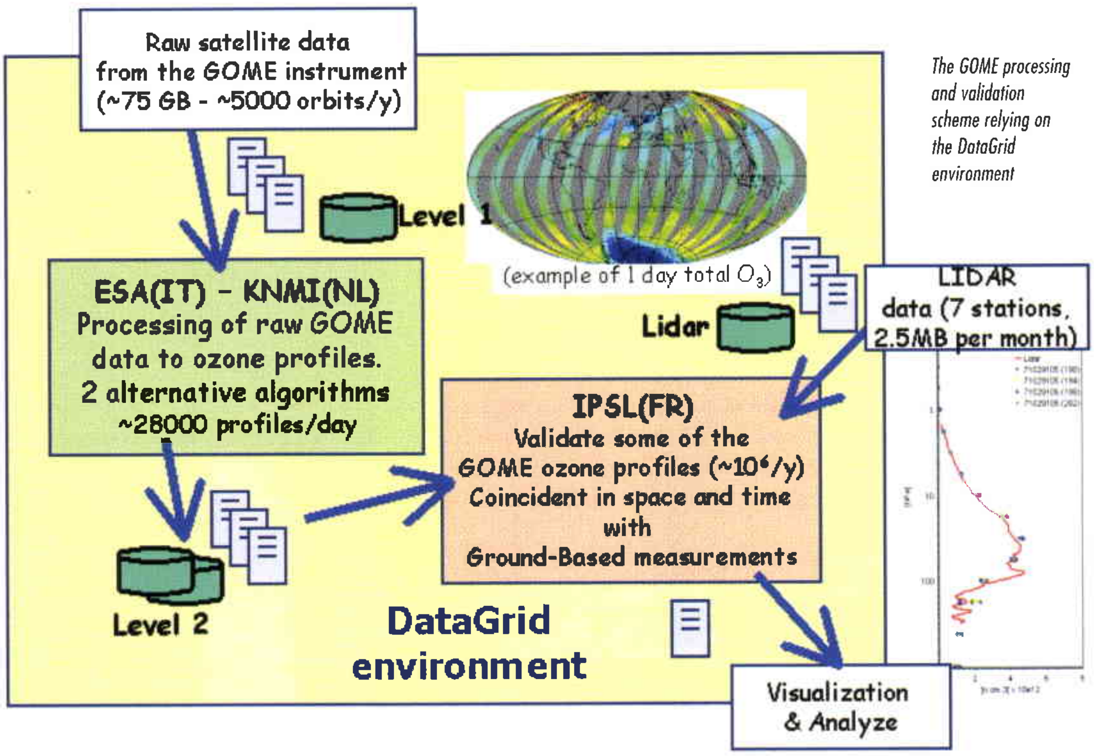
The European DataGrid

Participation in the European DataGrid Project (EDG), a major EC-funded Grid project begun in 2001, has been instrumental in allowing ESA to gain first-hand experience in the use of emerging Grid technologies. ESA leads the DataGrid EO application development activities, assisted by close collaboration with its partners in the project, the Royal Dutch Meteorological Institute (KNMI), the French Institut Pierre Simon Laplace (IPSL) and ENEA (the Italian National Agency for New Technologies, Energy and Environment).

To test the capabilities of the system, it was decided to use data from ERS-2's GOME instrument, consisting of global atmospheric-ozone measurements collected over several years of the mission. This data was chosen because it is fairly representative of the kind of large-scale, collaborative types of EO applications that stand to benefit most from a Grid-type scenario. Several ESA, KNMI and IPSL members formed the EO Virtual Organisation within DataGrid, working alongside the high-energy physics and biomedical VOs. Other participants in the EO VO are other members identified in the process of promoting Grid technology in the EO community. In particular, it is worth mentioning the collaboration started within the CEOS (Committee on Earth Observation Satellites) Working Group on Information Systems and Services) for demonstrating the potential interaction of European and US-based Grid systems, and with the company Dutch Space to demonstrate the use of the Grid for EO instrument simulation.

GOME Data Processing and Validation

GOME is one of several instruments onboard ESA's ERS-2 remote-sensing satellite, which has been orbiting the Earth since 1995. Every day, GOME makes some 30 000 measurements of atmospheric ozone and transmits them to the ERS ground stations. The raw readings are sent to the dedicated Processing and Archiving Facility in Germany (D-PAF), which produces the standard data products and distributes them to scientific investigators.



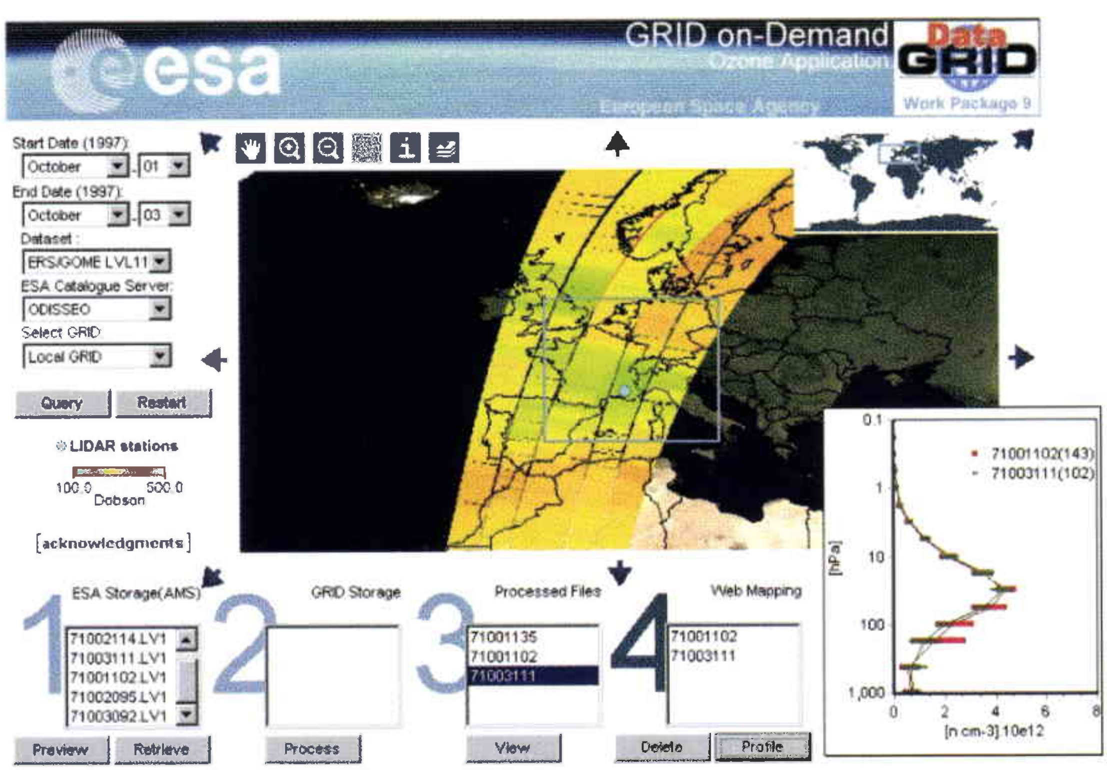
The GOME processing and validation scheme relying on the DataGrid environment

In recent years, a research activity has been started to derive special higher-quality data products – so-called 'GOME Level-2 Products' – which include the Earth's 'ozone profile' and 'total ozone column', which give the precise gas concentration at different altitudes above the Earth's surface at any location. By analysing the global GOME dataset over the whole period together with ground-based measurements, it will be possible to obtain an accurate picture of the speed with which the ozone concentrations in our atmosphere are changing. This, in turn, will allow scientists to improve the forecasting models used to predict future ozone concentrations in the near and longer term. Two different ozone-profiling algorithms developed by KNMI (NL) and ESRIN/University of Tor Vergata (I) have been selected for the purpose.

The GOME Web Portal

The EO applications need to be able to access the available Grid resources and services through user-friendly application portals. The GOME Web Portal – which constitutes a prototype integration of Grid and Web services – allows scientists to select a given geographical area and time period, retrieve the corresponding GOME Level-1 products and process them into Level-2 products. Data products covering an extended geographical area selected by the user can be processed in real-time by distributing the processing load across several available Grid resources. The resulting products then remain 'on the Grid' and can subsequently be accessed or validated by other members of the EO Virtual Organisation.

The GOME Portal is an excellent example of the integration of several technologies and distributed services to provide and end-to-end application process capable of being driven



The Web Portal for processing GOME products using Grid resources

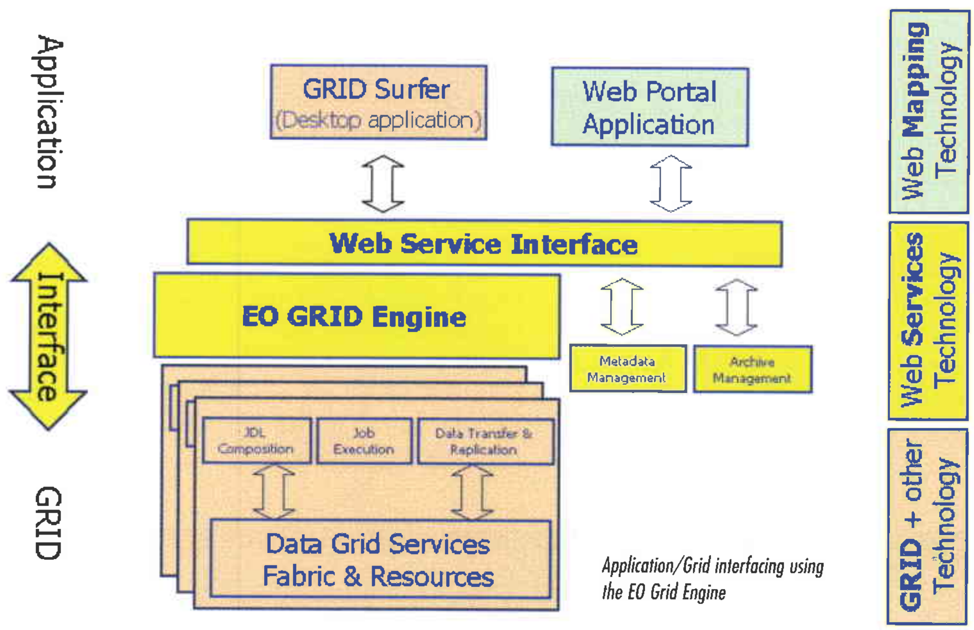
by the end-user. It integrates:
- user authentication services
- Web Mapping services for map image retrieval and data geolocation
- access to metadata catalogues such as Multimission User Information Services and SPITFIRE to identify the datasets of interest, access the ESRIN AMS archive and retrieve the data
- access to Grid FTP transfer protocols to transfer the data to the Grid
- access to the Grid computing and storage elements to process the data and retrieve the results - all in real-time.

ESA's Grid Infrastructure

As mentioned above, the European DataGrid project is currently running a Grid testbed involving some of Europe's main computing centres, commonly known as the 'EDG Testbed'. ESA's contribution is in the form of a dedicated infrastructure at ESRIN with resources that include a cluster of 32 PCs and a relatively large disk-array providing 5 terabytes of storage, interfaced to the ESA-ESRIN EO reference archive and user services system (MUIS). It provides DataGrid users with a wide range of services via three main levels of access:

- *Local Grid*: the user can access only the computing and storage resources available locally in ESRIN. In practical terms, the Local Grid allows the user to have greater control over the use of local resources.
- *Campus Grid*: this utilises the gigabit link connecting the ESRIN and ENEA high-performance computing facilities.
- *European-wide Grid*: this provides access to the full set of resources making up the EDG environment and distributed throughout Europe. In this mode, both the local and Campus resources are fully integrated into the EDG testbed and visible to all EDG users.

Experience to date with the ESRIN Grid infrastructure has been very encouraging and we are considering extending this approach to include other ESA facilities such as ESTEC and, building on Grid experience gained within the CEOS community, to incorporate access to wider international Grid infrastructures.



Application/Grid interfacing using the EO Grid Engine

Conclusion

The first European DataGrid Testbed release has been successfully validated and demonstrated, but we are still in the early stages and much work remains to be done to make the Grid sufficiently user-friendly for a wider range of candidate Earth Observation and Earth Science applications. Grid developments over the next few years, and on-going projects such as the EC's IST 6th Framework project, are expected to bring rapid advances and improvements in the design of architectures and protocols, aligning them with other rapidly developing technologies such as Web Services and the Semantic Web.

Since the start of the EDG project, ESA has made significant progress in recognising Grid as a technology that will bring significant benefit in various space-related disciplines. The results of the ESA internal Grid initiative, started with the SpaceGrid project and continued with the recognised need to build an ESA-wide Grid infrastructure, will become visible in the near future. For Earth Observation, the initial assessment of the potential benefits of a Grid system for carrying out large-scale processing of EO data is promising. The ease with which large amounts of data can be transferred between Grid nodes and processed using large numbers of concurrently executing jobs is impressive. The results of our evaluation using the EDG Testbed show that it is possible to cut processing time one-hundred fold or more using the Grid rather than conventional local resources (such as a single powerful PC, Sun or Linux work station). Although using a cluster system might speed the execution somewhat, it is a solution with limited scalability. The Grid, on the other hand, provides almost unlimited scalability, as well as a standard framework for collaboration.

Acknowledgements

This work has been partially funded by the DataGrid project, under the EU Commission Information Society Technologies (IST) 5th Framework Programme. Acknowledgements are also due to the Royal Dutch Meteorological Institute (KNMI), Institut Pierre Simon Laplace (IPSL), Universitá di Tor Vergata (Rome) and ENEA for their contributions to and partnership in the project.

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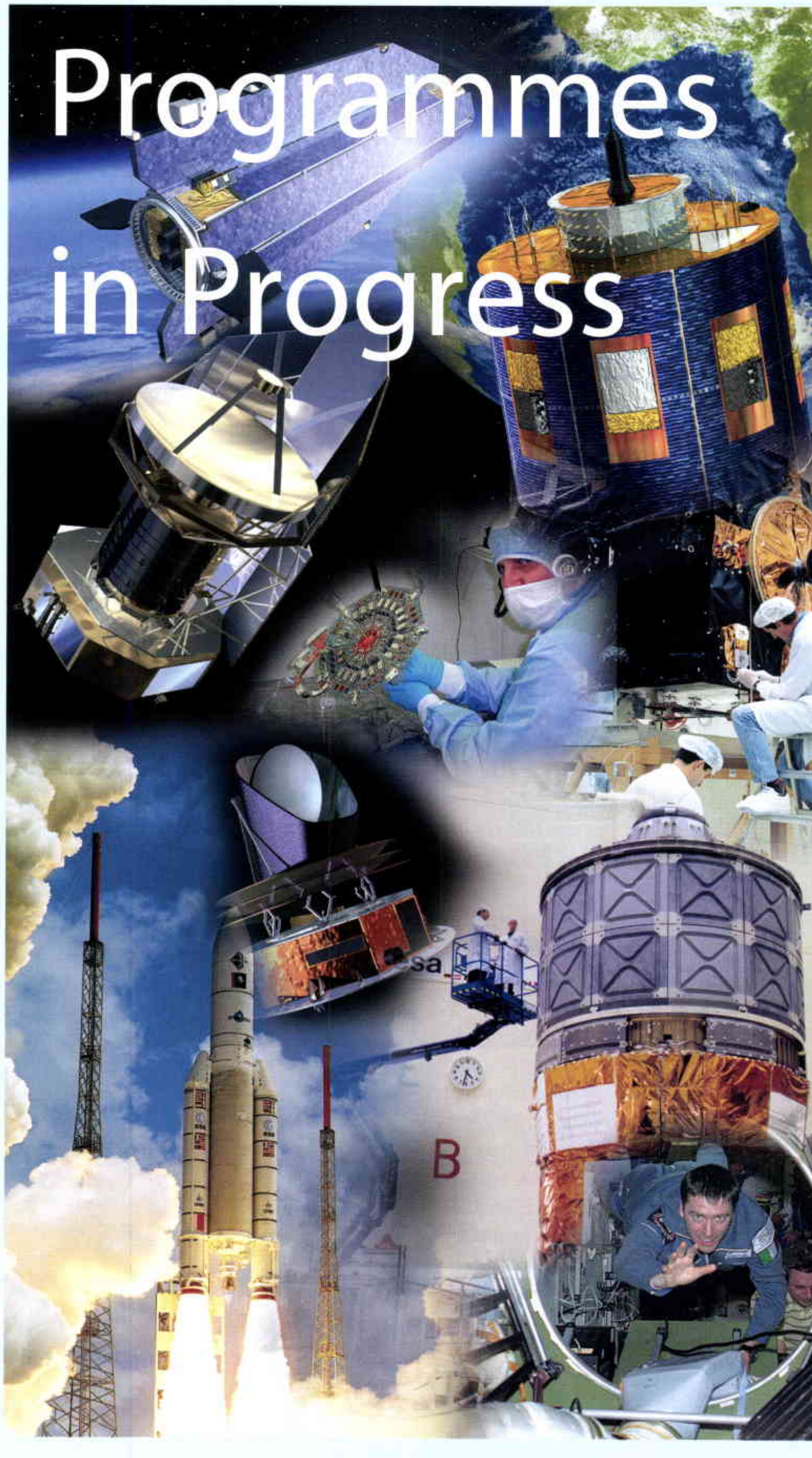
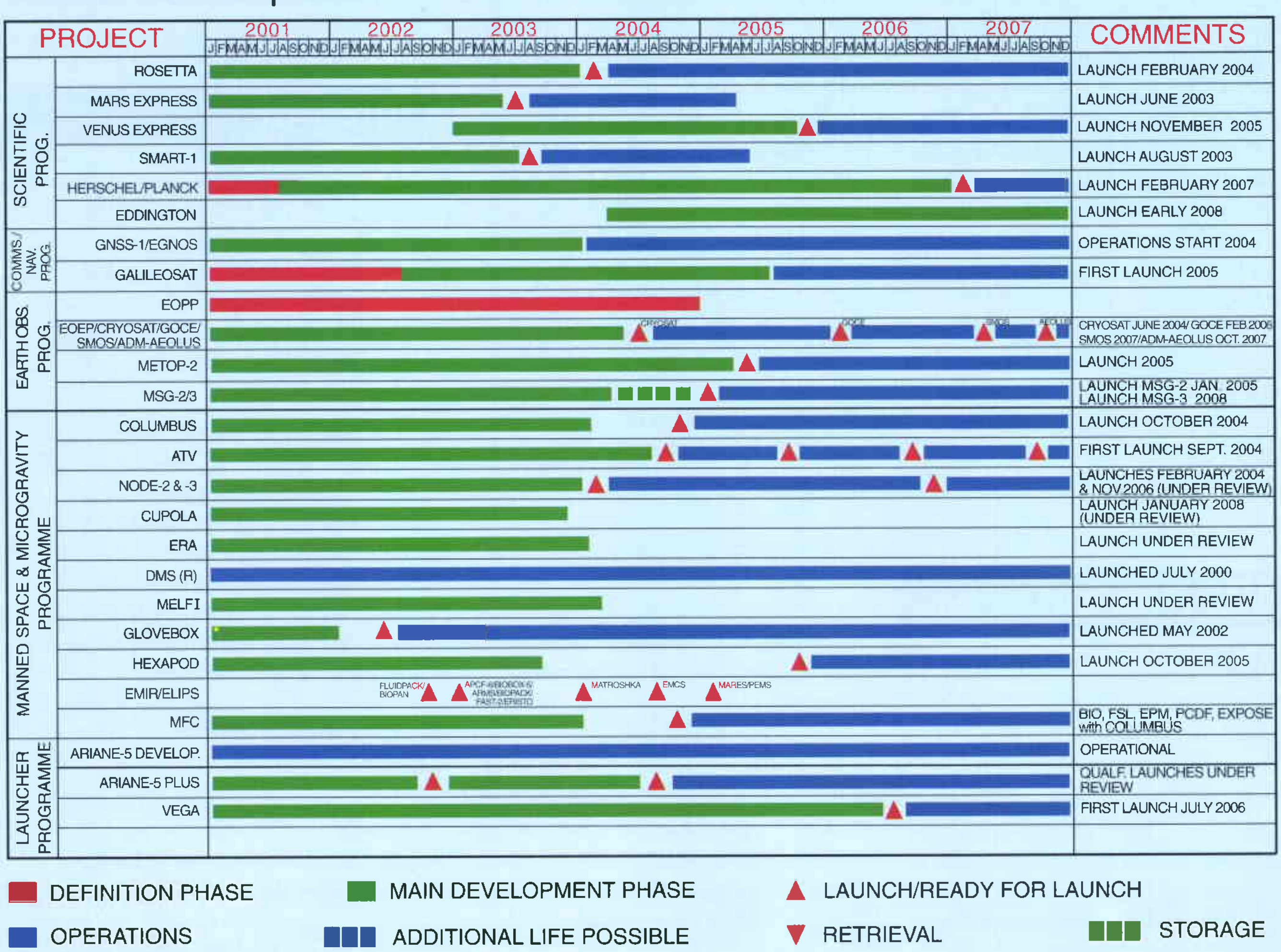

Programmes
in Progress
esa
B

In Orbit

Under Development



ISO

The ISO Data Centre Active Archive Phase activities have continued to run smoothly. The Archive remains busy and, on average, each month in 2003 has seen 60 users downloading some 13% of the content, i.e. the equivalent of the full scientific content is being retrieved every eight months by the community. Requirements have been consolidated for a new version of the ISO Data Archive (V.6), planned for release in July, which upgrades the functionality associated with, and visibility of, the Expert Reduced Data (i.e. data reduced systematically 'by hand'). Projects focussing on reducing data from selected observing modes are underway and a campaign for soliciting reduced data from the community is about to start.

A new approach to data-quality assessment has been laid down, upgrading from a small set of 'technical quality flags' to a well-structured quality report, which often includes a 'scientific assessment'. Implementation of this approach, which is the same as that foreseen for the XMM-Newton Science Archive, is planned for version 7 of the ISO archive, due for release end-2003.

ISO continues to have a significant presence in the refereed literature, with about 1000 articles drawing upon ISO data having appeared since late-1996, 143 of them in 2002, with a similar number expected this year. These ISO-based papers cover almost all areas of astronomy.


ISO

XMM-Newton

XMM-Newton operations continue to run smoothly. Radiation levels around the belts and during the remainder of the orbit have started to increase again, which is a well-known seasonal effect. The recent orbit-maintenance manoeuvre and the spring 2003 eclipse season went by without any problems.

All XMM-Newton ground-segment elements are being upgraded from SCOS-1b to SCOS-2000, to ensure satellite operability throughout its potential lifetime up to 2010.

Data processing and data shipment is proceeding according to plan; over 2500 observation sequences have been executed, and the data for 2400 of these have been shipped. Version 2.0 of the XMM-Newton Science Archive (XSA), including the first release of the Survey Science Centre (SSC) generated source catalogue, was successfully released on 7 April for use by the whole astronomical community.

The programme-completion status is as follows:
- Guaranteed time : 96.9 %
- AO-1 programme : 93.5 %
- AO-2 programme : 39.4 %

The third call for observing proposals (AO-3) was released on 17 March, with a deadline of 30 April, and is open to all astronomers worldwide.

On 27 February, a Gamma-Ray Burst (GRB) alert was received from ESA's Integral satellite and XMM-Newton was used to follow up this event. GRB030227 was discovered at 08:42 UT on 27 February in the field of view of Integral's IBIS telescope. Notification was received by Vilspa (E) at 10:00 UT and an observation was immediately approved by the XMM-Newton Project Scientist for execution at the beginning of orbit 590, which was starting at 11:09 UT the same day. The observation began at 16:39:39 UT and lasted for a total of 49 ksec. Already after the first 1000 sec of exposure, two sources were clearly present in the MOS field of view. Initial results can be found at:

http://xmm.vilspa.esa.es/external/xmm_news/items/grb030227/index.shtml

The above sequence of events clearly demonstrates XMM-Newton's ability to rapidly (< 6 h) follow up external triggers, and illustrates the powerful and unique capabilities offered by operating the Integral and XMM-Newton observatories in combination.

By the end of March, some 280 papers based on XMM-Newton data had been published in, or submitted to, the refereed literature.

Integral

Following its successful commissioning and performance-verification phases, Integral has entered routine operation, conducting observations on behalf of the astronomical community and guaranteed-observing-time holders. Operations are proceeding smoothly with no major concerns.

In February, the observing programme was interrupted to allow observations of the Crab Nebula 'standard candle' source. These observations will allow the sensitivities and responses of Integral's high-energy instruments to be accurately derived and provided to observers. Unfortunately, the Crab Nebula was not visible earlier in the mission due to solar-aspect-angle constraints.

As part of the guaranteed-time programme, Integral regularly scans the Galactic Plane looking for unusual activity and new gamma-ray sources. The first such new source, named IGR J16318-4848, was recently found in this way and prompted follow-on Target of Opportunity observations with ESA's other high-energy mission XMM-Newton. These revealed a compact high-energy source deeply embedded in dense surrounding material. This material blocks many of the emitted X-rays, while allowing the gamma-rays through much more easily. This results in a relatively faint X-ray source as viewed by XMM-Newton, but a bright gamma-ray source for Integral. Since then, Integral has discovered two more similar sources, hinting that such sources may be much more common than astronomers previously believed.

The detailed Integral observing programme is planned about one month in advance and can be found on the web site of the Integral Science Operations Centre (http://astro.estec.esa.nl/Integral). The first public data are now available on the web site of the Integral Science Data Centre (http://isdc.unige.ch/) located near Geneva (CH), and the first shipments of data and processed science products to observers are expected to start shortly.

Rosetta

Various new mission scenarios were presented to the Agency's Science Programme Committee (SPC) in February. The outcome was an SPC recommendation to study in detail a mission to comet Churyumov-Gerasimenko, which could be launched on an Ariane-5 G+ in February 2004. A ground observation programme has started to further characterise the new target comet, and a Lander Working Group has been set up to consider in detail the difficulties of landing on this particular comet nucleus, which is larger than Wirtanen.

An alternative is a mission to the original target comet Wirtanen, to be launched in January 2004 but using a more powerful launch vehicle, e.g. Proton. A back-up to these missions is also available to comet Churyumov-Gerasimenko with a launch on an Ariane-5 ECA or a Proton in February 2005. The final decision will be made by the SPC in May 2003.

The Rosetta flight-model spacecraft remains at the launch site in Kourou (Fr. Guiana), where preparations for off-loading the fuel are underway. It will now remain there and will be used for testing any software updates before the new launch campaign starts later in the year.

The engineering-model spacecraft has been transported to ESOC, where it will remain throughout the mission. It will also be used to test any new software updates, to train for the flight operations, and eventually as a facility for studying any anomalies when the spacecraft is in orbit.

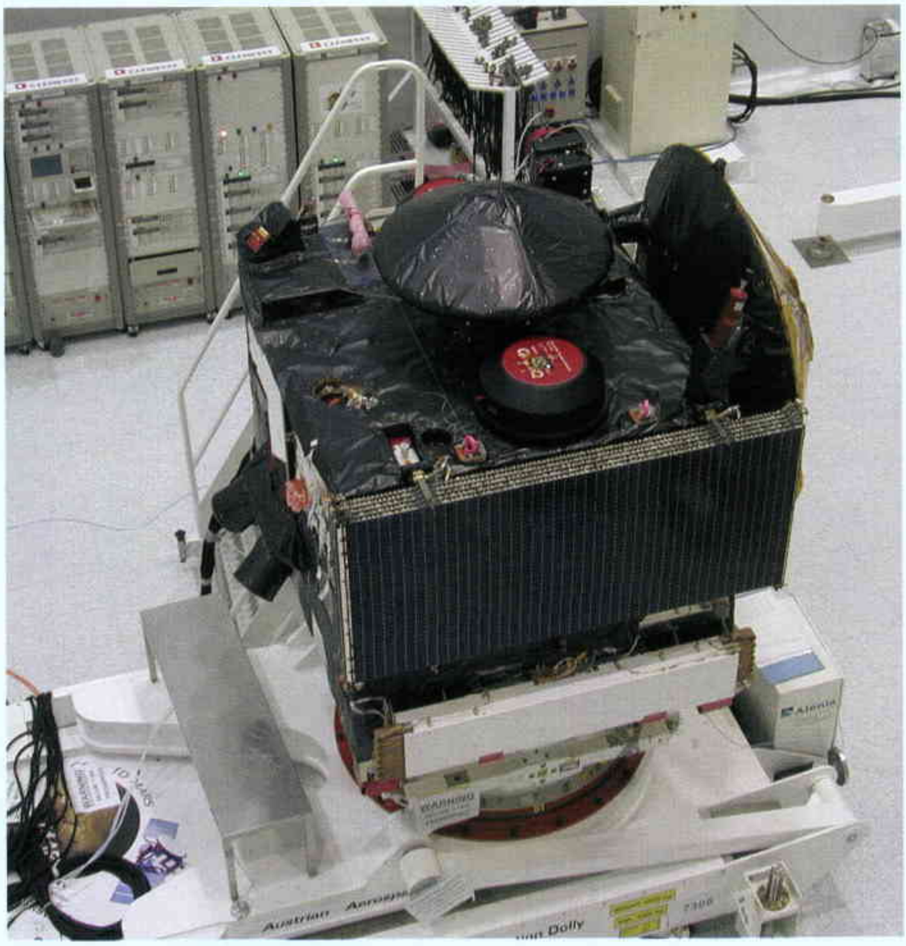
Mars Express

After the spacecraft had successfully completed all relevant tests, the Beagle-2 landing craft was mounted on it for the first time in early March. The spacecraft, Beagle-2 and all necessary support equipment have since been transported by two Antonov-124 cargo planes to Baikonur, on 19 and 21 March, respectively.

Concern about the proper functioning of a power distribution box on the spacecraft necessitated the removal and repair of this unit. Its re-installation on the spacecraft in Baikonur required extra work, inducing a slip in the launch date from 23 May to early June. The launch campaign is progressing well, with activities being executed ahead of the planned dates.

The Ground Segment Readiness Review was successfully completed in early February, and the Flight Acceptance Review for the spacecraft was held in mid-March.

See page 107 for latest news



Mars Express satellite integration at the Baikonur launch site

SMART-1

After completion of the environmental tests, the SMART-1 flight model successfully passed the second System Functional and Performance Test (SFPT-2). The Flight Acceptance Review (FAR) Board, meeting on 20 February, confirmed SMART-1's readiness to fly, provided that the actions assigned – mainly a documentation update and some extra verification tests – were satisfactorily closed out. Arianespace has identified a launch opportunity for SMART-1 between end-July and end-August. The spacecraft activities will be resumed with the final functional test and system verification test with ESOC, and the integration of the solar arrays, before transportation to the launch site. In the meantime, the FAR actions are being completed.

The SMART-1 Team in front of the Large Solar Simulator (LSS) at ESTEC in Noordwijk (NL)

Preparation of the Mission Control System (MCS) at ESOC (D) and the Science and Technology Operation Co-ordination (STOC) at ESTEC (NL) is going according to plan. The Ground Segment Readiness Review for the MCS has already been held, while a delta review for the STOC will take place at the end of May.

Due to the launch-configuration uncertainties, Arianespace has still to perform the final mission analysis for the SMART-1 launch. The associated review is now expected to take place in June, and its success is a pre-condition for the mission Flight Acceptance Review, expected to be held in early July.

Petals of the Herschel telescope after sintering at Boostec (F)

Herschel/Planck/ Eddington

Following the successful completion of the Spacecraft Preliminary Design Review (PDR) at the end of 2002, the project turned its efforts towards the detailed activities. Lower level PDRs took place for many units and subsystems (including some major ones such as the Attitude Control Subsystem), further contributing to the technical definition of the spacecraft at every level.

The Mission PDR – encompassing not only the spacecraft, but also the ground segment and the science operations – took place successfully in February and cleared the way for the programme to progress towards the next major milestone, the Critical Design Review (CDR).

There has also been progress in the definition of the later spacecraft testing activities. A facility specifically designed for vibration testing the Herschel instruments at cryogenic temperatures (- 260°C) has been finalised at CSL in Belgium, and so the Project can now simulate on the ground the conditions that the experiments will encounter during launch.

Testing of the first qualification models of the Herschel payloads in this cryogenic vibration facility is scheduled for May.

The scientific instruments themselves are also advancing in their development, and the first full hardware models are being built and will be tested throughout the rest of this year.

Another area where major milestones are being achieved is in the manufacturing of the Herschel Telescope. The 12 petals that, when put together, will make up the full 3.5 m primary mirror have already been manufactured and will be joined together (by brazing) in the coming weeks. Thereafter, the complete mirror has still to undergo a number of other lengthy processes, including polishing, coating, and cryogenic optical testing.

The Eddington mission, to be implemented in the Science Directorate's new 'Cosmic Vision' strategic plan as part of the overall Herschel/Planck/Eddington programme, has also made major progress. The ESA Industrial Policy Committee (IPC) approved the procurement proposal at its January meeting, authorising the release of the Invitation to Tender (ITT) for industry to conduct parallel definition studies, which should be kicked off in May. A contract has been placed for the manufacture and testing of the special CCD detectors needed for the Eddington mission.

Venus Express

Implementation of Venus Express has been progressing at a rapid pace. The structural elements are being assembled at Contraves in Zurich (CH). Implementation of the ground segment has been initiated in parallel and its Design Review will be completed by July. The contract for launch-service provision is being negotiated with Starsem and will be completed before the summer.

The Spacecraft Preliminary Design Review has already been successfully completed. The hot thermal environment is a major challenge for the mission design, impacting both the spacecraft's thermal protection and the design of the solar array. The latter is the one item that requires major changes with respect to the Mars Express re-use philosophy.

On the payload side, the scientific community has set up regular meetings to advise the project, and planning of the scientific observations during the mission has started.

Double Star

Since the birth of the Double Star project with an agreement signed in July 2001 between ESA and the Chinese National Space Administration (CNSA), regular interface and coordination meetings have been held between European and Chinese scientists and engineers. After eighteen months of intense interface definition work, the cooperative activities entered the hardware testing phase last autumn, with a successful compatibility test of European and Chinese equipment being carried out at Imperial College in London (UK).

Assembly of the structural-thermal model (STM) spacecraft was completed in China and it successfully passed its environmental test programme in February. The electrical subsystems for the first of the two flight-model spacecraft are being tested in Beijing and readied for the integration of the European and Chinese payload instruments at CSSAR (Centre of Space Science and Applied Research). In parallel, European scientists are refurbishing and adapting their Cluster flight-spare instruments for delivery to CSSAR by mid-May.

At that time, the European and Chinese-provided instruments will be subjected for the first time to an integrated system test and will undergo a full suite of interface and functional testing. Thereafter, all spacecraft and payload instruments will be mounted to the DSP-E (Equatorial) satellite structure, the first of the two Double Star satellites to be launched from Xichang in southwest China in December.

Artemis

After a 19-month journey in transfer orbit, the spacecraft finally arrived at its nominal geostationary position on 31 January, an odyssey reported in some detail in an article in the last issue of the ESA Bulletin (February 2003). Since then, the remainder of the platform commissioning tests have been performed and all subsystems were found to be in good order. All specified functions are available (and many non-specified ones as well, which have been discovered only as a result of the very novel way in which we had to operate the spacecraft during the orbit-raising manoeuvres). In parallel, the communication payload characterisation tests were executed by the Artemis team at the Redu station in Belgium. They were also very successful, with all payload functions available and all characteristics compliant with or better than specified values.

Rather spectacular communication tests have also been performed. Optical data links between Artemis and Spot-4 have been established successfully and have confirmed the good results of November 2001. Data-relay services between Artemis and the Envisat satellite have been carried out for the first time. Envisat pointed its high-gain antenna towards Artemis, whose data-relay antenna received the signal, locked onto it and maintained the link for the pre-programmed time. Image data were transferred at 100 Mbit/sec via this link from Envisat directly to the processing centre in Frascati, Italy.

Perhaps even more impressive were the tests performed between Artemis and the Japanese ADEOS-II satellite. High-data-rate link tests similar to those performed with Envisat were conducted, but in addition TTC (telemetry, tracking and command) data were transmitted to and from Artemis. Commands generated in the ADEOS-II control centre in Japan were transmitted via terrestrial lines to Redu. Redu then transmitted the data to Artemis, which forwarded it to ADEOS-II. The commands were executed on ADEOS and the corresponding telemetry data relayed back to Japan via Artemis and Redu.

These tests marked the end of the Artemis Commissioning Phase. The satellite is now operational, with the Land-Mobile payload being used since 1 April to provide an operational service to Telespazio/Eutelsat. By the end of April, the daily data-relay service to Envisat and Spot-4 will begin, and EGNOS will use the Navigation payload from summer onwards.

Meteosat Second Generation (MSG)

The MSG-1 in-orbit commissioning activities have continued since the satellite took its first image on 28 November. In December, they were temporarily interrupted to analyse an observed 'satellite wobble'. Detailed simulations showed that it had been caused by fuel migration within the thermally regulated fuel lines.

Functional and performance testing of the MSG-1 SEVIRI imaging radiometer are proceeding nominally. The preliminary results are of a very high quality and resulted in a successful Commissioning Results Review by the end of March.

Both the GERB instrument and the Search and Rescue (S&R) transponder have also been successfully commissioned.

MSG-1 commissioning will continue until mid-June, at which time Eumetsat will start the subsequent Commissioning Phase-B with the final Image Processing Facility configuration, with the goal of entering the MSG operational phase by the end of the year.

An Enquiry Board established to investigate the anomalous switch-off of a solid-state power amplifier (SSPA) on 25 October has now been concluded, with recommendations on the operation of MSG-1 and on the retrofitting of all SSPAs for MSG-2 and 3.

The MSG-2 satellite-level on-ground test activities are nearing completion. Following the thermal-vacuum testing in December, an optical vacuum test to verify the performance of the SEVIRI imager was conducted in January. Preliminary results show that all performances are nominal. Following a Pre-storage Review (PSR) planned in Cannes (F) for early June, the satellite will be put into storage to await its launch, which is scheduled for January 2005.

For MSG-3, pre-integration activities have started with the mating of the propulsion subsystem and thermal hardware onto the satellite structure. As all of the remaining subsystems have now been delivered, the satellite's main AIT (assembly, integration and test) programme will start in May.

MetOp

Integration work on the first flight model continues, with preparations for the start of MetOp-1 satellite integration and test activities being well advanced. Work at Payload and Service Module level is thus nearly complete for MetOp-1, and is continuing at full speed for MetOp-2 and -3.

The Satellite Qualification Review is currently being held, which is evaluating the results of the important module-level testing, examining the preparations for satellite-level integration, and checking the qualification status of all design elements. In parallel, Eumetsat is performing its own Critical Design Review of the overall Polar System, with active support from ESA and the MetOp team.

The first flight model of the IASI instrument is now well into its acceptance test cycle, with delivery to MetOp foreseen in the summer. A number of problems have been identified in this process, e.g. with the (redundant half) of the corner-cube mechanism, and the acoustic sensitivity of the laser subsystem. The way forward on these issues is being investigated.

The second flight model of the GOME-2

Artist's impression of how MSG builds up its scanned imagery as the spacecraft rotates at 100 rpm instrument has just been delivered. One performance issue has recently been identified, which points to a degradation in the gratings used in the instruments. The cause is not yet clear, but the solution may require a retrofit.

The GRAS instrument continues to make progress, albeit rather slowly. The antenna metallisation issue has been resolved, by the selection of gold to replace the silver previously used.

Failure of the AMSU and HIRS instruments during the MetOp environmental testing has required their return to the USA, where the problems are being investigated and the instruments repaired.

Eumetsat and NOAA have recently agreed a 'Joint Transition Agreement' which addresses the respective roles of the NPOESS system and EPS/MetOp in the 2010 time frame. The Agreement preserves a strong role for Europe in respect of the infrared atmospheric sounding mission in the morning orbit. Stemming from this Agreement is a possibility to have a rapid relaunch capability for MetOp, in the event of a launch or early-orbit failure. This concept is being evaluated.

ADM-Aeolus

Almost all of the Invitation to Tender (ITT) packages for subsystems and equipment have been approved. Proposals for about 15 of these tender actions have been received, and several have already been evaluated. In particular negotiations are taking place with Galileo Avionica with a view to placing a contract for the laser transmitter assembly.

The Agency has discussed with industry the lifetime-assessment programme run on laser pump diodes in preparation for the Aeolus mission. That programme has shown that an adequate stack lifetime is achievable, and significant elements of the qualification programme for stacks have been agreed. The programme will include extensive screening of stack components and a lot acceptance test on the flight stacks.

It has been decided that definitive launcher selection will not take place until late 2005. This will allow the on-going evolution in the launcher market, and particularly the readiness of Vega for Aeolus, to be taken into account. The structural-model campaign to be started next year will therefore ensure basic compatibility with several launchers.

The ground-segment configuration to support data reception is being studied by ESRIN. It must receive and process the data and forward them to operational meteorological centres within three hours. It will have one European ground station (probably Svalbard, Tromsø or Kiruna) and another in North America. Point Barrow, a NOAA station in Alaska, would be a suitable candidate, but the possibility of a new Canadian station with a 2.4 m antenna is also being discussed.

Supporting science studies have investigated the quality of Aeolus wind data based on backscatter information from the US LITE Shuttle experiment. They have shown that data at least as good as that from radiosondes can be obtained over most of the globe. There is a good wind yield in priority areas where few other wind measurements are available.

A separate study has shown that the two different wind directions measured by Aeolus on ascending and descending passes add significant information when integrated into a time-dependent assimilation scheme. The line-of-sight measurements used in this study provided a significant contribution to the analysis of tropical wind patterns.

CryoSat

The satellite development programme passed a major milestone in March 2003 with the delivery of the Cryosat spacecraft structure from Contraves (CH) to Astrium GmbH (D). Work on the test-beds for electrical and functional verification is making good progress. The Critical Design Review process has been started with a presentation at ESTEC and will assess the maturity of the design prior to the integration of the protoflight model satellite.


The Cryosat structure mounted on a trolley at Astrium GmbH

On the payload side, integration of the SIRAL altimeter engineering-model boxes at Alcatel Toulouse (F) is nearly complete. The antennas are currently being assembled at Saab-Ericsson (S) and the electrical performance tests are scheduled to begin by the end of May. Doris instrument development is progressing nominally at Thales (F); the flight model has been assembled and the initial electrical tests have started.

Interfaces between the satellite and the Eurockot launcher have been refined and are now under review in Moscow with Eurokot/Krunichev.

The ground segment's development is progressing well, and preliminary activities have started at the Kiruna station. The Cryovex campaign, which forms part of the Cryosat Cal/Val activities, is planned for April.

GOCE

About nine months into Phase-C/D, the space-segment development activities are focussed on completion of the detailed satellite design, achieved through breadboard manufacturing and testing and through the execution of equipment-level Preliminary Design Reviews (PDRs). Such PDRs have recently been successfully concluded for the S-band transponder and antenna, the Power Control and Distribution Unit (PCDU), the Command and Data Management Unit (CDMU), and the magnetic torquer. In addition, PDRs are in progress for the ion-thruster assembly, the satellite-to-satellite tracking instrument, and the Gradiometer Accelerometer Interface Electronic Unit (GAIEU). The manufacture and testing of the main on-board computer (i.e. CDMU) breadboard has been finalised and it is presently being used to support software development activities.

The GOCE industrial consortium is nearly complete. Negotiations have been concluded successfully with the suppliers selected for the solar generator's Photovoltaic Assembly (PVA) and substrate, respectively. Moreover, the independent-software-validation and the star-tracker contracts have been kicked-off.

On the Gradiometer side, mechanical testing of an accelerometer sensor head equipped with the selected stop material and coating was performed during the second half of March. On-going inspection of the test specimen is expected to confirm whether the current sensor-head design is able to withstand the vibrations experienced during launch. The accelerometer electronics development is an area of some concern due to the delays encountered so far. The Front-End Electronics Unit (FEEU) breadboard testing activities were recently completed and the results show a satisfactory level of compliance with the gradiometer performance requirements.

Concerning the Ion Propulsion Assembly, breadboard test activities for the xenon feed assembly have been completed and micro-vibration testing is in progress. Manufacture of the pre-verification model of the ion thruster has been completed, and a short 500 h endurance test has been initiated.

Ground-segment activities have focussed on finalisation of the documentation relevant to the Invitation to Tender (ITT) for the development of the Payload Data Segment (PDS), responsible for scientific data processing up to Level-1B and for the running archive of data products during the mission. The PDS ITT was released at the beginning of February and contractor selection is expected by the middle of this year.

Finally, the documentation relevant to the launch of an in-depth study of the tasks to be performed by the Calibration and Monitoring Facility (CMF) has been completed. The study itself is expected to start in May.

SMOS

The payload design phase (Phase-B) is progressing well, with successful conclusion of the Payload System Requirements (PSR) Review with the prime contractor, EADS-CASA, on 1 April. The PSR identified a major discrepancy between the payload mass and deployed inertias, and the capabilities of the PROTEUS platform. Immediate work-around solutions were initiated to recover the situation.

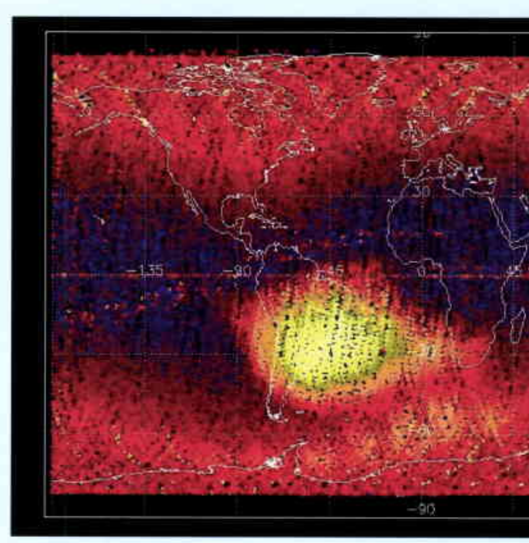
The formalisation of ESA-CNES cooperation is proceeding with the finalisation of a draft Memorandum of Understanding (MOU) between the two parties. The System Requirements Document (SRD) has been thoroughly reviewed and updated. System support studies have started on 4 March with CNES/Alcatel in support of payload development, and on 18 March with Rockot for satellite-to-launcher coupled load and trajectory analyses.

The ground-segment definition phase (Phase-A) with GMV, Indra and INSA, is proceeding according to plan, with completion expected by mid-2003.

The MIRAS Demonstrator Pilot Projects 1 and 2 should be concluded by September. Tasks remaining tasks include a measurement campaign with a Noise Injection Radiometer (NIR) at HUT, the final design review for the Digital Correlator (DICOS) at Astrium, and optical harness (MOHA) breadboarding and testing at Contraves.

PROBA

The last three months of usage of the PROBA spacecraft has been shared between technological activities and data collection from the spacecraft's space-environment instruments (SREM, MRM and DEBIE) and the Earth-observation instruments (HRC, CHRIS). The first CHRIS-PROBA Workshop has taken place in ESTEC to review the results from the first year in orbit and to prepare the observation plan for the next campaign. The ground support for PROBA has

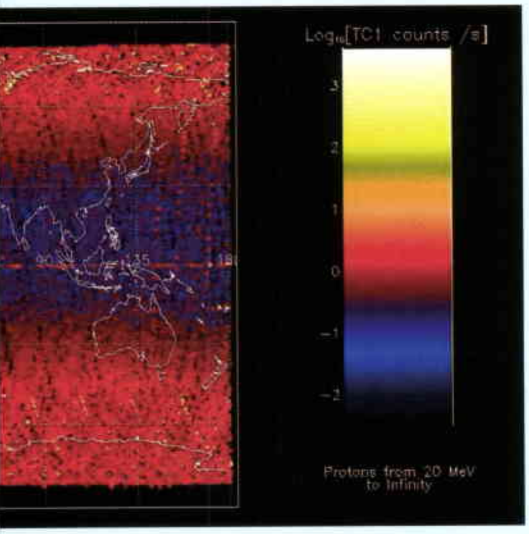


been upgraded so that data will now also be collected by the ESA/Earthnet station at Kiruna in Sweden, as well as ESA's Redu station in Belgium.

International Space Station

Research and applications programmes
Following the tragic loss of the Space Shuttle 'Columbia' and its crew on 1 February, the consequences for the ISS have been analysed. The Space Station Control Board (SSCB) evaluated the logistic needs for 2003 and 2004 assuming an absence of the Shuttle, and made several recommendations. As a result, the Multilateral Control Board (MCB) has decided to convert Soyuz flight 6S (April 2003) into a Crew Rotation Flight, and from April onwards a two-person crew will be the ISS baseline until the Shuttle returns to flight (a three-person crew is unsustainable, with the available number of Progress vehicles, beyond end-August 2003). Furthermore, the MCB approved the SSCB 'Option 2' scenario, which has added one extra Progress flight in 2003 and another in 2004, conditional upon funding availability. Unfortunately, to date this funding has not become available.

Specific activities related to the Heads of Agency Programme Action Plan, agreed at their meeting in Tokyo in December, have been slowed down by the Columbia disaster.



Data from PROBA's SREM instrument clearly indicate the increased proton flux in the South Atlantic Anomaly

However, before that the decision was taken to reinstate Node-3 as a part of the ISS baseline, and to outfit it with the US regenerative Environmental Control and Life-Support System (ECLSS), thereby fulfilling one of the US obligations that were not met in the 'US Core Complete' configuration.

Space infrastructure development
As part of the flight-model acceptance testing, the Columbus Laboratory thermal and electromagnetic compatibility (EMC) tests were performed successfully. Hardware/software compatibility testing has started and system functional qualification of the Electrical Test Model continues.

Node-2 flight-unit mechanical integration has been delayed by the unavailability of certain hardware and re-working of that already delivered. The Node-2 Flight Acceptance Review (FAR) has been concluded, but numerous issues remain open.

The Cryosystem design phase (Phase-B) is ongoing and the System Requirements Review (SRR) has been successfully performed.

Flight-unit harness and Meteroid and Debris Protection System (MDPS) deliveries have been made for the Cupola.

Flight-model manufacture and integration of the Automated Transfer Vehicle (ATV) is progressing. Manufacture of the refuelling system has been completed and Integrated Cargo Carrier flight-model integration has started. Electrical integration of the Functional Simulation Facility (FSF) with the Electrical Test Model (ETM) has been completed and electrical testing started. The System Critical Design Review (CDR) has also started. Some technical problems with propulsion-bay equipment are being worked on and flight-software delivery delays have been announced by Industry.

Following the Ariane-5 launch failure last December, the Ariane-5 configuration for ATV-1 will be based on Vulcain-2 and the EPS upper stage. If Vulcain-2 is not qualified in time, it will be launched by an existing qualified Ariane-5 configuration using Vulcain-1 and EPS, with reduced payload capability, but still within the planned up-load mass for the first flight.

Work on Europe's contributions to the X-38 vehicle has been completed.

Operations and related ground segments
Proposal negotiations for the Columbus Control Centre have been completed and signature of the contract for the main development phase (Phase-C/D) took place on 31 March.

Following the ATV Control Centre proposal evaluation and negotiation, the technical and financial baseline has been agreed and signature of the contracts for design and development, as well as for ATV operations preparation, is planned for mid-April.

An in-orbit operational problem with the Microgravity Science Glovebox (MSG) has been resolved and operations restarted.

The Data Management System in the Russian Service Module (DMS-R) is continuing to perform without problem.

Utilisation planning, payload development and preparatory missions
Nine new Microgravity Application Promotion (MAP) continuation proposals had been received by end-March, and they have been passed to the Expert Panel for evaluation.

The –80 degC Freezer (MELFI Flight Unit 1) has been installed in the Multi-Purpose Logistics Module (MPLM) ready for launch.

Delivery of the Hexapod to NASA is planned for May.

The SOLAR Instrument Safety Workshop identified a lack of design maturity in the scientific instruments. Relocation of the EXPOSE facility from the EXPORT assembly (with Coarse Pointing Device) to the EuTEF assembly (without CPD) has been implemented.

The payload Phase-C/D for the Atomic Clock Ensemble in Space (ACES) is on hold due to uncertainties about the funding of PHARAO.

The Critical Design Review (CDR) for Matroshka has been successfully completed and thermal testing is now in progress at ESTEC.

Functional qualification testing of the flight model of the European Robotic Arm (ERA) is continuing, but the launch date and scenario for ERA remains undefined.

The seven ESA payloads that were part of the Spacehab mission onboard Space Shuttle 'Columbia' were lost in that tragic accident. Telemetry and/or video data are available for ARMS, COM2PLEX and FAST, representing approximately 100% of the expected scientific return. For APCF, Biobox, Biopack and ERISTO, however, the scientific outcome was dependent on return of the processed samples, which were destroyed in the accident.

The Science Reference Model for Biolab is undergoing biological testing prior to delivery, the flight-model subsystems delivery is almost complete, and flight-model integration is also approaching completion.

The Fluid Science Laboratory (FSL) system flight-model assembly, integration and testing has been completed. Integration of the Canadian Microgravity Vibration Isolation System (MVIS) will now take place following the completion of FSL flight-model acceptance.

Testing of the NASA Quench Module Insert (QMI) in the engineering model of the Material Science Laboratory (MSL in US Lab) has been successfully completed. Engineering-model delivery to NASA is expected by May, and flight-model assembly has been initiated.

The European Physiology Module (EPM) flight-model system integration is ongoing with harness and thermal subsystems. NASA's Human Research Facility HRF-2, including the EPM contribution, the Pulmonary Function System, has been integrated into the MPLM and is awaiting launch on ULF-1.

ISS education
A review of the pilot version of the ISS Education Kit (for 12 to 15 year olds) by 800 teachers has been completed, with positive results. The final version of the kit will be produced in the last quarter of 2003. On 2/3 March, a workshop for Primary School Teachers was held at ESTEC to prepare for the development of the ISS Education Kit for Primary Schools.

Commercial activities
An industrial initiative has been taken to establish a European ISS Business Club, the purpose of which is to contribute to the promotion of ISS commercialisation opportunities throughout Europe's business communities. It will consist of contractors, subcontractors and suppliers in the area of ISS development, exploitation and utilisation, thus forming a unique industrial network motivated to promote the ISS.

A number of commercial proposals related to the improvement of crew quality-of-life have been received and are being considered for future ESA Taxi-flight missions.

In preparation for the selection of one or more commercial agents, a workshop for potential agents was held at ESTEC in February. It was attended by members of the Cooperation Agreement, the USOCs and the technology-transfer network, and new companies that operate as R&D brokers in Europe.

Astronaut activities
André Kuipers and Pedro Duque continued their training in Russia for their Soyuz Taxi-flight missions which, due to the 'Columbia' accident, have been postponed by six months. Their training schedules have been revised accordingly.

The training of Christer Fuglesang and his fellow crew members for the STS-116/12A.1 mission was suspended following the 'Columbia' accident, but resumed on 18 February. The future Shuttle flight schedule awaits the outcome of the accident investigations.

Vega and P80

The two main industrial contracts for the Vega Programme were signed in Colleferro (I) on 25 February. The first, for a firm fixed price of 221 MEuro, is between ESA and ELV, the Vega prime contractor and includes an industrial commitment to future launch pricing. The second, for a firm fixed price of 40.7 MEuro, has been signed by CNES, on behalf of ESA, and Fiat Avio, the prime contractor for the P80 stage demonstrator. Signature of this contract is complemented by a significant industrial investment. These concurrent events have concluded an intense negotiation phase in January and mark the full deployment of the resources needed to achieve the Vega launcher objectives, including a first launch in July 2006.

Current Vega activities include the finalisation of contracts at the lower industrial levels, and preparations for the Avionics Preliminary Design Review and the Level-1 Safety Review. The P80 development effort is also proceeding according to plan.

In the ground-segment area, final discussions have taken place between IPT and CNES/DLA/SDS on the basis of the updated proposal for the 'Technical Management Engineering and Test Activity of the Ground Segment'. Preparation of the Invitations to Tender (ITTs) for the main ground-segment elements has progressed and the pre-Tender Evaluation Boards for three of them (civil engineering, metal structures and control bench) took place in March. esa

In Brief

Galileo becomes a reality for Europe

The agreement reached by the Agency's Member States in a Council Meeting at Delegate level in Paris on 26 May has cleared the way for the official launch of the legal entity that will have the task of coordinating ESA and European Union involvement in the Galileo Programme. The Agency is now able to finalise the conditions for participation in this European initiative to develop a global satellite navigation system, and to approve the Galileo Joint Undertaking founding act soon to be signed by ESA and the EU.

The Galileo Joint Undertaking, to be headquartered in Brussels, has a key part to play in implementing the various phases of the Programme. This unique organisational structure, which will pave the way for the entity that will eventually operate the Galileo system, will be responsible for Galileo's development and validation phase, and also for the preparations for system deployment and operations.

Galileo will complement the existing satellite navigation system, which presently relies entirely on the American Global Positioning System (GPS). Funded equally by ESA and the EU, Galileo is designed to provide a complete civil system, which is scheduled to be operational by 2008. It will offer the citizens of Europe and the rest of the World an accurate and secure satellite positioning capability supporting a broad range of applications: e.g. control of road, rail and sea traffic, synchronised data transmission between computers, and many others.

Projections point to very significant economic benefits from this first project to be carried out jointly by ESA and the EU, with a return on investment factor of 4.6 and the creation of over 140 000 jobs. The Galileo system will be built around 30 satellites (27 operational and 3 reserve spacecraft) occupying three circular Earth orbits, inclined at 56° to the Equator, at an altitude of 23 616 km. This configuration will provide excellent global coverage. Two Galileo Control Centres will be established in Europe to control satellite operations and manage the new navigation system, from which all of Europe's citizen's will derive benefit.

On hearing about the successful outcome of the Council Meeting at Delegate Level, Mrs Edelgard Bulmahn, the German Minister of Education and Research, in Paris to chair the ESA Council at Ministerial Level the following day, commented:

"I am extremely delighted with this result. Galileo is now on its way. I am grateful to all ESA Member States that have striven to find a balanced solution and pleased that Europe has once again proved able to remain at the forefront of high-level technology for a programme useful to all of us in our everyday lives". esa

ISS Node 2 ready to go

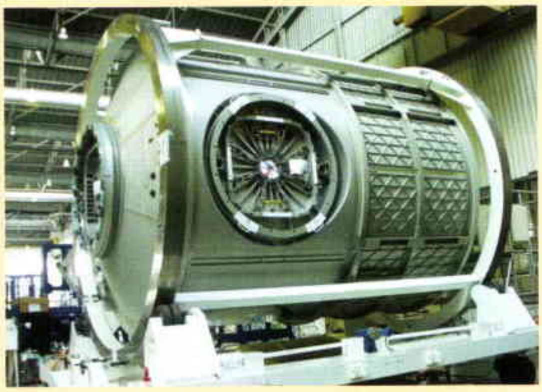
The first European node for the International Space Station has passed its acceptance review and is now about to be shipped to Kennedy Space Centre.

The nodes are elements interconnecting the laboratory and habitation modules of the ISS. When completed, the Station will have three nodes. Node 1, called Unity, has already been developed and manufactured by US industry under a NASA contract and was launched in December 1998. It connects the Russian Zarya module with the American Laboratory Destiny. Nodes 2 and 3 are being made in Europe for NASA, under a barter agreement, using European know-how and technology.

Node 2 will connect the US Laboratory Destiny, the European Columbus Laboratory, the Centrifuge Accommodation Module, and the Japanese Experiment Module Kibo. It also will be the attachment point for the Multi-Purpose Logistics Module (MPLM), and the Japanese H II Transfer Vehicle and it will carry a docking adapter for the US Space Shuttle. It will control and distribute resources throughout these Station elements and provide support to the crew and experiments, and will also provide a working base point for the Space Station Remote Manipulator System.

ESA entrusted the Italian Space Agency ASI with responsibility for the management, development and manufacture of the two nodes, which are being built under the prime contractorship of Alenia Spazio in Turin, leading a consortium of European industrial companies.

After a successful transportation readiness review, the Node 2 will be flown to the Kennedy Space Centre, Florida, USA, where it will be formally handed over from ASI to ESA and from ESA to NASA, which according to the terms of the barter agreement will then become the final owner of this ISS element.



The primary structure of the Node 2 flight unit at Alenia in Turin (I)

ESA signs contract with DLR for Columbus Control Centre

On 31 March at Oberpfaffenhofen, near Munich, Germany, ESA Director of Human Spaceflight Jörg Feustel-Büechl signed a 37.7 MEuro contract with DLR, the German national agency for aerospace research and spaceflight, to develop the Columbus Control Centre for the European Columbus laboratory on the International Space Station (ISS).

The main functions of the Columbus Control Centre will be to command and control the Columbus laboratory systems, to provide and operate the European ground communications network for the facility, and to coordinate operations for the European payloads on board the ISS.

"The Columbus laboratory and the Columbus Control Centre are vital elements of the European participation in the International Space Station," said Jörg Feustel-Büechl, *"the signature with DLR for the Columbus Control Centre demonstrates Europe's commitment to the International Space Station programme".*

Once the Columbus Control Centre is set up in Oberpfaffenhofen, on the premises of DLR's German Space Operations Centre (GSOC) and ready for operations in 2004, DLR will take responsibility under a further ESA contract for management of the centre and coordination and support of all on-orbit operations of the Columbus laboratory on behalf of ESA.

The Columbus assembly mission, scheduled for October 2004, and the first period of Columbus operations will be managed by an Integrated Flight Control Team consisting of DLR, Astrium and ESA personnel led by an ESA Flight Director. For subsequent periods, DLR will lead the Columbus Laboratory Flight Control Team, with up to 90 operators. The team will act on ESA's behalf vis-à-vis NASA and other ISS partners for the execution of all Columbus operations.

In placing this contract, ESA is recognising the long-standing experience and competence of DLR in Oberpfaffenhofen in the management of manned spaceflight operations. DLR has been involved in spacecraft operations for 35 years and in the management of manned spaceflight missions since the first European Spacelab mission in 1983. Since 1998 DLR specialists have contributed to the design and preparation of the Columbus Control Centre.

New Director of Launchers

Antonio Fabrizi will be ESA's new Director of Launchers from 1 July for a four-year term. Mr Fabrizi replaces Jean-Jacques Dordain, the current Director of Launchers, who takes up his new duties as ESA Director General on the same date.


Antonio Fabrizi

Antonio Fabrizi, 55, graduated in Mechanical Engineering at "La Sapienza" University in Rome. From 1975 to 1989 he held several positions at BPD, including responsibility for feasibility studies on Ariane boosters.

In 1990 he was appointed Commercial Manager at FiatAvio in charge of new initiatives development. In 1993 he became head of the Space Transportation Systems Business Unit at BPD. Between 1997 and 1999, within FiatAvio/UBS, he continued with the same responsibilities, including the Cyclone and Vega programmes.

Since 2000 Mr Fabrizi has been Vice-President, Space Business Unit, at FiatAvio and responsible for all space activities. In addition he holds several directorships (including Europropulsion, Regulus and Arianespace) and is President and Director General of Vegaspazio. esa

Europe's antenna in Australia

The European Space Agency's first deep space ground station opened in New Norcia, 150 km north of Perth in Australia, in March. The station will play a major role in the Agency's deep space missions, including Rosetta and Mars Express. The latter was launched on 2 June.


ESA's ground station in New Norcia

The key component of the ground station is its massive antenna which weighs over 600 tonnes and is more than 40 metres high. It can move 540 tonnes of ballast, cantilever and 35-metre dish while maintaining precision pointing of its beam.

Construction of the 28 MEuro project began in April 2000. The last six months of 2002 were devoted to testing the electronic and communication equipment. After an initial manned period, the station will be controlled remotely from ESA's European Space Operations Centre (ESOC) in Darmstadt in Germany and the Perth International Telecommunications Centre at Gnangara in Australia.

David Southwood, ESA's Director of Science, says New Norcia was chosen over a number of sites in the southern hemisphere. *"This site has excellent weather conditions, sits at the perfect latitude for deep space operations and is sufficiently distant from urban areas so that no other transmission devices disturb the satellite's transmissions,"* he said.

The Premier of Western Australia, the Hon Dr Geoff Gallop, officially 'switched on' the deep space ground station. esa

Successful launch for Maxus 5

The European Space Agency's Maxus 5 sounding rocket mission was successfully launched on 1 April at 08:00 CEST (06:00 GMT) from Esrange, north of the Arctic Circle near Kiruna in northern Sweden.

The rocket, an 11.5 tonne solid-fuelled Castor 4B, carried a 488 kg payload of five scientific experiments with their associated telemetry and video links. The five experiments were stacked in five self-contained modules. They were designed to investigate phenomena in biology, fluid physics, material science and fundamental physics.

The launch, originally planned for later in the morning, was brought forward due to the bad weather forecast for later in the day. Maxus 5 hurtled upwards through a partially cloudy sky to reach a maximum speed of about 3600 metres per second and maximum height of just over 700 km. From booster burnout 70 km up, until atmospheric re-entry 740 seconds later, the payload was in excellent microgravity conditions.

Mission telemetry used to monitor the experiments functioned perfectly. Video images and data received at Esrange show that the experiments went well. The payload package was located soon after landing and was recovered by two helicopters about 80 km downrange. esa

Mars Express spacecraft successfully launched

En route for the Red Planet
ESA's Mars Express space probe has been placed successfully on a trajectory that will take it beyond our terrestrial environment and speed it on its way to the Red Planet, where it will arrive in late December. This is the Agency's first probe to head for another planet and it go into orbit around Mars, from where it will perform detailed studies of the planet's surface, its subsurface structures and its atmosphere. It will also deploy Beagle 2, a small autonomous station which will land on the planet to study its surface and look for possible signs of life, either past or present.

Weighing in at 1120 kg, Mars Express was built for ESA by a European industrial team led by Astrium. Its Soyuz-Fregat launcher, operated by Starsem, lifted off from Baikonur in Kazakhstan on 2 June at 23.45 local time (17:45 GMT). A first firing of the Fregat upper stage put the spacecraft into an interim orbit around the Earth, and one hour and thirty-two minutes later it was injected into its interplanetary orbit.

"Europe is on its way to Mars to stake its claim in the most detailed and complete exploration ever made of the Red Planet. We can be very proud of this, and of the speed with which have achieved this goal", said Prof. David Southwood, ESA's Director of Science, witnessing the launch from Baikonur.

ESOC, ESA's satellite control centre in Darmstadt, Germany, quickly established contact with the spacecraft, confirming that it was pointing correctly towards the Sun, that its solar panels had been successfully deployed, and that all onboard systems are operating faultlessly.

Mars Express is now speeding through space at more than 30 km/s on its six-month and 400 million kilometre journey through the Solar System, during most of which the spacecraft will contact Earth only once per day.


The Soyuz-Fregat launcher carrying Mars Express lifting off from Baikonur on 2 June

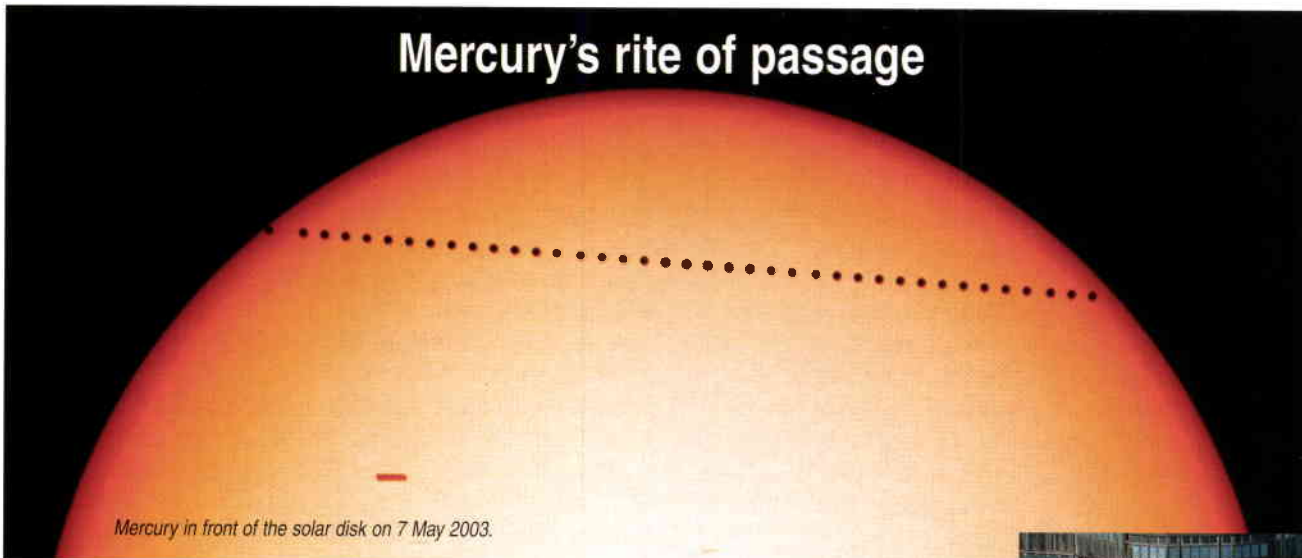
There in time for Christmas
At the end of November, Mars Express will get ready to release Beagle 2. The 60 kg capsule containing the tiny lander will be released on 20 December and will enter the Martian atmosphere on Christmas Day, after five days of ballistic flight. As it descends, it will be protected in the first instance by a heat-shield, two parachutes will then open to provide further deceleration, and three airbags will soften the final impact. This crucial phase in the mission will last just ten minutes, from entry into the Martian atmosphere to landing on the planet's surface.

Having deployed its solar panels and the payload adjustable workbench, a set of instruments (two cameras, a microscope and two spectrometers) mounted on the end of a robotic arm, Beagle will proceed to explore its new environment, gathering geological and mineralogical data that should allow Martian rock samples to be dated with absolute accuracy for the first time. Using a grinder and corer, and 'the mole', a wire-guided mini-robot able to burrow under rocks and dig to a depth of 2 m, it will collect samples to be examined in the GAP automated mini-laboratory, equipped with twelve furnaces and a mass spectrometer. It will be the spectrometer's job to detect possible signs of life and date the rock samples.

Meanwhile, the Mars Express spacecraft will have performed a series of complex manœuvres and motor firings in order to achieve a 7.5 hour quasi-polar orbit around the planet, which will take it to within 250 km of the surface. From there it will carry out a detailed investigation of the planet, pointing its instruments at Mars for between half-an-hour and an hour per orbit and then, for the remainder of the time, at Earth to relay the information that it has collected, and the data transmitted to it by Beagle 2. esa

A full feature on the Mars Express mission will appear in the August 2003 issue of the ESA Bulletin.

Mercury's rite of passage


Mercury in front of the solar disk on 7 May 2003.

In Greek mythology Hermes is the swift messenger of the gods who flies across the heavens at great speed. Hermes, or Mercury in the Roman form, has given his name to the closest of the planets to the Sun since early times. Mercury is a relatively bright object in the night and early morning skies, visible to the naked eye, orbiting the Sun every 88 days. Mercury's orbital inclination is tilted at seven degrees relative to the Earth's and it is usually unnoticeable when it passes between the Earth and the Sun. A visible transit of the Sun happens just once every 23 times Mercury passes the Earth and this has occurred only 14 times in the last century. It is thus a relatively rare occurrence despite the swiftness of Mercury's orbit.

On 7 May Mercury made one of these infrequent transits. The transit, as viewed from ESTEC, began at 9:50 CET and lasted five and a half hours until 15:17 CET. During the transit Mercury was never more than a small black spot, invisible to the naked eye, against the backdrop of the glaring Sun. This black spot was 1/160th of the diameter of the Sun and caused an almost undetectable dimming of the solar light. ESA's SOHO spacecraft was able to detect this, however, and measured it to be a diminution by one part in 30,000.

As with other solar events it was possible to view the transit in a number of ways. The safest was to use a small telescope with a screen of white paper below the eyepiece, allowing the telescope to project an image of the Sun onto it complete with the shadow cast by Mercury. This was one of four ways used to view the transit at ESTEC – alongside a 15-cm refracting telescope, a filtered video camera and screen and a telescope with protection filters for the sunlight also provided a glimpse of the event. Some 500 people queued up during the day in hopes of distinguishing Mercury and some were more successful than others in seeing the tiny black dot. The next planet to make a transit of the Sun will be Venus on 8 June 2004.


The safest way to see Mercury was to look at its projection on a piece of cardboard.


ESTEC scientists, who had set up different telescopes outside the reception, patiently explained the heavenly spectacle to the long queues of curious staff.

Space to make space

ESA is calling upon European design students to create products featuring new interior storage concepts by applying 'space methods' to life here on Earth.

What any spacecraft most lacks is physical space onboard. With the high cost of delivering payload, every cubic centimetre of interior volume must be exploited as efficiently as possible. So astronauts have to live at extremely close quarters, while engineers are driven to develop new methods of volume management and storage.

Now the Agency has issued a brief – 'From Outer Space To Inner Space: Implications For Innovative Storage Design' – as part of the 2nd D&AD NESTA Joint Product Design and Innovation Awards. It asks for a product featuring a new storage concept, designed for any interior, from a room of a home to the inside of a car. But it must incorporate techniques, technologies or materials developed for space or used extensively in it.

The competition is open to undergraduate and postgraduate student designers across Europe. The closing date for entries is 26 March 2004. Three winners will be selected by the Awards jury in June 2004, and each given funding and encouragement to develop their ideas.

The Awards are organised jointly by D&AD (Design & Art Direction), an organisation representing Britain's design and advertising communities and NESTA (the National Endowment for Science, Technology and the Arts), a body encouraging innovation in UK science, technology and the arts.

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Space weather comes to Berlin

The Space Weather Forum held in Berlin on 4 November last year was the opening event for the first European-wide Space Weather Week during the European Science and Technology Week 2002. The Forum was organised by the University of Greifswald's Institute for Physics/Space Weather Observatory, and 12 organisations, institutes and companies from all over Europe, including ESA and DLR.

Many newspapers and television/radio stations covered the Forum, which was attended by nearly 300 people from all over Europe – ranging from school children, students, teachers, journalists, scientists, people from industry and cultural organisations, to experts from ministries and other government bodies. Another 200 people from all over the world watched the event in real time via the Internet.

The programme of events included a direct video link with the International Space Station, which then had ESA astronaut Frank de Winne onboard. The presentations made at the Forum by acknowledged space-weather experts are still available online at http//:www.uni-greifswald.de. Space weather promotion products like the CD-ROM included with this copy of ESA Bulletin (for European addressees) and the poster (both are in English and German) that were on display at the Forum can be ordered from Frank Jansen, the Space Weather Forum Coordinator, at jansen@physik.uni-greifswald.de.

ESA's participation also included the display of models of its Soho, Cluster and Ulysses satellites. Data gathered by these and other satellites about the Sun and the Earth's environment were downloaded and explained to the Forum's attendees in real time.

Further information about the causes, implications and consequences of space weather can be found in the feature article in this issue of ESA Bulletin. esa

Alexi Glover (ESA) and Frank Jansen (Univ. of Greifswald) introduce the Forum participants to space weather

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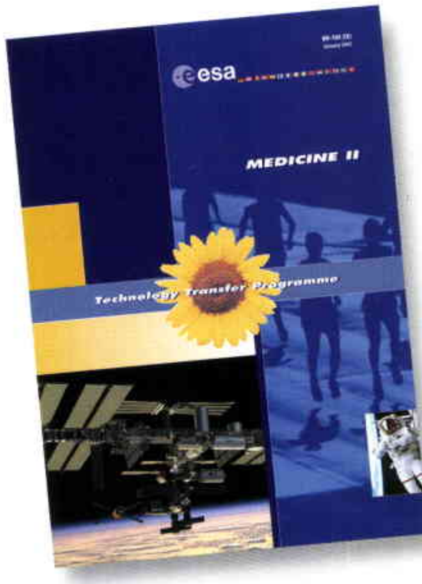

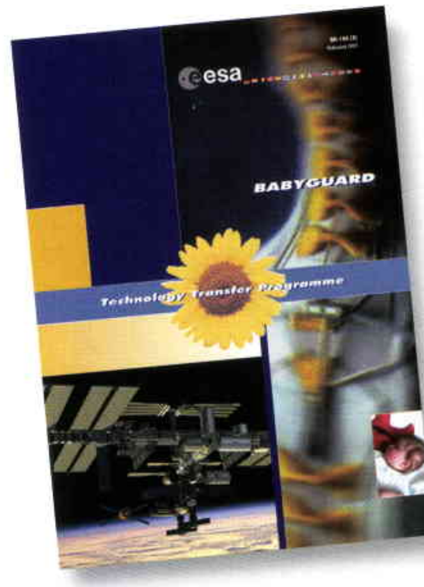

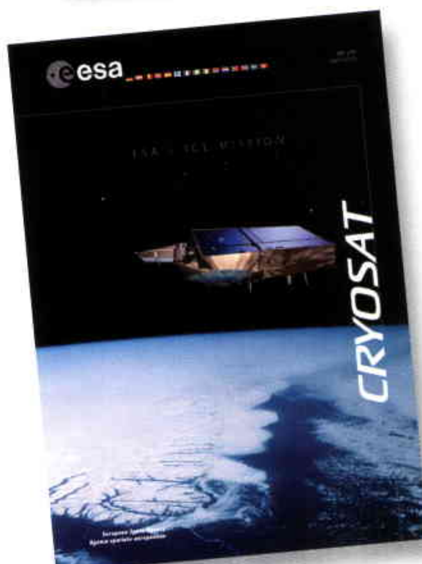

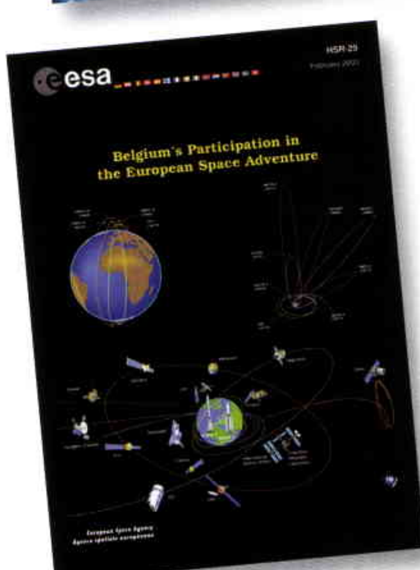

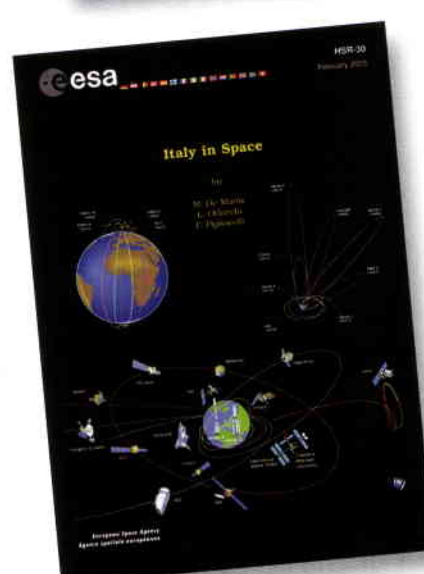

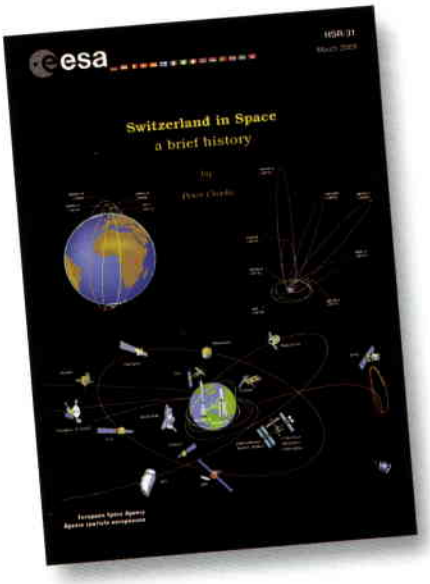

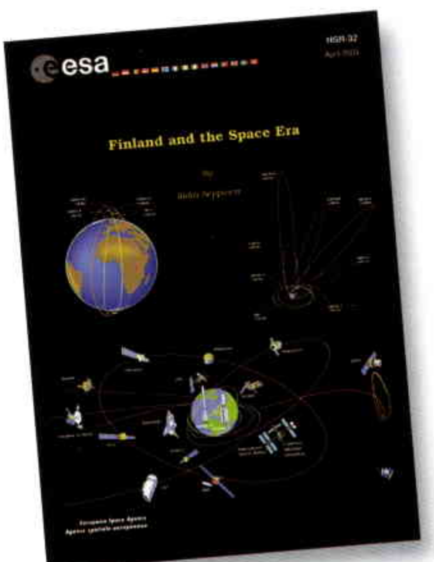

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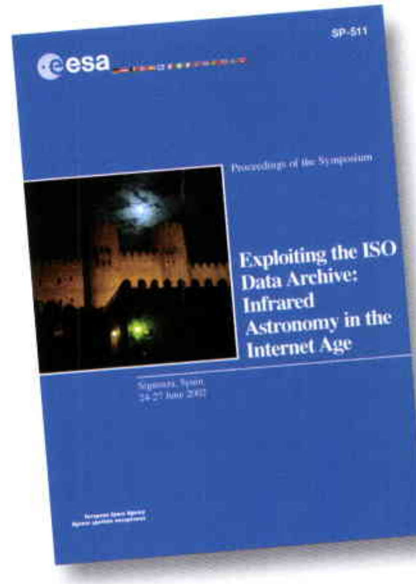

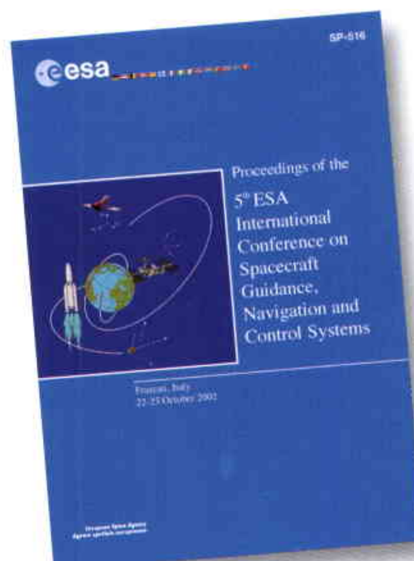

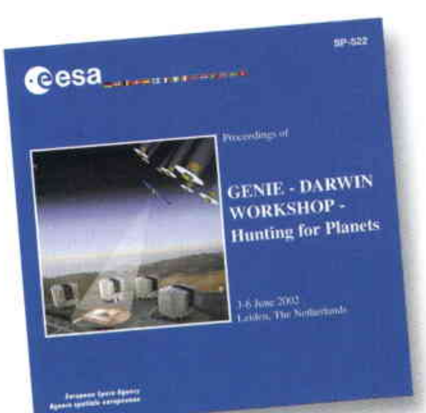

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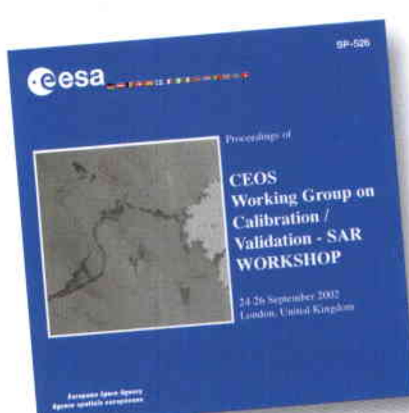

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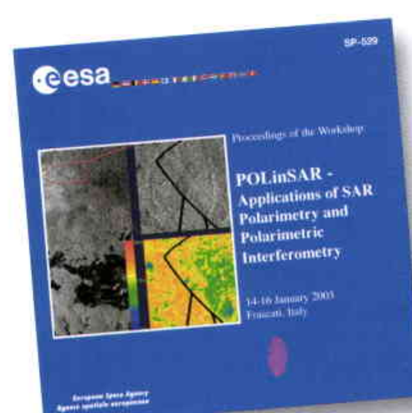

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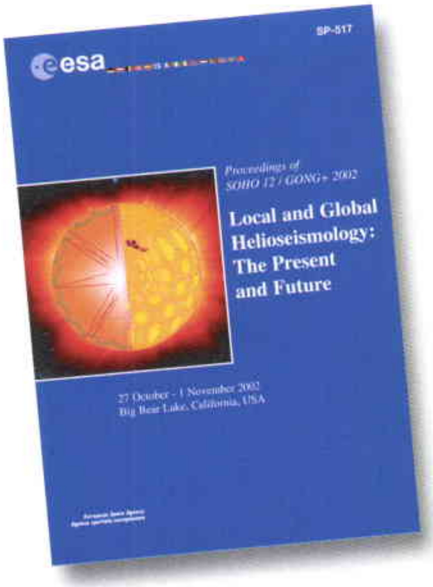

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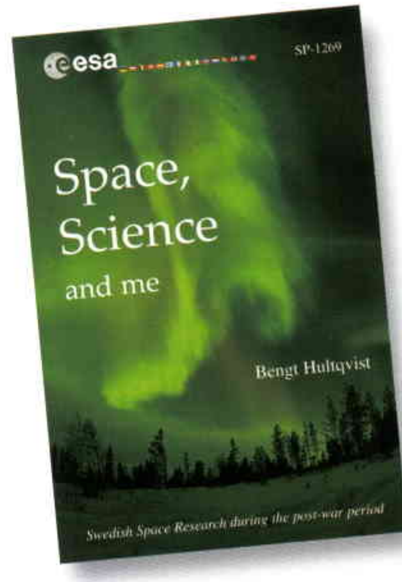

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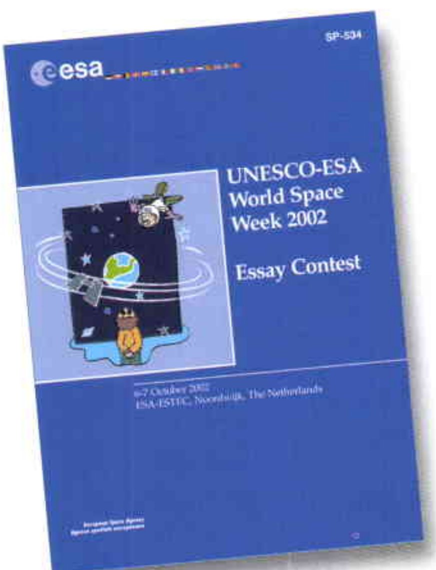

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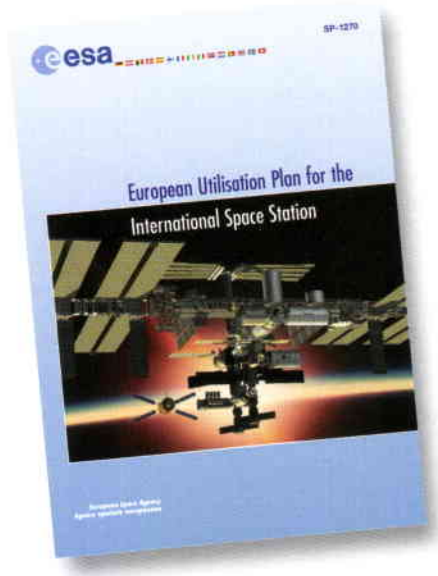

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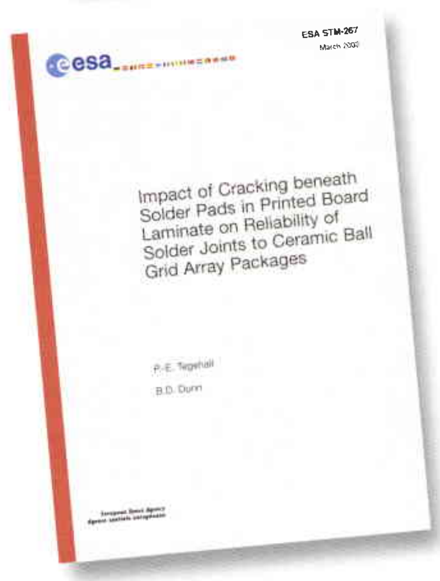

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